International Millets Conference & Futuristic Food Expo' 2023

IMCFFE 2023

Souvenir - Extended Summary and Abstracts





Editors

Dr. N. Manivannan
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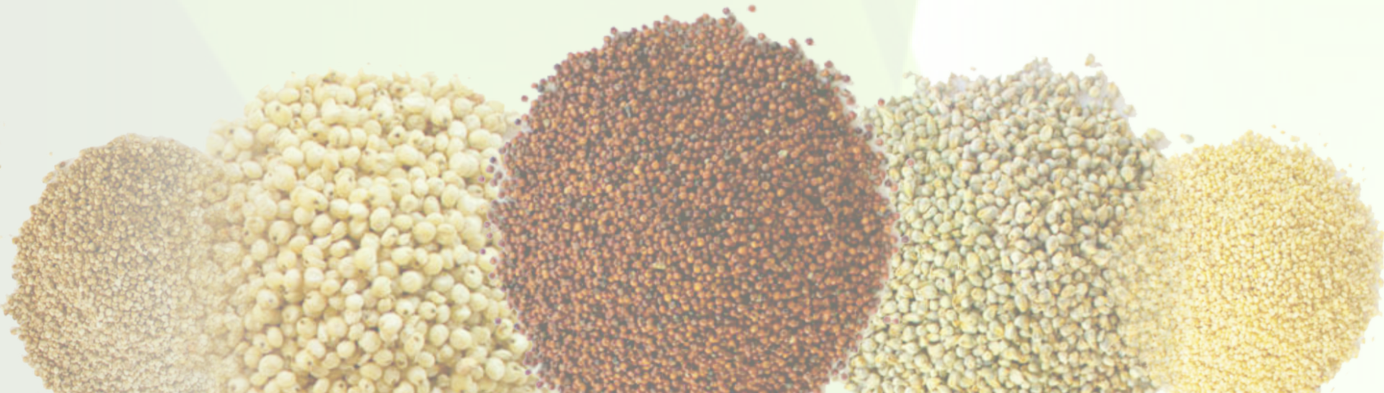

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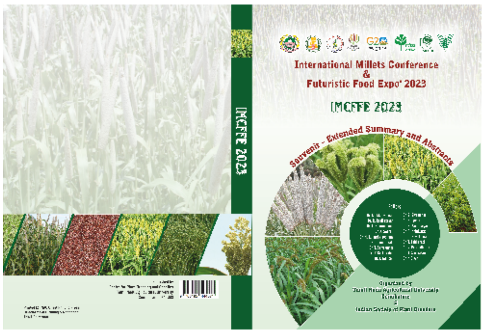

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TAMIL NADU AGRICULTURAL UNIVERSITY

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FOREWORD

In commemoration of the International Year of Millets 2023 and the Centenary year of Department of Millets, an International Millets Conference & Futuristic Expo' 2023 is jointly organized by Tamil Nadu Agricultural University and the Indian Society of Plant Breeders during 24 - 26th May 2023 at TNAU, Coimbatore. The international millets conference focuses on six thematic areas - crop improvement and biotechnological approaches, crop production and mechanization, crop protection, post harvest management, policy issues and entrepreneurship.

I hope this international conference will be a landmark event in fostering consumption of millets and promote research and development. Specifically, this event will also encourage young minds to integrate millets in their diet and lead a healthier and eco friendly lifestyle. I appreciate the participants, who will be presenting their research papers at the conference. I am sure that this Book of Abstracts would be useful to all scientists and research scholars for their future research work. I congratulate the organizers for their efforts in organizing the international conference.

V. Geethalakshmi 20/5/2023

(V. GEETHALAKSHMI)

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PREFACE

Millets are a group of highly variable small seeded grasses, widely grown around the world as cereal crops for food and fodder. They are highly tolerant to drought and comes up well in extreme weather conditions and are grown with low chemical and inputs such as fertilizers and pesticides. From time immemorial millets are the main source of nutritional food for healthy sustenance and long life of ancient Indians. Millets are important source of slow digesting carbohydrates, high nutritive status of proteins, fibres, vitamins, minerals like calcium, phosphorus, iron and zinc besides unsaturated fatty acids, phytochemicals and antioxidants.

Recognizing the importance of millets, Ministry of Agriculture and Farmers Welfare has declared Millets as "Nutri-Cereals" for production, consumption and trade point of view. India celebrated 2018 as 'The Year of Millets'. Considering its importance in nutrition and climate resilient nature, the U.N. General Assembly declared 2023 as the International Year of Millets, proposed by India and supported by more than 70 countries.

India is the global leader in production of millets with a share of around 15% of the world total production. In India, millets are cultivated in an area of 12.45 million hectares, producing 15.53 million tonnes with a yield of 1247 kg/ha.

Sorghum is the fourth most important food grain in India after rice, wheat, and maize in terms of area (3.84 Mn. ha) and production (4.31 Mn. MT). Bajra (7.05 m ha) is contributing more than 50 per cent of the country's area under millets with nearly equal percentage of production. India is the leading producer of Barnyard (99.9%), Finger (53.3%), Kodo (100%), Little millet (100%) and pearl millet (44.5%). Other millets occupies the minimal area across different Indian states. Millets can be used as super foods using various agri-processing and other modern technologies integrating the fundamental knowledge.

The Department of Millets, has released more than 100 high yielding millet varieties at state and national level and various technologies which benefitted the farmers. The Department of Millets has attained a remarkable milestone of reaching its centenary year. To recognize and commemorate the International Year of Millets 2023 & Centenary Year of Millet Breeding Station, TNAU, the International Millets Conference & Futuristic Food Expo 2023 has been brought. This book would be highly useful as a resource material for millet researchers. It has information about millet crop improvement, management and protection technologies, value addition and transfer of technology. I want to thank the authors for their hard work in putting together all the information available and presenting clearly. I am confident that this book of abstracts will be useful to the millet researchers.

CONTENTS

Theme 1 : Genetic Enhancement of Millets through Crop Improvement and Genomic Approaches

Theme 2: System of Millet intensification, Advanced Management Technologies and Farm Mechanization

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Theme 5: Millet Value Chain Management and Policies

Theme 6: Entrepreneurship/Start – Up and Success of FPOs

Theme 1

Genetic enhancement of millets through crop improvement and genomic approaches

Extended Summaries

T1-01
Estimates of genetic parameters in ICRISAT Pearl Millet [*Pennisetum glaucum*(L.) R. Br.] accessions for green fodder yield and related traits

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Abstract

A field experiment was conducted with fifty pearl millet genotypes raised in a randomized block design with two replications at Research Farm, Department of Plant Breeding and Genetics, AC &RI, Killikulam to study the green fodder yield and its related traits. High magnitude of variation in the experimental material of this study was reflected by high values of mean and range for almost all the 12 characters. The genotypes IP11840, IP15257, IP11839, IP15322, IP20347, IP15341, IP10437 and IP17428 were the best identified genotypes for green fodder yield coupled with tallness, increased number of tillers per plant, more leaf length, more number of leaves per plant, more stem girth and internode length, more LAI, more leaf stem ratio which indicated that these genotypes can be selected as parents in pearl millet improvement programme for the development of elite varieties/hybrids.

Keywords: Pearl millet, `variability, green fodder yield

Introduction

Pearl millet is an excellent forage crop and it has great potential among the millets. Its fodder is low in anti-quality factors like hydrocyanic acid and oxalic acid, while rich in protein, calcium, phosphorus and other minerals (Amit *et al.,* 2012). Success of dairy farming is largely depends on the feed and fodder of high nutritional value. Scarcity of fodder is a major limiting factor in the livestock community and India faces net deficit of 35.7% green fodder. To meet this requirement, high/multi-cut fodder yielding and nutritious varieties of fodder crops need to be identified. Crop improvement program requires information on genetic variation, nature of association among yield and its component traits, and how traits influence each other to finally express the trait of interest. Therefore, the present investigation was undertaken to study the genetic variability, heritability for green fodder yield and its components in fodder pearl millet genotypes.

Materials and Methods

The experimental material used in this study consisted of 50 Pearl millet genotypes collected from ICRISAT, Hyderabad and were evaluated during kharif, 2018. The experiment was carried out in Randomized Block Design with three replications. The seeds of 50 genotypes were directly sown in the field with a spacing of 45cm row to row and 15cm plant to plant spacing. The observations were recorded on the basis of five selected plants and average was taken on 12 biometrical traits. Mean values were used to compute the genetic parameters and statistical analysis of data was carried out for each character (Panse and

Sukhatme 1967). Heritability (Allard,1960) and the genetic advance(Burton,1952). The mean values of individual genotypes were analysed using statistical software's GENRES, Meta R and R studio software's.

Results and Discussion

Based on the mean performance, 50 pearl millet genotypes differed highly for all the 12 characters studied. Large variation among genotypes was found for majority of the traits which would offer scope of selection for development of desirable genotypes. The PCV were slightly higher than GCV indicating little influence of environment on the expression of characters suggesting the selection is effective (Table 2). In pearl millet, high PCV and GCV was recorded for all the traits studied except for leaf stem ratio. The traits plant height, number of tillers per plant, leaf length, leaf area index, number of leaves per plant, stem girth, internode length, dry fodder yield and green fodder yield exhibited high GCV and PCV. It showed more amount of genetic variations present between. Hence, selection towards these components will lead to development of dual purpose pearl millet varieties/hybrids. In the present study the trait green fodder yield, number of leaves per plant and dry matter yield per plant exhibited higher PCV and GCV and moderate PCV and GCV was observed for the trait leaf width which indicated these characters can be improved by the vigorous selection same was observed by Santhosh *et al*., 2017 in Napier grass. In pearl millet moderate GCV and PCV were observed for plant height, leaf length, dry matter per cent and leaf width as reported by Bika *et al*., 2015.Heritability estimates along with genetic advance were more useful than heritability estimates alone in predicting this response to selection. High heritability along with high genetic advance as per cent of mean was observed for plant height, number of leaves per plant, green fodder yield and dry matter yield. In this condition, selection will be more effective. Moderate heritability and genetic advance was observed for the trait leaf width and leaf stem ratio where the response to selection will be poor.

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Table 1. Analysis of variance for different characters in Pearl millet for fodder yield traits

Traits	Mean sum of squares		
	Replications (df = 1)	Genotypes (df = 1)	Error (df = 1)
DFF	37.96	112.19**	17.51
PH	10.83	7052.26**	29.38
NTPP	6.68	29.88**	2.44
LL	22.74	271.94**	8.75
LW	0.05	0.66**	0.14
LAI	0.07	125.95**	1.21
NLPP	5.28	5791.48**	16.08
SG	0.95	5.24**	0.1
LSR	0.04	1.77**	0.003
INL	40.1	225.03**	0.17
DFY	17.81	3176.09**	8.63
GFY	0.81	9222.87**	0.7

Table 2. Genetic parameter estimates in Pearl millet genotypes for fodder yield traits

Traits	Mean	Range	PCV (%)	GCV (%)	Heritability (%)	Genetic advance	Genetic advance as percentage of mean (%)
DFF	59.2	40-70	13.43	13.12	95.38	14.57	26.4
PH	207.91	110.31-383	33.41	28.05	70.45	85.4	48.49
NTPP	9	3-12	44.58	33.22	55.52	4.38	50.99
LL	41	11.21-62.64	29.11	28.65	96.85	20.84	52.55
LW	3.0	2 – 4.16	19.16	11.37	29.3	4.57	11.56
LAI	11.4	10.3-60.4	35.39	39.02	83.8	7.92	30.15
NLPP	87.3	10-160.5	62.22	62.04	97.36	89.14	97.45
SG	3.6	1.3 -6.3	43.55	42.52	95.32	3.15	85.51
LSR	0.23	0.2 – 0.36	9.59	7.46	60.54	7.18	11.96
INL	18.5	7.5 – 28.6	23.91	22.46	88.3	7.42	40.03
DFY	212.56	77-157.6	56.3	56.26	93.86	84.67	115.81
GFY	677.26	130- 970	58.85	58.79	99.99	92.22	121.22

DFF= Days to 50% flowering, PH=Plant height (cm), NTPP=Number of tillers per plant, LL= leaf length(cm), LW= leaf width (cm), LA= leaf area, NLPP=Number of leaves per plant, SG = stem girth, LSR = Leaf stem ratio, DFY – dry fodder yield(g) GFY = Green fodder yield(g)

T1-02
Character association studies in Pearl millet [*Pennisetum glaucum* L R.Br.] for grain yield traits

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Abstract

The present study was carried out to study the character association in fifty pearl millet genotypes for thirteen different biometrical traits. Character association studies revealed that grain yield was highly significant and positively correlated with seed weight per spike (0.70), spike length (0.69), 1000 grain weight (0.56), number of productive tillers (0.53), number of tillers per plant (0.49) and peduncle length (0.42). Highest direct effect on grain yield was contributed by the number of productive tillers per plant and seed weight per spike. Number of nodes per plant and number of tillers per plant showed high positive and indirect effect on grain yield through number of productive tillers. Hence, these traits were regarded as significant attributes in devising selection criteria for attaining yield objectives.

Keywords: Pearl millet, Genetic variability, Grain yield, Correlation coefficient

Introduction

Pearl millet is the staple food grain with high nutritional value and is also used as a feed, fodder, construction material and even its potential as a source of bio-fuel(Singh and Chhabra 2018). Improved grain yield of pearl millet depends upon contribution of the biometrical traits. The nature and degree of the yield correlated with other characters allows to predict the relative influence of individual character on yield improvement thereby enable the breeders to identify desirable traits that play a pivotal role in yield improvement. The objective of the present study was to investigate the genetic relations and to compare the correlations of the characters on grain yield present in the diverse pearl millet genotypes for the different characters.

Materials and Methods

The experimental material consisted of 50 pearl millet genotypes collected from ICRISAT, Hyderabad. The field trial was conducted at Farm premises of Agricultural College and Research Institute, Killikulam during *Kharif*, 2018. The experiment was carried out in Randomized Block Design and replicated twice. The seeds of 50 pearl millet genotypes were directly sown in field adopting a spacing of 45 x 15 cm. Observations were recorded on ten randomly selected plants for economically important biometrical traits *viz*., grain yield, flag leaf area,number of nodes per plant, peduncle length, seed weight per spike, number of productive tillers, number of tillers per plant, spike length, 1000 grain weight, flag leaf length, flag leaf width, plant height, days to 50% flowering. The mean values of individual genotypes were subjected to statistical analysis using statistical software's GENRES, Meta R and R studio software's

Results and Discussion

Association of plant characters with grain yield assumes a special importance in determining as to which traits, the selection should be applied to ultimately obtain high yielding hybrids. Genotypic correlation coefficient between all possible characters were presented in Fig1.It was observed that the characters *viz*., seed weight per spike (0.70), spike length (0.69), test grain weight (0.56), number of productive tillers (0.53), number of tillers per plant (0.49), peduncle length (0.42) exhibited highly significant positive correlation with grain yield. These results were accordance to previous reports of Pear millet research workers findings of Kumawat *et al.,* (2019) for number of productive tillers, Singh and Chhabra (2018)for seed weight per spike With regard to path analysis, the grain yield had positive high direct effect with number of productive tillers per plant and seed weight per spike which was similar to findings of Abuali *et al.,* (2012). Based on the correlation and path analysis the traits *viz.,* spike length, seed weight per spike, number of productive tillers per plant and number of nodes per plant is responsible for the grain yield improvement in Pearl millet.

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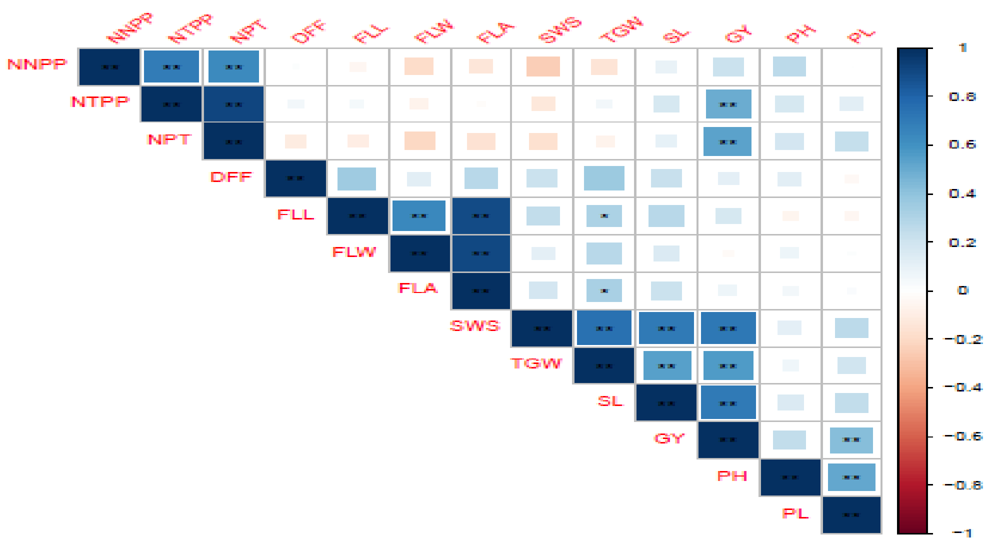
Fig.1. Genotypic correlation for yield and yield contributing traits in Pearl millet



** Significant at 1 percent level;

* Significant at 5 percent level

T1-03

Evaluation of barnyard millet [*Echinochloa frumentacea* (Roxb.) Link] germplasm under natural sodic soil condition

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Abstract

Barnyard millet is a hardy crop suitable to grown under stress condition. Sodicity is one among the stress which affects the barnyard millet crop yield. Hence, A study was carried out using barnyard millet accessions in a naturally sodic soil condition to assess the genetic diversity, variability and also to identify the genotypes best suited for sodic soils. Observations were recorded for 13 quantitative traits. Among the traits plant height, inflorescence width, lower raceme length, flag leaf length, flag leaf width, flag leaf area and grain yield per plant had high GCV, PCV, heritability and genetic advance as percent of mean suggests that selection could be productive. Mahalanobis D^2 analysis revealed cluster I and XI had highest inter-cluster distance, hence these genotypes could result in heterotic hybrids. Based on the *per se* performance the genotypes BAR242 followed by BAR252, BAR264 and BAR353 were observed to produce better yield than checks CO (KV) 2 and MDU 1 which indicated that these genotypes were more suitable under sodicity.

Keywords: Barnyard millet, Variability, Diversity, Sodicity.

Introduction

Barnyard millet is a multipurpose crop grown for both food and fodder. Sodic soils are characterised by high pH (>8.5) and Exchangeable Sodium Percentage (ESP > 15 %), low EC (< 4.0 dS/m) and imbalanced nutrition with ion toxicity which exhibits poor physical and chemical features that hinders seed emergence and crop growth. Sodicity is one of the major abiotic-stress which affects the barnyard millet crop yield. Hence, this study was carried out to estimate the performance of barnyard millet germplasm accessions under sodic condition.

Materials and Methods

The present study was carried out in natural sodic soil (pH : 9.07, EC : 0.95dS/m and ESP : 43.69%) at Anbil Dharmalingam Agricultural College and Research Institute, Trichy, Tamil Nadu during Summer 2018. The experimental material involved 99 germplasm lines including two commercial check varieties *viz.,* MDU1 and CO(KV) 2. The experiment was laid out in randomized block design with two replications. Observations were recorded for 13 quantitative traits. Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) were calculated using the formula given by Burton *et al.* (1952). Heritability in broad sense (h^2) was assessed according to Lush (1940) and expressed in percentage. The replicated data were subjected to D^2 analysis (Mahalanobis, 1936) and grouping of genotypes was done (Radhakrishna Rao, 1952). Statistical analysis was carried out using TNAUSTAT and GENRES softwares.

Results and Discussion

Wide range of variation was observed among the 99 genotypes for all the characters studied suggesting that selection could be possible under sodicity. The highest mean value for yield was recorded by BAR242 followed by BAR252 hence, can be deemed as sodicity tolerant. High PCV and GCV value was observed for flag leaf area followed by grain yield per plant lower raceme length, flag leaf width, inflorescence width, flag leaf length and plant height indicating stable nature of these characters (Table 1). Hence, selection for such traits will be effective for crop improvement programme under sodicity. High heritability and genetic advance as percent of mean was observed for grain yield per plant, plant height, flag leaf area, lower raceme length, flag leaf width, inflorescence width and harvest index indicating the preponderance of additive gene action in their inheritance. Hence, selection could be employed for improvement of these traits in barnyard millet. Cluster mean values for 13 characters are presented in Table 2. The percent contribution of each character towards divergence is presented in figure1. Among the yield contributing traits major contributors towards divergence were grain yield per plant (53.91 %) followed by plant height (17.44 %). By cluster analysis, the accessions from cluster I and cluster XI can be used for hybridization programme. Similar findings were reported by Arunachalam and Vanniarajan (2012), Anuradha *et al.* (2014), Renganathan *et al.* (2017), and Prakash *et al*. (2015). This study concluded that, the genotypes BAR242 followed by BAR252, BAR264 and BAR353 were observed to produce better yield than checks CO (KV) 2 and MDU 1 which indicated that these genotypes were more suitable under sodicity.

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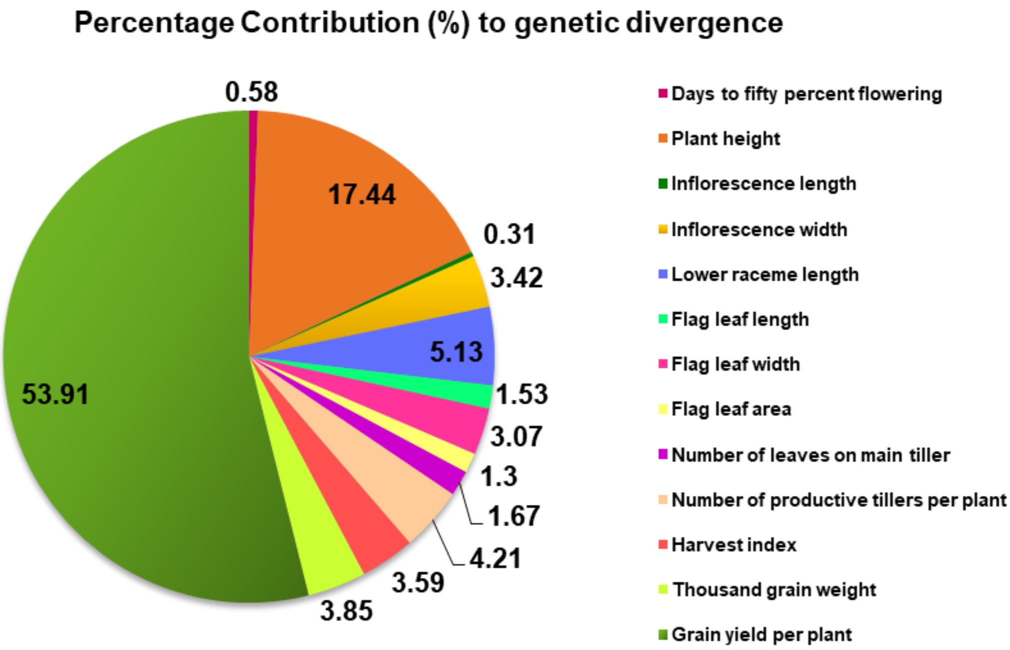
Table1.Variability parameters for yield and other yield component traits in barnyard millet under sodic soil

Characters	Mean	Range		Coefficient Variation (%)		Heritability	GA as per cent of mean
		Min	Max	PCV	GCV	h^2 (%)	(5% level)
DFF	37.37	35	46	7.65	5.62	54.06	8.52
PH (cm)	49.97	31.21	81.52	21.59	20.39	89.22	39.68
IL (cm)	10.15	6.76	16.29	20.25	17.16	71.85	29.97
IW (cm)	1.85	0.69	3.64	31.33	27.54	77.3	49.88
LRL (cm)	1.71	0.72	3.38	35.17	31.47	80.1	58.03
FLL (cm)	12.74	6.59	22.55	27.31	22.8	69.72	39.22
FLW (cm)	1.35	0.73	3.59	33.05	29.78	81.22	55.29
FLA (cm^2)	8.73	3.51	39.36	58.33	51.99	79.44	95.46
NLMT	4.77	4	7	18.4	12.47	45.97	17.42
NPT/P	4.96	3	8	25.32	15.95	39.69	20.7
HI	0.36	0.22	0.45	13.95	13.53	93.95	27.01
TGW (g)	2.13	1.2	3.01	14.71	9.69	43.35	13.14
GY/P (g)	12.03	3.1	41.88	48.99	47.88	95.51	96.39

Table 2. Clustering pattern of 99 barnyard millet germplasm by D^2 analysis under sodicity

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Genotypes	39	2	2	2	2	2	2	2	2	2	3	4	2	2	31

Fig. 1. Contribution of 13 biometrical characters to genetic divergence in barnyard millet germplasm under sodicity



T1-04

Physio-chemical analyses in barnyard millet [*Echinochloa frumentacea* (Roxb.) Link] raised under sodic soil

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Abstract

Barnyard millet (*E. frumentacea*) is a miracle crop due to its early mature, climate resilient capacity and nutrient potential. It is a hardy crop which can withstand a variety of abiotic stresses and one such limiting stress is sodicity. The crop also possesses immense potential in future as it holds an important stature in the quest for food and nutrition security. A study was conducted using ninety-seven barnyard millet germplasm along with two commercial checks *viz.,* MDU 1 and CO (KV) 2. Among the genotypes evaluated, 25 were selected (best and poor yielder) for physio-chemical analysis. Attributes related to sodicity stress like proline content and Na^+/K^+ ratio and iron nutrient content were estimated. Based on the study, the genotypes BAR-242, BAR-252 and BAR 264 were observed to have high proline with low Na^+/K^+ ratio and moderate iron nutrient content. The genotypes BAR242 followed by BAR252 and BAR264 were observed to produce better yield than checks CO (KV) 2 and MDU 1 with optimum nutrient. Hence, BAR242 and BAR252 could be considered as sodicity tolerant genotypes which could be exploited for future breeding programmes for development of sodicity tolerant barnyard millet genotypes.

Keywords: Barnyard millet, Proline content, Iron nutrient, Na^+/K^+ ratio, Sodicity.

Introduction

Millets are a traditional staple food of the dry land regions of the world, grown for both food and fodder. They are nutri-cereals and had unique adapting capacity at both biotic and abiotic stress condition. It needs less water for cultivation that makes these crops suitable for arid and semi-arid farming in the world. Globally, 37 per cent of the arable land is sodic in nature. Sodicity is one of the major abiotic stress which affects the barnyard millet crop yield. Sodic soils are characterised by high pH (>8.5) and Exchangeable Sodium Percentage (ESP > 15 %), low EC (< 4.0 dS/m) and imbalanced nutrition with ion toxicity which exhibits poor physical and chemical features (Khan and Duke 2001) that hinders seed emergence and crop growth. Barnyard millet has also been used for the reclamation of sodicity, arsenic and cadmium affected soils (Abe *et al*., 2011). Iron is one of the important mineral nutrients that plays a major role in our body as it is a vital component of haemoglobin. Its deficiency causes anaemia. Among different millet crops, barnyard millet is endowed with high iron content of upto 16 mg/100g of grain (Vanniarajan *et al.*, 2018). Estimation of physiological attributes related to sodicity stress like proline content and sodium/potassium ratio provides reliable knowledge for selecting best genotypes under sodic condition. Considering the above facts, this study was carried out to estimate the performance of barnyard millet germplasm accessions by physio-chemical analyses in sodic soil.

Materials and Methods

This study was carried out in natural sodic soil (pH: 9.07, EC: 0.95dS/m and ESP: 43.69%) at Anbil Dharmalingam Agricultural College and Research Institute, Trichy, Tamil Nadu during Summer, 2018. The experimental material consisted of 97 germplasm lines of barnyard millet obtained from Indian Institute of Millets Research (IIMR) and two commercial check varieties *viz*., MDU1 and CO(KV) 2. The experiment was laid out in randomized block design with two replications. Among the genotypes evaluated, 25 were selected (best and poor yielder) for the purpose of physio-chemical studies. Among the genotypes evaluated, 25 were observed to record significantly superior yield. The grain iron content of the 25 lines were estimated by Atomic Absorption Spectroscopy as suggested by Jackson (1973) and expressed in mg $100g^{-1}$ on seed weight basis. Proline content was estimated in fully expanded leaves at flowering stage following the method of Bates *et al.* (1973). Sodium and potassium content were estimated by flame photometer method using the triple acid extract of dry sample at maturity stage as proposed by Jackson (1973).

Results and Discussion

Proline is an excellent osmolyte (Hayat et al., 2012) and its accumulation was correlated with improved plant performance under stress condition by down regulation of the genes involved in proline catabolism. Under sodicity, proline content and Na^+/K^+ ratio exhibited wide range of variation. Incidentally high yielding genotypes (BAR242, CO (KV) 2, MDU 1 and BAR252) were observed to record the maximum proline content with low Na^+/K^+ ratio and proline was low with high Na^+/K^+ ratio for low yielders (BAR198, BAR228, BAR317 and BAR208) (Table.1). This indicates that under stress condition, accumulation of proline enhances photosynthetic yield (Hayat *et al.*, 2012) and this helps the plants to attain stability in performance (Dubey *et al*., 2018). Proline content is positively correlated with salt stress whereas Na^+/K^+ ratio was negatively correlated with it (Kumar *et al.,* 2017). This could be because of the facts that tolerant plants accumulate more K and Proline is an excellent osmolyte.

Highest iron content was recorded by the genotype BAR370 followed by MDU 1, BAR372, BAR252, BAR242 whereas low in BAR220 followed by BAR269, BAR389, BAR193 (Fig.1). The general pattern observed among genotypes for yield and iron content shows that increase in yield corresponds with increase in iron content, which indicates that there could be positive correlation between the two traits as reported by Vishnuprabha and Vanniarajan (2016) in barnyard millet. Genotypes with high yield and iron content could be exploited for future breeding programmes in the crop.

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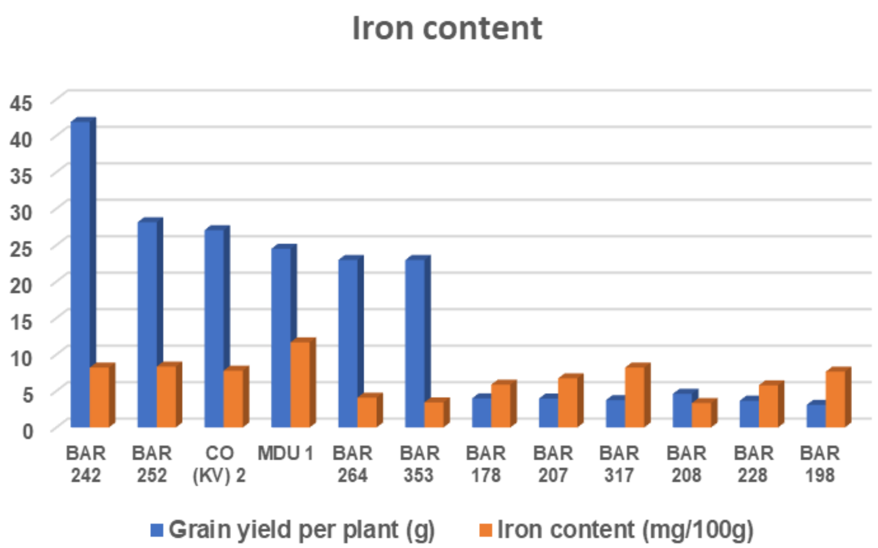
Table 1. Physio-chemical analyses in barnyard millet under sodicity

Genotypes	Na^+/K^+ ratio	Proline content µg/g	Grain yield per plant (g)	Iron content (mg/100g)
BAR 242	0.08	790	41.88	8.21
BAR 252	0.11	610	28.14	8.35
CO (KV) 2	0.22	710	27.05	7.79
MDU 1	0.27	670	24.5	11.67
BAR 264	0.12	650	22.96	4.09
BAR 353	0.12	420	22.95	3.44
BAR 178	0.36	310	3.99	5.87
BAR 207	0.39	270	3.97	6.74
BAR 317	0.41	210	3.75	8.21
BAR 208	0.42	220	4.61	3.345
BAR 228	0.46	170	3.67	5.78
BAR 198	0.67	140	3.1	7.65

Fig. 1. Iron content in barnyard millet under sodicity



T1-05
Valuation of sweet corn (*Zea mays L. saccharata.*) quality traits and genetic variability parameters

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Abstract

Sweet corn quality associated with consumer preference is kernel flavor, texture, and aroma. Sweetness in sweet corn is closely related to kernel sucrose content, the primary sugar in developing kernels. Textural eating quality of sweet corn consists of several factors, including pericarp tenderness, level of water-soluble polysaccharides or phytoglycogen and moisture content. The present study was consisting of evaluation of sweet corn genotypes for genetic variability, heritability and genetic advance estimates for quality traits in sweet corn. Analysis of variance for five quality traits *viz.,* total sugar, reducing sugar, sucrose, total carbohydrates and starch revealed that high significant mean sum of squares for all the characters indicating greater diversity among the genotypes. The genotypic coefficients of variation (GCV) for all the characters studied were lesser than the phenotypic coefficients of variation (PCV) indicating the influence of environment on the traits. High GCV and PCV values were observed for all the quality traits studied, suggesting that the existence of sufficient variability thus offers scope for genetic improvement through selection. High heritability coupled with high genetic advance as per cent of mean was observed for all the characters studied indicating the role of additive genes in governing the inheritance of these traits which could be improved through simple selection.

Keywords: Sweet corn, quality, Genetic variability, heritability, genetic advance

Introduction

Sweet corn is considered a common maize derived vegetable crop through recessive mutation that is characterized by wrinkled and translucent dry grains with high sugar and low starch contents in the endosperm. Several factors have contributed to this small expression, including the lack of adapted varieties and the presence of undesirable agronomic traits such as tall plants, lodging susceptibility and poor ear placement (Corn. 2009). The development of superior sweet corn genotypes is crucial to overcome these problems. Improvement of sweet corn yields, while retaining quality is one of the major challenges facing the sweet corn breeders (Hunsperger and Davis, 1987). Hence, an efforts was made to study the germplasm for different characters and to identify superior sweet corn genotypes that could be further used in the crossing programme to develop high yielding varieties and hybrids.

Materials and Methods

The experiment for the present study was conducted during *kharif,* 2014 at Department of Millets, Tamil Nadu Agricultural University, Coimbatore with 23 sweet corn lines *viz*., USC 1396-4, USC 1207-6-1, USC 3-1-2-2-1, USC 7855-2, USC 7-2, USC 1207-6-

2, USC 1378-5-2, USC 1-1-1, USC 1647-11-2, USC 1421-5-2-2, USC 11-2, USC 10-3-2-4, USC 10-3, USC 8322-4-3, USC 1-2-2, USC1-2-3-1, USC 72175-3, USC 1413-6-2, USC 7855-10, USC 72173-3, USC 7-1, USC 1413-6-1 and MADHURI , which were raised in Randomised Block Design with three replications. In every treatment, five plants were allowed for selfing by controlled pollination for the purpose of studying the quality characters *viz*., total sugar, reducing sugar, sucrose, total carbohydrates and starch. The procedure described by Dubios *et al.,* (1956) was followed for estimation of total sugar. Determination of reducing sugars by Nelson Somogyi method was followed. The sucrose, total carbohydrates and starch by anthrone method was followed. The genetic parameters *viz*., genotypic and phenotypic coefficient of variation (Burton, 1952), heritability in broad sense and genetic advance as per cent of mean (Johnson *et al*., 1955) were estimated for all the characters.

Results and Discussion

Analysis of variance revealed the existence of significant differences for all the five quality traits studied (Table 1). The frequency distribution of quality traits are shown in Fig. 1, 2a-e.

The total sugars ranged from 2.05 (USC 7-2) to 17.14% (USC 8322-4-3), reducing sugars from 0.12 (Madhuri) to 4.01%(USC 1378-5-2), sucrose from 0.91 (USC 7855-2) to 16.45% (USC 8322-4-3)), total carbohydrates from 16.03 (USC 7-2) to 62.6% (USC 1-2-3-1)) and starch from 2.59 (USC 1-2-3-1) to 13.36% (USC 3-1-1-2-2-1)).Phenotypic coefficient of variation were greater than genotypic coefficient of variation for all the traits studied (Table 2).

It implied that apparent variation was not only due to genotype but also due to the influence of environment. The phenotypic coefficient of variation was estimated to be high for all the characters *viz.,* reducing sugars (87.40) followed by sucrose (74.73), total sugars (60.43), starch (37.66) and total carbohydrates (28.64). Genotypic coefficient of variance showed a similar trend in all the traits studied and was observed to be high for all the characters studied *viz.,* (86.97) followed by sucrose (74.70), total sugars (60.31), starch (37.63) and total carbohydrates (28.62). High heritability along with high genetic advance (% of mean) was observed for all the five quality traits *viz.,* reducing sugars (178.27), sucrose (153.81), total sugars (124.00), starch (77.47) and total carbohydrates (58.93) indicating the role of additive genes in governing the inheritance of these traits which could be improved through simple selection.

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Table 1. Analysis of variance for different quality characters in sweet corn

S.No.	Parameters	Mean sum of squares		
		Replications(df=2)	Treatments (df=25)	Error (df=50)
1.	Total sugars	0.021	52.98**	0.07
2.	Reducing sugars	0.031	3.304**	0.01
3.	Sucrose	0.029	56.23**	0.02
4.	Total cho	0.03	499.83**	0.18
5.	Starch	0.05	21.49**	0.01

Table 2. Variability parameters for quality traits in sweet corn

Characters	Mean	Minimum	Maximum	PCV	GCV	Heritability	GA
Total Sugars(%)	7.00	2.05	17.14	60.43	60.31	99.62	124.00
Red. Sugars(%)	1.19	0.12	4.01	87.40	86.97	99.01	178.27
Sucrose (%)	5.81	0.91	16.45	74.73	74.70	99.91	153.81
Total CHO(%)	45.15	16.03	62.60	28.64	28.62	99.89	58.93
Starch(%)	7.16	2.59	13.36	37.66	37.63	99.87	77.47

Fig. 1. Frequency distribution of quality parameters in sweet corn genotypes

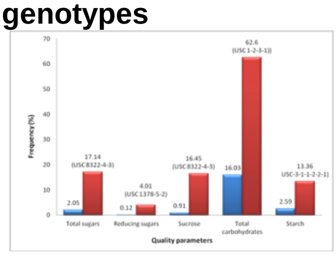


Fig. 2a. Frequency distribution of total sugars

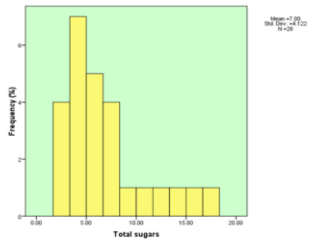


Fig 2b. Frequency distribution of reducing sugars

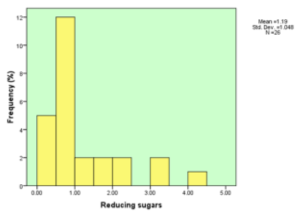


Fig 2c. Frequency distribution of total carbohydrates

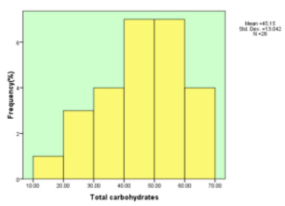


Fig 2d. Frequency distribution of sucrose

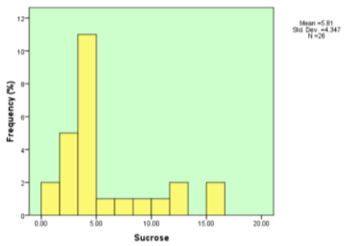
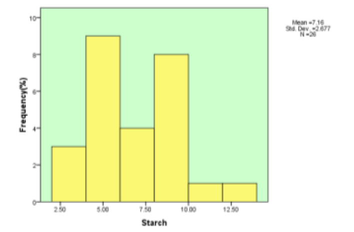


Fig 2e. Frequency distribution of reducing sugars



T1-06
A high yielding dual purpose sorghum variety K 13 suitable for rainfed vertisol tracts of Southern districts of Tamil Nadu

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Introduction

Sorghum is one of the most significant dryland crops grown for dual purpose, in kharif and rabi seasons in Tamil Nadu. It is cultivated over an area of 4.05 lakh hectares with an annual production of 4.27 lakh tones with a productivity of 1054 kg/ha of grain (Season and Crop report 2020-21). Sorghum is cultivated as a rainfed crop by the marginal farmers exceeding 85 per cent of the area to meet out the requirement of grain for consumption and dry fodder as animal feed. Healthy eating can transform life to live active and longer which demand sorghum grain as health food in urban areas. Besides sorghum is the major dry fodder to fulfil the requirement of dryland farmers. Sorghum is also prone to some of the pests like shoot and stem borer and diseases like grain mould and downy mildew. This necessitates the development of an early duration sorghum variety with high commercial value for the present day rainfed sorghum scenario. Crop breeding is the continuous endeavor to develop better crop varieties with wider adaptation, increased productivity and enhanced resistance to benefit the farming community. The latest rainfed sorghum variety released was K 12 during the year 2015. With the objective of developing more productive varieties than K 12, the sorghum culture TKSV 1036 has developed by crossing ICSB 518 x SPV 1489 and tested for its superiority in various yield trials.

Materials and Methods

Sorghum Culture TKSV 1036 is a hybrid derivative of the cross (ICSB 518 x SPV 1489) developed at the Agricultural Research Station, TNAU, Kovilpatti. This culture was evolved with an objective to develop high yielding dual purpose sorghum variety with enhanced tolerance to shootfly and stemborer and with improved fodder quality. It has been tested for its adaptability under Multilocation trials and on-farm trials in the southern district of Tamil Nadu. This culture has also been tested across the country under All India Coordinated Sorghum Improvement Project as SPV 2304 for its grain and fodder yields. The culture was subjected to natural as well as artificial screening for pest and diseases. The nutritional qualityof the grain and fodder was evaluated to assess the suitability of grain for consumption and fodder for invitro digestibility.

Result and Discussion

The culture, TKSV 1036 recorded an average grain yield of 2575 kg/ha over 118 locations which is 10.7 per cent and 3.5 per cent increase over K 12 (Local check) and CO 30 (check) respectively.(Table 1) TKSV 1036 is found to be highly suitable for cultivation under rainfed condition during winter season. The sorghum culture TKSV 1036 is a photo-insensitive nature, it is suitable for cultivation throughout the year. TKSV 1036 is a dual purpose sorghum culture which gave an average dry fodder yield of 11.4 tonnes /ha. The dry fodder yield increase is 26.6% over local check K 12.

TKSV 1036 is shorter in duration which matures in 95-100 days. The crop is of tan plant type, tolerant to drought and non-lodging. Grains are highly acceptable, creamy white colour, borne on medium cylindrical semi-compact ear heads. It is resistant to shoot fly and stem borer and moderately resistant to midge. The culture TKSV 1036 is highly resistant to ergot (0.0% incidence), resistant to downy mildew (4.60% incidence), grain mould (9.90% incidence) and rust and showed moderate resistance to leaf blight and anthracnose.

The quality of the grain was also found to be better in terms of high protein content (10.9 g) and crude fibre (3.2 g) and also has high digestibility *Invitro* Dry Matter Digestability (IVDMD) of 46.77 %. Hence, the sorghum culture TKSV 1036 was proposed as a new sorghum variety during the year 2023 and released as K 13 for cultivation in rainfed vertisol tracts of southern districts of Tamil Nadu.

Table 1. Overall performance of TKSV 1036 in different yield trials Grain Yield (kg /ha)

S. No.	Trials	No of trials conducted	Mean Grain Yield (kg/ha)			% increase over check variety	
			TKSV 1036	K 12 (c)	Co 30(c)	K 12	Co 30
1.	**Station trials** (2012-15) ARS., KPT	3	3647	3084	2525	18.3	44.4
2.	Multilocation trials (2015-17) TNAU Research Stations	15	2164	1836	1990	17.8	8.7
3.	AICRP trails (2014-15)	9	2334	-	3467	-	-
4.	ART Trials conducted by Dept. of Agrl. (2017-18, 2018-19)	82	2031	1809	1968	12.3	3.2
5.	OFT 2020 - 21	9	2698	2575	0	4.8	-
Over all Mean		**118**	**2575**	**2326**	**2488**	**10.7**	**3.5**

T1-07
Assessment of genetic diversity among elite genotypes of Foxtail millet (*Setaria italica* L.)

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Abstract
The present work comprised of 40 foxtail millet (*Setaria italica* L.) germplasm lines obtained from small millet scheme, MARS, Dharwad. These lines with checks were evaluated in replicated yield trial at millet scheme, MARS, Dharwad, during *rabi* 2020-21 for assessing genetic diversity. Based on D^2 values, the 40 genotypes were grouped into nine clusters. Among these clusters, cluster I was the largest with 28 genotypes followed by cluster VI with 2 genotypes whereas remaining 7 were solitary clusters. Inter cluster distance were worked out considering the eight characters and the inter cluster distance varied from 41.78 (between cluster II and IV) to 532.6 (between cluster IV and VI). These results suggested the presence of wide diversity between these clusters. The intra cluster distances indicated that, maximum intra cluster distance among the germplasm lines was recorded by cluster I (88.91) having 28 germplasm lines followed by cluster VI (55.27) with two germplasm lines. The maximum inter cluster distance was found between cluster II and IV, which indicates considerable diversity existed among 40 germplasm lines. The principal component analysis (PCA) identified five principal components (PCs) with more than 1 eigen values. These five PCs cumulatively explained 71.93% of total variation, among which first PC showed highest proportion of variance (29.49). The biplot of first two PCs showed similar kind of divergence, where the solitary cluster lines were plotted distantly.

Keywords: Foxtail millet, Genetic Diversity, PCA, D^2

Introduction
Foxtail millet (*Setaria italica* L.) is an annual, diploid (2n=2x=18) and self-pollinated crop. It is an important ancient crop of dryland agriculture and the potential climate-resilient crop for food and nutritional security in the current climate change scenario. Foxtail millet ranks second in the world's total production of millets. China has the highest area under foxtail millet and leads first in production of foxtail millet in world. In India, it is cultivated in an area of 5 lakh hectares and the production of 2.9 million tons with productivity of 600 kg per hectare.

Foxtail millet grains are rich in Protein, Carbohydrates, Lysine and Thiamin. The Grains contain dietary fiber, which improves glycemic index and lowers plasma lipid concentrations in patients with type 2 diabetes (Jali *et al*., 2012). In spite of the health benefits provided by foxtail millet, it has remained as a neglected crop from the mainstream of crop improvement research compared to cereals. Genetic diversity is the pre-requisite for hybridization program to obtain desirable genotypes. Genetic diversity is very much essential to meet the diverse goals in plant breeding such as for producing cultivars with increased yield. This study conducted to asses the genetic diversity among elite foxtail millet genotypes, to use them in further breeding programme.

Materials and Methods

The experimental material comprised of 40 germplasm lines of foxtail millet which were evaluated at MARS, UAS, Dharwad, during *rabi* 2021. The experiment was conducted in RBD with three replications with spacing 30 cm × 10 cm. The data was analysed using Mahalanobis D^2 statistic using dist function in R studio. All the genotypes were grouped into different clusters with the help of Tocher's method using toc function. The prcomp function was used to perform, the Principal Component Analysis (PCA) and the biplot function was used to plot PC1 vs PC2.

Results and Discussion

The D^2 analysis revealed that the genotypes were grouped into nine clusters using Tocher's methods as given by Rao (1952). The 40 genotypes were grouped in nine clusters. Among nine clusters, cluster I was the largest comprising of 31 genotypes followed by cluster VI with 2 genotypes and Cluster II, III, IV, V, VII, VIII and Cluster IX had one genotypes each. Intra cluster distance was highest in the cluster I (88.91) followed by the cluster VI (55.21). These results were in accordance with Gopi *et al*., (2021). Furthermore, maximum inter-cluster distance recorded between the clusters IV and VI (532.86) followed by cluster IV and VIII (529.32), cluster III and VI (456.81) and cluster VI and IX (88.3) suggesting enormous variability in the genetic makeup of the genotypes included in these clusters. Minimum inter-cluster distance recorded between cluster II and IV (41.78) followed by cluster III and V (43.43).

Principal component analysis revealed that five out of 15 principal components had more than one intrinsic value. A total of 71.93 percent of variance was explained by these first five PCs. The first PC explained 29.49% of total variance, followed by the second PC which explained 14.05%. Biplots of the first two PCs show that panicle length, panicle breadth, flag leaf length, and flag leave breadth are highly correlated with grain yield per plant. Similar type of correlation was observed by Amaranth *et* al., (2018). Also, the biplot showed similar types of divergence as in D^2, for instance, genotype 3 from the fourth cluster had maximum inter cluster distance with genotypes 15, 32, and 38. Like D^2 analysis, in the biplot, the 3rd genotype was on the left, while the other genotypes were on the right. The genotype 28, 24, 30, 37 and 21 plotted near to grain yield per plant indicates these were having high mean for yield and its correlated traits.

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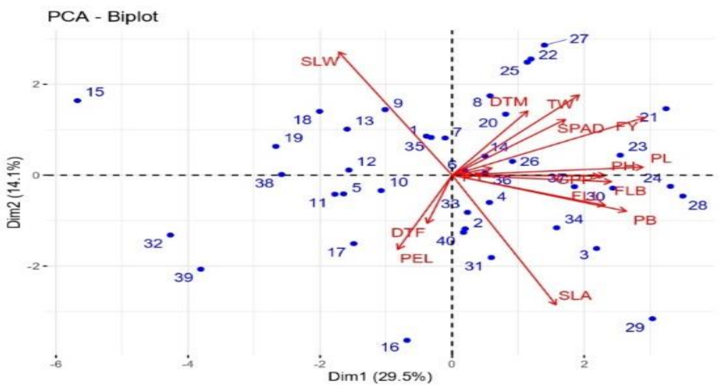
Table 1. Distribution of foxtail millet germplasm lines into different clusters

Cluster Number	Number of Germplasm lines	Genotype Number/ Name
I	31	1, 35, 5, 22, 9, 17, 12, 13, 10, 26, 6, 18, 8, 36, 31, 40, 33, 37, 30, 14, 16, 34, 4, 20, 2, 7, 21, 25, 11, 19, 39
II	1	28
III	1	23
IV	1	3
V	1	24
VI	2	32, 38
VII	1	27
VIII	1	15
IX	1	29

Fig. 1. Scatter diagram of 40 genotypes and fifteen characters of foxtail millet



T1-08

Combining ability effects and proportional contribution of line × tester interaction and gene action in maize (*Zea mays* L.) genotypes resistance to post flowering stalk rot

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Abstract

The project is based on line × tester analysis to study the combing ability effects, proportional contribution of lines, testers and L × T interactions and gene action in cross combinations of diverse maize genotypes for eight important biometrical traits. Twenty-three genotypes were evaluated in August 2019 in triplicate RBD designs at MRC, PJTSAU, Hyderabad. The results revealed highly significant differences ($P \leq 0.01$) among diverse genotypes for all traits. The average means suggest that all genotypes were resistant to PFSR, early maturing and high yield producers. The contribution of lines × tester seems to be high in majority of traits than individually. The combing ability effects and variances for all traits revealed predominance of non-additive gene action (additive and dominance), which could be exploited by heterosis and population improvement methods for development of future cultivars.

Keywords: Combining ability, gene action, line × tester, maize, post flowering stalk rot.

Introduction

In India yield lag is one of the major constraints that hinder maize production. Apart from biotic stresses, fungal disease post flowering stalk rots (PFSR) poses a major threat to maize (Andorf *et al*., 2019). PFSR *(Macrophomina phaseolina*) which commonly appears when there is scarcity of irrigation coupled with high soil temperature (30 to 35°C) at flowering stage is more destructive in Telangana State. The disease incidence ranged from 22.3 to 63.5% (Murtadha *et al*., 2018). In order to combat this problem, development of cultivars with genetic resistant represent is most cost-efficient. Thus study on heterosis and combining ability is a pre-requisite for developing a desirable maize hybrid coupled with high yield related traits were estimated using Line × Tester analysis.

Materials and Methods

A total of 23 genotypes which included 15 crosses generated by LXT mating of 8 parents and their respective parents were sown at farm of Maize Research Station, Rajendranagar, PJTSAU in August 2019 in triplicate RBD designs. Recommended agronomic, cultural and plant protection measures were kept uniform to all experiment. Disease score was recorded after splitting the stalks longitudinally in all inoculated plants using 1-9 scale (Payak and Sharma, 1983). Rerecorded data on genotypes were subjected to line × tester analysis of variance (ANOVA), combining ability variances, proportional Contribution of lines, Testers, and their interaction to total variance and gene actions as using "*agricolae*" R package (v4.1.2).

Results and Discussion

ANOVA for the different traits (table 1) revealed highly significant differences ($P \leq 0.01$) among diverse genotypes. Parents, crosses and parents vs. crosses and line × tester were also significant for all the traits under study. The average means suggest that all genotypes were resistant to PFSR, early maturing and high yield producers. The estimates of general combining ability (GCA) and specific combing ability (SCA) variances and their ratios are presented in the Table 2. The results revealed that SCA variances were higher than GCA variances for all traits which indicates predominance of non-additive gene action (additive and dominance), which could be exploited by heterosis and population improvement methods (Andorf *et al.*, 2019). The degree of dominance was >1 suggested the presence of over dominance in all traits between 1.01% (DS-field) and 2.32% (DS-lab). The results are in agreement with the earlier findings of Rajesh et al. (2018). The contribution of lines × tester (Table 2) seems to be high in majority of traits *viz*., DFT (52.94%), DFS (54.31%), SP (70.29%) and disease score (field-82.16% and lab-81.91%). The second contribution place was occupied by lines except for traits disease score (testers contributed more). So selection of lines, testers and line x testers is economic towards yield (Noorka and Taufiqullah, 2015). All the lines and testers were recorded negative significant gca effects for flowering traits except lines MGC92 and 11 crosses were recorded negative SCA effects out of 15 were good combiners for earliness. Similar trend in DS traits were negative SCA and GCA effects were shown resistance to PFSR *vice versa*. For yield related traits positive effects indicated good combiners with high grain production *vice versa*. Similar outcomes were reported by Murtadha *et al*. (2018), Rajesh *et al*. (2018) and Andorf *et al*. (2019) due to predominance of non-additive gene.

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Table 1. ANOVA of L × T and average mean for eight traits in maize genotypes

Source	df	DFT (Days)	DFS (Days)	CL (cm)	CG (cm)	GYP (g)	SP (%)	DS (1-9)	
								Lab	Field
Replications	2	0.03	2.67	0.09	0.51	13.44	2.38	0.37	0.96
Treatments	22	23.61**	20.87**	15.26**	7.03**	44.77**	12.24**	9.03**	11.03**
Parents (P)	4	17.36**	16.65**	3.53**	1.80**	35.28**	8.65**	12.06**	10.82**
P vs. C	1	15.92**	9.04**	16.10**	15.19**	67.39**	27.70**	0.21**	0.40**
Crosses (C)	14	18.30**	15.34**	16.64**	7.72**	40.15**	11.60**	10.32**	11.22**
Lines (L)	4	67.23**	63.02**	52.17**	18.83**	60.87**	13.93**	2.16**	4.55**
Testers (T)	2	10.16**	12.87**	7.15**	3.30**	27.83**	14.99**	16.39**	11.63**
L × T	8	13.10**	12.52**	8.43**	2.76**	17.99**	10.77**	10.36**	12.15**
Error	14	0.69	0.91	0.26	0.37	20.38	3.38	0.10	0.51
Mean		61.83	63.28	19.48	15.72	137.47	80.70	2.83	3.00
CV (%)		1.25	1.73	2.95	4.25	6.76	2.48	1.20	4.35
HSD (5%)		1.61	2.35	1.06	1.16	10.60	3.41	1.53	1.42

** Significant at 1% levels; df, degrees of freedom; CV, coefficient of variation; HSD, honest significance differences; DFT, days to 50% tasseling; DFS, days to 50% silking; CL, cob length; CG, cob girth; GYP, grain yield per plant; SP, shelling percent; DS, disease score.

Table 2. Proportional contribution of L × T components and gene action for eight traits

Traits	Proportional contribution (%)			Source of variation				Nature of Gene Action
	Lines (L)	Tester s (T)	L × T	σ^2gca	σ^2sca	σ^2gca/ σ^2sca	(σ^2sca/ σ^2gca)$^{0.5}$	
DFT (Days)	45.92	1.14	52.94	6.30	16.57	0.38	1.62	Non-Additive
DFS (Days)	44.15	1.54	54.31	5.79	15.55	0.37	1.63	Non-Additive
CL (cm)	59.32	2.33	38.35	2.93	4.08	0.72	1.17	Non-Additive
CG (cm)	70.59	2.33	27.08	1.57	3.93	0.40	1.57	Non-Additive
GYP (g)	96.79	0.24	2.97	566.21	614.57	0.92	1.03	Non-Additive
SP (%)	22.71	7.00	70.29	1.09	3.62	0.30	1.82	Non-Additive
DS (lab)	7.68	10.41	81.91	1.25	5.81	0.21	2.32	Non-Additive
DS (Field)	5.23	12.61	82.16	2.16	4.36	0.49	1.01	Non-Additive

σ^2gca = additive variance; σ^2sca = dominance variance; σ^2gca/σ^2sca = proportion of variances; (σ^2sca/σ^2gca)$^{0.5}$ = degree of dominance.

T1-09
Effect of *lpa 1* and *lpa 2* allele in elite maize background of UMI 1201

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Abstract

Corn (*Zea mays* L.) is a popular cereal crop among countries like America, Asia and Africa. It is the world's chief animal feed grain. However, the grain phtytic acid forms insoluble complex with minerals like P, K, Mg, Fe and Zn and hence they become unavailable for non-ruminants. Hence breeding efforts were taken to reduce phytic acid with introgression of either *lpa 1* or *lpa 2* allele. But no study was there with pyramiding *lpa* alleles. In this experiment three F_2 population were developed with *lpa 1, lpa 2, lpa 1* + *lpa 2* alleles. All the three F_2 population were compared for the study. Analysis showed that, *lpa* 1 introgressed homozygous plants showed 61 -51 % reduction in phytic acid and *lpa* 2 introgressed homozygous plants showed 57 – 49 % reduction in phytic acid content in grain. However, plants with *lpa 1* and *lpa 2* allele in combination did not survive due to the lethal effect of lpa alleles (*lpa 1lpa1 / lpa2lpa2)* under double homozygous recessive condition. Combining *lpa 1* and *lpa 2* allele is deleterious and pyramiding of *lpa* allele should not be attempted in breeding program. Contribution of phytic acid reduction in grains of maize is maximum in *lpa 1* followed by *lpa 2* allele. Hence breeding programme has to be attempted either by introgressing *lpa 1* or *lpa 2* allele. Experiment has also clearly indicated the deleterious effect of seed health with relation to phytic acid content in maize seed. Further evaluation is essential for confirming biochemical, morphological, physiological and molecular aspect and can be further used in the development of *lpa* inbred.

Keywords: Maize, phytic acid, *lpa 1, lpa 2*

Introduction

Corn (*Zea mays* L.) is a popular cereal crop among countries like America, Asia and Africa. It is the world's chief animal feed grain. A significant portion of consumption is by non-ruminant farm animals. The main anti-nutritional factor present in corn is phytic acid. Phytic acid is a storage form of phosphorous. Phytic acid is a negatively charged particle which binds with different mineral elements like P, K, Mg, Fe and Zn and forms an insoluble complex which impairs plant growth and development. Insoluble phytate sequestered in grains cannot be digested by monogastric animals. It leads to a global phytic acid problem through eutrophication which is one of the first issue with phytate. Second issue with phytate is increase need for P fertilizer application by absorbing a significant quantity of phosphorous which adds on to the cost of production. It impairs plant growth and development due to formation of insoluble complex with phosphorous, potassium and magnesium. Low phytic acid mutants *viz., lpa 1, lpa 2, lpa 3* were isolated by Victor Raboy (2020)*. lpa 3* and *lpa 2* mutations perturbs the phytic acid synthesis through supply pathway by blocking the conversion of inositol-3-phosphate to inositol-5-phosphate and inositol-5-phosphate to inositol – hexa phosphate respectively. *lpa* 1 disturbs the phytic acid synthesis by blocking its transport from cytosol into vacuole, where globoids were present which stores the phytic acid. To address these issues with phytic acid breeding studies were attempted to introgress *lpa 1* and *lpa 2* allele. Till now no evident on effect of pyramiding *lpa 1* and *lpa 2* allele in the same maize background. Hence, a hypothesis was framed to study the effect of introgressed *lpa 1* and *lpa 2* allele in the background of elite maize inbred UMI 1201which forms the female parent of the popular hybrid Co(H)M 8.

Materials and Methods

In this experiment, three F_2 populations were developed by crossing UMI 1201 with *lpa 2* - UMI 395 (A) and *lpa 1* – 707 (B) separately and the third cross with F_1 of A with *lpa-1* 707 (C). **Fig 1.** All the three population were genotyped using *lpa* gene specific markers. The plants with *lpa 1* and *lpa 2* allele from the cross A and B were tagged and phenotypically evaluated for phytate level and inorganic phosphorous using Wades assay and HIP assay respectively.

Results and Discussion

All the three F_2 population with *lpa 1, lpa 2* and *lpa 1+2* allele were genotyped using gene specific marker for *lpa 1* and *lpa 2* allele. Based on genotypic data, among the three F_2 population homozygous F_2 plants from *lpa 1* population and *lpa 2* population survived without any negative effect. However, recovery of F_2 plants with *lpa1+2* alleles in homozygous recessive condition was not possible due to deleterious effect of alleles on combination (**Fig 1a., 1b.**) Hence pyramiding cannot be done. Phytic acid content, it's percent reduction and percent increase of Pi over UMI 1201 using *lpa* 1 allele and *lpa 2* allele were presented in **Table 1**. It showed that F_2 plants with *lpa 1* allele had 61 -51 % reduction of phytic acid (PA) over UMI 1201 (3.52 mg/g), whereas F_2 plants with *lpa 2* allele had 57-49% reduction of phytic acid. Inorganic phosphorous (P_i) increases between 85 % - 68 % and 79 % - 68 % among *lpa 1* and *lpa 2* F_2 population respectively. Homozygote confers reduction of phytic acid and this homozygosity for *lpa* alleles (A & B) had no effect on germination, stand establishment, plant height, ear height and growth rate. These findings were in concordance with Victor Raboy, 2022 and Colombo *et* al. (2022). Breeding for *lpa* has ended up with change in seed parameters *viz.,* reduction in seed volume, reduction in seed length and width, embryo shrivelling and susceptibility to drought **(Fig 2.)**. Drought susceptibility was due to change in root architecture with *lpa* reduction (Colombo *et al*., 2022). Hence a compromise has to be made with these parameters while breeding for *lpa* content in maize.

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Table 1. Phytic acid (mg/g) and its percent reduction over UMI 1201 among F_2 plants with *lpa 1* and *lpa 2* allele

***lpa 1*- F_2 plants**	**Gene -tic code**	**PA (mg/g)**	**% reduction PA**	**% increase Pi**	***lpa 2* - F_2 plants**	**Gene -tic code**	**PA (mg/g)**	**% reduction PA**	**% increase Pi**
***lpa 1*- F_2-P-74**	-/-	**1.36**	**61.36**	**84.82**	***lpa 2*- F_2-P-7**	-/-	**1.52**	**56.82**	**79.27**
lpa 1- F_2-P-7	-/-	1.56	55.68	81.42	*lpa 2*- F_2-P-47	-/-	1.59	54.83	78.21
lpa 1- F_2-P-86	-/-	1.58	55.11	79.20	*lpa 2*- F_2-P-2	-/-	1.68	52.27	77.78
lpa 1- F_2-P-20	-/-	1.66	52.84	75.97	*lpa 2*- F_2-P-56	-/-	1.71	51.42	75.27
lpa 1- F_2-P-33	-/-	1.68	52.27	73.44	*lpa 2*- F_2-P-54	-/-	1.72	51.14	75.09
lpa 1- F_2-P-63	-/-	1.72	51.14	68.08	*lpa 2*- F_2-P-49	-/-	1.77	49.72	68.08
lpa 1- F_1	+/-	2.97	15.60	29.89					
UMI 1201	+/+	3.52							

Fig.1a. Phenotype of *lpa* pyramided population

Fig.1b. Molecular confirmation of pyramided allele

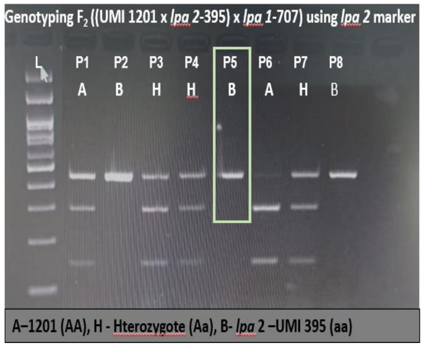
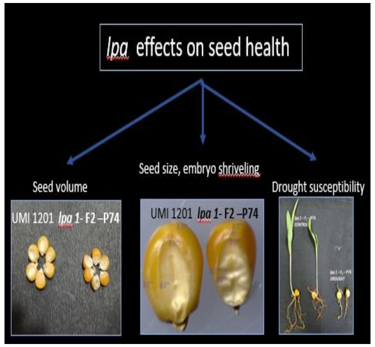


Fig. 2. Effect of *lpa* on seed parameters



T1-10
Identification of invertase inhibitor (*inh*) gene sequence(s) from sweet sorghum (*Sorghum bicolor* L. Moench)

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Abstract

Sweet sorghum is emerging as one of the most promising feedstocks for biofuel production. One of the main issues in exploiting the full potential of the crop for biofuel production is the poor shelf life of the stalk. Huge loss of juice quality and quantity are reported during transport of the raw material due to inversion of sucrose. Both endogenous and exogenous invertases are responsible for the loss of sugar content. In certain plant species invertase inhibitors (INH) are reported that regulate the action of invertases. This paper summarises the identification of two *inh* genes from sweet sorghum.

Keywords : Sweet sorghum, invertase, invertase inhibitor

Introduction

The cost of non-renewable petrochemical fuel sources is rising alarmingly, and alternate energy sources are the hope for tomorrow. Government of India policies currently allow blending of up to 20% of bioethanol with gasoline. Excessive water requirement, higher cost, and inadequate supply of sugarcane, the major source of biofuel in the country, necessitated the search for alternate feedstocks. Sweet sorghum (*Sorghum bicolor* L. Moench), a type of cultivated sorghum is a multi-purpose crop that is grown for food, fodder and fuel. The crop is characterized by significant accumulation of fermentable sugars in the range of 15 to 23% in the stem which is equivalent to that of sugarcane. Research studies and pilot experiments have identified that 1G (first generation) ethanol production from sweet sorghum is a viable and renewable ethanol source in India (Rao *et al*., 2014). Sweet sorghum grows well under hot and dry climatic conditions and is tolerant to drought and salinity unlike sugarcane and corn, the leading biofuel sources. This crop has a shorter duration of 3.5 to 4 months when compared to sugarcane (12 to 18 months), hence acting as a supplement during sugarcane off-season. Moreover, since sweet sorghum has considerable grain yield, ethanol production from the stalk doesn't compromise food security. It has the potential for dual farm income, from grain and stalk. Sweet sorghum can yield up to 8000 L ha^{-1} of ethanol which is twice as high as that of corn and 30% more than sugarcane (Umakanth *et al*., 2020). Stalk sugars are composed mainly of sucrose (70–80%), fructose, and glucose. Juice yield and brix content are important and decisive factors for bioethanol recovery percentage.

Harvested sweet sorghum stalks faces a major issue of qualitative and quantitative juice deterioration. Major technical challenge for biofuel production from sweet sorghum is the degradation of stalk sugar during storage. Almost 20% or more loss of sugars was noticed during room temperature storage. Significant changes in fermentable sugars and reduction in pH was noticed in some studies (Wu *et al*. 2010). This deterioration in quality is reported to be due to microbial fermentation (ethanol and lactic acid formation) and high content of invert sugars such as dextran and levan. Inhibitor proteins associated with invertases are reported in many dicot species. But their role in sugar accumulation in sweet sorghum is not characterized yet. They may be potentially important means for reducing in vivo activity of invertases.

Materials and Methods

Leaves were collected from sweet sorghum genotype SSV84 at the booting stage and were used for RNA extraction using the trizol method. First-strand cDNA was prepared using RevertAid first-strand cDNA synthesis kit (ThermoScientific). Sweet sorghum genome was searched for invertase inhibitor sequences in the Phytozome database (https://phytozome-next.jgi.doe.gov/). Primers were designed to amplify the complete gene sequence using Primer 3 software (https://primer3.ut.ee/). Amplified sequences were sequenced using Sanger sequencing from both ends. Sequence similarity search was carried out using NCBI BLAST (https://blast.ncbi.nlm.nih.gov/Blast.cgi).

Results and Discussion

Gene sequences showing maximum similarity to cereal invertase inhibitors upon similarity search in phytozome were shortlisted for designing primers. They were SbRio.04G003100.1 and SbRio.06G212900.1. Primers were designed to amplify the entire gene sequence of both genes. The list of primers designed is given in Table 1.

The genes, namely INH30 (*SbINH1*) and INH29 (*SbINH2*), were amplified using the cDNA as a template. The nucleotide sequences of *SbINH1* and *SbINH2* are 666bp and 537bp long and their protein sequences are 221 and 178 amino acids long (Figure 1). The sequences have been submitted in NCBI Genbank (OQ974337 and OQ974338). Apart from maximum homology to putative invertase inhibitor from sorghum, *SbINH1* showed maximum homology to *Zea mays* and *Setaria italica* in BLAST search, while *SbINH2* was most similar to putative invertase inhibitors from *S. italica*. Little is known about the existence and functions of INH in sweet sorghum. As per our understanding, this is the first report of invertase inhibitor (INH) genes from sweet sorghum. The expression analysis of these genes is underway currently and understanding the functional properties of these genes would enable us to devise strategies to regulate stalk sugar degradation by regulating the activities of invertase(s).

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Table 1. Sequences of the primers used for amplifying invertase inhibitor gene

Gene Name	Primer Name	Sequence (5' to 3')
INH 29	INH29F	ATGAGGTCATTCCTGGTGCA
	INH29R	CTAGTATAGACGCTTATTCGCGA
INH 30	INH30F	ATAGTAGCTCATGTAATTGCAATGT
	INH30R	TCATAGAAGGGAGATGATGGCG

Fig. 1. Nucleic acid and amino acid sequences of *SbINH1* and *SbINH2*

>SbINH1
ATGATAGTAGCTCATGTAATTGCAATGTCCTATCACACGAAGAAGAAGAAGAAGAAGA
TGCCACCACCACCATGCTATTGCTCCTCCCTGATAACAATAACAATAATCCTCCTCCTACA
ACAACAGAACAATCCCTGGACTACAGCTGCAGCAGCTTCAGCCATGGCCACCACCACCA
CCAAGCTTGGGTCGTCACCGTTGTCTGACGTGGTAAAGGACACCTGCGAGAGATGCAG
GCAGGGCAACCCACAGGTGAACTACACCCTCTGCGTCTCGTCTCTGTCGTCGGACCCCA
AGAGCAGGCAGGCGGACCTCCACGAGCTCGCCATGATCTCGGCCAAGCTGGTGAGGTC
AGGCGCAGTGGGCATGGAGGCCAAGATGGCGGAGCTCAGCAGGAAGGAGCGGCCAT
GGTCTCGCCGGAGGTCCTGCCTGGAGGCGTGCATGGGGGTGTACCACAACTCCCTCTAT
GACCTCGACGCCTCCATCGCAGCCATCCAGGAGAGGAGGTATGCGGACGCCAAGACGT
CCATGAGCGCCACCGTCGACGCGCCCATCACCTGTGAGGATGAGTTCAAGGAGCAGGG
CCTGGAGCCACCCATGAAAGCAGAGAGCAAACGCCTGTTTCAACAGGCGGCCATCACC
CTCGCCATCATCTCCCTTCTATGA
>SbINH1
MIVAHVIAMSYHTKKKKKMPPPPCYCSSLITITIILLLQQQNNPWTTAAAASAMATTTTKL
GSSPLSDVVKDTCERCRQGNPQVNYTLCVSSLSSDPKSRQADLHELAMISAKLVRSGAVGM
EAKMAELSRKERPWSRRRSCLEACMGVYHNSLYDLDASIAAIQERRYADAKTSMSATVDA
PITCEDEFKEQGLEPPMKAESKRLFQQAAITLAIISLL

>SbINH2
ATGAGGTCATTCCTGGTGCAACCTGTATCCATACTACTACTACTACTCTTCATCACAGCC
ATCGCTCCCGTGGTCACCGCCGGCGGCTCACCTGTCATCAACGCGACGTGTGCCGCGCTC
AAGTCCCTGCAACCCTACGACTACTGCGTGGGCGTGCTCTCCGCCGACCCAGCAGCCGCC
GCTGCCACAGACGTCCGGGGAGTGGCGGCAGCCGCCGTCAACATCACCGCGCAGAAGGCT
GCGTCCACGTTGCTCGTCATCAACTATCTCGCCGGCGATCTCAACACCTGCCGCGGGTAC
TACAGCAACATGTTGCAGTCGTTGGAGAATTCCCTCGTCCACTTTCGCGATGGTCGATTC
TTGAATGCGTCCCTAGGGATCGCCAATGCCACCGGAGATCCCACGGGCTGCGATTTACTG
CTGTTCGAGGGGAAAACGCACAAGGATCCGATTTCCGACGAGAACTATGAGAACATGCGC
TTGGTTGACCTAGCAGATGGTATCGTAGATCTATTCGCGAATAAGCGTCTATACTAG
>SbINH2
MRSFLVQPVSILLLLLFITAIAPVVTAGGSPVINATCAALKSLQPYDYCVGVLSADPAAAAATDVRGVAAA
AVNITAQKAASTLLVINYLAGDLNTCRGYYSNMLQSLENSLVHFRDGRFLNASLGIANATGDPTGCDLLLF
EGKTHKDPISDENYENMRLVDLADGIVDLFANKRLY

T1-11

Studies on genetic variability, heritability, correlation and path coefficient analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract

A study was conducted on twenty seven pearl millet genotypes to analyse the variability and correlation among different qualitative traits *viz*., plant height, number of productive tillers per plant, spike length, spike girth, leaf sheath length, leaf blade length, thousand grain weight, and single plant yield. PCV was found to be higher than GCV but a least amount of difference was found between them. It indicates the minimum influence of environment towards all the character. In the present investigation, high PCV and GCV were identified in number of productive tillers per plant, leaf blade width, 1000 grain weight and single plant yield. High heritability (broad sense) coupled with genetic advance as per cent of mean were found in all the nine traits studied. The association analysis for quantitative characters concluded that singe plant yield was positively correlated with spike length, spike girth, leaf blade length and 1000 grain weight. Path coefficient analysis revealed the presence of positive direct effect on yield by 1000 grain weight followed by spike length, spike girth, leaf blade length and number of productive tillers per plant. Genetic parameters in relation with genetic variability, correlation and path analysis revealed that traits such as number of productive tillers per plant, spike length, spike girth and 1000 seed weight will be useful for the selection of superior genotypes with high yield. The genetic analysis helps for the crop improvement programme through selection.

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R.Br.] is the sixth most important cereal food crop after wheat, rice, maize, barley and sorghum, with a majority of the area in Africa and the Indian sub-continent. Being one of the oldest cultivated cereal crops (Manning *et al.,* 2011), it plays a key role in the food, nutritional as well as economic security of poor farmers (Srivastava *et al.,* 2020). Day by day, the demand for pearl millet production is increasing due to its wider adaptability to climatic conditions and nutritional characteristics (Tako *et al.,* 2015). Recent research has revealed that the yield has been static over the past many decades and in order to meet the food demand, it is imperative that the yield plateau need to be breached. The availability of higher genetic diversity among parents is a prerequisite for the development of superior cultivars. Therefore, the present study was undertaken to screen the pearl millet genotypes for genetic diversity.

Materials and Methods

The study was conducted at the Department of Millets, Tamil Nadu Agricultural University, Coimbatore, during Summer, 2020. A total of 27 genotypes of pearl millet were used for evaluation. The experiment was laid out in Randomized Complete Block Design (RCBD) with two replications. All the management practices were followed meticulously to maintain good crop standard. Different biometrical traits, *viz.* plant height, the number of productive tillers per plant, spike length, spike girth, leaf sheath length, leaf blade length, thousand grain weight, and single plant yield, related to grain yield was recorded on five randomly selected plants from each entry in all replications. The data were subjected to statistical analysis in WINDOSTAT ver. 7.1 to assess the diversity among the genotypes.

Results and Discussion

The pace and success of conventional breeding is determined by the availability of desirable genetic variability for the targeted traits (Ara *et al.,* 2009). The analysis of variance for nine quantitative traits among 27 genotypes showed significant variation for all the traits studied. This indicates the presence of high degree of variability among the genotypes and ample scope of improvement by selection. In the experimental material, GCV and PCV expressed a wide range of variation. PCV was found to be higher than GCV but a least amount of difference was found between them. It indicates the minimum influence of environment towards all the character. In the present investigation, high PCV and GCV were identified in number of productive tillers per plant, leaf blade width, 1000 grain weight and single plant yield. Moderate PCV and GCV were reported in spike length, spike girth, leaf sheath length and leaf blade length. High PCV and moderate GCV were observed in plant height. The presence of variability in yield and yield attributing characters provides scope for the yield improvement through selection process. Heritability coupled with genetic advance will be helpful for predicting the genetic gain in the breeding programme. Based on the present study, high heritability (broad sense) coupled with genetic advance as per cent of mean were found in all the nine traits studied. The association analysis for quantitative characters concluded that singe plant yield was positively correlated with spike length, spike girth, leaf blade length and 1000 grain weight. The path coefficient analysis revealed the presence of positive direct effect on yield by 1000 grain weight followed by spike length, spike girth, leaf blade length and number of productive tillers per plant. Hence, major emphasis should be given to these characters (Fig 1).

The results of the present study showed, there exists a huge variability among all the pearl millet genotypes for all the traits studied. The genetic analysis helps for the crop improvement programme through selection. Genetic parameters in relation with genetic variability, correlation and path analysis revealed that traits such as number of productive tillers per plant, spike length, spike girth and 1000 seed weight will be useful for the selection of superior genotypes with high yield.

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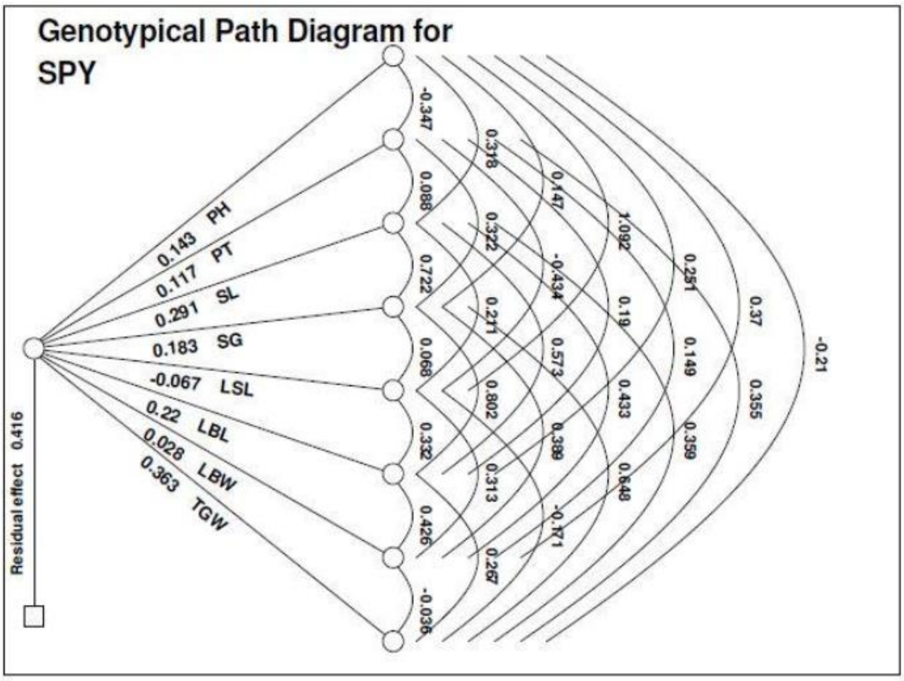
Fig. 1. Genotypic path coefficient diagram for single plant yield



T1-12
Genetic Association Studies in Barnyard Millet (*Echinochloa frumentacea* (Roxb.) Germplasms

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Abstract

Ninety barnyard millet germplasms along with two commercial checks varieties were evaluated at Anbil Dharmalingam Agricultural College and Research Institute in Trichy, Tamil Nadu Agricultural University. Experiment was conducted in a replicated trial and biometric characters were recorded. The traits i.e., plant height (cm), inflorescence length (cm), inflorescence width (cm), lower raceme length (cm), flag leaf length (cm), flag leaf width (cm), number of leaves on main tiller, number of productive tillers per plant, and grain yield per plant (g). Grain yield recorded positive significant correlation with Inflorescence width (cm) (0.6216), number of leaves on main tiller (0.226) and number of productive tillers per plant (0.5981). Studies on correlation provide cognition of association among different traits and yield which results in selecting genotypes possessing desired traits for genetic improvement of yield.

Keywords: Barnyard millet, germplasms and correlation.

Introduction

Barnyard millet is a small, under-utilized millet that has recently gained popularity due to its high nutritious content. Small millets have a great chance of surviving in the stressful environment. Small millets are traditional grains in India because they can be cultivated in arid, dry climates with acidic soil among other challenging agricultural circumstances. Compared to the previous 50 years, India's use of coarse grains restricts the growth of tiny millet. These crops are suited for farming in dry and semi-arid regions of the world since they require less water for growing. One of the most significant tiny millet crops, barnyard millet benefits the subsistence farming population and is produced in marginal environments. It is an annual summer crop that matures quickly and is highly suggested for famine-stricken areas (De Wet *et al*., 1983). The grain is rich in nutrients, particularly iron, which is very important for anaemic patients. Due to its dual potential as a nutritious food source for humans and as cattle feed, this crop has recently attracted the interest of several nations (Lim *et al*., 2021). It is beneficial for diabetes individuals since it contains less carbohydrate than cereal. It is the most ideal crop for areas where growing rice is impossible. Both biotic and abiotic stimuli have less of an impact on it (Renganathan *et al*., 2020). Studies on correlation provide cognition of association among different traits and yield which results in selecting genotypes possessing desired traits for genetic improvement of yield (Prabu *et al*., 2020, Dhanalakshmi *et al*., 2019).

Materials and Methods

An experiment was conducted at the Anbil Dharmalingam Agricultural College and Research Institute in Trichy, Tamil Nadu, to determine the character association of barnyard millet. The experimental material included two commercial check varieties, MDU1 and CO(KV) 2, as well as 90 germplasm lines of barnyard millet from the Ramiah Gene Bank, Department of Plant Genetic Resource, Tamil Nadu Agricultural University, Coimbatore. The suggested crop management practises were used in the experiment, which included a randomised block design and two replications. Data were recorded on nine quantitative traits *viz.,* plant height (cm), inflorescence length (cm), inflorescence width (cm), lower raceme length (cm), flag leaf length (cm), flag leaf width (cm), number of leaves on main tiller, number of productive tillers per plant, and grain yield per plant (g). The replicated data were used to estimate the correlation. R packages was used for analysing the data.

Results and Discussion

The genotypic and phenotypic correlation coefficients estimated between grain yield per plant with all quantitative traits. In the present investigation, the genotypic correlation coefficients were higher than the phenotypic correlation coefficient for the characters studied as observed by Johnson *et al*. (1955). This is because of polygene governing the traits were similar and influence of environment for the trait expression might be minimal. Grain yield performed positive significant correlation with Inflorescence width (0.6216) number of leaves on main tiller (0.226) and number of productive tillers per plant (0.5981). Grain yield performed positive non significant correlation with flag leaf length and flag leaf width. Grain yield performed negative non significant correlation with plant height, inflorescence length and lower raceme length. Number of leaves on main tiller performed positive significant correlation with inflorescence width and grain yield per plant. Inflorescence width performed positive significant correlation with Plant height, inflorescence length, lower raceme length, flag leaf length, flag leaf width, number of leaves on main tiller, number of productive tillers per plant and grain yield per plant. It has similarity with the findings of Arunachalam *et al*., (2012); Gupta *et al*. (2009); Upadhaya *et al*. (2014); Sood *et al*, (2015); Joshi *et al*. (2015) and Arya *et al*. (2017) in barnyard millet. Studies on correlation provide cognition of association among different traits and yield which results in selecting genotypes possessing desired traits for genetic improvement of yield.

Based on the correlation, main yield contributing characters in barnyard millet are Inflorescence width (cm) number of leaves on main tiller and number of productive tillers per plant these yield contributing traits could be benefited for crop improvement programme.

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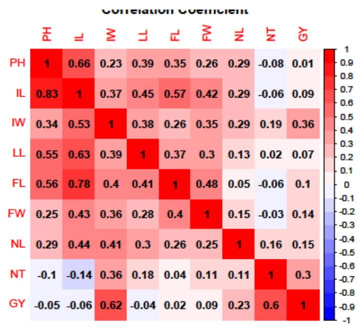
Fig. 1. Heat map of correlation coefficient of all quantitative traits



(PH:plant height, IL:inflorescence length, IW:inflorescence width, LL:lower raceme length, FL: flag leaf length, FW:flag leaf width, NL: number of leaves on main tiller, NL:number of productive tillers per plant and grain yield per plant.)

T1-13
Callus induction and efficient plant regeneration from different explants of Pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract

In vitro studies were carried out to standardize the hormonal requirement and to determine the best source of explant for callus induction and efficient plant regeneration in pearl millet. The genotypes selected for this study are CO 7, ICMV 221, PT 1890 and 81B. The explants used in this study were young leaves, seeds and young inflorescences from healthy plants. These explants were cultured on Murashige-Skoog (MS) medium supplemented with different concentrations of 2,4-D (2,4-Dichlorophenoxy acetic acid). The MS media was used with different concentrations of BAP in combination with IAA for shoot formation and with different concentrations of IBA in combination with IAA for root formation. MS medium supplemented with 2.0 mg/l 2,4-D induced maximum callus formation irrespective of explants. MS medium supplemented with 2.0 mg/l BAP + 0.5mg/l IAA for shoot formation and 1.0 mg/l IBA + 1.5mg/l IAA for root formation were superior to other hormonal combinations in terms of regeneration. The maximum response for callus induction and regeneration was obtained from young inflorescence followed by seed.

Keywords: Pearl millet, seed, leaf, young inflorescence, callus, regeneration

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the stable food of tropical and subtropical countries of the world. This crop is grown on a larger scale under rainfed condition in the arid tracts of India for its nutritive value. Its germplasm possesses abundant phenotypic variation. Pearl millet is also of interest as a biological model for studying domestication and crop/wild complex evolution (Poncet *et al.,* 2000). The development of reliable tissue culture methods for the production and maintenance of callus and regeneration of plants are imperative for the successful application of tissue culture to crop improvement. Considering the need for further genetic enhancement and improvement in pearl millet, studies were initiated to standardize an effective method for *in vitro* culture of pearl millet from callus tissue derived from different explants.

Materials and Methods

The genotypes selected for this study are CO 7, ICMV 221, PT 1890 and 81B and young leaves, seeds and young inflorescences from healthy plants were used as explants. These explants were cultured on MS medium supplemented with different concentrations of 2,4-D. 1 g/l casein hydrolysate, 1 mg/l kinetin, 3.0% sucrose and 0.8 g/l agar were included in all the callus induction media combinations. Surface sterilized seeds were cultured in callus induction medium. Surface sterilized and innermost tightly unfurled cream coloured leaves were cut and inoculated. Young unemerged inflorescence of 2-6 cm length was collected, surface sterilized, cut into segments and cultured. Cultures were incubated in dark at 25±2^{o}C for callus induction. The MS media was used with different concentrations of BAP in combination with IAA for shoot formation and with different concentrations of IBA in combination with IAA for root formation. The observations on duration for callus induction, callus induction percentage, duration for shooting, shooting percentage, duration for rooting and rooting percentage were recorded.

Results and Discussion

Among the explants tested, young inflorescence exhibited early callus induction, shoot-root formation, higher callus induction percentage, shooting and rooting percentage followed by seed and leaf (Table 1). The reasons attributed for the better performance of the young inflorescence are that the young unemerged inflorescence at the premeotic stage in which the primordial of individual florets were in very early stage of differentiation and the higher culture response of young inflorescence may also be more to the endogenous hormonal concentration on these tissues. In addition to that the poor response of leaf tissues may be due to the presence of mitotic inhibitors in mesophyll cells (Jung and Wernicke, 1993). A total of four levels of 2,4-D tried and earlier callus induction in 3.0 mg/l and higher callus induction percentage in 2.0 mg/l were observed irrespective of explants tested (Table 2). Out of the different levels of BAP and IAA used for shoot regeneration, 2.0 mg/l BAP + 0.5 mg/l IAA exhibited earlier shoots and higher shooting percentage regardless of genotypes and explants tested (Table 2). Among the various levels of IBA and IAA used for rooting, earlier roots and higher rooting percentage were noticed in 1.0 mg/l BAP + 1.5 mg/l IAA regardless of genotypes tested (Table 2). The genotypes CO 7, PT 1890 and ICMV 221 were observed to be highly *in vitro* responsive (Table 3). In contrast, the other genotype 81B was moderate *in vitro* responsive and it is to be subjected to refine tissue culture technique. The differences in *in vitro* responsive are due to genotypes of pearl millet (Nagarathna *et al*.,1993; Anirudha *et al., 2*012). It was concluded from the study that the ideal explants for *in vitro* culture of pearl millet is young inflorescence and the morphogenetic potential was high in CO 7. This study indicates the possibility for inducing genetic variability through tissue culture for pearl millet improvement.

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Table 1. *In vitro* response of different explants.

Explants	Mean number of days			Mean Percentage		
	Callus induction	Shooting	Rooting	Callus induction	Shooting	Rooting
Seed	19.07	11.90	10.97	57.31	39.17	33.25
Leaf	17.33	14.00	11.90	40.11	46.75	43.17
Young inflorescence	11.05	13.05	16.87	59.28	64.75	60.00
SEd	0.0360	0.0577	0.0569	0.3533	0.5813	0.6086
CD (P=0.05)	0.0708	0.1129	0.1121	0.6937	1.1452	1.1988

Table 2. Effect of hormonal concentrations on callus induction, shooting and rooting.

Callus induction			Shoot regeneration			Root regeneration		
2,4-D (mg/l)	Mean number of days	Mean (%)	BAP+IAA (mg/l)	Mean number of days	Mean (%)	IBA+IAA (mg/l)	Mean number of days	Mean (%)
1.5	16.37	53.44	1.5+0.5	13.91	43.89	1.0+1.0	14.21	40.67
2.0	16.03	54.37	1.5+1.0	13.22	48.56	1.0+1.5	12.17	50.44
2.5	15.60	52.18	2.0+0.5	12.11	56.44	1.5+1.0	13.27	47.11
3.0	15.27	48.92	2.0+1.0	12.28	52.00	1.5+1.5	13.34	43.67
SEd	0.0416	0.4080	SEd	0.0662	0.6713	SEd	0.0657	0.7027
CD (5%)	0.0817	0.8010	CD (5%)	0.1304	1.3224	CD (5%)	0.1295	1.3843

Table 3: *In vitro* response of different pearl millet genotypes.

Genotypes	Mean number of days			Mean Percentage		
	Callus induction	Shooting	Rooting	Callus induction	Shooting	Rooting
CO 7	13.94	12.06	11.80	71.11	62.22	57.50
ICMV 221	15.54	13.89	13.25	58.33	48.06	46.39
81 B	15.35	13.89	13.47	57.22	42.22	43.89
PT 1890	15.50	12.22	13.47	49.17	56.67	48.33
SEd	0.0658	0.1047	0.1039	0.6451	1.0614	1.1111
CD (P=0.05)	0.1292	0.2062	0.2047	1.2665	2.0908	2.1888

T1-14
In vitro response of CMS lines and their maintainers in Pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract

Tissue culture studies were carried out to standardize the hormonal requirement and to determine the best source of explant (seed, leaf and young inflorescence) for callus induction and efficient plant regeneration of CMS (Cytoplasmic Male Sterile) lines and their maintainers in pearl millet. The genotypes selected for this study are 843 A, 843 B, 5141 A, 5141 B, L111 A and L111 B. The explants were cultured on Murashige-Skoog (MS) medium supplemented with different concentrations of 2,4-D (2,4-Dichlorophenoxy acetic acid). The MS media was used with different concentrations of BAP in combination with IAA for shoot formation and with different concentrations of IBA in combination with IAA for root formation. MS medium supplemented with 2.0 mg/l 2,4-D induced maximum callus formation irrespective of explants. MS medium supplemented with 2.0 mg/l BAP + 0.5mg/l IAA for shoot formation and 1.0 mg/l IBA + 1.5mg/l IAA for root formation were superior to other hormonal combinations in terms of regeneration. Maximum response for callus induction and regeneration was obtained from young inflorescence followed by seed. The genotypes 5141 A, 5141 B and L111 B were highly *in vitro* responsive, L111 A was moderate *in vitro* responsive and 843 A and its maintainer line were poor *in vitro* responsiveness.

Keywords: Pearl millet, CMS lines, *in vitro,* callus, regeneration

Introduction

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the most important stable crop of millions of people in the semi-arid and arid regions of Asia and Sub-saharan Africa. Pearl millet like many other cereal crops has received but little attention in the past from the point of view of its genetic improvement and consequently the grain yield (Singh *et al.,* 2017). For hybrid development, cytoplasmic male sterility (CMS) is utilized to avoid hand emasculation and also to reduce the seed production cost. At present a number of CMS lines are available. Unfortunately most of them due to repeated use and loss of genetic stability have become susceptible to major disease like downey mildew. The study relating to *in vitro* response of different CMS lines of pearl millet will form the basic stepping stone in evolving disease resistant transgenic in future.

Materials and Methods

The genotypes selected for this study are 843 A, 843 B, 5141 A, 5141 B, L111 A and L111 B and young leaves, seeds and young inflorescences from healthy plants were used as explants. These explants were cultured on MS medium supplemented with different concentrations of 2,4-D. 1 g/l casein hydrolysate, 1 mg/l kinetin, 3.0% sucrose and 0.8 g/l agar were included in all the callus induction media combinations. Surface sterilized seeds were cultured in callus induction medium. Surface sterilized and innermost tightly unfurled cream coloured leaves were cut and inoculated. Young un-emerged inflorescence of 2-6 cm length was collected, surface sterilized, cut into segments and cultured. Cultures were incubated in dark at 25±2ºC for callus induction. The MS media was used with different concentrations of BAP in combination with IAA for shoot formation and with different concentrations of IBA in combination with IAA for root formation. The observations on duration for callus induction, callus induction percentage, duration for shooting, shooting percentage, duration for rooting and rooting percentage were recorded.

Results and Discussion

Among the explants tested, young inflorescence exhibited early callus induction, shoot-root formation, higher callus induction percentage, shooting and rooting percentage followed by seed and leaf (Table 1). The reasons attributed for the better performance of the young inflorescence are that the young un-emerged inflorescence at the pre-meotic stage in which the primordial of individual florets were in very early stage of differentiation. In addition to that the poor response of leaf tissues may be due to the presence of mitotic inhibitors in mesophyll cells (Jung and Wernicke, 1993). A total of four levels of 2,4-D tried and earlier callus induction in 3.0 mg/l and higher callus induction percentage in 2.0 mg/l were observed irrespective of explants tested (Table 2). Out of the different levels of BAP and IAA used for shoot regeneration, 2.0 mg/l BAP + 0.5 mg/l IAA exhibited earlier shoots and higher shooting percentage regardless of genotypes and explants tested (Table 2). Among the various levels of IBA and IAA used for rooting, earlier roots and higher rooting percentage were noticed in 1.0 mg/l BAP + 1.5 mg/l IAA regardless of genotypes tested (Table 2). The genotypes 5141 A, 5141 B and L111 B were observed to be highly *in vitro* responsive thereby indirectly revealing their adoptability in future usage under transgenic studies. In contrast, the male sterile line L111A was moderate *in vitro* responsive and it is to be subjected to refine tissue culture technique. The CMS line 843 A and its maintainer line were poor *in vitro* responsive (Table 3). Poor *in vitro* responsive genotypes were non-adoptive for transgenic studies because they will not bring any fruitful results. The differences in *in vitro* responsive are due to genotypes of pearl millet (Gnanasekaran *et al*.,2007; Anirudha *et al., 2*012). It was concluded from the study that the ideal explants for *in vitro* culture of pearl millet is young inflorescence and the morphogenetic potential was high in 5141 A, 5141 B and L111 B. These could be advocated to utilize for resistant gene transformation through novel genetic engineering technique and this converted resistant CMS line could effectively be utilized in profitable hybrid seed production. This study also indicates the possibility for inducing genetic variability through tissue culture for pearl millet improvement.

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Table 1: *In vitro* response of different explants

Explants	Mean number of days			Mean Percentage		
	Callus induction	Shooting	Rooting	Callus induction	Shooting	Rooting
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SEd	0.0360	0.0577	0.0569	0.3533	0.5813	0.6086
CD (P=0.05)	0.0708	0.1129	0.1121	0.6937	1.1452	1.1988

Table 2: Effect of hormonal concentrations on callus induction, shooting and rooting.

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2.5	15.60	52.18	2.0+0.5	12.11	56.44	1.5+1.0	13.27	47.11
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SEd	0.0416	0.4080	SEd	0.0662	0.6713	SEd	0.0657	0.7027
CD (5%)	0.0817	0.8010	CD (5%)	0.1304	1.3224	CD (5%)	0.1295	1.3843

Table 3: *In vitro* response of CMS lines and their maintainers

Genotypes	Mean number of days			Mean Percentage		
	Callus induction	Shooting	Rooting	Callus induction	Shooting	Rooting
843 A	18.06	14.78	14.47	36.75	38.61	32.78
843 B	17.61	14.08	14.25	40.09	38.89	36.11
5141 A	16.07	12.33	12.67	57.22	58.06	46.94
5141 B	15.24	12.00	13.08	54.81	60.28	48.33
L111 A	16.02	12.92	13.25	45.93	42.50	43.89
L111 B	14.83	13.14	12.75	63.33	54.72	50.56
SEd	0.0658	0.1047	0.1039	0.6451	1.0614	1.1111
CD (P=0.05)	0.1292	0.2062	0.2047	1.2665	2.0908	2.1888

T1-15

Participatory Varietal Selection in finger millet using farmers' indigenous knowledge and breeders' scientific approach

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Abstract

A group of 40 farmers including 21 farm women participated in the field exposure visit. Participatory Varietal Selection (PVS) approach was applied to select high-yielding elite finger millet genotypes using farmers' indigenous knowledge and breeders' scientific approaches. Most of the farmers preferred genotypes having high yield potential along with quality parameters like compact ear head, copper red colored grains, and resistance to lodging, drought, insect pests, and diseases. Based on the farmers' preference scores on different quality traits, the genotypes TNAU 1066, DHRS 1-1, VR 708, and OEB 532 were ranked 1, 2, 3, and 4, respectively. The decision-making of farmers revolved around the storage, marketing, and processing properties of the genotype.

Keywords: PVS, finger millet, quality traits, ear head shape, preference score.

Introduction

Involving farmers in the breeding process in Participatory Varietal Selection (PVS) takes a longer time. This can be achieved by examining the farmer's crop around harvest time and pre–selection, by farmers, of varieties from trials of many entries, grown on either a research station or on a farm. The extent of diversity can be evaluated in the trial and the best entries among the pre–release cultures are determined by using the criteria of farmers' preference (Witcombe *et al*., 2005). The specific objective of the present study was to select the diverse and productive finger millet cultures adapted to local conditions by farmers' indigenous knowledge and breeders' scientific approach.

Materials and Methods

Participatory variety selection

Forty farmers (19 men and 21 women), were invited to a `field exposure visit to the Department of Millets, Tamil Nadu Agricultural University, Coimbatore. The experimental material comprised of sixteen entries including local and national checks. The experiment was conducted in a randomized complete block design with three replications. Each entry was planted in a 2.25 x 3 m plot with a spacing of 22.5x 10 cm. The crop was managed with proper agronomic practices to have a good crop stand. The best entries were selected based on farmers' criteria at maturity stage. Based on the preferential evaluation made by the farmers on the quality parameters, scores of 1 to 5 (1 being the lowest and 5 the highest score) were given to each quality character except yield. The yield was measured on plot basis in each trial plot. The best-performing entries were selected based on the index value of each character.

Results and Discussion

In the present study, 16 finger millet genotypes were evaluated based on the preference of farmers for eight quality traits, attributed to the adaptation to the local environment (**Table 1**). The study included both men and women to analyse the gender preferences. Based on the farmer's knowledge, the top-ranking genotypes were TNAU 1066, DHRS 1-1, VR 708, and OEB 532. Breeders often recorded the yield and yield components and chose the genotypes OEB 532, VL 347, DHRS 1-1, and TNAU 1066 as top rankers. While considering both, the genotypes OEB 532, TNAU 1066, and DHRS 1-1 could be recommended for cultivation as regional-specific varieties. It is clearly understood that the PVS giving new high-yielding varieties to the participating farmers and allows the farmers to uplift their family income by the cultivation of these cultivars like TNAU 1066, DHRS 1-1, VL 347, and OEB 532. They would be suitable for cultivation with inter-crops such as pulses, red gram or lab–lab and oil seeds (mustard and niger) which pave the way for increasing the production and income. All categories of target farmers benefited from this exercise. Since women took part in the evaluation of varieties they also benefited from the selection of varieties that has the traits of their interests

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Fig 1. Preferance of farmers in general on various quality characters in Finger millet

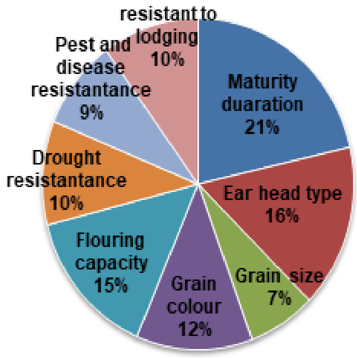

Table 1. Ranking of finger millet genotypes based on cumulative points

Genotypes	Maturity duration	Ear head type	Grain size	Grain color	Flouring capacity	Drought resistance	Pest and disease resistance	Overall appearance	Cumulative points	Rank
TNAU 1066	130	100	130	115	145	30	12	64	798	1
DHRS 1-1	130	100	130	6	145	30	12	64	689	2
VR 708	130	100	130	6	145	30	0	100	653	3
OEB 532	130	100	130	18	145	0	12	100	635	4
RAU 8*	24	100	130	115	145	0	12	64	590	5
OEB 526	24	100	130	6	145	88	12	64	569	6
VL 149*	24	100	130	115	145	0	0	9	523	7
CO(Ra) 14*	130	18	0	115	0	88	12	0	435	8
VL 347	130	18	0	18	0	88	0	100	426	9
PRM 6107	130	18	3	6	0	88	0	0	317	10
DM 1	130	18	0	18	0	0	0	64	230	11
HR 374*	24	18	40	115	8	0	12	9	226	12
VL 351	24	18	0	6	0	30	0	64	154	13
DM 7	24	18	3	18	0	0	12	64	139	14
GPU 45*	24	18	3	18	0	30	12	0	117	15
PPR 2885	24	18	0	18	0	0	12	9	81	16

*checks

* The cumulative points were calculated by multiplying the scale and points with number of preferred farmers for each character.

For example, the cumulative points for maturity duration is arrived as follows

No. of farmers preferred

a. Short duration (scale 1, points 5 x number of farmers preferred 26 = 130)
   scale 1 x score points 5 x 26 = 130
b. Medium duration (scale 3, score points 3 x number of farmers preferred 0 = 0)
   scale 3 x score points 3 x 0 = 0
c. Long duration (score 3, score points 1 x number of farmers preferred 8 = 8)
   scale 3 x score points 1 x 8 = 8

T1-16
Association of Grain Iron and Zinc content with productivity related traits in Sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract

Correlation and path analysis was carried out with eighty germplasm accessions and five checks, to understand the relationship and relative importance of plant morphological, productivity-related traits and grain micronutrient content towards grain yield enhancement.Character association studies revealed that seeds per panicle, panicle weight and harvestindex could be considered as an indicator trait while selecting plants for grain yieldimprovement owing to their highly significant and very strong positive association withgrain yield per plant. The association between nutritional traits *viz.,* grain iron and zincconcentration were found to be highly significant and positive.Path analysis revealed the true relationship of seeds per panicle with grain yield per plant and the role of flag leaf area in exporting photo-assimilates due to their high positive direct effects.Therefore, seeds per panicle, panicle weight and flag leaf area stand as potential yield traits, and they can be strategically used to improve the grain yield of sorghum

Keywords: Sorghumgermplasm, Grain iron and zinc, correlation and path analysis

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is a climate-smart nutri-rich as well as the fifth most important grain cereal in the world with a global production of 58.03 million metric tons (USDA, 2023). The phenotype of any plant is a result of the interaction of a large number of factors, and the resultant yield is a polygenic character, which results from the sum of several component characters. Therefore, direct selection for yield is often, not effective. Hence, knowledge of association among yield attributing traits along with grain micronutrient content is essential for formulating an effective breeding strategy with the attributing traits as effective indicators in selection.

Materials and Methods

Eighty germplasm accessions and five checks including land-races, released varieties and pre-release cultures that are in the advanced stage of yield trials obtained from Department of Millets were evaluated in Augmented Randomized Complete Block Design during *Kharif* 2019. Observations were made based on 13yield attributing traits *viz.,*days to fifty percent flowering,plant height (cm), leaf area index (%),flag leaf area (cm^2), panicle length (cm), panicle width (cm), number of primary branches per panicle, length of primary branches (cm), panicle weight (g),seeds per panicle, hundred seed weight (g), harvest index (%),grain yield per plant (g)and two grain micronutrient content *viz.,* iron (Fe) and zinc (Zn) (ppm).The grain Fe and Zn concentrations were determined as per Sahrawat*et al.*, 2002 in Atomic Absorption Spectrometer (AAS) at the Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore.The mean data was subjected to statistical analysis using Python for correlation analysis and TNAU STAT for path coefficients analysis.

Results and Discussion

Correlation provides a better insight into the mutual relationship that coexist among the traits (Fig 1). Thus a better understanding of their association with single plant yield would make the selection more precise and accurate with the attributing traits as effective indicators in selection.Grain yield per plant had a highly significant and a very strong positive association with seeds per panicle, panicle weight, and harvest index. Moreover, a significant positive association was observed with panicle characters like number of primary branches, panicle width, and hundred seed weight. Among the leaf characters, leaf area index and flag leaf area, showed a significant positive association with single plant yield. These results herein show that synthesis and translocation of photo-assimilates from leaf could significantly improve yield through enhanced grain filling and seed set. Therefore, these characters can be considered as an indicator trait while selecting plants for grain yield improvement. The high yielding ability of SO3 291 is associated with most of the panicle characters like panicle length, number of primary branches per panicle, length of primary branches, panicle weight, and seeds per panicle. Moreover, high values for all the leaf characters and panicle characters like panicle width, panicle weight, seeds per panicle, and hundred seed weight lead to the high yielding ability of TNS 663. The significant positive associations adopted herein are similar to those previously defined by El-Din *et al.* (2012).The association between grain iron and zinc concentration was very strong and highly significant. The significant positive associations might be due to a common molecular mechanism controlling the uptake and metabolism of minerals (Fe and Zn) in grain or common transporters controlling for the minerals.

Path coefficient analysis retrieves the directional contribution of different components towards yield and also permits partitioning of total correlation into components of direct and indirect effects.The high positive direct effect of seeds per panicle and harvest index indicates the true relationship of these characters with grain yield per plant.Hence, the direct selection of these traits would be rewarding for grain yield improvement.Flag leaf area showed moderate positive direct effect on grain yield.Berwal *et al.* (2017)specified that flag leaf acts as the major source of remobilizing micronutrients (iron and zinc) for seeds in pearl millet.The direct effect on grain yield was found to be low but positive in the case of panicle weight, leaf area index and hundred seed weight.

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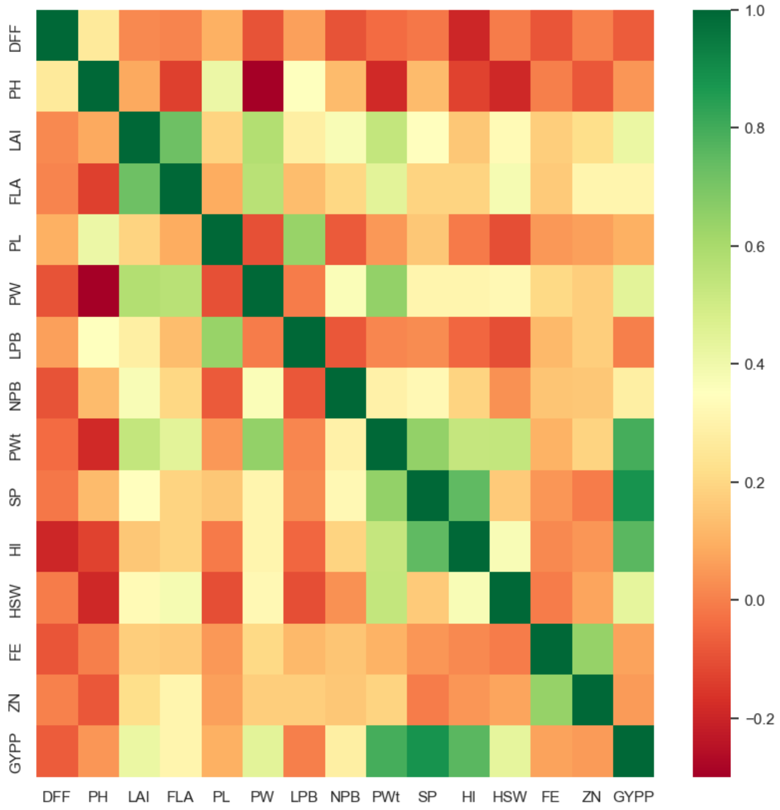
Fig.1 Heat map depicting the relationship among plant morphological, productivity-related traits and grain micronutrient (Fe and Zn) content



T1-17
Dynamics of sugar degradation in Sweet Corn inbred (*Zea mays* (L.) var *saccharata*)

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Abstract

Sweet corn has now emerged as a preferred food worldwide and its demand has increased steadily in the last decade. Among the various issues of concernwhich affect the storage life and the market value of sweet corn, loss of sweetness is the important one. Hence, pattern of sugar degradation was studied among 10 inbred at different harvest intervals (20, 24 and 28 Days After Pollination) as well asdifferent storage conditions *viz.,* ambient temperature and refrigerator (4^0C) for 3 days.The rate of sugar accumulation was maximum in most of the inbred on 20 DAPand it was stable till 24 DAP with the highest being in SC 17-3. The rate of sugar degradation was drastic under ambient conditions at all harvest intervals (around 30°C), whereas minimum when the freshly harvest produce was stored under low temperature condition. Hence, harvesting Sweet corn at right time *i.e.* 20–24days after pollination and immediate storage at low temperature could extend the storage life in sweet corn.

Keywords: Sweet corn inbred, Sugar degradation, harvest intervals, storage temperature

Introduction

Sweet corn (*Zea mays*(L.)var *saccharata*) is harvested before physiological maturity when the kernel has high water content and sugar concentration making it a very perishable fresh produce. To minimize post-harvest loss and prolong its shelf life, effective post-harvest handling is essential. Among the various issues of concern which affect the storage life and the market value of sweet corn, loss of sweetness is the important one. The critical factor driving this loss in sweet corn is storage temperature. Low temperature storage conditions have a critical role in ensuring a longer shelf life for sweet corn by limiting/slowing the metabolic process in it, restricting pathogen development, thereby extending shelf life. Hence, a preliminary study was conducted to analyse the pattern of sugar degradation at different harvest intervals as well as storage conditions in order to determine the optimum storage parameters for sweet corn for enhanced shelf life.

Materials and Methods

Ten sweet corn inbred obtained from Department of Millets, TNAU were raised in RBD with three replications during *Kharif*, 2021. Immature kernels were collected at milky stage *i.e*20, 24 and 28 Days After Pollination(DAP) for estimating the Total Soluble Solids(TSS). TSS were estimated using Hand refractometer (Olsen *et al.,* 1990) atdifferent harvest intervals (20, 24, 28 DAP) and different storage conditions *viz.,* ambient temperature and refrigerator (4^0C) for 3 days.

Result and Discussion

Since sweet corn is harvested at an immature physiological status, choosing the right time for harvest is crucial to ensure a high-quality produce with better sugar content. The rate of sugar accumulation was maximum in most of the inbred on 20 DAP and it was stable till 24 DAP with the highest being in SC 17-3 (Fig 1). Beyond 28DAP there was a declining trend. The gradual decline in soluble sugar content at 28DAP indicates that the sugar to starch conversion and dehydration has been initiated. However, in case of the inbred 45530 and 12068-1, the accumulation of sugar content showed an increasing trend from 20DAP to 28 DAP. This clearly suggests the expression of genotypic influence in this trait which could be studied in depth to elucidate the mechanism for delayed sugar accumulation. Hence, harvesting Sweet corn at right time *i.e.* 20–24days after pollination, where kernels would have reached their final size with maximum sugar content is advisable.

Storage conditions have a critical role in ensuring a longer shelf life for sweet corn. The rate of sugar degradation was drastic under ambient conditions at all harvest intervals (around 30°C) (Fig 2). The loss of sweetness is mainly due to active kernel metabolism which enables the conversion of sugars to starch (Carey *et al*., 1984).The critical factor driving these losses in sweet corn is temperature, which was vividly evident from the study. The rate of sugar degradation was minimum when the freshly harvest produce was stored under low temperature condition at 4°C.Among the inbred, sugar content was stable in SC 17-3.However, the storage life could be still extended if the sweet corn is stored in much lower temperature as opined byXie *et al.,* 2017. Such low temperatures would help to reduce microorganism development and sweet corn respiration rates, thereby drastically reducing sugar conversion and extending shelf life.

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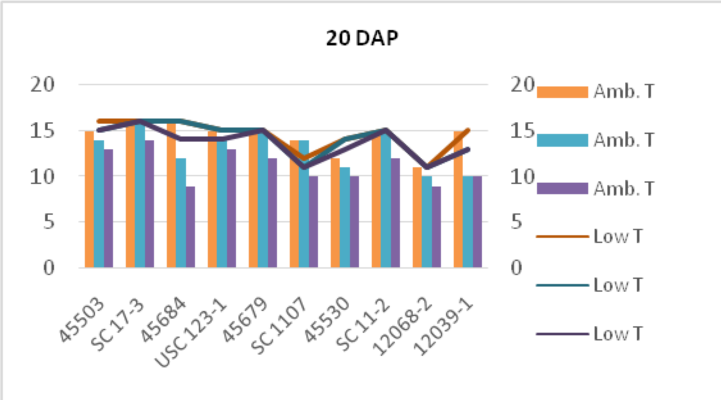
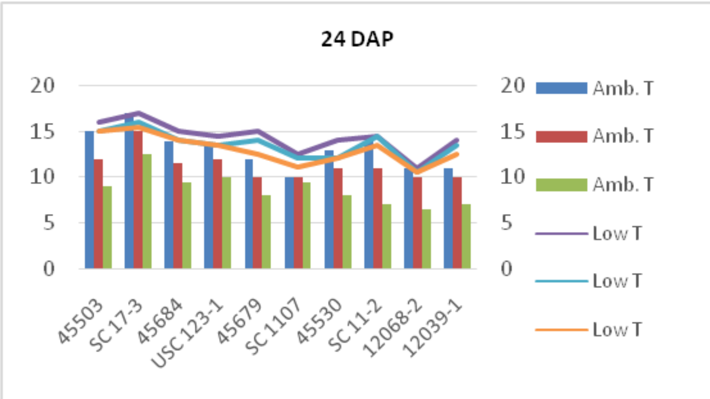
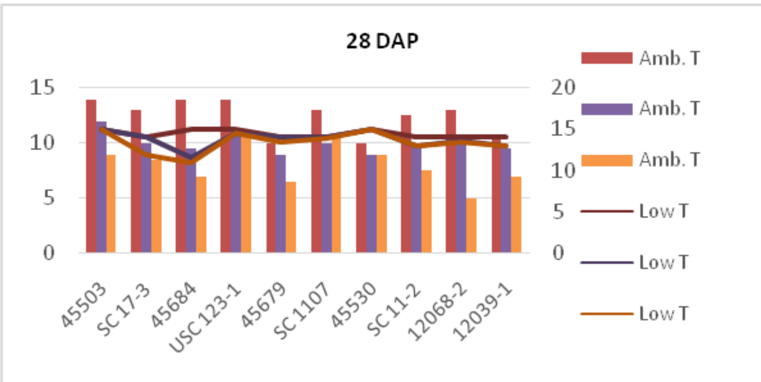
Fig. 1. Rate of total soluble sugar (TSS) accumulation at different harvest intervals as indicated by % Brix

Fig. 2. The pattern of sugar degradation at different storage conditions on20, 24 and 28 DAP







T1-18

Evaluation of Barnyard millet mutants for yield contributing traits

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Abstract

Barnyard millet is a self-pollinated crop. It is considered as a functional food crop due to its nutritional value. The study was conducted to examine the performance of barnyard millet mutants for yield contributing traits. The mutant lines were developed by using ethyl methane sulphonate and sodium azide mutagens. M_5 generation material from the above mutagen treated population was raised and observations were recorded for the traits *viz.,* days to 50 per cent flowering, days to maturity, plant height, number of basal tillers per plant, flag leaf length, flag leaf breadth, number of nodes, node length, stem girth, length of panicle, width of panicle, peduncle length, lower raceme length, number of racemes, single ear head weight,1000 grain weight and Single plant yield. The mutant ACM 21018 had significant higher mean values for the traits *viz.,* plant height, number of productive tillers plant $^{-1}$, flag leaf breadth, number of nodes, node length, panicle length, peduncle length, number of racemes, lower raceme length, stem girth, width of panicle, single ear head weight and single plant yield than the check. This stabilised mutant line was further forwarded to Advanced Yield Trialinvariety developmental programme.

Keywords: barnyard millet, mutants, mean performance

Introduction

Small millets are commonly called as ‘nutri-cereals’ due to its good nutritional value. Small millets consist of finger millet, barnyard millet, little millet, proso millet and kodo millet. Barnyard millet has two distinct species which are Indian barnyard millet [*Echinochloacolona* (L.) Link] and Japanese barnyard millet [*E. crus-galli* (L.) Beauv]. It is used as both grain and fodder purpose. It has low glycemic index which is amenable food for diabetes (Muthamilarasan and Prasad, 2021). Barnyard millet is a self-pollinated crop and small in floret size which has low variability. In this millet, emasculation and hybridization are very difficult due to small floret. Mutation breeding has been playing a key role in creating variability (Waghmode*et al*., 2020). Millets in general are an under-researched crop commodity. Recently, barnyard millet has received some attention from the research community in developing genetic and genomic resources (Upadhyaya *et al*., 2014).

Materials and Methods

The experiment was conducted at Agricultural College and Research Institute, Madurai during *rabi*,2021. The experimental material consists of 25 M_5mutant lines of the variety MDU1 which was developed using chemical mutagens ethyl methane sulphonate and sodium azide. These lines were evaluated in randomized block design with three replications in a spacing of 30 cm×15 cm and seventeen quantitative traits *viz.,* days to 50 per cent flowering, days to maturity, plant height, number of basal tillers per plant, flag leaf length, flag leaf breadth, number of nodes, node length, stem girth, length of panicle, width of panicle, peduncle length, lower raceme length, number of racemes, single ear head weight,1000 grain weight and Single plant yield were recorded from five randomly selected plants. The data was analysed using the TNAUSTAT statistical package.

Results and Discussion

The mutant lines such as ACM 21006, ACM 21008, ACM 21010, ACM 21015, ACM 21016, ACM 21017, ACM 21018, ACM 21023, ACM 21024 and MDU-1 were found significantly tall in plant height. ACM 21004 had a greater number of productive tillers per plant followed by ACM 21018. Among the 25 mutants, seven were found as an early flowering mutant. Arunachalamand Vanniarajan (2012) inferred that the early maturing genotypes had a habit of poor yielding. Eight mutants were recognised significantly higher than the average value of the trait flag leaf length. Twelve mutants were significantly above than the mean value of flag leaf breadth. ACM 21010 had a greater number of nodes then followed by ACM 21023. Nine mutants were observed significantly greater than the average node length. Among these, ACM 21012 mutant showed the lengthiest node. Out of 26 genotypes, six namely ACM 21006, ACM 21012, ACM 21018, ACM 21023, ACM 21024 and MDU-1 exceeded significantly more than mean panicle length. The mutant ACM 21006 showed the longest panicle among the studied mutants. The lengthiest peduncle was observed in the check variety. Among the 25 mutants, twelve were exposed above the average length of peduncle. The greatest number of racemes were observed in the check followed by the mutant ACM 21018. The lengthiest lower raceme was noted for the mutant ACM 21009. The thickest and the thinnest stem girth were recorded in ACM 21010 and ACM 21016 mutants, respectively. Only one mutant had significantly earlier maturity (ACM 21002) than the grand mean. The maximum and minimum single ear head weight pointed out in the mutants ACM 21017 and ACM 21013,respectively. Eight mutants were significantly greater than the grand meanof thousand grain weight. The low and high value of thousand grain weight was observed in the mutants ACM 21025 and ACM 21023. Eight mutants were noted for significantly higher than the average single plant yield. The highest single plant yield was recorded in the mutant ACM 21010. Similar results were found in finger millet (Waghmode*et al*., 2020). The mutant ACM 21018 had significant higher mean values for the traits *viz.,* plant height, number of productive tillers plant $^{-1}$, flag leaf breadth, number of nodes, node length, panicle length, peduncle length, number of racemes, lower raceme length, stem girth, width of panicle, single ear head weight and single plant yield than the check. This mutant was forward to further yieldtrails in a variety developmental program.

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Table 1: Mean performance of the mutants and check for quantitative traits

Mutants	PLH	NTP	DFL	FLL	FLB	NON	NOL	LEP	PEL	NBR	LRL	SGT	WOP	DTM	SEHW	TGW	SPY
ACM21001	103.14	6.40	63.33	31.02	2.84	7.53	14.70*	16.24	8.98*	45.40	3.08*	2.12	3.88	93.80	8.72	2.65	37.40
ACM21002	98.12	6.37	66.75	28.92	2.80	8.61	8.68	21.26	8.26*	59.80	2.96	2.34	4.22	88.00*	9.65	2.33	39.12
ACM21003	123.80	7.24	62.75	29.32	3.33*	8.80	9.32	22.38	7.64*	59.00	3.50*	2.35	6.84*	93.47	11.98*	3.69*	54.82*
ACM21004	117.34	8.43*	60.00*	30.76	3.48*	8.87	9.44	22.08	6.85	63.56	3.16*	2.18	6.27*	89.60	11.56*	3.00	59.48*
ACM21005	124.38	6.20	64.15	33.00*	3.55*	10.47*	10.04	22.82	6.12	64.06	3.42*	2.50	6.78*	94.58	11.96*	3.49	44.72
ACM21006	131.54*	8.12*	62.33	30.06	3.84*	10.12*	11.56*	26.94*	9.10*	70.54*	3.56*	2.52	5.66*	93.8	10.75*	2.71	42.42
ACM21007	122.47	6.08	65.56	30.16	3.08	9.60	12.12*	23.08	7.47*	67.47*	2.88	2.28	6.25*	92.47	11.94*	3.46	47.82*
ACM21008	133.13*	8.26*	64.23	30.86	3.07	9.13	13.66*	23.83	7.25	69.00*	2.34	2.24	5.96*	93.39	11.29*	4.34	62.66*
ACM21009	121.64	7.47*	67.58	30.74	3.04	8.60	10.32	22.64	7.91*	61.33	4.08*	2.25	4.58	95.62	8.70	2.86	43.60
ACM21010	145.22*	8.00*	63.47	30.00	3.36*	12.21*	9.86	24.40*	4.92	69.55*	3.52*	2.08	6.95*	93.53	11.71*	3.64*	60.98*
ACM21011	112.46	6.22	59.92*	26.64	2.56	9.32	9.60	22.84	5.76	62.22	2.32	2.44*	5.10	90.80	8.50	2.55	32.74
ACM21012	124.00	5.56	62.00	30.44*	3.00	8.40	13.96*	22.02	8.19*	62.20	2.36	2.11	4.15	92.26	9.85	3.01	31.56
ACM21013	112.78	7.06	66.44	30.54*	2.34	8.47	10.76	21.64	8.07*	59.80	2.34	2.53*	4.76	93.13	7.58	2.62	30.30
ACM21014	126.13	7.53*	65.08	31.12*	3.38*	9.80	9.38	23.44	7.50*	70.04*	3.00	2.26	5.38	95.44	9.16	2.91	40.84
ACM21015	133.67*	7.06	68.00	30.94	3.14	10.07*	12.24*	23.72	9.08*	68.80*	2.94	2.16	6.12*	95.86	11.02*	3.95*	40.90
ACM21016	130.55*	5.60	60.75	31.20*	3.30*	10.48*	9.26	20.64	5.41	53.33	2.88	2.68*	4.26	91.20	9.24	2.24	40.50
ACM21017	132.38*	8.23*	58.33*	26.15	2.86	10.83*	12.30*	23.16	6.66	68.60*	2.24	2.56	6.38*	90.23	15.20*	3.27	59.8*
ACM21018	136.33*	8.27*	65.66	28.62	3.38*	10.20*	11.68*	26.06*	9.01*	71.83*	3.62*	2.46*	6.52*	95.04	12.38*	3.98*	62.58*
ACM21019	104.22	7.08	64.55	26.06	3.26*	7.80	9.54	20.66	6.87	59.25	2.40	2.17	4.96	95.33	9.14	2.78	32.58
ACM21020	106.58	6.53	59.33*	28.38	3.08	8.40	8.00	22.44	4.12	58.67	2.54	2.34	4.12	89.91	9.00	4.30*	30.18
ACM21021	115.24	6.86	62.33*	28.46	2.86	8.26	7.84	22.12	5.09	58.80	3.08*	2.20	4.88	90.46	8.66	4.54*	34.62
ACM21022	110.50	8.35*	60.66	30.44	3.32*	8.42	10.28	23.50	5.00	64.15	2.82	2.44*	4.76	91.33	8.22	3.81*	40.30
ACM21023	129.84*	8.17*	60.12*	31.48*	2.92	9.04	16.04*	24.65*	6.73	70.47*	2.26	2.46*	5.13	90.60	10.49	4.09*	58.52*
ACM21024	138.68*	6.80	58.25*	31.40*	3.20	11.53*	11.04	24.89*	4.58	70.72*	3.24*	2.63*	5.27	89.42	9.12	3.24	37.26
ACM21025	123.02	4.53	67.66	28.92	3.38*	8.33	11.12	22.6	8.27*	56.38	3.40*	2.20	4.65	94.22	8.85	2.22	30.46
CheckMDU-1	142.44*	7.40*	63.33	32.00*	3.34*	11.00*	10.66	25.98*	9.62*	72.83*	3.20*	2.28	5.76*	95.33	11.72*	4.27*	57.08*
GM	123.06	7.07	63.18	29.91	3.14	9.40	10.90	22.92	7.09	63.76	2.97	2.34	5.37	92.65	10.25	3.42	44.36
S.E.	2.0081	0.1113	0.9303	0.4213	0.0431	0.1569	0.1669	0.3663	0.1204	1.0240	0.0392	0.0329	0.0795	1.3036	0.1449	0.0578	0.8287
C.D. (5%.)	5.7081	0.32	2.64	1.2	0.12	0.45	0.47	1.04	0.34	2.91	0.11	0.09	0.23	3.71	0.41	0.16	2.36

*Significance at 5%

PLH-Plant height; NTP-Number of basal tillers per plant; DFL-Days to 50% flowering; FLL-Flag leaf length; FLB-Flag leaf breadth; NON-Number of nodes; NOL-Node length; LEP-length of panicle; PEL- Peduncle length; NBR-Number of racemes; LRL-Lower raceme length; SGT-Stem girth; WOP-Width of panicle; DTM-Days to maturity; SEHW-Single ear head weight; TGW-Thousand grain weight; SPY-Single plant yield

T1-19
Character association of yield components of Maize (*Zea mays* L.) in water limited Conditions

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Abstract

Maize is grown over a wider range of environment and it has a higher level of industrial utilization than any other cereal grain because of its high production potential. Maize is cultivated under rainfed conditions to a larger extent and hence development of broadly adapted material with maximum genetic potential under water limited conditions is the current need to increase the production and productivity. Forty genotypes were used to study the relationship of the yield associated traits with grain yield. Correlation study was performed among ten traits in forty genotypes of maize to see if there is any interdependence among the traits. Plant height, cob length, number of rows per cob, number of kernels per row and shelling percentage exhibited positive association with yield at 1% significance level. Days to 50 % tasselling, days to 50 % Silking and Anthesis Silking interval showed negative association with yield at 1% significance level. Hence, cob characters *viz*., cob length, number of rows per cob, number of kernels per row, shelling percentage and early maturing genotypes with low ASI can be given more importance in selection criteria under water limited conditions.

Keywords: correlation, anthesis silking interval, cob length, number of rows

Introduction

Maize is grown over a wider geographical and over a wider range of environment than any other cereal crop. It has diversified uses as human food, animal feed and as a source for large number of industrial products. This crop is used to a higher level of industrial utilization than any other cereal grain because of its very high production potential, wider adaptability and industrial value. Drought stress, particularly at flowering stage, has beenidentified as the most important factor limiting maizeproduction and productivity in India. Development of broadly adapted material with maximum genetic potential as well as enhanced stability of yield when grown under water stress conditions is the current need to increase the production and productivity.Yield is a complex inherited character resulting from the interaction between the associated contributing characters. Therefore, direct selection for yield may not be the most efficient method for its improvement, but indirect selection for other yield related characters, which are closely associated with yield and high heritability estimates will be more effective.

Materials and Methods

The experimental study was conducted at Maize Research Station, Vagarai during 2020 under rainfed conditions. Forty genotypes were raised in two replications and correlation study was performed among the ten traits.Correlation study was done to study the interdependence among the ten traits *viz*., plant height, ear height, days to 50 % tasselling, days to 50 % silking, ASI, cob length, number of rows per cob, hundred seed weight, shelling percentage and yield

Results and Discussion

Drought stress at flowering stage is the most important factor limiting maizeproduction and productivity. Plant height, ear height, cob length, number of rows per cob, number of kernels per row and shelling percentage exhibited positive association with yield at 1% significance level.Cob length had positive association with number of rows per cob, number of kernels per row and shelling percentage. Number of rows per cob showed positive association with number of kernels per row and shelling percentage. The results indicated that selection of these positively associated traits *viz*., plant height, cob length, number of rows per cob and shelling percentage are highly rewarding.Days to 50 % tasselling, days to 50 % Silking and ASI showed negative association with yield at 1% significance level suggesting selection of early maturing genotypes for yield enhancement under water limited conditions.The association of the yield component traits is presented in the Table.1

In maize breeding,knowledge on the relationships among yield components is of the great importance, because it is likely to facilitate breeders to choose the most efficient selection criteria. Hence the cob characters *viz*., cob length, number of rows per cob, number of kernels per row, shelling percentage can be given more importance in selection criteria as they are contributing to yield. Water stress during flowering will lead to delay in silking which will ultimately prolong the anthesis to silking interval and poor seed set. Selection of genotypes with early maturity, shorter ASI, smaller tassels and stay green traits will assist in breeding for ware limited conditions.

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Table. 1. Correlation of yield and the associated traits

	Plant Height	Ear height	DAT	DAS	ASI	Cob length	NR/cob	HSW	Shelling %	Grain Yield
Plant Height	1									
Ear height	0.971**	1								
DAT	-0.536**	-0.525**	1							
DAS	-0.630**	-0.629**	0.830**	1						
ASI	-0.282*	-0.297**	-0.092	0.479**	1					
Cob length	0.812**	0.779**	-0.391**	-0.456**	-0.199	1				
NR /cob	0.702**	0.655**	-0.504**	-0.524**	-0.142	0.775	1			
HSW	0.617**	0.651**	-0.335**	-0.349**	-0.096	0.620**	0.539**	1		
Shelling %	0.691**	0.676**	-0.309**	-0.378**	-0.188	0.670**	0.544**	0.628**	1	
Grain Yield	0.737**	0.698**	-0.379**	-0.467**	-0.237*	0.812**	0.663**	0.589**	0.693**	1.000

* Significance at 1 % level; ** Significance at 1 % level
DAT – Days to 50% tasselling; DAS – Days to 50% silking; ASI – Anthesis Silking; Interval; NR/cob – No of rows per cob; HSW – Hundred seed weight

T1-20

Principal component analysis and diversity studies in sorghum germplasm for grain yield and yield components

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Abstract

Genetic diversity is an essential prerequisite for improving the genetic makeup of any crop. A study was carried out to assess the genetic divergence for seventeen morphological traits associated with yield in hundred and one germplasm accessions with seven checks. Cluster analysis grouped the germplasm accessions into four major clusters in which cluster I had the largest accessions followed by cluster II and III. The least number of accessions were found in cluster IV with nine accessions. The accessions from cluster I and IV can be used for hybridization programme. Principal component analysis revealed that the seven components were found to have eigen value more than one. Among the morphological traits associated with grain yield, maximum divergence was contributed by days to 50 per cent flowering, days to maturity and hundred seed weight. Hence, importance must be given to these traits.

Keywords: Sorghum germplasm, diversity analysis, Principal component analysis

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important crops which allow farmers to use one third less water than similar crop such as maize. It is the most important staple food for millions of rural people in the semi-arid tropics of Asia and Africa. Germplasm is defined as the total gene pool of a species consisting of landraces, advanced breeding lines, popular cultivars, wild and weedy relatives (Upadhyaya *et al.*, 2010). Knowledge of genetic diversity of crop usually helps the breeder in choosing desirable parents for the breeding programme and gene introgression from distantly related germplasm (Prasad and Biradar, 2017). Principal component analysis (PCA) explained the divergence of sorghum germplasm as measures the contribution of each component to total variance by means of phenotypic value of each trait. Thus, this study was done to identify the diversed genotypes and component traits with maximum variation, which can be used in upcoming breeding programmes.

Materials and Methods

The experimental materials include 101 germplasm with seven checks and the experiment was laid out during *kharif* 2018 in Department of Millets, Tamil Nadu Agricultural University, Coimbatore. The Augmented design II was followed with 4m row length and spacing of 45 cm x 15 cm. From each entry, five plants were tagged for recording observations on biometric traits. Mean of five plants from each entry were used for statistical analysis.

Observations were recorded on the following traits *viz.,* plant height (cm), stem diameter (cm), leaf length (cm), leaf width (cm), flag leaf length (cm), flag leaf width (cm), flag leaf area (cm), chlorophyll index, number of leaves, number of nodes, panicle length (cm), panicle length of branches (cm), days to 50 per cent flowering (no. of days), days to maturity (no. of days), dry fodder yield per plant (g), hundred seed weight (g) and grain yield per plant (g). The analysis of variance was performed and significance for these characters was studied. The diversity analysis was done using R software and principal component analysis was carried out using STAR software.

Results and Discussion

Diversity analysis and Principal component analysis was performed using seventeen yield contributing traits. A total of four main clusters were formed using diversity analysis (Fig 1), of which, the maximum number of accessions was found in cluster I (39 accessions) as reported by Sinha and Kumaravadivel (2015), and Desmae *et al.* (2016), followed by cluster II and III with 30 accessions. The least number of accessions was reported in cluster IV (9). The germplasms in cluster I had highest mean value whereas the germplasms in cluster IV showed poor mean performance for most of the traits. Thus, it is recommended that the accessions from cluster I and cluster IV can be used for hybridization programme.

In Principal component analysis, the first seven components had eigen value more than one. These components contributed 77.72 per cent of total variability in which PC 1 alone contributes 20.45% of total variance. The traits *viz.,* days to 50 per cent flowering, days to maturity and hundred seed weight exhibited extensive variation (Table 1) in the population screened and hence it can be used as selection indices for yield improvement in sorghum. This was in similar trend with Desmae *et al.* (2016).

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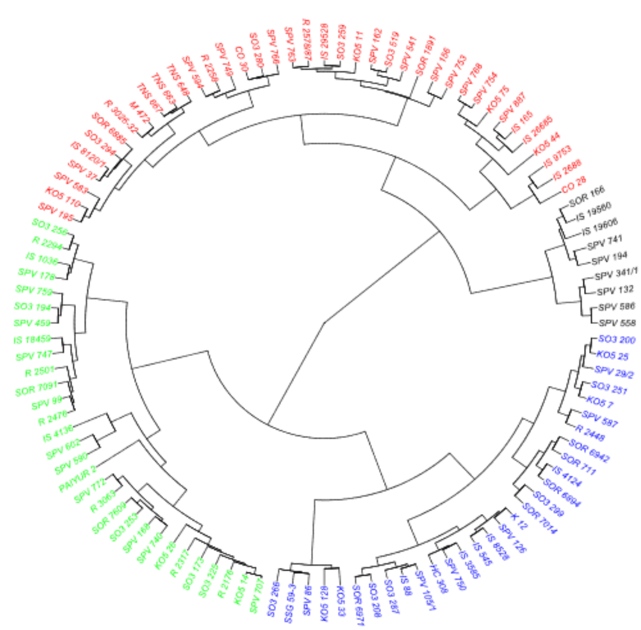
Table 1: Eigen vectors and scores for first seven components retained from PCA of yield and yield contributing traits

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Plant height (cm)	-0.204	0.247	-0.208	0.239	-0.226	0.060	-0.421
Stem diameter (cm)	-0.262	0.293	0.096	0.196	0.073	0.102	0.146
Leaf length (cm)	-0.293	0.105	0.093	0.138	-0.168	-0.244	-0.472
Leaf width (cm)	-0.150	-0.017	0.382	0.254	0.132	-0.450	-0.064
Flag leaf length (cm)	-0.359	-0.289	0.116	-0.218	-0.100	0.074	-0.139
Flag leaf breadth (cm)	-0.346	-0.267	0.293	-0.161	0.041	0.039	0.048
Flag leaf area (cm2)	-0.333	-0.299	0.263	-0.255	-0.104	0.120	-0.058
Chlorophyll index	0.092	0.038	0.300	-0.025	-0.510	0.089	0.378
Number of leaves	-0.319	0.408	-0.023	-0.081	0.123	0.206	0.072
Number of nodes	-0.319	0.408	-0.030	-0.081	0.121	0.204	0.081
Panicle length (cm)	-0.069	-0.226	-0.004	0.593	-0.101	-0.082	0.047
Panicle length of branches (cm)	-0.018	-0.043	-0.172	0.124	-0.677	0.227	-0.031
Days to 50 percent flowering	0.296	0.169	0.478	0.054	0.019	0.156	-0.223
Days to maturity	0.296	0.181	0.458	0.038	-0.006	0.177	-0.285
Dry fodder yield per plant (g)	-0.143	0.231	0.215	0.176	-0.135	-0.249	0.502
Hundred seed weight (g)	-0.027	-0.147	0.121	0.277	0.161	0.638	0.036
Grain yield per plant (g)	-0.096	-0.273	-0.061	0.436	0.269	0.171	0.087

Fig. 1. Dendrogram displaying the 108 accessions in various groups



T1-21

Studies on genetic variability for yield and yield contributing characters in Finger Millet (*Eleusine coracana* (L.) Gaertn,)

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Abstract

Twenty genotypes of finger millet were evaluated in a field study to assess the magnitude of genetic variability, heritability and genetic advance for yield and yield contributing traits. The analysis of variance revealed that there were significant differences among the entries for all the traits studied. A wide range of variation was recorded for plant height (cm), days 50% flowering, days to maturity, number of tillers per plant, finger length (cm), test weight (g), yield per plant (g), straw yield per plant (g). The phenotypic coefficient of variation was greater than genotypic coefficient of variation for all the characters studied which shows the influence of the environmental effect on the characters. High values for phenotypic coefficient and genotypic coefficient was recorded for number of tillers, fodder yield kg/ha, grain yield kg/ha, plant height and days to maturity indicating that these characters were controlled by additive gene effects. Selection based on these characters would be effective for future finger millet crop improvement program.

Introduction

Finger millet (Eleusine coracana L. Gaertn., 2n=4x=36) belongs to the family Poaceae. Among millets, it ranks third in importance after sorghum and pearl millets. Its wide adaptability to diverse environments and cultural conditions makes it a potential food crop. It also contains sufficient amount of iron and rich source of calcium. The availability of diverse genetic resources is a prerequisite for genetic improvement of any crop including finger millet. The basic information on the existence of genetic variability and diversity in a population and the relationship between different traits is essential for any successful plant breeding programme. Considering its importance in food and fodder security, adequate information on genetic variability between yield and its attributes is meagre in finger millet. Systematic breeding efforts in this crop have so far been neglected. For starting any crop improvement work, information about the genetic variability available in the population is a prerequisite. Presence of high variability in the genotypes of this crop offers much scope for its improvement (Poehlman, 1987). Estimation of genetic parameters in the context of trait characterization is an essential component in developing high yielding varieties. Hence, an attempt was made to estimate the extent of variation for yield contributing traits in twenty finger millet genotypes by studying the genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance, which may contribute to formulation of suitable selection indices for improvement in this crop.

Materials and Methods

The present study was conducted at Centre of Excellence in Millets during Kharif, 2022. Proper crop management practices was followed to raise a better crop. Evaluation of twenty genotypes were carried out using Randomised Block Design with three replications. Twenty rows of 4.5 meters length and 2 meters breadth with a spacing of 30 × 10 cm were raised in each plot. Biometrical observations were recorded on randomly five plants in each genotype in three replications on days to 50 per cent flowering, days to maturity, plant height, number of fingers/ear, finger length, number of fingers, thousand seed weight, grain yield/plant and straw yield/plant. Analysis of variance (ANOVA) was worked out by using the method suggested by Panse and Sukhatme (1967). The PCV and GCV were estimated by following the method given by Burton and Devane (1953). Heritability in broad sense was estimated as per Lush (1940) and characters were categorized as high, moderate and low heritability as per the way of Robinson *et al*. (1949). Genetic advance as percent of mean were calculated by using the method described by Johnson *et al*. (1955).

Results and Discussion

ANOVA indicated significant difference for all the 8 characters studied. Mean, Range and variability parameters for twelve characters are presented in Table 1.For all the twelve characters studied, the difference between the value of PCV and GCV was low which indicates the negligible contribution of environmental effect for the trait expression. Similar results were reported by Udamala*et al*. (2020). Greater value of PCV was recorded for number of tillers per plant (44.9%) and sand days to maturity (23.1%). Similar results were reported by Nandini, et al. 2010. Highest value of GCV was recorded for number of tillers (44.86%) and dry fodder yield / plant (20.8%). High PCV coupled with high GCV was recorded for number of tillers per plant which depicts that these two characters were highly variable and paves way for enhancement of the characters by direct selection between the genotypes. The results were in line with the findings of Lule *et al*. (2012). Similarly, the value of PCV and GCV was low for days to maturity which were found in the findings of Reddy *et al*. (2013). In case of phenotypic variance, the heritable portion is the heritability which is a good index which gives the information of transmission of characters from parents to off spring (Falconer, 1996). High heritability was recorded for all seven characters viz., plant height (83.5%), days to 50 per cent flowering (99.2%), number of tillers /plant (99.8%), finger length (60.7%), thousand seed weight (89.4%),fodder yield (92.2%) and grain yield / plant (90.0%).Similar results of high heritability for all the traits studied was reported by Ganapathy *et al*. (2011).

The value of genetic advance as per cent of mean was found high for number of tillers (92.3), fodder yield kg/ha (41.3 %) and grain yield kg/ha (38.2%,),plant height (29.2%), finger length (60.7%). The value of genetic advance as per cent of mean was found moderate for days to 50 per cent flowering (20.0%), days to maturity (24.0%), finger length (13.3%), thousand seed weight (15.6%). Genetic gain can be predicted with the help of heritability and genetic advance. Combination of high heritability with high genetic advance as percent of mean was recorded for number of tillers, fodder yield kg/ha, grain yield kg/ha, plant height and days to maturity. Similar results were reported for ear head length by Singamsetti*et al*. (2018), for number of productive tillers / plant as well as finger length by Mahanthesha et al. (2017), for straw yield / plant by

Devaliya*et al*. (2018). These characters would be subjected to direct selection due to the presence additive gene action.

In the experimental material, sufficient amount of variability was observed as a result of moderate to high PCV, GCV with high heritability associated with high genetic advance as per cent of mean were observed for number of tillers, fodder yield kg/ha, grain yield kg/ha, plant height and days to maturity. Characters with high heritability coupled with high genetic advance indicated the presence of additive gene action and less influence of environment which reveals that the selection based on these characters favours the improvement of yield, whereas the traits *viz.,* days to maturity indicates the presence of non-additive gene action with little scope for further improvement through individual plant selection.

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Table 1. Genetic variability parameters for yield and yield contributing traits of Finger millet

Traits	Mean	Range	PCV %	GCV %	ECV%	$h^{2(}$(%)	GA as % mean
Plant Height	77.6	58.1-108	9.0	15.5	6.9	83.5	29.2
Days to 50% flowering	99.1	87.3-123.6	9.8	9.8	0.9	99.2	20.0
Days to Maturity	3.9	3.3-6	23.4	16.5	16.6	49.8	24.0
Number of Tillers	9.7	5.7-26.3	44.9	44.9	2.2	99.8	92.3
Finger length	8.5	7.3-10.3	10.7	8.3	6.7	60.7	13.3
Thousand seed weight	3.2	2.7-3.7	8.5	8.0	2.8	89.4	15.6
Fodder yield kg/ha	4847.2	3794.8-7401.8	21.7	20.9	6.1	92.2	41.3
Grain yield kg/ha	3868.0	3049.2-5739.2	20.6	19.5	6.5	90.0	38.2

T1-22
Multivariate analysis for morpho-physiological traits associated with grain yield in Sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract

Sorghum (*Sorghum bicolor* (L.) Moench) is one of the most important dietary staple food crop in the world and was domesticated in Ethiopia, Africa. India is the largest producer and consumer of sorghum. It is popularly known to be Cholam, Jowar, Indian millet and Milo. Sorghum is referred to as "The king of coarse cereals" due to the presence of numerous nutritional qualities. An edible starchy grain contains full of iron, protein, minerals, fiber content and gluten free properties (Derese *et al.* 2018). Principal component analysis (PCA) is a multivariate method used to study the relationship between different quantitative variables and it is the best tool to exploit the diversity in sorghum (Upadhyaya *et al.* 2019).

A total of 102 sorghum germplasm accessions along with seven checks were characterized at the Department of Millets, Tamil Nadu Agricultural University, Coimbatore in an augmented design during *Summer,* 2021. Seventeen traits *viz*., plant height, days to 50 % flowering, stem diameter, flag leaf length, flag leaf breadth, flag leaf area, number of leaves, leaf length, leaf breadth, panicle length, days to maturity, hundred seed weight, SPAD chlorophyll content, leaf area, leaf area index, soluble protein and grain yield per plant were recorded on five random plants in each germplasm accession. The principal component analysis was analyzed in "R- Studio" using "Factoshiny" package.

This yield contributing traits were separated into 17 principal components of which five components had more than one eigen values (Fig 1). 74 percent of total variation was observed from these five principal components. Traits *viz.,* plant height, days to 50% flowering, stem diameter, flag leaf length, flag leaf breadth, flag leaf area, number of leaves, leaf length, leaf breadth, days to maturity, hundred seed weight, leaf area, leaf area index and grain yield per plant contributed maximum of 35 % in the principal component (PC1) with 5.93 eigen value. Divergence of second principal component was mainly contributed by plant height, days to 50% flowering, leaf length, panicle length, days to maturity, leaf area and leaf area index. Eigen value for principal component 2 (PC2) was 2.80 and contributes about 16% of total variation. Contribution of divergence by Principal component 3 (PC3) was observed to be 10% with eigen value of 1.70. Traits responsible for variation in PC3 were leaf length, leaf breadth, 100 seed weight, SPAD chlorophyll index, leaf area and leaf area index. Total variation contributed by Principal component 4 (PC4) was 7% with an eigen value of 1.20. Major variation contributing trait in principal component 4 was grain yield per plant. Other variation contributing traits were plant height, stem diameter, leaf length, panicle length, hundred seed weight, SPAD chlorophyll index, leaf area, leaf area index and soluble protein. Fifth principal component (PC5) contributes 6% of total variation and had 1.02 eigen value. Grain yield per plant contributed more variation

in fifth principal component. Mofokeng *et al.* (2017) analyzed 98 accessions and the top three principal components accounted for 86% of the total variation. Seed weight, plant height and grain yield contributed more variation to the principal components. Similarly, Derese *et al.* (2018) and Mumtaz *et al.* (2018) reported three principal components with more than one eigen value.

Based on the significant loading factors important traits were considered. From the research findings, days to 50% flowering, stem diameter, leaf length, leaf breadth, leaf area, leaf area index, grain yield per plant, panicle length and hundred seed weight contributes more variation among germplasm accessions. Hence, Selection of germplasm coupled with these traits will be better utilized in hybridization programme.

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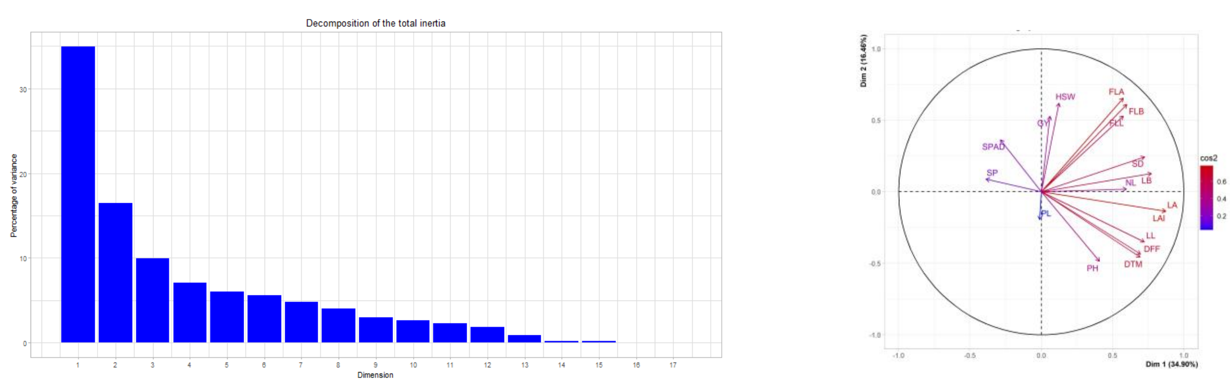
Fig. 1. Biplot and Scree plot showing the variations for 17 principal components



T1-23
Physiological evaluation of foxtail millet genotypes for drought tolerance

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Abstract

Foxtail millet (*Setaria italica* L.), is an important food and fodder grain crop in arid and semi-arid regions of Asia and Africa. Foxtail millet together with proso millet ranks second in the total world production of millets. An investigation was carried to understand the physiological, biochemical and yield responses of foxtail millets to drought during flowering stage. The pot culture experiment was conducted in twenty foxtail millet genotypes and the drought was imposed by withholding irrigation for 15 days during panicle initiation stage and various physiological, biochemical and yield parameters associated with drought tolerance were measured. Among the genotypes, ISe 317 showed higher root volume, root length whereas SiA 2854 showed better results in root weight under drought stress. In case of gas exchange parameters, the genotypes ISe 27, PS 4, ISe 138 and AP 4 showed better performance under drought. Based on physiological parameters, such as water use efficiency, chlorophyll fluorescence, chlorophyll meter reading, relative water content, chlorophyll stability index, excised leaf water loss, osmotic potential and osmotic adjustment, the genotypes, ISe 27, PS 4, AP 4, ISe 138 and ISe 174 were grouped as tolerant genotypes. The genotypes, AP 4, ISe 27, PS 4 and Prasad were grouped as drought tolerant genotypes based on biochemical parameters such as proline content, nitrate reductase activity, catalase, peroxidase, superoxide dismutase and DPPH radical scavenging assay. In conclusion, ISe 27 showed better results in terms of physiological, biochemical and yield components and therefore, emerged as most drought tolerant genotype. AP 4 and PS 4 were showed better results in term of physiological and biochemical traits yet with poor yield. Consequently, these genotypes can be used for breeding program to develop drought tolerant high yielding variety by crossing with agronomically superior varieties.

Introduction

Abiotic stresses one of the major limiting factors that affect the crop growth and productivity. Among the abiotic stresses, drought and salinity affect more than 30 per cent of land, which result in more than 50 per cent decline in the average yield of major crops worldwide. Drought is considered to be a moderate loss of water, which leads to stomatal closure and limitation of gas exchange and more extensive loss of water, which can potentially lead to gross disruption of metabolism and cell structure and eventually to the cessation of enzyme catalyzed reactions and drought stress reduces crop yields by as much as 50 per cent (Bray *et al*., 2000). Understanding plant responses to drought is a great importance and also a fundamental part for making the crops as stress tolerant.

Foxtail millet (*Setaria italica* L.), is an important food and fodder grain crop in arid and semi-arid regions of Asia and Africa. Apart from being rich in a variety of amino acids and nutritional minerals, foxtail millet exhibits high photosynthetic efficiency and drought tolerance. Crops grown in arid and semi-arid regions including foxtail millet are affected by drought at the reproductive stage. Foxtail millet is thought to be an excellent experimental model in studying abiotic stress tolerance system due to its small genome, low amount of repetitive DNA, a highly conserved genome structure relative to the ancestral grass lineage, inbreeding nature and short life cycle . To increase the productivity and to stabilize production in the ever-changing environment, development of genotypes that are capable to survive better under abiotic stresses is essential. Therefore, it is imperative to understand the responses of foxtail millet genotypes to drought especially in flowering stage in terms of changes in physiological and biochemical traits.

Materials and Methods

Twenty foxtail millet genotypes were used for pot culture experiment. The drought stress was imposed by withholding irrigation for 15 days during flowering stage and the experiment was conducted in three replication using completely randomized design. Various morphological, physiological traits were measured to study the response of genotypes to drought and yield parameters also measured.

Results and Discussion

The response of genotypes was studied using various physiological, biochemical and yield traits. Among the genotypes, ISe 317 showed higher root volume, root length whereas SiA 2854 showed better results in root weight under drought stress. In case of gas exchange parameters, the genotypes ISe 27, PS 4, ISe 138 and AP 4 showed better performance under drought. Based on physiological parameters, such as *water* use efficiency, chlorophyll fluorescence, chlorophyll meter reading, relative water content, chlorophyll stability index, excised leaf water loss, osmotic potential and osmotic adjustment, the genotypes, ISe 27, PS 4, AP 4, ISe 138 and ISe 174 were grouped as tolerant genotypes. Solute accumulation in the cytoplasm is a mechanism that plants use during water deficits to adjust to low water availability (Kudoyarova *et al*., 2013) The genotypes, AP 4, ISe 27, PS 4 and Prasad were grouped as drought tolerant genotypes based on biochemical parameters such as proline content, nitrate reductase activity, catalase, peroxidase, superoxide dismutase and DPPH radical scavenging assay.

Yield and yield components *viz*., earhead length, earhead weight, number of grains per earhead, spikelet fertility, 1000 grain weight, yield per plant, total biomass and harvest index were found declined under drought stress. The genotypes, ISe 27, ISe 1230 and Prasad recorded lower per cent reduction in yield and yield components under drought stress and grouped as drought tolerant genotypes. On the whole, ISe 27 showed better results in terms of physiological, biochemical and yield components and thus, emerged as most drought tolerant genotype. This genotype can be used directly for the region where the drought is predominant. The genotypes, AP 4 and PS 4 were showed better results in term of physiological and biochemical traits yet with poor yield. Therefore, these genotypes can be used for breeding program to develop drought tolerant high yielding variety by crossing with agronomically superior varieties.

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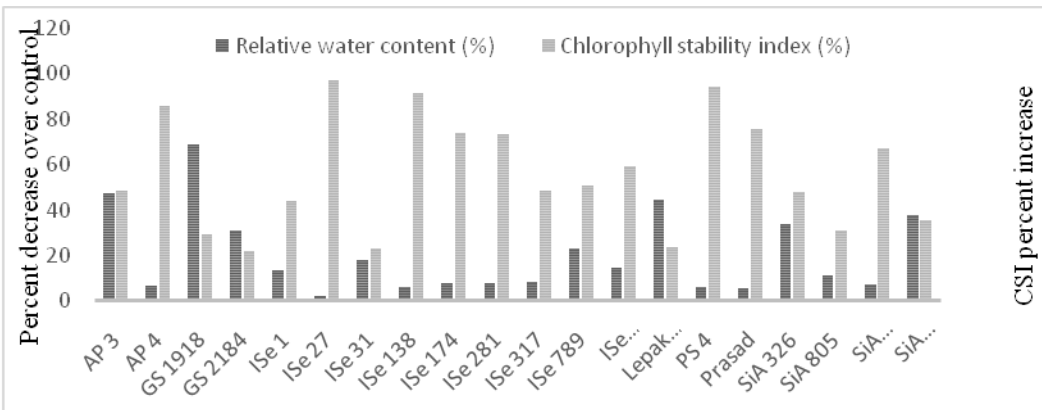

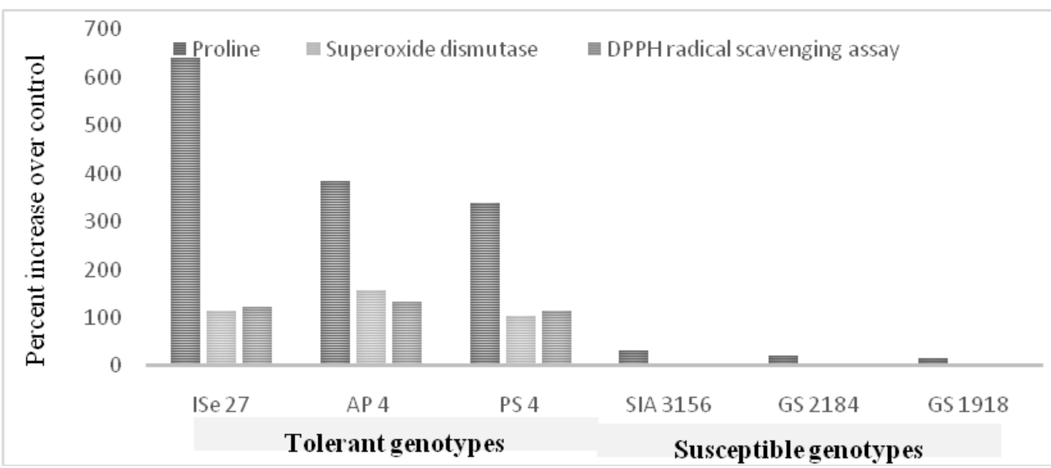

T1-24

The longevity of crop seeds conserved under gene bank conditions

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Abstract

Gene banks, the richest reservoirs of valuable plant genetic resources, hold numerous unexploited traits which are useful for crop improvement. Ramiah Gene Bank (RGB) is the first of its kind in any state Agricultural University in the country with a total holding of 28,651 germplasm accessions of more than 51 crop species. Maintenance of seed viability plays a critical role to the sustainability of ex-situ conserved seed collections in long-term storage, monitored regularly, and regenerated as and when required. Viability and vigour are most important indices for assessing seed quality. Therefore, the present experiment was carried out to assess seed vigour, viability and field emergence of 10 years conserved germplasm of sorghum, pearl millet and foxtail millet at RGB to evaluate its storage potential and also to determine the rejuvenation period. Results revealed that initially all the germplasm accessions recorded >80% viability at the time of deposition. Ten years after storage (YAS), all the accessions maintained viability to the (≥80%) standards and 10-20% reduction in seed viability and 10-30% reduction in field emergence was observed in some of the accessions of sorghum, pearl millet and foxtail millet. While comparing laboratory germination and field emergence %, field emergence was lower by 10-20% than laboratory germination %.

Keywords: Germplasm conservation, sorghum, pearl millet, foxtail millet, seed viability, field emergence

Introduction

India is one of the richest countries with respect to plant biodiversity. The plant genetic diversity is being lost at an alarming rate, putting in threat sustainability of agriculture and ecosystem services and their ability to adapt to changing conditions, threatening food and livelihoods security as crop improvement mainly depends on the availability of genetic diversity. Hence, to feed the growing human population and to develop climate resilient crop varieties, these genetic wealth needs to be conserved. Gene banks, the richest reservoirs of valuable plant genetic resources, hold numerous unexploited traits which are useful for crop improvement (Kiran babu *et al*., 2018). Knowing the importance of germplasm conservation, Tamil Nadu Agricultural University, Coimbatore has established '*Ramiah seed Gene Bank (RGB)*' to conserve genetic wealth of agricultural and horticultural crops. Germplasm collection at RGB includes modern and obsolete varieties, land races, mutants, breeding lines and wild species of various crops. Presently a total of 28,651 accessions of more than 51 species are conserved in gene bank. Maintenance of seed viability plays a critical role to the sustainability of ex-situ conserved seed collections in long-term storage, monitored regularly, and regenerated as and when required. Viability and vigour are most important indices for assessing seed quality but there may be a difference in field emergence (%) and viability (%) of long term stored germplasm (Desheva *et al*. 2017). Therefore, the present experiment was carried out to assess seed vigour, viability and field emergence of 10 years conserved germplasm of sorghum, pearl millet and foxtail millet at RGB to evaluate its storage potential and also to determine the rejuvenation period.

Materials and Methods

Seeds of 500, 400 and 774 no's of sorghum, pearl millet and foxtail millet germplasm have been deposited at RGB during 2011, 2010 and 2010, respectively conserved at 5°C. Viability percentage and moisture content (%) of each germplasm accessions were assessed at the time of deposition and germplasm accessions which are having more than 80% of seed viability and moisture content between 4 to 8 percent are deposited in the gene bank. Seed viability is monitored at once in every 5 years for the germplasm accessions conserved at medium term cold storage unit (5°C). Ten no's of germplasm accessions from each crop were selected randomly and tested for its viability to find out the loss in seed vigour and viability over a period of storage by adopting Completely Randomized Design. The results were subjected to analysis of variance and tested for significance according to Panse and Sukhatme (1999). Percentage values were transformed into arcsine values prior to analysis.

Results and Discussion

Initially all the germplasm accessions recorded >80% viability at the time of deposition. At 10 YAS, germplasm accessions maintained its viability (≥80%) to the standards and 10-20% reductions in seed viability and 10-30% reduction in field emergence was observed in of the accessions of sorghum, pearl millet and foxtail millet. While comparing laboratory germination and field emergence percent, 10-20% lower field emergence was recorded. From this study it was concluded that germplasm accessions of sorghum, pearl millet and foxtail millet maintained its viability percent during conservation at medium term cold storage units (5°C) of RGB even after 10 YAS. Thus, this genetic wealth in RGB will play a vital role to develop climate resilient crop varieties for sustainable nutrient rich food system.

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Table 1. Viability (%) and field emergence (%) of sorghum, pearl millet and foxtail millet germplasm accessions under *ex-situ* conservation at 10 years after storage.

Sorghum			Pearl millet			Foxtail millet		
Name of the germplasm	**Viability (%)**	**Field emergence (%)**	**Name of the germplasm**	**Viability (%)**	**Field emergence (%)**	**Name of the germplasm**	**Viability (%)**	**Field emergence (%)**
IS4883	100 (89.72)	50 (45.00)	PT5517	80 (63.44)	70 (56.79)	CB-ISE-2	80 (63.44)	70 (56.79)
IS14332	80 (63.44)	30 (33.21)	PT 5579	90 (71.57)	80 (63.44)	CB-ISE-5	90 (71.57)	80 (63.44)
IS3932	80 (63.44)	50 (45.00)	PT 5497	100 (89.72)	100 (89.72)	CB-ISE-8/1	100 (89.72)	80 (63.44)
IS18588	70 (56.79)	30 (33.21)	PT 5605	90 (71.57)	80 (63.44)	CB-ISE-9/1	100 (89.72)	100 (89.72)
IS4724	80 (63.44)	40 (39.23)	PT 5557	90 (71.57)	90 (71.57)	CB-ISE-11	80 (63.44)	80 (63.44)
IS9342	90 (71.57)	70 (56.79)	PT 5526	100 (89.72)	90 (71.57)	CB-ISE-12	90 (71.57)	90 (71.57)
IS8953	80 (63.44)	40 (39.23)	PT5548	90 (71.57)	80 (63.44)	CB-ISE-15	90 (71.57)	80 (63.44)
IS6308	90 (71.57)	100 (89.72)	PT5477	90 (71.57)	90 (71.57)	CB-ISE-18	100 (89.72)	100 (89.72)
IS4136	80 (63.44)	50 (45.00)	PT5599	80 (63.44)	80 (63.44)	CB-ISE-18/1	100 (89.72)	90 (71.57)
IS2872	90 (71.57)	50 (45.00)	PT5556	80 (63.44)	70 (56.79)	CB-ISE-20	90 (71.57)	90 (71.57)
Mean	84 (66.42)	51 (45.57)	Mean	89 (70.63)	83 (65.65)	Mean	92 (73.57)	86 (68.03)
SEd	1.320	1.562	SEd	2.670	1.694	SEd	2.371	1.390
CD (P=0.05)	2.701**	3.274**	CD (P=0.05)	5.482**	3.410**	CD (P=0.05)	4.780**	2.873**

Plate1. Seed viability testing

T1-25
In vitro screening of pearl millet genotypes for seedling stage drought tolerance

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Abstract

Pearl millet is a dynamic crop grown in various soil and weather conditions. It is known for its drought tolerance potential. However, initial drought stress reduces the crop stand and terminal drought reduce the yield potential. In this study,31 pearl millet genotypes were screened for seedling stage water stress using PEG 6000 at various water potentials 0, -3.0, -5.0 and -7.5 bars. The reduction in the germination percentage, shoot length, root length and increase in root/shoot ratio were observed in all the genotypes with increase in stress levels. The seedling vigour index is used as a trait for selection of earlystage drought tolerant genotypes. Among the genotypes, PT 5721 followed by PT 6029, PT 5748, PT 5456, PT 6475, PT 6317 and PT 5456 showed the highest performance for seedling vigour index under high level water stress condition (-7.5 bar). The identified seedling stage drought tolerant genotypes has to be further evaluated at field stress conditions and can be used in the breeding programme for the development of high yielding drought tolerant pearl millet hybrids.

Keywords: Pearl millet, PEG 6000, seedling vigour index and drought tolerance.

Introduction

Pearl millet is an important crop among the millets with larger production 9.02 million tonnes in India. The pearl millet is drought tolerant crop which is being cultivated as rainfed crop. Butwater stress occurs at initial and terminal growth stageaffects the overall productivity(Shivhare and Lata, 2017). So, the improvement of yield along with drought tolerance is essential.Govindaraj*et al.* (2010) suggested a rapid, simple and cost-effective method to screen large germplasm accessions at initial stage using poly ethylene glycol (PEG 6000). Based on the seedling vigour index, the genotypes can be shortlisted for further field level screening and hybridization programme to develop drought tolerant hybrids.

Materials and Methods

This experiment was conducted in factorial completely randomized design with two replications. The two factors are 31 pearl millet genotypesand four water potential levels. Osmotic solutions with different water potential such as 0, -3.0, -5.0 and -7.5 bars were obtained by preparing 0, 11.5, 19.6 and 23.5 % of PEG 6000, respectively.Germination paper was placed in the petri dishes (90mm diameter) and added 7ml of respective osmotic solutions. The randomly selected twenty seeds were placed on the moistened germination paper in the petri dishes and closed with lid. After 10 days, germination percentage, shoot length (cm), root length (cm), root - shoot ratio and seedling vigour index were recorded and the data were analysed in the AGRES statistical package.

Results and Discussion

In the present study, analysis of variance showed that the genotypes, treatments and their interaction were found to be significant. The average germination percentage was reduced from 90.6 to 20.3 % (Fig. 1). The reduction in shoot length from 5.1 to 0.3 cm is the effect of reduced cell division and cell elongation (Kramer, 1983). The reduction in root length was observed in genotypes at -5.0 and -7.5 bar water stress level. At mild stress condition, it was observed to increase in root length compared to control (7.8 to 9.0 cm). It is the inherent nature of the plants to tap water from deep soil layer during drought stress conditions. The increasing trend of root - shoot ratio was observed upto -5.0 bar. It shows the physiological dynamics of the seedlings to increase root length by arresting the shoot growth for withstanding under less water conditions. The pearl millet genotypes showed decreasing trend (1172.9 to 16.6) in seedling vigour index (SVI) with increase in stress levels (Fig. 1). Since it is the index that includes all growth parameters of the seedling, SVI under stressed conditions could be considered as an indicator for their tolerance (Abdel-Raheem *et al.,* 2007). The genotype, PT 5721 showed highest seedling vigour index at -7.5 bar followed by PT 6029, PT 5748, PT 5456, PT 6475, PT 6317 and PT 5456 (Fig. 2). The superior performance for SVI is due to their higher germination potential, shoot length and root length under water stress conditions (Govindaraj*et al.* (2010). Thus, these genotypes were considered as drought tolerant at early growth stages.

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Fig. 1. The response of pearl millet seedling traits to PEG 6000 induced water stress.

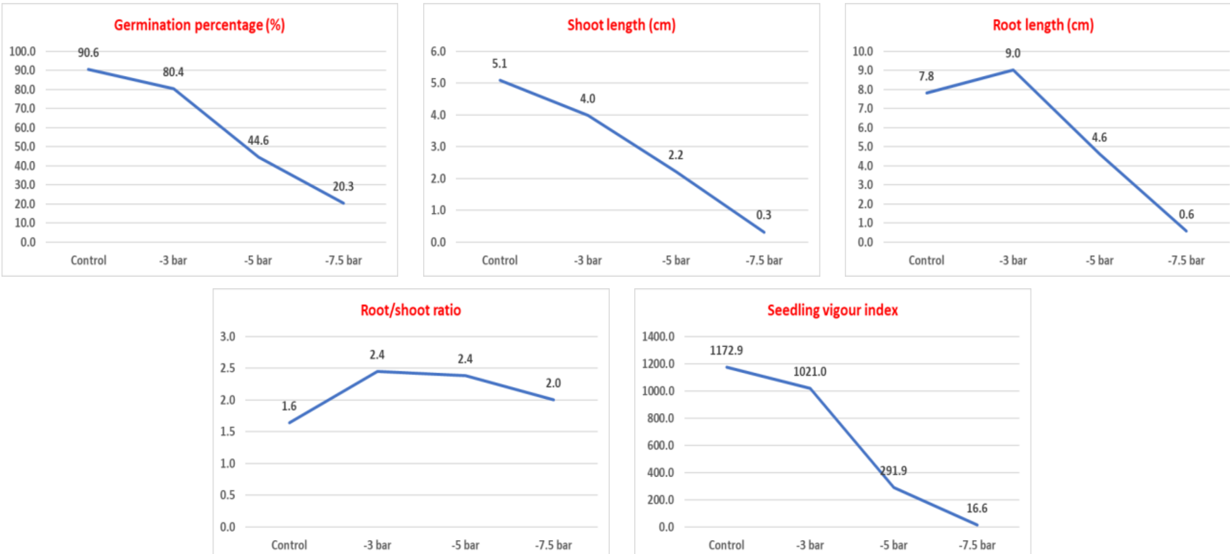
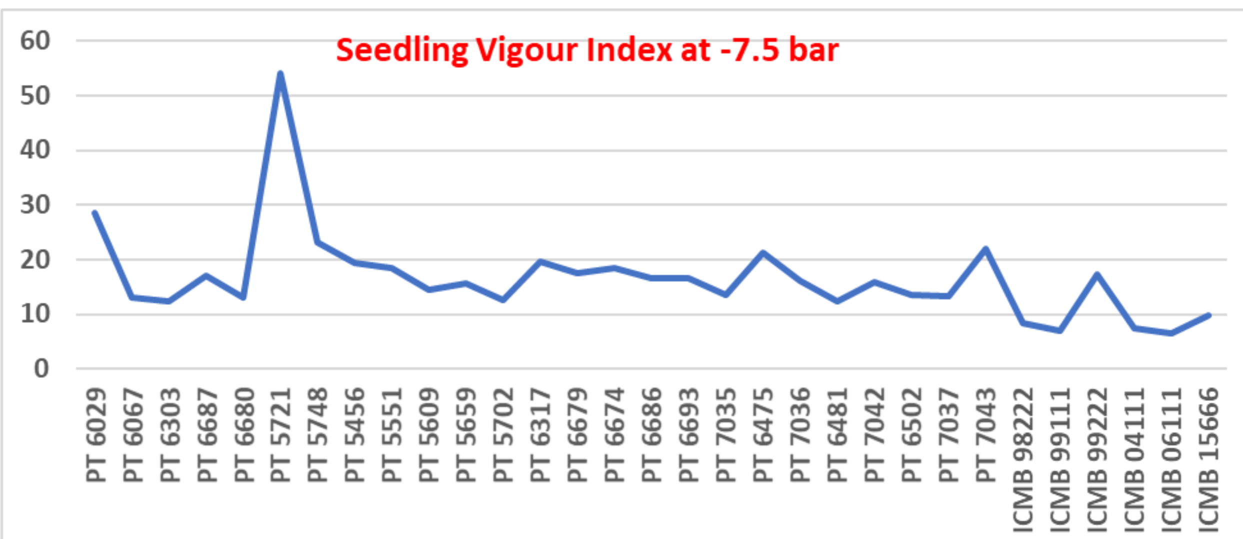


Fig. 2. Seedling vigour index of 31 pearl millet genotypes at -7.5 bar water potential.



T1-26
Chlorophyll index as an early phenotyping trait to screen sorghum genotypes for drought stress tolerance

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Introduction

Sorghum is the fifth most important cereal crop (Muluken *et al*., 2022) grown mostly in the arid and semi - arid regions where drought stress is a major limiting factor (Kibrom *et al.*, 2022). Although sorghum is highly adaptable and can be produced in various environmental conditions, anthesis and grain filling stages are regarded as the most sensitive growth stages under drought condition (Krupa *et al*., 2017).

Sorghum plant has a special characteristic to produce and deposit large amount of epicuticular wax which plays an important role in reducing the cuticular transpiration (Jenks *et al*., 1994). Similarly, stomatal traits such as density and size are considered as an index of growth rate and water balance under water deficit conditions (Diller et al., 2008). Though stomatal traits and epicuticular wax are important adaptive traits offering protection against drought, by reducing the water loss, measurement of both of these traits are time consuming and requires high end microscopes. In contrast, chlorophyll index measurements represent a simple, non – destructive, inexpensive and rapid tool for indirectly estimating the chlorophyll content within the same tissue and provide information about the physiological condition of the plants. Till date there are not many studies addressing chlorophyll index as an important trait underlying moisture deficit tolerance in sorghum.

With this background the current experiment was designed with the following objective to assess the genetic variability for chlorophyll index and group the diverse set of sorghum genotypes for drought tolerance/ susceptibility

Materials and Methods

Plant materials and drought treatments: Twenty-nine sorghum genotypes including four checks were sourced from ARS, Kovilpatti, and IIMR, Hyderabad. Sorghum plants were raised with a spacing of 45 x 15 cm and recommended dose of fertilizer 90:45:45 N:P:K at TNAU, Coimbatore. Plants were raised in augmented design where replication was maintained only for checks. There were two treatments *viz.,* irrigated and drought. Drought stress was imposed by withdrawal of water at booting stage (50 DAS) for the period of three weeks.

Chlorophyll index: Chlorophyll index was recorded at one week after imposing drought stress by using portable chlorophyll meter [Soil Plant Analysis Development (SPAD)] and expressed as SPAD units.

Results and Discussion

Chlorophyll index as an easy phenotyping trait to classify sorghum genotypes for drought tolerance/ susceptibility: There was a significant reduction in chlorophyll index in sorghum genotypes exposed to drought stress. Among the twenty-nine genotypes and four check varieties subjected to water deficit stress, PEC 17 recorded higher chlorophyll index under drought stress (55.89) followed by PEC 14, PEC 34 and EP 90. These genotypes along with the checks were grouped as highly tolerant to drought stress. Based on Z-score values all the twenty-nine genotypes along with four checks were grouped into four different category viz., highly tolerant (PEC 14, PEC 34, PEC 17, EP 90, M 35-1, CSV-27, CSV-29-R, K 12), tolerant (TKSV 1036, PEC 31, TKSV 1707), moderately susceptible (TKSV 1146, TKSV 1158, TKSV 1704, TKSV1707, TKSV1712, TKSV1801, TKSV1802, K8, PEC 5, PEC12, PEC16, PEC 22, PEC23, PEC32, PEC35, PEC36, EP 72, EP 93, EP 94) and susceptible (PEC 24, PEC 33, EN 55, EP 87) (Fig. 1).

Drought stress is generally characterized by chlorophyll loss accompanied by gradual decline in photosynthetic process. Thus, chlorophyll index was exploited as an easy and early phenotyping trait to select genotypes for drought tolerance based on the amount of chlorophyll present. Drought stress at pre and post flowering phenophases of sorghum leads to a decline in chlorophyll content (De Souza *et al.,* 2021). To confirm chlorophyll index as an early screening trait, three genotypes from each group *viz.,* highly tolerant (EP 90, PEC 17, PEC 34), tolerant (TKSV 1036, TKSV 1707, PEC 31), moderately susceptible (TKSV 1704, TKSV 1801), susceptible (EN 55, EP 87, PEC 24) along with four checks (M 35-1, K12, CSV-29-R, CSV-27) were further analysed for morphological, physiological and yield traits.

The study concluded that chlorophyll index can be used as a trait to rapidly screen the genotypes for drought tolerance at a much early stage. Among 29 genotypes, PEC 17 was identified as a highly tolerant genotypes for reproductive stage drought stress.

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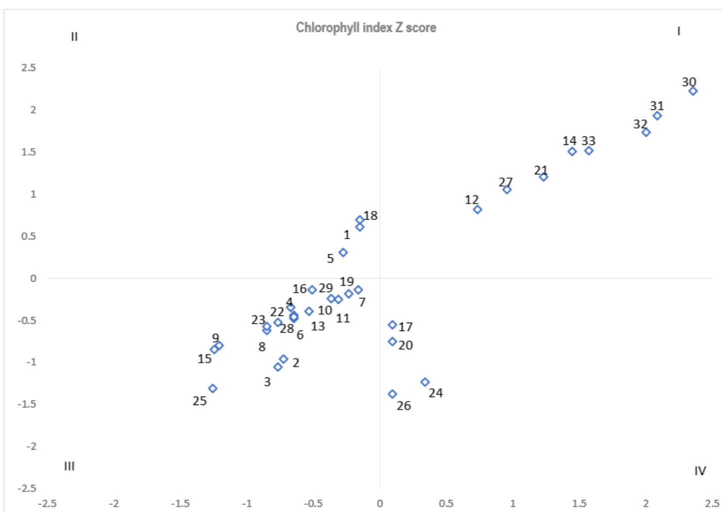
Table 1. Genotypes/ Checks used in the study

S.N.	Genotype/ Acc. No.	S.N.	Genotype/ Acc. No.	S.N.	Genotype/ Acc. No.
1.	TKSV 1036	12.	PEC 14	23.	PEC 36
2.	TKSV 1146	13.	PEC 16	24.	EN 55
3.	TKSV 1158	14.	PEC 17	25.	EP 72
4.	TKSV 1704	15.	PEC 22	26.	EP 87
5.	TKSV 1707	16.	PEC 23	27.	EP 90
6.	TKSV 1712	17.	PEC 24	28.	EP 93
7.	TKSV 1801	18.	PEC 31	29.	EP 94

Category	Genotypes/Checks
I Highly tolerant	PEC14 (12), EP 90 (27), PEC 34 (21), PEC 17 (14), CSV- 29-R (Check) (33), CSV- 27 (Check) (32), K 12 (Check) (31), M 35-1 (Check) (30)
II. Tolerant	TKSV 1036 (1), PEC 31 (18), TKSV 1707 (5)
III Moderately susceptible	TKSV 1036 (2), TKSV 1158 (3), TKSV 1704 (4), TKSV 1712 (6), TKSV 1801 (7), TKSV 1802 (8), K 8 (9), PEC 5 (10), PEC 12 (11), PEC 16 (13), PEC 22(15), PEC 23(16), PEC 32(19), PEC 35 (22), PEC 36 (23), EP 72(25), EP 93(28), EP 94(29)
IV Susceptible	PEC 24(17), PEC 33(20), EN 55 (24), EP 87 (26)

8.	TKSV 1802	19.	PEC 32	30.	M 35-1(Check 1)
9.	K8	20.	PEC 33	31.	K 12 (Check 2)
10.	PEC 5	21.	PEC 34	32.	CSV- 27(Check 3)
11.	PEC 12	22.	PEC 35	33.	CSV- 29- R (Check 4)

Fig. 1. Drought induced genetic variability for chlorophyll index in diverse sorghum genotypes



T1-27

Drought resilience studies in Sorghum [*Sorghum bicolor* (L.) Moench] to screen for resistant genotypes

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Abstract

Genetic improvement for drought tolerance in association with stable grain yield of sorghum is considered as an essential effort. In this study, 20 genotypes comprising of released, resistant, susceptible check and popularly cultivated local types were screened for drought tolerance by imposing water stress during flowering stage. From this study found that almost all the local types were matured earlier than the released varieties and resistant check. The promising genotypes *viz*., Markandapuram local, Edappadi local, Tenkasi local, Chithalandur local and CO 32 were identified as tolerant for drought stress under field condition. Hence these genotypes may be utilized in the breeding programmes to develop drought resistant genotypes.

Introduction

Drought is a single most important factor responsible to decrease crop yield gain in all crops in worldwide. By considering the fluctuating weather conditions, identification or development of genotypes with resistant to drought combined with good level of adaptability to wide environments are the essential prerequisites to mitigate the drought problem. Among the grain crops sorghum (Sorghum bicolor (L.)Moench) is one of the important example for drought tolerance and utilized in the evaluation of various drought resistant mechanisms. Plants adaptation to drought stress is controlled by several factors *viz.,* morphological, physiological, biochemical and genetic level. Several traits including chlorophyll content, Relative water content, Transpiration rate, epicuticular wax, Leaf rolling, stay green, root morphology and its anatomical structures are known to play important role in screening drought resistant genotypes. In general sorghum is mostly cultivated under rainfed condition and is severely affected by drought stress. Drought response of sorghum is grouped into pre flowering and post-flowering stages and stress response of post-flowering sorghum is considered as most important one to reduce grain yield. Modern sorghum varieties contribute limited genetic potential towards improvement and development of new varieties with increased grain yield under drought stress condition.

Materials and Methods

To evaluate the performance of newly released sorghum variety CO 32 under drought condition, the experiment was carried out at Tamil Nadu Agricultural University, Coimbatore during Summer2020. The experiment was laid out under randomized block design (RBD) with two replications as under post flowering moisture stress imposed by withholding irrigation from flowering to maturity. In this study, CO 32 along with six local genotypes, one resistant check and one susceptible check *viz*., B35 and CO 26 respectively. Data were recorded for days to 50 per cent flowering, SPAD chlorophyll, relative water content, plant height, stay-green trait and grain yield.

Results and Discussion

The study revealed that relative water content, SPAD chlorophyll reading and stay green trait play a major role in drought tolerance of the genotype. Among the genotypes studied invariably all the local types were matured 7-10 days earlier than the released sorghum variety CO 32. The local types were matured between 82 days (Markandapuram local and Edappadi local) to 85 days (Tenkasi local and Chithalandur local). Sorghum CO 32 matures in 95 days under water stress situation. The SPAD chlorophyll meter value indicating that the higher chlorophyll concentration is vital for adaptation to water deficit conditions during post flowering growth period. In this study local types were observed with 50 – 59 percent SPAD chlorophyll value. Sorghum CO 32 was also recorded the SPAD chlorophyll meter value of 51.65 percent. Whereas in susceptible check CO 26, it was recorded with less value of 37.79 percent and drought tolerant variety B 35 recorded with 60.15 percent SPAD chlorophyll content. Regarding Relative Water Content (RWC), low level of RWC ie 41 percent was recorded by susceptible check variety CO 26 and highest value of 63 percent was recorded by resistant check variety B 35. Sorghum CO 32 recorded with RWC value of 57 percent and local types also observed with 55- 62 percent. Stay green is a proven trait conferring drought resistance.

Stay green trait was recorded based on visual scoring for the greenness of the leaves at maturity. The stay green trait score ranged between 1 (most leaf area green) to 5 (< 10% leaf area green). In this study all the local types and CO 32 were registered with stay green score value of 3 (26-50% leaf area green). Whereas resistant check B 35 recorded with 1 score and susceptible recorded with score value of 5. For considering single plant grain yield local types recorded with 20-22 g and CO 32 registered with 28-30 g.

From this study concluded that based on the important drought indices *viz*., RWC, SPAD chlorophyll value and stay green trait CO 32 is on par with the local sorghum genotypes for drought tolerance. The local types were found to earlier maturity than CO 32. With respect to grain yield performance, CO 32 is found to be superior than local sorghum genotypes. Improving drought tolerance in sorghum is one of the most important objectives of plant breeders, to minimize the yield losses resulting from moisture stress, which is a regular feature of most sorghum growing environments. From this study found that almost all the local types were matured earlier than the released varieties and resistant check. The promising genotypes *viz*., Markandapuram local, Edappadi local, Tenkasi local, Chithalandur local and CO 32 were identified as tolerant for drought stress under field condition. Hence these genotypes may be utilized in the breeding programmes to develop drought resistant genotypes.

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T1-28

Correlation studies for grain yield components and nutritional quality traits in Foxtail millet (*Setaria italica* (L.) Beauv) germplasm

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Abstract

The correlation co-efficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be imposed for genetic improvement in yield. Single plant yield had positive and significant association with crude fibre and copper. The traits *viz.,* crude protein, iron, zinc and manganese exhibited negative correlation with grain yield. Iron content registered significant inter correlation with zinc and copper. Crude fibre and zinc had positive significant correlation with copper. ISe 289, a promising accession identified in the present study was superior to the other accessions both in quality and quantity. ISe 907, another superior accession performed moderately for grain yield but possessed the highest iron, zinc and copper content. The accession ISe 90 and ISe 842 were found to have high amount of crude protein and manganese. The yield performance of these genotypes was moderate so these genotypes can be used in recombination breeding programme. The high yielding genotype ISe 289 should be subjected to further yield testing trials.

Keywords: *Foxtail millet,* correlation*, quality, yield*

Introduction

. Foxtail millet is an underutilized, drought-tolerant crop that stands to become much more important in a potentially much warmer and drier future environment (Diao, 2011; Dwivedi *et al*., 2011). The grain is a good source of protein and contains β-carotene, minerals *viz*., calcium, iron, potassium, magnesium, zinc, antioxidants and vitamins (Rai, 2002). The correlation co-efficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be imposed for genetic improvement in yield. Present study envisage the relationship among six nutritional quality traits , grain yield and yield attributes on a diverse range of 50 foxtail millet genotypes.

Materials and Methods

The present study comprised of 49 foxtail millet germplasm accessions collected from ICRISAT, Hyderabad along with a local check variety Co 7. The experiment was carried out during *rabi* 2016 in Randomized Block Design (RBD) with three replications. Each entry was sown in single row with spacing of 60 cm between rows and 15 cm between plants. Observations on 13 quantitative characters were recorded on five randomly selected plants for each genotype at various stages of crop growth. Based on the yield performance ten top ranking genotypes were identified and subjected for six nutritional characters estimations *viz*., crude fibre, crude protein, iron, zinc, copper and manganese. The data obtained was then subjected to standard statistical procedures.

Results and Discussion

Analysis of variance revealed significant differences among 50 genotypes. The results of genotypic correlation for the yield and nutritional quality characters were presented in Table. 1. Single plant yield had positive and significant association with crude fibre and copper. The traits *viz.,* crude protein, iron, zinc and manganese exhibited negative correlation with grain yield. This is in confirmation with the findings of Srisha *et al.* (2009), Prasanna *et al.* (2014) and Kavya (2016) for crude protein content. Iron content registered significant inter correlation with zinc and copper. Crude fibre and zinc had positive significant correlation with copper.

In general, it is accepted that yield performance of genotype is inversely proportional to quality parameters. In the present study, it was observed that some of the genotypes had increased nutritive value coupled with moderate yield. The genotype ISe 90 was found to be promising with respect to its yield performance and crude protein content. This indicated that there are chances of exploiting genotype high yield with high nutrient content. All these genotypes had moderate yield. So these genotypes could be used as donor parents in breeding programme. The accession ISe 289 was found to be superior for grain yield, yield contributing traits, nutritional content, especially crude fibre content. So the stability of this genotype has to be tested in different locations. ISe 289, a promising accession identified in the present study was superior to the other accessions both in quality and quantity. It had a mean yield of 22.25 g with high amount of crude fibre content (2.89 mg/100g). ISe 907, another superior accession performed moderately for grain yield but possessed the highest iron, zinc and copper content. The accession ISe 90 and ISe 842 were found to have high amount of crude protein and manganese. The yield performance of these genotypes was moderate so these genotypes can be used in recombination breeding programme. The high yielding genotype ISe 289 should be subjected to further yield testing trials.

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Table1. Simple correlation coefficient of six nutritional traits for ten high yielding foxtail millet genotypes

	Crude fibre (mg /100g)	Crude protein (g/100g)	Iron (mg/ 100 g)	Zinc (mg/ 100 g)	Copper (mg/ 100 g)	Manganese (mg/100 g)	Grain yield per plant (g).
Crude fibre (mg /100 g)	1.000	-0.139	-0.096	0.043	0.450*	-0.365	0.364
Crude protein (g/100 g)		1.000	0.048	0.029	-0.273	-0.177	-0.209
Iron (mg/100 g)			1.000	0.856*	0.718**	-0.021	-0.144
Zinc (mg/100 g)				1.000	0.682**	0.316	-0.343
Copper (mg/100 g)					1.000	-0.238	0.074
Manganese (mg/100 g)						1.000	-0.288
Grain yield per plant (g).							1.000

T1-29

Discrimination of Red Sorghum germplasm using linear discriminant analysis- An essential tool for breeding programs

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Abstract

The farmers in southern districts of Tamil Nadu, India predominantly cultivate Red Sorghum landraces which are renowned for their high content of anthocyanin (3-deoxyanthocyanin), low glycemic index, dietary fiber, astringency, and high protein, as well as their resistance to biotic and abiotic stresses. During *Rabi*, 2021, 68 Red Sorghum genotypes and four checks (CO 4, Paiyur 2, Usilampatti local, and AURS 013) were evaluated to identify the variations and character associations among grain yield and yield component traits. The study revealed a substantial level of variation among the genotypes, based on observations for thirteen quantitative traits.After clustering the genotypes and analyzing the Linear discriminate analysis (LDA) biplot, it was inferred that the genotypes within clusters 1 and 2 hold promise for their potential utility in future breeding programs.The observed phenotypic data were statistically analyzed using LDA to identify and distinguish all the accessions appropriate for breeding projects.

Keywords: Red sorghum . Linear discriminate analysis

Introduction

Sorghum, scientifically referred to as *Sorghum bicolor* (L.) Moench, is a widely cultivated grain crop that has several names*viz.,* great millet, Indian millet, milo, and durra. Its cultivation is dominant in Africa and Asia, where it serves various purposes such as food, fodder, fuel, and fiber. It is a crucial staple food for millions of people residing in tropical and semi-arid areas. However, its yield potential is constrained by several environmental stresses that negatively impact its productivity. Sorghum belongs to the Poaceae family and is known for its proficient photosynthesis, high yield, efficient nutrient use, and drought tolerance. Additionally, it demonstrates resilience by flourishing in marginal terrains and exhibiting resistance to both biotic and abiotic stresses.A good understanding of genetic variability among the accessions will enable precision breeding. So profiling the genetic diversity of sorghum is imminent. Discriminant analysis is a technique used to discriminate between groups of objects based on categorical dependent variables and metric independent variables.Data observed on biometrical characters were analysed statistically by Linear Discriminant Analysis (LDA) to effectively categorize genotypes into appropriate groups (Boedeker*et al*., 2019).

Materials and Methods

The experiment was conducted at the Department of Millets at Tamil Nadu Agricultural University, Coimbatore during *Rabi*season of the year 2021-2022. A total of 68 germplasm lines of Red Sorghum, including known check varieties such as CO 4, Paiyur 2, and local collections like Usilampatti local and AURS 013, obtained from the Ramaiah gene bank of the Department of Plant Genetic Resources and the Department of Millets at TNAU, Coimbatorewereeevaluated in the augmented block design I (ABD I) . The genotypes were discriminated by Linear discriminant analysis developed by R.A Fisher in 1936 to identify and distinguish accessions appropriate for breeding projects.

Results and Discussion

The phenotypic characterisation and genotype classification are crucial to comprehending the relevance of accessions and then utilising them in breeding programmes for evolving high yield varieties is useful in sorghum breeding. The Linear Discriminant Analysis demonstrated a high degree of discrimination (Sau *et al.,* 2018). Different combinations of independent variables were used to create a scatter plot (Figure 1), which showed that there was more overlap between the groups. The frequency distribution for each variable was predicted using a histogram, while certain variables were found to have a positive relationship through the correlation coefficient. The sorghum accessions were categorized into four distinct groups based on clustering, with prior probabilities indicating that 36.20%, 20.68%, 18.96%, and 24.13% of members belonged to clusters 1, 2, 3, and 4, respectively.

The findings of the LDA showed that all three discriminant functions (DFs) were often extremely essential in separating the varietal contributions to different clusters, as indicated by very high correlation coefficients(Harding and Payne 2012 and Jombart and Collins (2015).The LDA coefficients for each function, with separation achieved at three levels were represented in Table 1. The percentage of separation by LD1, LD2, and LD3 stood at 79.77%, 16.48%, and 03.75%, respectively.The analysis of the LD1 histogram revealed a significant degree of separation between clusters 1, 2, and 3, with minimal overlap. However, there was a discernible overlap between cluster 3 and 4, as indicated by the 79% separation achieved by LD1, as shown in Figure 2. Conversely, the LD2 histogram illustrated a higher degree of overlapping, with a separation of only 23.7%, which is substantially lower than LD1's separation of 70.14%. Abiplot was produced using LD1 in the X-axis and LD2 in the Y-axis (Figure 3). The biplot effectively demonstrated the partitioning between the different groups, as evidenced by the high degree of separation achieved by LD1 (79.77%) and LD2 (16.48%). Specifically, cluster 1 and cluster 2 were entirely separated, falling within the range of -10 to -2 and 3 to 10, respectively.

However, clusters 3 and 4 exhibitedoverlapping, falling in the middle. The study indicated that it was a valid method to discriminate genotypes with a high level of accuracy (Alajas*et al.,* 2021). The genotypes discriminated are presented in Table 2..Thus, it was recommended that genotypes from clusters 1 and 2 couldbe utilized for future breeding programme.

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Table 1. Coefficients of linear discriminants function

Variables	LD 1	LD 2	LD 3
PH	-0.104	0.010	0.078
DFF	0.076	0.014	-0.063
FLL	0.016	0.113	0.049
FLW	0.268	0.177	-0.148
NOL	-0.049	-0.323	-0.110
SD	-0.335	1.136	-0.918
PL	-0.042	0.048	0.103
PW	-0.054	-0.006	0.128
PWt.	0.070	0.163	0.011
DM	-0.052	0.049	0.062
HSW	0.326	0.827	0.881
DFY	-0.097	-0.064	0.122
GYPP	-0.062	-0.221	-0.014

Fig. 1. Scatter plot, Frequency distribution and Correlation coefficient

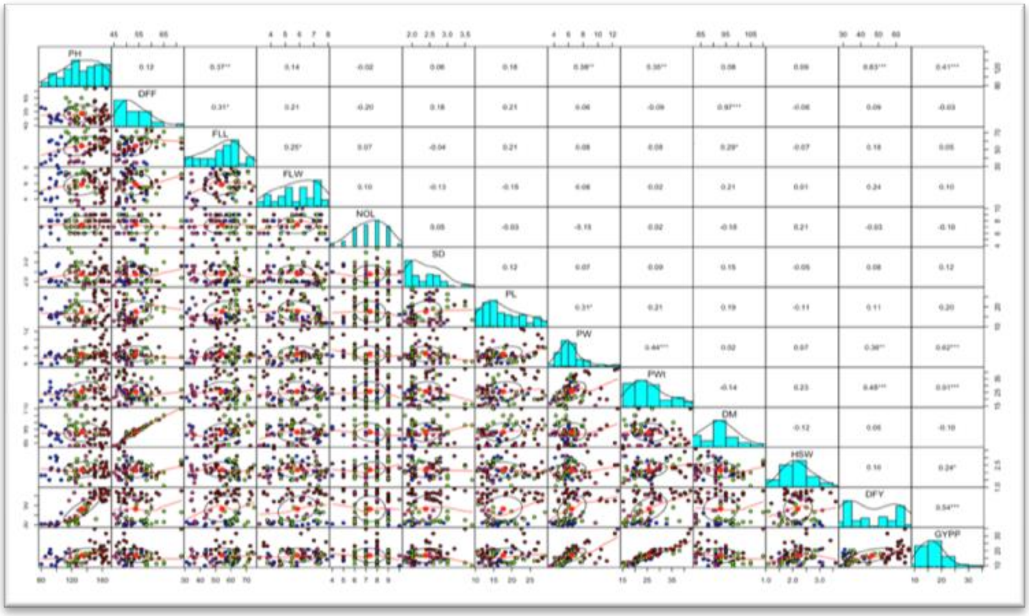


Fig. 2. Histogram for percentage of separation, a based on LD1, b based on LD2

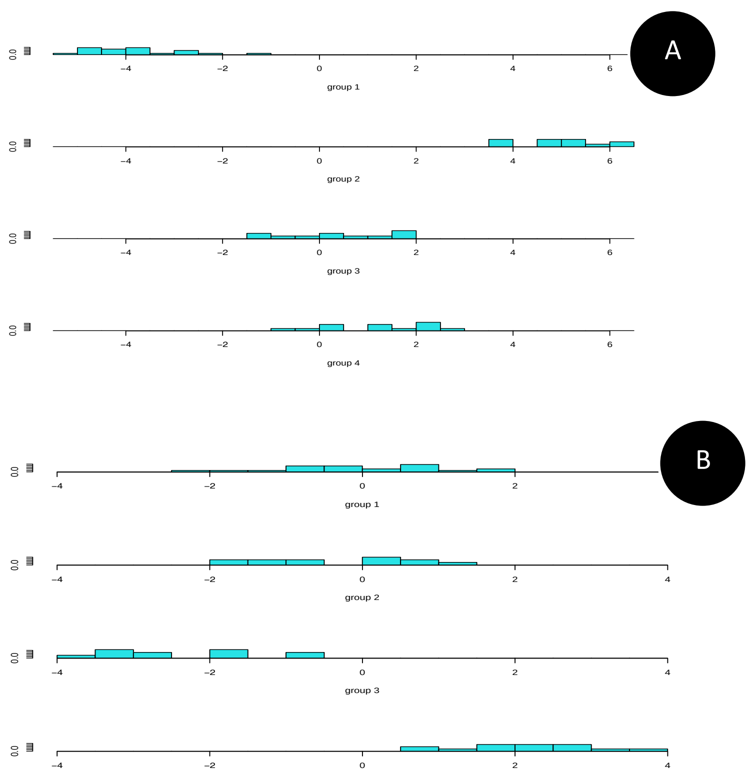
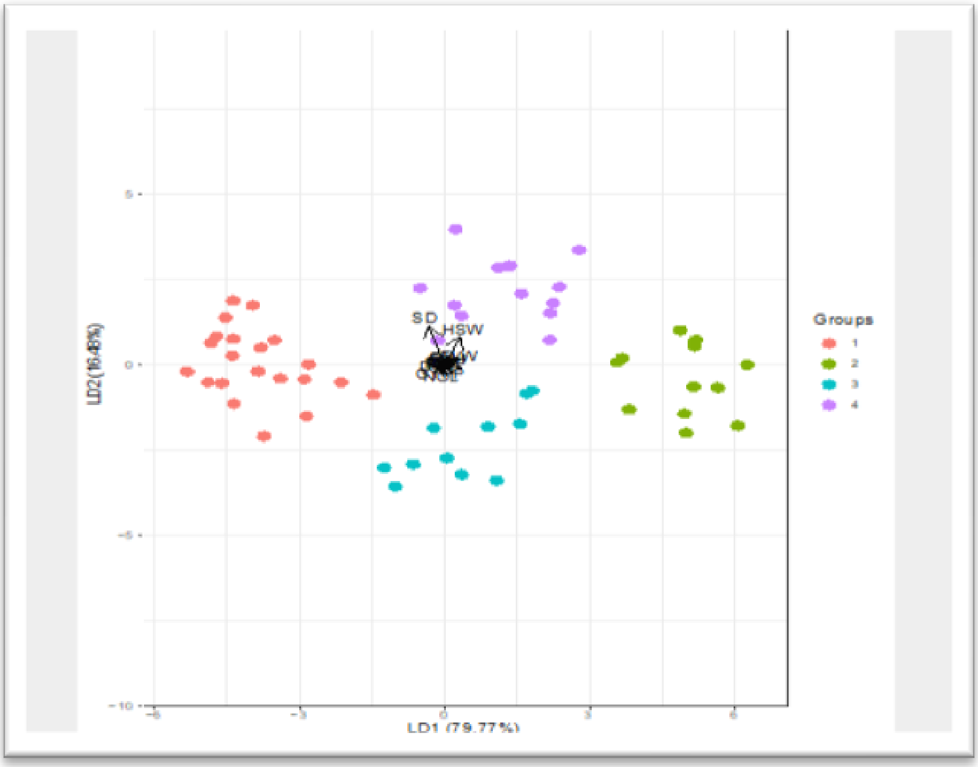


Table 2. List of genotypes divided in clusters

Cluster 1	Cluster 2	Clustrer 3	Cluster 4
Red grain AxR 30651	IS 1255	IS 4966	IS 4092
IS 21713	IS 29556	Chen Cholam 2	IS 8012
TRs 18010	IS 23460	IS 4956	SD 272
MS 7863	SD 12885	IS 2583	IS 1052
IS 30414	IS 20507	Chen Cholam 1	IS 3076
IS 29218	SD 776	IS 4105	IS 20740
IS 20603	03 CS	IS 1233	TRs 18003
IrunguCholam	IS 10930	IS 30330	ISC 304-4
Red IrunguCholam	IS 29705	SD 8374	TRs 18008
IS 29690	IS 19536	IS 30450	IS 13980
IS 22764	SD 2033	SD 824	IS 19118
IS 18195	SD 8375	IS 13506	IS 29640
IS 22794	AS 5546		55-CS
IS 21544			IS 29315
TRs18007			ISC 304-1
IS 10718			ISC 304-3
Chen Cholam 3			
IS 14775			
34-CS			
SD 8348			
IS 29630			
IS 29322			
38 CS			
IS 30536			
IS 12804			
IS 23390			
TKSV 1008			

Fig. 3. Biplot generated between LD1 and LD2 of the clusters



T1-30
Induced mutagenesis promotes photosynthetic efficiency and lodging resistance in Kodomillet (*Paspalum Scrobiculatum* L.)

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Abstract

The current study focuses on the development of photosynthetically efficient (PhE) and non-lodging mutants in the kodomillet variety CO 3, which is prone to lodging, using ethyl methane sulphonate (EMS) and gamma radiation. In the M_2 (second mutant) generation, there were striking differences in a number of morphological characteristics such as leaf anatomy for PhE and culm thickness for lodging resistance. Transcriptomic investigations were performed on the discovered mutations to better understand their molecular underpinnings. In the mutants CO 3-100-7-12 (PhE) and CO 3-200-13-4 (less efficient), expression profiles for pyruvate phosphate dikinase (PPDK), Nicotinamide Adenine Dinucleotide Phosphate Hydrogen—(NADPH), and NADP-dependent malate dehydrogenase (NADP-MDH) were performed. For the lodging phenotype, two mutants were chosen for expression profiling: CO 3-100-18-22 (lodged) and CO 3-300-7-4 (non-lodged) using the genes *GA2ox6 and Rht-B*. The findings confirmed that PPDK expression rose 30-fold, NADP-ME2 expression increased 1-fold, and NADP-MDH10 was also substantially expressed in the mutant CO 3-100-7-12. According to these expression profiles, kodomillet has a NADP-malic enzyme subtype C_4 photosynthetic system. *Rht-B* expression was considerably increased in CO 3-300-7-4. The study focuses on the differential expression patterns of the same gene in various lines at different stress and non-stress time points. This implies that the mutation has an effect on their expression; otherwise, the levels of expression will remain unchanged. Grain yield could be improved by generating a phenotype with high PhE and a culm with dense sclerenchyma cells.

Keywords: Induced mutation, lodging resistance, photosynthetic efficiency, transcriptomics

Introduction

Kodomillet (*Paspalum scrobiculatum* L.) is native to India (De Wet *et. al.,* 1983). It is gaining popularity as a C_4 plant due to its adaptability amid shifting agro-climatic conditions, as most arable land in India (69%) is arid and dry. Most small millet crops suffer from lodging constraints, resulting in significant grain yield losses. Rice grain yield and quality were reduced by 60%-80% by limiting rice canopy photosynthesis, since these attributes had unfavorable relationships with lodging (Weng *et al.,* 2017). Increased photosynthetic efficiency and lodging resistance lines will add more value to the crop in order to boost yield potential. Kodomillet is considered to have more free radicals than other millets (Hegde *et. al.,* 2005).

The current study is an assessment of the extent of genetic variability induced for two traits, photosynthetic efficiency, and lodging resistance, with the goal of isolating productive mutants in the M_2 (mutant second) generation. To understand the genetic basis of both features, mutants of the desirable types were discovered and subjected to transcriptome analyses.

Materials and Methods

The mutagenized population was screened for the deviations in phenotypic characters in comparison with the control plants for two characters 1) photosynthetic efficiency (PhE), and 2) lodging resistance. For PhE, traits like flag leaf length (cm), flag leaf breadth (cm), chlorophyll index, stomatal distribution, stomata leng, width and Stomatal density The following observations were made for lodging resistance, culm thickness (millimeter), culm strength by measuring the pushing resistance of the stem using a handy force-gauge meter, (Kashiwagi *et. al.,* 2004). In microtome, cross sections of intermodal region from the unique mutants were studied for their difference in thickness (micrometres) of the culm and of the width in the sclerenchymatous cells. These quantitative phenotypic trait values were utilized for assessing the promising mutant line pertaining to PhE and lodging resistance which was further utilized for the transcriptome analysis.

Results and Discussion

Two extreme mutants from M_2 generation for PhE and lodging trait were selected. Expression profiling was done for three genes *viz.,* PPDK, NADPH-ME and NADP-MDH in the mutant CO 3-100-7-12 which showed high chlorophyll index (47.97) and high stomatal number of 79 per unit leaf area and in CO 3-200-13-4 which had the least stomatal count (27) per unit leaf area (Table 1). The expression of *PPDK* was increased by 30-fold, *NADP-ME2* by~1-fold and *NADP-MDH10* was also highly expressed at 12 h post-treatment in CO 3-100-7-12 (PhE mutant).These expression profiles suggest that kodomillet uses an NADP-malic enzyme subtype C_4 photosynthetic system to fix carbon.

For lodging trait two extremes mutants (Table 2) CO 3-100-18-22 (lodged) and CO 3-300-7-4 (non- lodged) were selected for expression profiling using two genes namely *GA2ox6* and *Rht-B.* At 12 h post-dehydration treatment, the expression of *GA2ox6* showed an incremental decrease in gene expression in CO 3-300-7-4. The expression of *Rht-B* was significantly upregulated in CO 3-300-7-4 at both the time points. The transcript abundance of *Rht-B* gene suggests that an interesting evidence of GA regulated stress responsive machinery that might operate in these lines. The study highlights the differential expression patterns of the same gene in different lines at different timepoints of stress as well as non-stress conditions. The study suggests that the mutation in regulatory elements of each gene might have altered the motifs for recognition and binding of transcription factors, this could have led to a differed transcriptional regulation of gene expression.

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Table 1. List of mutants selected for photosynthetically efficient trait

S.No.	Mutants	Stomatal number	Stomatal length	Chlorophyll index	Flag Leaf Length	Flag Leaf breadth
1.	CO 3-100-1-5	45.00	9.03	38.97	22.77	1.30
2.	CO 3-100-7-12(↑PhE)	79.00	10.27	47.97	28.47	1.33
3.	CO 3-200-1-3	58.00	7.99	41.37	18.10	1.20
4.	CO 3-200-4-1	71.00	9.16	35.20	19.57	1.17
5.	CO 3 200-13-4 (↓PhE)	27.00	9.18	34.10	28.17	1.00
6.	CO 3-200-14-1	56.00	8.85	37.00	20.27	1.30
7.	CO3-40.25-12-4	58.00	9.90	37.57	32.33	1.30
8.	CO 3-40.25-30-2	61.00	9.46	41.97	29.10	1.57
	Control	55.00	9.34	35.62	32.38	1.17

Table 2. List of mutants selected for non lodging trait

S.No.	Mutants	Culm thickness	Culm strength
1.	CO 3-100-7-3	3.30	34.73
2.	CO 3-100-10-5	3.47	22.08
3.	CO 3-100-18-22 (unstable)	0.77	6.88
4.	CO 3-200-16-3	3.53	29.73
5.	CO 3-200-17-2	3.53	24.18
6.	CO 3-200-19-4	3.90	39.63
7.	CO 3-300-2-5	2.90	43.65
8.	CO 3-300-7-4 (highly stable)	4.00	39.73
9.	CO 3-40.25-13-2	3.13	30.27
10.	CO 3-40.25-18-5	3.10	34.49
	Control	2.53	24.53

T1-31

Induced genetic variability for yield and yield attributing traits in M3 mutants of Barnyard Millet

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Abstract

Current study is aimed to create variability in Barnyard millet variety viz. CO (Kv) 2 mutation treatment. This variety was subjected to irradiation with five various levels *viz.,* 0.2%, 0.4%, 0.6%, 0.8% and 1.0% of Ethyl Methane Sulfonate for creating variability. In this experiment, LD50 value was finalized as 0.51% EMS. M1 breeding material was evaluated with two doses 0.4% and 0.5%. In 0.4% EMS treatment, plants with early duration, thick stem, larger panicles and high yielding were observed in M2 and M3 generations. Induced variability depicted that employing ideal selection procedures, prominent development might be obtained in mutated populations. In M3 generation, mutants with early duration, dwarf type, lengthy panicles and high yielding were observed which would be forwarded to next generation for evaluation.

Keywords: Barnyard millet, EMS, macro-mutants, variability, M3 generation

Introduction

Barnyard millet is a self-pollinated crop with less variability. Local genotypes are available but they are poor yielders having lesser genetic variations. Since this crop is having complex floral structure and biology, development of new varieties is based on selection and other breeding procedures. One of the conventional breeding methods *viz.,* mutation breeding can be employed for genetic development of Barnyard millet. New varieties with acceptable characters can be developed through induced variability and appropriate selection methods. Non-lodging and higher yielding genotypes in barnyard millet can be evolved through induced mutagenesis followed by selection which has been proved to create variability in breeding populations. Mutation breeding creates wide range of yielding characters *viz.,* plant ideotype, yielding potential and maturity duration *etc.* Plant molecular techniques *viz.,* isolation of desirable genes and study of their structure and function can be executed through induced mutation. Current study was focused to investigate the variability created through induced mutation in M3 population of barnyard millet and selection of desirable mutants to forward to next generation.

Material and Methods

This research study was executed at the Dryland Agriculture and Research Station, Chettinad, Tamil Nadu during kharif 2019. The material subjected for the study included thirty

M3 mutants of Barnyard millet variety, CoKv2. This variety is having following characters like more plant height varying from 140 – 150 cm, dull whitish seed colour, lodging at maturity, flowering period varying from 96-100 and maturity period ranging from 110 to 125 days. This variety was subjected to mutation to create varieties with earliness, dwarfness and non-lodging nature. This variety was used for studying the effect of mutation on germination and different agronomic traits.

For creating mutated population of CoKv2 barnyard millet, chemical mutagen *viz.,* Ethyl Methyl Sulfonate (EMS) was used. Each hundred seeds were subjected with various levels of EMS *viz.,* 0.2%, 0.4%, 0.6%, 0.8% and 1.0%. Germination studies were conducted in those treatments with control. Germination percentage was studied six days after treatment and LD 50 value was determined. For generating M1 population, different treatments were fixed based on LD 50. M2 generation was raised forwarded from selected M1 population. Wide variations were observed in M2 generation. In M2 generation, six progenies *viz.,* 30-1, 56-3, 149-1, 29-1, 13-1 and 102-1 were chosen and forwarded to M3 generation. Plant to progeny method was followed to evaluate M3 population by by adopting 30cm and 10cm spacing between rows and plants respectively. Different mutants were observed in M3 generation. Five randomly selected plants of each entry were subjected for observation of yield attributing characters.Mutants with desirable morphological characters were observed and selected.Desirable traits of the selected M3 mutants are given in Table.1

The individual plants of selected six progenies were coded from G1 to G30. The mean data of yield contributing characters were statistically analyzed by using TNAUSTAT software for Progeny analysis for non replicated data.

Result and Discussion

Characters *viz.,* Days to 50% flowering, days to maturity, plant height and single plant yield of mutants recorded wide range of variability. Mean values of all characters are presented in table 2. There was much difference in flowering duration among irradiated populations. In M3 mutants, days for fifty per cent flowering were observed (57.14 days) earlier than the untreated population (70.2 days). The entries *viz.,* G3 (45 days) and G13 showed earliness (49 days) whereas G5, G9 and G30 required more days to flowering (66 days). The finding showed early panicle maturity in mutated population

The mean period to panicle maturity (86 days) was early when compared to control (106.2 days). The entries *viz.,* G3, G12, G11 and G1 showed earliness maturing in 71 to 73 days) and G24 (95 days), G18 (94.3 days) and G29 (94.5 days) showed late maturity. The findings were supported by the research work by Hayat et al. (1990) in sorghum. Muduli et al. (2012) also confessed with the same findings in M3 population of finger millet.

The character, plant height determines the vegetative growth of a plant which in turns expresses the yielding potential. Dwarf plant requires less quantity of water for its vegetative growth than tall plant. In this study, mutants recorded mean plant height of o113.3 cm which was lesser than that of control plants (135.74 cm). In mutants, there was a wide variation in plant height ranging from 73 cm for G25 and 76.11 cm for G23 to 140.7 cm for G4. The entries *viz.,* G4 (140.7 cm), G5 (133.45 cm) and G14 (132.9 cm) had tall plants. The entries *viz.,* G25 (73.1 cm), G23 (76.1cm) possessed dwarf plants. The character *viz.,* numbers of tillers per plant recorded notable amount of variation.

In general, irradiation caused noticeable increase in number of tillers per plant. The entries *viz.,* G1 (6.6 tillers/plant), G20 (6.5 tillers/plant) recorded maximum number of tillers per plant whereas the genotypes *viz.,* G24 and G21 (5 tillers/plant) possessed less number of tillers per plant. The mutants showed a mean of 5.8 tillers/plant. The finding of the study stated that there was a high level of variation in panicle length. The genotypes, (23.86 cm), G24 (23.8 cm) and G12 (23.25cm) had longer panicles whereas the entries, G8 (14.1cm) and G1 (15.9cm) possessed shorter panicles. When compared to the panicle length of the control plants (14.24 cm), the mutants showed an increased panicle length (19.96 cm) which was a desirable outcome of mutation breeding. This finding was supported by that of Nirmala kumari et al. (2007) in little millet.

The character *viz.,* single plant yield is the most important one which determines the selection criterion. From this study, prominent variation was noticed among the mutants for this character. The genotype G29 (29.17 g), G20 (27.38 g), G15 (25.7 g) and G19 (25.38 g) recorded notable single plant yield. The entries, G3 (15.73 g), G5 (16.5 g) and G2 and G4 (17.55 g) had lesser yield. The mean single yield per plant (21.69 g) was slightly higher than that of control (20.6 g). This finding was very similar to that of Ganapaty et al. (2008) in little millet, Haradari et al. (2012) in finger millet and Bhave et al. (2016) and Kate et al., (2018) in proso millet.

From the study, it had been concluded that for advancement of yield deciding characters *viz.,* maturity, number of productive tillers per plant, panicle length and single plant yield, the treatment with 0.4% EMS was found good. Prominent desirable mutants could be observed through mutation followed suitable selection methods. Mutants with early duration, dwarf type, lengthy panicles and yielding potential were identified in M3 population which would be forwarded to next generation for evaluation. The entries *viz.,* G3, G12, G11 and G1 would be exploited for developing early varieties. The genotypes *viz.,* G25 and G23 would be utilized for breeding dwarf varieties and the entries *viz.,* G29, G20, G15 and G19 would be involved in breeding program for evolving high yielding barnyard millet varieties. These entries with desirable characters could be much exploited in breeding program for evolving new varieties with preferable characters.

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Table 1. Selected M3 entries with desirable characters

S.No.	Entry	Source	Desirable Characters
1	29-1-1	0.4% EMS	Early duration, Good yielder, Pink pigmentation, Non-lodging
2	30-1-2	0.4% EMS	Early duration, Good yielder, dwarf, Non-lodging
3	56-3-1	0.4% EMS	Good yielder, dwarf, Non- lodging
4	102-1-1	0.4% EMS	Late maturing, Good yielder, Non-lodging
5	149-1-2	0.4% EMS	Early duration, Good yielder with lengthy panicles, Tall, Non-lodging
6	13-1-1	0.5% EMS	Early duration, Good yielder, Pink pigmentation, Non-lodging, Short statured

Table 2. Variability among genotypes in M3 generation of Barnyard millet

Entry	Days to 50% flowering	Days to Maturity	Plant Height(Cm)	Number of Productive Tillers	Panicle length (cm)	Single plant yield (g)
G1	50.50	73.75	103.95	6.58	15.90	17.90
G2	51.00	75.25	125.68	6.25	20.00	17.55
G3	45.33	71.00	131.73	6.33	19.13	15.73
G4	61.75	89.75	140.70	6.22	21.88	17.55
G5	66.00	89.50	133.45	6.00	18.15	16.50
G6	57.00	83.00	119.00	5.63	18.80	19.80
G7	54.33	77.67	116.97	5.27	19.70	20.23
G8	59.00	87.50	102.45	5.55	14.10	22.60
G9	66.33	91.00	127.37	5.17	22.23	18.13
G10	56.00	78.60	126.04	5.74	23.86	23.24
G11	50.50	73.50	121.25	5.35	18.20	24.15
G12	49.50	72.00	117.75	5.50	23.25	20.95
G13	49.00	76.67	122.63	5.97	21.83	23.47
G14	51.67	80.67	132.87	5.57	24.20	24.03
G15	53.00	78.33	125.57	6.13	21.80	25.70
G16	63.67	90.00	117.60	5.87	20.53	20.47

G17	59.67	91.67	128.31	5.43	18.00	21.73
G18	60.33	94.33	93.73	5.40	19.60	23.93
G19	55.50	87.25	98.89	6.00	21.88	25.38
G20	53.25	85.75	86.32	6.50	18.58	27.38
G21	61.25	94.25	111.21	5.00	19.77	25.42
G22	60.00	93.50	102.39	5.20	18.20	24.30
G23	53.33	87.67	76.11	6.07	22.97	18.53
G24	64.00	95.00	104.19	5.07	23.80	20.63
G25	54.00	87.00	73.07	5.20	22.15	22.40
G26	53.33	86.00	101.09	6.07	21.80	24.50
G27	57.33	91.33	99.30	6.00	16.53	29.17
G28	59.00	92.67	105.49	6.30	16.23	17.77
G29	60.00	94.50	121.63	5.65	20.50	21.95
G30	65.50	93.00	112.99	5.35	20.90	22.60
CoK v2	70.2	106.2	132.44	6.2	14.24	20.6
GM	57.14	86.07	113.30	5.76	19.96	21.75
Min	45.33	71.00	73.07	5.00	14.10	15.73
Max	70.20	106.20	140.70	6.58	24.20	29.17
SE	2.15	2.84	6.05	3.363	1.34	2.26
SD	3.75	4.95	10.45	3.611	2.24	3.77
Variance	22.03	44.20	168.04	3.500	8.32	16.69
cv (%)	6.93	6.10	9.32	25.265	11.65	17.24

SE – Standard Error, SD- Standard Deviation, CV-Coefficient of Variation*************

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Artificial hybridization in Barnyard Millet

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Abstract

Barnyard Millet is wonder millet with high nutritive value and low glycemic index. The crop can serve the nutrient requirement and also the diabetic population of our country. As the crop is highly self-pollinated, the variability available is very limited. With an objective of creating variability, the present study was taken up to calculate the efficiency of artificial hybridization in the crop. A maximum of 26.4% successful hybridization was recorded by hot water method. The heterosis in the F_1s for single plant yield was significantly high with 26.59%. This successful hybridization promises to accelerate the crop improvement program in Barnyard millet.

Keywords Wonder millet, artificial hybridization, heterosis

Introduction

Millets are miracle crops growing on drylands demanding very minimum management practices for their cultivation. Small millets include finger millet, Foxtail millet, Little millet, Barnyard millet, Kodo millet, and Proso millet. They are suitable for the cultivation in an environment of climate change and global warming and assure food and nutritional security. Their high genetic diversity & self – fertilization results in lower human input.

Barnyard millet is a store-house of nutrition and hence is an excellent candidate for nutritional security. In comparison to major food crop such as rice it has higher fiber content i.e., 9.8g/100g, fat content 5.8g/100g, calcium 14mg/100g, iron content 18.6 mg/100g etc. Recent years have seen several food products being developed using grains of barnyard millet including flakes, biscuits, snacks, breads etc. (Vijeta Joshi (2013)).

Barnyard millet is a highly self-pollinated crop and has made limited variations for improvements. However, the protocol for crosses in *Setaria viridis* given by Hui Jiang *et al.,* 2013 and hybridization done by Baltensperger *et al.,* 2004 in proso millet have given a good scope of conducting crosses in barnyard millet for the exploitation of heterosis.

The inflorescence of Barnyard Millet is an erect terminal panicle. In the inflorescence the elliptical shaped spikelets occur in pairs. The upper floret is comprised of lemma and palea enclosing three stamens, a superior ovary with two well-defined styles, and a plumose stigma (Sundararaj and Thulsidas, 1976). The anthesis is at peak during the initial 6 to 8 days after panicle emergence and occurs at 6 am lasting till 10 am (Jayaraman et al., 1997). These minute spikelets are the way more a hinderance when it comes for artificial hybridization. The easier way for hybridizing the florets by emasculation and dusting is through hot water technique.

Materials and Methods

A crossing programme was conducted at AC and RI, Madurai, at Department of Plant Breeding and Genetics during *Rabi*, 2014 involving the cultures of Barnyard Millet, *viz.* CO2, ACM-10-145 and ACM-10-161 as female parent and ACM 331 and ACM 332 as male parent. The male cultures have characteristic purple pigmentation on stem and on grains. These were deliberately included as male parent for easier identification of true F_1s.

Emasculation: Hot water emasculation is otherwise called Russian method. Emasculation could be carried out in the early morning itself prior to pollinating. The sufficient amount of crossed seed set is achieved through hot water method of emasculation by Raj *et al.* (1964) in finger millet. The panicle heading to anthesis was selected and the opened and immature spikes on top and bottom were trimmed leaving the middles spikes. The emasculation was done by immersing the panicle into hot water at (48°C) for 4 to 5 min a thermos flask (Gupta et al., 2011). This makes the sensitive pollen grains to lose fertility and stigma to emerge out. Then the crop becomes the female parent.

Pollination: The male parent was as selected that the anthesis has started and the pollen grains have just started dispersing. The panicle of the male parent grown next to female parent was tied to the female panicle together and covered with butter paper cover, a method called Contact method as suggested by Ayyangar (1934). If the male parent and female are grown in isolation, following Approach method, the selected male panicle is cut, immersed in water in a cover or bottle and tied to the female panicle.

The hybrid seeds from each of the crosses were harvested and cultivated in the next season. The purple pigmentation of male parents was taken as the marker for identifying the true F_1s and were tagged. The hybridization efficiency and heterosis for the biometrical data was calculated.

Results and Discussion

The hybridization efficiency and heterosis were calculated and are furnished below in Table 1 and 2.

Thus, the significant hybridization efficiency and heterosis in the crop proves a way more for its exploitation by Selection of hybrids for recombination breeding and isolation of useful segregants in the desirable direction in the subsequent generations.

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Table 1. Hybridization efficiency of the cross combinations

S.No.	Cross combinations	Hybridization efficiency (%)	S.No.	Cross combinations	Hybridization efficiency (%)
1.	CO 2 **/** ACM 331	26.4	4.	ACM-10-145 **/** ACM 332	24.3
2.	CO 2 **/** ACM 332	18.9	5.	ACM-10-161 **/** ACM 331	19.2
3.	ACM-10-145 **/** ACM 331	23.71	6.	ACM-10-161 **/** ACM 332	25.2

Table 2. Heterosis Percentage of the Biometric characters studied (Standard parent – CO 2)

S.No.	Cross combinations	Plant height (cm)	No. of Tillers	Earhead weight (g)	Single plant yield (g)
1.	CO 2 **/** ACM 331	20.41**	-12.5	61.62**	26.59**
2.	CO 2 **/** ACM 332	18.66**	-12.5	27.31	6.52
3.	ACM-10-145 **/** ACM 331	34.95**	50.00**	52.77**	9.09
4.	ACM-10-145 **/** ACM 332	21.78**	-28.33**	43.54	17.50*
5.	ACM-10-161 **/** ACM 331	19.15**	-41.67**	21.03	21.44**
6.	ACM-10-161 **/** ACM 332	34.92**	16.67*	103.32**	11.15

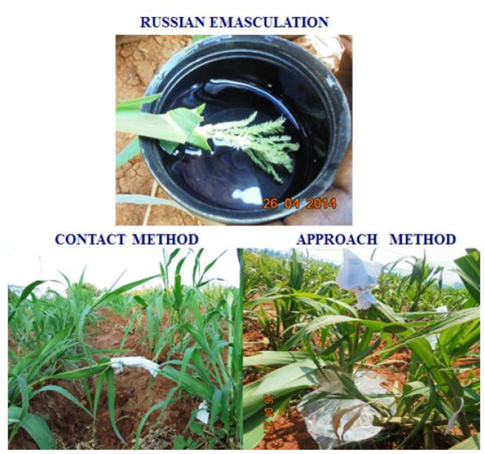

Fig. 1. Different types of crossing method in barnyard millet

T1-33

Association studies and path analysis in F_4 generation of Red Sorghum

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Abstract

Sorghum is a C_4 tropical crop with a remarkable ability to withstand drought conditions and known for its wide range of diversity. It is primarily cultivated for various purposes, including food production, animal feed, and beverage production. Association and path analysis were carried out in F_4 generations of the sorghum cross Paiyur 2 × Ammapatti local- 1. Thirteen quantitative traits were recorded. The association studies revealed several significant correlations. In the F_4 generation single plant yield was observed to have positively significant correlation with traits *viz.* plant height, number of leaves, leaf width, stem girth, days to maturity, panicle width, number of primary branches per panicle and test weight. Pathway estimates indicated that no. of primary branches had the highest positive direct effect, followed by stem girth, test weight, number of leaves and days to fifty percent flowering.

Keywords: Quantitative trait, association studies, path analysis.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important crop cultivated for food and animal feed in semi-arid regions. Understanding the relationships between different quantitative traits is crucial for selecting multiple traits simultaneously. This evaluation helps to assess the impact of secondary traits on the genetic improvement of primary traits. Positive genetic correlation between desirable traits enables plant breeders to enhance both traits concurrently. However, a negative correlation between desirable traits hinders or prevents significant improvements in both traits. The present study was performed to investigate the association among different characters and their direct and indirect effects on yield in selected sorghum genotypes.

Materials and methods

The plant material consisted of single plant populations derived from an inter-specific cross between red sorghum genotypes *viz.*, Paiyur 2 x Ammapatti Local 1 and evaluation was done in the F_4 generation. The single plant population was raised in the *Rabi* 2021, at Agricultural College and Research Institute, Madurai. Among the single plant populations, well performing and nearly homozygous populations were selected. For the selected population, observations on thirteen quantitative traits viz., days to fifty percent flowering (DFF), days to maturity (DM), plant height (PH), number of leaves per plant (NL), leaf length (LL), leaf width (LW), stem girth (SG), number of primary branches per panicle (NPB), panicle length without peduncle (PL), panicle width (PWd), panicle weight (PWt), test weight (TW), single plant (SPY) were recorded. Correlation analysis was carried out through OPSTAT software and path analysis was done through TNAUSTAT statistical package.

Result and Discussion

Correlation analysis is necessary to understand the relationship among the traits for crop improvement and to produce well performing lines. The correlation coefficient analysis was carried out to study the relationship between the thirteen observed traits. In the cross studied, single plant yield was observed to have positively significant correlation with traits *viz.* plant height(0.765), number of leaves(0.724), leaf width (0.499), stem girth (0.653), days to maturity (0.574), panicle width (0.470), number of primary branches per panicle (0.561) and test weight (0.745) indicating importance of these characters on grain yield. As a result, an increase in one or more of these traits will lead to a further increase in single plant yield. This finding was consistent with that of previous studies conducted on sorghum. A positive correlation between plant height and seed yield was observed by Birhan *et al.,* 2020; test weight and single plant yield by Subbalakshmi *et al.,* 2019; stem girth and grain yield by Mengesha *et al.,* 2019. These findings highlighted the importance of selection of these correlated traits to enhance overall yield in sorghum.

The correlation study gives the direction of selection but out of numerous correlation coefficients, it is hard to find the mutual effects between the traits. Hence, it is also necessary to study the path coefficient analysis. The progenies recorded a high direct effect of number of primary branches per panicle (0.4887) followed by stem girth (0.4340), test weight (0.3325), number of leaves and days to fifty percent flowering (0.1828). Therefore, selection based on these traits would lead to development of high yielding lines in future generation. Similar results for direct effect on single plant yield were observed by traits *viz.,* stem girth (Singh *et al*.,2018); test weight (Tefera, 2020). In this study, indirect effect on single plant yield was strongly observed by the traits viz., number of primary branches contributed through plant height, leaf length, leaf width, panicle width and test weight.

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Table1. Correlation analysis estimates of thirteen quantitative traits in F_4 population of red sorghum.

Traits	PH	NL	LL	LW	SG	DM	DFF	PL	PWt	PWd	NPB	TW	SPY
PH	1.00												
NL	0.643**	1.00											
LL	0.492*	0.411	1.00										
LW	0.407	0.480*	0.394	1.00									
SG	0.699**	0.528*	0.015	0.517*	1.00								
DM	0.462**	0.493*	0.266	0.483*	0.450*	1.00							
DFF	-0.051	-0.210	-0.324	0.104	0.259	0.250	1.00						
PL	-0.062	-0.307	0.175	-0.298	-0.394	-0.351	0.006	1.00					
PWt	0.446*	0.317	0.084	0.262	0.697**	0.259	0.430	-0.072	1.00				
PWd	0.817**	0.327	0.377	0.445*	0.666**	0.307	-0.122	0.046	0.469*	1.00			
NPB	0.496*	0.275	0.626**	0.436	0.104	0.166	-0.410	0.026	-0.249	0.412	1.00		
TW	0.567**	0.635	0.375	0.615**	0.444	0.459*	-0.122	-0.296	0.163	0.413	0.424	1.00	
SPY	0.765**	0.724**	0.347	0.499**	0.653**	0.574**	-0.031	-0.380	0.226	0.470*	0.561*	0.745**	1.00

*Significant at 5% level; ** Significant at 1% level

Table1. Pathway estimates of thirteen quantitative traits in F_4 population of red sorghum.

Traits	PH	NL	LL	LW	SG	DM	DFF	PL	PWt	PWd	NPB	TW	SPY
PH	**0.1337**	0.1740	-0.0142	-0.1266	0.3031	0.5016	-0.0093	0.0051	-0.0470	-0.1363	**0.2423**	0.1885	0.7650
NL	0.0860	**0.2706**	-0.0119	-0.1493	0.2291	0.0551	-0.0383	0.0252	-0.0334	-0.0545	0.1343	0.2111	0.7239
LL	0.0658	0.1111	**-0.0289**	-0.1225	0.0064	0.0297	-0.0593	-0.0144	-0.0089	-0.0629	**0.3058**	0.1247	0.3467
LW	0.0544	0.1298	-0.0144	**-0.3112**	0.2243	0.0540	0.0189	0.0244	-0.0276	-0.0742	**0.2131**	0.2044	0.4990
SG	0.0934	0.1428	-0.0004	-0.1608	**0.4340**	0.0503	0.0474	0.0323	-0.0734	-0.1111	0.0508	0.1477	0.6529
DM	0.0618	0.1333	-0.0077	-0.1503	0.1954	**0.1117**	0.0457	0.0288	-0.0273	-0.0511	0.0809	0.1526	0.5738
DFF	-0.0068	-0.0567	0.0094	-0.0322	0.1125	0.0279	**0.1828**	-0.0005	-0.0452	0.0187	-0.2002	-0.0406	-0.0310
PL	-0.0084	-0.0830	-0.0051	0.0926	-0.1711	-0.0392	0.0012	**-0.0820**	0.0076	-0.0076	0.0129	-0.0984	-0.3805
PWt	0.0597	0.0857	-0.0024	-0.817	0.3025	0.0289	0.0785	0.0059	**-0.1053**	-0.0782	-0.1218	0.0541	0.2262
PWd	0.1093	0.0884	-0.0109	-0.1385	0.2891	0.0343	-0.0205	-0.0038	-0.0494	**-0.1668**	**0.2015**	0.1374	0.4702
NPB	0.0663	0.0744	-0.0181	-0.1357	0.0451	0.0185	-0.0749	-0.0022	0.0262	-0.0688	**0.4887**	0.1411	0.5606
TW	0.0758	0.1718	-0.0109	-0.1913	0.1927	0.0513	-0.0223	0.0243	-0.0171	-0.0689	**0.2074**	**0.3325**	0.7453

Residual effect = 0.2731; *Significant at 5% level; ** Significant at 1% level

Days to fifty percent flowering (DF), Days to maturity (DM), Plant height (PH), Number of leaves per plant (NL), Leaf length (LL),Leaf width (LW), Stem girth (SG), Number of primary branches per panicle (NPB), Panicle length without peduncle (PL), Panicle width (PWD), Panicle weight (PWT), Test weight (TW), single plant (SPY).

T1-34
Genomics approaches for Proso Millet improvement

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Abstract

Proso millet (*Panicum miliaceum*) is among the small millets which is rich in starch and protein content. It is a C4 crop and show considerable level of resilience to climate change. It is a potential crop for the future, however poorly studied at molecular level. An association panel with 200 diverse proso millet genotypes was evaluated for grain yield and protein content. SNP data was generated through genotyping-by-sequencing. A total of 22000 SNPs were called for association studies. Significant markers were identified for grain yield and protein content. In addition, transcriptome sequencing was performed from the developing grain at three stages for identifying genes regulating grain filling and thus yield. Proso millet shows overlapping of vegetative and reproductive phases, hence the genetic regulation for photosynthesis and accumulation occurs simultaneously in proso millet. During the grain development stage that is, 15 days after pollination the transcriptional activity enhances gradually. Nearly 5000 transcripts show differential gene expression (DEGs) between leaf and panicle. The panicle at 10 days after anthesis and 20 days after anthesis was transcriptionally more active. Similarly, gene expression levels were observed in three stages of leaf corresponding to three stages of the panicle development and DEGs were identified.

Keywords: *Panicum miliaceum*, germplasm, GWAS and transcriptome

Introduction

Paleo-botanical study revealed that proso millet was one of the oldest crop domesticatd by early human during Neo-lithic era. Resilience to drought, high temperature and low fertility levels makes this crop suitable for the changing climate regime. The crop has great adaptability, with the range from 3000 mean sea level to the sea level. It is grown in all the continents of the world. In India, over the years, the area under proso millet has declined drastically due to various reasons, in particular being low yield. The major production constraint is low yield and processing. The crop is rich in protein content, varying from 11.5% to 20.8 % in our genotypes. However, to harness the potential of this crop, efforts must be put to increase acreage under this crop. To make the crop more remunerable, the yield, and contributing primary traits must also be improved along with protein content. For higher genetic gains, genomics and the latest breeding methodologies and biotechnological tools must be adopted. Sequencing of proso millet genome has opened genomics studies in proso millet (Zou et al. 2019).. Using the genomic sequence information available for proso millet we have developed SSR markers. Genome wide association studies for yield and protein content and transcriptomics studies for identifying the genetic control of panicle development in proso millet. This is the first report in India of SSR marker development and GWAS for yield and protein content. It is an illustration of targeted improvement of important traits in proso millet.

Materials and Methods

ICAR-IIMR gene-bank holds 1439 accessions of proso millet which include accessions conserved in ICAR- NBPGR and breeding material from TNAU. The NBPGR accessions mostly consisted of indigenous collection of landraces throughout India. Data on qualitative and quantitative traits was recorded for classification of genotypes and selection of promising entries.

*SSR marker development:*For the development of genome wide SSR markers the whole genome sequence of proso millet (Zou et al, 2019) was used. GMATA tool was used to fish-out genome wide SSRs in proso millet (Wang and Wang 2016).

GWAS

Out of the 1439 accessions, a set of 200 accessions were selected for the study which also include released cultivars like TNAU 145, TNAU 151, TNAU 164 and TNAU 202. Data was recorded on yield and protein content estimated using Kjeldhal method. GBS was done to generate SNP data. Association analysis was performed using TASSEL software (Bradbury et al. 2007).

*Transcriptomic studies:*Whole transcriptomes were developed inform leaf and panicle tissues at three different growth stages (10 days after anthesis (DAA), 20 DAA and 30 DAA). Gene expression comparison study was undertaken between leaf and panicle across three stages of panicle development. DEGs were identified using references from *Zea mays*, *P.virgatum* and *P.halii*.

Results and Discussion

The TNAU collections were mproved lines. Data recorded in 1439 accession included quantitative and qualitative traits. The genetic variability for yield and related traits was high in the proso millet accessions. Variability for plant type, days to flowering, yield, panicle type was abundant to practice selection and purification of landraces. Selection for grain yield per plant and test weight was most effective in selection of lines for enhancing yield in proso millet. Accessions were selected for high yield, earliness, tillering and high test weight. Out of 1439 genotypes, a set of 200 lines were selected to form an association mapping (AM) panel. Use of single trait for selection of accessions viz. single plant yield or per plot yield is best for selection however to understand the component traits, correlation study was conducted. Some traits like biomass per plot showed very high correlation to yield per plot, irrespective of the plant type viz. spreading or erect type.

Development of SSR markers using proso millet genome: Around ~117,000 markers were developed. Out of this huge number of markers only 90 markers were selected. The marker selection criteria were defined to ignore markers from centromeric and telomeric regions, the expected amplicon size was between 150-400 bp, di-, tri- and tetra- repeat motifs, conserved sequence flanking microsatellite region and Tm between 50-60 ^{o}C. On an average, five markers were selected per chromosome, covering the entire proso millet genome.

Phenotypically diverse panel of 24 genotypes of proso millet was used to assess the utility of these 90 markers in diversity analysis. These markers produced allele pattern as expected, showing homozygotes and heterozygotes for a locus in the genotypes as discrete bands in the gel.

*Genome wide association studies for yield and protein content:*Genome wide association mapping for grain yield and protein content was performed for the set of 200 phenotypically diverse lines were selected to formulate the AM panel. Capturing the diversity in the entire AM panel was ensured. These genotypes were sequenced and genome wide SNPs were called using GBS pipeline. A total 24000 SNPs spanning all 18 chromosomes of proso millet genome were used for association studies using TASSEL program. The SNPs associated with grain yield and protein content were identified for further validation. The results will be presented in the conference.

*Dissecting starch accumulation in proso millet grains:*Panicle development and setting of seeds in crop species involves complex genetic regulation. The DEGs were identified in three stages of proso millet panicle development. The DEGs in the study were related to starch metabolism, storage protein, senescence, embryo development etc. It gave an insight into the translocation of photosynthates from source to sink. The major pathways involved in grain and embryo development were identified.

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T1-35

Exploring the variability on Races, Regions and Biological status in Finger Millet Global Germplasm Diversity Panelfor Improvement of Yield and its Related Traits

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Abstract

Finger millet [*Eleusine coracana* (L.) Gaertn.] is an important climate-resilient nutrient-dense crop grown as a staple food grain in Asia and Africa. Utilizing the full potential of the crop mainly depends on an in-depth exploration of the vast diversity in its germplasm. In the present study, a wide range of variability was available in the finger millet diversity panel for yield and its component traits among races, regions and biological status. Race *vulgaris* was early flowering, produced long flag leaf sheath and peduncle, whereas race *plana* had higher stover yield and 100-seed weight, produced tall plants. *Elongata* had the longest inflorescence and *compacta* had the shortest spike. All four races did not differ significantly for the grain yield. Accessions from Africa were late flowering, had higher stover yield, produced tall plants with more nodes, fewer tillers and had long inflorescence than Asian accessions. Breeding lines had early flowering, higher grain yield, greater 100-seed weight and more tillering than landraces.The present study provides insight into the variability present in the germplasm collections that could be used in selection of diverse parental lines from different regions, landraces for the finger millet improvement to improve the socio-economic status of people in semi-arid regions of the world.

Introduction

Finger millet [*Eleusine coracana* (L.)] is one of the underutilized crops that belongs to the family Poaceae. It is highly adapted to the semi-arid regions of the world and is grown extensively as a staple food crop in Asia and Africa. Finger millet was originated and domesticated in about 5000 BC in western Uganda and the Ethiopian highlands and then spread to India 3000 BC in the Western Ghats of India; thus, Africa is considered as a primary centre of origin and India is a secondary centre of diversity for finger millet (deWet *et al*., 1984). Germplasm is the basic raw material to drive any crop improvement program.The genetic characterization can lead to exploring the variation in germplasm. The great diversity in finger millet comes from its gene pool, including different races and subraces of cultivated species and nine species of genus *Eleusine* (Vetriventhan et al., 2020), centre of diversity. The widespread cultivation of high-yielding varieties, crop substitution, recurrent drought and urbanization have all increased the risk of traditional landraces being eroded in the farmer's field. Thus, this study was undertaken to explore the diversity present in finger millet races, regions and biological races for their utilization in the breeding for high yielding cultivars.

Materials and Methods

The genetic material for this study consisted of 314 finger millet accessions including four checks namely GPU 26, KMR 204, MR 6 and VL 149. The experiment was conducted at ICRISAT, Patancheru, Telangana, India, in an alpha lattice design with three replications in alfisols to evaluate the accessions for morpho-agronomic traits in three consecutive years (2018, 2019 rainy and 2020 summer seasons). Data on twenty-one quantitative (Days to 50% flowering (days), Basal tiller numbers, Plant height (cm), Nodes, Flag leaf blade length (mm), Flag leaf blade width (mm), Flag leaf sheath length (mm), Peduncle length (mm), Panicle exertion (mm), Inflorescence length (mm), Inflorescence width (mm), Longest finger length (mm), Longest finger width (mm), Panicle branches number, Culm thickness length (mm), Culm thickness width (mm), Days to maturity (days), Grain yield (kg ha^{-1}), Stover yield (kg ha^{-1}), Harvest index, 100-seed weight (g)) traits were recorded following finger millet descriptors (IBPGR, 1985). Mean comparisons among finger millet races (*vulgaris*, *plana*, *compacta*,*elongata*), regions (Africa, Asia) and biological status (Landraces, Breeding Lines) were performed.

Results and Discussion

A noticeable amount of diversity was observed for agronomic traits among races and showed significant differences among races except for harvest index, basal tiller numbers, plant height, number of nodes, flag leaf blade length, panicle exertion and panicle branches number (Table 1). Among the races, the race vulgaris flowered significantly early (73 days) and matured in 105 days, whereas race plana had a higher stover yield (7721 kg ha^{-1}), 100-seed weight (0.27 g), flag leaf blade width (10.21 mm), longest finger width (9.54 mm), culm thickness length (11.12 mm) and width (7.06 mm). *Elongata* had the longest inflorescence length and *compacta* had the shortest spike. However, all four races did not differ significantly for the grain yield, which is also similar to the results obtained for kodo millet races (Vetriventhan and Upadhyaya, 2019) although race *plana* had higher grain yield than *vulgaris, compacta, and elongata*.

In this study, 314 finger millet accessions were grouped into two regions: Africa, Asia. A difference was observed for agronomic traits between the regions and it was significant for most of the traits except grain yield, 100-seed weight, flag leaf blade length and width, panicle exertion and longest finger width Accessions from Africa were late flowering (seven days late than Asian accessions), produced tall plants (123 cm) with a low number of tillers (4 tillers) and higher stover yield (7440 kg ha^{-1}) than accessions from Asia. (Table 1).The mean of quantitative traits compared between landraces and breeding lines indicated a significant difference in agronomic traits namely for days to 50% flowering, days to maturity, grain yield, harvest index, 100-seed weight, basal tiller numbers, plant height, flag leaf sheath length and peduncle length.

Breeding lines flowered and matured early, produced higher grain yield (2583 kg ha^{-1}) with higher harvest index (0.27), 100-seed weight (0.28), basal tiller number (5 tillers), flag leaf sheath length (112.80 mm) and peduncle length (224.88 mm) than landraces.However, no significant difference was observed for stover yield. In comparison, breeding lines had early flowering, higher grain yield with a greater 100-seed weight with more tillering than landraces (Table 1).

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Table 1. Mean comparison on races, region and biological status of 314 finger millet accessions on agronomic traits

Traits [#]	Races				Region		Biological status	
	***Compacta* (28)**	***Elongata* (31)**	***Plana* (48)**	***Vulgaris* (202)**	**Africa (160)**	**Asia (136)**	**Breeding lines (50)**	**Landraces (264)**
DF	75±1.82ab[†]	78±1.43a	79±0.95a	73±0.56b	78±0.52a	71±0.72b	70±1.14b	75±0.50a
BTN	4±0.09a	4±0.13a	4±0.05a	4±0.05a	4±0.04b	5±0.06a	5±0.08a	4±0.04b
PH	118.49±1.96a	121.01±2.15a	123.71±1.45a	118.84±0.71a	123.48±0.65a	114.8±0.02b	115.98±1.48b	120.54±0.63a
Nodes	6±0.08a	6±0.08a	6±0.07a	6±0.03a	7±0.03a	6±0.03b	6±0.06a	6±0.03a
FLBL	331.65±4.38a	343.75±4.74a	340.92±3.99a	336.22±1.45a	339.28±1.99a	334.89±1.65a	337.3±2.25a	337.34±1.46a
FLBW	9.91±0.10b	9.87±0.10b	10.21±0.07a	9.88±0.04b	10.07±0.04a	9.78±0.04a	9.9±0.08a	9.94±0.03a
FLSL	103.24±1.46ab	104.21±1.45ab	100.46±1.08b	107.4±0.59a	101.97±0.56b	110.2±0.69a	112.8±0.97a	104.28±0.5b
PedL	216.95±2.81ab	212.64±3.05b	211.74±2.41b	220.95±1.08a	215.15±1.30b	222.85±1.31a	224.88±2.13a	217.35±1b
PE	113.75±1.86a	109.11±2.05a	111.58±1.79a	113.76±0.77a	113.39±0.97a	112.97±0.9a	112.55±1.56a	113.27±0.71a
InfL	68.58±1.96d	112.1±6.13a	89.9±1.94b	80.17±1.07c	88.18±1.75a	79.06±1.45b	83.23±2.40a	84.2±1.29a
InfW	51.82±0.43b	53.19±0.46a	54.17±0.31a	53.51±0.18a	54.87±0.19a	53.07±0.24b	53.88±0.40a	53.42±0.16a
LFL	56.32±1.41d	95.12±5.39a	75.22±1.77b	65.88±0.90c	73.75±1.53a	64.54±1.21b	68.34±1.99a	69.82±1.14a
LFW	9.14±0.10b	8.7±0.18c	9.54±0.09a	9.21±0.03b	9.31±0.05a	9.10±0.04a	9.24±0.05a	9.2±0.04a
PBN	7±0.15a	7±0.19a	7±0.10a	7±0.06a	7±0.05b	8±0.08a	7±0.10a	7±0.05a
CTL	10.61±0.17b	10.45±0.13b	11.12±0.09a	10.4±0.06b	10.86±0.06a	10.16±0.07b	10.42±0.13a	10.57±0.05a
CTW	6.8±0.1b	6.64±0.1b	7.06±0.06a	6.63±0.04b	6.92±0.04a	6.46±0.05b	6.62±0.08a	6.74±0.03a
DM	108±1.94ab	111±1.55a	112±1.04a	105±0.59b	111±0.56a	103±0.75b	103±1.19b	108±0.53a
GY	2261±86a	2149±120a	2295±63a	2267±331a	2252±34a	2307±48a	2583±57a	2206±29b
SY	7374±300ab	7227±241ab	7721±169a	6833±100b	7440±83a	6620±142b	7184±253a	7058±83a
HI	0.23±0.01a	0.23±0.01a	0.23±0.01a	0.25±0.01a	0.23±0.01b	0.26±0.01a	0.26±0.01a	0.24±0.01b
Swt	0.25±0.004b	0.25±0.006b	0.27±0.005a	0.26±0.002ab	0.26±0.002a	0.26±0.002a	0.28±0.003a	0.26±0.001b

[#]DF = Days to 50% flowering (days), BTN = Basal tiller numbers, PH = Plant height (cm), Nodes, FLBL = Flag leaf blade length (mm), FLBW = Flag leaf blade width (mm), FLSL = Flag leaf sheath length (mm), PedL = Peduncle length (mm), PE = Panicle exertion (mm), InfL = Inflorescence length (mm), InfW = Inflorescence width (mm), LFL = Longest finger length (mm), LFW = Longest finger width (mm), PBN = Panicle branches number, CTL = Culm thickness length (mm), CTW = Culm thickness width (mm), DM = Days to maturity (days), GY = Grain yield (kg ha^{-1}), SY = Stover yield (kg ha^{-1}), HI = Harvest index, Swt = 100-seed weight (g). [†]Mean followed by the same letters are not significant at $P \leq 0.05$, and means followed by different letters are significant at $P \leq 0.05$.

T1-36
Nutrient profiling in Red Sorghum crosses

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Abstract

Micronutrients get more importance because of their trace availability in food products which are essential for human metabolism. The daily requirement of micronutrient consumption is not met in the daily food and food products which results in malnutrition and also the food consumed by the lower economic portion of people contains very low micronutrients. Developing sorghum varieties with more micronutrients helps to overcome this situation since it is the major food for poor people of the world. In this study, three red sorghum crosses along with their parents were evaluated for micronutrient profiles to further improve their nutritional status.

Keywords: malnutrition, micronutrients& major food.

Introduction

Sorghum is a cereal grain that originated in Africa and is widely cultivated in many parts of the world. It is used for human food, animal feed, and biofuel production. Sorghum has many nutritional benefits, such as being high in protein, gluten-free, and rich in antioxidants. However, sorghum also contains various micronutrients that are essential for human health. Micronutrients are nutrients that are required in small amounts by the body, such as vitamins and minerals. Some of the micronutrients found in sorghum include calcium, iron, magnesium, manganese, zinc, potassium, niacin, thiamine, vitamin B6, and phosphorus. These micronutrients play important roles in various physiological and biochemical functions in the human body, such as energy metabolism, the immune system, the nervous system, bone health, blood formation, and antioxidant defense. Therefore, understanding the micronutrient content of sorghum and how it can contribute to human nutrition and health is important for promoting its consumption and utilization.

Materials and Methods

In this study triacid mixture method was used to estimate the micro-nutrients and trace elements as per the protocol stated by Sahrawat *et al.,* 2002.Three different red sorghum crosses *viz*., Paiyur 2 X PYR RS.16.07, Paiyur 2 X Kottathur local-5, Paiyur 2 X Ammapatti local-1 in F_4 generation were utilized to compare their micronutrient levels. 1g ground sample of selected progenies were taken in a 100 ml conical flask, a triacid mixture of 15ml was added to the flask, and the clear solution was transferred to a 100 ml volumetric flask. The diluted sample was used to estimate the micronutrients and was fed to Inductive Coupled Plasma Mass Spectrometry (ICP) for estimation. The working process involves pumping the sample solution into the equipment using a peristaltic pump, nebulizing it in a spray chamber, and injecting an argon plasma with a temperature of 6000–8000 K. The proportion of micronutrients present in the seed sample was displayed in the monitor and the process was repeated for all the selected samples.

Results and Discussion

Three crosses used in this study outperformed the check in all the analysed nutrients. The *cross* I Paiyur 2 X PYR RS.16.07 recorded high zinc and potassium, cross II Paiyur 2 X Kottathur local-5 had high levels of zinc, iron, phosphorous, cross IIIPaiyur 2 X Ammapatti local-1 recorded with high level of calcium in comparison with all other crosses. The check and parent PYR 2 contained high levels of zinc and iron; Kottathur local-5 recorded with high levels of calcium; Ammapatti local -1 recorded with high levels of potassium and phosphorous in comparison with all other parents.The level of calcium and zinc recorded in Cross I progenies were more than that of recorded by Tasie and Gebreyes (2020) in sorghum. Mohammed *et al.* (2019) also observed that zinc and potassium content of the progenies were comparatively high than their parents in red sorghum. The cross II progenies contained more zinc when compared to the result documented by Balcerek *et al.* (2020). Mohammed *et al.* (2019) also observed that the traits *viz.,* zinc and potassium content of the progenies were comparatively high than their parents in red sorghum. The micronutrients *viz.,* iron, zinc, calcium and potassium levels of cross III was high when compared to the findings of Mohammed*et al*. (2019). The quantity of calcium and zinc in cross III surpassed the value recorded by Tasie and gebreyes (2019) in sorghum. The quantity of zinc in cross III exceeded the value recorded by Balcerek*et al*. (2019) in sorghum.

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Table 1. Micronutrient of red sorghum crosses along with their parents

Biochemical characters	Parents				Crosses		
	PYR 2 (Check)	PYR.RS.16.07	Kottathur Local-5	Ammapatti local-1	Cross I	Cross II	Cross III
Zinc (mg/kg)	12.25	14.11	9.47	11.18	18.67	69.25	17.65
Iron (mg/kg)	58.30	54.00	49.80	48.90	63.57	244.10	55.03
Calcium (mg/kg)	226.3	238.1	240.2	209.20	237.03	230.30	246.59
Phosphorous (mg/kg)	21.68	23.62	24.10	26.32	31.03	151.11	24.89
Potassium (mg/kg)	146.20	140.35	148.20	151.20	162.15	69.25	157.27

T1-37
Protein profiling in high-yielding F4 generation Red Sorghum

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Abstract

Sorghum is a cereal crop that can grow in diverse environments and has many nutritional benefits. Analysing the protein content of sorghum can help breeders develop improved varieties and farmers optimize their production. Plant-based protein sources like sorghum are high in fiber, vitamins and antioxidants that promote bone, heart and immune health. In this study, the Kjeldahl method was employed to analyse the protein content of sorghum. Three red sorghum crosses *viz*., Paiyur 2 X PYR RS.16.07, Paiyur 2 X Kottathur local-5, Paiyur 2 X Ammapatti local-1 were analysed for their protein content.

Keywords: nutritional benefits, protein & health.

Introduction

Sorghum is an important crop for many countries today. It is used for food, animal feed, building material, and fuel for cooking, especially in dryland areas. Sorghum is also a gluten-free cereal that is significant in the present-day scenario where the occurrence of Celiac Disease (CD), an immunological response to gluten intolerance, is on the rise. Regular consumption of sorghum grains provides numerous health benefits, including preventing cancer due to the rare antioxidants present in the grain's bran layer. Sorghum is also rich in vitamins and minerals like B vitamins, magnesium, potassium, phosphorus, iron, and zinc. One of the important aspects of sorghum quality is its protein content, which affects its digestibility and functionality. Sorghum is an important source of plant-based protein, containing 10.62 g/100 g. 1 cup (192 gram) serving of cooked whole-grain sorghum contains 22 grams of protein. Protein provides the building blocks for bone, muscle, skin, and enzyme development. Certain sorghum varieties have substantial antioxidant properties due to phytochemical compounds including condensed tannins and anthocyanins mainly located in the bran fraction.There are different methods for analyzing the protein content of sorghum, such as Kjeldahl, Dumas, and near-infrared spectroscopy (NIRS). Each method has its advantages and limitations in terms of accuracy, cost, and speed. Therefore, choosing the appropriate method depends on the purpose and context of the analysis.

Materials and Methods

In this study, the Kjeldahl method was employed to analyze the protein content of sorghum. Three different red sorghum crosses *viz*., Paiyur 2 X PYR RS.16.07, Paiyur 2 X Kottathur local-5, Paiyur 2 X Ammapatti local-1 in F_4 generation were utilized to compare their protein levels. The Kjeldahl method consists of three steps: digestion, distillation, and titration. First, the sorghum samples were digested with concentrated sulfuric acid and a catalyst to convert the organic nitrogen into ammonium sulfate. Then the digested samples were distilled with sodium hydroxide to release ammonia gas, which was captured by a boric acid solution. Finally, the boric acid solutionwas titrated with a standard acid solution to measure the amount of ammonia and the endpointwas indicated by the appearance of brick red color. By multiplying the nitrogen content by a conversion factor of 6.25, the protein content of each sorghum samplewas obtained.

Results and Discussions

The parents of the three red sorghum crosses involved in this study *viz.,* PYR 2, PYR.16.07, kottathur local 5 and Ammapatti local 1 were appraised to have a protein content of 10.30 %, 11.64 %, 17.40 % and 9.70% respectively. The parent Kottathur local 5 recorded high protein content in comparison with all other parents. The three red sorghum crosses had a protein content of 12.24 %, 13.72 % and 11.38%.Cross II registered the highest protein content among the three crosses. From the results, it was concluded that all the crosses outperformed the check variety (PYR 2) in terms of crude protein content. The level of protein recorded in this study was in accordance with the resultsobserved byMohapatra *et al.* (2021), Kaplan *et al.* (2020), Tasie and Gebreyes (2020), Rocchetti *et al.* (2020), Abdelhalim *et al.*(2019), Wahyuningsih *et al.*(2019), Ahmad *et al.*(2018),Gassem and Osman (2003) and Njuguna *et al.*(2018) in sorghum. All three crosses outperform their parents and check both in case of yield. Cross II registered for the highest yield in comparison with its parents and other crosses.

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Table 1. Estimated protein content and yield of red sorghum parents and their F_4crosses

S.No	Parents /cross	Protein content %)	Yield g/plant)
1	PYR 2	10.3	22.96
2	PYR.RS.16.07	11.64	19.06
3	Kottathur Local- 5	17.4	25.19
4	Ammapatti local-1	9.7	23.61
5	Paiyur 2 X PYR RS.16.07	12.24	25.97
6	Paiyur 2 X Kottathur local-5	13.72	27.94
7	Paiyur 2 X Ammapatti local-1	11.38	26.92

T1-38

Association studies for yield attributing traits in Maize (*Zea mays* L.) germplasm

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Abstract

Correlation studies provide valuable insights into the relationships between different traits, enabling breeders to understand the co-occurrence and interdependence of traits. Correlation studies also aid in the identification of indirect selection criteria, where easily measurable traits can be used as indicators for the expression of complex or difficult-to-measure traits. Association studies in maize germplasm help breeders make informed decisions, optimize selection strategies, and accelerate the development of improved maize varieties with desired trait combinations. The present study is conducted using 50 maize germplasm lines for yield attributing traits and their correlations. Correlation analysis reveals strong positive associations between traits such as days to 50% tasseling and days to 50% silking, as well as between various other traits such as ear diameter, number of rows per cob, number of kernels per row, cob weight, and hundred grain weight. Cob weight shows a strong positive correlation with hundred grain weight, ear diameter, ear length, number of rows per cob and kernel row number. These correlations provide insights for targeted breeding programs and identifying potential indirect selection criteria.

Keywords: Maize, germplasm, variability, heritability, genetic advance, correlation

Introduction

Maize (*Zea mays* L.), besides being a food source, has diverse industrial applications and serves as a staple crop, providing nutrition and livelihoods to millions of people worldwide (Omprakash et al.,2017). Due to its widespread cultivation and increasing demand, breeders prioritize increasing yield to meet these needs. Maize germplasm is particularly important in breeding programs due to its genetic diversity, which offers a wide range of traits and genes for developing improved varieties. This diversity enhances yield, disease resistance, drought tolerance, and nutritional quality. Maize germplasm collections serve as a valuable resource for incorporating desirable traits into elite breeding lines, enabling the development of superior hybrids. Additionally, germplasm provides access to genetic resources suited to different agro-climatic conditions, enhancing maize adaptability and productivity. Trait correlation studies in plant breeding are important for several reasons. They help breeders understand the relationships between different traits, allowing for more efficient selection and simultaneous improvement in multiple traits. By identifying positive correlations, breeders can target desirable trait combinations and select individuals with favorable traits. Trait correlations also enable indirect selection, using easily measurable traits as proxies for those that are more difficult to assess directly. Overall, trait correlation studies provide valuable insights for breeders to make informed decisions and develop superior plant varieties.

Materials and Methods

The present study was carried out using 50 germplasm lines maintained by the maize unit, department of Millets, TNAU during 2022. The experiment was laid out in Augmented block design II using 5 checks *viz.* UMI-1200, UMI-1201, UMI-1205, UMI-1220 and UMI 1230. Each entry was sown in two rows with a spacing of 60 x 20 cm. Biometrical observations such as days to 50% tasseling, days to 50% silking, plant height (cm), ear height (cm), ear length (cm), ear diameter (cm), number of rows per cob, number of kernel rows, cob weight (g) and hundred grain weight (g) are recorded from five plants of each genotype and the average is taken. The data was statistically analyzed to study the variability and trait association using OPSTAT software.

Results and Discussion

The correlation analysis (table 2) reveals significant relationships among the traits. The correlation table revealed significant relationships among the traits. Days to 50% tasseling shows a strong positive correlation with Days to 50% silking and a moderate positive correlation with ear diameter, number of rows per cob, and hundred grain weight. Days to 50% silking exhibits a strong positive correlation with ear length and number of kernels per row. Ear diameter shows a strong positive correlation with number of rows per cob and hundred grain weight. Number of rows per cob has a moderate positive correlation with number of kernels per row and a weak positive correlation with cob weight. Number of kernels per row exhibits a strong positive correlation with cob weight and hundred grain weight. Cob weight shows a strong positive correlation with hundred grain weight, ear diameter, ear length, number of rows per cob and kernel row number. Similar findings are in agreement with Noor et al. (2018) Nzuve *et al.,* (2014), Reddy *et al.,* (2012) and Rajwade *et al.,* (2018).

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Table 1. Correlation analysis for ten biometrical traits in maize

DFT: days to 50% tasseling, DFS: days to 50% silking, PH:plant height (cm), EH: ear height (cm), EL: ear length (cm), ED: ear diameter (cm), NRC: number of rows per cob, NKR: number of kernel rows, CW: cob weight (g) and HGW: hundred grain weight (g)

	DFT	DFS	PH	EH	EL	ED	NRC	NKR	CW	HGW
DFT	1.000									
DFS	0.961**	1.000								
PH	0.164	0.156	1.000							
EH	0.121	0.149	0.299*	1.000						
EL	-0.034	-0.017	0.062	0.142	1.000					
ED	0.246	0.276	0.403**	0.172	0.485**	1.000				
NRC	0.249	0.271	0.193	-0.019	0.197	0.592**	1.000			
NKR	-0.009	-0.030	0.126	0.031	0.830**	0.407**	0.123	1.000		
CW	0.174	0.195	0.337*	0.100	0.626**	0.752**	0.506**	0.576**	1.000	
HGW	0.294*	0.363**	0.311*	0.017	0.440**	0.590**	0.332*	0.376**	0.731**	1.000

T1-39

Identification novel mutants of kodo millet (*Paspalum scrobiculatum* L.) induced by Gamma Radiation

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Abstract

Growing interest among consumers preference for healthy diets and climate-resilient features of small millets, emphasize the necessity of directing more research and development towards small millets. The present study was undertaken to identify the desirable mutants by gamma radiation in the kodo millet genotypes TNPSc 176 and TNPSc 262. Seeds of the two genotypes were subjected to gamma irradiation at a dose of 300, 400, 500 Gray based on LD 50 value. Among the different doses of gamma rays, 500 Gy was observed as suitable for optimum recovery of viable mutants like earliness (93 days), non-lodging, strong culm in the genotype TNPSc 176 during fifty percent flowering stage.

Keywords: Kodo millet, induced mutation, early mutant, lodging resistance, gamma rays

Introduction

The global population is anticipated to reach 9.8 billion by 2050, will require a 60–70% increase in food production from the current level, posing a significant challenge to feed growing population. The rising population to a great extent depends on three cereals, rice wheat and maize for sustenance. In this situation, the potentials of traditional crop plants including millets are being gradually revisited for their genetic constitution which is becoming increasingly relevant in the changing agricultural scenario. Small millets fit the bill as a healthy food choice because they provide high energy, high dietary fibre, protein with balanced amino acid profile, many essential minerals, vitamins, antioxidants, and have a low glycemic index (GI) (Saleh et al., 2013). Among the six smart food crops / nutria-cereals, kodo millet (*Paspalum scrobiculatum* L.) is indigenous to India. Being a C4 plant, it gains attention to changing agro-climatic conditions as most of the arable lands (69%) in India are arid and dry. Lodging is a limitation in most of the small millet crops causing considerable loss in grain yield. Severe lodging also increases harvest costs and reduces grain quality and cultivating lodging-resistant varieties is the most productive way to shrink losses due to lodging (Baker *et al.,* 2014).. Stem lodging is more frequently observed than root lodging in fields. Mutation induction offers the possibility of inducing desired attributes that either cannot be found in nature or have been lost during evaluation. Poornima Jency *et al.* (2020) focused in the development of non-lodging mutants by utilizing ethyl methane sulphonate (EMS) and gamma irradiation in the kodo millet variety CO 3 and reported that two mutants CO 3-100-18-22 (lodged) and CO 3-300-7-4 (non-lodged) were selected for expression profiling using genes GA2ox6 and Rht-B. Due to the limited genetic variability available in the germplasm, the present study aims to induce mutations using different doses of gamma rays and isolate desirable mutants in M_2 (mutant second) generation for earliness, non-lodging and non-shattering which will be utilized for genetic improvement of kodo millet.

Materials and Methods

Methodology for Generating Mutant Population and Identifying the Desirable Mutants: The genetic variability was induced in Kodo millet genotypes TNPSc 176 and TNPSc 262 using different treatments of physical mutagen (gamma rays). The genotypes were provided by the Centre of Excellence in Millets (CEM), Athiyandal. Mature and viable seeds (moisture 12.0%) of the kodo millet genotypes were irradiated with five doses 300 - 700 Gy with a radioisotope ^{60}CO (Cobalt-60) which served as a source at the gamma chamber at BARC, Mumbai. The irradiated seeds were raised in field experiment at CEM, Athiyandal during *Kharif* 2020 to induce and create variability in the genotypes. Self-pollinated fertile M_1 plants were harvested individually from Athiyandal and healthy seeds from each harvested plant were sown in plant progeny rows for growing M_2 generation (Fig.1) during *kharif* 2021 with check TNAU 86 at AC&RI, Kudumiyanmalai. In M_2 generation, viable mutations were observed from flowering stage *viz*., early flowering, late flowering, plant stature (dwarf/tall), leaf shape and size, culm thickness, response to environment, fertilizer changes in all the doses for evaluation novel mutants and also the chlorophyll, viable mutants of kodo millet genotypes were observed to study the mutation rate.

Results and Discussion

From the plant breeder point of view, the frequency of mutants expressed in percentage of mutants on M_2 population basis is more realistic and helpful. Before the beginning of the mutation-breeding program, information on the relative effectiveness of the mutagens is essential, to determine the correct dose/concentration of the mutagens. Probit analysis was carried out using seed germination values gamma rays for mutagens to determine the LD_{50}. In addition to environmental factors (e.g. rains, winds, soil types, etc.), crop-management practices such as high seeding rates and heavy fertiliser applications affect the occurrence of stem lodging and the crop-management measures for avoiding lodging in cereal crops, encompassing cultivation, sowing date, rate and depth, nitrogen fertiliser rate, and use of plant growth regulators (Berry *et al*. 2004). Based on the observations on days to first and fifty percent flowering, a total of 10 mutants were identified as early (93 days from sowing to 50 % flowering) in the genotype TNPSc 176 at 500 gy and the plant stature, number of basal tillers, culm strength were also observed after unexpected rain and wing during flowering stage. We identified non-lodging plants in 500 Gy of the genotype TNPSc 176 (Fig.2).

Early flowering was also reported in *Lathyrus sativus* L by Girhe and Choudhary (2002) and in finger millet Eswari *et al*. (2014) showed that gamma rays and EMS can change the days to flowering and fruit maturity. The lodging-resistant genotypes had greater stem-breaking strengths than the lodging-susceptible genotypes in the basal three internodes. Hence, it was observed that 500 Gy irradiation showed the desirable mutants (early and non-lodging) and these will be utilized for further selection in kodo millet.

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Fig. 1. Field view of M_1 and M_2 generation at CEM, Athiyandal and AC&RI, Kudumiyanmalai

Fig. 2. Early and non-lodging mutant in M_2 generation

T1-40

Studies on Frequency distribution parameters in early segregating population of extra early Barnyard Millet involved crosses

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Abstract

The investigation took place at Agricultural College and Research Institute, Madurai, where two crosses involving a high-yielding parent and an early maturing parent were examined. The crosses consisted of ACM-15-343 x IEc 82 and Co (Kv) 2 x IEc 107. Sixteen biometrical traits were assessed, including days to flowering, days to maturity, plant height, number of nodes, length of nodes, stem diameter, number of basal tillers, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, length of peduncle, length of lower raceme, number of racemes, single ear head weight, and grain yield per plant. Skewness and kurtosis were analyzed to understand gene action and the number of genes controlling the traits.In cross I, days to maturity and length of peduncle were influenced by fewer genes with dominance and complementary gene action. These traits displayed dominance and duplicate epistasis, protecting against deleterious alleles. Selection for these traits requires intense effort with slow genetic gain. Stem diameter, number of basal tillers, width of inflorescence, number of racemes, and grain yield per plant were controlled by multiple genes and complementary gene action, necessitating intensive selection for rapid genetic gain. In both crosses, days to flowering and maturity, plant height, length and width of inflorescence, and single ear head weight appeared to be governed by a large number of genes with duplicate gene action, indicating additive x additive gene effects. These traits can be improved through mild selection. In cross II, all traits were controlled by many genes with additive gene effects, suggesting wider variability and the potential for rapid genetic gain through intense selection.

Keywords: Skewness, gene action, Kurtosis, no. of genes, effective selection

Introduction

Barnyard millet is known to be a potential millet crop and its cultivation is taking speed at present due to its nutritional and agronomic importance. It has tolerance to both biotic and abiotic stresses. The recent cultivars in barnyard millet are found with a duration of 95-105 days. Its cultivation has spread in different topographies including hills and plains. It is being cultivated in both rabi and kharif seasons. Hence, cultivars with reduced duration together with high yield can help farmers to cultivate the crop in all seasons, also in mixed or intercropping and in crop rotation. This would enhance the agronomic and economic stability of the farmhands. This study aimed at selecting the early maturing genotypes from the segregating population involving extra early maturing parents. Knowing the distribution of the population may hep in effective selection of the desired genotype from the early segregating population.

Materials and Methods

The present inquisition involves the F_2 population of extra early barnyard millet involved crosses such as ACM-15-343 x IEc 82 and Co (Kv) 2 x IEc 107. The true F_1 progenies were raised to F_2, which were grown in unreplicated trial. Two hundred and fifty plants were selected and the data for sixteen yield contributing characters were recorded which includes days to flowering, days to maturity, plant height, number of nodes, length of nodes, stem diameter, number of basal tillers, length of flag leaf, width of flag leaf, length of inflorescence, width of inflorescence, length of peduncle, length of lower raceme, number of racemes, single ear head weight and grain yield per plant. High order statistics includes skewness and kurtosis, used for assessment of extent of variation present in the segregating population (Nadarajan *et al*., 2016). It was calculated by the method given by Snedecor and Cohron (1967).

I. Skewness

$$\text{Skewness} = \frac{n\,\Sigma\,(Y-\mu)^3}{(n-1)\,(n-2)\,\sigma^3}$$

SE (Skewness) = $\sqrt{6/n}$; Test of significance, t = Skewness/ SE

where n = number of observations Y= raw data; μ = mean of the data; σ = Standard deviation

II. Kurtosis

$$\text{Kurtosis} = \frac{n\,(n+1)\,\Sigma(Y-4)^3}{(n-1)(n-2)\,(N-3)\,\sigma^4} - \frac{3\,(n-1)^2}{(n-2)\,(n-3)}$$

SE (Kurtosis) = $\sqrt{24/n}$; Test of significance, t = kurtosis/ SE

where n = number of observations ; Y= raw data; μ = mean of the data; σ = Standard deviation

The calculated 't' values are compared with the 't' table @ 5% significance with n-1 degrees of freedom. The analyses were carried out using Microsoft Office Excel 2016.

Results and Discussion

Frequency distribution studies include the estimation of skewness and kurtosis. The co-efficient of skewness reveals the nature of gene action and kurtosis unwraps the number of genes controlling the traits. However, the presence of skewness and kurtosis can be confirmed only when they are significant. When skewness is significant positive, complementary gene action prevails and when negative significant, duplicate gene action can be concluded. Study of gene action helps to ameliorate the efficiency of selection (Dinesh *et al.,*2018). When the kurtosis is non-significant, negative or zero, no gene action is present and when significant, gives the number of genes present (Choo and Reinbergs, 1982)

ACM-15-343 x IEc 82

In cross ACM-15-343 x IEc 82, negative skewness was noticed for days to flowering, days to maturity, plant height, length and width of flag leaf and single ear head weight. Similar results were obtained by Prabhu (2020) in barnyard millet; Sumathi *et al*. (2018) in maize. Positive skewness was identified for number and length of nodes, number of basal tillers, stem diameter, length and width of inflorescence, length of lower raceme and peduncle, number of racemes and grain yield. Similar results were concluded by Prabhu (2020). Significant positive skewness was observed for stem diameter, number of basal tillers, width of inflorescence, length of peduncle, number of racemes and grain yield per plant. This indicates the presence of complementary gene action. In these traits, rapid genetic gain is promoted when the selection is intense and genetic gain is slow when there is mild selection. Significant negative skewness was noticed for days to flowering and maturity, plant height, length and width of inflorescence and single ear head weight, which confirms the existence of duplicate gene action and mild selection can be implied to improve these traits. The traits days to flowering and maturity, number and length of nodes, stem diameter, length of peduncle and number of racemes show positive kurtosis co-efficient. Plant height, number of basal tillers, length and width of flag leaf, length and width of inflorescence, length of lower raceme, single ear head weight and grain yield per plant show negative kurtosis co-efficient. Prabhu (2020) proved the same results in barnyard millet. Positive significant kurtosis indicates the leptokurtic nature of days to maturity and length of peduncle. This shows that these traits are controlled by fewer genes and show narrow variability. Other than these traits, all show negative and non-significant kurtosis which register the platykurtic nature of the traits and they are controlled by large number of segregating genes with additive effect (Sulistyowati *et al*., 2015) and display wider variability. Here, intense selection can be implied to improve the genetic gain.

Co (Kv) 2 x IEc 107

Positive skewness was noticed for days to maturity, plant height, number of basal tillers, width of inflorescence, length of lower raceme and peduncle and number of racemes, similar to the outcomes of Prabhu (2020) and Kamdar *et al*. (2020). Negative skewness was noticed for days to flowering, number and length of nodes, stem diameter, length and width of flag leaf, length of inflorescence, single ear head weight and grain yield per plant. Results were in complement with Prabhu (2020); Sumathi *et al*. (2018). Kurtosis was positive for days to flowering, length of nodes, number of basal tillers, stem diameter, length and width of flag leaf, length of inflorescence and number of racemes and negative for days to maturity, plant height, number of nodes, width of inflorescence, length of peduncle, single ear head weight and grain yield per plant. All the traits showed non-significant kurtosis, indicating the presence of no gene interaction, similar to the consequels of Prabhu (2020). They show normal distribution with mesokurtic nature. Thus, all the traits in this cross are controlled by many genes with additive effects. These traits show wider variability and rapid improvement in genetic gain is achieved by intense selection.

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Frequency distribution parameters in cross ACM-15-343 x IEc 82 and Co (Kv) 2 x IEc 107

Characters	Cross 1 ACM-15-343 x IEc 82		Cross 1 Co (Kv)2 x IEc 107	
	Skewness	**Kurtosis**	**Skewness**	**Kurtosis**
Days to flowering	-0.92	1.15	-0.60	0.04
Days to maturity	-0.22	0.26	0.09	-0.16
Plant height	-0.12	-0.49	0.07	-0.72
Number of nodes	0.07	0.01	-0.09	-0.68
Length of nodes	0.05	0.10	-0.55	1.40
Number of basal tillers	0.34	-0.12	0.42	0.86
Stem diameter	0.39	0.36	-0.43	0.17
Length of flag leaf	-0.33	-0.42	-0.36	0.23
Width of flag leaf	-0.54	-0.07	-0.44	0.56
Length of inflorescence	0.01	-0.28	-0.31	0.14
Width of inflorescence	0.32	-0.47	0.14	-0.25
Length of lower raceme	0.22	-0.24	0.22	-0.44
Length of peduncle	1.31	2.98	0.47	-0.86
Number of racemes	0.49	0.40	0.40	0.27
Single ear head weight	-0.25	-0.30	-0.51	-0.49
Grain yield per plant	0.22	-1.07	-0.10	-0.97

T1-41

Assessment of genetic parameters in F_2 segregating generation of Foxtail millet (*Setaria italica* (L.) P. Beauv.)

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Abstract

Genetic variability studies were carried out for yield and yield components in segregating generation of cross TNAU 579/1 x IC 308966/2 in foxtail millet. Eight biometrical characters were studied for estimating the genotypic coefficient of variation, phenotypic coefficient of variation, heritability, genetic advance as per cent of mean and frequency distribution. In F_2 populations, high coefficients of variation were observed for basal tillers, panicle exsertion and single plant grain yield. The traits like panicle length, flag leaf blade length, flag leaf blade width and panicle width recorded medium variability. Heritability estimate was high for all the characters. Genetic advance as per cent of mean was also high for all the characters except plant height and panicle exsertion. Traits like plant height, panicle exsertion, flag leaf blade length, flag leaf blade width showed a normal distribution and near normal distribution. The traits *viz*., basal tillers, panicle length, panicle width and grain yield showed a positively skewed distribution. The positively skewed traits might be used a selection criteria for yield improvement in foxtail millet.

Keywords: Genotypic coefficient of variation, phenotypic coefficient of variation, frequency distribution, foxtail millet

Introduction

Foxtail millet is one of the world's most ancient domesticated crops and its domestication in China dates back to 8,700 years ago (Lu *et al*., 2009). It is widely distributed in tropical, sub-tropical and temperate parts of the world. It has high nutritional and medicinal value and also it has low glycemic index (GI) which makes it as an ideal food for people suffering from diabetes (Thathola *et al.,* 2010). It may be cooked and eaten like rice, either as whole grain or broken; flour used for making porridge and puddings. Foxtail millet is also used as bird feed for feeding cage birds and the by-product of the foxtail millet is used as animal feed. At present, foxtail millet is regaining its value and emerging as important crop after realizing the nutritional and health benefits of foxtail millet and adaptability to changing climate. Many quantitatively inherited characters are fixed rapidly emphasizing the need to test character expression in large populations of F_2. Mean and variability are the important factors for selection. Quantification of the extent of variability created in grain yield and its attributing traits by segregation after hybridization and the knowledge of heritability and genetic advance in the segregating populations are the prerequisites for selection of desirable segregants in any crop breeding programme. In view of importance of variability in breeding programs, the present study was conducted in F_2 population of foxtail millet to evaluate genetic variation among yield and its related traits and frequency distribution of these traits.

Materials and Methods

The experiment was conducted at Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. The experimental materials consists of F_2 population (TNAU 579/1 x IC 308966/2) accommodating 250 plants. The parents TNAU 579/1, IC 308966/2 and check, ISe 375 were also grown along with F_2 population in three replications with spacing of 22.5 cm row to row and 10 cm between plants. All the recommended agronomical practices were followed to raise a good and healthy crop throughout the experimental period. Observations were recorded on eight characters *viz.*, plant height (cm), number of basal tillers per plant, panicle exsertion (cm), panicle length (cm), panicle width (cm), flag leaf bade length (cm), flag leaf blade width (cm) and grain yield per plant (g).

Results and Discussion

The F_2 is the critical generation in plant breeding and it determines eventual success or failure of the hybridization programme. The typical F_2 generation from diverse parents is made up of bewildering array of undesirable segregants with good ones. In the present study, the estimates of range, mean, phenotypic and genotypic coefficients of variation, heritability and genetic advance as per cent of mean of F_2 populations for eight characters are presented in Table 1. In the present investigation, values of phenotypic coefficients of variation were greater than genotypic coefficients of variation for all the characters studied. Among the eight characters studied, most of the characters showed differences between phenotypic and genotypic coefficients of variation suggesting their vulnerability to environment.

Basal tillers, panicle exsertion and single plant grain yield recorded high variability. While panicle length, flag leaf blade length and flag leaf blade width and panicle width recorded medium variability. Similar result was reported by Nandini *et al.* (2010) in segregating populations of finger millet. The plant height recorded low variability. Heritability estimate was high for all the characters. Genetic advance as per cent of mean was also high for all the characters except plant height. In contrast, high heritability along with low genetic advance was reported by Salini (2011) in segregating populations of little millet. High heritability accompanied with high genetic advance indicated additive gene action and selection for this character might be rewarding. Traits like plant height, panicle exsertion, flag leaf blade length, flag leaf blade width showed a normal distribution and near normal distribution. The traits *viz*., basal tillers, panicle length, panicle width and grain yield showed a positively skewed distribution. These traits might be used a selection criteria for yield improvement in foxtail millet. The occurrence of transgressive segregants might be the result of complementation of favourable and unfavourable alleles from either of the parents.

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Table 1. Variability parameters for grain yield and yield attributing traits in F_2 populations of TNAU 579/1 x IC 308966/2 foxtail millet

S. No.	Traits	Mean	Range		PCV (%)	GCV (%)	h^2(%) (BS)	GAM
			Min.	Max.				
1	Plant height (cm)	140.49	96.00	180.00	10.30	9.19	79.60	16.89
2	Number of basal tillers per plant	1.24	1.00	3.00	41.45	27.14	42.87	36.60
3	Panicle exsertion (cm)	8.31	-4.00	18.50	42.91	34.36	64.12	56.68
4	Panicle length (cm)	20.23	2.50	30.00	17.83	15.35	74.14	27.22
5	Panicle width (cm)	1.72	1.00	3.50	20.10	18.00	80.21	33.21
6	Flag leaf blade length (cm)	31.00	21.00	42.00	13.81	13.08	89.59	25.49
7	Flag leaf blade width (cm)	2.47	1.50	3.50	20.38	18.78	84.86	35.63
9	Grain yield per plant (g)	13.64	5.12	47.56	23.56	20.01	72.01	34.55

T1-42

Genetic diversity of small millet (*Panicum sumatrense*) germplasm based on morphological traits

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Abstract

A set of fifty-five accessions of small millet from Dr. Ramaiah gene bank at Plant Genetic Resources were raised for rejuvenation and evaluated at field of Department of Cotton, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore during December 2023 to study their genetic diversity for seventeen morphological traits. The morphological DUS descriptors could be effectively used for identification, documentation and grouping of germplasm based on Agglomerative clustering method using Gower distance. Dendrogram revealed the grouping of germplasm into five clusters with considerable genetic variations.

Keywords: Little millet, Germplasm, Genetic variation, Clustering and Plant Genetic Resources

Introduction

Progress in any crop improvement programme depends mainly on the degree of variation for the desired characters existing in the germplasm collection. In order to utilize the variability available in the gene pool, it is imperative to critically evaluate and characterize the available germplasm collections. An assessment of qualitative and quantitative traits of large collections will help to choose diverse germplasm for formation of core set in a crop for further characterization and utility. Hence, the present study is an attempt to classify 55 little millet accessions for morphological traits.

Materials and Methods

The experiment was conducted at field of Department of Cotton under the jurisdiction of Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. A total of fifty-five accessions of little millet germplasm representing collections from TNAU and IIMR under deposition at Dr. Ramiah Gene Bank were used in this study. Each accession was sown in ridges and furrows of 4.0m length during December 2022. Recommended crop agronomy was followed to maintain a healthy crop stand.

The traits namely growth habit (GH), basal tillers number (BT), days to fifty per cent flowering (DFF), leaf sheath pigmentation (LSPi), leaf sheath pubescence (LSPu), ligule pubescence (LPu), leaf blade pubescence (LBPu), Inflorescence shape (IS), peduncle length (PLL), flag leaf blade length (FLBL), flag leaf blade width (FLBW), culm branching (CB), panicle length (PL), panicle compactness (PC), lodging (LOD), plant height (PH) and seed shattering (SS) were recorded in ten plants per accession as per distinctness, uniformity and stability (DUS) guidelines. Cluster analysis was performed to assess the level of similarity or dissimilarity among evaluated germplasm. Dendrogram was generated based on agglomerative clustering using Gower distance in PB tools software.

Results and Discussion

Cluster analysis based on seventeen traits divided the germplasm into five main clusters (Fig 1). Cluster five was largest which comprised of twenty germplasm followed by cluster two (13) and cluster three (12). Cluster one and four consisted of eight and two lines respectively (Table 1). Germplasm in the same cluster were highly related and in different clusters were diverged based on the characters studied. Accessions in distant clusters namely 1 and 5 were highly unrelated and hence, selection from these two clusters could be reliable to exploit in the hybridization programme. Natesan *et al*., (2020) performed characterization of five little millet varieties (ATL 1, CO(Samai) 4, Paiyur 2, BL 6, TNPSu 176) using fifteen quantitative traits and seven qualitative traits in which ATL 1 was different from other varieties for more than sixteen characters studied. Hence, this study will create a database and also useful to identify the elite little millet germplasm for any trait specific characterization in future breeding programs and formation of core set.

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Fig 1. Agglomerative clustering pattern of fifty-five little millet germplasm

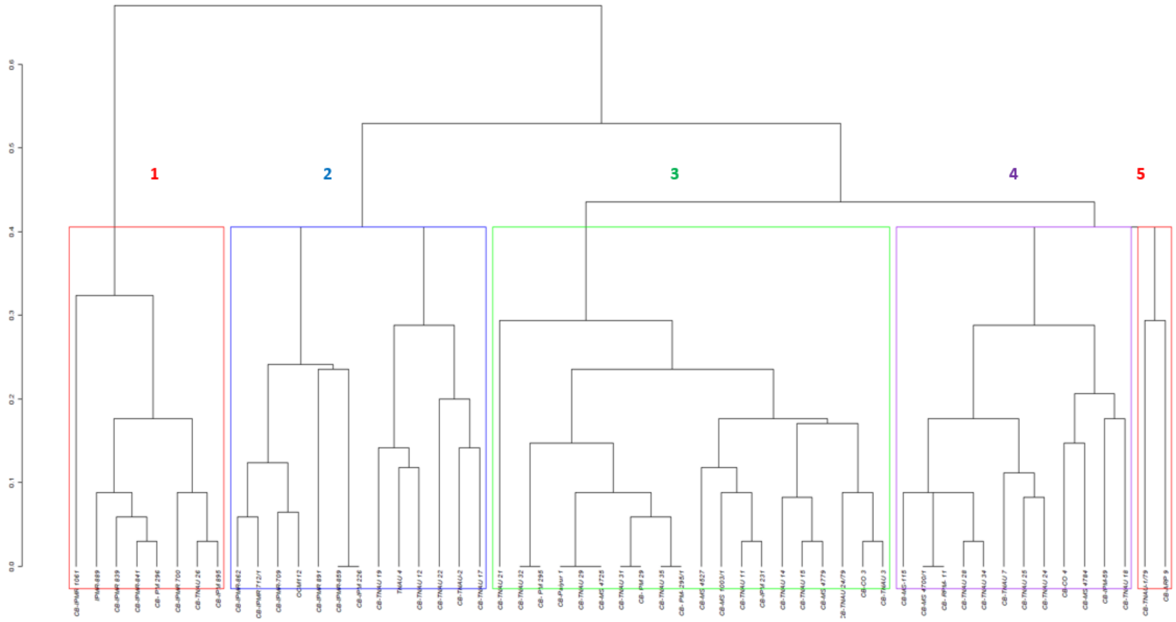

Plate 1. Field view of little millet

Table 1. Classification of little millet germplasm based on 17 morphological traits

Clusters	Size of cluster	Members of cluster
1	8	IPMR-889, CB-IPMR-841, CB- PM 296, CB-IPMR 700, CB-IPMR 839, CB-IPMR 1061, CB-TNAU 26, CB-IPM 895
2	13	CB-IPMR-859, CB-IPMR-862, CB-IPMR-709, CB-TNAU-2, TNAU 4, CB-TNAU 12, CB-TNAU 19, CB-TNAU 22, CB-TNAU 17, CB-IPM 226, CB-IPMR 891, CB-IPMR 712/1, OCM112
3	12	CB-CO 4, CB-IPM-59, CB-TNAU 7, CB-TNAU 18, CB-TNAU 28, CB-MS 4700/1, CB- RPM- 11, CB-TNAU 34, CB-MS-115, CB-TNAU 25, CB-MS 4784, CB-TNAU 24
4	2	CB-TNAU-1/79 and CB-ARP 9
5	20	CB-TNAU 14, CB-TNAU 24/79, CB-TNAU 29, CB-TNAU 31, CB-TNAU 32, CB-TNAU 35, CB-MS 4725, CB-PM 29, CB- PM 295, CB- PM 295/1, CB-CO 3, CB-Paiyur 1, CB-TNAU 3, CB-TNAU 11, CB-TNAU 15, CB-IPM 231, CB-MS 1003/1, CB-MS 4527, CB-MS 4779 and CB-TNAU 21

T1-43

Characterization of Foxtail Millet (*Setaria italica* L.) germplasm using DUS descriptors

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Abstract

Foxtail millet (*Setaria italica* L.) is one of the earliest cultivated crops, extensively grown in the arid and semi-arid regions of Asia and Africa. In this study, a total fifty-eight foxtail millet (*Setaria italica* L.) germplasm accessions stored at Dr. Ramiah Gene Bank, TNAU were subjected to DUS characterization using 20 traits. These germplasm were evaluatedduring January 2023 at Tamil Nadu Agricultural University, Coimbatore. A total of twenty qualitative and qualitative traits were recorded and agglomerative clustering method was employed to group the genotypes. The clustering results revealed that the genotypes were grouped into six different clusters. The cluster one and five consisted of highest number of accessions exhibiting greater divergence, whereas the cluster four consisted of minimum number of germplasm. This preliminary grouping will help in formation of core set or for choosing some parents for breeding programs

Keywords: Fox tail millet, germplasm, qualitative trait, quantitative trait, clustering

Introduction

The foxtail millet *Setaria italica* (L.) has been considered an important ancient crop for dry land agriculture for thousands of years. It is the potential climate-resilient crop for food and nutritional security in the current climate change scenario (Sharma and Niranjan, 2018). A large amount of diversity exists within the species of foxtail millet (Singh & Upadhyaya, 2015). A deep understanding of variability and genetic diversity paves the way for the successful exploitation of available germplasm materials in breeding programmes and the release of commercial varieties. Germplasm characterization is most important for further in depth studies on trait specific characterization or formation of core sets. As a preliminary assessment this study focussed on Distinctiveness, Uniformity and Stability (DUS) characters among 58 foxtail germplasm accessions stored at Dr. Ramiah Gene Bank, Department of Plant Genetic Resources, CPBG, TNAU

Materials and Methods

The experiment was conducted during January 2023 at the field of Department of Cotton, Directorate of Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. A total of fifty-eight accessions of foxtail millet germplasm collections were raised for rejuvenation. Each accession was raised in separate ridges and furrows of 4.0m length with a plant to plant spacing of 10cm. All package of practices were followed for a healthy crop.

The 20 DUS characters namely, Plant Growth Habit (PGH), Leaf Colour (LC), Plant Pigmentation at Auricle (PPA), Leaf Attitude (LA), Leaf Sheath: Pubescence (LSP), Leaf Sheath Intensity: Pubescence (LSIP), Leaf Blade: Pubescence (LBP), Flag Leaf Blade Length (FLBL), Flag Leaf Blade Width (FLBW), Days to 50% Flowering (DFF), Inflorescence Shape (IS), Inflorescence Bristle (IB), Inflorescence Length of Bristle (ILB), Peduncle Length (PL), Inflorescence Compactness (IC), Inflorescence Lobes (IL), Plant Height at Maturity (PHM), Number of Productive Tillers per plant (NPT), Ear Head Length (EHL) were recorded in ten plants per accession. Cluster analysis was used to assess the level of similarity or dissimilarity among the evaluated germplasm. Dendrogram was generated based on agglomerative clustering using Gower distance in STAR software.

Results and Discussion

In the clustering analysis, fifty-eight germplasm lines were categorized into six clusters based on twenty traits (Fig-1). First and fifth clusters accommodated the maximum number of germplasm lines,namely 12 each. Cluster 2 had the second highest number of lines of ten, followed by cluster 6 (9) and cluster 3 (8). The least number of accessions were grouped in cluster 4 (7) (Table-1). The dendrogram showed cluster 1 and cluster 5 were distant, while cluster 2 and cluster 1 were less distant. The crosses involving accessions from diverse clusters like cluster 1 and cluster 5 may produce more recombinants, which could be utilized in genetic improvement of foxtail millet. Gopi *et al*., (2021) evaluated eighty foxtail millet genotypes and grouped them into twelve clusters using D^2 analysis. They found the cluster 8 and cluster 12 were more diverse and suggested the cross between them could be utilized in recombination breeding. Also these diverse lines can be used for further characterization and in formation of core-sets in fox-tail millet

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Table 1. List of fox tail millet germplasm in different clusters based on DUS descriptors

Clusters	Size of cluster	Members of cluster
1	12	ISE21/1, ISE-140, GS-507, GS-678, GS-1157, GS-1369, GS-1641, GS-1942, GS-2158, ISE-1655, ISE-25335, ISE-538
2	10	TNAU-121/1, GS-959, GS-1373, GS-1827, GS-2284, GS-1607, GS-2076, GS-2098, ISE-776, GS-1638
3	8	TNAU-137, SG-1159, GS-1430, GS-1549, GS-1756, GS-2252, GS-669, GS-1381

4	7	TNAU-181, GS-1957, GS-2047, GS-1263, GS-1918, GS-2047/1, Ise-1468
5	12	GS-683, GS-1492, GS-618/1, GS-715/1, GS-773, GS-2069, GS-2101, GS-2137, GS-2236, GS-1832, GS-2093, GS-2152
6	9	GS-849, GS-1404, GS-1498, GS-1792, GS-1919, GS-2069/2, GS-2145, ISE-673/1, GS-764

Fig. 1. Agglomerative hierarchical clustering pattern of foxtail millet germplasm accessions

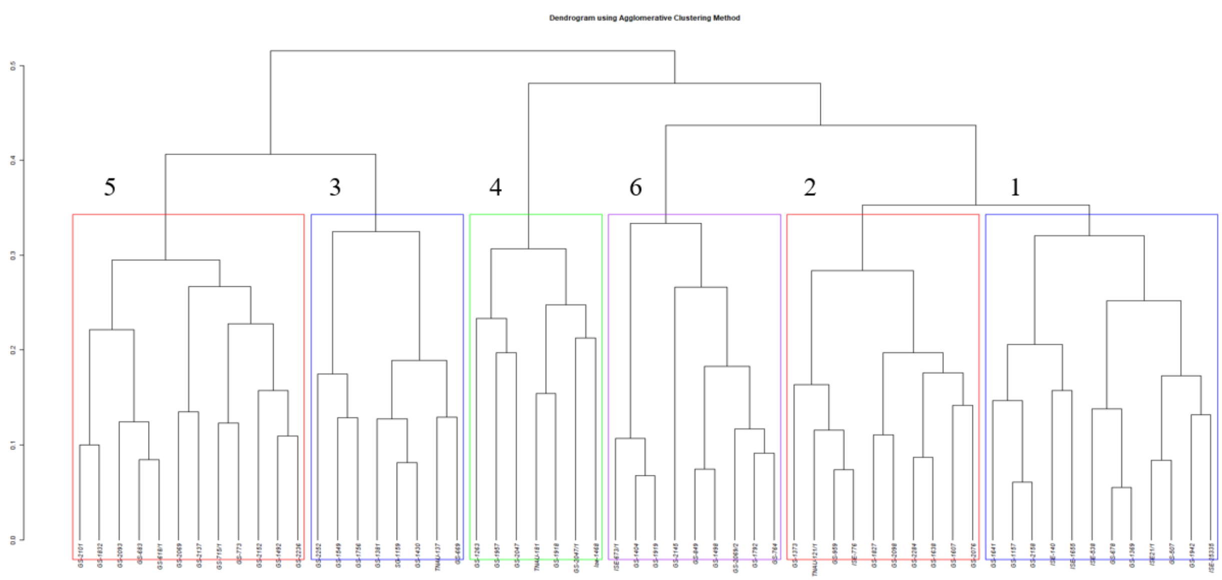

Fig. 2. Field view of foxtail millet germplasm evaluation

T1-44

Selection indices of yield and yield attributed characters in parental lines of Pearl millet [*Pennisetumglaucum*(L.)R BR]

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Abstract

. Selection indices are valuable in determining the degree of yield enhancement that can be achieved by combining certain characters. It serves as the foundation for assessing correlated features for improved yield selection.With this view, selection indices in37 parental lines of pearl millet were carried out for six important yield attributed characters. In general, the indices, which include more than one character, gave high genetic advance suggesting the utility of selection index for simultaneous improvement of several characters. It was observed that inclusion of characters one by one in the function gave fluctuating changes in the value of genetic advance and relative efficiencies over yield. The index based on four characters *viz.,*grain yield, spike length, spike girth and plant height were expected to produce same genetic gain and relative efficiency when its compared with combinations of six characters. Genetic gain and relative efficiency of this combination of four traits were 90.49 and 384.60 respectively. The use of this index will helpful to select high yielding genotypes in pearl millet.

Keywords :Pearl millet, selection indices, genetic gain and grain yield.

Introduction

Pearl millet is a one of the important nutritious and food security crop cultivated by small and marginal farmers in arid and semi-arid regions of African and Indian continent. It is the one of the sixth most important cereal crop cultivated in world and forth most extensively grown crop in India after rice, wheat and maize. Grain yield is a complex and polygenic trait and depends upon the action and interaction of a number of factors. It is felt that progress can be accelerated if simultaneous selection for most of the economic characters contributing to grain yield is considered for crop improvement. Selection indices are useful in understanding the extent of improvement that can be effected in yield by combination of characters. It forms the basis in considering the correlated characters for higher efficiency in selection for yield. The success of any selection is dependent on the genetic variability for the trait and high correlation coefficients, high heritability coupled with high genetic advance. The practice of selection indices in plant breeding program will enable the selection of best genotypes based on the combination of traits and economic weight attributed to them.

Materials and Methods

A set of 37 parental lines were evaluated at Department of Millets, TNAU Coimbatore during summer 2022 in RBD designwith two replication. The data were recorded in five randomly selected plants in each replication for 6 quantitative traits. The mean data was subjected to statistical analysis using the software

Results and Discussion

The analysis of variance revealed that highly significant difference exists between genotypes for all the studied characters. It indicated that the experimental material has enough variability for selection and improving yield and yield attributed characters. However, variation itself not sufficient to practice selection. Thus, based on heritability of traits and genetic advance of dependent character like yield were used to construct the selection index by giving equal weightage to make efficient selection (Antony *et al.,* 2023).

The discriminant function analysis revealed that the average relative efficiency of selection was gradually increased with number of traits (Table -1). Thus, selection based on seed yield alone will be less effective than simultaneous selection of multiple characters (Lakshmi prasanna *et al.,* 2013). The maximum average efficiency was observed, when all six characters were considered for selection. The maximum genetic advance of 91.29% and relative efficiency of 387.99 would be achieved when selection includes all traits. However, the results of different trait combination indicated that the selection based on four traits 1, 2, 3 and 5 would result similar genetic advance (90.49%) and efficiency (384.60) as indicated in the table-2. The genetic advance of seed plant yield while this trait alone was 72.13%, which increased to 90.49% when selection will be based on the discriminant function using four traits *viz.,* 1, 2, 3 and 5. Thus this discriminate function (0.9516 x1+ 1.0112 x2 + 1.0512 x3 + 1.0028 x5) can utilized in the selection of studied genotypes to increase seed plant yield (Table 2). (Venkataramana *et al.,* 2021) The traits 2, 3 and 5 along with seed yield per plant were recommended for selection which helps simultaneously to improve the yield and also maximizes the genetic gain for seed yield per plant.

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Venkataramana S. Kalagare, N. Meenakshiganesan, K. Iyanar, T. Chitdeshwariand C. N. Chandrasekhar2021."Strategy of multiple selection indices for discrimination of potential genotypes and associated traits for yield improvement in pearl millet [*Pennisetumglaucum*(L.)R.Br.] Electronic journal of plant breeding Vol 12(3):895

Table 1. Average selection efficiency of various combinations of traits in pear millet

No. of traits in the index	Percent relative efficiency
One	84.52197
Two	154.1399
Three	217.7247
Four	277.2546
Five	333.8287
Six	387.9964

1 –single plant yield, 2- Spike length, 3-Spike girth, 4-Number of productive tillers,5- Plant height, 6- Test weight

Table 2 List of selection indices constructed to maximize grain yield in Pearl millet

Trait	Discriminant function	Expected genetic advance	Precent relative efficiency
1	0.9981 x1	72.13	306.56
1, 5	0.9581x1 + 1.0032 x2	83.88	356.50
1, 2, 5	0.9516 x1 + 1.0138 x2 + 1.0036 x5	88.98	378.20
1, 2, 3, 5	0.9516 x1+ 1.0112 x2 + 1.0512 x3 + 1.0028 x5	90.49	384.60
1, 2, 3, 5, 6	0.9452 x1 + 1.0168 x2 +1.0374 x3 + 1.0033 x5 + 1.0614 x6	91.35	388.28
1, 2, 3, 4, 5, 6	0.958 x1 + 0.9924 x2 + 1.0989 x3 + 0.673 x4 + 1.0023 x5 + 0.9349 x6	91.29	387.99

1 –single plant yield, 2- Spike length, 3-Spike girth, 4-Number of productive tillers,5- Plant height, 6- Test weight

T1-45

Investigation of fertility restoration in diversified cytoplasmicgenic male sterile (CGMS) lines based hybrids in Pearlmillet [*Pennisetum glaucum* (L.)R BR]

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Abstract

Male sterile lines are the backbone of hybrid seed production in pearl millet .The identification and commercial utilization of Tift 23A (A_1) cytoplasmic male sterile source gives remarkable landmark in pearl millet and employed for hybrid development. But most of the released hybrids failed due to susceptibility of this A_1 cytoplasm to downy mildew disease incidence. Therefore, diversified source of male sterile line was required for the development of the hybrid. The commercial use of these male sterile sources depends on a line that can restore fertility in their hybrids. With this view, 65 hybrids were developed by using three different cytoplasmic back ground male sterile lines (A_1, A_4 and A_5). Seed set percentage of hybrid under selfing condition and pollen fertility were assessed mainly for this study. The lines *viz.,* PT 6024, PT 6029, PT 6067, PT 6069, PT 6686, PT 6707 and PT 6715 performed as common restorers for both A_1 and A_4 male sterile lines whereas PT 6059 expressed zero per cent seed set and it may be used as maintainer for all three diverse cytoplasm source. Along with this, pollen fertility of F_1 was calculated for better results. Out of 65 hybrids,34 hybrids come under restorer category, 24 were maintainer category and remaining F_1's were partial maintainer category. A_1, A_4 based hybrids restore the male fertility while A_5 based hybrid were found to be sterile in nature. Utilization of CGMS system with a standard male sterile source enhances the hybrid production in pearl millet and is essential to broaden the existing sources for further improvement program.

Keywords :Pearl millet, diverse male sterile lines, fertility restoration, hybrid.

Introduction

Male sterile lines are the important genetic sources of hybrid seed production in pearl millet and it has major influence on the grain yield of hybrids. Only Tift 23A (A_1) source was previously employed for hybrid development, but it was later shown that hybrids developed using this cytoplasm were prone to downy mildew incidence. Therefore, diversified source of male sterile line was required for the development of the hybrid.The diversification of cytoplasmic sources not only protects the crop from any cytoplasm-related calamity but also gives breeding program more adaptability and nuclear diversity. It is necessary to explore suitable restorers and identified good combining restorers for commercial exploitation of heterosis. Identification of better restorer line is a prerequisite step in hybrid breeding programme.

Materials and Methods

A total of 65 hybrids were developed by using three different cytoplasmic back ground of male sterile lines (A1, A4 and A5) which was developed by converting the elite breeding line into male sterile line through backcross method at Department of Millets,CPBG, TNAU, Coimbatore.These male sterile lines were crossed with best performing restorer lines and restoring ability was mainly assessed by seed set percentage of hybrid under selfing condition and pollen fertility percentage through staining method.

Results and Discussion

The restorer lines were grouped into six different categories *viz.,*Strong(>90%), high(80-90%), moderate(>60 - 80%),partial (>40 – 60%) low restorer(<10%) and maintainer (0%) based on their restoring ability and F1 seed set percentage (Table 1). Based on the restoring ability of restorer classification, the lines PT 6024, PT 6029, PT 6067, PT 6069, PT 6686, PT 6707 and PT 6715 performed as common restorers for both A1 and A4 cytoplasm based male sterile lines whereas PT 6059 expressed zero per cent seed set and it may be used as maintainer for all three diverse cytoplasm source. Apart from this pollen fertility percentage of hybrids were calculated for better result. Based on pollen fertility, hybrids were categorized into four types. When pollen fertility per cent is more than 80 in hybrids were grouped into restorer, 20 to 80% were partial restorer, 10 to 19% were partial maintainers and >10% were maintainers category its due to carbohydrates present in the fertile pollen was reacted with potassium iodide and its produce stained pollen grains (Vetriventhan*et al.,* 2010) (Fig 1). Out of 65 hybrids, 34 hybrids comes under restorer category, 24 were maintainer category and remaining F1's were partial maintainer category (Table 2). According to seed set percentage and pollen fertility studies in restorer lines and hybrids respectively showed that A1, A4 based hybrids restore the male fertility while A5 based hybrid were found to be sterile in nature. In future fertile hybrids will further evaluated and the sterile line may be used as new male sterile line after back crossing with pollen parent for developing new hybridsadapted to local environment.

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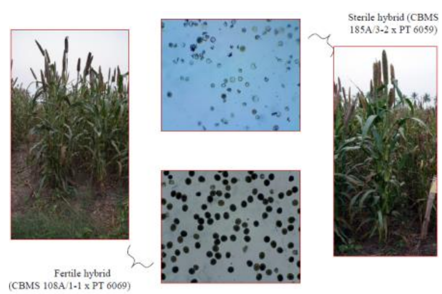
Table 1. Classification of restoration of diverse cytoplasm source based on seed set percentage

	Classification of restorers														
	Strong restoration (>90%)			High restoration (80 – 90 %)			Moderate restoration (>60 – 80 %)			Low restoration (< 10 %)			Maintainers (0 %)		
	A1	A4	A5	A1	A4	A5	A1	A4	A5	A1	A4	A5	A1	A4	A5
PT 6024	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓
PT 6029	-	-	-	✓	✓	-	-	-	-	-	-	-	-	-	✓
PT 6059	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓	✓
PT 6067	✓	-	-	-	✓	-	-	-	-	-	-	✓	-	-	-
PT 6069	✓	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓
PT 6347	-	-	-	-	-	-	✓	-	-	-	-	-	-	✓	✓
PT 6684	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓	✓
PT 6686	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓
PT 6693	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓	✓
PT 6694	-	-	-	✓	-	-	-	-	-	-	-	-	-	✓	✓
PT 6707	✓	-	-	-	-	-	-	✓	-	-	-	-	-	-	✓
PT 6715	✓	✓	-	-	-	-	-	-	-	-	-	-	-	-	✓
PT 6674	-	-	-	-	-	-	-	-	-	✓	-	-	-	✓	✓

Table 2. Restoration percentage in diverse cytoplasm source based on seed set percentage (Selected crosses)

Lines / Testers	CBMS 173A/4-5 (A1)	CBMS 108A/1-1 (A4)	CBMS 185A/3-2 (A5)
PT 6024	Strong restorer(95%)	Strong restorer(95%)	Maintainer (0%)
PT 6029	Strong restorer(95%)	Strong restorer(95%)	Maintainer (0%)
PT 6059	Maintainer (0%)	Maintainer (0%)	Maintainer (0%)
PT 6067	Strong restorer(95%)	High restorer(85%)	Low restorer(10%)
PT 6069	High restorer(85%)	High restorer(85%)	Maintainer (0%)
PT 6347	Maintainer (0%)	Low restorer(10%)	Maintainer (0%)
PT 6684	High restorer(85%)	Maintainer (0%)	Maintainer (0%)
PT 6686	High restorer(85%)	Strong restorer(95%)	Maintainer (0%)
PT 6693	High restorer(85%)	Maintainer (0%)	Maintainer (0%)
PT 6694	Moderate restorer (80%)	Low restorer(10%)	Maintainer (0%)
PT 6707	High restorer(85%)	Strong restorer (82%)	Maintainer (0%)
PT 6715	Moderate restorer (80%)	Strong restorer(95%)	Maintainer (0%)
PT 6674	Maintainer (0%)	Maintainer (0%)	Maintainer (0%)

Fig. 1. Microscopic and field view of fertile and sterile hybrids



T1-46
Multivariate analysis for yield attributing traits in Maize (*Zea Mays* L) inbreds

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Abstract

In the present investigation, a total of 55 maize inbred lines were studied to assess the genetic diversity for 16 quantitative traits using principal component analysis. The PCA identified five principal components (PCs) with Eigen value greater than 1.00 and accounted for 75.19 per cent of total variation. The PC1 had 29.95%, PC2 showed 20.13%, PC3 exhibited 9.62%, PC4 showed 8.21% and PC5 showed 7.28 % variability for the traits under study. PC scores revealed that the genotypes UMI 112, UMI 60, UMI 354, UMI 1005, UMI 64, UMI 117, UMI 68, UMI 109, UMI 1200 and UMI 1201 had highly and positively associated for the characters contributed for yield traits suggesting their use in breeding programmes for the exploitation of heterosis. The study of association analysis revealed that grain yield was positively and highly significantly correlated with the traits viz., tassel length, cob length, cob diameter, cob weight, no of kernels per row, hundred seed weight and shelling percentage which suggested that grain yield can be improved through simultaneous selection for these traits.

Keywords: Principal component, Eigen value, Correlation, Selection

Introduction

Maize (*Zea mays* L.) is referred as Miracle crop and Queen of Cereals due to its high productivity potential compared to other poaceae family members. To develop high yielding hybrids in maize, the development and evaluation of inbreds form the major thrust area of the plant breeding programmes. Multivariate analysis based on principal component analysis (PCA) is mostly used to evaluate the magnitude of genetic diversity among the germplasm (Mounika *et al*., 2018). Also, knowledge regarding the association between yield and its components traits and among the component parameters themselves will improve the efficiency of selection in plant breeding (Pahadi *et al*., 2017). In view of the above, this study was conducted with the aim to identify better performing maize genotypes with the help of principal component analysis and association analysis of major quantitative traits of the crop.

Materials and Methods

The field experiment was conducted in the research fields of Department of Millets, TNAU, Coimbatore during *kharif* 2021. A set of 55 maize inbred lines maintained in the maize germplasm pool was raised in an Augmented block design. Each entry was sown in single row of 4 m length with a spacing of 60 cm between rows and 25 cm between plants. Normal agronomic practices including need based irrigation and plant protection measures were followed to raise a good crop. Observations on sixteen quantitative characters *viz.*, plant height (cm), ear height (cm), days to 50% tasseling, days to 50 % silking, days to maturity, leaf length (cm), leaf width (cm) cob length (cm), cob diameter (cm), cob weight (g), number of kernel rows per cob, number of kernels per row, shelling %, hundred seed weight (g) and grain yield per plant (g) were recorded. The data recorded was analyzed with STAR statistical tool for Principal component analysis (PCA) to measure the dimensional reduction and to know the importance of different traits in explaining multivariate polymorphism.

Results and Discussion

In this experiment, first five principal components (PC) based on 16 quantitative traits showed eigen values greater than 1 (Table 1). The contribution of these five PCs was 75.19% in the overall variability among the genotypes. The contribution of PC1 was found to be 29.95% in the total divergence of the studied population, in which the major contributing traits were grain yield per plant, cob weight, cob length, cob diameter, hundred seed weight, no of kernels per row, shelling percentage, tassel length, leaf length, no of rows per cob, ear height and plant height. The second principal component (PC2) was responsible for about 20.13% of the variation and was mainly contributed by No of kernels per row, leaf length, shelling percentage, cob diameter, grain yield per plant and cob weight. The third principal component (PC3) explained 9.62 % of variation and was associated mainly with plant height, ear height, tassel length, no of rows per cob, leaf length, hundred seed weight and leaf width. The fourth principal component (PC4) explained 8.21% variation and was contributed by leaf width, tassel length, number of kernels per row, cob diameter, hundred seed weight, cob length, plant height, shelling percentage and days to 50% tasseling. The fifth principal component (PC5) showed 7.28% variation and was contributed by leaf length, tassel length, no of kernels per row, cob diameter, plant height, days to 50% silking, days to 50% tasseling and shelling percentage.

Principal component scores (PC score) were estimated in 55 maize genotypes of these five components (PC1-PC5). Top eight PC scores revealed that genotypes UMI 60, UMI 112, UMI 354, UMI 1005, UMI 109, UMI 1037, UMI 1200 and UMI 1201 in PC1 indicated that they had highly and positively associated for the traits viz., grain yield per plant, cob weight, cob length, cob diameter, hundred seed weight, no of kernels per row, shelling percentage, tassel length, leaf length, no of rows per cob, ear height and plant height. The highest PC score of UMI 117 followed by UMI 64, UMI 941, UMI 334, UMI 654, UMI 1217, UMI 1110 and UMI 1060 in PC2 exhibited for characters no of kernels per row, leaf length, shelling percentage, cob diameter, grain yield per plant and cob weight. PC analysis ultimately confirmed the amount of variation for the traits among the inbred lines which could be utilized in designing a breeding programme aimed at improving yield as it is generally assumed that maximum variation yields maximum heterotic effects (Ali *et al*, 2018).

Pahadi *et al*. (2017) reported that Eigen values (in PCA) have primary importance for numerical diagnostics to assess variation attributed by number of large variables on the dependent structure and their data matrix in a graphical display. The biplot of this study showed that the traits cob weight, cob diameter, cob length, shelling percentage, number of kernels per row, tassel length, grain yield per plant lie together while the traits days to 50% tasseling, days to 50% silking and days to maturity form different grouping and the trait leaf width was found to lie farther away. We can thus observe the traits in such group behave similarly (Sinha *et al.,* 2019). PCA helps to identify the traits with the highest variability as well as those ones that characterize the distinctness among selected genotypes.

Correlation analysis measures the mutual association between a pair of variables independent of other variables under consideration (Noor *et al.,* 2018). In this study, grain yield was positively and highly significantly correlated with the traits viz., tassel length, cob length, cob diameter, cob weight, no of kernels per row, hundred seed weight and shelling percentage. Positive correlation coefficient among the traits shows that the changes of two variables are in the same direction i.e. high value of one variable is associated with high value of other and vice versa. The yield attributing traits like cob length, cob diameter, cob weight, no of kernels per row, hundred seed weight, shelling percentage and grain yield per plant had highly significant positive association among the traits. These yield related traits displaying positive and significant association with grain yield per plant suggested that grain yield can be improved through simultaneous selection for these traits.

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Table 1. Eigen values, proportion of the total variance represented by 16 Principal components, cumulative per cent variance and component loading of different characters in maize (*Zea mays* L.)

Variables	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10	PC11	PC12	PC13	PC14	PC15	PC16
SD	2.1889	1.7946	1.2408	1.146	1.0794	0.932	0.8607	0.7837	0.7262	0.6773	0.5375	0.511	0.3578	0.2584	0.125	0.013
Prop. of Variance	0.2995	0.2013	0.0962	0.0821	0.0728	0.0543	0.0463	0.0384	0.033	0.0287	0.0181	0.0163	0.008	0.0042	0.001	0.000
Cum. Proportion	0.2995	0.5008	0.597	0.679	0.7519	0.8062	0.8524	0.8908	0.9238	0.9525	0.9705	0.9868	0.9949	0.999	1.000	1.000
EigenValues	4.7915	3.2205	1.5395	1.3132	1.1651	0.8686	0.7407	0.6142	0.5274	0.4588	0.2889	0.2611	0.128	0.0668	0.016	0.000
Traits																
PH	0.0321	-0.2071	0.6365	0.0419	0.1849	0.0004	0.0117	-0.0333	0.4547	-0.2032	0.2307	-0.4026	0.1606	0.1411	-0.069	0.002
EH	0.0648	-0.2893	0.4245	-0.207	-0.044	-0.2563	-0.1965	-0.5538	-0.3243	0.1402	-0.037	0.3555	-0.1174	0.0969	-0.018	0.0026
DTT	-0.017	-0.5373	-0.166	0.0045	0.0252	-0.0018	0.0316	-0.033	0.1313	0.0064	0.048	-0.0188	0.0259	-0.2852	0.7608	0.0088
DTS	-0.004	-0.5263	-0.201	-0.07	0.0466	0.0301	-0.0436	0.0356	0.1088	-0.0275	0.0058	0.0924	0.1436	-0.4948	-0.62	-0.0124
DTM	-0.056	-0.4981	-0.257	-7E-04	-0.022	0.0723	-0.0607	0.1969	0.0437	0.09	-0.083	-0.0675	-0.2876	0.718	-0.123	0.0055
LL	0.118	0.0509	0.0939	-0.523	0.4256	0.4179	-0.3478	0.2922	-0.1059	0.2695	0.0629	0.0846	0.1877	0.0172	0.0903	0.0015
LW	-0.229	-0.0077	0.0163	0.5855	-0.138	0.1968	-0.3708	-0.0951	0.0527	0.4729	0.2176	0.107	0.3339	0.0594	-0.007	-0.003
TL	0.1751	-0.1236	0.3876	0.4279	0.2304	-0.0038	0.2601	0.5009	-0.1614	0.0813	-0.161	0.3691	-0.2074	-0.1058	0.0155	-0.003
CL	0.3939	-0.0965	-0.092	0.1251	-0.047	0.1034	0.0419	-0.0545	-0.1708	-0.417	-0.221	0.1741	0.6631	0.2646	0.0452	-0.0044
CD	0.362	0.0429	-0.03	0.1792	0.1734	0.1255	-0.1727	-0.2756	0.1755	0.2473	-0.667	-0.331	-0.1541	-0.1129	-0.015	0.0006
CW	0.3977	0.013	-0.05	-0.111	-0.161	-0.0266	0.3542	-0.0445	0.1704	0.3834	0.2071	0.0502	0.0744	0.05	-0.04	0.6648
NKR	0.3206	0.1089	-0.184	0.1837	0.2294	0.2679	-0.2059	-0.2537	0.2684	-0.3312	0.3665	0.3522	-0.3824	0.013	-0.007	0.0046
NRC	0.0846	-0.0018	0.2485	-0.163	-0.732	0.2859	-0.2508	0.2277	0.2536	-0.1221	-0.191	0.1671	-0.1321	-0.0923	0.0443	0.0011
HSW	0.3384	-0.1204	0.0362	0.1381	-0.201	0.1895	-0.1107	0.0513	-0.5938	-0.0628	0.3313	-0.4964	-0.1698	-0.1304	-0.03	-0.0032
SP	0.2337	0.0586	-0.093	0.0439	0.0299	-0.6834	-0.5617	0.3245	0.0822	-0.0617	0.047	-0.032	0.0322	-0.0188	0.0333	0.1623
GYP	0.4136	0.0246	-0.065	-0.096	-0.138	-0.1765	0.196	0.0276	0.18	0.336	0.201	0.0381	0.0647	0.0516	-0.01	-0.729

PH: Plant height, EH: Ear height, DTT: Days to 50% tasseling, DTS: Days to 50% silking, DTM: Days to maturity, LL:leaf length, LW: Leaf width, TL: Tassel length, CL: Cob length, CW: Cob width, CW: cob weight, NKR: No of kernels per row, NRC: No of rows per cob, HSW: Hundred seed weight, SP: Shelling percentage, GYP : Grain yield per plant

T1-47

Effect of salinity on seed germination and early developmentstage in Sorghum (Sorghum bicolor (L.) Moench)

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Abstract

Sorghum is one of the fifth most important C4 cereal crop originated from Ethiopia. Naturally sorghum has abiotic stress tolerance and highly suitable to grow as a rainfed crop. Due to increasing population and climate change there is an urgent need to identify/develop sorghum genotypes for problem soils like saline environment. In sorghum, initial development is one of the highly susceptible stages under salinity. Good germination is highly essential to maintain plant population to get good yield of the particular crop. In this experiment the effect on salinity stress on germination, radicle length and plumule length were estimated. Among these three characters plumule length is highly affected by salinity and this leads to stunted growth of the plant. Based on Salt susceptibility index CSV 33 and TNS 227 were highly susceptible and CO32, TNS 703 and TNS 225 were showed tolerance to salinity.

Keywords: sorghum, salt tolerance, germination, radicle length, plumule length, SSI

Introduction

One of the most significant abiotic stressors that has a detrimental impact on global plant growth and development is salinity (Parida et al., 2005). According to reports, salt stress affects 2.1% of dry land and about 19.5% of all irrigated land (FAO report 2005). Because of improper irrigation management, saline zones are still growing in size. Additionally, the salinization process takes place in arid and semi-arid areas due to rapid evaporation and insufficient precipitation to prevent significant leaching. Through a variety of complicated features including osmotic stress, ion toxicity, mineral deficiencies, and physiological and biochemical abnormalities, salinity limits crop growth and development (Munns et al., 2008). Reactive oxygen species (ROS) are furthermore produced in chloroplasts, mitochondria, and the apoplastic membrane under saline circumstances by osmotic and ionic stress.Sorghum (*Sorghum bicolor* (L.)Moench), is a C4 and fifth most important C4 cereal in the world.

This cereal is well adapted to arid and semiarid regions because of its abiotic stress tolerance nature. Even though it shows abiotic stress tolerance, numerous studies reported that there are more genetic variations in sorghum genotypes in response to salinity. These genetic variability can be utilized to identify the most tolerant genotype for the soils affected due to salinity. Germination and early emerging stages are most sensitive stage in sorghum (Mbinda and Kimtai., 2019). Investigation on response of different sorghum genotypes under salt stress condition during germination and early vegetative stage is highly essential to develop salt-tolerant sorghum genotype suitable for saline soils and improve the sorghum production and productivity. Based on the following assumptions this experiment was carried out 1. The genotypes taken for this experiment has more variation for salt tolerance and different salinity levels have distinct effects on seed germination and seedling growth.

Materials and Methods

Eleven sorghum genotypes viz., CO30, CO32, K12, TNS225, TNS227, CSV33, TNS661, TNS698, TNS,701, TNS702, TNS703 (cultivated varieties and advanced cultures) were obtained from department of Millets and screened at germination and early seedling stage to identify the salt tolerant genotypes. The experiment was carried in two replications in complete randomized design with five treatments (0,25,50,75 and 100 mMNaCl). 25 sorghum seeds were placed in germination sheet and allow for germination under different NaCl solutions and monitored for 9 days to the end of germination. After 9 days the germination percentage, radicle and plumule length, fresh and dry weight of seedlings were recorded. Two factorial analysis was carried out to know the significance difference among genotypes and treatments. Salt susceptibility index was also calculated based on dry weight basis.

Results and Discussion

All the measured parameters under study showed thesignificant main effects of salinity and genotypes and also the interaction effect between them. All the genotypes taken for this study behaved differently under different salt concentration. In most of the crops the final plant The average germination percentage under control condition was more (94) whereas under 100mM Nacl stresswas less(82). These resultsclearly indicated that the germination is affected due to salinity this was also confirmed in sweet sorghum by Almodares et al., 2007.

The radicle length was slightly increased in slight increase in salinity stress (20mM) then it was observed that the reduction by increasing salinity stress this result was also confirmed by Shanthi et al., (2021) in blackgram. The dry matter weight is slightly increased by increasing salinity that may be due the accumulation of salt in cells. This also confirmed by Shanthi et al (2022 and 2021) in greengram and blackgram. Based on Salt susceptibility index CSV 33 and TNS 227 were highly susceptible and CO32, TNS 703 and TNS 225 were showed tolerance to salinity. These genotypes can be recommended for saline environments and also used for development of salinity tolerant varieties.

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T1-48

Characterization of Pearl millet genotypes for Grain Fe and Zn content through rapid screening method

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Abstract

Pearl millet is a major source of dietary energy for millions of people living in the regions of Africa and Asia. Genetic enhancement of grain iron (Fe) and zinc (Zn) content is one of the way to increase the uptake and reduces the problems of anemia and stunted growth among millet dependent food consumers. The presence of variation in diverse breeding lines is useful to improve grain micronutrients in high-yielding varieties. The study was conducted to assess the effectiveness of rapid screening for grain Fe and Zn and also identify the lines for the genetic improvement in Pearl millet using 35 genotypes with check variety Dhanasakthi. Different staining procedure used to classify the genotypes within a shorter period based on its colouring pattern. Fourteen genotypes observed with more intensity of blue colour for high Fe in Prussian blue staining while only six genotypes showed more intense of red colour for high Zn when treating with DTZ stain. Few genotypes *viz*, ICMB 10881, ICMR 10048, ICMR 101206, PT 5531 and PT 6476 were shown more intense of blue and red colour for its Fe and Zn content respectively indicated that the presence of high Fe and Zn. The selection and utilisation of these lines may helpful for developing lines with high Fe and Zn content.

Keywords: Pearl millet, micronutrients, Fe and Zn, improvement

Introduction

Pearl millet (*Pennisetum glaucum* (L.) R.Br.) is a climate resilient and nutritionally dependable cereal crop serving several millions of people in arid and semi-arid tropics of the Indian subcontinent and several African regions (Srivastava *et al.,* 2021). It is critically important for food and nutritional security. Across the world about 2 billion people suffer from micronutrient deficiencies. Diets deficient in iron (Fe) and zinc (Zn), which are important micronutrients, are the major cause of anemia and stunting, respectively in children and pregnant women (Pujar *et al*., 2020). Pearl millet, being naturally gifted with relatively higher proportions of grain iron (Fe) and zinc (Zn) compared to all other staple cereal food crops, is considered as a potential crop to combat micronutrient malnutrition, especially in the millet growing regions of India. Hence, assessing the genetic variability present in the population helps the breeders for the development of hybrids with high Fe and Zn content.

Materials and Methods

The experimental material comprised of thirty five genotypes, 13 B lines and 12 R lines and they were analysed for its colouring pattern using following staining methods along with check variety Dhanasakthi. Standard staining procedure were followed to estimate to estimate the Fe through Perl's Prussian Blue Staining (Velu *et al*., 2006) and Zn through DTZ (1,5-diphenyl thiocarbazone) method (Velu *et al*., 2008). Scoring was carried based on colour intensity and genotypes were grouped.

Results and Discussion

Grain flour of pearl millet genotypes was treated with 2% Prussian blue solution in the petri-dishes produced varying intensity of blue colour in genotypes (Figure 1). The genotypes having high Fe content showed more intense blue colour than in those having medium Fe content. No colour was developed in genotypes having low Fe content. Out of 35 inbreds screened, 14 genotypes showed the higher intensity of blue colour comparing with Dhanasakthi (check) and 4 genotypes exhibited no colour development (Table 1). Velu *et al*., 2006 reported that the rank correlation between the measured grain Fe content and the colour intensity score was highly significant and positive indicating that higher the Fe content in the grain, the more the intensity of blue colour. These results suggested that Prussian blue staining was more effective way when handling with large number of germplasm accessions or breeding lines for differentiating genotypes with high and low Fe content.

When the flour treated with DTZ stain the genotypes showed increase in the intensity of red colour formation with increasing Zn concentration (Figure 2). Only six genotypes exhibited the more intense red colour when comparing with check Dhanasakthi (Table 2). Relationship between grain Zn content and intensity of red color produced by the Zn-DTZ complex was strong, indicating that the higher the grain Zn content, the greater will be the intensity of red color (Velu *et al*., 2008). These results suggest that DTZ staining is effective in separating genotypes with high and low Zn content. However, few genotypes namely, ICMB 10881, ICMR 10048, ICMR 101206, PT 5531 and PT 6476 were shown more intense of blue and red colour for its Fe and Zn content respectively (Table 3). Most of the genotypes observed with the positive correlation between Fe and Zn. Thus the selection of Fe rich genotypes would also be increase the grain Zn content simultaneously (Pujar *et al*., 2020 and Govindaraj *et al*. 2013). Hence the lines with high Fe and Zn content can be used as hybrid parents and may also helps in further genetic investigations in Pearl millet.

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Table 1. Categorization of Pearl millet genotypes for Fe content through Prussian Blue Staining method

S No	Colour intensity	Stain score	Entries
1.	More intense blue colour	3	**Dhanasakthi (check)**, ICMB 101881, ICMB 102059, ICMB 102069, ICMR 10048, ICMR 101206, ICMR 100187, ICMR 102504, ICMR 15222, ICMR 103090,, ICMR 103100, ICMR 103111, PT 5123, PT 5531, PT 6476
2.	Medium intense blue colour	2	ICMB 101878, ICMB 102056, ICMB 102065, ICMB 102068, ICMB 101601, ICMB 88004, ICMB 98222, ICMB 00888, ICMB 04888, ICMB 1508, ICMR 103092, PT 5113, PT 5318, PT 5367, PT 5369, PT 5188
3.	No colour	1	ICMB 92111, ICMB 07999, ICMR 102543, PT 6710, PT 6129

Table 2. Categorization of Pearl millet genotypes for Zn content through DTZ Staining method

S No	Colour intensity	Stain score	Entries
1.	More intense red colour	3	**Dhanasakthi (check)**, ICMB 101881, ICMB 98222, ICMR 10048, ICMR 101206, PT 5531, PT 6476
2.	Medium intense red colour	2	ICMB 102059, ICMB 102069, ICMR 100187, ICMR 102504, ICMR 15222, ICMR 103090, ICMR 103100, ICMR 103111, PT 5123, ICMB 101878, ICMB 102056, ICMB 102065, ICMB 102068, ICMB 101601, ICMB 00888, ICMB 04888, ICMB 1508, PT 5113, PT 5318, PT 5367, PT 5369, PT 5188, PT 6129
3.	Less intense red colour	1	ICMB 88004, ICMR 103092, ICMB 92111, ICMB 07999, ICMR 102543, PT 6710

Table 3. Grouping of genotypes for Fe and Zn content through rapid screening method

Fe and Zn category	Entries
High Fe and high Zn	**Dhanasakthi (check),** ICMB 10881, ICMR 10048, ICMR 101206, PT 5531, PT 6476
High Fe and Medium Zn	ICMB 102059, ICMB 102069, ICMR 100187, ICMR 102504, ICMR 15222, ICMR 103090, ICMR 103100, ICMR 103111, PT 5123
Medium Fe and High Zn	ICMB 98222

Low Fe and medium Zn	PT 6129
Medium Fe and medium Zn	ICMB 101878, ICMB 102056, ICMB 102065, ICMB 102068, ICMB 101601, ICMB 00888, ICMB 04888, ICMB 1508, PT 5113, PT 5318, PT 5367, PT 5369, PT 5188
Medium Fe and low Zn	ICMB 88004, ICMR 103092
Low Fe and low Zn	ICMB 92111, ICMB 07999, ICMR 102543, PT 6710

Fig. 1. Differential Prussian blue staining of pearl millet grain flour with varying levels of grain Fe content

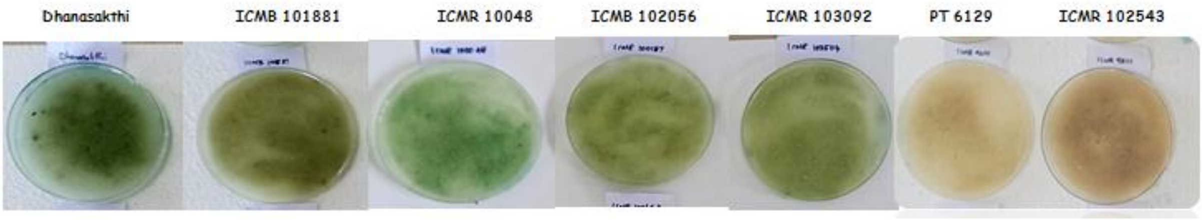

Fig. 2. Differential DTZ staining of pearl millet grain flour with varying levels of grain Fe content

T1-49

Assessment of Pearl millet genotypes for drought tolerance at seedling stages by Polyethylene glycol (PEG) 6000

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Abstract

Pearl millet is one of the most important cereals grown in drought-prone areas and is the staple grain for million of people in West Africa and India. It encompasses the potential to produce a higher biomass with better grain quality. Although, its natural habitat pertains drought tolerance, there is a significant reduction in plant stand due to the water stress imposed during the initial growth stage. This experiment was aimed to screen the Pearl millet genotypes for drought tolerance at seedling stages with different level of osmotic stress viz., -3, -5, -7.5 and -10 bars using PEG 6000. The results indicated a significant reduction in germination %, shoot length, root length and seedling vigour index under higher osmotic stress. The genotypes PT6029,PT6067 and ICMB 99222 were superior for their germination percentage and seedling vigour index under -7.5 bar osmotic stress condition. Hence, the system used in this study appeared to be a simple, rapid and cost effective method for screening seedling traits response to water stress condition to improve the drought tolerance in pearl millet.

Keywords: Pearl millet, PEG-6000 osmotic stress, Germination Percentage,seedling vigour index and drought tolerance

Introduction

Pearl millet [*Pennisetumglaucum* (L.) R. Br.] is one of the most important millet crops suitable for arid and semi-arid tropics of the country. Drought is an unpredictable natural phenomenon which can adversely affect the crop growth and yield. Climate change and early cessation of rainfall leads to crop failure under rainfed farming systems. Even though pearl millet is known for drought tolerance, if drought occurs at the initial and terminal growth stage, crop yield is ultimately affected.In laboratory conditions, using osmotic solution is one of the best methods for drought screening. PEG 6000 mediated screening is the rapid, easy and costeffective method to identify drought tolerant genotypes. PEG 6000 limits the availability of water to the germinating seeds as that of dry soil leading to reduced germination, root length and shoot length. Tolerant genotypes are capable of increasing their root length to maintain seedling vigour under higher osmotic potential.

Materials and Methods

The experimental material consists of eight genotypes including maintainer and restorer lines were subjected to drought tolerance studies with PEG 6000.The treatment concentrations viz.,0,-3,-5,-7.5,-10 bars osmotic pressure were created in the genotypes under laboratory conditions in petridishes in the Department of Millets,TNAU,Coimbatore.The seedling parameters viz.,germination percentage, root length (cm), shoot length (cm) and root shoot ratiowere recorded on 10th day of treatment imposement.The experiment was conducted in CRD and analysed in Factorial experiment.The seedling vigour index (SVI) was calculated as follows:

SVI = Germination Per cent × (Shoot length + Root Length).

Results and Discussion

In the present study, the analysis of variance showed that there is a significant difference for all the seedling traits of pearl millet under different osmotic stress levels. Germination is the initial process that gets affected by the stress conditions and the expression of this stress can easily be observed by means of their root and shoot length.Water deficit in soil affects the germination of seed and the further growth of seedlings negatively. The mean performance of pearl millet genotypes are given in the table1. Among the genotypes screened at varying osmotic stress conditions,IMB99222 was observed to exhibit a better performance in control and lower stress conditions (-3.0 and -5.0 bar). Considering the higher stress level at -7.5 bar, PT6029,PT6067 and ICMB99222 was found to exhibit an good germination of 70 per cent. Therefore, PT6029,PT6067 and ICMB99222 could be identified as better germinating lines under higher osmotic stress conditions.The early vigour of seedling can increase the crop water use efficiency. the selection of drought tolerant hybrids based on high seedling vigour index under higher osmotic stress would be fruitful. Among the genotypes, PT6679 was found to have a higher SVI under control and PT6067 has higher SVI under stress(-3 and -5 bar).PT6067,PT6313,PTPT6475 has higher SVI under higher stress(-7.5 bar).

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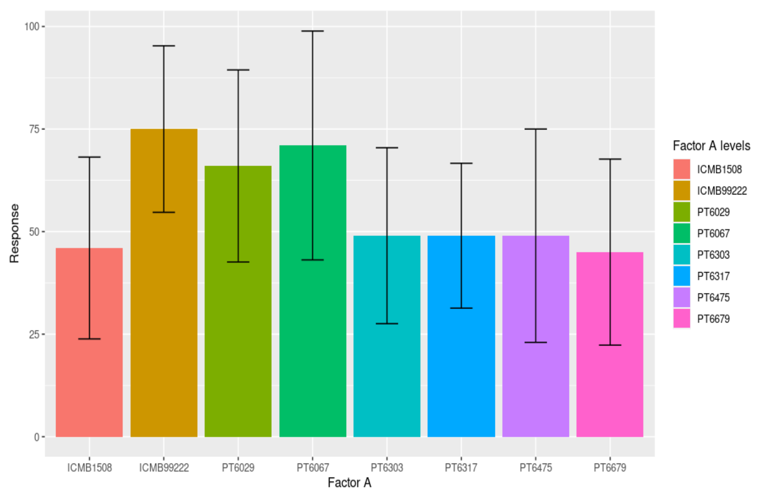
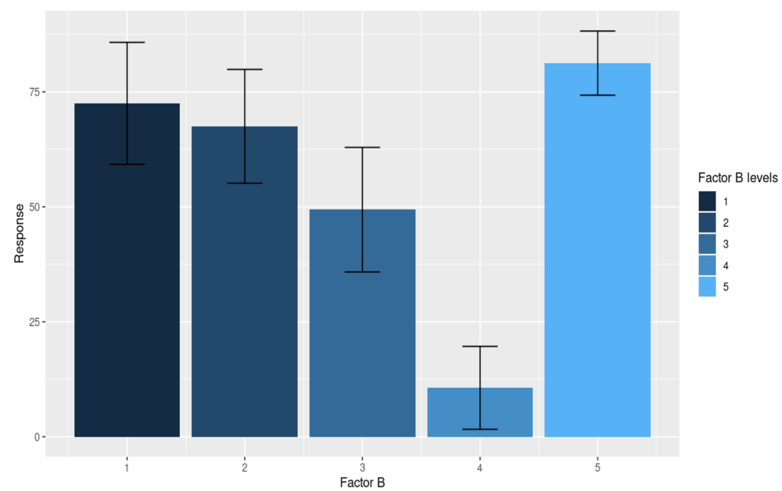
Mean performance of pearl millet genotypes on seedling traits under PEG induces osmotic stress conditions

GENOTYPES	GERMINATION PERCENTAGE					ROOT LENGTH(cm)					SHOOT LENGTH(mm)					ROOT SHOOT RATIO					SEEDLING VIGOUR INDEX				
	WATER POTENTIAL(Bars)					WATER POTENTIAL(Bars)					WATER POTENTIAL(Bars)					WATER POTENTIAL(Bars)					WATER POTENTIAL(Bars)				
	0	-3	-5	-7.5	-10	0	-3	-5	-7.5	-10	0	-3	-5	-7.5	-10	0	-3	-5	-7.5	-10	0	-3	-5	-7.5	-10
PT6029	90	45	95	60	40	8.9	2.1	3.5	1.74	1.04	8.36	2.99	4.62	1.35	.37	1	0.3	0.7	2.1	2.8	1569	466.5	772.5	185.5	55
PT6067	90	95	100	70	0	7.5	4.3	6.2	2.22	0	9.66	4.19	5.26	2.28	0	0.7	1	1.1	1	0	1551	821	1153.5	316.2	0
PT6303	70	75	50	50	0	12.4	4.2	2.7	1.39	0	9.31	4.07	2.85	1.54	0	1.3	1	0.9	0.8	0	1544	626.5	249	146.5	0
PT6317	65	65	60	50	5	7.8	3.4	4.0	3.42	.3	7.3	3.46	3.6	2.95	.4	1	1	1.1	1.1	0.3	975	446	461.5	320	7
PT6475	85	55	65	40	0	10.9	4.7	4.8	2.36	0	9.01	5.22	4.66	2.09	0	1.2	0.8	1	0.5	0	1702.5	551.5	625.5	356.5	0
PT6679	85	65	50	20	5	9.2	3.7	2.2	1.85	.3	11.7	5.34	3.02	2.66	.2	0.7	0.6	0.7	0.7	0.7	1779.5	588.5	254	96.5	5
ICMB1508	70	80	45	35	0	6.7	1.8	2.7	2.24	0	7.14	2.58	2.85	2.06	0	0.9	0.7	0.9	1	0	991	354	272	155	0
ICMB99222	95	100	75	70	35	9.6	5.7	3.6	1.09	.65	6.07	4.13	2.89	1.34	.23	1.6	1.3	1.2	0.9	2.8	1501	988.5	494	160.3	31.5
SEd(G)			8.03					.49					.481					0.19					94.9		
SEd(T)			6.34					.391					.38					0.15					75.0		
SEd(G*T)			17.9					1.10					1.07					0.44					212.2		
CD(5%)(G)			16.3					1.0					.972					0.39					191.8		
CD(5%)(T)			12.8					.791					.769					0.31					151.7		
CD(5%)(G*T)			36.2					2.23					2.17					0.89					429		





T1-50

Genetic studies on yield contributing characters in F_4 population of Red Sorghum

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Abstract

Sorghum is a staple food in the drier parts of tropical Asia, Africa and grows well in dry regionsl. However, the production status of Sorghum is far below its potential. This study aimed to assess the genetic variability, heritability, and genetic advance as a percentage of the mean in red sorghum genotypes resulting from a cross between Paiyur 2 x Paiyur.RS.16.07 with data on thirteen quantitative traits. The analysis of variability showed a low level of variation for traits such as plant height, number of leaves, leaf length, days to maturity, days to fifty percent flowering, and panicle weight. However, moderate levels of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were observed for traits like leaf width, stem girth, panicle length, panicle width, number of primary branches, test weight, and single plant yield. High heritability accompanied with significant genetic advance was observed for leaf width, stem girth, panicle length, panicle width, number of primary branches, test weight, and single plant yield. The minimal difference between the phenotypic and genotypic coefficients of variation for all traits indicated that environmental factors had a minimal impact on the expression of those characteristics.

Keywords: GCV, PCV, heritability, genetic advance.

Introduction

Sorghum (*Sorghum bicolor)* is mainly cultivated for its grains. These grains have various uses including human and livestock consumption as well as ethanol production. Among cereal crops, sorghum ranks fifth in global importance after maize, rice, wheat, and barley (FAOSTAT 2021). In terms of nutrition, sorghum is highly valuable and comparable to other cereals, earning it the label of "nutritious grain" (Aruna *et al.,* 2020). It is rich in secondary metabolites which contribute to its resilience against various biotic and abiotic stresses in the environment. Red sorghum has significant potential as a stable food colorant, even under high temperatures and alkaline pH levels.

Assessing the variation within a population is crucial for improving desired traits through breeding programs. The initial step involves estimating the true breeding value by differentiating genetic variance from phenotypic variance and eliminating environmental factors. Various parameters, such as PCV, GCV, heritability (h2), genetic advance, and genetic advance per cent mean (GAPM), are computed to analyze the characteristics. These calculations provide valuable information on the genetic potential of the population, aiding breeders in making informed decisions regarding selection and breeding strategies. This study was conducted to identify the best performing genotypes among the F_4 generation of red sorghum genotypes. This was achieved through variability.

Materials and Methods

The plant materials consisted of individual plant progenies obtained from a cross between red sorghum varieties, Paiyur 2 and Paiyur.RS.16.07. These populations were evaluated in the F_4 generation during the *rabi*, 2021 at the Agricultural College and Research Institute in Madurai. Thirteen quantitative traits were observed for the selected populations including days to fifty percent flowering (DFF), days to maturity (DM), plant height (PH), number of leaves per plant (NL), leaf length (LL), leaf width (LW), stem girth (SG), number of primary branches per panicle (NPB), panicle length without peduncle (PL), panicle width (PWd), panicle weight (PWt), test weight (TW), and single plant yield (SPY). Descriptive statistics for these thirteen traits were computed using Microsoft Excel 2021. Variability parameters such as genotypic coefficient of variation, phenotypic coefficient of variation, genetic advance, and heritability were calculated using TNAUSTAT software.

Results and Discussion

In this study, the progenies exhibited a superior mean performance in most of the yield-contributing traits such as the number of leaves, leaf length, and leaf width compared to Paiyur 2 indicating an improved source-sink relationship compared to the check variety.

In this study, PCV was generally higher than the corresponding GCV for all the traits assessed. Moderate estimates of PCV and GCV were observed for leaf length (PCV=15.72%, GCV=14.69%) and panicle width (PCV=15.18%, GCV=13.93%) which indicated that these characters would be influenced by environment to some extent. Similar findings were reported by Sheetal *et al*. (2021) and Tamirat *et al*. (2021). In the progenies, level of variation between GCV and PCV was negligible. This suggested that the influence of environmental variation on the quantitative traits was minimum.

Heritability and genetic advance play crucial role in the selection process as they determine the amount of information passed from parents to offspring. In this study, leaf length, panicle width, and single plant yield demonstrated high heritability accompanied by high genetic advance, indicating higher influence of additive gene action. Hence, selection would be particularly effective for improving these traits. This finding was consistent with previous studies conducted by Mamo (2020) and Shivaprasad *et al.* (2019). Similarly, leaf width, days to maturity, panicle weight, and the number of primary branches exhibited high heritability with moderate genetic advance suggesting that both genetic factors and environmental effects might have contributed to the observed heritability. Previous studies conducted by Mamo *et al.* (2020) and Ravali *et al.* (2021) also reported similar results of high heritability and moderate genetic advance for panicle weight and Nirosh *et al.* (2021) for days to maturity.

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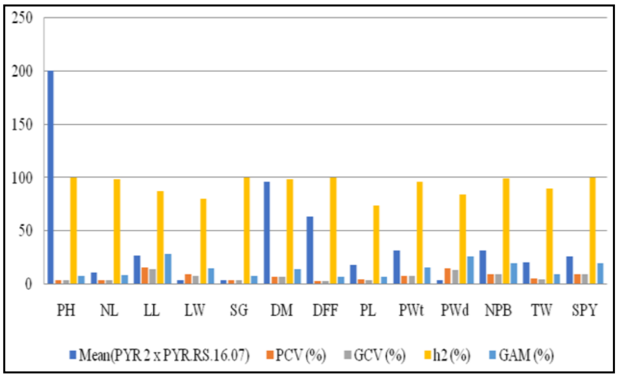
Table 1. Genetic variability estimates of the thirteen quantitative traits in F_4 population of red sorghum

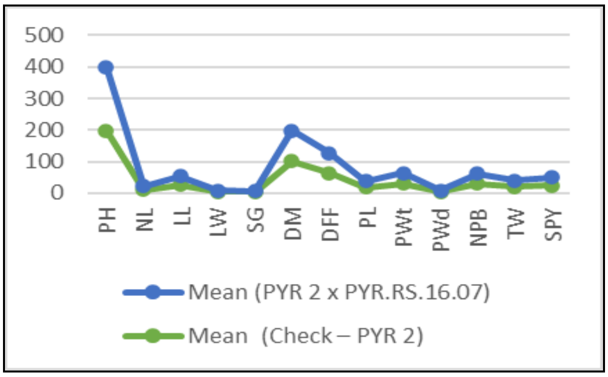
Character	Mean (Check – PYR 2)	Mean (PYR 2 x PYR.RS.16.07)	PCV (%)	GCV (%)	h^2(%)	GAM (%)
PH	198.9	200.95	3.99	3.98	99.97	8.24
NL	10.5	10.8	4.25	4.23	98.82	8.67
LL	25.1	27.44	15.72	14.69	87.34	28.27
LW	3.7	3.87	9.3	8.35	80.74	15.46
SG	2.1	3.62	3.82	3.82	99.96	7.87
DM	101	96.3	6.94	6.91	99.02	14.17
DFF	63	64	3.47	3.46	99.95	7.14
PL	18.84	18.35	4.56	3.93	74.22	6.98
PWt	30.73	32.1	7.97	7.81	96.14	15.78
PWd	3.74	3.72	15.18	13.93	84.27	26.34
NPB	30.03	32.1	9.61	9.58	99.33	19.67
TW	20.16	20.44	5.35	5.08	90.18	9.94
SPY	22.96	25.97	9.77	9.76	99.98	20.13

DFF - Days to fifty percent flowering ; DM -Days to maturity; PH- Plant height; NL- Number of leaves per plant;LL- Leaf length; LW- Leaf width; SG- Stem girth; NPB -Number of primary branches per panicle; PL- Panicle length without peduncle ; PWd -Panicle width; PWt- Panicle weight; TW-Test weight; SPY- Single plant

Fig. 1a. Genetic variability parameters in red sorghum



1b. Mean performance of F_4 progenies and check



T1-51

Polyethylene Glycol Screening of Sorghum (*Sorghum bicolor* L. Moench) Genotypes for Drought Tolerance at Seedling Stage

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Abstract

Sorghum is one of the most important staple food crop in semi- arid and arid regions which are often prone to unpredictable climate change. Though sorghum can withstand drought, it may create crop failure upon the crop exposure to heat and water stress at their critical stages. Hence it is necessary to identify the drought tolerant genotype that are suitable to cultivate in this regions. The screening was done under artificial drought condition that was initiated by polyethylene glycol (PEG) 6000 at different concentrations like control, 10%, 15% and 20% to induce osmotic potential at -2 bars, -3 bars and -5 bars respectively. Among 25 genotypes taken, B35, TNS661, K8, Madurai kattai vellai, Muthaiyampalayam, Nainagaram, PYR(RS)16-3 and Tenkasi local are performing well even in -5 bars with high shoot length, root length, root-shoot length ratio and seed vigour index. Thus, this genotypes can be used for furthur evaluation on drought tolerance at upcoming critical stages sorghum.

Keywords: sorghum, drought, PEG screening, shoot-root length ratio, seed vigour index (SVI)

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is widely used as food, feed, fibre, and bioenergy crop. The grain is used as food or feed; the stem can be used as a source of fibre, fuel, and lately as feedstock for cellulosic ethanol.It is an important crop in the semi-arid and arid regions of South Asia and sub-Saharan Africa that are subjected to frequent droughts, low and erratic rainfall and high mean temperature.

Drought is defined as a prolonged shortage of plant available water, primarily due to insufficient rainfall or precipitation. It can also occur due to exceptionally high temperatures and low humidity driving the evapo transpiration in plants. Drought is one of the significant environmental factors affecting crop growth and productivity worldwide.

Drought stress affects almost all the developmental stages of a plant, however seed germination and early seedling growth phase and reproductive stages are highly sensitive and critical, in sorghum.. Sorghum is identified as moderately tolerant to drought and mostly grown as rainfed crop in tropical regions. Drought at different stages may affect the yield of sorghum, about 28% of the total sorghum cultivated area is affected by drought. Hence, screening at early stage of crop establishment i.e., at the time of germination was done.

Materials and Methods

Twenty five accessions that are used in this experiment are received from the Department of Millets, TNAU, Coimbatore. Polyethylene glycol (PEG) 6000 MW is a water soluble, molecular compound that create water stress by lowering water potential in root.

This polymer interferes with the root in water absorption by decreasing osmotic potential. The screening was done under artificial drought condition that was initiated by polyethylene glycol (PEG) 6000 at different concentrations like control, 10%, 15% and 20% to induce osmotic potential at -2 bars, -3 bars and -5 bars respectively. This experiment was designed in Complete Randomized (CRD) fashion. A volume of 7.5 ml of each concentration of PEG6000 and control (distilled water) solution was poured in petri-plates to moisten the germination sheet that placed on it. Before the seeds were placed on the germination sheet under aseptic condition they were treated in 0.1% sodium hypochloride solution for two minutes for surface sterilization purpose. These petri-plates were kept undistubed for one week. On 8^{th} day after inoculation, the seedlings characters like germination percentage, shoot length, root length were observed.

Results and Discussion

From the analysis of variance (ANOVA), it was concluded that there was a significant difference between all seedling characters observed during the course time of this experiment (table: 1).

Drought is one of the major constrains that cause yield loss though sorghum naturally blessed with drought tolerance, it is also affected by heat stress at critical stages. The non-ionic solution of PEG6000 was used to create osmotic stress at the germination stage of sorghum crop. The germination percentage decreased with increase in the concentration of PEG 6000. B35, K8, Nainagaram and Tenkasi local genotypes had not showed any difference in germination percentage till -5 bars with 80% and genotypes like CO32, IS 18551, Dhummanakanpatti local and Kalugumalai with 0% germination percentage. It was followed by M35-1, CO26, TNS661, Edappadi, Kalakuruchi, Madurai kattai velai, Muthaiyampalayam, PYR(RS)16-3 and Vilathikulam with 70-60%.

The shoot and root length ratio of seedlings were also tend to decrease along with the increased concentration of treatment solution. The sensitive genotypes like CO26, Edappadi local and Kalakuruchi drastically decreased with the raise in osmotic stress.

A small change in the water potential drastically influences the Seedling vigour index (SVI). Thus, the entries CO32, K11, IS 1551,Chinnamanjal cholam, Dhummanayakanpatti, Edappadi local and Kalugumalai were displaying very low SVI than tolerant entries B35, Maduraikattai vellai, Muthaiyampalayam, PYR(RS)16-3 and Tenkasi local. From *fig.1* the superior performance of B35 and Tenkasi local on SVI traits are evident.

Among 25 genotypes taken, B35, TNS661, K8, Madurai kattai vellai, Muthaiyampalayam, Nainagaram, PYR(RS)16-3 and Tenkasi local that plays uniqueness game by showing higher germination percentage, shoot – root length ratio and SVI.

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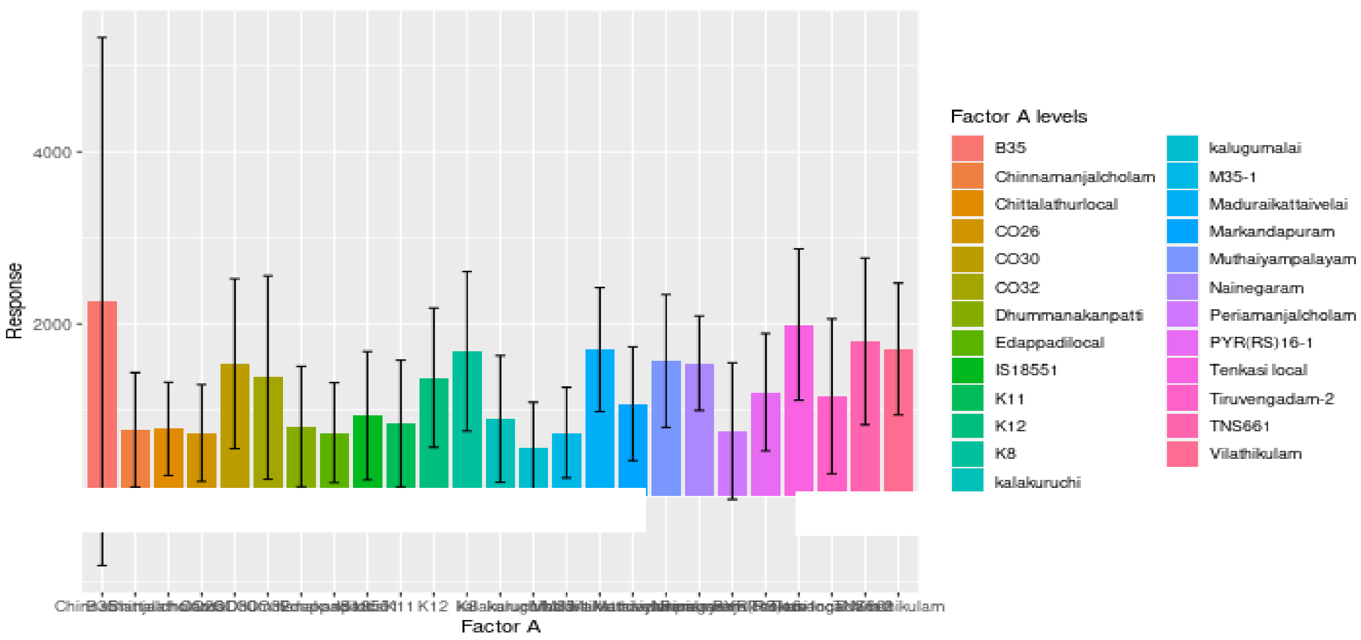
Table 1. Two factor analysis of variance (ANOVA) for seedling traits of sorghum under different PEG 6000 concentration

Source	df	Mean Sum of Square				
		Germination percentage	**Shoot length**	**Root length**	**Root-shoot length ratio**	**Seedling vigour index (SVI)**
Genotype	24	1618.875**	31.983**	117.669**	5.338**	1778555.9**
Treatment	3	27076.500**	714.140**	1326.697**	0.691**	42482644.4**
G x T	72	276.153**	3.753**	54.274	1.312	612466.4**
Error	100	124.500	1.460	55.202	0.336	631766.5

** Significant at 1% probability level

Fig. 1. Interaction between genotypes and SVI



T1-52

Cross-genera transferability of Foxtail Millet, pearl millet and rice genomic SSRs to Kodo Millet (*Paspalum scrobiculatum* L.)

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Abstract

Kodo millet is an important crop from nutritional point of view, nevertheless, the genetic information is very scarce. In the present investigation, foxtail millet, pearl millet and rice genomic SSRs were used for assessing cross transferability, identification of polymorphic markers and genetic diversity analysis of 103 kodo millet genotypes. The cross-genome transferability of 11 SSR markers of foxtail millet, 44 SSR markers of pearl millet and 6 SSR markers of rice were analyzed in 103 genotypes. Cross transferability of 81.81% was observed for foxtail millet SSRs, of which 22.22% were polymorphic, while 75% of pearl millet markers were cross transferable with 24.24% polymorphic out of them. The PIC values varied from 0.05 (PSMP 2201) to 0.99 (b109) at an average of 0.572. SSR data of foxtail millet and pearl millet combined together grouped the genotypes into 21 clusters. Cluster III was the largest comprising of 31 genotypes and the clusters VI, VIII, XI, XV, XVI, XVII, XVIII, XIX, XX and XXI included solitary genotype. This study would pay the way to understand the genetic structure and the identified SSR markers can also be used for further studies on analysis of germplasm characterization and population structure analysis.

Keywords: Kodo millet, germplasm, SSR markers, cross-genera transferability, molecular diversity

Introduction

Kodo millet is an important tetraploid (2n = 4x = 40) millet crop with genome size of 1.91 – 1.98 pg (Burton, 1940; Jarret *et al.* 1995). It is drought tolerant crop, rich in nutritional properties, also used as food and fodder purposes. Though, the crop has several advantages than other cereals, the genomic studies in kodo millet is very meagre in comparison to other small millets (Kushwaha *et al.* 2015). Development of new SSR markers requires high cost for sequencing and other related techniques, therefore identifying the suitable genomic SSRs in kodo millet through cross-transferability from the closely related species is very useful. Thus, this research was focused to study the cross-transferability of 61 SSR markers to amplify microsatellite loci in kodo millet and validated by assessing the genetic diversity among the 103 kodo millet genotypes.

Materials and Methods

The material for this study included 103 kodo millet germplasm were selected from the Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, India. The genomic DNA was isolated from the young leaves using modified CTAB (Cetyl Trimethyl Ammonium Bromide) method (Zidani, 2005). The kodo millet genotypes were genotyped with 61 SSR markers selected from foxtail millet (11 markers), pearl millet (44 markers) and rice (6 markers). Polymorphism information content (PIC) for each SSR marker was calculated by using the formula: PIC=1-Σpi^2. The scored binary results were used to analyze the genetic similarity and constructed a dendrogram using NTSYSpc-2.0 software package (Rohlf, 2001). The similarity coefficients were used for cluster analysis and dendrogram was constructed by the UPGMA (Unweighted pair group method with arithmetic mean) (Sneath and Sokal, 1973).

Results and Discussion

A set of 61 genomic SSR markers were used to amplify DNA in 103 kodo millet genotypes. Nine markers in foxtail millet (81.81%) and 33 markers in pearl millet (75.00%) produced clear and scorable amplicons among all the genotypes. This cross transferability indicated that the usefulness of genomic SSR markers of foxtail and pearl millet in kodo millet genome. Two markers from nine foxtail millet markers and eight markers from 33 pearl millet markers were produced clear, scorable polymorphic marker profile and used for studying genetic diversity at molecular level (Table 1). Polymorphic information content generated by the polymorphic primers ranged from 0.05 in PSMP 2201 to 0.99 in b109 with an average of 0.572. Based on the Jaccard's similarity coefficient, 103 genotypes were grouped into 21 clusters. Cluster III was the largest comprising of 31 genotypes indicating high degree of similarity between these genotypes. The genotypes such as TNAU 137, RK 50, APK 1, TNAU 177, TNAU 194, TNAU 174, TNAU 149, TNAU 180 and TNAU 201 formed solitary clusters. This is in accordance with the findings of Naga *et al.* (2012) in finger millet. The study enriched the kodo millet genomics by studying the cross-transferability and identifying the suitable polymorphic markers which can be used for genotype identification and diversity analysis.

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Table 1. Comparison of polymorphism parameters of foxtail millet, pearl millet and rice microsatellite markers in kodo millet genotypes

S. No.	Genetic polymorphism parameters	Foxtail millet	Pearl millet	Rice
1.	Total markers used for amplification	11	44	6
2.	Total amplified markers	9 (81.81%)	33 (75.00%)	0
3.	Total polymorphic markers	2	8	0
4.	Percentage of polymorphism	22.22%	24.24%	-
5.	Mean allele number	3.00	2.87	-
6.	Minimum allele number	3	2	-
7.	Maximum allele number	3	4	-
8.	Mean PIC	0.65	0.55	-
9.	Minimum PIC	0.32	0.05	-
10.	Maximum PIC	0.99	0.98	-

Theme 1

Genetic enhancement of millets through crop improvement and genomic approaches

Abstracts

T1-53

Assessing the genetic potential of drought tolerance in Pearl millet [*Pennisetum glaucum* (L.) R Br]

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Abstract

Pearl millet being monocotyledon exhibits fibrous root system. Initially, the roots sense a water shortage therefore it is the main organ to improve crop tolerance to moisture stress. Root architectural study was rare in pearl millet due to the difficulty in taking direct measurements under the soil. Among the millets, pearl millet has more drought tolerance due to its evolution. It is mostly cultivated as rainfed crop. Though, it is notable for its drought tolerance, moisture stress at early and terminal developmental stage affects the yield. Hence, drought tolerant crop is necessary to withstand extended drought period with increased grain yield. The present experiment was carried out at Department of Millets, Tamil Nadu Agricultural University, Coimbatore during 2021-2022. A set of thirty-three elite pearl millet genotypes were assessed for drought tolerance and grain yield through morphometric, physiological and root system architectural traits and analyzed for variability and assessment of genetic potential.

The analysis of variance for morphometric, physiological and root system architectural traits exhibited that the effect of genotype all the observed traits except average root width and network bushiness had significant variations among the genotypes. There are significant variations observed among the treatments for all the traits except spike girth, average root width, network bushiness and leaf length. The effect of interactions between genotypes and treatments had significant variations in all the traits observed except spike girth, average root width, network bushiness, maximum number of roots, median number of roots and leaf length. Based on mean performance, the genotypes significantly performed under both irrigated and drought conditions for yield and its contributing traits were MP 7878, ICMB 10444, PT 5721, PT 6679 and Nattu cumbu. These genotypes were suggested for utilizing in the further breeding programme. The genotype ICMB 99222 and Kattu cumbu 1 were found be drought susceptible and it needs better environments for expressing its full genetic potential.

T1-54

Demonstration of COHM 6 maize hybrid cultivation in Kanyakumari District

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Abstract

Maize (Zea mays L.) is an important coarse cereal cultivated in 150 mha of about 160 countries in the world. It is known as the queen of cereals as it has highest genetic potential among the cereals. Maize has wider adaptability under varied agro climatic zones. The USA is the largest producer of Maize accounting for 35% of global production with the

highest productivity of 9-10 tonnes/ha. In India Maize Is the third most important food crop after wheat and rice. In India it is cultivated in an area of 8.7 mha and contributes nearly 9% to the national food basket and provide employment to over 100 million man days at the farm and agricultural and industrial sector.In Kanyakumari district, cultivation of maize is in negligible area. Being an important crop utilized as food, feed, fodder and industrial raw material, cu;tivation of maize in the district needs to be promoted. In this context, cultivation of maize hybrid COHM 6 was demonstrated with integrated crop management practices in 10 farmers holdings each with one acre. The management practices adopted were ; seed treatment with Azospirillum, soil test based application of fertilizers and foliar spray of Maize maxim @ 2lit /ac.The yield and yield parameters viz., Cob weight, grain yield, stover yield, Net return and BC ratio were recorded. The cob weight ranged from 200 – 350 g with a mean of 312.4 g. The mean grain yield was 3200 kg and stover yield was 7750 kg/ha. The net return recorded was Rs.81280/ha with a benefit cost ratio of 3.3. According to the farmers feed back the net return obtained by cultivation of maize was more than rice cultivation and is achieved in lesser duration of 90 days and minimum management practices than rice cultivation.Hence, cultivation of Maize hybrid COHM 6 in Kanyakumari district is found to be more remunerative than rice cultivation. Maize cultivation can also promoted in Coconut based cropping system as intercrop with an additional income of Rs.50000/ha apart from supplying nutritive green fodder for domestic livestock.

T1-55

Characterization and evaluation of red sorghum (*Sorghum bicolor*) germplasm and land races

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Abstract

A field experiment was carried out for characterization of 14 local land races of sorghum collected from the farmers field of Dharmapuri and Krishnagiri districts and 16 accessions obtained from the Department of Plant Genetic Resources, TNAU, Coimbatore. The accessions were raised along with two prominent checks Paiyur 1 and Paiyur 2. Eleven qualitative characters, 22 quantitative characters and six drought tolerant traits were recorded in the genotypes. The results of characterization revealed that the land races 16-05 (RS), 2457, 16-01 (RS), 2657 and 4269 were early (82-85 days) flowering, high yielding (28 to 29.3g/plant), having high photosynthetic rate, (38.6 umolm^{2} s^{-1}), high Proline content (394 ugg^{-1}) and high soluble protein content (14.4 mgg^{-1}). The observations made it clear that these five land races possessed all the criteria to meet out the criteria for a short duration, drought tolerant and high yielding cultivar. The selected line could be used as a parent in future crossing programme to develop a promising hybrid with high yield, earliness and drought tolerance.

Keywords: Sorghum, characterization and land races

T1-56

Assessment of molecular diversity in elite finger millet lines revealed by RAPD, ISSR and SSR Markers

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Abstract

Molecular characterization of genotypes is made possible by DNA markers because they provide more accurate information on genetic relationships than other markers India has tremendous genetic diversity in finger millet. When analysing genetic diversity, PCR-based markers like RAPD and ISSR markers have been very useful because they have a high frequency of polymorphism, which are simple to use technically, require only a small amount of DNA, don't require knowledge of the DNA sequence in advance and are automatable. Molecular analysis was performed for seventeen finger millet genotypes. In the present investigation, among the four SSR markers, two markers showed polymorphism and among the seven RAPD markers, a total of ninety-five bands were produced in which 38 bands were polymorphic and for ISSR primers, average of eighty-nine amplified DNA bands were observed. The number of alleles produced in SSR marker ranged from one to three. The number of bands per RAPD ranged from eight (OPBE-04) to eighteen (OPBE-09). Totally eighty-nine bands were amplified for ISSR markers. For SSR marker, PIC value ranged from 0.46 to 0.65. The PIC value of the RAPD markers ranged from 0.06 to 0.24 and the PIC value of ISSR markers ranged from 0.11 to 0.36. The genotypes PYR 2 and Karunchuruttai had the highest dissimilarity index value which indicates the extent of genetic diversity present in the population in SSR marker analysis, the value of the dissimilarity index between GPU 28 and Karunchuruttai was found to be high (0.43) in RAPD marker analysis and according to the ISSR marker analysis, the genotypes GPU 48 and PR 1506 have the highest disimilarity coefficients (0.45). Dendrogram based on Unweighted Pair Group Method grouped the seventeen genotypes into six clusters in SSR marker analysis, two cluster groups in RAPD marker analysis and three groups in ISSR marker analysis.

Keywords: Molecular Diversity, Finger millet, RAPD, ISSR and SSR

T1-57

Introgression of sorghum shoot fly resistance QTLs in elite sorghum varieties using KASP markers

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Abstract

Marker assisted breeding has a great challenge in designing the host plant resistance of sorghum shoot fly resistance using the component traits like leaf glossiness and trichome density. The translation of identified SNP markers into high throughput genotyping platform makes it cost-effective. In this regard, ICRISAT designed the SNP assay for plant breeders using a set of ten SNPs linked to leaf glossiness and trichome density (shoot fly resistance trait). By using the SNP, multitrait assay 233 individuals were screned. The set of individuals comprised of K8 X IS 2205 (F_6), K8 X IS 18551 (F_5) SPV2424 x IS 9807 (F_2) families and CO(S) 28 x IS18551 (BC_3F_4 and BC_2F_4) inter varietal populations. In total, 10 SNPs markers were used in marker-assisted selection (MAS). Among the two traits linked to shoot fly resistance, the leaf glossiness locus always has strong association with snpSB000142 and snpSB000143 markers along with the high level of resistance. The trichome density character was tightly linked with the SNP markers snpSB000164 in all the population.

Keywords: Sorghum, Shoot fly, SSR, SNP (KASP)

T1-58

Effectiveness of selection in M_4 and M_5 generations for yield and yield related traits in Kodo millet (*Paspalum scrobiculatum* L.)

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Abstract

Selection and hybridization are the major focus in crop improvement. Among which, selection has a predominant role in enhancing the frequency of desirable alleles in the population. Kodo millet, being a highly self-pollinated crop completely relies on selection of induced variability for varietal development. Hence, in a view of this a study was conducted

to induce variability in kodo millet. The variety CO 3 of kodo millet was treated with EMS and gamma rays for effective selection in yield related traits from mutants. During the process of selection for yield related traits, the overall mean performance of M_5 population was found to show a significant increased to that in M_4. The major yield related traits that had exhibited a positive increase were single plant yield, number of tillers and number of seeds per panicle. Subsequently, as a result of effective selection for these traits, the selection differential and selection intensity were higher in M_5 than M_4. Regarding the fodder yield, the overall mean performance of M_5 population was lower than M_4. Thereby, the selection intensity and selection differential for fodder yield was significantly lower in M_5 than M_4. Further, although the selection was effective, the intergeneration correlation for M_4 and M_5 was positively significant. Thus, the overall variability of the population for yield related traits were retained in the subsequent generations. However, the narrow sense heritability among the M_4 and M_5 mutant population was found to be higher for number of seeds per panicle and moderate in fodder yield and number of tillers per plant. Thus, it is observed that the number of seeds per panicle was comparatively having a higher influence for yield in the subsequent generations. The genetic advance under selection was positive for all the yield and fodder related traits among the M_4 and M_5 generations. Therefore, it could be observed that the selection carried out among the different families of M_4 to M_5 was rewarding and effective for developing a higher yielding line in kodo millet.

Keywords: Kodo, mutants, Selection differential, Selection response

T1-59
Harnessing the heterotic potential of sweet corn (*Zea mays* var. *saccharata* L.) hybrids with super-sweet (shrunken 2) genes

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Abstract

The object of the study is to develop sweet corn (shrunken 2) hybrids coupled with high yield and extended shelf life. The inbreds with shrunken (*sh2)* gene, were selected based on morphological markers (shrunken kernel and lack of anthocyanin pigment at the stem base) and validated at the molecular level using the *Sh2* gene-based dominant marker, *M1-sh2.* The selected inbreds *viz.,* six lines (SC 11-07, SC 11-2, SC 1421-5-2-1, WNC 12069-2, WNC 12039-1 and USC 1-2-3-1) and five testers (MRCSC 11, WNDMRSCY 19R763, DMSC 20, 951-7 and DMSC 36) were crossed in Line × Tester mating design and the 30 hybrids were evaluated for important yield contributing traits. Relative proportion of GCA variance to SCA variance was less than unity, specifying the preponderance of non-additive gene action for all the traits studied. The lines SC 11-07, SC 11-2 and testers, MRCSC 11, WNDMRSCY 19R763 were identified as ideal parents for synthesizing high yielding hybrids with high mean and *gca* effects for green cob yield in addition to some of the yield contributing traits. The line SC 11-07 was identified as a potential parent with high total sugar content. Among the hybrids, SC 11-07 × MRCSC 11 followed by SC 11-07 × WNDMRSCY 19R763 and SC

11-2 × WNDMRSCY 19R763 were found to be the best performers with significant *per se* performance and *sca* effects and standard heterosis for green cob yield and contributing traits. Remarkably, SC 11-07 × MRCSC 11 also recorded superiority for quality traits. Hence, these hybrids could be subjected to further multi-location evaluation to assess the yield stability across varying environments and exploited for commercial cultivation.

T1-60
Millets and Tamil Sangam Literature

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Abstract

The United Nations General Assembly adopted a resolution declaring 2023 as the International Year of Millets, as proposed by India to the Food and Agriculture Organization. The purpose of this initiative is to increase the awareness of millets on health benefits among the people and their suitability for cultivation under climate change. Due recognition was given to agriculture profession in most of the Tamil literatures and Millets are interwoven with such historical markings. Sangam landscapes, particularly, *Kurinji*, *Mullai* and *Marutham* landscapes were shown to have Millets cultivation. *Tolkappiyam,* the most ancient extant Tamil grammar text and the oldest extant long work of Tamil literature, is composed of short formulaic compositions i.e., *noorpaa* in three books (*viz., Ezhuttadikaram, Solladikaram* and *Poruladikaram). Marapiyal* chapter of *Poruladikaram, noorpaa* 623 defines about eight kinds of food that were prevailing in 2000 years ago and Ilampooranar, a commentator of *Tolkappiyam* indicated that those eight kinds of food are paddy, horse gram, kodo millet, great millet, foxtail millet, little millet, forage and wheat and highlighted their importance in catering the food and nutritional needs of the ancient Tamil people. *Purananuru* (collection of poems that deal with the puram aspect of the Sangam literature (i.e., war, politics and public life), highlighted the hospitality of a housewife, who had used the stored seed stock of little millet and common millet (Kodo) to feed the needy, which is usually a uncommon practice. Besides *Purananuru* provided several proofs for millet usage in ancient Tamil culture: the main staple food of the king and his crew (who were portrayed as epitome of masculinity) was millets. It also depicted that hardy soil of *Kurinji* was used to cultivate kodo millet in the furrows dug by the wild boar and millet cuisines (prepared with distinctive ingredients, techniques and dishes) were the key offerings during ritual programs. Another famous adage in Tamil, "*thenum tenai maavum*" is usually refers to Foxtail millet flour mixed with honey and still it is the Sacred Food in the temples of Lord Muruga.Similarly, the traditional use of millets has been cited in several ancient literatures such as *Kurunthogai, Perumpanatrupadai, Pattinappalai, Mathuraikanchi* and *Thirukural* lines and it clearly depicted the prosperity of Sangam era of Tamil Nadu harnessed the benefits of millets.

T1-61

Discerning diversity among Sorghum (*Sorghum bicolor*) land races based on hierarchical cluster analysis

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Abstract

A study was undertaken to study genetic diversity among sorghum land races and to assess the association among yield contributing traits. The experimental material comprised of 30 land races collected from different districts of Tamil Nadu and Uttar Pradesh, and conserved by ICAR-IIMR, Hyderabad. The land raced were raised along with three checks (CO 30, PY 2 and K 12) in RBD with two replications, under sodic soil condition (EC: 0.95 ds/m and ESP: 43.69%) at AnbilDharmalingam Agricultural College and Research Institute, Trichy, during 2019-20 and observations were recorded on eight morphometric traits. ANOVA revealed significance of mean squares for all the traits studied suggesting existence of wide diversity among the genotypes. Hierarchical clustering of the 33 genotypes grouped them in to three broad clusters.The cluster I was composed of 13 genotypes, which were characterized by low values for the variables like plant height, panicle length and leaf length, cluster IIwas populated by 14 genotypes characterized by longer leaves and cluster IIIcomprised of six genotypes which were characterized by high values for the variables plant height, number of leaves and panicle length. The grouping of genotypes was found to be independent of their geographical origin. This non-synchrony between geographical origin and clustering pattern could be because of genetic drift and migration caused by exchange of seed materials among farming communities.The improved varieties CO 30 and PY 2 were found to be grouped with 12 other land races in cluster II, while K 12 was grouped with other land races in cluster 1. This could be because of the alikeness in performance of the improved varieties and land races for key morphological traits. Study on character association indicated that plant height and panicle length expressed strong positive correlation with grain yield per plant. Thus, based on morphological performance, genotypes in cluster III EG 85, EG 92, EG 96, EG 100, ERS 1 and ERS 2 which were characterized by better performance for the above traits, could be exploited in breeding programs aimed at developing varieties for sodic soil conditions, in view of their better performance in the said condition.

Keywords : Sorghum, diversity, hierarchical clustering, correlation

T1-62

Studies on genetic potential of pearl millet [*Pennisetum glaucum* (L.) R. Br.] parents and hybrids through combining ability analysis

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Abstract

Pearl millet is a highly cross-pollinated crop in which the development of hybrids is necessary for yield improvement. In the present study a set of six female parents (lines) and seven restorers (testers) of pearl millet were crossed in Line × Tester mating fashion during *rabi*, 2019. The newly synthesized 42 hybrids were evaluated for yield performance during summer, 2020 along with their parents. Biometrical observation on days to 50 per cent flowering, plant height (cm), number of productive tillers per plant, leaf length (cm), leaf width (cm), panicle length (cm), panicle girth (cm), 1000 grain weight (g) and single plant yield (g) were recorded and the same was subjected to analysis of combining ability. High magnitude of SCA variance for all traits indicated predominance of non-additive gene. Hence, heterosis breeding method is suggested to exploit this kind of gene action. The estimates of *gca* effects for yield and its component characters were high in the line ICMB 04111 and the tester PT 6029. Considering the *per se* performance of hybrids (significant mean), *gca*status of the parents (atleast one parent with significant positive *gca*), *sca* effect of hybrids and standard heterosis over CO 9 hybrid for yield and yield related characters, the hybrid combination ICMB 04111 × PT 6029 was identified as superior followed by ICMB 04111 × PT 6317, ICMB 15666 × PT 7043 and ICMB 99222 × PT 6029. Hence, the above hybrids could be evaluated in further yield trials and exploited commercially.

Keywords: Pearl millet, Line × Tester, combining ability and heterosis.

T1-63

Genetic variability and interrelationship between yield and yield related traits in Finger Millet (*Eleusine corocana* (L.) Gaertn.)

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Abstract

A total of 65 fingermillet entries were evaluated for yield and yield related traits in randomized complete block design with three replications. Observations were recorded in five randomly selected competitive plants per entry on nine quantitative traits . Phenotypic coefficient of variation (PCV) ranged from 9.07 to 32.21 per cent. The highest PCV was recorded by productive tillers per plant, whereas the lowest was recorded by plant height. Genotypic co-efficient of variation (GCV) followed similar trend as that of PCV. The PCV and GCV levels were high for number of productive tillers per plant and moderate for the traits

viz., days to 50 per cent flowering, days to maturity, ear length, number of finger per ear, fodder and grain yield per ha. This implied that there is a potential natural genetic variability among finger millet landraces and hence varietal improvement through conventional breeding will be successful. Maximum heritability was recorded by days to maturity (97.60%) and the minimum was recorded by the trait, numbers of fingers per ear (70.64%). The highest genetic advance as per cent of mean was expressed by the trait, number of productive tillers per plant (55.92 %) and the lowest (16.67 %) was expressed by the trait plant height. High heritability coupled with high genetic advance was observed in days to 50 per cent flowering, days to maturity, number of productive tillers per plant, ear length, number of fingers per ear, fodder yield, harvest index and grain yield per hectare, which indicated the predominance of additive gene effects. In controlling these traits, early and simple selection could be exercised due to fixable additive gene effects.

The estimated genotypic correlations for most of the characters were greater than their corresponding phenotypic ones. Grain yield was positive and significantly correlated with ear length, number of fingers per ear, fodder yield and harvest index. Path co-efficient analysis revealed that the characters ear length, number of fingers per ear, fodder yield and harvest index had positive direct effects towards grain yield.

T1-64

Identification of stable single cross hybrid in Maize (*Zea mays*.L)

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Abstract

Maize is most important cereal crop after rice in the state of Andhra Pradesh. It is being cultivated throughout the year because of its high yield potential , short duration, multiple uses and market ability. Development of a suitable single cross hybrid for cultivation in all the seasons *viz*., kharif, rabi and summer is to be given priority so that grower can use the same hybrid for cultivation round the year. Forty five single cross maize hybrids synthesized with10 inbredswere tested across three different seasons *kharif, rabi* and *summer* from 2016-17 to 2017-18at ARS , Perumallapalle. Data were recorded on agronomical and physiological traits in each season. Analysis of data pooled over three seasons by GGE biplot revealed that*rabi*season was found to be the best season(environment) for expression of kernel yield potential followed by *kharif* whereas *summer* season was identified as the most unfavourable season. The hybrids *viz.,*DFTY × PDM 1452, BML 2 × Heypool, PDM 1452 × PDM 1474,BML 2 × BML 7 and DFTY × PDM 1428 were found to be moderately stable across seasons based onkernel yield and most of the yield components besides early in maturity while DFTY × Heypool, Heypool × PDM 1474 and BML 15 × PDM 1452 were found suitable for *kharif.,* DFTY × PDM 1452 and PDM 1452 × PDM 1474 for *rabi* and PDM 1452 × PDM 1474 for *summer* season. The single cross hybrids identified as moderately stable involved atleast one parental inbred line as the best general combiner. They also recorded higher mean, kernel yield higher *sca* and percent standard heterosis. The parental inbred lines also possessed higher frequency of favourable alleles for grain yield, no.of kernels per cob, no.of kernel rows per cob and 100 kernel weight.

Keywords: Maize single cross hybrids , GGE biplot, kernel yield and heterosis.

T1-65

Association studies between morpho-physiological traits and grain yield in Sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract

In this present investigation, a simple correlation was worked out between seventeen morpho-physiological traits and grain yield for 102 sorghum germplasm accessions. The experiment was laid at augmented design with seven checks during summer 2021at Department of Millets, Tamil Nadu Agricultural University, Coimbatore. Traits *viz*., plant height, days to 50% flowering, stem diameter, number of leaves, leaf length, leaf breadth, panicle length, days to maturity, hundred seed weight, SPAD chlorophyll content, leaf area, leaf area index, soluble protein, and grain yield per plant were measured from five randomly selected plants. Grain yield had a significant and positive correlation with hundred seed weight, flag leaf length, flag leaf area, flag leaf breadth and stem diameter. It had a significant and negative correlation with plant height and days to maturity. Plant height had a significant and positive correlation with days to maturity, days to 50% flowering, number of leaves, stem diameter, leaf length, panicle length, leaf area and leaf area index. Days to 50% flowering had a significant positive association with days to maturity. Stem diameter had significant and positive association with leaf area, leaf area index, number of leaves, leaf breadth, flag leaf area, flag leaf breadth, flag leaf length, days to maturity, leaf length and hundred seed weight. Leaf area index had a significant and positive correlation with leaf area. Soluble protein had significant negative correlation with leaf area index.

Keywords: Sorghum, Association, germplasm, morpho-physiological traits

T1-66

Influence of sodium/potassium ratio on Barnyard Millet [*Echinochloa frumentacea* (Roxb.) Link] yield under Sodicity

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Abstract

Barnyard millet is an important nutri-rich crop grown for both food and fodder. Being a millet crop, it is known for its adaptation to various growing conditions. Sodicity is one of the major abiotic- stress which influence the yield of barnyard millet. Reduced aeration under high sodium results in anoxic or hypoxic conditions for roots which unfavourably influences crop performance. Estimation of sodium/potassium ratio provides reliable knowledge for

selecting best genotypes under sodic condition. Hence, a study was carried out to identify sodicity tolerant barnyard millet from 20 germplasm accessions at Anbil Dharmalingam Agricultural College and Research Institute, Trichy, Tamil Nadu during January 2018. The EC and pH of the irrigated water are 4.9dS/m and 7.6 respectively. Triple acid extract method was adopted to estimate sodium and potassium content by flame photometry using dry sample at maturity stage as proposed by Jackson (1973).Highest Na^+/K^+ ratio was recorded by the genotype BAR198 followed by BAR228, BAR208 and BAR317 whereas, these genotypes recorded the lowest values for grain yield per plant. Low Na^+/K^+ ratio was observed in BAR242 followed by BAR252, CO (KV) 2 and MDU 1 which also exhibited higher mean value for grain yield per plant. This indicates the negative association between Na^+/K^+ ratio and grain yield. This could be because of the fact that under sodicity stress, tolerant plants accumulate more potassium which excludes Na^+ accumulation in leaves as a tolerance mechanism and produce better yield. Hence, this study concluded that high yielding genotypes were more suitable as tolerant for sodicity.

Keywords: Barnyard millet, Na^+/K^+ ratio, sodicity tolerant.

T1-67

Conversion of local land race Thalaivirichan Sorghum into high yield with early maturity and photo insensitive type through induced mutagenesis

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Abstract

In Vellore district, the sorghum cultivation is taken up in *Kharif* season as a rainfed crop with local landrace called thalaivirichansorghum (free and open ear head). The features of this land race are drought tolerant, grows very tall, more biomass, larger stem girth, non-lodging and photo sensitive with maturity duration of 150 days. Thalaivirichan sorghum is short-day photoperiod sensitive crop delays the genetic tendency to flower by forcing the plant to wait for a specific signal. Thus, most of the development occurs under a decreasing day length, which explains why the duration of their cycle shortens when sowing is delayed during the kharif season.Local land race thalaivirichan sorghum has sown in one month interval from 15th March to 15th July (range 120 days), all plants flowered within the 10-day period between 15 and 25th October. It is concluded that the mechanism of flowering date was probably determined by photoperiod.This photosensitive tendencycauses strictly hampering their cultivation in other seasons. If the difficult effect formed by photoperiod sensitivity is eliminated, yield and its stability could be enhanced through critical selection of yield components.Besides, the peak flowering period (second fortnight of October) coincidence with high rainfall period (North east monsoon) leads to complete washout of pollen grain causing very poor seed set. Hence, developing early maturity with photo insensitive type sorghum facilitates to bypass all the above problems. This project is aimed to convert the local land race thalaivirichan sorghum into reduced plant height, early maturity with photo insensitive nature through induced mutagenesis using physical (Gamma rays)

and chemical mutagens (EMS). The local land race sorghum line treated with both gamma rays and EMS showed reduced plant height of 2.5 m with early maturity (75 day for flowering with 120 days maturity) in M_3 generation as against the control lines of 4 m height with late maturity (100 days for flowering with 150 days to maturity). The mutated lines showed early flowering of 75 days in first week of September which is low or nil rain fall period and thereby avoids pollen washout.

T1-68
Widening the genetic base of hybrid parents through inter specific hybridization in Sorghum

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Abstract

Sorghum is known as great millet because it constitutes the staple diet in some regions of India, Africa and part of diet in many other regions. The grain can be processed into a wide range of value-added products to suit the palate and nutrition of human. In India, productivity of sorghum has been increased many-fold in past 50 years through hybrid technology in *Kharif* (the rainy season). Primary gene pool of sorghum has been extensively used for this purpose, however, further increase in yield is a challenge, and bringing in the variation from other gene pools is recommended. In this study,the variation was created and developed through wide hybridization using tertiary gene pool of sorghum. Our objective is to widen the genetic base of the two popular hybrid parental lines, 27 and 126; characterize them through multi-location field trials and molecular analysis. The variants from three crosses *viz*., 27Bx *S versicolor*, 27B x *S usumbarense* and 126B x *S. versicolor* was investigated. F_1 plants were in between wild and cultivated species. F_2 progeny was a mixture of both the parents, but shattering of grains, covered glumes and very loose panicles and low yield were limiting factors. Therefore, one back cross was attempted and selection for yield, non-shattering and less glume coverage was carried out from BC_1F_1 onwards. Thirteen lines were identified from three crosses that were field evaluated for three years in in-house trials and six seasons for grain mold, shoot-fly, stem-borer resistance and yield traits and multi-location trials at six locations.Molecular analysis was conducted with these 13 derivatives using 80 different markers and clustered them. Based on theresults of field data for yield, pest, disease resistance and molecular data,the genotypes were selected.

T1-69

Development and characterisation of high yielding mutants in Proso Millet (*Panicum miliaceum* L.)

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Abstract

Proso millet is a small millet crop with the highest water use efficiency among cereal crops. It is rich in protein, fibre, vitamins and minerals. However, the crop has lower yield compared to popular cereals like rice and wheat. Hence, yield improvement was the main objective of the study. Seeds of Proso millet variety ATL 1 were mutated using physical and chemical mutagens *i.e*., gamma rays and EMS. Mutation induced variability was documented in M_2 generation. The mutant plants were screened for yield and yield contributing traits in M_2 and M_3 generation. Observations were recorded for flag leaf length, third leaf length and breadth, plant height, panicle length, number of panicles, number of tillers, days to flowering, days to maturity, grain yield, fodder yield and photosynthetic rate. Putative high yielding mutants were further evaluated in replicated trial in M_4 generation. Variability and association analysis was carried out to understand the interrelationship between the yield and yield contributing traits. Molecular characterisation of two contrasting mutants for yield along with control was also carried out using GBS based sequencing. In M_4 generation, 16 mutant families were confirmed for high grain yield. Among these mutants, the traits *viz*., flag leaf length, third leaf length, number of panicles and fodder yield had high to moderate GCV, high heritability, high genetic advance and exhibited significant positive correlation with yield and can be relied upon for efficient selection for grain yield. Molecular characterisation detected mutation induced changes as SNPs and InDels. Two functional SNPs of low yielding mutant have occurred in the sequence coding for the enzyme starch synthase which is involved in starch biosynthetic pathway. The identified putative and confirmed mutants in M_3 and M_4 generations has to be further confirmed for their stability in further generations and can be used as donors for trait improvement in breeding programmes or for direct varietal release.

T1-70

Genetic analysis of downy mildew resistance in maize (*Zea mays* L.)

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Abstract

A 8 x 8 diallel analysis was carried out at Department of Millets, TNAU, Coimbatore using eight maize inbreds*viz.,* UMI 13, UMI 39, UMI 57, UMI 62, UMI 97, UMI 118, UMI 743 and CM 500 with an objective to identify potential parents and hybrids for downy mildew resistance and to understand the nature of gene action for 14 characters *viz.,* days to tasseling, days to silking, plant height, ear height, number of leaves, tassel length, ear length, ear diameter, ear weight, number of kernel rows per ear, number of grains per row, 100 grain weight, grain yield per plant and per cent protein content. To get detailed insight on the gene action for quantitative characters, generation mean analysis was performed with six parents and eight crosses.The 56 diallel hybrids synthesized from eight inbreds comprising two resistant inbreds (UMI 57 and UMI 39), two moderately resistant inbreds (UMI 62, UMI 97 and UMI 743) and three susceptible inbreds (CM 500, UMI 118 and UMI 13) were studied for their disease reaction under sick plot conditions. The F_2's of eight crosses were raised to observe the disease reaction and determination of inheritance pattern. The disease reaction of the genotypes used in this study ranged from 0 to 100 per cent. The maximum disease incidence was registered in CM 500. The incidence was recorded nil in UMI 57. The F_2 cross combination CM 500 x UMI 39 segregated in the ratio of 3:1 for resistant: susceptible and the cross combination CM 500 x UMI 57 segregated in the ratio of 15: 1 (resistant: susceptible) confirming digenic duplicate interaction. The following two crosses *viz.,* UMI 743 x UMI 39 and UMI 743 x UMI 57 were found to be moderately resistant and F_2 segregated in the ratio of 9:7 and 13:3 for resistant : susceptible respectively, confirming the digenic complementary interaction. Genetic studies for downy mildew resistance have revealed the occurrence of monogenic, digenic and also the possible preponderantly role of polygenic inheritance. Among 56 F_1 hybrids evaluated for downy mildew resistance, the following ten resistant hybrids *viz.,* UMI 57 x UMI 743, UMI 57 x CM 500, UMI 743 x UMI 39, UMI 743 x UMI 57, UMI 743 x UMI 62, UMI 743 x UMI 97, CM 500 x UMI 39, CM 500 x UMI 57, CM 500 x UMI 62 and CM 500 x UMI 97 were found to possess significantly higher concentration of total phenols, soluble protein, peroxidase and polyphenol oxidase. Hence, these biochemical substances could have a possible role in the resistance behavior of the genotypes against downy mildew.

Keywords: Maize, resistance, downy mildew, gene action

T1-71

Characterization of sorghum germplasm accessions for DUS descriptors

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Abstract

Sorghum (*Sorghum bicolour* (L)) is India's fifth important food crop, the best-suited cereal crop for semi-arid environments. It is sub stantially popular among farmers due to its greater adaptability and various forms of utility such as grain, green fodder, Stover and silage. It had highly tolerant to drought and used as a fodder crop for semi-arid areas compared to Corn. Genetic diversity of the crop species is the gift of nature and arises due to geographical separation or due to genetic barriers to cross ability. The use of morphological characters is the most common approach utilized to estimate relationships between genotypes. A better understanding of genetic diversity in sorghum will facilitate crop improvement. Therefore there is a need to evaluate the available accessions for genetic diversity. A total of 100 numbers of sorghum germplasm genotypes were received from the Department of PGR, TNAU, Coimbatore for characterization during Rabi 2021 and characterization has been done based on descriptor traits. Among the germplasm lines IL 545, MR 943 and A 404 were identified for grain sorghum type and the lines IL 406, MR 8, MR 47, ICSPIR 132 and PC 53 were identified for forage type which will be used in the sorghum improvement program. Some genotypes such as IL 219, MR 852, MR 943,D 12803, D 30258, AS 219, IS 10370, AS 4242, AS 4517, AS 4522 and AS 5132 were identified as red color grain type. These genotypes will be utilized in sorghum crop improvement

T1-72

Partitioning gene actions governing morphological traits in grain sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract

Sorghum, one of the five main cereal crop serves as a stable food for billions of people across the globe. It is well adapted to high temperature, dry conditions but the production of sorghum is relatively low compared to other cereals. Understanding the genetic architecture of the traits helps in adopting suitable breeding method for trait improvement. Therefore, the generation mean analysis was employed in crosses CO 4 × CO 30 and Paiyur 2 × IS 29640 to dissect the nature and magnitude of intra- and inter-allelic gene actions governing the morphological traits. Five generations namely, P_1,P_2,F_1, F_2 and F_3 were evaluated for 10 morphological traits *viz.*, days to flowering, plant height, umber of leaves, flag leaf length, flag leaf width, panicle length, panicle weight, number of primaries

100-seed weight and grain yield per plant. The scaling test indicated the presence of epistatic interaction for all the traits except flag leaf length in both the crosses and flag leaf width in Paiyur 2 × IS 29640. The additive gene action with positive and significant effects was observed for several traits namely, plant height, panicle weight, number of primaries, 100-seed weight and grain yield per plant from the Paiyur 2 × IS 29640 cross while the same was negative and significant in the other cross. One or the other non-additive gene action was present in all the traits under study. The plant height and panicle weight traits alone showed the absence of dominance gene action. Epistasis was present in all the traits except flag leaf length and width from the cross Paiyur 2 × IS 29640. The opposite signs for dominance and dominance × dominance type of gene action revealed the presence of duplicate type of gene action for most of the traits except for the presence of complementing gene action for number of primaries and grain yield per plant from the cross Paiyur 2 × IS 29640. To conclude, the crosses varied in the nature and magnitude of gene effects governing the traits under study highlighting the importance of adoption of specific breeding strategy for trait improvement in a particular cross. The presence of both additive and non-additive gene action recommends the adoption of population improvement by reciprocal recurrent selection method to develop high yielding sorghum varieties.

T1-73

Genetic architecture of grain yield related traits in early generation of sorghum inter-varietal crosses

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Abstract

Improvement of grain yield is of immense importance in any crop improvement program. Sorghum being photosynthetically more efficient than C_3 plants has an yield advantage. However, grain yield is a complex polygenic trait which is highly influenced by environment. Direct selection of the trait seems to be ineffective. Therefore, identification of associated traits with stability of associationin different genetic backgroundseems to be an effective means for delivering better results. To accomplish this, two inter-varietal crosses namely, CO 4 × CO 30 and Paiyur 2 × IS 29640 were performed and theF_2 populations of the crosses raised during *summer' 2021*were subjected to correlation and path analysis. The observations were recorded for 10 quantitative traits. Correlation studies in the F_2 population revealed the presence of positive and significant association of yield with all traits in CO 4 × CO 30 cross while the association was only with days to flowering, plant height, number of leaves, flag leaf length, flag leaf width and number of primaries in Paiyur 2 × IS 29640. Eight traits namely days to flowering, number of leaves, flag leaf length, flag leaf length, panicle length, panicle width, number of primaries, 100-seed weight were found to have high direct effects on yield improvement in CO 4 × CO 30 cross. Four traits namely plant height, number of leaves, flag leaf length and number of primaries along with flag leaf length were found to have medium and high direct effects on grain yield improvement in Paiyur 2 × IS 29640. Both correlation and path analysis revealed the possibility for simultaneous

improvement of plant height, number of leaves, flag leaf length, flag leaf width and number of primaries along with grain yield per plant irrespective of the genetic background of the crosses. The identified traits can strengthen the selection criteria for sorghum yield improvement program.

T1-74

Is selection effective in the early generation of Sorghum inter-varietal crosses: An intergenerational trait transmission study

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Abstract

Sorghum, a climate smart cereal crop has forte to produce grain and fodder even under low input condition and in marginal lands. Yield improvement in the crop can significantly improve the production from marginal lands. Therefore, an attempt of inter-varietal crosses, Co 4 × CO30 and Paiyur 2 × IS 29640 were made to widen the variability available for yield and its attributing traits. The distribution and effectiveness of selection for ten quantitative traits namely, days to flowering, plant height, umber of leaves, flag leaf length, flag leaf width, panicle length, panicle weight, number of primaries 100-seed weight and grain yield per plantwere studied in the F_2 and F_3 population raised during *summer'2021* and *kharif'2021* seasons. Employing third order statistical measures and regression analysis. Most of the traits recorded in F_2 population of the Co 4 × CO 30 cross were under multigenic control and showed symmetrical distribution. The intense selection practised in F_2 generation shifted the platykurtic and mesokurtic curve of plant height and flag leaf length to leptokurtic cure in the F_3 generation. The presence of playkurtic curve for traits *viz.* days to flowering, panicle weight, 100-seed eight and grain yield per plant in both the generations indicate the genetic control of these traits by several genes. The F_2 and F_3 generation of Paiyur 2 × IS 29640 cross exhibited negative skewness and leptokurtic curve for grain yield per plant signifying yield improvement with relatively less effort. The intergenerational correlation and regression were positive and significant for most of the traits indicating the possibility of isolation of superior genotypes in early generations of both the crosses. The estimates of narrow sense heritability were moderate for all the traits in both the crosses. The comparative study between crosses revealed the genetic complexity of the trait in association with the cross and identification of key traits for selection of elite genotypes in early generation.

Keywords Sorghum, regression, correlation, kurtosis, inter-varietal cross

T1-75

Tenai ATL 1: A spoon for rainfed farmers of Villupuram District

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Abstract

Tenai ATL 1 variety is a high yielding drought tolerant fertilizer responsive non-lodging variety and was developed at Centre for Excellence in Millets, TNAU, Athiyandhal. It is a crossderivative between PS 4 x Ise 198. Under rainfed condition, this variety performed well and has recorded an average grain yield of 2117 kg/ha and straw yield. It is endowed with special attributes like easy threshability, synchronized maturity, non-lodging growth habit and is drought tolerance. Besides, its nutritional qualityand it has good grain qualities for cooking and value addition. Additionally, it was also observed to possess tolerance to blast and rust diseases. Considering the above features, foundation seed production of Tenai ATL 1 variety was taken up under farmers participatory mode in order to popularize the variety and improve the farmers income. The Krishi Vigyan Kendra, Villupuram has conducted frontline demonstration on " Demonstration of Tenai ATL 1 seed production techniques by farmer participatory mode"at Nagar village, Marakkanam block of Villupuram District for dissemination of new Tenai Variety ATL 1 during *Kharif*, 2022 under rainfed conditions along with farmers variety (Local variety). The results revealed that Tenai ATL 1 performed better interms of yield (1940 kg/ha), net return (Rs.86,635/ha) and benefit cost ratio (2.83) compared to farmers variety and which was 1519 kg/ha, Rs.34,855/ha, 2.04, respectively. The knowledge level of farmers on new Tenai variety ATL 1 was improved from 13 to 70 percent which was made through frontline demonstration programme.

T1-76

Combining ability analysis for morphological and physiological characters in little millet (*Panicum sumatrense* Roth ex Roem. and Schult.)

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Abstract

The present study entitled "Combining ability analysis for morphological and physiological characters in little millet (*Panicum sumatrense* Roth.exRoem and Schult) was carried out at Agricultural Research Station, Perumallapalle, Tirupati, Andhra Pradesh during *kharif,* 2019.Twenty crosses generated by crossing four lines(BL-6, GPUL-4, Nallasama and WV-126**)** with five testers (BL-150, DHLTMV-14-1, GPUL-2, KOPLM-53 and OLM-203) in a Line x Tester mating design were evaluated to get information on combining ability and heterosis for yield and yield attributing traits. Combining ability analysis indicated the

predominance of non- additive gene action for all the characters. Higher *sca* variance than *gca* variance revealed good scope for heterotic breeding followed by selection at later generations. High degree of heterosis for grain yield per plant was mainly through multiplicative effect of heterotic response of days to 50% flowering, days to maturity, number of productive tillers per plant, panicle length, main panicle weight, harvest index and fodder yield per plant. Based on *per se* performance and *gca* effects, the parents *viz.*, GPUL-4, BL-6, Nallasama , KOPLM- 53, OLM-203 and GPUL-2 were found to be good general combiners. The crosses BL-6 X OLM-203 and GPUL-4 X OLM-203 could be exploited through recombination breeding programme for development of superior high yielding purelines. Association analysis indicated that days to maturity, plant height, main panicle weight per plant, fodder yield per plant, harvest index and SPAD Chlorophyll meter reading were effective in improving grain yield as they exhibited significant positive correlation with grain yield per plant. Path analysis revealed high positive direct influence of fodder yield, harvest index and main panicle weight per plant on grain yield per plant. Hence, selection for fodder yield, harvest index and main panicle weight per plant could be considered, while constructing selection indices for selecting desirable genotypes.

Keywords: combining ability, little millte, physiological characters, morphological characters.

T1-77

Assessment of genetic diversity in Foxtail Millet (*Setaria italica* L.) genotypes for yield and yield attributing traits

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Abstract

Analysis of genetic relationship among crop species is an important component of plant breeding program, since it provides information about genetic diversity of the crop species which is a basic tool for crop improvement. In this background, present investigation was carried out for assessing the genetic diversity and variability among 127 foxtail millet germplasm lines for various yield and yield attributing traits during 2017-18 at Dryland Agricultural Research Station, Chettinad. Quantitative traits contributing for yield such as days to 50% flowering, days to maturity, plant height, number of basal tillers, culm branches, length of inflorescence, no. of inflorescence lobes, length of seed, width of seed and single plant yield were recorded.

The data was subjected to analysis using “R Studio” statistical software and circular clusters were obtained with 5 clusters (I, II, III, IV and V). Cluster I was having 38 genotypes, cluster II was largest with 43 genotypes, cluster III was having 27 genotypes, cluster IV with 12 genotypes and cluster V was having 7 genotypes. Maximum inter cluster distance was observed between cluster IV and V (8.08) indicating the highest diversity among the genotypes of these clusters followed by clusters I and V (7.79) and clusters III and V (6.48), while the minimum was between clusters II and III (4.53) indicating the lowest diversity

among the genotypes of these clusters followed by clusters I and II (4.76). The cluster means of 10 characters of 127 foxtail millet genotypes revealed that the existence of differences for almost all of the characters.

Genotypes present in the different clusters may be used as potential donor for future hybridization programme to develop high yielders in foxtail millet.

Keyword: Foxtail millet, quantitative traits, diversity analysis, cluste

T1-78

Decoding the core microbiome associated with Finger Millet (*Eleucine coracana* L. Gaertn) for moisture stress resilience through NGS: A way forward to microbiome- integrative breeding

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Abstract

The global increase in water deficit due to climate change is a major concern for sustaining crop productivity. Finger millet (*Eleucine coracana* L. Gaertn) is an annual herbaceous nutri-cereal cultivated predominantly as a rainfed crop.Drought is one of the major limiting factors affecting finger millet production. Long-term breeding shapes plant characteristics and also impacts plant-associated microbiomes substantially. The plant-associated microbiome is an unsung entity in eliciting drought tolerance through induced systemic tolerance, which includes the production of cytokinins, ABA, auxins, antioxidants, microbial volatile (mVOCs) bouquets and degradation 1-aminocyclopropane-1 carboxylate (ACC) by ACC deaminase etc. Core microbiome refers to the microbial taxa set and associated genomic and functional attributes defining the host characteristics. Using high throughput amplicon sequencing using a nanopore platform targeting 16SrRNA, the core bacterial microbiome was assessed in the root and shoot of finger millet cultivar CO15.Different taxonomic bacterial communities were assessed based on 16S rDNA hypervariable V1 and V9 regions with 25550 and 34839 reads generated for roots and shoots respectively. A total of225 unique OTUs at species representing 47 bacterial phyla were detected in the roots. Taxonomic analysis based on relative abundance revealed the abundance of chloroflexi (8.51%), followed by action bacteria (7.45%) cyanobacteria and proteobacteria (6.38 % each), bacteroides and verrumicrobia (5.32%), gemmatimonadates (4.26%), firmicutes and planctomyces (3.19). Other classes such as fusobacteria, fibrobacters, synergistetes, lentispharae, thermotogae and cladothrix represented a relatively minor portion of the total diversity. In contrast to roots, the total reads obtained were more in shoots (alpha diversity 4.15) represented by two domains: Bacteria and archaea are the two domains observed, dominated by the class chloroplast followed by alpha proteobacteria,

gamma proteobacteria, clostridia, bacilli and action bacteria. Around 226 genera encompassing 69 species were identified in the finger millet var CO51 shoot. The taxonomic diversity is represented by the predominant genus *Spingopyxis* with 329 clade reads *Pseudomonas* (117), *Micorcoleus* (88 clade reads) followed by *Leptolynbya*, *Sinorhizobium, Rhizobium, Stenotrophomonas, Pseudoalteromonas, Blautia, Megaspira, Gemella etc.* Interestingly, *Bradyrhizobiumelkanii*, *Lactobacillus delbruecki*, *Propionibacteriumacenes*, *Bifidobacteriumlongum* were identified at the species level. Further, we isolated root, shoot and apoplastic microbes and were screened for their moisture stress tolerance ability in PEG 6000-infused agar plates.*R. esperanza*CRB6, a root bacterial endophyte of finger millet genotype CO15, tolerated upto-6.25 MPa and possessed plant growth traits such as P and Zn solubilization, IAA production, ACC deaminase activity and bio-control activities. While exploring the volatile blends (mVOCs), nonanol, 1-pentanol, benzothiazole and glucopyranoside benzo sulphonate were unravelled as signature molecules and are significant in trehalose and sorbitol synthesis. The metabolic footprint of *R.esperenzae* CRB6under induced stress showed upregulation of osmoprotectants such as proline, phenol, ethanol, ascorbic acid and geranyl isovalerate, the precursor of abscisic acid (ABA).The study provided a deep insight into the finger millet microbiome assembly and the inheritance of microbial signatures, representing the significance of microbiome-driven breeding approaches for developing resilient/tolerant genotypes.

Keywords: Core microbiome, Finger millet, High -throughput amplicon sequencing, Inheritance, Moisture stress

T1-79

Morpho-physiological and molecular responses of Finger millet (*Eleusine coracana* G) genotypes to PEG Induced Moisture Stress

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Abstract

Finger millet, also known as Ragi (*Eleusine coracana* G.), is the third most important millet crop in India. It plays a crucial role as a food crop in South Asia and Africa. In India, finger millet is grown in an area of 1.01 million hectares, yielding 1.67 million tonnes with a productivity of 1,747 kg per hectare. It is adversely affected by intermittent droughts, irrespective of it phenological phases and a trait-based selection for drought tolerance is expected to enhance yield stability.In the present study, four genotypes were evaluated for 17 morpho-physiological traits in a completely randomized design with five replications. In hydroponics screening, moisture stress was induced artificially using PEG 6000 MW to create an osmotic potential of (-) 20 bars for 5 days at 28 ± 2 ºC. Subsequently, the stress intensity was increased at a rate of (-) 10 bars upto (-) 50 bars. . The study revealed that the PEG-induced moisture stress reduced germination percentage, shoot and root lengths, while increasing the R/S ratio in drought-tolerant genotypes compared to the susceptible ones. The tolerant genotype CO 15registered higher germination per cent and root-to-shoot ratio

(R/S) under moisture stress followed by Paiyur 1, and the least values for PR 202.Under hydroponic studies, both NS and S environments showed phenotypic (29.53 & 341.04) and genotypic (29.11 & 340.82) variations in germination percentage. Maximum variability in NS conditions was observed for shoot length (phenotypic: 29.95%, genotypic: 29.94%), while in moisture stress conditions, seed vigor exhibited the highest variability (phenotypic: 48.98%, genotypic: 48.97%). The environmental influence was highest for shoot length and total seedling height in NS conditions, while in stress conditions, seed vigor followed by root shoot ratio showed the least influence.Genetic advance was highest for shoot length (61.67) under NS whereas seed vigor (100.85) in stressed environment. Classical drought-responsive genes (EcCAT1, EcSOD, EcPSCS, EcGR, EcP5CS and EcGR) were expressed in the leaf and root tissues of both tolerant and susceptible genotypes. The expression levels were higher in leaf and root tissues of CO15 followed by Paiyur1. Based on these findings, the genotypes CO15 followed by Paiyur 1, hold promise for the genetic improvement of drought tolerance in finger millet through biotechnological approaches.

Keywords: Drought-responsive genes**,** Finger Millet, Hydroponics, Moisture stress, Variability, Genetic advance

T1-80
Next-generation tools for trait improvement in millets

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Abstract

Millets, also known as coarse cereals are mainly cultivated in rain-fed areas of arid and semi-arid zone. Belong to the Poaceae family but are superior to other major cereals in terms of nutritional qualities, climate resilience, and other agronomical traits. Therefore, identifying and applying agronomically important traits for millet breeding programs is important. However, classical breeding programs such as traditional, mutation, and transgenic breeding are very laborious and challenging. Therefore, new breeding techniques assisted by gene editing, epigenetic modification and heritable targeted mutation must be applied for crop improvement. Clustered regularly interspaced short palindromic repeat (CRISPR)/CRISPR-associated protein 9 (Cas9) nuclease system is a powerful gene-editing (GE) tool can be used for targeted mutations in millets. The genetic manipulation of QTLs is challenging, but GE tools possess great potential in QTLs editing to integrate desired alleles into several crops by eluding the requirement of excessive crossing. Utilization of several genetic markers, such as genome-wide small nucleotide polymorphism (SNP) marker, novel sequencing approaches such as genotyping by sequencing (GBS), restriction site-associated DNA (RAD) sequencing and whole genome resequencing can be applied for trait improvement. Different “omics” approaches, including transcriptomics, proteomics, and metabolomics, enable the quantitative and qualitative analysis of candidate genes in millets to unravel the different regulatory networks. Recently, a nano-particle based delivery system for plasmids, ribonucleoproteins and RNA are under developed for speedy trait improvement. Though, these concepts have not been utilized in millets improvement, they

hold a promising future. Super-pangenome approach of wild varieties of small millets could help explore the complete genetic diversity of a genus level, accelerating the millet improvement programs. Therefore, these successful next-generation breeding tools can accelerate trait improvement in millets.

Keywords: Millets, Gene-editing, CRISPR/(Cas9), SNP, next-generation, omics

T1-81
RNAi induced gene silencing to increase shelf-life in pearl millet flour

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Abstract

Pearl millet (*Pennisetum glaucum*) is a major millet crop in India . This “nutri-cereal” is an excellent source of micronutrients like iron and zinc. This once forgotten staple is gaining traction today in various forms of value-added products. Due to the high lipid concentration, it encourages the development of fatty acidity, lipolytic activity and the accumulation of lipid peroxides in the meal during storage, thus its flour develops a rancid odour within a few days of milling. Pearl millet lipid (5.1% on a dry weight basis) is mainly unsaturated fatty (70%) and saturated fatty acid (30%) in combination with lipase (triacylglycerol acylhydrolase) enzyme accounts for the stepwise hydrolysis of the triacylglycerol into diacylglycerol, monoacylglycerol, glycerol and free fatty acids.In the presence of moisture and oxygen, they get oxidised resulting in undesired characteristics i.e. rancidity and lower shelf life. The pearl millet lipase shows relatively higher activity than that of most other cereal grains. So, aiming to reduce the lipase activity by RNAi mediated approach can be used by the introduction of homologous double stranded RNA (dsRNA) to specifically target a gene's product, resulting in null or hypomorphic phenotypes. PgTAGLip1 or PgTAGLip2 genes of pearl millet can be targeted, by introducing a reverse-orientation copy of the gene (anti-sense) that hinders the translation of lipase mRNA in the post transcriptional level to reduce the formation of lipases. These genes are not essential for germination or post-germination growth but only mitigate rancidity in elite milled pearl millet germplasm.

Keywords : Pearl millet,Shelf-life, Lipase, Rancidity, RNA interference

T1-82
Millets: A Diabetic's Refuge

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Abstract

Glycemic Index (GI) is a measure of the increase in the level of blood glucose caused by eating a specific carbohydrate compared with eating a standard amount of glucose. High glycemic index edibles release glucose rapidly and cause a quick rise in blood glucose while a low GI diet would help diabetic and prediabetic people to manage their glucose levels and reduce body weight. Millets have a low to moderate GI, meaning they cause a slower and more gradual increase in blood sugar levels. Barnyard millet has the lowest glycemic index followed by foxtail millet, whereas finger millet, kodo millet, little millet, pearl millet and sorghum fall under the intermediate GI category with mean GI ranging from 55-65. The cause of low glycemic index in millets can be attributed to the presence of various phenolic compounds such as ferulic acid, catechins, quercetin and kaempferol. The amylolytic enzymes, α-glucosidase and α-amylase have key roles in carbohydrate metabolism which have been inhibited by these specific phenolic compounds in millets. Inhibition activities of these enzymes, control the absorption of glucose in the intestine. The inhibition of α-amylase and α-glucosidase activity was profound in the Bound Phenolic Fraction (BPF) when compared to the Free Phenolic Fraction of the cells, which may be due to the high content of phenolics in BPF. The type and quantity of phenolic compounds in millets may vary depending on the variety and growing conditions. Combining genomic and genetic approaches can provide valuable insights into the biosynthesis of phenolic compounds in millets and identify candidate genes and markers that could be used for breeding programs. Also, selection of high-phenolic lines using appropriate screening techniques and genetic engineering approaches to increase the expression of genes involved in phenolic compound biosynthesis in millets would have potential application in millets as diabetic food.

Keywords: Glycemic Index, diabetes, phenolic compounds, millets.

T1-83
Association mapping and nested association mapping studies in Millets

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Abstract

Indian millets are a group of nutritiously rich, drought tolerant and mostly grown in the arid and semi-arid regions of India. They are small-seeded grasses belonging to the botanical family Poaceae. They constitute an important source of food and fodder for millions of resource-poor farmers and play a vital role in ecological and economic security of India. These millets are also known as "coarse cereals" or "cereals of the poor". Indian Millets are nutritionally superior to wheat and rice as they are rich in protein, vitamins and minerals.India is among the top 5 exporters of millets in world. Mapping of resistence Gene and other Quantitative Traits Loci (QTL) for agronomical performance can be of great use for improving Millet genotypes and also adaptation of domesticated species to diverse Agroclimatical Region Has Led To Abundant Trait Diversity. However ,The Resulting Population Structure and Genetic heterogenety confounds Association Mapping of adaptive traits to Address this challenge a Nested Association Mapping (NAM) population is used. Increased availability of high throughput genotyping technology together with advances in DNA sequencing and in the development of statistical methodology appropriate for genome-wide association scan mapping in presence of considerable population structure contributed to the increased interest association mapping in plants.

Keywords : Quantitative Traits Loci (QTL), Nested Association Mapping (NAM) population Nested Association Mapping (NAM) population, Association Mapping , high throughput genotyping

T1-84
Self-Nitrogen Enriching Sorghum Lines

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Abstract

Nitrogen is the most important nutrient for crops, having a dynamic impact on all growth, yield, and grain-quality-determining processes. Thus, increasing nitrogen use efficiency (NUE) in sorghum would provide opportunities to achieve higher yield and better-quality grain. Nitrogen drives plant growth which stops when plants run out of nitrogen. Nitrogen to some extent controls the efficient utilization of phosphorus and potassium. Nitrogen availability to plants is reflected in the dark green colour of stems and leaves and vigorous growth. Increasing nitrogen use efficiency (NUE) in sorghum would provide opportunities to achieve higher yield and better-quality grain. It has been identified that a

maize line called oloton has the ability to increase the available soil nitrogen itself. The oloton maize lines produce gummy exudates through their aerial root points, which are colonized by microorganisms that are usually involved in soil nitrogen fixation. Unlike in soil, these microorganisms can directly use the atmospheric nitrogen which then upon processing gets converted into nitrate form. The gummy exudates are produced at frequent intervals which allows the old exudate to fall and settle in the soil. Thus, the nitrogen-containing exudate produced by sorghum enriches the fields resulting in improved yield even without fertilizer application. Transfer of genes and structural modification of such traits to other regular millets like sorghum will help to reduce the dependency on fertilizers, reduce environment pollution and economically aids the farmers.

Keywords : nitrogen, plant growth, oloton, nitrogen fixation, high yield.

T1-85
Improvements in millets in the genomic era

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Abstract

Millets are food and nutrient security crops in the semi-arid tropics of developing countries. The whole-genome sequence (WGS) of millets provides new insight into understanding and studying the genes, genome organization and genomic-assisted improvement of millets. The genome sequence of foxtail millet has recently triggered a plethora of post-genomic analyses and envisaged foxtail millet as a model organism for the C4 grasses and bioenergy research. The WGS of millets helps to carry out the genome-wide comparison and co-linearity studies among millets and other cereal crops. This approach might lead to the identification of genes underlying biotic and abiotic stress tolerance in millets. The available genome sequence of millets can be used for SNP identification, allele discovery, association and linkage mapping, identification of valuable candidate genes, and marker-assisted breeding (MAB) programs. Next generation sequencing (NGS) technology provides opportunities for genome-assisted breeding (GAB) through genomic selection (GS) and genome-wide association studies (GAWS) for crop improvement through the discovery of high-throughput markers and multiplexed genotyping of germplasm.

T1-86

Utilization of Crop Wild Relatives in genetic improvement of Maize

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Abstract

Maize is a popular crop with great yield potential and diverse utility. It is very popular among crop breeders and is being continuously exploited for hybridization and selective breeding for decades. This has led to a reduction in the genetic diversity and truncation of several desirable alleles. The presence of sufficient genetic variability forms the basis of any plant breeding program. In crops of great significance such as maize, it is essential to improve the crop in aspects of yield, nutritional quality, pest and disease tolerance, environmental stress tolerance, harvestability, forage traits, and other traits of industrial significance. Wild maize germplasm is the storehouse of significant variation for several important stress tolerant and quality traits (Kumar *et al*, 2019, Kumar *et al*, 2020 &Karn*et al*, 2017), many of which remain unexplored. The wild alleles in the crop wild relatives, teosinte and tripsacum can be exploited for introgression and diversification of the genetic base (Adhikari*et al*., 2021) and, they could possess some of the novel variation for crop improvement. The teosinte are wild grasses native to Mexico and Central America. These include annuals spp. viz., *Zea mays* ssp. *mexicana* (Schrader) Iltis (2n = 20), *Zea luxurians* (Durieu) Bird (2n = 20), and *Zea mays* ssp. *parviglumis* Iltis and Doebley (2n = 20). The other two species *Zea diploperennis* (2n = 20) and *Zea perennis* (2n = 40) are perennials. The genus *Tripsacum* belonging to the same tribe Maydeae as maize consists of 12 perennial species which are mostly native to Mexico and Guatemala.*Tripsacum dactyloides* is observed to possess tolerance to salinity, and resistant to *Puccinia sorghii* and *Colletotrichum graminicola*. *Zea luxurians*has been reported to be tolerant to flooding, while *Zea mays* ssp. *parviglumis* is tolerant to drought.*Zea mays* ssp. *mexicana*is observed to be resistant to Fusarium rot and corn borer, and *Zea diploperennis*is reported to be resistant to maize chlorotic dwarf virus. Besides profuse tillering, prolificacy and kernel composition traitscan also be explored.Pre-breeding enables the introgression of the desirable exotic alleles from the exotic background to the contemporary inbred lines that can be readily utilized in the genetic improvement of maize.

T1-87

Genome wide analysis of different gene families in regulating abiotic stresses in Foxtail Millet

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Abstract

Foxtail millet *(Setaria italica* L.*)* is an important small millet crop that is grown in arid regions. It has excellent drought tolerance and water-use efficiency and cultivated as a dietary staple in the arid and semiarid regions in the world, particularly in India. Foxtail millet has become an ideal model species for grass genomics studies because of its small diploid genome (~510 Mb). Therefore, examining the response of foxtail millet to various abiotic stresses revealed that different gene families involved in stress responses. The 187 *bHLH* genes were identified in foxtail millet and showed a difference in transcription level of *SibHLH* genes to abiotic stress response. Another study showed that 10 *MIKC* type *MADS* gene were induced by abiotic stresses and may play an important role in various stresses. Another studies showed that 10 *LIM* gene (*SiWLIM2b*) were over expressed in drought stress. *LOX* gene family had *SiLOX7* gene may play an important role in responses to abiotic stresses. This study revealed that *SiDi19-3* and other *SiDi19* members regulate salt tolerance and other abiotic stress responses in foxtail millet. However, further investigation is needed to decipher the functional characterization of these gene families.

T1-88

Exploration of genetic and genomic resources for abiotic and biotic stress tolerance in Finger Millet

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Abstract

Finger millet (*Eleusine coracana*) is an important cereal crop that is widely cultivated in various regions of the world, especially in semi-arid and tropical areas. Despite its nutritional and economic significance, finger millet production is often hampered by abiotic and biotic stresses, including drought, salinity, heat, pests, and diseases. These stress factors can severely limit crop productivity and result in substantial yield losses. To address these challenges, the exploration of genetic and genomic resources has become crucial for developing finger millet varieties with enhanced tolerance to abiotic and biotic stresses. This abstract highlights the recent advancements in understanding the genetic basis of stress tolerance in finger millet and the utilization of genomic tools to accelerate breeding programs. Studies have identified several stress-responsive genes and quantitative trait loci

(QTLs) associated with abiotic and biotic stress tolerance in finger millet. These genetic markers can be used for marker-assisted selection (MAS) to introgress stress tolerance traits into elite finger millet cultivars. Furthermore, the advent of high-throughput sequencing technologies and bioinformatics tools has facilitated the discovery of stress-related candidate genes and regulatory networks in finger millet. Genomic approaches, such as genotyping-by-sequencing (GBS), RNA-sequencing (RNA-Seq), and genome-wide association studies (GWAS), have been employed to unravel the genetic diversity and identify key genes involved in stress responses. The integration of transcriptomics, proteomics, and metabolomics data has provided insights into the molecular mechanisms underlying stress tolerance in finger millet. Genetic engineering techniques, including gene editing and genetic transformation, offer opportunities to introduce or enhance stress tolerance traits in finger millet. In conclusion, the exploration of genetic and genomic resources in finger millet has significantly contributed to the understanding of stress tolerance mechanisms and the development of improved varieties. Continued research in this area will facilitate the breeding of finger millet cultivars with enhanced resilience to abiotic and biotic stresses, ensuring sustainable production and food security in regions where finger millet is a staple crop.

Keywords: Abiotic stress, Genomics, Biotic stress, GWAS, Transcriptomics

T1-89
Proso Millet: A potential source of Food, Feed, and Fodder

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Abstract

With the increasing technology the world is developing but it comes with many challenges for agriculture and the environment. It is estimated that by 2050 the world population will increase to 9 billion and with this increasing population there is a challenge to feed the population besides other challenges like climate change, resource scarcity, water scarcity, nutritional security, and many more. For overcoming these challenges breeders need to develop varieties that can be best suited for all situations and millets are the best crops that can overcome these problems for sustainable agriculture. Out of all the millets, proso millet is a food crop domesticated around 10,000 years ago and is known for its climate resilience traits and nutritional properties. Proso millets have the potential to be the "health food for the future" as it has immense potential in addressing the global concerns of increased demand for food production, water scarcity, and malnutrition. In addition to that proso millet also have a low glycaemic index, is gluten-free, with high fiber content. Being marginal and short duration crop proso millet can be easily fitted in any cropping system. It is consumed as food in many parts of the Asian continent with its comparable nutrient value to wheat. As it is gluten-free in nature many food industries are interested to exploit the crop more so that it can be used as food for people with gluten intolerance or celiac disease. In major parts of the USA, the proso millet is exploited as bird feed due to its small grain size,

and easy availability. It can also be used as pelleted feed for poultry farming in place of corn or milo. Therefore, it can be used as a substitute feed. In many parts of North America, it is also used as fodder. Upon harvesting the crop it gives more straw which can be a useful fodder crop in dry land area. Lastly, the coarse nature of millets makes them unpopular and underutilized in developed countries, despite their benefits and agro-economic potential. Mutation is the best method for creation of variability in crops. In proso millet also chemical and physical mutagens were used for evolving proso millet mutants with high photosynthetic efficiency, earliness and fodder value in the variety ATL 1. Many mutants were identified with above traits and are under evaluation in M4 generation. After yield trials they will be utilised commercially.

T1-90
Biofortification in millets: A sustainable approach for nutritional security

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Abstract

Nutritional insecurity is a major threat to world's population that is highly dependent on cereals based diet, deficient in micronutrients. Commercial food fortification alone will not be sufficient to combat problem of malnutrition, however biofortification can enhance nutritional value of plant-derived foods. Millets are nutritionally superior as their grains contain high amount of proteins, essential amino acids, minerals and vitamins. There are some conventionally bred high iron pearl millet in India to tackle iron deficiency. Molecular basis of waxy starch has been identified in foxtail millet, prosomillet to facilitate their use in infant foods. Biofortification in millets is still limited by presence of antinutrients like phyticacid, polyphenols and tannins. RNA interference and genome editing tools (Zinc Finger Nucleases - ZFNs, Transcription Activator Like Effector Nucleases – TALENs and clustered regularly interspaced short palindromic repeats - CRISPR) needs to be employed to reduce these antinutrients. Biofortified millets have a great potential to reduce micronutrient deficiency in developing countries.

Keywords: Biofortification, Millets, Quality improvement

T1-91
The Changing situations – Dealing with Biotic and Abiotic Stresses

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Abstract

It's not reality to have stress free environment, plants are exposed to wide ranges of stresses ranging from biotic agents like sub microscopic Viroid and microscopic, bacteria, fungi, nematode and macroscopic insects, and weeds, and abiotic agents ranging from drought, salt, mineral, cold, heat and etc. Hence it is difficult to achieve the potential yields. Hence, plant protection studies must be given utmost importance so that we could meet food, feed, nutritional needs of growing human population. National family health survey

tells us or gives us the alarm sign of Indian population is dealing badly with malnutrition, anaemia and mineral deficiency, hence its responsibility to deal with yields and also nutritional improvement keeping in plant protection in view.

The changing climate which we could see in this century because of frequent catastrophic gives us a broad picture of importance of understanding changing climate and its influence on plant growth and development and unexpected consequences leads to new studies. The changing climate also leads to change in pathogen and insect dynamics which in turn also influence plant and pathogen/ insect relations.

Hence dealing with plant protection and developing varieties for biotic and abiotic stresses in one of the great responsibilities of a plant breeder. Understanding plant pathogen interaction (i.e, molecular and genetic interactions), coevolution and responses of plant in presence of pathogen and changing dynamics of gene interactions, regulations, understanding plant responses to high salts, heat, cold and water and physiological relations is ultimate to deal with these biotic and abiotic stresses.

Hence mere identification the real/ actual cause of stress is equally important, there are many recent discoveries of plant pathogens, identification of Southern Rice black streaking dwarf virus in Punjab by Punjab Agriculture University. However, technological advancements enabled us to deal with even complex problems, gene editing technologies such as CRISPER CAS 9 enables us to solve problems without the mark of plants being transgenic.

Keywords: Coevolution, Gene for Gene, S genes, R genes, Immunity, resistance, Water relation

T1-92
Exploration of innovative breeding technologies in Millets

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Abstract

Millets - the nutri-cereals, the smart-food cropswere the first cereal grains been domesticated. They are the versatile crops whichfit the bill and land as a healthy food and crop of choice, respectively. They are the wonderful climate resilient crops which are highly resistant to biotic and abiotic stresses. They are also an excellent complement and supplement to major staple food crops. Despite these immense values, they remain highly underutilized. Plant breeding is getting progressed in every phase of life which drastically changed the concept from conventional breeding to smart breeding which includes multitudes of phenotyping and genomics technologies to genome editing till date. Millet improvement using these modern genetic and genomics tools are falling behind other cereal crops. It is attributed that their cultivation is restricted to less developed countries and the scientists are reluctant to utilize these modern tools in millets for improvement. Finger millet and foxtail millet alone have received minimal research attention in terms of development of genetic and genomic resources. Globally, about only 1,33,849 cultivated germplasm of small millets are conserved in gene banks. So far genomes of only five millets have been sequenced. As of now, transcriptome of only foxtail millet had been released. To study the post-translational modifications, knowledge on and metabolomics in millets are also lagging.

Also, mapping of genes and genomic regions using markers is done only in foxtail millet. Also, compared to other major cereals like rice, genetic transformation studies are also lagging in millets. There are substantial number of reports only on finger millet and foxtail millet on genetic transformation. Genome editing systems like CRISPR/Cas9 have been frequently used in other major cereals like rice for functional genomics and crop improvement studies. It is also utilised only in foxtail millet because there is no transformation protocol yet standardised in millets. Genomics assisted breeding also will facilitate the identification of novel alleles and genes. But currently, recombination breeding has been the approach used, especially in finger millet, resulting in the development of diverse and high grain yielding cultivars in India. This year being the International Year of Millets, these technologies of modern era must be well utilised in these immense valued nutri-cereals to uplift the health of the planet.

Keywords: Millets, Nutri cereals, Crop improvement and Genomic resources.

T1-93

Heterotic grouping in Maize (*Zea mays* L.) and its importance in crop improvement

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Abstract

Heterotic grouping, a fundamental concept in maize breeding, plays a pivotal role in maximizing hybrid performance and achieving significant yield gains. Heterotic grouping in maize involves the classification of parental lines into distinct groups based on their genetic compatibility and ability to produce high-performing hybrids. Multiple techniques are being employed by the breeders to create heterotic groups or to classify the inbreds into heterotic groups. Grouping through analyzing the combining ability estimates using testers is the most commonly used method of heterotic grouping. Recently molecular markers have found their use in heterotic grouping due to their environment neutral behavior. By focusing on crosses between genetically compatible parental lines within the same heterotic group, breeders can streamline the breeding process, reduce the number of crosses needed, and accelerate the development of improved hybrids. This efficiency saves time, resources, and effort, enabling breeders to rapidly develop and deploy high-yielding maize hybrids that meet the evolving needs of farmers and consumers.

Keywords: Maize inbreds, heterotic grouping, combining ability, molecular markers, Line x Tester

T1-94

Genetic variability studies in nutritional improvement in finger millet (*Eleusine coracana* (L.) Geartn)

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Abstract

Finger millet (*Eleusine coracana* (L.) Gaertn) or *ragi* is an important food crop in Africa and south Asia. Finger millet is commonly called as "nutritious millet" as the grains are nutritiously superior to many cereals providing fair amount of protein, minerals, calcium and vitamins in abundance to the people. The protein of finger millet is considered to be "Biologically complete" as in the case of milk. Combining ability studies are useful in classifying the parental lines in terms of their hybrid performance. It also helps in identifying the parents suitable for hybridization programme and deciding suitable breeding methodology. The Line x Tester analysis is one, which helps to find out combining ability of parents for yield and yield attributes.

Keywords: Finger millet, Nutritious millet, Combining ability, Molecular markers.

T1-95

Harnessing wild alleles for Maize germplasm diversification and development

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Abstract

Maize is a highly valuable cereal crop that plays a crucial role in meeting diverse needs such as food and feed requirements, raw materials for industries, and serves as a valuable model plant for genetic research. However, the domestication process has led to significant changes in maize, resulting in the loss of many adaptive and quality-related alleles in modern varieties. In the face of climate change, it is essential to reintroduce these allelic variations to enhance grain yield and quality. The wild relatives of maize, known as teosintes, offer promising opportunities as potential donors for valuable traits such as stress tolerance, pest and disease resistance, as well as improved yield and quality characteristics .By crossing *Zea mays* subsp. *parviglumis* with maize lines, we have successfully identified Quantitative Trait Loci (QTLs) responsible for traits such as Banded Leaf Sheath Blight (BLSB), Maydis Leaf Blight (MLB), resistance to the red flour beetle, high protein content, and alterations in flowering behaviour. Additionally, we have observed desirable characteristics such as multiple ears, stay-green phenotype, reduced angle between leaf

and stem (suitable for high-density planting), and hybrids with high biomass production. Furthermore, we are harnessing the waterlogging tolerance potential of *Zea nicaraguensis* by developing populations for mapping QTLs and genes, as well as developing tolerant lines for integration into the Indian maize breeding program. However, wild teosintes also carry undesirable genes and alleles that can reduce the efficiency of introgressed lines. To address this challenge, we have implemented random mating among backcrossed inbred lines to minimize linkage drag. Additionally, we have integrated the *in-vivo* doubled haploid (DH) technology, which accelerates the development and fixation of alleles as homozygous lines. Our innovative approaches aim to domesticate wild alleles, fortify maize germplasm, develop climate-resilient hybrids, and address challenges in maize breeding and climate change.

Keywords: Sustainable maize production, Allelic variations, Wild teosintes, Introgression breeding and Resilient hybrids.

T1-96

Breeding for Improving Nutritional Quality in Pearl Millet

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Abstract

Pearl millet (*Pennisetum glaucum*) is a nutrient-rich cereal crop that has the potential to address malnutrition and improve food security in resource-limited regions. However, there is room for enhancing the nutritional quality of pearl millet through targeted breeding approaches. One key objective is to increase the content of essential micronutrients, such as iron, zinc, and provitamin A carotenoids, in pearl millet grains. These nutrients play critical roles in human health, and their deficiency can lead to various micronutrient malnutrition disorders. Another aspect of nutritional quality improvement involves enhancing the amino acid composition of pearl millet. Lysine, an essential amino acid, is often limited in cereal grains, including pearl millet. Breeding efforts focus on identifying and introgressing genes responsible for higher lysine content, resulting in pearl millet varieties with improved protein quality. Furthermore, efforts are being made to reduce antinutritional factors present in pearl millet, such as phytic acid and polyphenols. Genomic tools and technologies, such as marker-assisted selection and genomic selection, are employed to accelerate the breeding process and select desired traits related to nutritional quality. These tools aid in the identification and characterization of genes and quantitative trait loci (QTLs) associated with nutrient content and quality, enabling breeders to develop improved varieties with enhanced nutritional profiles. Additionally, the inclusion of consumer preferences and market requirements is crucial in breeding programs. Understanding the sensory attributes and acceptability of improved pearl millet varieties ensures their adoption and consumption by target populations.

Keywords: Millets, Pearl millet, Nutrients quality, QTLs, Crop improvement.

T1-97
Breeding millets for the climate resilience

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Abstract

Millets are the highly nutritious food crops, which contain balanced minerals and vitamins. To attain the nutritional security there is need for inclusion of millet-based food in our diet regularly. Millets possess several morpho-physiological, molecular and biochemical characteristics which confer better tolerance to environmental stresses than major cereals, considering this parameters enhancement of the target traits for changing dynamic environmental conditions is required, many advanced breeding methods can be employed to achieve that, although millets have been cultivated from many centuries, importance given to it is currently more. In the case of millets, ample genetic resources are available, However the information available on genomic resources including molecular markers and physical/genetic maps are scarce as compared to major cereals. Genome assisted breeding (GAB) could be used for crop improvement in millets by generating genomic data in millets through understanding genetics of the millets thoroughly, this increases the accuracy of breeding also reducing the time. Marker assisted breeding can also be utilized for the improving existing cultivars in accordance for the present cultivating conditions or environment. Tackling the emerging pests and diseases by having the resistant cultivars, which can be obtained by marker assisted backcross breeding, where this method will reduce the number of backcross and also the required number of generations for the transfer of the donor gene and also in obtaining the genetic background of the recipient parent (background selection), as there is requirement of more number of varieties very frequently suitable for the particularly growing population. Thus by considering the growing population, nutritional importance and changing climate breeding millets for that accordingly is very much required.

Keywords : Millets, Climate resilience, Marker assisted breeding, Nutritional security,

T1-98

Genetic Enhancement of Minor Millets in Genomic and Post-Genomic Era: A Review

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Abstract

Agriculture is facing the challenge of feeding an ever-increasing population estimated to reach up to ten billion by 2050. The current global warming and climate change trends severely threaten the productivity of major cereal crops. Hence, it is desirable to utilize nutrient-rich climate-resilient millets, which have the potential to offer nutrient security to a growing population. Mainstreaming millets for cultivation and using genomics technologies to dissect the climate-resilient traits to identify the molecular determinants underlying these traits are paramount for addressing food and nutritional security. In this framework, the review discusses the genomics and genome modification approaches for investigating key traits in minor millets and their application for improving these traits in cultivated germplasm.

Keywords: Genomics, Millets, Nutrient security

Theme 2

System of Millet Intensification,
Advanced management technologies and Farm mechanization
Extended summaries

T2-01
Drought mitigating strategies and irrigation scheduling for higher water use efficiency and grain yield of Maize

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Abstract

Field experiments were conducted to evaluate the drought mitigation strategies and irrigation scheduling to increase irrigation use efficiency and grain yield of hybrid maize at Maize Research Station, Vagarai during 2019 and 2020. A significant higher plant height (135.2 cm and 142.5 cm respectively) was obtained the treatments applied with PPFM (1 %) foliar spray at knee high, pre flowering and flowering stages and irrigation scheduling at 50 % ASM at 50 DAS. Grain yield of maize was significantly higher (5,564 kg/ha) in spraying of PPFM (1 %) at critical stages of maize *viz.,* knee high stage, pre flowering and flowering stages. Irrigation given at 50 % ASM gave significantly higher grain yield (8,355 kg/ha) than other irrigation schedules. The crop water use efficiency was higher (13.31) in irrigation scheduling at 50 % ASM.The net returns and benefit cost ratio were higher (Rs.40,023/ha and 1.65) respectively in spraying of PPFM (1 %) at critical stages and Rs.88,776/ha and 2.44 respectively in irrigation scheduling of 50 % ASM.

Keywords: Maize, Drought mitigation, Irrigation scheduling, PPFM, Water use efficiency.

Introduction

The reduction of maize productivity under drought stress conditions depends on different factorssuch as plant development stage, drought intensity and duration of water deficit, and varietal sensitivity to drought stress (Fiedrick*et.al*., 1989). Aslam *et.al*.reported that potassium improves drought tolerance by improving root growth, cell turgor pressure, and osmotic pressure. Pink pigmented facultative methylotrophic bacteria (PPFM) are associated with the roots, leaves and seeds of most terrestrial plants and utilize volatile C1 compounds such as methanol generated by growing plants during cell division (Irvine *et.al.*, 2012).

Materials and Methods

The field experiment was conducted at Maize Research Station, Vagarai during the years 2018-19 and 2019-20.The drought mitigating martials *viz.,*KCl (1 %) (Potassium Chloride) solution (D_2) and PPFM (1 %) (Pink Pigmented Facultative Methylotrophs) solution were sprayed at critical stages (D_3) with control (D_1). The drought mitigation materials were spraying was scheduled based on available soil moisture (ASM) at 50 % ASM (S_1), 40 % ASM (S_2), 30 % ASM (S_3) and 20 % ASM (S_4).The maize hybrid Co 6 with the spacing of 60 X 25 cm was taken. The field was prepared and seeds were sown at 5 cm depth. The experiment was replicated thrice and used the statistical design for analysis with spit plot design.The recommended fertilizer dose of 250: 75: 75 kg NPK per hectare was given as 25 % N + 100 % P_2O_5 and 100 % K_2O at basal, 50 % N at knee high stage and 25 % N at flowering stage was given.

Results and Discussion

The significant higher dry matter was obtained (6,715 kg/ha and 7,522 kg/ha respectively) in foliar spray of PPFM (1 %) at critical stages and irrigation scheduling at 50 % ASM. Similar findings were reported that the higher dry matter production recorded in the treatments might be due to increase in plant height and better root development in rice (Aswathy*et.al.* 2020).

Grain yield of maize was significantly higher (5,564 kg/ha) in spraying of PPFM (1 %) at critical stages of maize *viz.,* knee high stage, pre flowering and flowering stages than other drought mitigation methods *viz.,* spraying of KCl (1 %) and control (no mitigation strategy). Whereas, spraying of KCl (1 %) gave the onpar grain yield (5,520 kg/ha) to the PPFM (1 %) spray. As for as irrigation scheduling for maize hybrid was concern, irrigation given at 50 % ASM gave significantly higher grain yield (8,355 kg/ha) than other irrigation schedules. The crop water use efficiency was higher (13.31) in irrigation scheduling at 50 % ASM. Radhika *et.al.* (2008) observed that significantly higher maize grain yield (7941 kg/ha) was recorded in PPFM @ 5 litres/ha foliar applied plots. Among the foliar application treatments foliar application of PPFM 1% recorded significantly higher grain yield of 6847 kg/ha (Rajasekar *et.al.*, 2019). The higher net returns and benefit cost ratio of Rs.40,023/ha and 1.65 respectively in spraying of PPFM (1 %) at critical stages and Rs.88,776/ha and 2.44 respectively in irrigation scheduling of 50 ASM.

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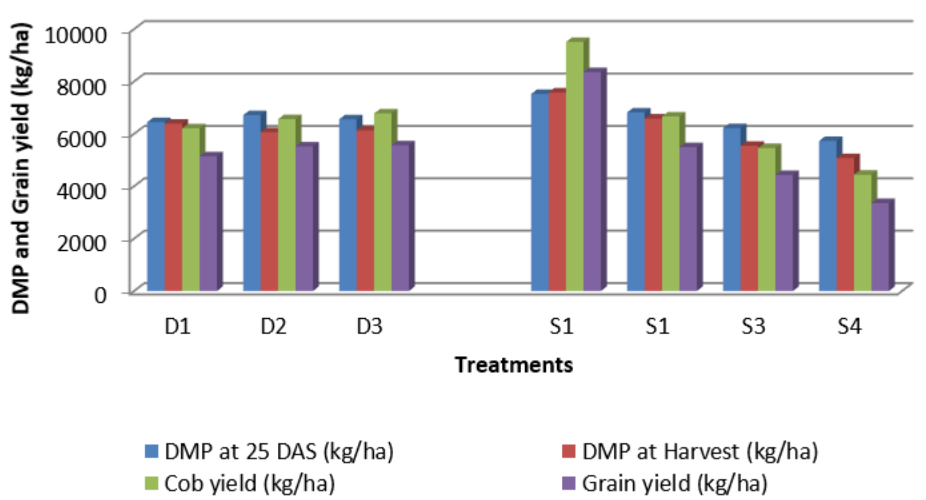
Table 1. Effect of drought mitigation strategies and irrigation scheduling on yield and economics of maize hybrid

Treatments	Grain yield (kg/ha)	Stover yield (kg/ha)	CWUE (kg/ha mm)	Net returns (Rs./ha)	BCR
Drought mitigation method					
D1 – Control (No mitigation method)	5145	5028	11.19	37123	1.65
D2 – KCl foliar spray (1%)*	5520	5099	12.04	39333	1.64
D3 – PPFM foliar spray (1%)*	5564	5465	11.89	40023	1.65
SEd	95.5	234.1	--	--	--
CD (p=0.05)	265.1	NS	--	--	--
Irrigation scheduling					
S_1 – Irrigation given at 50 % Available Soil Moisture	8355	6668	13.31	88776	2.44
S_2 – Irrigation given at 40 % Available Soil Moisture	5495	5547	11.51	39923	1.68
S_3 – Irrigation given at 30 % Available Soil Moisture	4431	4602	11.74	22519	1.39
S_4 – Irrigation given at 20 % Available Soil Moisture	3358	3973	10.25	4089	1.08
SEd	343.1	204.5	--	--	--
CD (p=0.05)	720.8	429.5	--	--	--

Fig. 1. Effect of drought mitigation strategies and irrigation scheduling on DMP and Grain yield



T2-02
Climate resilient assessment through Ecological Intensification in Maize based cropping system

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Abstract

In the *kharif* and *rabi* seasons of the years 2017, 2018 and 2019, an experiment to assess the impact of management factors associated with climate resilient which affect the crop production in maize based cropping system (i.e. Maize – Pulse (Green gram)). Different ecological attributes were combined and evaluated for their contributions to the yield improvement in maize system.TNAU maize hybrid CO6 and for pulse, green gram Co 8 cultivar were taken for testing. The result of the experiments revealed that a significantly higher grain yield (8,958kg/ha) was recorded in T_2 (Ecological Intensification) in maize and in green gram the grain yield was also significantly higher (1,137 kg/ha). In maize, there was a higher net returns recorded in T_2 (EI) (Rs.90,610 /ha) and the benefit cost ratio was 2.7 in T1- Farmers practice and 2.3 in T2 (Ecological intensification treatments respectively. The calculated use efficiencies of the maize crop revealed that the higher nutrient use efficiency (28.5) was calculated in T_1 and followed by T_2 (21.3) and lesser in T_6 (where T_4 was EI-nutrient management, it was 'Zero'). Significantly higher Agronomic Efficiency (5.0) was calculated in T_2 (EI) treatment and followed by T_1 (farmers practice). Contradictorily, there was a negative Agronomic Efficiency (-12.5) was calculated in T_6 treatment.

Keywords: Ecological Intensification, Maize-pulse system, Grain yield, Use efficiency, BCR

Introduction

Maize (Zea mays L.) is an important cereal food crop of the world with highest production and productivity as compared to rice and wheat. It is the most versatile crop which is being grown in more than 166 countries across the globe including tropical, sub tropical and temperate regions from sea level to 3000 m msl (ASG, 2011). Maize is the third most important cereal after rice and wheat for human food by contributing almost 9 % to India's food basket and 5 % to World's dietary energy supply (Annual Report, AICRP, 2007). Maize can be grown over a range of agro-climatic zones and this quality makes it a versatile crop. Maize is suitable to be grown in diverse environmental conditions which is not possible for any other crop. It is grown from 58°N to 40°S, from below sea level to altitudes higher than 3000 m, and in areas with 250 mm to more than 5000 mm of rainfall per year (CIMMYT, 2000 and Tripathi et al.2011) and with a growing cycle ranging from 3 to 13 months (Tripathi et al.2011).

Materials and Methods

The treatments comprised of T_1 – Farmer's practice (based on the survey of 50 farmers from the adjoining area of region and mode will be selected), T_2 – Ecological intensification(EI) (it comprises of best tillage and residue management practices, best planting density and genotype, precision nutrient management based on nutrient management in maize 4 R nutrient management guidelines for other crops, application of water at critical growth stages, integrated weed, disease and insect management), T_3 – EI minus tillage practice (Conventional tillage without residue retention in all crops), T_4 – EI minus nutrient management (Absolute control for nutrient in all crops), T_5 – EI minus planting density (Farmer adopted genotype and density in all crops), T_6 – EI minus water management (Complete rainfed for maize and farmers practice for rest of the crops), T_7 – EI minus weed management (no weed management in all crops), T_8 – EI minus disease and insect management (no management in all crops). Different ecological attributes were combined and evaluated for their contributions to the yield improvement in maize system.TNAU maize hybrid CO6 and for pulse, green gram Co 8 cultivar were taken for testing. Experiment was laid out in randomized block design with three replications, having the plot size of 25 m^2.

Results and Discussion

The result of the experiment revealed that there was a significant difference noticed both in Green gram and Maize. There was a significant higher grain yield of 1,137 kg/ha of green gram recorded in T2-Ecologial Intensification treatment, which comprises of including all ecological factors in recommended level. The same trend was also recorded in maize crop. i.e. a significant higher maize grain yield (8,958 kg/ha) was recorded in T2 treatment.

In maize, there was a higher net returns recorded in T_2 (EI) (Rs.90,610 / ha) and the benefit cost ratio was 2.7 in T1- Farmers practice and 2.3 in T2 (Ecological intensification treatments respectively. A negative net return and BCR (Rs. -12,244/ha and 0.8 respectively). were also calculated in T_6 (EI-water management). In Green gram the net returns and BCR were comparatively higher in T1 – Farmers practice (Rs. 30521/ha and 2.3 respectively) followed by T2 – Ecological Intensification (Rs. 26509/ha and 1.7 respectively).

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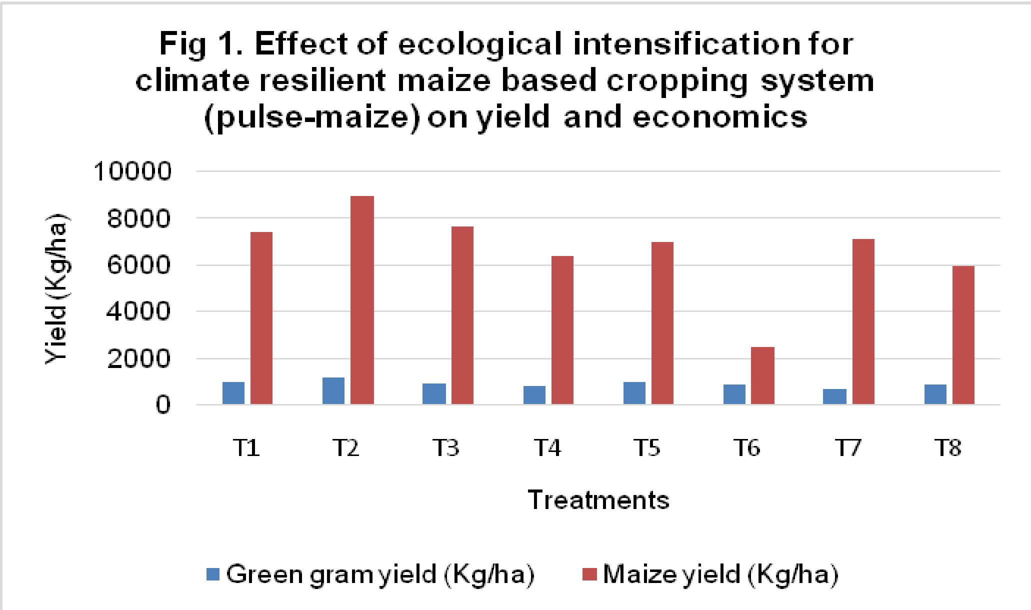
Table 1. Effect of ecological intensification for climate resilient maize based cropping system (pulse-maize) on yield and economics

Treatment	Green gram			Maize			Nut. Use Effic.	Agron. Effic.
	Grain yield (Kg/ha)	NR (Rs./ha)	BCR	Grain yield (Kg/ha)	NR (Rs./ha)	BCR		
T_1 – Farmer's practice	989	30521	2.3	7397	81664	2.7	28.5	3.6
T_2 – EI	1137	26509	1.7	8958	90610	2.3	21.3	5.0
T_3 – EI minus Tillage	891	18234	1.6	7649	74423	2.2	18.0	1.6
T_4 – EI minus NM	782	23720	1.9	6357	65745	2.5	0.0	0.0
T_5 – EI minus PD	970	18984	1.6	7007	64104	2.1	17.9	1.5
T_6 – EI minus IM	863	9351	1.3	2476	-12244	0.8	3.8	-12.5
T_7 – EI minus WM	661	4030	1.1	7086	62867	2.1	18.8	2.5
T_8 – EI minus DPM	864	11302	1.3	5978	41089	1.8	17.8	1.5
SED	722.2			4123.6			15.8	0.4
CD	214.6			1469.0			3.5	3.6

NM nutrient management, PD plant density, IM irrigation management, WM weed management DPM disease and pest management



T2-03
Evaluation of late maturity maize (*Zea mays*) hybrids under varying plant density and nutrient levels

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Introduction

Maize(*Zea mays* L.)is the most promising cereal crop in India after rice and wheat and it is cultivated in almost all parts of India for multivarious purposeowing to its wide adaptability.In maize, three different maturity groups *viz*., early maturity, medium maturity and late maturity are being released by ICAR Research Institutes and State Agricultural Universities for cultivation in different ecosystem based on the climatic and edaphic factors, irrigation facilities etc.Among them,late maturity hybrids have immense yield potential,which is to be exploited to the greatest extent through adoption of innovative technological interventions.Influence of plant density and nutrient levels on yield attributes and yield differ from hybrid to hybrid and also vary across locations.Keeping in view the above facts, the experiments were conducted to evaluate the performance of late maturity maize hybrids under varying plant density and nutrient levels.

Materials and Methods

Field experiments wereconducted during*Rabi*,2019-20 and *Rabi*, 2020-21at Department of Millets, Tamil Nadu Agricultural University, Coimbatoreto evaluate the performance of late maturity maize hybridsunder varying plant density and nutrient levels.The experiments were laid out in a split-split plot design. In the main plot, two planting densities *viz*.,60×25 cm(D_1) and 60×20 cm(D_2) and in the sub plot, three nutrient levels *viz*., 100% RDF:250:75:75 NPK kg/ha(N_1),90%RDF:225:68:68 NPK kg/ha(N_2) andSTCR-IPNS:131:38:38 NPK kg/ha(N_3) and in the sub-sub plot, three late maturity maize hybrids from TNAU*viz*.,CMH12-686(G_1), CMH15-005(G_2), COH (M) 6 (G_3) and one hybrid from private sector-NK6240(G_4) were tried in three replications in both the years.Observations on yield attributes and yield were recorded.The data on various characters studied during the investigation were statistically analyzed by Gomez and Gomez (2010) for split-split plot design. Wherever the treatment difference was significant, critical differences were worked out at 5 per cent probability level.

Results and Discussion

Planting densities failed to exert significant influence on cob length(Table 1). Nevertheless, spacing of 60×25cm recorded higher cob length of 17.8 cm than 60×20cm spacing.With respect to nutrient levels,100% RDF recorded higher cob length of 17.9 cm,which was comparable with90% RDF (225:68:68 NPK kg/ha) but was significantly superior toSTCR-IPNS (131:38:38 NPK kg/ha). Increased levels of fertilizer favoured more nutrient availability and efficient absorption and higher assimilation by the crop which increased the cob length. The results are in accordance with the findings of Adhikary et al.2020.Among the hybrids, CMH15-005 and CMH12-686 recorded higher cob length of 18.2 cm and 18.0 cm, respectively. This was comparable with COH (M) 6 but was significantly superior toNK6240.Similar view has been expressed by Azam et al.2007**.** The interaction was not significant.In spite of 60×25 cm spacing and 100% RDF recording higher cob girth (Table 1) of 15.2 cm and 15.3 cm, respectively,planting densities and nutrient levels had no significant influence on cob girth. Among the hybrids,CMH12-686 andCMH15-005 recorded higher cob girth of 15.4 cm and 15.2 cm, respectively. This was comparable withCOH (M) 6 but was significantly superior to NK6240.The interaction effect was found to be non-significant.

Planting densities exerted significant influence on number of grains/row(Table 1). Higher number of grains/ row was recorded under 60×25 cm spacing which was significantly higher than 60×20cm.Nutrient levels did not evince significant influence on number of grains/row. Nevertheless,100% RDF recorded higher number of grains/row(36.1).Late maturity hybrids also had no significant influence on number of grains/row.However,CMH15-005 and CMH12-686 recorded higher number of grains/row (36.3 and 36.1).The interaction effect was not significant.Planting densities, nutrient levels and hybrids failed to exert significant influence on number of grain rows/cob(Table 1).However, higher number of grain rows/cob was recorded under 60 ×25 cm spacing(14.6) with100% RDF(14.7). The result corroborates with the findings of Adhikary et al.2020**.**Among the hybrids,CMH12-686 and CMH15-005 recorded higher number of grain rows/cob.(14.6 and 14.5). The interaction effect was found to be non-significant.

Grain yield was significantly influenced by planting densities, nutrient levels and hybrids(Table 1).In respect of planting densities,spacing of 60×20cmrecorded higher grain yield of 9295kg ha^{-1}which was significantly superior to 60×25cm**.** The increase in grain yield was ascribed to high plant stands per unit area which intercepts more solar radiation and utilizes space, nutrient, water effectively resulting in high yield**.**The results confirm the findings ofShapiro and Wortmann, 2006who reported 25% more grain yield was obtained under high density compared to low density.With respect to nutrient levels,100% RDF recorded higher grain yield of 9345kg ha^{-1}which was comparable with 90% RDF but was significantly superior to STCR -IPNS.This might be due to improvement in yield attributes favoured by increasing level of fertilizers,which ensured adequate nutrient supply to the crop resulting in enhanced nutrient uptake**.** The results are in accordance with the findings ofDawadi and Sah, 2012**.**Among the late maturity maize hybrids,CMH15-005 and CMH12-686 recorded higher grain yield of 9120kg ha^{-1}and 9051 kg ha^{-1}, respectively. This was comparable with COH (M) 6 but was significantly superior to NK6240.The increase in yield was due to better yield attributes obtained through efficient absorption and translocation of photosynthates to sink. The results were in agreement with the findings ofSharma et al. 2019**.**The interaction was not significant

Based on the results of two years of experimentation, it is concluded that among the late maturity maize hybrids, CMH15-005 and CMH12-686 were found to be the most promising hybrids under a spacing of 60×20 cm with application of 100% recommended dose of fertilizer @250:75:75 NPK kg/ha.

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Table 1. Effect of planting density and NPK levels on yield attributes and yield of late maturity maize hybrids

Treatments	Cob length (cm)	Cob girth (cm)	No.of grains/row	No.of grain rows/cob	Grain yield (kg/ha)
Main plot					
60×25 cm spacing	17.8	15.2	36.4	14.6	8188
60×20 cm spacing	16.8	14.4	35.1	14.3	9295
SEd	0.28	0.19	0.16	0.07	140.1
CD(P=0.05)	NS	NS	0.71	NS	603
Sub plot					
100% RDF	17.9	15.3	36.1	14.7	9345
90% RDF	17.5	14.9	35.8	14.5	9081
STCR-IPNS	16.6	14.2	35.3	14.2	7798
SEd	0.42	0.53	0.33	0.16	354.3
CD(P=0.05)	0.96	NS	NS	NS	817
Sub sub plot					
CMH12-686	18.0	15.4	36.1	14.6	9051
CMH15-005	18.2	15.2	36.3	14.5	9120
COH (M) 6	17.3	14.5	35.4	14.4	8595
NK6240	16.1	14.2	35.1	14.4	8201
SEd	0.78	0.58	0.56	0.20	339.7
CD(P=0.05)	1.59	1.14	NS	NS	689

T2-04
Augmenting land use efficiency, growth and productivity of finger millet by legume intercropping

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Abstract

Legumes and non-leguminous crops are intercropped in order to increase water use efficiency, control pests and diseases, and perhaps improve major yield components than a single crop. Various intercropping systems have proven to be superior to single crops because they make better use of one or more agricultural resources in terms of both time and space. Pulses crops have a positive impact on soil health through biological nitrogen fixation, leaf fall, the addition of a significant amount of organic matter through root biomass, and improved microbial biomass. The main benefit of intercropping systems is the higher productivity and more effective use of soil, water, nutrients, and other resources when compared to each crop grown separately in a irrigated ecosystem. Choice of ecologically sound crops as millets and adoption of intercropping systems are two of suitable options for maximization of productivity in drylands cropping system due to the reason that competition of plant could be minimized not only by spatial arrangement, but also by combining those crops which have best able to exploit soil nutrients.A field experiment was scheduled to estimate the impact of intercropping ragi with blackgram and redgram cropping system oncrop growth rate, chlorophyll content, total dry matter production and grain yield at Agricultural College and Research Institute, Vazhavachanur, Tiruvannamalai during *Rabi*' 2022 and 2023 with Randomized Block Design. The aim of this study was to evaluate and compare ragi with blackgram and redgram inter cropping effects, as well as reveal which intercrops better adopts to improve water use efficiency in the production.

Keywords: Ragi, Blackgram, Crop Growth Rate, Chlorophyll content and yield.

Introduction

Intercropping has benefits over monocropping, because the component crops can use growth resources that are complimentary in both area and time. Most of the farmers from Tiruvannamali district can grow small millets is a sole one. Generally small millets are low yielding one, ragi with legume intercropping to reduce the risk of monoculture. Numerous intercropping systems have demonstrated superior yields as compared to single crops (Yang *et al*., 2011) since intercropping more efficiently utilises one or more agricultural resources in terms of both labour, inputs, time and space. Innovative and active strategies are required for handling the yield reduction of small millets, which is an urgent issue. Intercropping has been reported to enhance soil water conservation and reduce run-of (Sharma *et al.,* 2017), increase the use of available soil water (Yang *et al.,* 2011) and improve crop yield.

Materials and Methods

A field study was conducted to estimate the impact of intercropping ragi with blackgramand redgram cropping system under irrigated condition at Agricultural College and Research Institute, Vazhavachanur, Tiruvannamalai during *Rabi*' 2022 and 2023 with Randomized Block Design. Available soilN, P, and K were analysed adapting a method outlined by Jackson (1973). The experiment is comprised of 7 treatments given below:

T_1– Sole finger millet in row planting

T_2 – Finger millet with blackgram 3:1 ratio

T_3 – Finger millet with blackgram 3:2 ratio

T_4– Finger millet with blackgram 4:1 ratio

T_5 – Finger millet with blackgram 4:2 ratio

T_6– Finger millet with redgram 6:1 ratio

T_7– Finger millet with redgram 8:1 ratio

All agronomic practices are considered as normal for all the treatments except those which were under study.

Results and Discussion

T_4– Finger millet with blackgram 4:1 ratio was found to be the better performer in increasing the leaf area (611) and leaf area index. Crop growth rate value (1.192) was observed that finger millet with blackgram 4:1 ratio followed by Finger millet with blackgram 4:2 ratio at grain filling stage (1.120). Chlorophyll content of the plants influences photosynthetic rate and there by the efficiency of the plant for increased biomass production is obtained. Finger millet with blackgram 4:1 ratio maintainedhigher chlorophyll content in all stages than others. Intercropping is mainly practiced to cover the risk of failure of one of the component crops due to vagaries of weather or pest and disease incidence. Yield advantages in intercropping system are mainly because of differential use of growth resources by component crops.Chellaiah and Earnet (1994) reported that when the yield of fresh and dry matter was higher when sorghum and cowpea were intercropped than when they were grown separately.Finger millet with Blackgram 4:1 ratio treatment had a favourable influence on the growth attributes, physiological and biochemical parameters.

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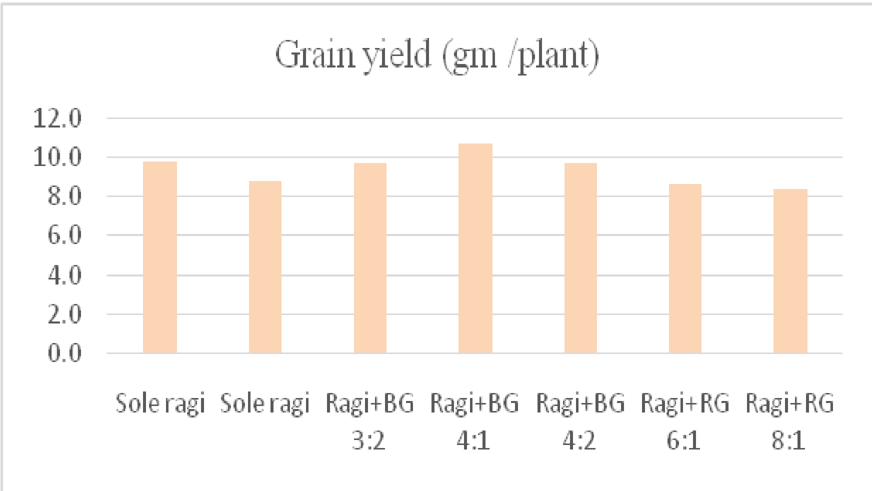
Table 1.Evaluation of Finger Millet Intercropping with Blackgram and Redgram under Irrigated Eco-System on leaf area (cm^2 $plant^{-1}$), Specific Leaf Weight (g cm^{-2}), Crop growth rate (g m^{-2} day^{-1}) and Total chlorophyll content (mg/g) of ragi

Treatments	Leaf area (cm^2/ plant)	Specific Leaf Weight (g /cm^2)	Crop Growth Rate (g/ m^2 / day^{-1})	Total chlorophyll content (mg/g)
T_1– Sole finger millet in row planting	430	0.976	0.880	2.054
T_2 – Finger millet with blackgram 3:1 ratio	448	1.088	1.117	2.438
T_3 – Finger millet with blackgram 3:2 ratio	420	1.006	1.005	2.659
T_4– Finger millet with blackgram 4:1 ratio	611	1.091	1.192	3.145
T_5 – Finger millet with blackgram 4:2 ratio	561	0.942	1.120	3.022
T_6– Finger millet with redgram 6:1 ratio	458	0.924	0.805	2.783
T_7– Finger millet with redgram 8:1 ratio	418	1.001	1.020	2.717
Sem	3.09	0.04	0.10	0.03
CD (P=0.05)	9.51	0.11	0.30	0.09

Fig. 1. Evaluation of Finger Millet Intercropping with Blackgram and Redgram under Irrigated Eco-System on grain yield (gm/ plant)



T2-05
Effect of PPFM spray and nutrient management strategies on rainfed barnyard millet (*Echinochloa frumentacea*)

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Abstract

A field experiment was conducted at Agricultural Research Station, Paramakudi during *Rabi* 2018 to study the effect of nutrient levels and PPFM application on rain-fed Barnyard millet (MDU 1).Application of PPFM inhibits the production of ethylene in crop an aging hormone to withstand the drought. Production of 1-aminocyclopropane-1-carboxylate was inhibited by the PPFM application, which is immediate precursor of ethylene production. There is a wide yield gap between the potential and actual yield of crop due to uncertainty in rainfall amount and its distribution in rainfed tract. At present recommended fertilizer dose for barnyard millet under irrigated ecosystem is 66:33:22 kg NPK ha^{-1} as a basal dose. Hence there is scope for split application of nitrogen and potassium on critical growth stages of plant. The results revealed thatnutrient levels and PPFM application had significant influence on growth parameters and yield of Barnyard millet.The highest net returns of ₹ 25,134 ha^{-1} and B: C of 1.67 was observed with the treatment150 % RDF (NK: 25 % Basal, 75 % in equal split at Tillering & Flowering) + 1 % PPFM spray(T_{12}). Hence application of 99: 49.5: 30 kg NPK ha^{-1} (NK: 25 % Basal, 75 % in equal split at Tillering & Flowering) + 1% PPFM spray) may be recommended for barnyard millet grown under rain-fed condition.

Keywords: Barnyard millet, PPFM spray, Rainfed ecosystem, Split application

Introduction

Cereals occupy major area of about 101 m ha and millets occupy 0.61 m ha. The production of cereals was 288 m t with the average productivity of 3.0 t ha^{-1}. Millet production was 44 m t with the productivity of 714 kg ha^{-1}(Indiastat 2023) and for the future with growing population, increase in malnutrition and extreme weather events there is a need for subordinate crop for the current growing crop. These questions emerge as a threat to find out the alternate crop give nourishment to the growing world as well as the climatic abnormality.Among the millets barnyard millet is known for its adaptability to water logging as well as extreme drought situations and it has the capacity to withstand the challenges viz., increase in temperature, increase in water stress and severe malnutrition (Dhananivetha, 2016). To overcome these constraints, application of essential plant nutrients along with drought mitigation technology like PPFM spray may helpful to the rain-fed farmers to increase the production of barnyard millet under rain-fed condition. Kumar *et al.,*(2022) studied the effect of organic manures along with PPFM spray and revealed the influence of PPFM spray on barnyard millet production.

Materials and Methods

Field experiment was conducted at agricultural research station, Paramakudi during *Rabi* 2018 to study the effect of graded level of fertilizer along with PPFM application on productivity of barnyard millet (*Echinochloa frumentacea*) under rain-fed condition. The barnyard millet variety used was MDU 1. The recommended dose of fertilizer was applied in the form of Urea and SSP and MOP. The recommended doses of fertilizer were 66:33:20 kg NPK ha^{-1} (100 %) and the enhanced fertilizer doses were 99:49.5:30 kg NPK ha^{-1} (150 %). Fertilizer was applied to the crop as treatments schedule. Entire dose of phosphorous is applied as basal for all the treatment, nitrogen and potassium alone were applied in a split manner at tillering and flowering stage of crop. PPFM application (1 per cent spray solution) is done 30 and at 50 days after germination.

Results and Discussion

Grain yield and straw yield was significantly influenced by the different levels and method of nutrient application Table 1. Grain yield of barnyard millet under different nutrient levels and PPFM application ranged between 918 to 1,568 kg ha^{-1}. The straw yield ranged from 3,604 to 7,739 kg ha^{-1} with different treatments. Application of 150 % RDF (NK: 25 % Basal, 75 % in equal split at Tillering & Flowering) + 1 % PPFM (T_{12}) recorded highest grain yield of 1,568 kg ha^{-1} and it was comparable with 150 % RDF (NK: 25 % Basal, 75 % in equal split at Tillering& Flowering) (T_6), which recorded a grain yield of 1526 kg ha^{-1}. The lowest grain yield of 918 kg ha^{-1} was recorded at RDF (66:33:20 kg NPK ha^{-1}) as basal (T_1). Among the levels of nutrients, application of 150 % RDF (NK: 25 % Basal, 75 % in equal split at Tillering and Flowering) + 1 % PPFM (T_{12}) influenced the straw yield and registered higher straw yield 7,739 kg ha^{-1} than the other levels tried. Significantly lowest straw yield of 3604 kg ha^{-1} was recorded at (T_1) RDF (66:33:20 kg NPK ha^{-1}) as basal.

The highest net returns of ₹ 25,134 ha^{-1} and B: C of 1.67 was also observed with the treatment T_{12} (150 % RDF (NK: 25 % Basal, 75 % in equal split at Tillering & Flowering) + 1 % PPFM spray) Fig 1.

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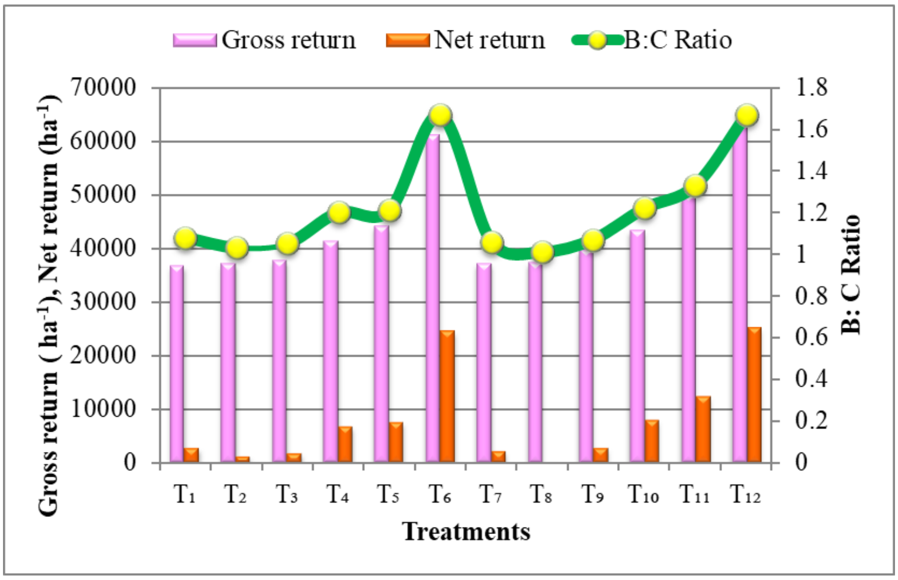
Table 1. Effect of nutrient management and PPFM application on Grain yield and Straw yield (kg ha^{-1}) of barnyard millet

Treatments	Grain yield	Straw yield
T_1: RDF	918	3604
T_2: RDF (25% Basal, 25% Tillering & 50% Flowering)	929	4197
T_3: RDF (25% Basal, NK in equal split at Tillering & Flowering)	944	5062
T_4: 150% RDF	1031	5270
T_5: 150% RDF (25% Basal, 25% Tillering & 50% Flowering)	1104	6312
T_6: 150% RDF (25% Basal, NK in equal split at Tillering & Flowering)	1526	6875
T_7: RDF + 1% PPFM	926	3958
T_8: RDF (25% Basal, 25% Tillering & 50% Flowering) + 1% PPFM	933	4750
T_9: RDF (25% Basal, NK in equal split at Tillering & Flowering) + 1% PPFM	995	5104
T_{10}: 150% RDF + 1% PPFM	1083	5625
T_{11}: 150% RDF (25% Basal, 25% Tillering & 50% Flowering) + 1% PPFM	1250	6625
T_{12}: 150% RDF (25% Basal, NK in equal split at Tillering & Flowering) + 1% PPFM	1568	7739
SEd	57.0	237.7
CD (0.05%)	118.30	493.12

RDF: Recommended Dose of Fertilizer

PPFM: Pink Pigmented Facultative Methylotrophs

Fig. 1. Effect of nutrient management and PPFM application Gross return, net return and B: C Ratio



T2-06
Soil test crop response based integrated plant nutrition system for Finger millet on *Alfisol*

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Abstract

Long-term food security necessitates striking a balance between raising crop yield, offering reasonable plant nutrition, preserving soil health, and maintaining environmental sustainability. With this context in mind, the current study has been conducted with finger millet to clarify the relationship between soil test results and crop response to applied fertilizers, to create fertilizer prescription equations (FPEs) under the Integrated Plant Nutrition System (IPNS) by targeted yield model, and to assess the degree of fertilizer input savings under IPNS. There were 24 treatments in the test crop experiment on finger millet, with four levels of N (0, 30, 60, and 90 kg ha^{-1}), P_2O_5 (0, 15, 30, and 45 kg ha^{-1}), and K_2O (0, 15, 30 and 45 kg ha^{-1}). Each fertility strip's 24 treatments were randomly distributed such that each treatment happened in both directions. The IPNS treatments, namely NPK alone, NPK + FYM @ 6.25 t ha^{-1}, and NPK + FYM @ 12.5 t ha^{-1}, were overlaid across the strips. There were three levels of FYM (0, 6.25, and 12.5 t ha^{-1}). Nomograms were created using the fertilizer prescription equations for an array of soil test values under IPNS and NPK alone for the finger millet yield objectives that were required. For initial soil nutrient status, 48 kg, 23 kg, and 44 kg of fertilizer nitrogen, phosphorus, and potassium are required for every 1000 kg increase in finger millet output respectively. This led to an IPNS-based economy of reduction in fertilizer consumption.

Keywords: Nutrient requirement, Fertilizer prescription, Finger millet.

Introduction

Ragi, also known as finger millet (*Eleusine coracana*), is a crop that has been grown for a very long time throughout Africa and Asia. It is highly nutritious and resistant to climate change (Kumar et al., 2018). Since it can resist drought and high temperatures and thrives in marginal regions with low soil fertility, it is a crucial crop for food security in many developing nations (Goron & Raizada, 2015). The development of an integrated plant nutrition system that takes into consideration the unique soil conditions and nutritional requirements of the crop is essential to maximizing finger millet output and ensuring sustainable farming practices. One of the main soil orders, *Alfisols* is distinguished by their ability to drain well, their range of base saturation, and their subsurface strata that are abundant in clay (Soil Survey Staff, 2014). Where finger millet is frequently farmed, in semiarid and subhumid areas, these soils are common. Despite their promise for agricultural production, *Alfisols* frequently require careful nutrient management to maintain soil fertility and prevent nitrogen imbalances that might adversely affect crop yields (Lal, 2016). In the context of finger millet cultivation on *Alfisols*, an STCR-based IPNS would involve analyzing soil samples to determine nutrient levels, conducting crop response studies to identify the optimal nutrient inputs for finger millet, and integrating these findings into a comprehensive nutrient management plan. This plan would consider the use of organic and inorganic fertilizers, as well as other agronomic practices, to ensure balanced nutrient supply and efficient nutrient use by the crop (Kumari *et al*., 2020).

Materials and Methods

Each strip was split into 24 plots (5m × 5 m) after the fertility gradient was created to keep up with 24 treatments (21 treatments + 3 controls), for a total of 72 (24 × 3) plots in three strips. Three blocks with eight treatments were created throughout each strip using amounts of farmyard manure. Using a fractional factorial randomized block design, the experiment was organized. The treatments included three levels of FYM (0, 6.25, & 12.5 t FYM ha^{-1}) for finger millet crop and four levels of fertilizer nitrogen (0, 30, 60, & 90 kg N ha^{-1}), phosphorus (0, 15, 30, & 45 kg P_2O_5 ha^{-1}), and potassium (0, 15, 30, & 45 kg K_2O ha^{-1}).The basic parameters, the nutrient requirement (NR), the contribution of nutrients from the soil (Cs), fertilizer (Cf), and farmyard manure (Cfym), were calculated as described by Ramamoorthy *et al*. (1967) using data on the yield of finger millet, total uptake of N, P, and K, initial soil test values for available N, P, and K, and doses of fertilizer N, P_2O_5 and K_2O applied.

Results and Discussion

Adopting the targeted yield model, the three basic parameters viz., i) nutrient requirement (NR) in kg per quintal of finger millet seed, ii) per cent contribution from soil available nutrients (Cs) and iii) fertiliser nutrients (Cf) (Fig. 1) were computed in the present investigation to calibrate soil test values and prescribe fertiliser doses for desired yield target of finger millet. Ready reckoners (nomograms) were formulated for a range of soil test values and for desired yield target of finger millet under NPK alone and IPNS (NPK+FYM). An assessment of the estimates showed that when NPK alone (Table 1) was applied, for a soil test value of 220:22:220 kg ha^{-1} of $KMnO_4$-N, Olsen-P and NH_4OAc-K respectively, the fertiliser N, P_2O_5 and K_2O doses required to achieve a desired yield target of 3.0, 3.5 and 4.0 t ha^{-1} were 69, 39 and 45 kg ha^{-1}; 90, 45 and 45 kg ha^{-1} and 90, 45 and 45 kg ha^{-1}, respectively. Whereas the fertiliser N, P_2O_5 and K_2O doses required when FYM @ 6.25 t ha^{-1} was applied along with NPK were 49, 27 and 29 kg ha^{-1}; 73, 38 and 45 kg ha^{-1} and 90, 45 and 45 kg ha^{-1} respectively for 3.0, 3.5 and 4.0 t ha^{-1}. Similarly when FYM @ 12.5 t ha^{-1} was applied along with NPK, the required fertiliser doses were 30, 15 and 15 kg ha^{-1}, 53, 26 and 34 kg ha^{-1} and 77, 37 and 45 kg ha^{-1}, respectively. The use of STCR-based fertilizer recommendations has been shown to improve crop yields and reduce fertilizer use in various crops (Ranjan *et al*., 2018) and also help to reduce the environmental impact of farming practices by minimizing the use of fertilizers and reducing greenhouse gas emissions (UshaKiruthika, 2020).

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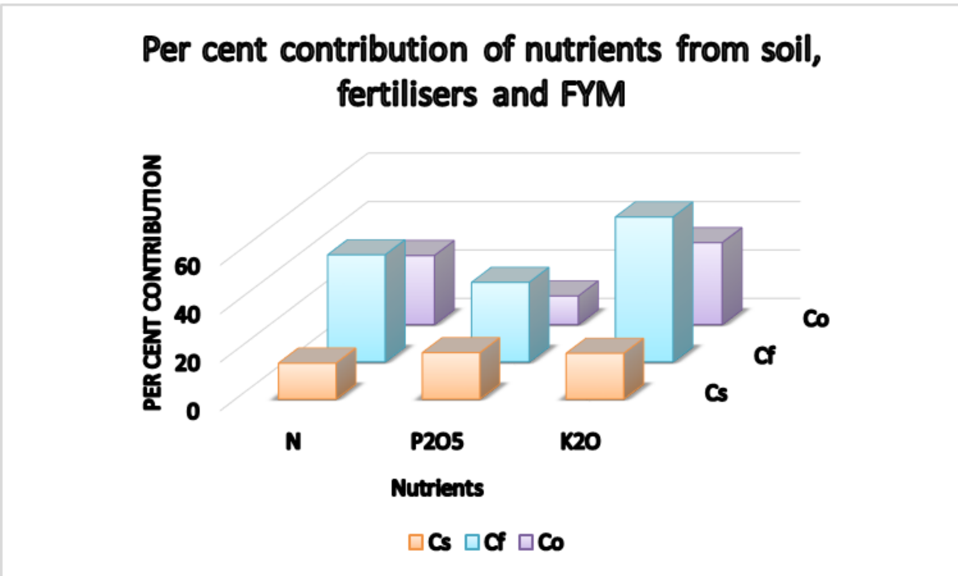
Table 1. Ready Reckoner of NPK alone for finger millet

NPK alone											
Soil test values (kg ha^{-1})			Fertilizer doses (kg ha^{-1})								
			3.0(t ha^{-1})			3.5 (t ha^{-1})			4.0 (t ha^{-1})		
$KMnO_4$-N	Olsen-P	NH_4O Ac-K	FN	FP_2O_5	FK_2O	FN	FP_2O_5	FK_2O	FN	FP_2O_5	FK_2O
220	10	220	69	45**	45**	90**	45**	45**	90**	45**	45**
240	13	240	63	45**	39	86	45**	45**	90**	45**	45**
260	16	260	56	45**	31	80	45**	45**	90**	45**	45**
280	19	280	49	43	24	73	45**	45**	90**	45**	45**
300	22	300	42	39	16	66	45**	38	90	45**	45**
320	25	320	36	35	15*	59	45**	30	83	45**	45**

Fig. 1. Basic Parameters for Finger millet – Cs, Cf, and Co



T2-07

Impact of organic nutrient management on the physiological performance and yield of Finger Millet (*Eleusine coracana* L.)

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Abstract

A field experiment was conducted at Agricultural College and Research Institute, Killikulam during the rabi season of 2019-2020 to investigate the impact of different organic nutrient management practices on the physiological characteristics and yield of transplanted finger millet (*Eleusine coracana* L.). The experiment was designed in a randomized block design with three replications comprising ten treatments, including 100% N through FYM and 100% N through poultry manure, along with their combination with liquid organic supplements such as jeevamrutham, beejamrutham and panchagavya (3% foliar spray at 30 and 45 DAT), as well as 100% RDF and an absolute control. Finger millet Co (Ra) 15 was selected as the test variety. The results showed that all treatments significantly influenced the physiological attributes and yield of transplanted finger millet, surpassing the RDF and control treatments. Among the treatments, the highest physiological characteristics and yield were observed with the application of 100% poultry manure + 3% panchagavya at 30 and 45 DAT. Conversely, the lowest grain yield was observed in the absolute control treatment. The study suggests that the use of organic supplements particularly poultry manure and panchagavya can improve the physiological performance and yield of finger millet. These findings provide insight into sustainable agriculture practices that can improve crop yield and quality while also reducing the environmental impact associated with chemical fertilizers.

Keywords: Organic management, Finger millet, Poultry manure, Panchagavya, Grain yield

Introduction

Millets are ancient crops that can grow well in poor soil and moisture conditions as rainfed crops. They are highly nutritious, easy to digest and non-acid-forming foods making them an important remedy for malnutrition. Finger millet also known as Ragi, is a significant crop among small millets and India alone contributes over 50% of the global production of finger millet. With changing food habits and an increasing demand for organic products, farmers are realizing the benefits of using organic farming methods to improve soil fertility, quality and sustainable development. However, the use of organic manures is decreasing due to several reasons and there is a need to generate an effective manurial strategy with the available resources. Over the past few years, liquid organic formulations such as panchagavya, jeevamrutham and beejamrutham have gained importance among many organic farmers as they promote good vegetative growth, provide immunity to the plant and increase yield. These liquid organic manures are prepared with on-farm materials rich in naturally occurring microflora and beneficial microbes (Devakumar *et al.*, 2014). Therefore, the influence of various organic nutrient management practices on the physiological response and yield of transplanted finger millet could have significant implications for sustainable agriculture production.

Materials and Methods

In the rabi season of 2019-20, a study was conducted at the Agricultural College and Research Institute in Killikulam to investigate the effect of organic nutrient sources on the yield and physiological performance of transplanted finger millet. The experiment used the finger millet Co (Ra) 15 variety in RBD design with three replications. The experiment included ten treatments: T_1 - 100% recommended dose of fertilizers, T_2 - 100% nitrogen through farmyard manure (FYM), T_3 to T_5 - 100% nitrogen through FYM with organic foliar spray (3% Jeevamrutham, 3% Beejamrutham and 3% Panchagavya at 30 & 45 DAT), T_6 - 100% nitrogen through poultry manure, T_7 to T_9 - 100% nitrogen through poultry manure with organic foliar spray (3% Jeevamrutham FS, 3% Beejamrutham FS and 3% Panchagavya FS at 30 & 45 DAT) and T_{10} - absolute control. Physiological parameters such as CGR, Chlorophyll content (SPAD) and light interception (%) were measured and the grain yield was determined at harvest. The data was analyzed for ANOVA and the standard error and critical differences among treatments were calculated at a probability level of 0.05.

Results and Discussion

The physiological parameters like crop growth rate (CGR), chlorophyll content (SPAD) and light interception (%) were significantly higher in 100% N through Poultry manure + 3% Panchagavya FS at 30 & 45 DAT (T_9) followed by 100% N through Poultry manure + 3% Jeevamrutham FS at 30 & 45 DAT (T_7) and it was comparable with 100% N through Poultry manure + 3% Beejamrutham FS at 30 & 45 DAT (T_8). Grain yield also followed the same trend (Table 1) (Fig. 1). The timely availability of nutrients from poultry manure helped to increase plant growth and develop a denser canopy that intercepted more light, resulting in a higher SPAD value. The availability of nitrogen from organic manures also contributed to the increased crop growth rate. The higher yield might be due to the superior nutrient status and greater response of finger millet to poultry manure. Furthermore, the use of panchagavya spray containing natural beneficial microorganisms and growth-promoting substances improved the physiological performance and yield of finger millet. These results were consistent with the findings of Ananda *et al.* (2018); Harika *et al.* (2019); Jagadeesha *et al.* (2016).

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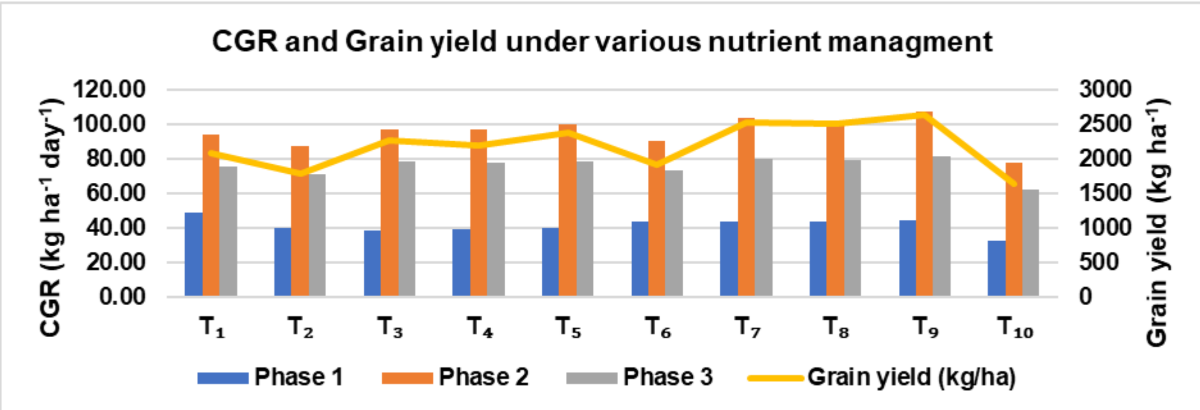
Table 1. Physiological response of finger millet to different nutrient management

Treatments	SPAD value			Light interception (%)		
	30 DAT	60 DAT	Harvest	30 DAT	60 DAT	Harvest
T_1	44.27	45.63	19.95	65.02	71.84	67.09
T_2	25.14	39.78	15.64	59.54	66.26	61.87
T_3	24.72	50.42	21.92	60.50	76.54	71.18
T_4	24.58	49.39	21.79	60.01	75.46	70.65
T_5	25.59	53.15	23.31	61.07	80.24	74.23
T_6	30.38	41.93	18.0	62.95	69.08	64.92
T_7	29.46	56.75	25.41	63.54	83.75	77.63
T_8	29.14	56.26	25.20	63.21	83.04	76.71
T_9	30.57	59.35	27.56	63.76	86.25	79.65
T_{10}	18.35	28.25	11.12	53.87	61.87	56.89
SEd	1.2	0.81	0.94	0.34	0.83	0.51
CD (P=0.05)	2.5	1.7	1.2	0.75	1.70	1.05

Fig. 1. Crop growth rate & yield of finger millet influenced by nutrient management



T2-08
Nitrogen use efficiency, uptake and yield of maize as influenced by coating of urea granules

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Abstract

Poor management of fertilizers is a well-known inefficiency that poses a threat to the environment. Fertilizer efficiency must be considerably increased to avoid harmful environmental implications. The current study was conducted during 2022, where three different type of urea coating were synthesized and applied in a field experiment conducted in a farmer's field in Vaiyampalayam, Coimbatore. Urea granules were coated with a layer of ethyl cellulose, starch-superabsorbent polymer as a single layer and a double layer of ethyl cellulose and starch-superabsorbent polymer. The nitrogen use efficiency was superior for the treatment with the application of Urea coated with EC + starch-SAP (100% of RDF) with 65.8%. Due to enhanced cell division and expansion, which accounted for greater nutrient uptake and use by the crop, better nutrient availability led to optimal growth of the crop, which in turn resulted in an increased biomass production. Hence, in the present investigation, the treatment with Urea coated with EC + starch-SAP (100% of RDF) has a superior dry matter production, which is followed by Urea coated with EC + starch-SAP (75% of RDF) with values 9519 and 9116 kg ha^{-1} respectively.

Keywords: slow release fertilizer, nitrogen use efficiency, maize productivity

Introduction

Excessive application of unconventional fertilizers has the potential to contaminate natural aquifers and increase greenhouse gas emissions. One significant anthropogenic source of gaseous N losses, including nitrous oxide (N_2O) and ammonia (NH_3) emissions, is the excessive and inappropriate application of nitrogen (N) fertilizer in agricultural fields. For sustainable agricultural development, it is crucial to reduce volatilization and soil nitrate leaching losses from agricultural ecosystems and increase crop yield as well as nitrogen use efficiency with effective nutrient management strategies (Lu *et al.*, 2016).

Materials and Methods

To minimize adverse environmental impact, fertilizer efficiency must be enhanced. In light of this, the current investigation was undertaken in 2022, involving the synthesis of three different types of urea coating and their application in a field trial in a farmer's field in Vaiyampalayam, Coimbatore. Ethyl cellulose coating, starch-superabsorbent polymer coating, and a coating with both layer of ethyl cellulose and starch-superabsorbent polymer were used to coat the granules of urea.

Results and Discussion

The dry matter production in was significantly higher with the application of Urea coated with EC + starch-SAP (100% of RDF) and Urea coated with EC + starch-SAP (75%

of RDF) with 6279 and 6041 kg ha^{-1} respectively. Due to enhanced cell division and expansion, which accounted for greater nutrient uptake and use by the crop, better nutrient availability led to optimal growth of the crop, which in turn resulted in an increased biomass production. This indicates that administering nitrogen by various slow-release urea plays a major role in controlling nitrogen availability at all the growth stages by minimizing mineralization, reducing leaching to a great extent, and preventing their risk of loss due to volatilization. The mentioned results were in correspondence to the findings of Kashiri *et al.* (2013).

The nitrogen use efficiency was found to be superior for the treatment with the application of Urea coated with EC + starch-SAP (100% of RDF) with 65.8% where the normal nitrogen use efficiency for conventional Urea without coating (100% of RDF) only recorded 45.2%. Though the rate of application was similar, this indicates that there was an enormous amount of nitrogen loss from the uncoated urea in the field condition through volatilization or leaching losses. Similar results were observed under the application of urea coated with pine oleoresin in Vertisol by Kundu *et al.* (2016) where NUE was increased from 19.34% to 32.80%.

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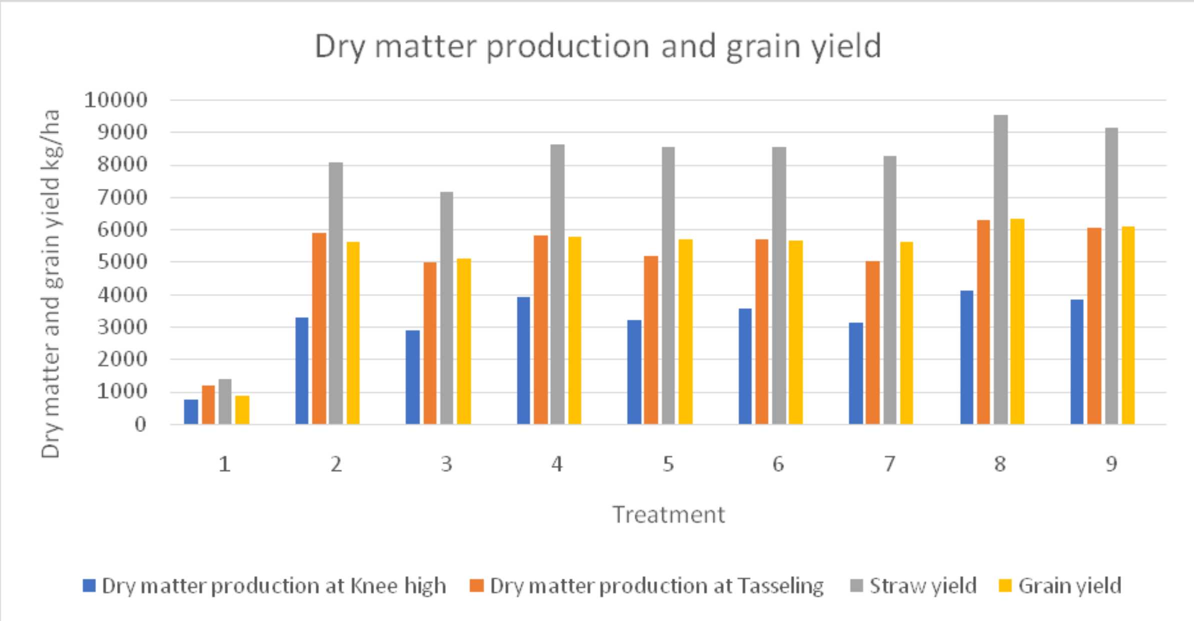
Table 1. Nutrient use efficiency (NUE) of maize

Treatments	N (%)	P (%)	K (%)
T_1: Control	0.0	0.0	0.0
T_2: Urea without coating (100% of RDF)	45.2	40.9	136.5
T_3: Urea without coating (75% of RDF)	36.1	33.2	114.2
T_4: Urea coated with Ethyl cellulose + Stearic acid (100% of RDF)	51.3	46.1	158.3
T_5: Urea coated with Ethyl cellulose + Stearic acid (75% of RDF)	50.1	44.5	157.3
T_6: Urea with Starch- Super absorbent polymer (SAP) (100% of RDF)	50.5	46.8	163.1
T_7: Urea with Starch- Super absorbent polymer (SAP) (75% of RDF)	46.8	42.5	150.7
T_8: Urea with Ethyl cellulose + Starch- Super absorbent polymer (SAP) (100% of RDF)	65.8	57.2	187.7
T_9: Urea with Ethyl cellulose + Starch- Super absorbent polymer (SAP) (75% of RDF)	58.8	50.8	176.0
Mean	45.0	40.2	138.2

Fig. 1. Effect of slow release fertilizer on dry matter production and grain yield



T2-09
Evaluation of Plant-Amendments-Microbial interactions for improving the productivity of Maize hybrids and soil fertility in Calcareous soils

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Introduction

Soil calcareousness is the major yield limiting abiotic stress and widely observed abiotic stress in the regions having arid and semi-arid climate affecting over 800 million hectares of land world-wide. These soils were identified by the presence of more than 5% free calcium carbonate ($CaCO_3$) as an accumulation of lime (Alagappan, 2020) with the pH of 8.30. The extent of calcareous soil in India is about 228.8 m ha (69.4% of total area) and in Tamil Nadu it accounts for 3.70 m ha (28.4 % of total area) The poor soil organic matter, high pH with lesser availability of all essential plant nutrients due to fixation and precipitation is the common problem that corresponds to very low nutrient use efficiency and crop yields (Manal et. al. 2021). Hence developing suitable management strategies is essential to get maximum yield and quality of the produce with improved soil health.

Materials and Methods

A field experiment was conducted with maize hybrids COH (M)6, COH(M) 8 and CM-12-686 to evaluate the effect of various inorganic (elemental sulphur on sulphur equivalent basis at 40 kg S) and organic amendments (5t vermicompost, 10t pressmud and 12.5 t FYM ha^{-1}) along with calcite dissoluting microbe (CDM) and standard checks viz., VA Mycorrhiza (VAM) and Phosphorus solubilising bacteria (PSB) on calcareous soil. Recommended crop production and protection practices were carried out and the crops were grown to maturity and harvested. The growth and yield attributes, yield and DMP were recorded. Post- harvest soil and plant samples were collected and analyzed for nutrient availability and uptake by the crop. The phytosiderophore content in the root exudates was also determined to understand the mechanism of enhanced nutrient availability and uptake by crops on calcareous soils.

Results and Discussion

Application of organic amendments and calcite dissoluting microbes in the presence of elemental sulphur had significant influence on the growth and yield attributes, yield and calcite dissolution in soil by all the maize genotypes. Soil test based NPK along with 12.5 t FYM + Calcite dissoluting microbe at 500 ml ha^{-1} recorded better growth attributes such as plant height (224, 216 and 242 cm), root length (21.7, 19.9 and 23.7 cm) and lateral root length (13.2, 11.4 and 13.8 cm) in COH (M) 6, COH (M) 8 and CMH-12-686, respectively. This was closely followed by NPK+5t vermicompost and NPK + 10 t pressmud with calcite dissoluting microbe. The lowest growth and yield attributes were observed in NPK control. Between the three maize genotypes, higher growth and yield attributes were registered with COH (M) 6 followed by CMH-12-686 and COH (M) 8 on calcareous soil.

Application of soil test based NPK + 40 kg sulphur as elemental sulphur + 12.5 t FYM and calcite dissouting microbe recorded higher grain (8427, 8272 and 8977 kg ha^{-1}) and stover yield (11490, 11399 and 12510 kg ha^{-1}) in COH (M) 6, COH (M) 8 and CMH-12-686 respectively. The lowest grain and stover yield was noticed in NPK control plots irrespective of genotypes. In case of genotypes, CMH-12-686 performed better (16.7%) than other two with higher mean grain and stover yield (7141 and 11322 kg ha^{-1}, respectively). About 11.7 to 12.6% yield reduction was observed in un-amended plots by skipping the amendment elemental sulphur to calcareous soils.

Inclusion of amendments (40 kg S as elemental sulphur) and calcite dissoluting microbes significantly reduced the soil pH and free $CaCO_3$ content in calcareous soil which ranged from 7.19 to 6.60, 7.30 to 6.75 and for 7.11 to 6.50 pH and 9.20 to 6.07%, 9.30 to 6.11% and 9.13 to 5.07% for free $CaCO_3$ respectively with COH (M) 6, COH (M) 8 and CMH-12-686. The calcite disoolution potential of the amendments and microbe was computed and found that, application of NPK+ 40 kg S as elemental sulphur + 12.5 t FYM and 500 ml CDB recorded the maximum calcite solubilization of 34.0%, 36.3% and 44.5% in COH (M) 6, COH (M) 8 and CMH-12-686 respectively. The lowest calcite solubilistaion was noticed with un-amended control (9.62 to 10.7%).

As regards the nutrient availability, higher P, Zn and Fe availability was observed with the application of NPK+ 12.5 t FYM + 500 ml CDB + 40 kg sulphur as elemental sulphur in all the maize hybrids. This was followed by PSB > VAM along with 12.5 t FYM + 40 kg S as elemental sulphur. The lowest nutrient availability was noticed in un-amended control. To understand the mechanism underpinning the improved nutrient availability and reduced pH and free $CaCO_3$ content in calcareous soil, root exudates of the plant was collected and estimated for phytosiderophore production. Application of NPK along with 12.5 t FYM + CDB recorded the highest phytosiderophore content in COH (M), COH (M) 8 and CMH-12-686 (1.33 to 1.61 nmol of Fe equivalent/g). The lowest phytosiderophore production was noticed in un-amended control. Among the maize hybrid, CMH-12-686 (1.13 to 1.61 nmol of Fe equivalent/g) produced higher phytosiderophore content than COH (M) 6 (0.93 to 1.33 nmol of Fe equivalent/g) and COH (M) 8 (1.02 to 1.46 nmol of Fe equivalent/g).

The results emanated from the study revealed that application of soil test based NPK+40 kg sulphur as elemental sulphur+12.5 t FYM + 500 ml calcite dissoluting microbe ha^{-1} was found beneficial in improving the yield of maize hybrids and nutrient availability in calcareous soils. The performance of maize hybrid CMH-12-686 was better on calcareous soil than COH (M) 6 and COH (M) 8.

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Fig. 1. Effect of amendments and microbes on the grain yield of maize hybrids in calcareous soil (Error bar indicates the mean of three replications, CDB - Calcite dissoluting microbe ; VC -vermicompost ; PM - Pressmud)

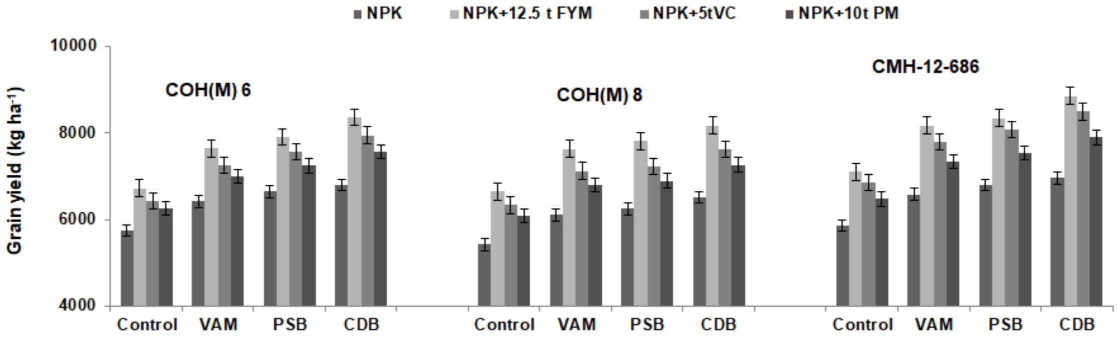
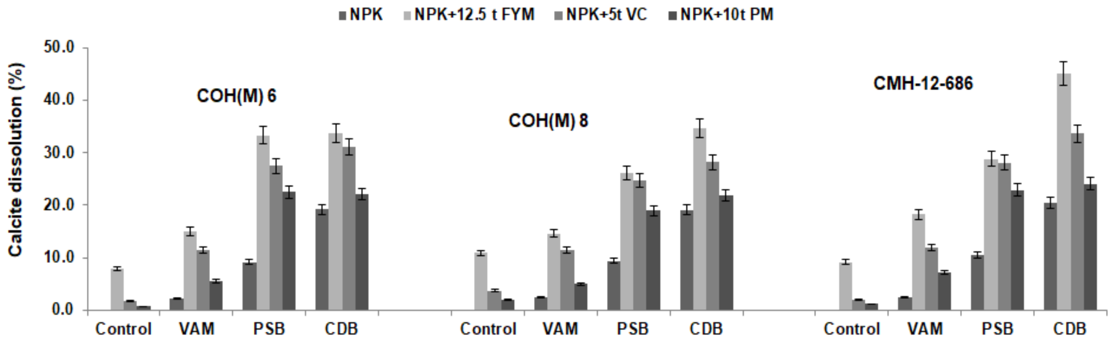


Fig. 2. Effect of amendments and microbes on calcite dissolution in calcareous soil (Error bar indicates the mean of three replications, CDB - Calcite dissoluting microbe VC -vermicompost PM - Pressmud)



T2-10
Effect of organic basal nutrition and foliar sprays on growth and yield attributes of ragi (*Eleusine coracana*) under irrigated condition for sustainable soil heath and productivity

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Abstarct

Field experiments were conducted at Centre of Excellence in Millets, Athiyandal, Thiruvannamalai during *Kharif*, 2015 and *Kharif*, 2017 to assess the suitable basal nutrition for ragi through organic sources and study the effect of foliar nutrition through organic sources on growth and yield of ragi. The experiment was laid out in split plot design and replicated thrice. The treatments are different nutrient sources in main plot B_1 - Farm Yard Manure @ 12.5 t $ha^{-}1$, B_2 - Vermi compost @ 5 t $ha^{-1,}$ B_3 - 6.5 t Farm yard manure + raising sunhemp & plough in situ on 45 DAS, B_4 - Recommended Dose of Fertilizers (60 : 30 :30 kg/ha) and different organic foliar spray as subplot F_1 - 3 % Panchagavya spray, F_2 - 3 % Vermiwash spray , F_3 - 3 % Jeevamruth spray, F_4 - Water spray and F_5 - 5 % coconut water. The results revealed that soil application of 6.5 t/ha of Farm yard manure with insitu incorporation of sunhemp on 45th DAP of ragi significantly recorded higher grain yield (2382 Kg/ha) and straw yield (3286 kg/ha). With respect to organic foliar sprays, 3 % Panchakavya enhanced the growth attributes, yield attributed like grain (2318 kg/ha) and straw yield (3220 kg/ha) respectively.

Introduction

Finger millet (*Eleusine coracana*.) is a tropical small millet indigenous to India. It is a traditional long duration, hardy and drought resistant crop. The continuous use of inorganic fertilizers under intensive cropping system has caused widespread deficiency of secondary and micronutrients in soil. A keen awareness has sprung on the adoption of "organic farming" as a remedy to cure the ills of chemical agriculture (Reddy *et al*, 2018). Foliar fertilization is a simple and effective method of providing nutrients to crops. This study was programmed with the objective to evaluate the basal application of organic sources and foliar nutrition on growth and yield parameters of finger millet. Application of foliar spray of organic nutrients along with chemical fertilizers would be a sound proposition in the input management leading to better yields. Foliar spray is a simple and effective method of providing nutrients to crops. This is considered as an efficient and economic method of supplementary nutrient management.

Materials and Methods

A field experiment was conducted at Centre of Excellence in Millets, Athiyandal, Thiruvannamalai during *kharif,* 2017 to evolve a suitable organic source of nutrient with foliar application. Soil at the experimental site was classified as sandy clay loam. A field experiment was laid out at Centre of Excellence in Millets, Athiyandal during *kharif*, 2018 with four organic sources fertilizers and five different nutrients as organic foliar sprays under split plot design with three replications. Application of organic sources such as M_1-Farm yard manure @ 12.5 t ha^{-1}, M_2 - Vermi compost (5 t ha^{-1}) M_3 - Farm yard manure with sun hemp insitu incorporation on 45 DAP and M_4 - Inorganic source of recommended dose of fertilizer as a control. Application of organic foliar sprays such as S_1-3 % Panchakavya, S_2 - 3 % Vermiwash , S_3- 3 % Jeevamruth , S_4- 5 % Coconut water and S_5 - Water spray a control .

Results and Discussion

The results revealed that soil application of 6.5 t/ha of Farm yard manure with insitu incorporation of sunhemp on 45^{th} DAP of ragi significantly recorded higher grain yield (2382 Kg/ha) and straw yield (3286 kg/ha). With respect to organic foliar sprays, 3 % Panchakavya enhanced the growth attributes, yield attributed like grain (2318 kg/ha) and straw yield (3220 kg/ha) respectively. Plant growth is also dependent on the rate of accumulation of dry matter. The dry matter accumulation may reflect on the economic yield in view of the fact that vegetative parts of the plant serve as a source where as grains are the sink. Increase in grain yield differed significantly due to different nutrient sources. Foliar application of organic source of nutrients at the flowering stage may improve the physiological efficiency and may play a significant role in raising the productivity of the crop. The improvement in iron and calcium content of finger millet with panchagavya spray might be ascribed to beneficial effects of panchagavya on crop quality.

Soil application of Farm yard manure with sunhemp insitu incorporation at 45 Days after planting with 3 % panchakavya spray (M_3S_1) at 30 and 45 Days after sowing recorded higher grain yield and straw yield of ragi. Foliar nutrition at critical growth stages significantly influenced the growth and yields of finger millet.

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Table 1. Effect of different organic sources and suitable organic foliar spray on yield parameters and yield of *Kharif*, 2018

Treatments	Plant height (cm)	Productiv e tillers (Nos)	No. of fingers/ear (Nos)	Grain yield (Kg/ha)	Straw yield (kg/ha)
Main plots					
$M_{1:}$ Farm Yard Manure @ 12.5 t ha^{-1}	83.6	2.6	4.4	2143	3045
M_2: Vermicompost @ 5 t ha^{-1}	82.12	2.6	4.2	1848	2752
M_3: 6.5 t Farm yard manure + Sunhemp (in situ)	92.4	3.8	4.7	2382	3286
M_4: Recommended Dose of Fertilizers	88.64	2.6	4.2	1985	2888
S.Em$\pm$	3.54	0.18	0.32	73.83	118
C.D. = 0.05	8.66	0.36	0.64	180.67	289
Sub plots					
S_1 : 3% Panchagavya spray	97.75	4.0	6.3	2318	3220

S_2 : 3% Vermiwash spray	88.00	3.3	5.7	2104	3006
S_3 : 3% Jeevamruth spray	88.30	3.5	5.6	2092	2996
S_4 : Water spray	78.00	2.9	4.4	1885	2788
S_5 : 5% Coconut water	82.50	3.4	4.6	2050	2953
S.Em$\pm$	3.94	0.11	0.17	113.57	146
C.D. = 0.05	8.04	0.33	0.34	231.33	310
Interaction (MXS)					
S.Em$\pm$	3.43	0.23	0.34	112	117
C.D. = 0.05	NS	NS	NS	NS	NS

T2-11
Effect of samai based cropping systems for higher productivity and profitability to achieve sustainable income

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Abstract

Samai is one of the important rainfed as well as dry land crop and is widely cultivated throughout country in dry tracks with fewer natural resources. It is an urgent demand of incorporation the pulses and oilseeds in cereals production system. An experimental trial was laid out during *kharif* 2016, 2017 and 2018 in randomized block design replicated thrice to evolve a suitable inter and sequential cropping in samai based cropping system under rainfed condition at three centres as CEM, Athiyandal, DARS, Chettinad and RRS, Paiyur. Variety of Co (samai) 4 was used as base crop and it was intercropped with Redgram at three different row proportions (4:1, 6:2 and 8:2 respectively). The growth attributes *viz*., plant height, higher leaf area index, SPAD and Crop growth rate was found to be significantly influenced the different intercropping row combinations i.e 4:1 ,6:2 and 8:2 respectively. Among the different intercropping systems, higher plant height was registered higher at samai intercrop with redgram with succeeding crop of mothbean at 8:2 row combinations (96.6cm).

Introduction

Intercropping is important for the development of sustainable food production systems, particularly in cropping systems with limited external inputs. This may be due to some of the potential benefits for intercropping system such as high productivity and profitability, improvement of soil fertility, efficient use of resources, reducing damage caused by pests, diseases and weeds (Rathore *et al.* 2003). The competitive effects between main and intercrop depends on the rooting pattern, canopy structure and days to maturity. The intercropping system of cereals + pigeonpea/legumes were tested and found to be profitable systems (Patil, 2003). The present experiment, therefore was planned to study the competitiveness of short duration little millet with long duration pigeonpea and lablab crops grown in intercropping systems with sequential crops of horsegram and moth bean.

Materials and Methods

A field experiment was conducted at Centre of Excellence in Millets, Athiyandal, Dry Land Agricultural Research Station - Chettinad and Regional Research Station – Paiyur district during kharif, 2017, 2018 and 2019. The experiment was comprised of nine treatments, viz., -Samai + Redgram (4:1) - Moth bean, Samai + Redgram (4:1) – Blackgram, Samai + Redgram (4:1) – Horsegram, Samai + Redgram (6:2) – Moth bean, Samai +

Redgram (6:2) - Blackgram, Samai + Redgram (6:2) – Horsegram, Samai + Redgram (8:2) – Moth bean, Samai + Redgram (8:2) – Blackgram, Samai + Redgram (8:2) – Horsegram. The experimental was laid out in randomized block design with three replications, the little millet variety Co (Samai) 4, was sown with Pigeonpea (Co (Rg) 7) as a intercrop followed by sequential crops of moth bean TMV (Mb)1, horse gram (Paiyur2) and Black gram (T9). Basal application of 44:22:0 kg NPK / ha was given for base crop of little millet uniformly to all the plots at the time of sowing and no additional dose of fertilizers was used for intercrops. Recommended package of practicses were followed as per the crop production guide.

Results and Discussion

Pooled mean analysis of three centre data of CEM, Athiyandal, DARS Chettinad and RRS, Paiyur during *kharif*, 2017, 2018 and 2019. Plant height of samai was found to be higher at all the stages under the treatment, little millet + pigeonpea - mothbean at 8:2 ratio (T7) (96.6 cm at harvest) followed by littlemillet + pigeonpea - horsegram at 8:2 ratio (T9) (94.2 cm at harvest) (Table. 1). Similar results were also obtained by Kaushik and Sharma (2017) in wheat based intercropping system. The yielding ability of a crop is reflected through its yield attributing characters. The yield attributes of littlemillet like number of productive tillers per hill, panicle length and test weight is found to be increased when intercropped with pigeonpea at 8:2 ratio (Table.1). This might be due to development of better complementary relationship and non-renewable resources like water, nutrients and incoming sunlight.

Intercropping system provides higher cash return to smallholder farmers than growing the monocrops. Increase the productivity per unit area in little millet intercropping system under rainfed conditions of Tiruvannamalai district, growing of samai and pigeonpea at 8:2 row ratio with horsegram or mothbean in sequence have been found superior over other intercropping systems under rainfed conditions

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Table 1. Effect of littlemillet and pigeonpea intercropping on growth and yield attributes (Pooled mean of three years)

Treatments	Plant height (cm)	Leaf area index	Productive tillers (Nos)	Panicle length (cm)	Grain yield (Kg/ha)	Straw yield (Kg/ha)
Samai+ Red gram (4:1) - Mothbean	92.3	1.48	6.8	25.3	536	1506
-Samai + Red gram (4:1) -Blackgram	92.6	1.68	6.5	25.0	499	1422
Samai+ Red gram (4:1) - Horsegram	90.1	1.64	6.9	24.3	502	1441
Samai+ Red gram (6:2) - Mothbean	92.7	1.63	8.2	24.3	530	1403
-Samai + Red gram (6:2) - Blackgram	93.3	1.68	8.0	25.0	556	1429
Samai + Red gram (6:2) - Horsegram	95.9	1.53	7.5	24.9	582	1559
Samai + Red gram (8:2) - Mothbean	96.6	1.54	8.0	24.8	619	1602
Samai + Red gram (8:2) - Blackgram	93.2	1.61	8.0	24.6	652	1676
-Samai + Red gram (8:2) - Horsegram	94.2	1.51	8.0	25.0	648	1652
S.Em.±	3.2	0.2	0.6	0.5	69	72
CD (P=0.05)	9.7	0.6	1.7	1.4	203	212

T2-12

Productivity and Profitability enhancement in Finger millet (*Eleusine coracana* L.) by Front Line Demonstrations in Tiruvallur District of Tamil Nadu

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Abstract

Millet grains have significant advantages as a drought resistant crop, produce high yields in water-scarce regions in India. Finger millet (*Eleusine coracana* L. Gaertn) is one of the important millets grown extensively in Tiruvallur District during Chittaraipattam and Margazhipattam. The results revealed that recent high yielding variety seed of ATL 1(5 kg/ha) ATL 1 @ 5 Kg/ha and KMR 630 @ 5 KG/ha; MN mixture 12.5 kg/ha, ST – *Azospirillum & Phosphobacteria* each @ 600 g/ha seed & SA @ 2.0 kg/ha + seed treatment (*Trichoderma viridi* 5 g/kg + PSB 25g/kg) + plant protection (yellow sticky trap+ Insect based management) recorded average highest yield of 2.31 t/ha followed by 1.86 t/ha in farmers practice. Benefit cost ratio for demonstration and control was 2.72 and 2.42 respectively.

Introduction

Finger millet, also known as Ragi, is a nutrient-dense cereal that has been a staple food in India for centuries. Finger millet (*Eleusine coracana* L. Gaertn) is one of the important millets grown extensively in Tiruvallur District during Chittaraipattam and Margazhipattam. It is mainly grown for its grains and it is highly nutritious. Its grains contain carbohydrate (65-75%), protein (5-8%), dietary fibre (15-20%), minerals (2.5-3.5%) and vitamins (Chethan and Malleshi, 2007) It has gained popularity in recent years as a "nutri-cereal" due to its impressive health benefits and nutritional content. Millet grains have significant advantages as a drought resistant crop, produce high yields in water-scarce regions in India. It is a hardy crop, has good adaption to wide range of environment especially heat, drought, marginal and degraded soils (Okalebo etal., 1991)

Hence, there is a great demand for improving finger millet production productivity enhancement in Finger millet through Frontline demonstration in Tiruvallur district.

Problem diagnosed: Finger millet is one of the important millets grown extensively in Tiruvallur District during Chittaraipattam and Margazhipattam extensively covered an area of 60 percent under Irrigated condition. Farmers facing the problem of moisture stress at various crop growth stages thereby experiencing low yield and crop loss to some extent. Besides moisture stress, lack of knowledge on the availability of drought tolerant varieties, non-adoption of improved cultivation practices, prevalence of nutrient deficiency, pest and disease incidence also lowers the fingermillet productivity.

Materials and Methods

Frontline demonstration was conducted to demonstrate the potential of the drought tolerant, short duration variety with the improved package of practices in comparison with the existing farmers practice in the farmers' holdings of Tiruvallur district during *rabi* 2021 under irrigated condition.

Frontline demonstration (FLDs) on finger millet was conducted by ICAR-Krishi Vigyan Kendra, Tirur in Thiruvallur district in the following villages of Poondavakkam, Purivakkam, Agoor and RK Pet Block of Tiruvallur during the *rabi* season of 2021-2022. Each demonstration was conducted in an area of 0.4 ha and with an adjacent area of 0.4 ha selected for farmers practice. In the demonstration, the improved practices including cultivation of finger millet variety ATL1, released from Centre of Excellence in Millets, Athiyandal, TNAU during 2020. It has 105-110 days duration, high yielding variety, tolerant to drought and blast disease. In farmers practice, finger millet local variety was grown with the existing farmers practices such as broadcasting of seeds, basal application of complex fertilizers, etc.

Results and Discussion

The results revealed that recent high yielding variety seed of ATL 1(5 kg/ha) ATL 1 @ 5 Kg/ha and KMR 630 @ 5 KG/ha; MN mixture 12.5 kg/ha, ST – *Azospirillum & Phosphobacteria* each @ 600 g/ha seed & SA @ 2.0 kg/ha + seed treatment (*Trichoderma viridi* 5 g/kg + PSB 25g/kg) + plant protection (yellow sticky trap+ Insect based management) recorded average highest yield of 2.31 t/ha followed by 1.86 t/ha in farmers practice. Benefit cost ratio for demonstration and control was 2.72 and 2.42 respectively. From the study it can be concluded that the ragi production could be enhanced by encouraging the farmers through adoption of recommended technologies which were followed in the Front-Line Demonstrations.

Results of the demonstration revealed that cultivation of finger millet variety ATL1 with integrated crop management practices increased the yield and income of the farmers under irrigated condition.

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Table 1. Gowth and yield parameters of finger millet varieties local and ATL1 as influenced by farming practices

Treatments	**Plant height (cm)**	**Number of tillers/ plant**	**Percent yield increase of farmers practice**	**Grain yield (Kg/ha)**	**Cost of cultivation**	**Gross Cost (Rs./ha)**	**Net Returns (Rs/ha)**	**Benefit Cost Ratio**
Farmers practice	66.2	2.42	-	1865	23,112	55950	32,838	2.42
Improved technology	78.3	4.82	24.07	2314	25,510	69420	43,910	2.72

T2-13
Ways to enhance the nutrient content and productivity in Pearl millet

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Abstract

Occurrence of widespread Zn deficiencies in Indian soils and presence of Fe in non-available form (oxidized form) in the arable soils, cultivation of high yielding varieties and multiple cropping systems as well as increasing soil degradation have aggravated the micronutrient deficiencies in India.Zn deficiency in soil and Zn deficiency induced malnutrition in human beings match with each other across the different regions/countries of world. Pearl millet, a dry land crop of the arid and semi-arid tropics is a suitable crop for iron bio-fortification as it harbours sufficient genetic variability for grain iron (Fe) and zinc (Zn) in the existing germplasm. Agronomic bio-fortification involves deliberate use of mineral fertilizers (including enriched manures) to increase the concentration of target mineral in edible portions of crop to increase dietary intake of target mineral.Pearl millet having high Fe and fairly Zn content: however commercially available cultivars are low in Fe (31- 125 ppm) and Zn (35-82 ppm).With this background genetically bio fortified variety and TNAU ruling pearl millet variety was used with agronomic bio-fortification techniques. Soil application of Zinc in the form of chemical and microbial and combination of both and also through foliar application(Zn&Fe) in the form of chemical was assessed for the enhancement of Zn level in pearl millet with the objectives to develop a compendium technology for enhancement of Fe & Zn in pearl millet through agronomic bio fortification. Cultivation of CO 10 with 100 %recommended quantity of Zn through chemical form $ZnSO_4$ @25 kg/ha through soil and foliar application $ZnSo_4$ @0.5 % + 0.5 % spray of FeSO4 +Nano urea foliar spray @5 ml/litre of water along with recommended agronomic practices is important to achieve higher yield, net income and BCR and resulted in higher nutrient content and productivity.

Keywords: Agronomic fortification, Zinc content, Fe content

Introduction

Cultivation of high yielding varieties and multiple cropping systems as well as increasing soil degradation (Bhattacharyya et al., 2015) have aggravated the micronutrient deficiencies in India and needs immediate attention (Shahane and Shivay, 2021).Zn deficiency in soil and Zn deficiency induced malnutrition in human beings match with each other across the different regions/countries of world.(Cakmak, 2008) Agronomic bio-fortification through the application of mineral micronutrient fertilizers to soils or plant leaves to increase micronutrient contents in edible parts of crops has the potential to fight hidden hunger.

Materials and Methods

The Field experiment was conducted at Central farm, AC&RI, Madurai with the technical programme of design followed was Factorial RBD and replicated thrice by using the test variety and hybrid of CO 10 and ICMH 1202 and considered as main factor. The different forms of zinc and method of application were followed as sub factor viz., 100 %Recommended quantity of Zn through chemical form $ZnSO_4$ @25 kg/ha, 125%Recommended quantity of Zn through chemical form $ZnSO_4$ @31.25 kg/ha, 100 %Recommended quantity of Zn through chemical form $ZnSO_4$@25 kg/ha+0.5 % spray of FeSO4 +Biological form (*Bacillus megaterium* @ 500 ml/ha) through soil application, 125%Recommended quantity of Zn through chemical form $ZnSO_4$ @31.25 kg/ha+0.5 % spray of FeSO4 +Biological form (*Bacillus megaterium* @ 500 ml /ha) through soil application, 100 %Recommended quantity of Zn through chemical form $ZnSO_4$ @25 kg/ha through soil and foliar application $ZnSo_4$ @0.5 % + 0.5 % spray of FeSO4 , 100 %Recommended quantity of Zn through chemical form $ZnSO_4$ @25 kg/ha through soil and foliar application $ZnSo_4$ @0.5 % +Biological form through soil application +0.5 % spray of FeSO4,100 %Recommended quantity of Zn through chemical form $ZnSO_4$ @25 kg/ha through soil and foliar application $ZnSo_4$ @0.5 % + 0.5 % spray of FeSO4 +Nano urea foliar spray(@5 ml/litre of water) and Foliar application $ZnSo_4$ @0.5 % + 0.5 % spray of FeSO4 + Nano urea foliar spray(@5 ml/litre of water.

Growth and yield parameters was observed and calculated economics and presented in table 1and Fig 1.The mineral content was evaluated by utilising the facility available at Agricultural College and Research Institute Madurai.

Higher growth and yield of 3245 kg/ha wasrecorded in the treatment combination of CO 10 cultivated with 100 % recommended quantity of (T_7)Zn through chemical form $ZnSO_4$ @25 kg/ha through soil and foliar application $ZnSo_4$ @0.5 % + 0.5 % spray of FeSO4 +Nano urea foliar spray(@5 ml/litre of water)and also recorded highestnet income(Rs.42155/ha and BCR(2.18).Cultivation of CO 10 with 100 %recommended quantity of Zn through chemical form $ZnSO_4$ @25 kg/ha through soil and foliar application $ZnSo_4$ @0.5 % + 0.5 % spray of FeSO4 +Nano urea foliar spray @5 ml/litre of water along with recommended agronomic practices is important to achieve higher yield, net income and BCR and resulted in higher nutrient content and productivity.

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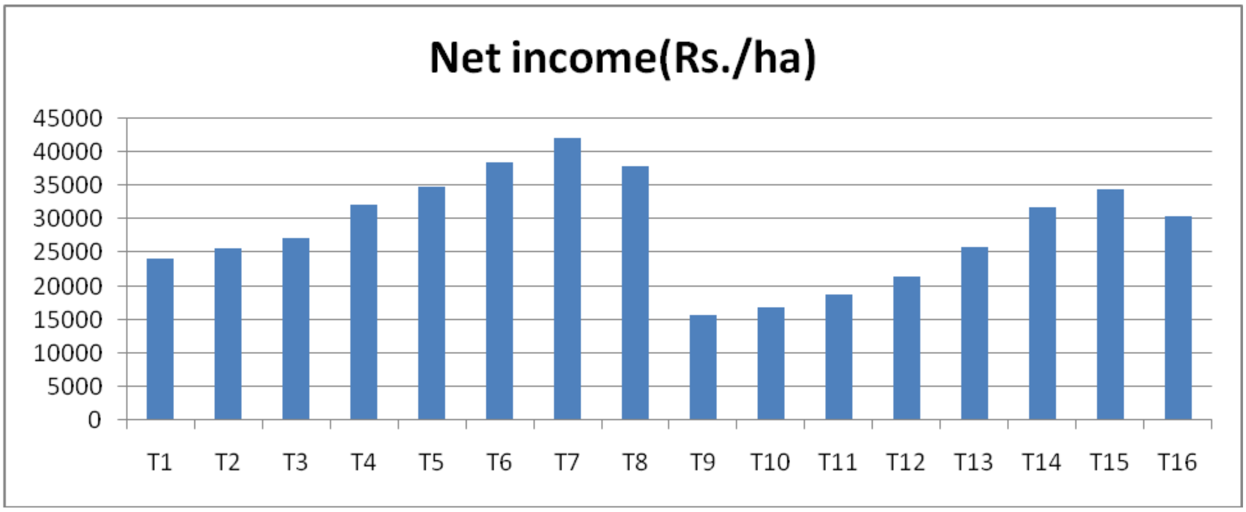
Table 1. Effect of combination treatment on growth and yield of Pearl millet

Treatments	Plant height at 50 % flowering (cm)	Flower initiation (DAS)	Plant height at harvest (cm)	Number of tillers	Grain yield(kg/ha)	Straw yield (kg/ha)
T_1	132	47	186	3.96	2431	5592
T_2	134	47	194	4.16	2570	5685
T_3	141	46	196	4.28	2614	5872
T_4	144	46	198	4.32	2872	5946
T_5	146	48	203	4.84	2912	5764
T_6	148	48	206	5.08	3082	5882
T_7	151	49	211	5.42	3245	6145
T_8	143	48	204	5.21	3064	6004
T_9	92	45	121	2.68	2068	5126
T_{10}	91	45	125	2.72	2196	5286
T_{11}	93	45	126	2.81	2252	5431
T_{12}	96	45	129	2.84	2418	5672
T_{13}	99	47	136	3.04	2532	5318
T_{14}	98	45	138	3.09	2786	5658
T_{15}	112	46	141	3.12	2917	5912
T_{16}	106	45	134	2.86	2746	5824

Fig.1. Effect of combination treatment on Economics



T2-14
Performance of Barnyard Millet variety MDU 1 under rainfed condition of Pudukkottai District

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Abstract

Kudhiraivali (Barnyard Millet) is one of the most preferred millet crops by the people. Now-a-day people are aware on the medicinal properties and nutritious enrichment of minor millets and consumption is being increased. But millet production is not sufficient to match the demand. So to sensitize the people on millet cultivation, seeds materials of Kudhiraivali variety MDU 1 were distributed to 10 farmers belonging to various block of Pudukkottai district and to assess the performance. The crop was raised in an area of one acre at each farmer's holding during Rabi 2022 under rainfed condition. Standard agronomic practices were followed to get good crop. MDU 1 variety recorded average yield of 14.70q/ha which is 66.8% increase over check variety (8.81q/ha) which the farmers were used. The MDU 1 recorded productive tillers about 7.0 nos./plant and 1000 seed weight (3.80g) whereas the farmers practiced local variety recorded the productive tillers of 5.4 nos./plant and 3.10 respectively. The feedback of farmers indicated that MDU 1 had quick and vigorous growth in initial stage which arrests the growth of weeds and also given higher yield than the local variety we used. The cost benefit ratio was 1:1.72 over the farmer's practice of using local variety which had BC ratio 1:1.40

Keywords: Barnyard millet, seed yield, rainfed, Pudukkottai

Introduction

Kudhiraivali (Barnyard Millet) is one of the most preferred millet crops by the people India is the biggest producer of barnyard millet, both in terms of area (0.146 mha) and production (0.147 mt) with average productivity of 1034 kg/ha (IIMR, 2018). Among many cultivated and wild species of barnyard millet, two of the most popular species are *Echinochloa frumentacea* (Indian barnyard millet) and *Echinochloa esculenta* (Japanese barnyard millet) (Sood et al., 2015). It is very drought resistant but is also capable of withstanding water logging conditions. Kudiraivali grains are consumed just like rice. They are also used in making rice pudding (kheer). Barnyard millet is significant in digestible protein (40%) and helps you feel gentle and energized after having eaten it. It is a high-fibre food with a great balance of soluble or insoluble fragments. A food's dietary fibre content helps in the preventative measures of incontinence, surplus gas, constipation, and extraneous stomach cramps. The grain is eaten mostly by the poor classes, but sometimes it is brewed the beer. It is also used as feed for cage birds. The straw makes good fodder for cattle. Its green fodder is very much relished by cattle. In terms of nutritive value, barnyard millet is superior to major and minor millets. Barnyard millet grains are a rich source of dietary fiber, iron, zinc, calcium, protein, magnesium, fat, vitamins, and some essential amino acids (Singh et al., 2010; Chandel et al., 2014). Now-a-day people are aware on the medicinal properties and nutritious enrichment of minor millets and consumption is being increased. But millet production is not sufficient to match demand.

However, the productivity of barnyard millet is very low, due to lack of awareness on high yielding varieties, mostly cultivated in low fertility soil and non-adoption of integrated crop management practices. So to sensitize the people on millet cultivation, it has been planned to conduct front line demonstrations with the provision latest technological inputs.

Materials and Methods

The demonstration was conducted at Krishi Vigyan Kendra, Tamil Nadu Agricultural University, Pudukkottai during Rabi 2022. The variety used for this experiment was Kudhiraivali variety MDU 1 which was released during 2017 from Department of Plant Breeding and Genetics, Agricultural College and Research Institute, TNAU, Madurai. MDU 1 Kudhiraivali variety is short duration variety matured at 100 days having profuse tillering and come up very well all type of soil, resistant to shoot fly, stem borer were distributed to 10 farmers belonging to various block of Pudukkottai district and to assess the performance and .The crop was raised in an area of one acre at each farmer's holding during the season Rabi 2021 under rainfed condition of Puratasi pattam (September-October). Standard agronomic practices were followed to get good crop. Data were recorded from five selected plants in each demonstration for three characters *viz.,* mean seed yield (kg/plot), No. of productive tillers and 1000 seed weight (g) and subjected to simple first order statistical analysis. Finally, the cost benefit ratio was workout.

Results and Discussion

The performance of demonstrated technology was presented in table 1. The variety MDU 1 recorded average yield of 1470kg/ha which is 66.8% increase over check variety (881kg/ha) which the farmers were used. The MDU 1 recorded productive tillers about 7.0 nos./plant and 1000 seed weight (3.80g) whereas the farmers practiced local variety recorded the productive tillers of 5.4 nos./plant and 3.10 respectively. The feedback of farmers indicated that MDU 1 had quick and vigorous growth in initial stage which arrests the growth of weeds and also given higher yield than the local variety we used. More over MDU 1 is short duration variety matured at 100 days having profuse tillering and come up very well all type of soil, resistant to shoot fly, stem borer. The cost benefit ratio was 1:1.72 over the farmer's practice of using local variety which had BC ratio 1:1.40.

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Table 1. Performance of the technology

Title	No. of Location	Yield (q/ha)	Net Return (Rs./ha)	B:C Ratio	Productive Tillers/Plant	1000 Seed Weight (g)
Demonstrated Technology 1 (MDU 1)	10	14.70	20,930	1.72	7.00	3.80
Farmers Practice (Local variety)		8.81	8,596	1.40	5.40	3.10

T2-15

Augmenting farmer's income through short duration pearl millet cultivation under changing climate scenario in Villupuram district

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Introduction

Villupuram district is basically an agrarian district and has bimodal pattern of rainfall with an annual average of 1060 mm and bulk of precipitation is received during the North East Monsoon. This district is also prone for cyclical drought. Climate change is emerging as an important threat to agriculture, food security and livelihoods. The impacts are likely to be more in rainfed agriculture (Rama Rao *et al*., 2019). A network project on National Innovations on Climate Resilient Agriculture (NICRA) of ICAR is being operated at KVK, Villupuram and selected drought prone villages in the district. The village selected under NICRA is known for erratic monsoon and suffers due to intense heat during summer. Crops raised during kharif and summer face intermittent drought and it has wetland, garden land and dry land systems. Millets can withstand extreme temperature, droughts, and floods. Millets grow well in arid zones/rainfed locations with marginal soil fertility and moisture. Among the millets, pearl millet is a tropical warm weather crop, farmer friendly and grow well in a wide range of ecological conditions and can still yield well even under unfavourable conditions of drought stress and high temperatures. So, the drought tolerant high yielding pearl millet hybrid CO 9 and composite CO 10 were selected as climate resilient interventions with an objective to minimize the climatic change impacts and increasing the income of farmers having rainfed lands.

Materials and Methods

The demonstrations of drought tolerant high yielding Cumbu hybrid CO 9 (resistant to downy mildew disease) and composite Co 10 were carried out under rainfed condition by the scientists of Krishi Vigyan Kendra, Villupuram under NICRA scheme as a climate resilient technology during *Kharif season* of 2019-2020 at Agoor village, Mailam block of Villupuram district in Tamil Nadu with active participation of farmers. In general, soils of the village were sandy loam in texture with a pH of 7.55, EC 0.46 dS m^{-1}, low in organic carbon status (0.45%) and available nitrogen (145 kg/ka) and medium in phosphorus (11.9 kg/ka) and potassium (177 kg/ka). Crop was raised during the month of July 2019 and harvested during October 2019. Each demonstration was conducted in farmer's field in an area of one acre for each farmer. In total 20 demonstrations in 20 acres were organized. The package of this intervention includes providing seeds, biofertilizer and biocontrol agents.

Results and Discussion

The data (Table 1) indicated that the frontline demonstration has given a good impact among the farming community of the village as they were motivated by the new agricultural technologies applied in the demonstrations.

The result of demonstrations showed that the short duration high yielding hybrid CO 9 along with ICM practices produced on an average grain yield of 3676 kg/ha and fodder yield of 7727 kg/ha, while composite CO 10 given an average grain yield of 3400 kg/ha and fodder yield of 7800 kg/ha. The grain and straw yield ranged from 2872 – 4102 kg/ha and 7320 - 8204 kg/ha respectively in CO 9 hybrid and it might be due to the difference in maintenance of farms by the farmers, soil variability and other factors. The economics (Cost of cultivation, gross and net return) of these demonstrations were worked out. The demonstration on pearl millet hybrid CO 9 recorded higher average cost of cultivation (Rs.29,008/ha), gross returns (Rs.88,234 /ha) and net return (Rs.59,226 /ha) with higher benefit cost ratio (3.04) while composite CO 10 recorded an average cost of cultivation (Rs.28,000/ha), gross returns (Rs.82,600/ha) and net return (Rs.54,600/ha) with higher benefit cost ratio (2.95). When these two interventions compared, hybrid CO 9 with ICM practices recorded little higher yield (8.12 %) and income (8.47%). Collectively pearl millet is best comparing farmer's practice of keeping the land fallow during Kharif season. The results suggest this technology is a higher profitability and economic viable technology in the drought prone areas of the district. This might be due to higher production and income earned under FLDs as compared to the prevailing farmers practice.

It may be concluded that the frontline demonstrations on short duration high yielding pearl millet hybrid along with integrated crop management technology is a more productive, profitable and feasible technology particularly during kharif season in Villupuram district compared to prevailing farmers practice of keeping the land fallow. This will substantially increase the income as well as the livelihood of the farming community.

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Table 1. Performance of pearl millet in drought prone village of Villupuram district

S. No.	Name of the farmers	Seed yield (kg/ha)	Fodder yield (kg/ha)	Cost of cultivation (Rs./ha)	Gross income (Rs./ha)	Net income (Rs./ha)	B:C Ratio
Hybrid Co 9							
1	Mr. P. Kumar	3254	6684	28115	78096	49981	2.78
2	Mr.S. Venkatesan	3620	7320	27336	86880	59544	3.18
3	Mrs. T. Thavakodi	2872	7684	29178	68928	39750	2.36
4	Mr. P. Velmurugan	3770	7324	28224	90480	62256	3.21
5	Mr.P. Narayanan	4602	7352	27108	110448	83340	4.07
6	Mr. R.Mahalakshmi	3678	7336	28508	88272	59764	3.10
7	Mr.R. Murugan	3680	7562	29185	88320	59135	3.03
8	Mr. K. Dass	3162	8204	29124	75888	46764	2.61
9	Mr. V. Sundaram	4102	7889	29110	98448	69338	3.38
10	Mr.G. Balaraman	3760	7645	29112	90240	61128	3.10
Mean		**3676**	**7727**	**29008**	**88234**	**59226**	**3.04**
Composite Co 10							
1	Mr. M.Seenuvasan	2254	7843	28115	54547	26432	1.94
2	Mr.M. Jeyapal	3512	7889	27336	84990	57654	3.11
3	Mr. K. Dass	2782	7684	28457	67324	38867	2.37
4	Mr. P. Velmurugan	3712	8243	28224	89830	61606	3.18
5	Mrs.S. Abirami	4602	7352	26218	111368	85150	4.25
6	Mr. M.Munusamy	3245	7842	28119	78529	50410	2.79
7	Mr.V. Sundaram	3322	7563	27824	80392	52568	2.89
8	Mr. K. Chinnu	2232	8202	29128	54014	24886	1.85
9	Mrs. R. Jeya	4612	7872	29110	111610	82500	3.83
10	Mrs.R. Mahalakshmi	3727	7510	27469	90193	62724	3.28
	Mean	**3400**	**7800**	**28,000**	**82,600**	**54,600**	**2.95**

T2-16
Response of perl millet to split application of nitrogen under irrigated condition

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Abstract

A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore to study the response of pearl millet to split application of nitrogen under irrigated condition. The experiment was laid out in split plot design with four replications. It comprised of two factors: Factor A – Nitrogen dose with three levels (100%, 112.5% and 125% RDN) and Factor B – Split application of N with four levels (full dose as basal, 50% N each at sowing and tillering, 50% N each at sowing and booting and 25% N at sowing, 50% N at tillering and 25% N at booting stages. The results revealed that application of 125% RDN in three splits *viz*., 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS) registered higher grain yield and economics compared to other treatments.

Keywords: pearl millet, nitrogen, split application.

Introduction

Pearl millet is grown in arid and semi-arid regions of the country where no other crops can be successfully grown due to its hardy nature. It accounts for about two-thirds of millets production in India, occupying an area of 6.93 million ha with a production of 8.61 million tonnes and productivity of 1243 kg/ha (Directorate of Millets Development, 2020). The major production factor to boost up the yield of pearl millet is fertilizer management, whose contribution is to an extent of 27 per cent. Among the three major nutrients, nitrogen is one of the decisive as well as expensive inputs which govern the production of crop. It has the quickest and the pronounced effect on plant growth. Insufficient nitrogen may reduce yield drastically and deteriorates the quality of produce. Split application of N fertilizer commensurate with crop growth stage is an useful approach for increasing the efficiency of applied N in pearl millet and it is therefore necessary to judiciously manage the inflow of the nitrogen. Therefore, levels and split of nitrogen are found crucial in pearl millet productivity.

Materials and Methods

A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during *Kharif*, 2021 with an objective to study the growth and yield of pearl millet in response to split application of nitrogen at different crop growth stages. The pearl millet hybrid, CO 9 was used for the experiment, sown with the crop geometry of 45 x 15 cm. The experiment was laid out in Split plot design with four replications as follows. The experiment comprised of two factors as nitrogen dosage in main plots and split application of nitrogen in sub-plots. The main plot factor consisted of three levels *viz*., 100%, 112.5% and 125% Recommended Dose of Nitrogen (RDN) while the sub-plot factor consisted of four levels *viz*., application of entire N as basal at sowing (S_1); 50% N at sowing + 50% N at tillering (20-25 DAS) (S_2); 50% N at sowing + 50% N at boot stage (35-40 DAS) (S_3) and 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS) (S_4).

The experimental soil was sandy clay loam in texture with slightly alkaline pH (8.03), non-saline nature (EC 0.36 dS/m) with low organic carbon content (0.39%). The initial soil nutrient status of the experimental field showed low status of available nitrogen (199 kg/ha), medium status of available phosphorus (16 kg/ha) and available potassium (549 kg/ha). Also, the micronutrient status of the soil indicated deficiency status of iron (3.50 ppm) and zinc (0.77 ppm). The recommended dose of phosphorus @ 40 kg/ha was applied uniformly to all the treatments as basal in form of single super phosphate. Nitrogen through urea was applied as per treatments. Biometric observations on growth parameters were recorded at different growth stages while yield parameters and yield were recorded at harvest.

Results and Discussion

The results of the experiment (Table 1) revealed that significant difference among the nutrient management treatments was observed for different growth and yield attributes and grain yield. Among the three doses of nitrogen evaluated, application of higher dose of N (125% RDN) registered taller plants (186.4 cm), more number of total tillers (4.4) and effective tillers (4.2). It was statistically on par with application of 112.5% RDN (N_2) and significantly higher than application of 100% RDN (N_1). Similar trend was observed for grain yield also wherein, nitrogen dose @ 125%RDN had recorded higher grain yield of 3050 kg/ha. It was on par with 112.5%RDN while significantly higher than 100% RDN. Among the sub-plot treatments, significant difference was noticed for the production of tillers and grain yield. Application of N in three splits *viz*., 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS registered more number of total tillers (4.4) and effective tillers (4.2). It was statistically on par with S2 and S3 treatments and significantly higher than S1 treatment. With regard to grain yield, application of N in three splits (S_4) produced higher grain yield of 3108 kg/ha. However, the treatment was statistically on par with split application of N in two splits applied at 50% as basal and 50% at booting stage (S_3) while significantly higher over S_2 and S_1 treatments. It might be due to the supply of required quantity of nitrogen in split doses at the critical stages of the crop to put forth its optimum growth without facing any shortage of nutrient during the cropping period. Similar findings were reported by Patel (2014).

With regard to economics (Table 2), application of 125% RDN in three splits viz., 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS) registered higher economic indicators viz., Gross returns (Rs. 64860/-), net returns (Rs. 31692/-) and BCR (1.96) when compared with other treatment combinations. Application of 100% RDN as complete dose at sowing (basal) registered the lowest values of Gross returns (Rs. 50960/-), Net returns (Rs. 20856/-) and BCR (1.69).

It could be concluded from the experimental results that application of higher dose of fertilizers either 112.5% or 125% RDN in three splits *viz*., 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS) depending of the soil fertility could be recommended to achieve higher productivity and profitability in hybrid pearl millet cultivation.

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Table 1. Growth and yield of pearl millet hybrid as influenced by dosage and split application of nitrogen

Treatments	Pl. Ht. at harvest (cm)	Total tillers/ plant (No.)	Effective tillers/ plant (No.)	Grain yield (kg/ha)
N_1 (100% RDN)	170.4	4.01	3.81	2752
N_2 (112.5% RDN)	172.9	4.23	3.99	2900
N_3 (125% RDN)	186.4	4.43	4.16	3050
SEd.	5.08	0.15	0.11	81
CD (p=0.05)	11.45	0.28	0.24	179
S_1 (100% at S)	174.5	4.02	3.77	2712
S_2 (50% at S & 50% at T)	175.5	4.21	4.07	2878
S_3 (50% at S and 50% at B)	176.6	4.17	3.93	2903
S_4 (25% at S, 50% at T & 25% at B)	179.6	4.40	4.20	3108
SEd	6.62	0.16	0.15	107
CD (p=0.05)	NS	0.34	0.31	221

Table 2. Economics of pearl millet hybrid as influenced by dosage and split application of nitrogen

S. No.	Main plot (Nutrient management)	Subplot (N split application)	GR (Rs./ha)	TC (Rs./ha)	NR (Rs./ha)	BCR
1	N_1 – 100% RDN	S_1 - Entire dose of N at sowing	50960	30104	20856	1.69
2		S_2 - 50% N at sowing + 50% N at tillering (20-25 DAS)	54500	31004	23496	1.76
3		S_3 - 50% N at sowing + 50% N at boot stage (35-40 DAS)	54980	31004	23976	1.77
4		S_4 - 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS)	59740	32904	26836	1.82
5	N_2 – 112.5% RDN	S_1 - Entire dose of N at sowing	54000	30236	23764	1.79
6		S_2 - 50% N at sowing + 50% N at tillering (20-25 DAS)	57880	31136	26744	1.86
7		S_3 - 50% N at sowing + 50% N at boot stage (35-40 DAS)	58240	31136	27104	1.87
8		S_4 - 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS)	61900	33036	28864	1.87
9	N_3 – 125% RDN	S_1 - Entire dose of N at sowing	57800	30368	27432	1.90
10		S_2 - 50% N at sowing + 50% N at tillering (20-25 DAS)	60340	31268	29072	1.93
11		S_3 - 50% N at sowing + 50% N at boot stage (35-40 DAS)	61020	31268	29752	1.95
12		S_4 - 25% N at sowing + 50% N at tillering (20-25 DAS) + 25% N at boot stage (35-40 DAS)	64860	33168	31692	1.96

T2-17
Evaluation of production factors contributing towards yield and economics of Pearl Millet

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Abstract

A field experiment was conducted at Tamil Nadu Agricultural University to study the influence of individual production factor towards the productivity and profitability of pearl millet cultivation. The experiment was laid out in Randomised Block Design, replicated thrice with eight different treatments consisting of the complete package of production factors and exclusion of individual factor from the complete package. The results of the study indicated that complete package of all production factors influenced the productivity and profitability of pearl millet cultivation. Non adoption of each production factor resulted in decline of crop yield.

Keywords: Pearl millet, nutrient management, irrigation, weeding, thinning, gapfilling.

Introduction

Pearl millet is considered to be the sixth most important food crop for the human population and is extensively cultivated in the tropical semi-arid regions of African and Asian sub-continents. The regions of pearl millet cultivation are characterised by low input, rainfed agriculture with annual rainfall of 150 to 600 mm. Most farmers cultivate pearl millet in low fertile soils with less external inputs, resulting in lesser grain yields. Numerous studies reveal that the crop yields are low due to traditional farming practices with low plant population, limited water and inadequate nutrient supply (Payne, 2000). Crop productivity depends on many management factors *viz*., fertilizer application, thinning, gap filling, weeding, hoeing and irrigation and every factor has its own contribution towards productivity. Non-adoption of the improved package of practices by the farmers is one of the major causes for lower yield in pearl millet. Therefore, the contribution of individual factor or combination of full package of factors has to be evaluated towards the crop yield. Considering the above facts, the present study was framed out.

Materials and Methods

A field experiment was conducted during *Kharif* season 2021at Tamil Nadu Agricultural University, Coimbatore during *Kharif* season 2021 to study the quantification of individual production factors of crop management towards productivity and economics of pearl millet. The pearl millet hybrid HHB 299 was used for the experiment. The experiment was laid out in Randomised Block design, replicated thrice with eight treatments *viz*., Full package & practices of the location [RDF + $ZnSO_4$ @25 kg/ha + $FeSO_4$ @ 0.5-0.75% at 20-25 DAS + bio-inoculant seed treatment + thinning& gap filling + weeding & hoeing (3-5 WAS) + irrigation] (T_1); T_1 – RDF (T_2); T_1 - $ZnSO_4$ @25 kg/ha (T_3); T_1 - $FeSO_4$ @ 0.5-0.75% at 20-25 DAS (T_4); T_1 - bio-inoculant seed treatment (T_5); T_1 - thinning& gap filling (T_6); T_1 - weeding & hoeing (3-5 WAS) (T_7) and T_1 – irrigation (T_8).

The soil of the experimental field was sandy clay loam in texture with slightly alkaline pH (8.03), non-saline nature (EC 0.36 dS/m) with low organic carbon content (0.39%). The initial soil nutrient status of the experimental field showed low status of available nitrogen (199 kg/ha), medium status of available phosphorus (16 kg/ha) and available potassium (549 kg/ha). Also, the micronutrient status of the soil indicated deficiency status of iron (3.50 ppm) and zinc (0.77 ppm). The pearl millet hybrid was sown at 45 x 15 cm spacing. All the production factors, viz, seed treatment with biofertilizer, irrigation, weeding and hoeing, application of macro nutrients and micronutrients were provided to the crop plants as per treatments. Biometric observations on growth parameters were recorded at different growth stages while yield parameters and yield were recorded at harvest.

Results and Discussion

The results of the field experiment (Table 1) revealed that significant difference among the treatments were observed for different growth and yield attributes, grain and stover yields of pearl millet hybrid. With regard to plant population at harvest, most of the production factors were on par in sustaining maximum plant stand except the treatments that withheld weeding (T_7) and irrigation (T_8) factors where the plant population was less due to suppression by weed growth and non-availability of sufficient soil moisture for all the plants to retain themselves in the field till harvest. Pearl millet cultivation with full package of practices *viz*., RDF + $ZnSO_4$ @25 kg/ha + $FeSO_4$ @ 0.5-0.75% at 20-25 DAS + biofertilizer seed treatment + thinning & gap filling + weeding & hoeing (3-5 WAS) + irrigation (T_1) had produced taller plants of 181.1 cm and it was on par with all other treatments, however, significantly higher over the treatments that withheld weeding and irrigation factors. Production of higher number of total tillers per plant (4.4) and number of effective tillers per plant (4.2) was recorded due to adoption of all the production factors (treatment T_1) and it was statistically on par with other treatments except T_6 and T_7 which produced significantly lower number of total tillers and effective tillers per plant. Non-adoption of gapfilling and thinning operations besides carrying out of weeding and hoeing operations in the crop might have resulted in production of limited number of tillers per plant.

The study also revealed that highest grain yield of 3120 kg/ha was obtained with adoption of all production factors in time at different growth stages of the crop (T_1), which could have reflected in higher crop productivity. This increase in grain yield might be due to the application of balanced fertilizer, adequate water supply, seed treatment with biofertilizer and weed control thereby resulting in better root growth and development, more nutrient uptake and higher dry matter accumulation/plant and its subsequent translocation to the developing panicles/ earhead. Similar reports were given by Kumar *et al.* (2014). The treatments T_3, T_4& T_5 were in the next order in producing higher crop yield which showed the secondary role of application of micronutrients *viz*., $ZnSO_4$ and $FeSO_4$ followed by biofertilizer application. The least grain yield of 2090 kg/ha was recorded under unweeded treatment plot wherein, high competition between the crop and weeds could have expressed such decline in yield. The contribution of individual agronomic factors was assessed and it revealed that withholding irrigation resulted in 46% yield reduction and it was followed by skipping of weeding and hoeing accounting to 45% yield reduction. Thinning and gapfilling (29%), application of RDF (21%) and micronutrients (11%) also exhibited their individual contribution towards the productivity of pearl millet.

With regard to economics, all the economic indicators worked out recorded higher gross returns (Rs. 62400/-), higher net returns (Rs. 28581/-) and higher BCR (1.85) with adoption of complete package of practices at respective growth stage of the crop (T_1) when compared to other treatments and they were lower for the treatment T_8 which emphasized the need of irrigation factor as a critical input in crop production for achieving higher productivity and profitability.

It could be concluded from the experimental results that pearl millet cultivation with complete package of practices *viz*., RDF (80:40:40 kg NPK/ha) + $ZnSO_4$ @ 25 kg/ha + foliar application of 0.5% $FeSO_4$ at 25-30 DAS + biofertilizer seed treatment + timely thinning and gap filling, weeding and hoeing on 3 to 5 weeks after sowing with irrigation at critical stages of the crop had produced the highest grain yield and economic returns. Among the various production factors evaluated, irrigation, weeding, thinning & gapfilling and fertilizers application (both RDF and $ZnSO_4$) had shown their key contribution individually towards the yield and economics of pearl millet.

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Table 1. Influence of different production factors on pearl millet productivity and economics

Treat-ments	Plant population ('000/ha)	Plant height (cm)	Total tillers/ plant (No.)	Effective tillers / plant (No.)	Grain yield (kg/ha)	Net returns (Rs./ha)	BCR
T_1	147.26	181.1	4.4	4.2	3120	28581	1.85
T_2	147.05	176.5	4.0	3.7	2485	20235	1.69
T_3	146.85	176.3	4.1	3.7	2843	23548	1.71
T_4	147.52	178.4	4.2	4.0	2960	26306	1.80
T_5	147.43	178.5	4.3	4.0	2940	25017	1.74
T_6	147.97	176.6	3.5	3.1	2265	13731	1.43
T_7	145.33	158.4	3.4	3.0	2090	12481	1.43
T_8	145.74	153.3	3.8	3.3	2160	12081	1.39
SEd.	0.43	6.7	0.14	0.13	141	Data not statistically analysed	
CD (0.05)	0.94	14.4	0.30	0.29	290		

T2-18
Effect of supplemental irrigationon growth and yield attributes of Kudiraivali CO (Kv) 2 under rainfed situation

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Abstract

Field experiment was conducted at Field No. 16, Agricultural Research Station, Vaigai Dam during *Rabi* 2014-15, to find out the effect of soil moisture conservation to enhance the productivity of Kudiraivali CO (Kv)2 through reuse of rain water. The experiment consisted of following treatments *viz*., T1- Irrigation at Primordial Formation, T2- Irrigation at flowering, T3 - Irrigation at Primordial Formation and flowering and T4- Control (without supplemental irrigation). The trial was laid out in a Randomized block design with four replications.The results revealed that supplemental irrigation at primordial Formation & flowering stage recorded higher plant height (145.6 cm) and drymatter production (3095 kg/ha). This was followed by irrigation at primordial formation stage. The lowest values of these parameters were observed in control (without supplemental irrigation).The crop came to 50 % flowering on 49 th day of sowing and came to maturity 8 days earlier than the control. Supplemental irrigation at primordial Formation & flowering stage recorded higher grain yield of 1036 kg/ha and straw yield of 2059 kg/ha and higher economic returns of 1.64

Keywords: Reuse of rain water, supplemental irrigation,primordial formation, flowering

Introduction

Barnyard Millet (*Echinochloafrumentacea)*is a short duration crop that can grow in adverse environmental conditions with almost no input and can withstand various biotic and abiotic stresses. In addition to these agronomic advantages, the grains are valued for their high nutritional value and lower expense as compared to major cereals like rice, wheat, and maize. It contains a rich source of protein, carbohydrates, fiber, and, most notably, micronutrients like iron (Fe) and zine (Zn) that are related to numerous health benefits. These features make barnyard millet an ideal supplementary crop for subsistence farmers and also as an alternate crop during the failure of monsoons in rice/major crop cultivating areas.

Materials and Methods

Field experiment was conducted at Field No. 16, Agricultural Research Station, Vaigai Dam during *Rabi* 2014-15, to find out the effect of soil moisture conservation to enhance the productivity of Kudiraivali CO (Kv)2 through reuse of rain water. The experiment consisted of following treatments *viz*., T1- Irrigation at Primordial Formation, T2- Irrigation at flowering, T3 - Irrigation at Primordial Formation and flowering and T4- Control (without supplemental irrigation). The trial was laid out in a Randomized block design with four replications. The trial was taken during 46 th standard week (15.10.2014) with a spacing of 22.5 cm X 10 cm.

The experimental field was red sandy loam type. Soil moisture content was measured by oven dry method at fortnight interval. All other agronomic management practices were followed as regular rainfed crop. Observations regardinggrowth and yieldattributes, grain yield, strawyield and soil moisture content at fortnight intervals were recorded. The crop was harvested on 18.01.2015.

Rainfall recorded during the cropping period

The rainfall received during the cropping period = 311.9 mm

No. of rainy days = 26

Results and Discussion

Among the irrigation management practices, supplemental irrigation at primordial Formation & flowering stage recorded higher moisture content at all stages of observation and was followed by the treatment irrigation at Primordial Formation. During the crop growth period the soil moisture content for the irrigation management practices ranged from 3.3 per cent to 17.7 per cent. Irrigation management practices significantly influenced the growth and yield attributes of Kudiraivali (CO (Kv) 2). The results revealed that supplemental irrigation at primordial Formation & flowering stage recorded higher plant height (145.6 cm) and drymatter production (3095 kg/ha). This was followed by irrigation at primordial formation stage. The lowest values of these parameters were observed in control (without supplemental irrigation). The crop came to 50 % flowering on 49 th day of sowing and came to maturity 8 days earlier than the control. Supplemental irrigation at primordial Formation & flowering stage recorded higher grain yield of 1036 kg/ha and straw yield of 2059 kg/ha and higher economic returns of 1.64

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Prakash P, RagavanT, GeethalakshmiV,Saravanapandian P and AmuthaR.2019. Different land configuration and establishment methods on physiological parameters of aerobic rice. *International Journal of Agriculture Sciences* 11(10):8502-8509

Table 1. Effect of supplemental irrigationon growth,yield attributes and economics of rainfed Kudiraivali

Treatments	Plant height at harvest (cm)	DMP at harvest (kg/ha)	Number of productive tillers/hill	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	BC ratio
T1	142.2	2643	4	885	1758	15275	22125	6850	1.45
T2	140.3	2608	3	873	1735	15275	21825	6550	1.43
T3	145.6	3095	5	1036	2059	15775	25900	10125	1.64
T4	128.1	2136	2	715	1421	14775	17875	3100	1.21
SEd	2.01	70	0.5	43	76				
CD (P=0.05)	4.36	151	1.0	93	165				

T2-19

Effect of different *in situ* moisture conservation practices for enhancing the productivity of Kudiraivali CO (Kv) 2 under rainfed situation

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Abstract

Field experiment was conducted at Field No. F 18, Agricultural Research Station, Vaigai Dam during *Rabi* 2014-15, to find out the effect of different *in situ* moisture conservation practices for enhancing the productivity of Kudiraivali CO (Kv)2 under rainfed situation. The experiment consisted of T1- Broad Bed and Furrow (BBF), T2- Compartmental Bunding (CB), T3- Ridges and Furrows (RF), T4-Tied Ridges (TR), T5 -Basin Listing (BL), T6-Vertical Mulching (VM) and T7.Flat Bed (FB). The trial was laid out in a Randomized block design with three replications. The results revealed that among the different *in situ* soil moisture conservation practices evaluated under rainfed condition, the highest growth parameters such as plant height (146.5 cm) and drymatter production (3420 kg/ha) were recorded with Tied Ridges (TR) followed by Ridges and Furrows (RF). The crop came to 50 % flowering on 49 th day of sowing and came to maturity 10 days earlier than the flat bed method. This treatment recorded higher grain yield of 1145 kg/ha and straw yield of 2275kg/ha and it was on par with ridges and furrows system. Higher economic returns were observed with ridges and furrows system due to its reduced cost of cultivation than the tied ridges system

Keywords: *In situ* moisture conservation, rainfed, drymatter production, grain yield and straw yield

Introduction

Barnyard millet (*Echinochloafrumentacea)*is a grain crop of lesser importance. It is very drought resistant but is also capable of withstanding water logging conditions. It is generally grown as a rainfed crop. Kudiraivali grains are consumed just like rice. They are also used in making rice pudding (kheer). The digestibility of protein is 40 per cent. The grain is eaten mostly by the poor classes, but sometimes it is brewed the beer. It is also used as feed for cage birds. The straw makes good fodder for cattle. Its green fodder is very much relished by cattle. Hence, this study was taken to find out the suitable land configuration method for increasing the productivity of Kudiraivali

Materials and Methods

Field experiment was conducted at Field No. F 18, Agricultural Research Station, Vaigai Dam during *Rabi* 2014-15, to find out the effect of different *in situ* moisture conservation practices for enhancing the productivity of Kudiraivali CO (Kv)2 under rainfed situation. The experiment consisted of the following treatments *viz*., T1- Broad Bed and Furrow (BBF), T2- Compartmental Bunding (CB), T3- Ridges and Furrows (RF), T4-Tied Ridges (TR), T5 -Basin Listing (BL), T6-Vertical Mulching (VM) and T7- Flat Bed (FB). The trial was laid out in a Randomized block design with three replications. Kudiravali variety CO (Kv) 2 taken for the experimentation. The different land configuration practices such as broad bed and furrow (105 cm width and 50 cm furrow depth), compartmental bunding (8x5cm), ridges and furrows (25x15cm), tied ridges (25x15) at 60 cm intervals, basin listing (10x15 cm), vertical mulching (25x30cm) were formed on 14.10.2014 with residual soil moisture and these treatments were compared with flat bed. The trial was taken during 46 th standard week (15.10.2014) with a spacing of 22.5 cm X 10 cm.

The experimental field was red sandy loam type. Soil moisture content was measured by oven dry method at fortnight interval. All other agronomic management practices were followed as regular rainfed crop. Observations regarding growth and yield attributes, grain yield, straw yield and soil moisture content at fortnight intervals were recorded.

Rainfall recorded during the cropping period

The rainfall received during the cropping period = 311.9 mm

No. of rainy days = 26

Results and Discussion

Among the *in-situ* soil moisture conservation techniques, tied ridges registered the highest soil moisture content at all the stages of crop growth. This was followed closely by ridges and furrows. During the crop growth period the soil moisture content for the land management practices ranged from 1.5 per cent to 16.5 per cent. (Table 1). *In situ* soil moisture conservation practices significantly influenced the growth and yield attributes of Kudiraivali (CO (Kv) 2). The results revealed that among the different *in situ* soil moisture conservation practices evaluated under rainfed condition, the highest growth parameters such as plant height (146.5 cm) and drymatter production (3420 kg/ha) were recorded with Tied Ridges (TR) followed by Ridges and Furrows (RF). The crop came to 50 % flowering on 49th day of sowing and came to maturity 10 days earlier than the flat bed method.

Regarding the yield attributes and grain yield, the tied ridges system recorded higher yield attributes. This treatment recorded higher grain yield of 1145 kg/ha and straw yield of 2275kg/ha. and it was on par with ridges and furrows system. Higher economic returns were observed with ridges and furrows system due to its reduced cost of cultivation than the tied ridges system. (Table 1).

Among the *in-situ* soil moisture conservation practices, tied ridges system recorded higher grain yield (1145 kg/ha) and straw yield of (2275 kg/ha). Higher soil moisture content was recorded under this system at all stages of observation. However, it was on par with the ridges and furrows system. Regarding the economic returns higher benefit cost ratio (1.84) was obtained with ridges and furrows system due to its lower cost of cultivation.

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Prakash P, Ragavan T,Geethalakshmi V, Saravanapandian P andAmutha R.2019. Different land configuration and establishment methods on physiological parameters of aerobic rice. *International Journal of Agriculture Sciences* 11(10):8502-8509.

Table 1. Effect of *insitu* moisture conservation practices on growth, yield attributes and economics of rainfed Kudiraivali

Treatments	Plant height at harvest (cm)	DMP at harvest (kg/ha)	Number of productive tillers/hill	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	BC ratio
T1	136.6	3062	3.2	1025	2037	15000	25625	10625	1.71
T2	140.4	3286	4.3	1100	2186	15275	27500	12225	1.80
T3	143.3	3354	4.4	1123	2231	15275	28075	12800	1.84
T4	146.5	3420	5.1	1145	2275	16275	28625	12350	1.76
T5	135.5	2957	2.8	990	1967	14775	24750	9975	1.68
T6	138.2	3220	3.5	1078	2142	16775	26950	10175	1.61
T7	131.8	2614	2.1	875	1739	15400	21875	6475	1.42
SEd	2.0	92	0.49	60	85				
CD (P=0.05)	4.4	200	1.06	130	184				

Cost of Kudiraivali grain : Rs.25/kg

T2-20
Evaluation of organic, inorganic and integrated production systems in Barnyard Millet

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Abstract

Barnyard millet (*Echinochloa* species) is an ancient millet crop grown in warm and temperate regions of the world and widely cultivated in Asia, particularly India, China, Japan, and Korea. It is the fourth most produced minor millet, providing food security to many poor people across the world. Globally, India is the biggest producer of barnyard millet, both in terms of area (0.146 m ha^{-1}) and production (0.147 mt) with average productivity of 1034 kg/ha during the last 3 years (IIMR, 2018). Field experiment was carried out to evaluate organic, inorganic and integrated production systems in pearl millet in Eastern block farm, TNAU, Coimbatore. The results revealed that plant height at harvest (134.2 cm), number of tillers per hill (6.8), number of earheads per hill (4.4), earhead length (19.9 cm) and earhead weight (13.4 g) were recorded to be maximum in plots treated with state recommended management practices, followed by 50% organic (50 % FYM + 50 % vermicompost) + 50 % inorganic fertilizers applied plots. Plots maintained under state recommended management practices registered the maximum grain and straw yield of 1873 and 3785 kg/ha, respectively, followed by plots maintained with 100 % organic manures (1795 and 3533 kg/ha, respectively). Supply of 100 % nutrients through organic manures fetched the highest net return of Rs. 30,096/ha followed by supply of 50 % nutrients through organic manures + beejamrith, ghanajeevamrith and jeevamrith applied management practices (MP_1-II) (Rs. 22,565/ha). Benefit cost ratio was maximum (1.63) in 100 % as organic manures followed by 50 % of nutrient source as organic manures + beejamrith, ghanajeevamrith, jeevamrith applied plots (1.50).

Keywords: Barnyard millet, organic, inorganic and integrated production systems

Introduction

Barnyard millet (*Echinochloa* species) is an ancient millet crop grown in warm and temperate regions of the world and widely cultivated in Asia, particularly India, China, Japan, and Korea. It is the fourth most produced minor millet, providing food security to many poor people across the world. Globally, India is the biggest producer of barnyard millet, both in terms of area (0.146 m ha^{-1}) and production (0.147 mt) with average productivity of 1034 kg/ha during the last 3 years (IIMR, 2018). Barnyard millet is primarily cultivated for human consumption, though it is also used as a livestock feed. Among many cultivated and wild species of barnyard millet, two of the most popular species are *Echinochloa frumentacea* (Indian barnyard millet) and *Echinochloa esculenta* (Japanese barnyard millet) (Sood *et al*., 2015).

Materials and Methods

Field experiment was carried out to evaluate organic, inorganic and integrated production systems in pearl millet in Eastern block farm, TNAU, Coimbatore. The experiment was laid out as non-replicated trial with treatment plot size of 50 m^2. Direct sowing of pearl millet variety CO (Kv) 2 was done with the recommended spacing of 25 x 10 cm with six treatments.

Treatments details

MP_1-I	100% organic (organic manures equivalent to 100% N requirement of the system) (50 % FYM + 50 % vermicompost)
MP_1-II	Supply of 50% nutrients through organic sources + Seed treatment with Beejamrit + application of Ghanajeevamrith @ 250 kg/ha, Jeevamrit @ 500 litres/ha / time twice a month with irrigation water and complete organic management as per NPOF
MP_2-I	100% inorganic (No organic manures; RDF alone)
MP_2-II	State recommendation (FYM @ 12.5 t/ha + Azophos @ 2 kg/ha + RDF)
MP_3-I	50% organic (50 % FYM + 50 % vermicompost) + 50% inorganic
MP_3-II	25% nutrients through organic sources + 25% nutrients through inorganic sources + Seed/Seedling treatment with Beejamrit + application of Ghanjeevamrit @ 250 kg/ha, Jeevamrit @ 500 litres/ha/time twice a month with irrigation water

*MP - Management Practice

Results and Discussion

Growth parameters: plant height at harvest (134.2 cm), number of tillers per hill (6.8), number of earheads per hill (4.4), earhead length (19.9 cm) and earhead weight (13.4 g) were recorded to be maximum in plots treated with state recommended management practices, followed by 50% organic (50 % FYM + 50 % vermicompost) + 50 % inorganic fertilizers applied plots (Table 1).

Yield and Economics: Plots maintained under state recommended management practices registered the maximum grain and straw yield of 1873 and 3785 kg/ha, respectively, followed by plots maintained with 100 % organic manures (1795 and 3533 kg/ha, respectively). Supply of 100 % nutrients through organic manures fetched the highest net return of Rs. 30,096/ha followed by supply of 50 % nutrients through organic manures + beejamrith, ghanajeevamrith and jeevamrith applied management practices (MP_1-II) (Rs. 22,565/ha). Benefit cost ratio was maximum (1.63) in 100 % as organic manures followed by 50 % of nutrient source as organic manures + beejamrith, ghanajeevamrith, jeevamrith applied plots (1.50) (Table 2). Similar results were reported in tomato and brinjal (Manickam *et al.,* 2021).

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Table 1. Effect of treatments on growth and yield characters of pearl millet

Treatment	Plant height at harvest (cm)	No. of tillers / hill	No. of earheads /hill	Earhead length (cm)	Earhead weight (g)
MP1-I	131.0	6.1	4.2	18.0	12.9
MP1-II	126.5	5.5	3.6	16.8	12.4
MP2-I	130.9	5.5	3.6	17.7	12.2
MP2-II	134.2	6.8	4.4	19.9	13.4
MP3-I	131.4	6.5	4.0	18.4	13.0
MP3-II	129.4	5.8	3.8	17.2	12.6

Table 2. Effect of treatments on yield and economics of pearl millet

Treatments	Grain Yield (kg/ha)	Straw Yield (Kg/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
MP1-I	1795	3533	47816	77912	30096	1.63
MP1-II	1569	3027	45354	67919	22565	1.50
MP2-I	1608	3156	42294	57708	15414	1.36
MP2-II	1873	3785	59394	67545	8151	1.14
MP3-I	1762	3395	45123	63045	17922	1.40
MP3-II	1676	3228	43990	59964	15974	1.36

T2-21
Rationalized fertilizer prescription for Foxtail millet on calcareous soil

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Abstract

To develop rationalised fertilizer prescription for foxtail millet, field experiments were conducted on black calcareous soil (*Vertic Ustropept*) in Eastern block farm of Tamil Nadu Agricultural University, Coimbatore. By adopting the Inductive cum targeted yield model, variations in soil fertility were established through gradient experiment with fodder sorghum and test crop experiment was conducted with foxtail millet. Using the experimental data, the basic parameters *viz*., nutrient requirement (NR) and contribution of nutrients from soil (C_s), fertiliser (C_f) and farm yard manure (C_{fym}) were computed and rationalised fertiliser prescription equations (FPEs) were developed for foxtail millet on calcareous soil. The results emanated from the present investigation revealed that foxtail millet requires 2.50 kg of N, 1.47 kg of P_2O_5 and 2.80 kg of K_2O for producing one quintal of grain. The results showed that for the application of FYM @12.5 t ha^{-1} with 26 per cent moisture and 0.55, 0.27 and 0.52 per cent of N, P and K respectively, the fertiliser saving was 33, 19 and 23 kg of fertiliser N, P_2O_5 and K_2O respectively

Keywords: Foxtail millet, Calcareous soil, STCR-IPNS, Fertilizer Prescription

Introduction

Foxtail millet is regarded as one of the world's oldest crops and globally it is the second most cultivated millet next to pearl millet. Compared to other whole grain flours, foxtail millet had a higher protein digestibility with good quality essential amino acids, polyunsaturated fatty acids and higher starch digestibility. These features endure foxtail millet as a desirable diet to all age groups. Furthermore, foxtail millet has many positive effects on the adjuvant treatment of diabetes, cancer and cardiovascular diseases.

Calcareous soils are widely spread in arid and semiarid regions. It has been estimated that these soils comprise over one-third of the world's land surface area and in Tamil Nadu it occupies a major area. The presence of $CaCO_3$ directly or indirectly affects the chemistry and availability of nitrogen, phosphorus, iron, zinc, magnesium, calcium, potassium and copper. Fertilizer management on calcareous soils differs from that of non calcareous soils because of the effect of soil pH on soil nutrient availability and chemical reactions that affect the loss or fixation of some nutrients. Hence, improved nutrition management is required to grow crops successfully on calcareous soils. Use of fertilizers by the farmers without information on soil fertility status and nutrient requirement by the crop result in adverse effect on soil and crop either by nutrient toxicity or deficiency. This can be eliminated by adopting the Inductive cum targeted yield methodology developed by Ramamoorthy *et al*. (1967) involving Soil Test Crop Response studies under Integrated Plant Nutrition System (STCR - IPNS) which provides a scientific basis for balanced fertilization not only between fertilizer nutrients but also with the soil available nutrients and nutrients absorbed by the plant. Keeping the above points in view, an investigation has been carried out with foxtail millet on mixed black calcareous soil for developing FPEs.

Materials and Methods

To develop fertilizer prescription equations for foxtail millet, gradient experiment and test crop experiments were conducted on mixed black calcareous soil (*Vertic Ustropept*) in Eastern block farm of Tamil Nadu Agricultural University, Tamil Nadu, India. The gradient experiment was conducted with fodder sorghum *var.* CO 30 in order to create fertility gradient in one and the same field as per the approved protocol as followed in All India Co-ordinated Research Project (AICRP) on Soil Test Crop Response (STCR). By applying graded levels of fertilisers and by growing a gradient crop, the operational range of fertility levels in the three strips was created deliberately. After confirming the establishment of fertility gradients in the experimental field, test crop experiment was conducted with foxtail millet (*Var*. CO 7) in Fractional Factorial Randomized Block Design. Each strip was divided in to 24 sub plots. Twenty four treatment combinations were super imposed consisting of 4 levels of N (0, 20, 40 and 60 kg ha^{-1}), P_2O_5 (0, 15, 30 and 45 kg ha^{-1}) and K_2O (0, 15, 30 and 45 kg ha^{-1}) and 3 levels of FYM (0, 6.25 and 12.5 t ha^{-1}). Across the strips, NPK alone, FYM @ 6.25 t ha^{-1} and 12.5 t ha^{-1} were imposed to study the effect of IPNS components.

Results and Discussion

The progressive increase in green fodder yield from 22.8 t ha^{-1} in strip I to 39.3 t ha^{-1} in strip III, variation in total NPK uptake and soil available N, P and K status among various strips in gradient experiment confirmed the fertility gradients among the strips.

In test crop experiment, the plots where NPK alone were applied, the grain yield ranged from 12.25 to 22.64 q ha^{-1} with a mean value of 17.23 q ha^{-1} and in NPK plus FYM @ 12.5 t ha^{-1} applied plots, the yield ranged from 11.10 to 25.06 q ha^{-1} with a mean of 17.40 ha^{-1}. This might be attributed to improvements in soil physico-chemical qualities, nutrient delivery in a balanced proportion and gradual nutrient release through the integrated usage of FYM. Similar, findings were reported by Udayakumar *et al.* (2019) in pearl millet and Selvam *et al.* (2022) in barnyard millet on black calcareous soil (sandy clay loam).

Using the data on grain yield, uptake of NPK, initial soil test values and the doses of N, P_2O_5 and K_2O applied the basic parameters were calculated *viz.,* Nutrient Requirement in kg per quintal of grain (NR), per cent contribution from soil available nutrients (Cs), fertilizer nutrients (Cf) and FYM (C_{fym}) and fertilizer prescription equations under Integrated Plant Nutrition System were developed. FN =6.53 T- 0.39 SN-0.68 ON; FP_2O_5=3.37T- 1.21 SP-0.78 OP; FK_2O=5.03T- 0.12 SK-0.50 OK where, FN, FP_2O_5 and FK_2O are fertiliser N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the yield target in q ha^{-1} ; SN, SP and SK respectively are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K in kg ha^{-1} supplied through FYM.

Nomograms were formulated for the desired yield targets of foxtail millet for a range of soil test values under STCR-IPNS (NPK plus FYM @ 12.5 t ha^{-1}). A perusal of the estimate showed that when FYM @ 12.5 t ha^{-1} was applied along with NPK, to produce 20.0 q ha^{-1} of grain yield for a soil test value of 200:24:500 kg ha^{-1} of available N, P and K, the fertiliser N, P_2O_5 and K_2O doses required were 22, 19 and 18 kg ha^{-1}. The results of validation experiments conducted in farmer's holdings of various locations with foxtail millet on mixed black calcareous soil indicated that the achievement of grain yield was more than 90 per cent proving the validity of the fertilizer prescriptions for foxtail millet on calcareous soil. Target yield equations generated from STCR-IPNS technology envisages a balanced nutrient supply to foxtail millet and ensures not only sustainable crop production but also economise the use of costly fertilizer inputs.

Therefore, Soil Test Crop Response based rationalized fertiliser prescriptions under Integrated Plant Nutrition System (STCR-IPNS for 2.25 t ha^{-1}) can be recommended for black calcareous soils to attain higher yield, response ratio and BCR in foxtail millet.

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T2-22
Feasibility of millet-pulse intensification under low budget natural way farming

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Introduction

The advent of cereal crops encouraged the Indians to consume more cereal-based foods, which increased their intake of excess carbohydrates, thus elevating the probability of developing diabetes (Mohan *et al*., 2018). After four decades, Indians have progressively prioritized traditional nutri-cereal crops since they have realized the consequences of cereal-based diets. Hence, millet cultivation is one such approach that promises to be the solution to poverty alleviation, malnutrition, and climate change of present era (Behera, 2017). Millets are small-seeded grains that are hardy grasses that perform well in rain-fed crops in dry regions (Singh *et al*., 2020). And also, the United Nations (U.N.) has declared 2023 as the International Year of Millets, resulting from international recognition of these nutrient-rich crops. Of the millets, small millets could be cultivated in poor soil and under changing climates. As millets farming has traditionally been done in a multi-cropping farming system, introducing pulses to the millets production system could stabilize the production to address the needs of an expanding population while also improving the nutritional status of the soil. This is the rationale behind the intensification of millets with pulses on the same piece of land. Additionally, black gram and cowpea, both fix more nitrogen into the soil and, therefore, included in the cropping system study are potential pulse crops. Hence, the study was attempted to find out best LBNF practices and also suitable pulse intercropping system for millets.

Materials and Methods

The experimental studies were carried out in A block at the Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, which is located in the southern agroclimatic zone of Tamil Nadu in 2021-22 and 2022-23. The experimental farm is situated at 9°54' N latitude and 78°54' E longitude, at an elevation of 147m above mean sea level (MSL). The field experiment was set up in a split plot design with the incorporation of five distinct types of leguminous tree leaves known as biomass transfer technique (BMT) along with foliar spraying of three different tree leaf extracts (hereafter referred to as Leaf Tea spray-LTS) being distributed to the main plots. Eight intercropping systems were assigned to the sub plots and they were replicated twice. The main plot treatments exemplify the incorporation of tree leaf biomass of five different tree species as *Peltophorum ferrugineum*, *Albizia lebbek*, *Gliricidia sepium*, *Delonix regia* and *Pongamia pinnata* (L.) respectively, to supply the recommended nitrogen dose for millets raised as main crop, followed by leaf tea spray with three different tree species *viz*., *Annona squamosa, Mangifera indica* and *Moring oleifera* at 5% concertation at fortnight intervals. The subplot represents various millet + pulse intercropping systems such as barnyard millet + blackgram at 3:1 ratio, kodo millet + blackgram at 3:1 ratio, foxtail millet + blackgram at 3:1 ratio, finger millet + blackgram at 3:1 ratio, barnyard millet + cowpea at 3:1 ratio, kodo millet + cowpea at 3:1 ratio, foxtail millet + cowpea at 3:1 ratio and finger millet + cowpea at 3:1 ratio. Two comparison plots were maintained such as CPG (Crop production guide-based practice) and zero input practice to compare the LBNF practices. And also, sole crops of both main and intercrops were raised to compare the feasibility of blackgram and cowpea with millets.

Results and Discussion

The findings of two-year field experimentation supported for adopting innovative idea of combining the LBNF practices with the different millet-pulse intercropping systems *i.e*. tree leaves incorporation in soil on an N-equivalent (dry weight) basis six weeks before sowing a crop and spraying of leaf tea during critical growth stages have demonstrated positive results on LAI millets at harvest stage. A higher LAI in millets was found in the treatment combination with *Delonix regia* (Boj.) as tree leaf biomass followed by foliar spraying of *Moringa oleifera* L. along with the intercropping system of barnyard millet + cowpea at the ratio of 3:1. It was about only 8.07% and 14.9 % less than CPG practice during 2021-22 and 2022-23, respectively. The treatment combination of *Delonix regia* (Boj.) fb *Moringa oleifera* L. combined with finger millet + cowpea (3:1) (M_4S_8) registered the highest grain yields of 2157 and 2324 kg ha^{-1} during 2021-22 and 2022-23, respectively. Rady and Mohamed (2015) provided support that the application of moringa leaf extract had a positive impact on the growth metrics. This is mainly due to release of organic components such as amino acids, organic acids, carbohydrates, vitamins and mucilage during crop growth after the decomposition of applied tree leaf biomass (Rani *et al*., 2021) may have stimulated vegetative growth, which in turn improved leaf area index while implementing LBNF practices (Islam *et al*., 2015).

The present study concluded that LBNF practice of incorporation of *Delonix regia* leaf biomass six weeks before sowing followed by leaf tea spray of *Moringa oleifera* at 5% concentration at fortnight intervals during crop growth for the intercropping system of barnyard millet + cowpea at 3:1 ratio produced more LAI in turn increase the grain yield.

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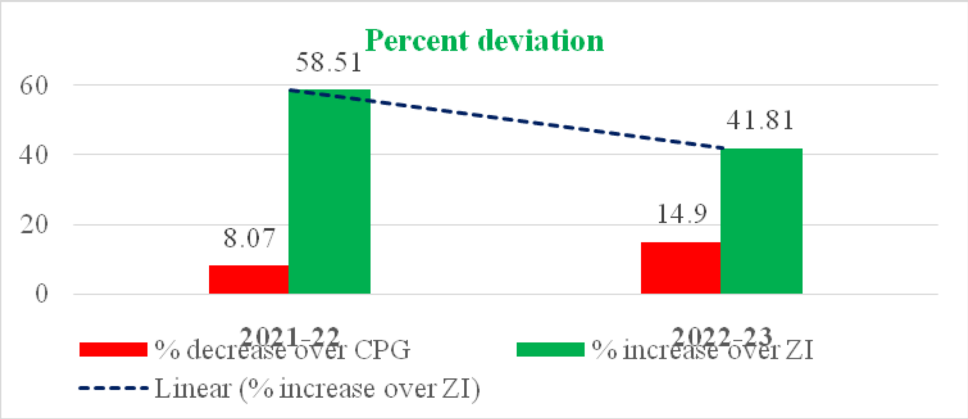
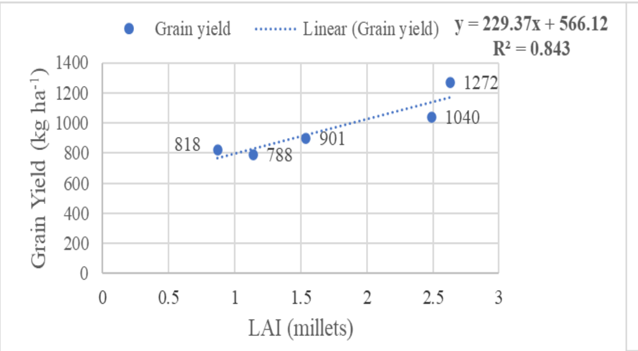
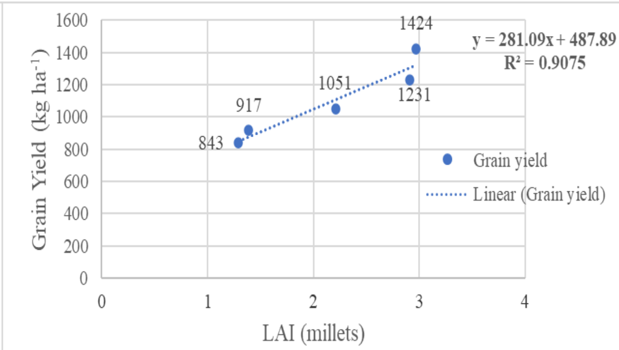
Fig. 1. Impact of the best LBNF practise (M_4S_5) on LAI of the main crop (millets) over CPG and ZI practices in 2021-2022 and 2022-23



LAI (mean of LBNF practices) and millet grain yields regression analysis for 2021-2022



LAI (mean of LBNF practices) and millet grain yields regression analysis for 2022-23



T2-23

Soil inversion tillage: An effective and sustainable tillage practice for weed management in Cotton-Maize-Pulse cropping system

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Abstract

Weeds are a major constraint to crop production worldwide. They compete with crops for water, nutrients, and light, and can reduce yields by up to 50%. This study investigated the effects of different tillage practices on weed management and crop growth in maize. The study found that soil inversion tillage by poclain, which involves completely overturning the soil profile, was the most effective tillage practice for weed control and soil enhancing soil fertility. It resulted in significantly lower weed densities and biomass than other tillage practices, such as cultivators, rotavators, and disc ploughs. It resulted in higher maize yields than other tillage practices. These findings suggest that soil inversion tillage is an effective and sustainable tillage practice for weed management in maize. The study also found that cultivators and rotavators tended to have higher populations of broadleaf weeds compared to disc ploughs and inversion tillage. Farmers can utilize these findings to make informed decisions about tillage practices, considering their weed control objectives and crop yield goals.

Introduction

This extended summary discusses how tillage operations contribute to weed control. It emphasizes that weed pressure, including both perennial and annual germinating species, is influenced by various factors controlled by the cropping system. These factors include crop rotation, soil fertility, nutrient strategy, tillage, and direct control methods such as weed harrowing and hoeing.No-till practices are known to keep weed seeds on the soil surface, which is considered unfavourable for seed germination due to poor seed-to-soil contact. The distribution of weed seeds within the soil is modified by tillage, thereby strongly affecting germination and emergence rates (Fracchiolla*et al*., 2018).While inversion tillage can lead to improved weed control (Cooper *et al*., 2016). Shallow non-inversion tillage is a viable option for organic farmers who aim to enhance soil quality while minimizing yield impacts. Implementing integrated weed management with strategic tillage can result in lower soil carbon levels and better weed control. The distribution of weed seeds within the soil is modified by tillage, thereby strongly affecting germination and emergence rates (Fracchiolla*et al*., 2013).

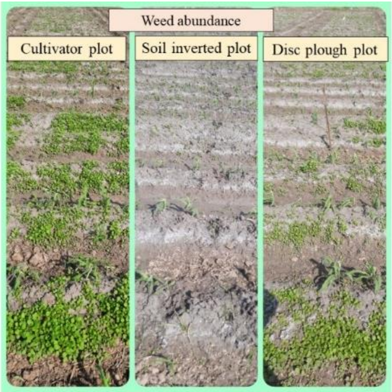
Maize, an important cereal crop cultivated worldwide, faces significant yield reductions due to weed competition for nutrients, water, and light. Various tillage practices, such as soil profile inversion, cultivators, rotavators, and disc ploughs, can be employed to manage weeds in maize crops. Soil profile inversion involves completely overturning the soil profile, bringing subsoil to the surface and burying the topsoil. On the other hand, cultivators, rotavators, and disc ploughs are surface tillage practices that disturb the topsoil. The impact of these tillage practices on weed management in maize crops is complex and depends on factors such as weed species, soil type, and timing of tillage operations.The objective of our study was to investigate the influence of soil profile inversion and various tillage practices on weed management in maize crops.Our findings will provide valuable insights into the effectiveness of different tillage practices for weed management in maize crops.

Materials and Methods

A field experiment was conducted during the kharif season of 2021 to investigate the impact of different tillage practices and soil profile inversion on weed occurrence, growth parameters, and maize yield in a cotton-maize-pulse cropping system. The study took place at the Eastern Block of TNAU in Coimbatore, Tamil Nadu. The experimental site had sandy clay loam soil with a pH of 8.34 and low organic carbon content (0.34%).The data collection involved recording the species-wise weed count within a quadrant measuring 50 cm x 50 cm at 25 and 50 days after sowing (DAS), at harvest stage also. The data was collected from three replications and averaged. The density of major weed species per square meter and the density of weeds categorized as sedges, grass, and broadleaf weeds at 60 DAS were determined and presented in Table 1. Additionally, the total dry weight of weeds was recorded at the same stage (25, 50 and at harvest stage respectively).

Results and Discussion

Based on the results of a maize field experiment, different tillage practices have shown varied impacts on weed populations. Cultivators and rotavators tend to have higher populations of broadleaf weeds compared to disc ploughs and inversion tillage (Shrestha, 2006). This could be attributed to the fact that cultivators and rotavators plough the soil to a depth of only 0-10 cm, while disc ploughs reach depths of 0-30 cm and inversion tillage reaches depths of 0-60 cm.Soil profile inversion is a technique that can be employed to reduce weed growth and enhance crop growth (McPheeters *et al.,* 2022). By completely overturning the soil profile, weed seeds can be buried at greater depths, leading to reduced germination and emergence in the short term (Milligan *et al*., 2017). Furthermore, the disturbance caused by soil profile inversion can decrease the density of established weeds by uprooting or burying them in the soil. This technique also promotes crop growth and competitiveness by improving soil structure and nutrient availability, thereby suppressing weed growth.Deep ploughing mixes surface weeds and buries them in the deeper layers of the soil profile, resulting in minimal weed populations in deep tillage plots. Inversion tillage brings nutrient-rich subsoil to the surface, facilitating maize growth. The combined effect of reduced weed population and increased nutrient availability in the inverted tillage treatment maximizes maize crop growth.Tillage practices have various effects on weeds, including uprooting, dismembering, and burying them deep enough to prevent emergence, as well as modifying the soil environment (Cooper *et al.,* 2016).Overall, the use of soilinversion tillage and various tillage practices can significantly impact weed management and promote crop growth. Farmers can utilize these findings to make informed decisions about tillage practices, considering their weed control objectives and crop yield goals.



Weed population in various tillage

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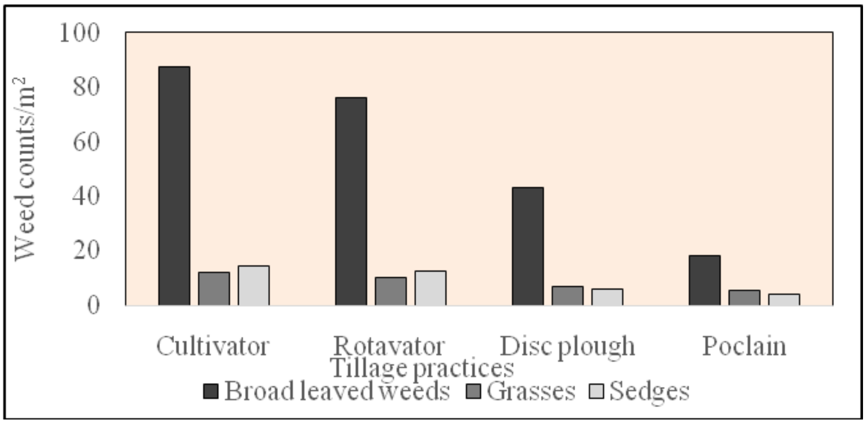
Table 1. Effect of various tillage practices on weed density/ m^2 in Cotton-maize-pulse cropping system

Weed flora	25th day			50th day			At harvest		
	Broad leaved weeds	Grasses	Sedges	Broad leaved weeds	Grasses	Sedges	Broad leaved weeds	Grasses	Sedges
Cultivator	87.4	12.3	14.4	65.7	10.3	9.3	53.6	9.4	7.2
Rotavator	76.1	10.4	12.6	67.3	8.3	11.6	51.8	9.8	8.5
Disc plough	43.4	7.2	6.2	34.2	6.6	5.2	27.3	6.1	5.6
Poclain	18.3	5.5	4.1	16.3	4.2	2.4	14.3	3.3	3.2

Fig.1. Effect of tillage practices on weed population in maize cropping system



T2-24
Profit maximization in irrigated pearl millet through altered crop geometry and intercropping system

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Abstract

The field experiment was carried out during *Kharif* 2019 Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore to determine the yield and economics under different crop geometry and intercropping system in irrigated pearlmillet. Results of the experiment revealed that Grain yield, Pearlmillet Grain equivalent yield (PGEY), Gross return, net return and BC ratio was recorded in Pearlmillet in Paired Row Sowing (PRS) 30/90 x 15 cm (M_4) + greengram (S_1). It was concluded that PRS 30/90 x 15 cm with greengram was found to be more profitable intercropping system

Keyword: Paired row system, greengram, sesame, Pearlmillet Grain Equivalent Yield

Introduction

Millets are important food source for millions of people, especially in dry parts of the world, mainly cultivated in marginal areas under agricultural conditions in which most of the cereals fail to give better yield (Adekunle *et al.*, 2013). Major type of millet is pearl millet which occupies 50 percent of the world production. It is well suited to low rainfall (200-600 mm), high temperature, low soil fertility and it is also well adapted to high saline soils. Since, there is some limitation in fetching more land area under cultivation both under rainfed and irrigated conditions. A strategy should be adapted for increasing the productivity by increasing cropping intensity. Intercropping was suitable approach to increase productivity per unit area, avoid risk of failure of crops and increase the monetary returns. Pearlmillet is conventionally cultivated by farmers either broadcasting or uniform row spacing of 45 cm where it is difficult to accommodate an intercrop. Modification of planting pattern of the base crop without changing the base crop plant population would make more feasible to intercropping. Therefore, the objective was to determine the yield and economics under different crop geometry and intercropping system in irrigated pearlmillet.

Materials and Methods

A field experiment was carried out during *Kharif* 2019 (July to October) at Eastern Block farm, Department of Agronomy, TNAU, Coimbatore. The experiment was designed in split plot design and replicated thrice. In main plot *viz.,* crop geometry [M_1-Pearlmillet in 45 x 15 cm, M_2-Pearlmillet in 60 x 15 cm, M_3- PRS 30/60 x 15 cm and M_4- PRS 30/90 x 15 cm] and intercropping [S_1-Greengram, S_2-Sesame and S_3-No intercrop] were allotted in sub plot. Pearlmillet (CO 10) was used as maincrop and the intercrops were greengram [CO (Gg) 8] and sesame (TMV 7). Observations *viz.,* Grain yield, Pearlmillet Grain equivalent yield (PGEY), Gross Return (GR), Net Return (NR) and Benefit Cost Ratio (BCR) was done.

Results and Discussion

Crop geometry and intercropping produces significant impact on grain yield and grain equivalent of pearlmillet (Table 1). PRS 30/90 x 15 cm (M_4) produced higher yield and

PGEY. In wider spacing between rows individual plant can develop maximum canopy with well-developed root system. Availability of above and below ground resources were maximum under wider spacing crops, effectively transferred the assimilates to the individual grains and allowed to develop bold grains and produced higher yield. This result was similar with the findings of Singh *et al.* (2019). Among the different intercrops, no intercrop (S3) produced more yield and grain equivalent yield. Greengram seems to be less harmful and its short life span and also their growth peaks were not coincided with each other. Hooda *et al.* (2004) also found similar results. While in interaction, PRS 30/90 x 15 cm (M_4) + greengram (S_1) recorded higher PGEY because of higher yield of pearlmillet and additional advantage of greengram yield due to healthy complementary relationship and good price of greengram resulted in highest PGEY. Similarly, Higher GR, NR and BCR were recorded in above geometry (**Fig 1**). This might be due to both pearlmillet and intercrops performed well under wider spacing leads higher grain equivalent yield These results were in agreement with the findings of Sharma *et al.* (2009). With regarding to intercropping system, greengram (S_1) recorded more economic returns. This might be due to complementary relationship of greengram and less dominance of pearlmillet in greengram which helped to increase pearlmillet grain equivalent yield and resulted in higher gross return, net return and benefit cost ratio (Kumar *et al.*, 2005). From the above result's it was concluded that pearlmillet in PRS 30/90 x 15 cm with greengram was found to be more profitable intercropping system under irrigated condition in western Agro climatic zone of Tamilnadu.

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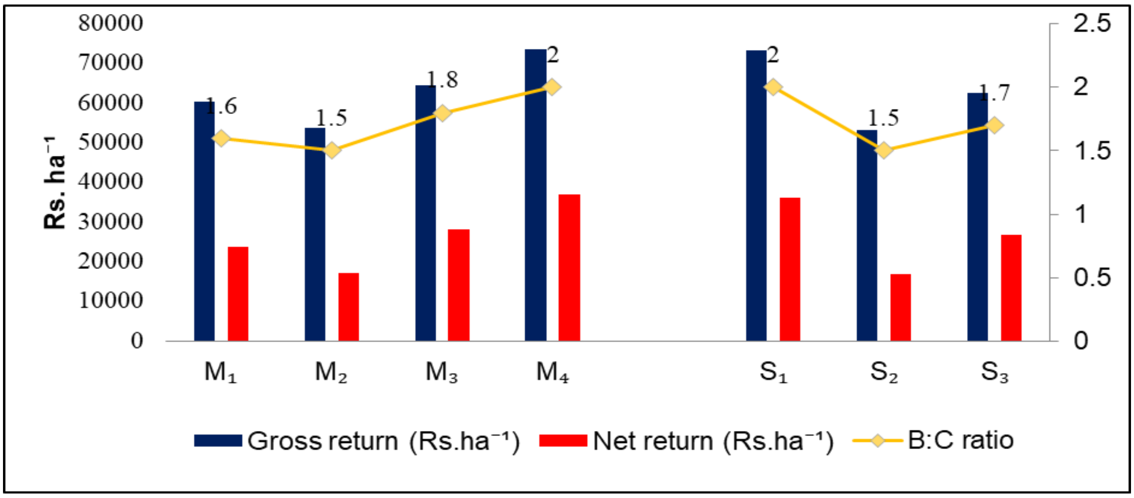
Table 1. Grain yield (kg ha-1) and Pearlmillet Grain Equivalent Yield (kg ha-1) as influenced by crop geometry and intercropping in pearlmillet

Treatment	Grain yield (kg ha^{-1})					Pearl millet grain equivalent yield (kg ha^{-1})				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	3135	2522	2967	3316	2985	3452	2910	3742	4550	3663
S_2	2398	2487	2753	2821	2615	2404	2500	2787	2951	2661
S_3	3197	2642	3150	3553	3135	3197	2642	3150	3533	3130
Mean	2910	2551	2957	3230	2912	3018	2684	3226	3678	3152
	M	S	M at S	S at M		M	S	M at S	S at M	
SEd	129	87	192	175		119	90	189	179	
CD (P=0.05)	316	185	NS	NS		291	190	425	380	

Fig 1. Gross return (Rs. ha-1), Net return (Rs. ha-1) and B:C ratio as influenced by crop geometry and intercropping in pearlmillet as influenced by crop geometry and intercropping in pearlmillet



T2-25
Foliar application of TNAU Crop Booster-Maize Maxim boosts up the yield attributes in Maize

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Abstract

Nutrient application via foliar spray at critical stages of growth is becoming increasingly vital to effective nutrient utilization and improved crop production. With this in consideration, the current study was to use an unmanned aerial vehicle instead of a traditional hand sprayer for foliar application of TNAU Maize Maxim. There were five treatments with seven replications in a randomized block design. The treatments include T_1 - 1% TNAU Maize Maxim using Drone, T_2 - 1% TNAU Maize Maxim using Drone, T_3 - 1% TNAU Maize Maxim using Drone, T_4 - 1.5% Foliar application of TNAU Maize Maxim using Hand operated sprayer and T_5 - Control. It was given a two intervals viz., 50% Tasseling, and Cob filling stage. Growth and yield attributes were observed. TNAU Maize maxim, treated with a drone at 3% spray fluid, produced the highest growth and yield features compared to other treatments. Improved growth attributes such as plant height (258 cm) and yield attributes such as cob weight (226 g plant^{-1}), seed dry weight of (163 g plant^{-1}), grain number cob^{-1}(526), hundred seed weight (35g), and grain yield (3282 kg acre^{-1}) compared to other treatments. As a result, drones can be used for foliar spraying of TNAU Maize maxim for increase productivity as well as where hand spraying is impractical at various stages of the maize crop.

Keywords: Maize, Yield attributes, Crop Booster, Maize Maxim, Foliar application, Drone

Introduction

Maize (*Zea mays* L.) is a major cereal crop in a majority of developing and developed countries all over the world. In Tamil Nadu Maize is cultivated in an area of 4 Lakh ha with a production of 28.27 Lakh MT (Dept. of Economics and Statistics, TN, 2022). In Tamil Nadu maize is predominantly cultivated as Maize is predominantly grown as a rainfed crop in India. Currently rainfed yields (1.9 tonne ha^{-1}) are much lower than irrigated yields (3.5 tonne ha^{-1}) in India (CRIDA, Annual Report 2013-14). Yield in maize is influenced by several factors, including agronomical and crop management practices. Fertilizer application to the soil results in nutrient losses through various means. As a result, efforts are being made to boost crop productivity through foliar fertilization of nutrients in addition to the recommended dose of fertilizer. Foliar nutrient feeding has always been standard practice in crop production in recent decades, with both the objective of enhancing yield and improving crop quality (Shwetha *et al.,* 2018). This study was undertaken to study the impact of TNAU Maize Maxim in boosting up the maize yield under irrigated conditions.

Materials and Methods

During Purattasi pattam 2022, a field experiment was conducted at TNAU's Eastern block farm in Coimbatore to investigate the effect of foliar application of TNAU Maize Maxim using two distinct nutrient application techniques. Maize hybrid COH (M) 8 was utilized as a test crop. This experiment contained five treatments and seven replications and was carried out using a Randomised Block Design. The treatments include T_1 - 1% TNAU Maize Maxim using Drone, T_2 - 1% TNAU Maize Maxim using Drone, T_3 - 1% TNAU Maize Maxim using Drone, T_4 - 1.5% Foliar application of TNAU Maize Maxim using Hand operated sprayer and T_5 - Control. Foliar application of TNAU Maize Maxim was given a two intervals viz., 50% Tasseling, and Cob filling stage. Foliar application of TNAU Maize Maxim using Drone at tassel initiation and grain filling stages. Recommended Crop nutrient and protection management practices were followed as per TNAU Crop Production Guide (2022). The plant growth parameters like plant height (cm) and yield parameters like cob weight (g), seed dry weight (g), number of grains cob^{-1}, 100 seed weight (g), seed yield (kg m^{-2}) and seed yield (kg acre^{-1}), were recorded.

Results and discussion

Plant height, which is an important component of maize growth, differed significantly across treatments. T_3 (258cm) and T_4 (235cm) treatments have 14.6% and 4.4% larger plant heights than T_5 (225cm), respectively. Because micronutrients promote crop development, rapid cell division and cell elongation are inextricably related. Saleh *et al.,* 2020 found a similar finding in their study. The spray of TNAU Maize maxim foliar spray by drone and hand sprayer had a significant impact on maize yield indices. T_3 (226 g plant^{-1}) and T_4 (142 g plant^{-1}) treatments produce 94.8% and 22.4% more cob weight, respectively, than T_5 (116 g plant^{-1}). T_3 (163 g plant^{-1}) and T_4 (113 g plant^{-1}) treatments have greater seed dry weights than T_5 (108 g plant^{-1}) by 50.9% and 4.6%, respectively. Compared to T_5 (324 Seed No. cob^{-1}), T_3 (526 Seed No. cob^{-1}) and T_4 (378 Seed No. cob^{-1}) treatments had 62.3% and 16.7% more seeds per cob, respectively. The 100 seed weight for the T_3 (35 g) and T_4 (34 g) treatments is 9.4% and 6.7% greater than for the T_5 (32 g), respectively. In comparison to T_5 (0.65 kg m^{-2}), seed yields for T_3 (1.06 kg m^{-2}) and T_4 (0.73 kg m^{-2}) treatments are 63% and 12.3% higher, respectively. The seed yield per acre for T_3 (3282 kg acre^{-1}) and T_4 (3156 kg acre^{-1}) treatments is greater than that of T_5 (2738 kg acre^{-1}) by 63% and 12.3%, respectively. The growth and yield parameters are given in Table1. The findings of Kumar *et al*. 2018 and this investigation were discovered to be comparable. Due to the strong absorption of TNAU Maize maxim, the yield in drone spray was higher than that of the traditional knapsack sprayer. The shape of maize plants and the downward airstream from the drone create the optimum conditions for droplet deposition.

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CRIDA, Annual Report 2013–2014. Central Research Institute for Dryland Agriculture, Hyderabad, India, pp. 197.

Shwetha BN, Anupama C, Sowmya TM and Yaligar R, 2018. Effect of foliar nutrition on productivity of groundnut crop. *Journal of Pharmacognosy and Phytochemistry*. 7(1S): 2357-2360.

Maize (*Zea mays* L.) is the third largest grain crop in India, after rice and wheat. It is cultivated in an area of 9.09 million hectares (M ha), has an annual production of 24.26 million metric tonnes (MMT), and an average national productivity of 2.56 metric tonnes per ha (tonnes/ha)

Saleh HS, Dawood RA, El-Far IA and El-Nagar GR, 2020. Impact of some Micro-Nutrients Foliar Application on Two Maize Hybrids Productivity. *Assiut Journal of Agricultural Science*. 51(3): 14-26.

Kumar AS, Sakthivel N, Subramanian E, Kalpana R, Janaki P and Rajesh P, 2018. Influence of foliar spray of nutrients and plant growth regulators on physiological attributes and yield of finger millet *(Eleusine coracana (L.) Gaertn.)*. *Inter J of Chem Studies*. 6(3): 2876-2879.

Table 1. Effect of ariel spray of TNAU Maize Maxim on Maize growth and yield parameters

Treatments	Plant height (cm plant^{-1})	Cob weight (g plant $^{-1}$)	Seed dry weight (g plant^{-1})	Seed number cob $^{-1}$	100 seed weight (g)	Seed yield (kg m ^{2})	Seed yield (kg acre^{-1})
T_1	245	201	151	488	34	0.92	3208
T_2	261	218	163	514	34	1	3230
T_3	258	226	163	526	35	1.06	3282
T_4	235	142	113	378	34	0.73	3156
T_5	225	116	108	324	32	0.65	2738
Mean	245	181	140	446	34	1	3123
SD	14.3	46.0	25.5	84.7	1.0	0.2	207.2

T_1 - 1% TNAU Maize Maxim using Drone, T_2 - 1% TNAU Maize Maxim using Drone, T_3 - 1% TNAU Maize Maxim using Drone, T_4 - 1.5% Foliar application of TNAU Maize Maxim using Hand operated sprayer and T_5 - Control

T2-26

Efficient and Economic use of Nutrients for hybrid Pearl millet through STCR-IPNS approach on Mixed Black Calcareous Soils of Tamil Nadu

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Abstract

Soil test based fertiliser prescription is an essential component of any crop production system so as to enhance the productivity and sustain soil fertility. At this moment, adoption of Soil Test Crop Response – Integrated Plant Nutrition System (STCR-IPNS) based nutrient recommendation helps the farmers to achieve the targeted yield with efficient and economic use of fertilisers. Keeping these facts in view, Fertiliser Prescription Equations under IPNS have been developed for hybrid pearl millet on mixed black calcareous soils adopting the Inductive cum Targeted yield model. In the present study, to validate the fertiliser prescription equations under IPNS for pearl millet (TNAU Cumbu Hybrid CO 9) on Perianaickenpalayam series (*Typic Ustropept*– mixed black calcareous soils), experiments were conducted at five locations of Dindigul Dt. (Southern Agro-climatic zone) during kharif and rabi seasons of 2017-18. There were ten treatments *viz.,* blanket (RDF alone), blanket (RDF + FYM @ 12.5 t ha^{-1}), STCR-NPK alone - 3.0, 3.5 and 4.0 t ha^{-1}, STCR-IPNS - 3.0, 3.5 and 4.0 t ha^{-1}, farmer's practice and absolute control. At all the five locations, the per cent achievement was within +/-10 per cent variation in STCR-NPK alone and STCR-IPNS treatments proving the validity of the equations. The mean of the five validation experiments indicated that the highest mean grain yield was recorded in STCR-IPNS-4.0 t ha^{-1} (4155 kg ha^{-1}) followed bySTCR-NPK alone-4.0 t ha^{-1} (3999 kg ha^{-1}). Though the highest fertiliser use efficiency (in terms of Response Ratio) was recorded in STCR-IPNS-3.0 t ha^{-1} (11.85 kg kg^{-1}) followed by STCR-IPNS-3.5 t ha^{-1}(11.56 kg kg^{-1}), the highest BCR was recorded in STCR-IPNS-4.0 t ha^{-1} (1.86).In general, STCR treatments proved their superiority over blanket and farmer's practice in terms of yield, RR and BCR. The mean increase in yield due to STCR-IPNS- 4.0 t ha^{-1} was 61.7 per cent over blanket (RDF alone), 18.8 per cent over blanket + FYM and 76.4 per cent over farmer's practice. Post-harvest soil fertility data indicated that there was either maintenance or built-up of soil available N, P and K in all the fertilised treatments while depletion has been noted in absolute control. Therefore, Soil Test Crop Response based fertiliser prescriptions under Integrated Plant Nutrition System (STCR-IPNS for 4.0 t ha^{-1}) *i.e.* application of fertiliser N, P_2O_5 and K_2O based on initial soil test values along with FYM @12.5 t ha^{-1} can be recommended for hybrid pearl millet for achieving higher yield, response ratio and BCR with soil fertility maintenance on Perianaickenpalayam series (mixed black calcareous soil) of Tamil Nadu.

Key words: STCR-IPNS, mixed black calcareous, hybrid Pearl millet,Response ratio & BCR

Introduction

Rationalised fertiliser prescription through integrated use of various sources of nutrients is one of the vital tools for enhanced yield of crops and maintenance of soil fertility.

In this regard, adoption of Soil Test Crop Response – Integrated Plant Nutrition System (STCR-IPNS) based nutrient prescriptions helps the farmers to achieve the targeted yield with efficient and economic use of fertilisers by eliminating over or under usage of fertiliser inputs(Dey and Santhi, 2014).Pearl millet (*Pennisetum glaucum*), an undernourished crop, is being fertilised with a blanket recommendation of 80:40:40 and 70:35:35 kg N, P_2O_5 and K_2O ha^{-1} for hybrids and varieties respectively along with FYM @ 12.5 t ha^{-1} in Tamil Nadu. Keeping these facts in view, Fertiliser Prescription Equations under IPNS have been developed for hybrid pearl millet on mixed black calcareous soils adopting the Inductive cum Targeted yield model of Ramamoorthy *et al*. (1967).

Materials and Methods

To validate the fertiliser prescription equations under IPNS for pearl millet (TNAU Cumbu Hybrid CO 9) on Perianaickenpalayam series (*Typic Ustropept*– mixed black calcareous soils), experiments were conducted at five locations of Dindigul Dt (Southern Agro-climatic zone) *viz.,*Kottur Avarampatti (location I&II),Palam Rajakkapatti (location III), Ayyampatti (location IV&V), Dindigul district during kharif and rabi seasons of 2017-18.The fertiliser prescription equations for validation are as below:

Fertiliser Prescription equations

$$FN = 6.04\,T - 0.49\,SN - 0.80\,ON$$

$$FP_2O_5 = 2.78\,T - 1.65\,SP - 0.97\,OP$$

$$FK_2O = 3.29\,T - 0.17\,SK - 0.58\,OK$$

where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1} respectively; T is the yield target in q ha^{-1}; SN, SP and SK respectively are alkaline $KMnO_4$-N,Olsen-P and NH_4OAc-K in kg $ha^{-1}$and ON,OP and OK are the quantities of N, P and K in kg ha^{-1} supplied through FYM.

There were ten treatments *viz.,* blanket (RDF alone), blanket (RDF + FYM @ 12.5 t ha^{-1}), STCR-NPK alone – 3.0, 3.5 and 4.0 t ha^{-1}, STCR-IPNS – 3.0, 3.5 and 4.0 t ha^{-1}, farmer's practice and absolute control. Based on the initial soil test values of available N, P and K and the quantities of N, P_2O_5 and K_2O supplied through FYM, fertiliser doses were calculated and applied for STCR treatments for various yield targets. STCR-NPK alone treatments received only inorganic fertilisers based on STCR equations, whileSTCR - IPNS treatments received FYM @ 12.5 t ha^{-1} basally and NPK fertilisers were applied after adjusting the nutrients supplied through FYM based on STCR-IPNS equations. At all the locations, fertiliser doses have been imposed as per the treatment schedule and all the improved agronomic practices were carried out periodically. At harvest, grain yield has been recorded treatment wise and post-harvest soil samples were collected and analysed for available N, P and K status. The details of fertiliser doses applied, yield, response ratio (RR) and BCR are furnished in Table 1.

Results and Discussion

At all the five locations, the per cent achievement was within+/-10 per cent variation in STCR-NPK alone and STCR-IPNS treatments proving the validity of the equations. The range and mean values of the five validation experiments indicated that the highest mean grain yield was recorded in STCR-IPNS-4.0 t ha^{-1} (4155 kg ha^{-1}) followed bySTCR-NPK alone-4.0 t ha^{-1} (3999 kg ha^{-1}). Though the highest RR was recorded in STCR-IPNS-3.0 t ha^{-1} (11.85 kg kg^{-1}) followed by STCR-IPNS-3.5 t ha^{-1}(11.56 kg kg^{-1}), the highest BCR was recorded in STCR-IPNS-4.0 t ha^{-1} (1.86).In general, STCR treatments proved their superiority over blanket and farmer's practice in terms of yield, RR and BCR. Similar findings have been reported by Kanchana *et al.* (2020) for pearl millet variety on an *Inceptisol.*

The mean increase in yield due to STCR-IPNS- 4.0 t ha^{-1} was 61.7 per cent over blanket (RDF alone), 18.8 per cent over blanket + FYM and 76.4 per cent over farmer's practice. STCR-IPNS treatments recorded relatively higher per cent achievement, RR and BCR as compared to STCR-NPK alone treatments. Farmer's practice recorded relatively lower yield (2356 kg ha^{-1}) and RR (9.54 kg kg^{-1}) and BCR (1.15) as compared to blanket and STCR treatments. The mean increase in RR due to STCR-IPNS-4.0 t ha^{-1} over blanket, blanket (RDF + FYM @ 12.5 t ha^{-1}) and farmer's practice was 1.34, 1.21 and 1.54 kg kg^{-1} respectively while that of BCR was 0.62, 0.26and 0.71 respectively. Post-harvest soil fertility data indicated that there was either maintenance or built-up of soil available N, P and K in all the fertilised treatments while depletion has been noted in absolute control.

Therefore, Soil Test Crop Response based fertiliser prescriptions under Integrated Plant Nutrition System (STCR-IPNS for 4.0 t ha^{-1}) *i.e.* application of fertiliser N, P_2O_5 and K_2O based on initial soil test values along with FYM @12.5 t ha^{-1} can be recommended for hybrid pearl millet for achieving higher yield, response ratio and BCR with soil fertility maintenance on Perianaickenpalayam series (mixed black calcareous soil).

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Table 1. Range and mean values of Results of validation experiments on pearl millet (mean of five locations)

Location :	Farmers' holdings, DindigulDistrict	Soil	:	*Vertic Ustropept* Periyanaickenpalayam series (Mixed Black Calcareous)
Hybrid :	TNAU Cumbu Hybrid CO 9	Season	:	Kharif & Rabi 2017

S. No.	Treatments	Fertiliser doses(kg ha^{-1})			Grain yield (kg ha^{-1})	Percent achieve -ment	RR (kg kg^{-1})	BCR
		FN	FP$_2$O$_5$	FK$_2$O				
1.	Blanket (RDF alone)	80	40	40	2569	-	9.74	1.24
2.	Blanket(RDF+FYM@ 12.5 t ha^{-1})	80	40	40	3497	-	9.87	1.60
3.	STCR- NPK alone3.0 t ha^{-1}	87-96	42-57	20*-47	2906	96.86	11.09	1.40
4.	STCR - NPK alone3.5 t ha^{-1}	110-126	56-71	23-63	3454	98.7	10.81	1.60
5.	STCR - NPK alone4.0 t ha^{-1}	140-156	70-86	39-80	3999	100	10.52	1.83
6.	STCR-IPNS- 3.0 t ha^{-1}	40-56	20*-35	19-20*	3034	100.94	11.85	1.42
7.	STCR-IPNS- 3.5 t ha^{-1}	70-86	32-47	20*-35	3593	102.64	11.56	1.64
8.	STCR-IPNS- 4.0 t ha^{-1}	100-116	46-62	20*-52	4155	103.66	11.08	1.86
9.	Farmer's practice(NPK alone to NPK+ FYM@ 5 t ha^{-1})	60-70	0-45	30-40	2356	-	9.54	1.15
10.	Absolute Control	0	0	0	1010	-	-	0.53

STCR-IPNS: NPK+FYM @ 12.5 t ha^{-1}; *maintenance dose **maximum dose
Initial soil available nutrients: NP&K: 174 - 207, 15.0 - 25.0 & 305 - 518 kg ha^{-1}; Zn, Fe, Mn &Cu: 0.30-0.52, 3.96-6.02, 4.10 -8.15 &1.00 -1.54 mg kg^{-1}

T2-27
Effect of different doses of potassium nutrient on growth and yield of Small Millets

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Abstract

Small millets are called nutri- cereals because of its nutrient content. Generally small millets are grown in *Kharif* season as a rainfed crop. *Kharif* season facilitates both water logging and water stress during cropping season due to rainfall uncertainity. The contribution of millets to national food security and their potential health benefits, millet grain is now receiving increasing interest from food scientists, technologists and nutritionists. In small millets nutrient management plays a important role in productivity. This study was conducted to know the response of potassium in small millet productivity. Application of 20 kg/ha potassium application with recommended dose of N and P recorded the higher yield in proso mille (1.41t/ha), Banyard millet (2.11/ha), kodomillet (2.26 /ha), and browntop millet (2.81/ha) and remunerative economics in millets when compare to other treatment.

Keywords: Small millet, Potassium, Economics, Net return, Benefit Cost Ratio.

Introduction

Small millets are important crops of rainfed areas in semi-arid regions. Currently, they are grown on a limited area representing a small portion of global millet production, because of the shift from traditional crops to cash crops. Some of these small millets are considered as weeds, particularly the wild forms. However, they are the crops of local importance that provide reliable yields on marginal lands, and contribute significantly to the food security. Small millets are cultivated in dryland conditions, soils are commonly low fertile in nature. The productivity of small millets was very low due to improper nutrient management. In dry land condition potassium application has been neglected in many countries, including India, which has resulted in soil K depletion in agricultural ecosystems and a decline in crop yields (Brar, 2022). Potassium plays a important role in developement of growth and regulates stomatal movement and quality of grains. It also provides drought tolerant capacity and pest and disease resistant to the crop.

Presently population needs to strengthen the immune system to protect from various diseases. Hence increasing the small millet production is most important. Hence, the present study was carried out to increase the yield by application of potassium.

Materials and Methods

Field experiments were conducted during *kharif* 2020 and to *kharif* 2021 at the Centre of Excellence in Millets, Athiyandal Thiruvannamalai. During the cropping period monthly mean maximum and minimum temperature ranged between 34.4 and 24.9°C, The treatments were laid out in split plot design with three replication. In main plot four crops were sown *viz*., C_1- Proso millet, C_2 - Barnyard millet, C_3 - Kodo millet and C4 -Browntop millet. In sub plot four doses of potassium fertilizer were applied like K_1 - 0, K_2 -10, K_3 - 20 and K_4 - 30 kgs /ha. After sowing where seeds failed to germinate, gap filling was done 10 days after sowing. When more than one seedling was present in a hill that were thinned out to maintain one seedling for proper spacing at 20 days after sowing. From each experimental plot, 5 plants were randomly tagged for recording observations on growth *viz*., plant height (cm), number of tillers/plant; yield attributes *viz*., number of panicles /plant, 1000 grain weight (g), biomass production/ plant (g) and grain yield (kg/ha) Economics was calculated as per the standard methods formulated by CIMMYT (1988). For each treatment budget was calculated to determine the expenses incurred and net returns based on the present prices of inputs prevailing in the market during 2020 and 2021 of cropping season to calculate the benefit-cost ratio (BCR). Growth and yield parameters were observed during different stages of the crops. The statistical analysis of the data was done by the analysis of variance (ANOVA) method for split plot design.

Results and Discussion

From the pooled data, various potassium management practices had significant effect on the growth and yield parameters (Table 1& 2).

Data presented in Table 1 and 2 stated that the growth and yield contributing characters *viz*., Plant height, number of productive tillers, grain yield and benefit cost ratio were significantly influenced by the different levels of potassium application. The higher plant height recorded at Proso millet (96.6 cm),Barnyard millet (125.7 cm), Kodo millet (68.9cm) and Browntop millet (71.5 cm), Higher grain yield recorded at proso millet (1.41t/ha), Banyard millet (2.11/ha), kodomillet (2.26 /ha), and browntop millet (2.81/ha) and higher Benefit Cost ratio was recorded at proso millet (1: 1.52), Banyard millet (1: 2.27), kodomillet (1: 2.44 /ha), and browntop millet (1 : 3.03 /ha) when application of 20 kgs of potassium per hectare when compare with other treatments. The same result revealed that K recorded significantly higher in plant height, number of tillers per m^2, number of effective tillers per m^2, grain yield and harvest index in finger millet (Eleti sujit Reddy and Shikha singh, 2021).

- From the above results, it could be concluded that the application of 20 kgs of potassium per hectare with recommended dose of N and P recorded the higher yield and remunerative economics in millets.
- Yield increased up to 31.8 % and tolerant to lodging
- Reduced pest and disease incidence than control

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Table 1. Role of potassium in growth of various small millets

Treatments	Plant height (cm)					No. of productive tillers				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
K_0	73.0	109.7	66.6	58.9	77.1	3.2	4.2	6.1	9.4	5.7
K_1	81.9	113.4	67.3	64.4	81.8	3.6	4.9	6.1	13.8	7.1
K_2	96.6	125.7	68.9	71.5	90.7	4.7	4.4	6.3	15.6	7.7
K_3	88.0	118.3	67.2	69.1	85.6	4.0	4.0	6.5	14.1	7.2
Mean	84.9	116.8	67.5	66.0		3.9	4.4	6.3	13.3	
		C	K	C x K	K x C		C	K	C x K	K x C
S.E.d.		1.58	1.52	3.07	3.04		0.28	0.35	0.66	0.69
CD (p=0.05)		3.86	3.14	6.65	6.28		0.67	0.71	1.41	1.43

Table 2. Role of potassium in yield and Economics of various small millets

Treatments	Grain yield (t/ha)					B: C ratio				
	C_1	C_2	C_3	C_4	Mean	C_1	C_2	C_3	C_4	Mean
K_0	0.99	1.63	1.83	2.27	1.68	1.08	1.79	2.01	2.49	1.84
K_1	1.06	1.80	2.06	2.54	1.87	1.16	1.96	2.24	2.77	2.03
K_2	1.41	2.11	2.26	2.81	2.15	1.52	2.27	2.44	3.03	2.32
K_3	1.19	1.92	2.16	2.65	1.98	1.27	2.05	2.31	2.83	2.12
Mean	1.16	1.86	2.08	2.57		1.26	2.02	2.25	2.78	
		C	K	C x K	K x C					
S.E.d.		0.04	0.04	0.07	0.07					
CD (p=0.05)		0.09	0.08	0.16	0.15					

T2-28

Crop residue mulching and hydrogel application on productivity and profitability of rainfed Pearl Millet (*Pennisetum glaucum* L.)

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Abstract

To assess the influence of crop residue mulching and hydrogel application on productivity and profitability of rainfed pearl millet, field experiment was conducted during *Kharif* season, 2019 at Department of Millets, TNAU, Coimbatore with the following treatments with three replication *viz*., T_1 - Control, T_2 - Crop residue mulch @ 5.0t ha^{-1}, T_3 - Hydrogel @ 2.5kg ha^{-1}, T_4 - Hydrogel @ 5.0kg ha^{-1}, T_5 - Hydrogel @ 7.5kg ha^{-1}, T_6 - T_2 + Hydrogel @ 2.5kg ha^{-1}, T_7 - T_2 + Hydrogel @ 5.0kg ha^{-1}, and T_8 - T_2 + Hydrogel @ 7.5kg ha^{-1}. The results of the field experiment revealed that, application of crop residue mulch @ 5.0t ha^{-1} + hydrogel @ 7.5kg ha^{-1}, significantly registered higher plant height (155.0cm), total tillers $plant^{-1}$ (5.0) and effective tillers $plant^{-1}$ (3.7) at harvest stage, grain yield (3324kg ha^{-1}) and dry fodder yield (4487kg ha^{-1}) and gross return (₹66,480 ha^{-1}). However, higher net return (₹66,480 ha^{-1}) and B: C ratio (2.20) was recorded in application of crop residue mulch @ 5.0t ha^{-1} + hydrogel @ 5.0kg $ha^{-1.}$ From the experimental result, it was concluded that combined application of crop residue mulch @ 5.0t ha^{-1} + hydrogel @ 5.0kg ha^{-1} found to be an economically viable options for maximizing the productivity and profitability of rainfed pearl millet.

Keywords: Rainfed pearl millet, mulching, crop residue, hydrogel, productivity and economics

Introduction

Pearl millet [*Pennisetum glaucum* L.) is a hardiest and warm season crop in nature, and it is largely cultivated in drought prone, low fertile and low productivity sandy soil of arid and semi-arid agro-climatic conditions of the World. In Indian sub-continent, pearl millet is predominantly cultivated as rainfed crop with limited soil moisture conservation practices and marginal crop management options, thus leads to realisation low productivity and profitability. Hence, to maximise the yield and profit of rainfed pearl millet, it is crucial to conserve the rainfall *in-situ*, and to utilize the stored soil moisture effectively at critical and moisture sensitive phases of plant growth and development (Yadav *et al*., 2019). Application of crop residue as a mulching material significantly reduce soil moisture loss through evaporation, besides it moderate soil temperature and microbial activity in root zone of the plants (Saini *et al.,* 2018). Similarly, soil incorporated Pusa hydrogel, absorbs water and expands 300 times from its original size, and whenever the available soil moisture gets deficit to temporary wilting point and soil temperature escalate, absorbent polymer slowly release the moisture to the soil and nourish the crop and thus it mitigate plant moisture stress and thereby increases crop yield by 10 - 25 *per cent*. Hence, soil moisture conservation through crop residues mulch and Pusa hydrogel could be a prudent and sustainable strategy to mitigate soil moisture deficit at sensitive stages of the crop and to maximise the yield and profitability of rainfed pearl millet on sustainable basis.

Materials and Methods

To assess the influence of crop residue mulching and hydrogel application on productivity and profitability of rainfed pearl millet, field experiment was conducted during *Kharif* season, 2019 at Department of Millets, Tamil Nadu Agricultural University, Coimbatore with the following soil moisture conservation practices *viz*., T_1 - Control (without crop residue mulch and hydrogel application), T_2 - Crop residue mulch @ 5.0t ha^{-1}, T_3 - Hydrogel @ 2.5kg ha^{-1}, T_4 - Hydrogel @ 5.0kg ha^{-1}, T_5 - Hydrogel @ 7.5kg ha^{-1}, T_6 - T_2 + Hydrogel @ 2.5kg ha^{-1}, T_7 - T_2 + Hydrogel @ 5.0kg ha^{-1}, and T_8 - T_2 + Hydrogel @ 7.5kg ha^{-1} and replicated thrice. Pre-treated seeds of pearl millet TNAU hybrid Co 9 were sown with spacing of 45cm x 15cm in ridges and furrow land configuration in a gross plot of 5.0m x 3.6m and a net plot of 4.1m x 2.7m. The crop was fertilized with recommended dose of fertilizer of 80: 40: 40kg of $NP_2O_5K_2O$ ha^{-1} through urea, single super phosphate and muriate of potash fertilizer respectively. Observed data on growth and yield attributes, grain and dry fodder yield were tested and compared using Analysis of Variance (ANOVA).

Results and Discussion

Among the soil moisture conservation practices studied, combined application of crop residue mulch @ 5.0t ha^{-1} + hydrogel @ 7.5 kg ha^{-1} (T_8) significantly recorded higher plant height (155.0cm), total tillers plant^{-1} (5.0 Nos.), effective tillers plant^{-1} (3.7 Nos.), grain yield (3324kg ha^{-1}) and dry fodder yield (4487kg ha^{-1})**.** Nonetheless, it was on par with the treatment combination of crop residue mulch @ 5.0t ha^{-1} + hydrogel @ 5.0kg ha^{-1} (T_7). However, no significant variation was observed in test weight by adoption of different soil moisture conservation practices. Significant improvement in growth and yield attributes, grain and dry fodder yield of pearl millet might be due to effective *in-situ* conservation of seasonal rainfall and consistent supply of stored soil moisture around the root zone by the integrated soil moisture conservation practices of crop residue mulching and Pusa hydrogel, which may also provide favourable soil condition and micro environment for better uptake and efficient translocation of the essential nutrients at critical stages of plant growth and development, which finally resulted in higher productivity in rainfed pearl millet. Similar results were also reported by Saini *et al.,* (2018).

Pertaining to profitability of the rainfed pearl millet, higher gross return (₹66,480 ha^{-1}) was recorded in application of crop residue mulch @ 5.0 t ha^{-1} + hydrogel @ 7.5 kg ha^{-1}, however the maximum net return (₹35652 ha^{-1}) and B: C ratio (2.20) were recorded in combined application of crop residue mulch @ 5.0 t ha^{-1} + hydrogel @ 5.0 kg ha^{-1}**.** Economic analysis of the experiment also advocates that *in-situ* soil moisture conservation through crop residue mulching and hydrogel application resulted in adequate availability of soil moisture and nutrients for better crop growth and development, which led to enhancement in grain and dry fodder yield thereby realisation of maximum profit in rainfed pearl millet. The finding of the experiment in accordance with the results of Yadav *et al*., (2019).

From the field experimental result it was concluded that, combined application of crop residue mulch @ 5.0t ha^{-1} + hydrogel @ 5.0kg ha^{-1} found to be an economically viable options to maximize the productivity and profitability of rainfed pearl millet.

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Table 1. **Influence of mulching and hydrogel on growth and yield parameters, productivity and profitability of rainfed pearl millet**

Treatments	Plant height (cm)	Total tillers/plant (No.)	Effective tillers/plant (No.)	Test weight (g)	Grain yield (kg/ha)	Dry fodder yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
T_1	120.6	2.6	1.1	11.9	2274	2865	25268	45480	20212	1.80
T_2	135.3	3.3	1.9	12.3	2639	3510	27068	52780	25712	1.95
T_3	126.3	3.0	1.5	12.0	2509	3212	27128	50180	23052	1.85
T_4	140.0	3.5	2.0	12.3	2720	3563	28628	54400	25772	1.90
T_5	144.0	3.9	2.3	12.6	2892	3702	30128	57840	27712	1.92
T_6	149.9	4.0	2.5	12.7	2962	3939	28208	59240	31032	2.10
T_7	154.6	4.6	3.3	12.9	3268	4379	29708	65360	35652	2.20
T_8	155.0	5.0	3.7	13.3	3324	4487	31208	66480	35272	2.13
SEd.	6.7	0.2	0.2	0.7	133	194	-	2662	2662	0.09
CD (p=0.05)	14.3	0.5	0.4	NS	286	416	-	5709	5709	0.20

T2-29

Evolving profitable weed management practices for irrigated Pearl Millet (*Pennisetum glaucum* L.)

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Abstract

To evolve economically viable weed management methods for irrigated pearl millet (*Pennisetum glaucum* L.), field experiment was conducted during *Kharif*, 2019 at Department of Millets, TNAU, Coimbatore with following weed management practices in randomized complete block design with three replication *viz*., T_1 - Weedy check, T_2 - Weed free, T_3 - Two hand weeding at 3 and 5 Weeks After Sowing (WAS) , T_4 - Atrazine 50WP @ 400gm a.i. ha^{-1} on 3 DAS *fb* hand weeding at 3-4 WAS, T_5 - Tembotrione 42SC @ 90gm a.i. ha^{-1} at 3-4 leaf stage of weeds, T_6 - Tembotrione 42SC @ 100gm a.i. ha^{-1} at 3-4 leaf stage of weeds, T_7 - Tembotrione 42SC @ 110gm a.i. ha^{-1} at 3-4 leaf stage of weeds, and T_8 - Tembotrione 42SC @ 120gm a.i. ha^{-1} at 3-4 leaf stage of weeds. The experiment result revealed that, two hand weeding at 3 and 5 WAS significantly registered lower weed density (2.50 and 3.9 Nos. m^{-2}), weed dry weight (1.39 and 3.46g m^{-2}) and thereby higher weed control efficiency (82.5 and 84.0%) at 30 DAS and at harvest stages respectively. It also recorded maximum plant height (150.0cm), total tillers plant^{-1} (5.6) and effective tillers plant^{-1} (4.3) at harvest stage, grain yield (2797 kg ha^{-1}) and dry fodder yield (3804kg ha^{-1}) and gross return (₹55940 ha^{-1}). Whereas, maximum net return (₹30472 ha^{-1}) and B: C ratio (2.20) was recorded in application of Atrazine 50WP @ 400gm a.i. ha^{-1} on 3 DAS *fb* hand weeding at 3-4 WAS. From the experimental result, it was concluded that IWM practices of application of atrazine @ 400gm a.i ha^{-1} on 3 DAS *fb* one hand weeding at 3-4 WAS found to be an economically viable weed management options for maximizing the productivity of irrigated pearl millet.

Keywords: Irrigated pearl millet, pre-emergence herbicide, early post emergence herbicide, hand weeding, integrated weed management

Introduction

Pearl millet (*Pennisetum glaucum* L.) is a main and staple food crop for diet insecure and nutritionally vulnerable communities living in arid and semi-arid tropical and sub-tropical areas of the Asia and Africa continents. Being the ephemeral and drought tolerant crop, has the higher production potential in adverse climatic conditions under better crop management practices. Among the biotic stresses hindering the production potential, uncontrolled weed prevalence and persistence deprives off soil fertility and moisture availability and thus reduction in crop yield to the tune of 35% (Nibhoria *et al.,* 2021). The prevalent inter-culturing and hand weeding practices are found effective, but unavailability of labourers during peak cropping season incur higher labour cost for wedding, and delay in weeding at critical crop growth period leads to severe yield penalty and thus realisation of lower profit (Kumar *et al*., 2021). In this context, availability of pre-emergence and early post mergence herbicides in combination or integration with inter-culturing and hand weeding could be explored as a best option for developing cost effective and efficient weed management methods for maximising the yield and profit of irrigated pearl millet.

Materials and Methods

To evaluate economically viable weed management methods for irrigated pearl millet (*Pennisetum glaucum* L.), field experiment was conducted during *Kharif*, 2019 field experiment was conducted during *Kharif* season, 2019 at Department of Millets, Tamil Nadu Agricultural University, Coimbatore with following weed management practices in randomized complete block design with three replication *viz*., T_1 - Weedy check, T_2 - Weed free, T_3 - Two hand weeding at 3 and 5 Weeks After Sowing (WAS) , T_4 - Atrazine 50WP @ 400gm a.i. ha^{-1} on 3 DAS *fb* hand weeding at 3-4 WAS, T_5 - Tembotrione 42SC @ 90gm a.i. ha^{-1} at 3-4 leaf stage of weeds, T_6 - Tembotrione 42SC @ 100gm a.i. ha^{-1} at 3-4 leaf stage of weeds, T_7 - Tembotrione 42SC @ 110gm a.i. ha^{-1} at 3-4 leaf stage of weeds, and T_8 - Tembotrione 42SC @ 120gm a.i. ha^{-1} at 3-4 leaf stage of weeds. Bio-pesticide and bio fertilizers treated seeds of pearl millet TNAU hybrid Co 9 were sown with spacing of 45cm x 15cm in ridges and furrow land configuration in a gross plot of 5.0m x 3.6m and a net plot of 4.1m x 2.7m. The crop was fertilized with recommended dose of fertilizer of 80: 40: 40kg of $NP_2O_5K_2O$ ha^{-1} through urea, single super phosphate and muriate of potash fertilizer respectively. Observed data on growth and yield attributes, grain and dry fodder yield were tested and compared using Analysis of Variance (ANOVA).

Results and Discussion

Application of pre-emergence, early post emergence herbicide, hand weeding and integrated weed management practices significantly influenced weed density, weed dry weight as well as growth and yield attributes and productivity of the pearl millet. Among the weed management methods investigated, hand weeding twice at 3 & 5 weeks after sowing (T_3) significantly registered lower weed density of 2.50 and 3.9 Nos. m^{-2}, weed dry weight of 1.39 and 3.46g m^{-2} and thereby the higher weed control efficiency of at 82.5% and 84.0% at 30 DAS and at harvest stages respectively, thus leads to significantly higher plant height plant height (150.0cm), total tillers $plant^{-1}$ (5.6) and effective tillers $plant^{-1}$ (4.3) at harvest stage, grain yield (2797 kg ha^{-1}) and dry fodder yield (3804kg ha^{-1}), however it was on par with integrated weed management practices, comprising application of atrazine @ 400gm a.i./ha on 3 DAS *fb* HW at 3-4 weeks after sowing (T_4). Realisation of better growth and yield attributes, higher grain and dry fodder yield mainly ascribed to effective weed control by integrated weed management practices at critical growth period, which improved the availability and sufficient uptake of essential nutrients and moisture by the crop, thus enhanced photosynthetic activities and translocation of photosynthates to economic parts of pearl millet. Results of the present study is in line with the findings of Nibhoria *et al.,* (2021).

In term of economics, lowest gross return (₹27980 ha^{-1}), net return (₹10812 ha^{-1}) and B: C ratio (1.63) was recorded in weedy check, whereas highest gross return (₹55940 ha^{-1}) was recorded in hand weeding twice at 3 & 5 weeks after sowing (T_3), while maximum net return (₹30472 ha^{-1}) and B:C ratio (2.20) was recorded in IWM practices of application of atrazine @ 400gm a.i. ha^{-1} on 3 DAS *fb* one HW at 3-4 weeks after sowing (T_4) followed by hand weeding twice at 3 & 5 weeks after sowing (T_3). Realisation of maximum profit and benefit-cost ratio under IWM practices are possibly due to early and preventive weed control by pre-emergence herbicide application followed by hand weeding at critical growth period resulted in weed free condition during peak vegetative and reproductive phases of the crop thus leads to higher values of yield attributes *viz.* effective tillers $plant^{-1}$, grain yield and dry fodder yield and ultimately which reflected in profitability of irrigated pearl millet. Similar results was also reported by Kumar *et al.,* (2021).

From the field experiment result, it could be concluded that integrated weed management practices comprising of pre-emergence application of atrazine @ 400gm a.i ha^{-1} followed by one hand weeding at 3-4 weeks after sowing significantly registered higher weed control efficiency, better growth parameters, yield attributes, grain yield in pearl millet and thereby maximum net return and benefit: cost ratio.

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Table 1. Effect of herbicidal and integrated weed management practices on weed control, growth, yield and economics of irrigated pearl millet

Treatments	Weed intensity (Nos. m^{-2})		Weed dry weight (g m^{-2})		Weed control efficiency (%)		Plant height (cm)	Total tillers/plant (No.)	Effective tillers/plant (No.)	Test weight (g)	Grain yield (kg/ha)	Dry fodder yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
	30 DAS	at harvest	30DAS	at harvest	30 DAS	at harvest										
T_1	6.2 (39.0)	9.1 (83.7)	7.96	21.67	-	-	106.7	2.3	1.6	12.1	1399	1805	17168	27980	10812	1.63
T_2	-	-	-	-	100.0	100.0	153.3	5.6	4.3	13.3	2828	3959	29768	56560	26792	1.90
T_3	2.5 (6.0)	3.9 (14.9)	1.39	3.46	82.5	84.0	150.0	5.6	4.3	13.3	2797	3804	27968	55940	27972	2.00
T_4	4.1 (16.7)	4.2 (17.3)	2.84	4.10	64.3	81.1	147.7	5.3	4.0	13.3	2793	3771	25388	55860	30472	2.20
T_5	3.6 (13.0)	6.1 (37.7)	2.22	9.23	72.0	57.3	131.3	4.3	3.0	13.1	2347	3028	23710	46940	23230	1.98
T_6	3.5 (12.3)	5.8 (33.6)	2.07	8.09	73.9	62.5	129.0	4.3	2.9	13.0	2321	2971	24178	46427	22249	1.92
T_7	3.5 (12.0)	5.5 (30.0)	1.93	7.29	75.8	66.3	127.7	4.0	2.6	12.9	2287	2859	24588	45740	21152	1.86
T_8	3.2 (10.3)	5.2 (26.9)	1.76	6.36	77.8	70.6	125.6	3.9	2.3	12.9	2278	2779	25038	45560	20522	1.82
SEd.	0.1	0.2	1.6	4.7	1.0	1.5	7.4	0.3	0.3	0.2	131	203	-	2266	2266	0.09
CD (p=0.05)	0.3	0.3	3.5	10.1	2.2	3.3	15.8	0.7	0.7	NS	281	436	-	4860	4860	0.19

* - Figures in parenthesis are original values subjected to $\sqrt{(x+0.05)}$ transformation

T2-30
Bi Decadal expansion of coconut area in Tamil Nadu – perceptible shift or obscure drift in Millets perspective

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Abstract

Millets are resilient crops that can handle biotic and abiotic stresses with relative ease compared to other commercial crops of Tamil Nadu. Millet production in the state is undergoing a roller coaster ride because of plethora of causes like low marginal returns and reduced plate share because of life style changes. Bidecadal scrutiny of data through Compound Annual Growth Rate (CAGR) analysis indicates that millet area in the state is largely replaced by coconut, the cause mainly attributed to labour scarcity and complacent returns from the latter. In Food Security perspective, the unhalting expansion of coconut in the place of food crops is not appreciable but obscure.

Keywords: Coconut, Decade, Millets, Compound Annual Growth Rate (CAGR)

Introduction

Millets, eulogized as ‘Coarse cereals’ or ‘Cereals of the Poor’ were the major crops consumed in India about five decades ago. The plate share of millets and concomitantly its field share have declined recently in favour of rice, wheat and other commercial crops. In India, coconut is proclaimed as a crop of small and marginal farmers as 98 % of the coconut plantations vests with holdings < 1.0 ha. Millets are resilient crops that can handle critical challenges such as food, fuel, malnutrition, health and climate change with less water and carbon foot prints. There are nine types of millets grown in India with the major millets sorghum, pearl millet, and finger millet occupying 95% of the total millet growing area in India and the rest 5% are little millet, foxtail millet, barnyard millet, proso millet, kodo millet, and browntop millet. Coconut is annexing its territories by engulfing the area under food crops in the state of Tamil Nadu. In the International Year of Millets (2023), it is imperative to perform a trend analysis of millet area in the state and the extent to which it is replaced by coconut so as to formulate strategies for expanding its acreage

Materials and Methods

Area under millets like sorghum, ragi and cumbu were compared with the area under coconut for the period 2000-2020 by collecting information from www.indiastat.com and Salient Statistics on Agriculture, 2020, Government of Tamil Nadu. Employing time series of data set of millets and linear functions, exponential CAGR was estimated. The semi-log functional form Log Qt = a + bt was used to estimate the growth rate, wherein Qt – Area, Production and productivity of millets, a – constant, t – time variable in year, b-Regression coefficient that shows the rate of change or growth rate in a series (Surendar and Satinder, 2014). Annual growth rate was determined based on the incremental values over the preceding years.

Results and Discussion

At national level, CAGR in area of coconut during 2000 – 2021 was +0.5 % whilst the production showed a depression by 1.1 % and productivity by 1.7 % **(Fig. 1)**. In the same period, the CAGR in area of millets was -1.48 %, production was -0.127 % and the productivity was +1.55 %. For the state of Tamil Nadu, area, production and productivity of millets and coconut for the period 2000 – 2020 is furnished in **Table 1.** The CAGR of millets was negative in terms of area, production and productivity whilst that of coconut was positive for the above parameters. During the past two decades, except maize, the area under major food crops of the state *viz.,* paddy registered a negative growth rate of -12.12%, pearl millet -51.2%, finger millet – 31.35 %, sugarcane –45.71%, sesame – 60.19% and groundnut – 53.22% (Statista.com.2020). The main reason attributed to the decline in millets area in the state is due to the promotion of rice after green revolution period and low margins associated with millet production together with highly volatile international prices. Relatively shorter shelf life of the crops, change in lifestyle pattern and consumer preferences have also added for lower demand. Affluent water facilities, acute labour scarcity, scope for mechanization for operations from irrigation to harvest, favourable agroclimate and complacent returns compared to other field crops are the key players behind expanding area of coconut in the state. Coconut has engulfed more area of millets and thus the non halting expansion of this horticultural crop is a matter of concern not only for millets but also for the major food crops of the state

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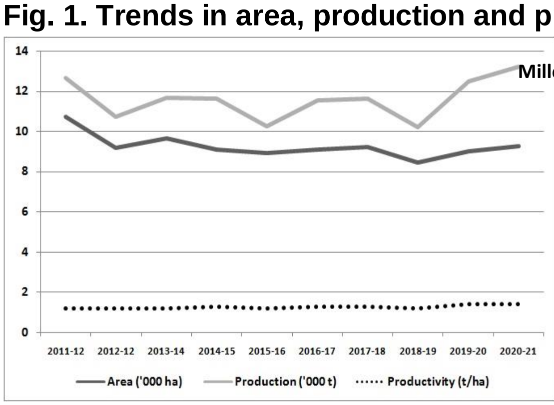
Fig. 1. Trends in area, production and productivity of millets and coconut (2011-2021)



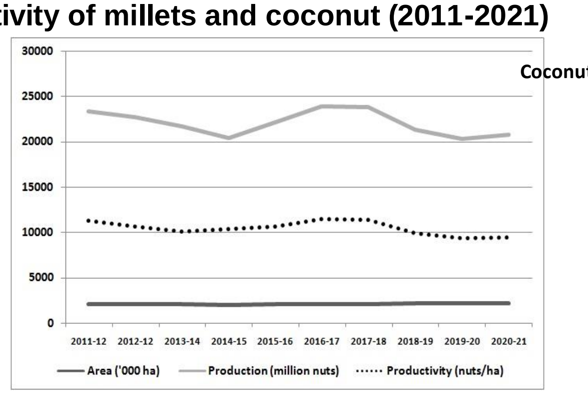


Table 1. Area, production and productivity of millets and coconut in Tamil Nadu

Year	Millets			Coconut		
	Area (L.ha)	**Production (L.tonnes)**	**Productivity (kg /ha)**	**Area (L.ha)**	**Production (L.nuts)**	**Productivity (nuts/ha)**
2000-01	6.51	7.98	1.22	3.23	31920	9868
2005-06	5.38 (-0.174)	4.88 (-0.388)	0.91 (-0.259)	3.70 (+0.146)	48671 (+0.525)	13136 (+0.331)
2010-11	4.01 (-0.255)	5.29 (+0.083)	1.32 (+0.454)	4.10 (+0.108)	58942 (+0.211)	14371 (0.094)
2011-12	3.57 (-0.108)	6.28 (+0.188)	1.76 (+0.332)	4.19 (+0.022)	62009 (+0.052)	14785 (+0.029)
2012-13	3.51 (-0.019)	3.96 (-0.370)	1.13 (-0.537)	4.24 (+0.012)	50747 (-0.182)	11965 (-0.191)
2013-14	5.53 (+0.576)	10.28 (+1.596)	1.86 (+0.647)	4.28 (+0.009)	46680 (-0.080)	10893 (-0.090)
2014-15	6.05 (+0.095)	14.31 (+0.392)	2.37 (+0.272)	4.27 (-0.002)	49890 (+0.069)	11661 (+0.071)
2015-16	5.12 (-0.153)	8.93 (-0.376)	1.74 (-0.263)	4.35 (+0.019)	59626 (+0.195)	13711 (+0.176)
2016-17	4.03 (-0.213)	3.92 (-0.561)	0.97 (-0.443)	4.35 (0)	47064 (-0.211)	10803 (-0.212)
2017-18	3.86 (-0.042)	4.31 (+0.100)	1.12 (+0.149)	4.36 (+0.002)	41765 (-0.113)	9579 (-0.113)
2018-19	3.86 (0.000)	4.64 (+0.077)	1.20 (+0.077)	4.39 (+0.007)	40929 (-0.020)	9307 (-0.028)
2019-20	4.50 (+0.166)	5.20 (+0.121)	1.16 (-0.039)	4.39 (0)	49474 (+0.209)	11271 (+0.211)
2020-21	4.05 (-0.100)	4.27 (-0.179)	1.05 (-0.088)	4.44 (+0.011)	51282 (+0.037)	11528 (+0.023)
2021-22	3.97 (-0.174)	4.27 (0.000)	1.08 (+0.020)	Data not available		
CAGR (%)	**-3.4750**	**-4.3675**	**-0.92461**	**+ 2.4776**	**+3.71429**	**+1.20319**

(Figures in parentheses represents Annual Growth Rate)

Source : Salient Statistics on Agriculture, 2020

T2-31
Farmer participatory validation of TNAU organic package of practices in finger millet

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Abstract

Field experiments were conducted with finger millet variety ATL 1 at Coimbatore, Athiyandal and Paiyur. The results revealed that plant height at harvest (99.3 cm), number of productive tillers per hill (5.8), earhead weight (8.2 g), earhead length (9.2 cm) and number of fingers per earhead (7.1) were recorded to be the maximum in TNAU organic package of practices applied plots followed Farmers' practices applied plots. Plots treated with FYM @ 3t/ha + Vermicompost @1.5 t/ha + 3% Panchagavya + Azophos @ 2kg/ha registered the maximum grain and straw yield of 2722 kg/ha and 4395 kg/ha respectively. It was followed by plots treated with Farmers' practices with grain and straw yield of 2100 kg/ha and 3240 kg/ha respectively. The highest gross return (Rs. 115260/ha), net return (Rs. 50815/ha) and B: C ratio (1.79) were recorded in TNAU organic package of practices applied plots as it produced higher grain and straw yield. It was followed by Farmers practices applied plots with gross return,net return and B: C ratio of Rs.88470/ha, Rs.36470/ha and 1.70, respectively.

Keywords: Finger millet, Organic production, Validation, Farmer's participatory approach

Introduction

India is the largest producer of various kinds of millets. Out of the total minor millets produced, finger millet (*Eleusine coracana* L. Gaertn.) accounts for about 85% of production in India (Divya, 2011). Finger millet is grown in India, Srilanka, Nepal, parts of Africa, Madgaskar, Malaysia, Uganda and Japan. In India, finger millet is cultivated over an area of 1.19 million hectares with a production of 1.98 million tonnes giving an average productivity of 1661 kg per ha. Karnataka accounts for 56.21 and 59.52% of area and production of finger millet followed by Tamil Nadu (9.94% and 18.27%), Uttarakhand (9.40% and 7.76%) and Maharashtra (10.56% and 7.16%), respectively. Finger millet has manifold nutritional benefits; it has thirty times more calcium than rice. Finger millet straw is an extensive feed in the livestock sector (Millet Network of India-Deccan Development Society-FIAN, 2009).

Materials and Methods

Field experiments were conducted with finger millet variety ATL 1 at Senguttai, Tholampalayam, Coimbatore, Athiyandal and Paiyur. The experiment was laid out as non-replicated trial with treatment plot size of 25 cents. Direct sowing of was done with the recommended spacing of 30 x 10cm.

Treatments details

T_1	TNAU organic package of practices (FYM @ 3t/ha, Vermicompost @1.5 t/ha at 0 & 30 DAS + 3% Panchagavya at 30 & 45 DAS + Azophos @ 2kg/ha)
T_2	Farmers' practices (Goat penning)
T_3	Control

Results and Discussion

Growth and yield parameters: The highest plant height (99.3 cm) at harvest was recorded in TNAU organic package of practices applied plots followed Farmers' practices applied plots (91.1 cm). The number of productive tillers per hill was more (5.8) in TNAU organic package of practices applied plots followed by Farmers' practices applied plots (5.3). The lowest productive tillers per hill (3.5) were observed in control plots. Plots that received TNAU organic package of practices (FYM @ 3t/ha + Vermicompost @1.5 t/ha + 3% Panchagavya + Azophos @ 2kg/ha) showed the highest earhead weight (8.2 g) followed by Farmers' practices applied plots (7.1 g). Similar trend was followed for earhead length and number of fingers per earhead with TNAU organic package of practices applied plots registering highest earhead length (9.2 cm) and number of fingers per earhead (7.1) (Table 1).

Yield and economics: The plots that treated with FYM @ 3t/ha + Vermicompost @1.5 t/ha + 3% Panchagavya + Azophos @ 2kg/ha registered the maximum grain and straw yield of 2722 kg/ha and 4395 kg/ha respectively. It was followed by plots treated with Farmers' practices with grain and straw yield of 2100 kg/ha and 3240 kg/ha respectively. The lowest grain and straw yield was noted in control plots.

Cost of cultivation incurred per hectare was highest (Rs. 64445/ha) in TNAU organic package of practices applied plots followed by Farmers practices (Rs. 52000/ha) applied plots. The highest gross return (Rs. 115260/ha), net return (Rs. 50815/ha) and B: C ratio (1.79) were recorded in TNAU organic package of practices applied plots as it produced higher grain and straw yield. It was followed by Farmers practices applied plots with gross return,net return and B: C ratio of Rs.88470/ha, Rs.36470/ha and 1.70, respectively (Table 2).

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Table 1.Effect of treatments on growth and yield characters of finger millet*

Treat-ments	Plant height at harvest (cm)	Productive tillers / hill (Nos.)	Earhead weight (g)	Earhead length (cm)	No. of fingers/ earhead	Grain yield (Kg/ha)	Straw yield (Kg/ha)
T_1	99.3	5.8	8.2	9.2	7.1	2722	4395
T_2	91.1	5.3	7.1	8.5	6.7	2100	3240
T_3	83.5	3.5	5.9	7.9	6.2	1282	2109

*Pooled mean of three locations

Table 2. Effect of treatments on yield and economics of finger millet*

Treat-ments	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
T_1	64445	115260	50815	1.79
T_2	52000	88470	36470	1.70
T_3	46500	44787	-1713	0.96

*Pooled mean of three locations

T2-32
Evaluation of organic, inorganic and integrated production systems in Pearl Millet

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Abstract

Pearl millet, which accounts for about two thirds of millet production in India, is grown in the drier areas of the country. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat, and maize. It occupies an area of 6.93 million ha with an average production of 8.61 million tons and productivity of 1,243 $kgha^{-1}$ (Directorate of Millets Development, 2020). Nutrient management in organic millet farms should economically meet crop nutrient needs and avoid nutrient depletion, while maintaining or improving soil productivity without excessive nutrient losses.Field experiment was carried out to evaluate organic, inorganic and integrated production systems in pearl millet in Eastern block farm, TNAU, Coimbatore. The results revealed that plant height at harvest (210.5 cm), number of productive tillers per hill (6.5), earhead weight (53.9 g), earhead length (35.9 cm) and earhead girth (32.6 mm) were recorded to be maximum in plots treated with state recommended management practices, followed by 50% organic (50 % FYM + 50 % vermicompost) + 50 % inorganic fertilizers applied plots. Plots maintained under state recommended management practices registered the maximum grain and straw yield of 2382 and 6734 kg/ha, respectively, followed by plots maintained under 50% organic (50 % FYM + 50 % vermicompost) + 50 % inorganic management practices (2102 and 6445 kg/ha, respectively). Supply of 100 % nutrients through organic manures fetched the highest net return of Rs. 24876/ha followed by supply of 50 % nutrients through organic manures + beejamrith, ghanajeevamrith and jeevamrith applied management practices (MP_1-II) (Rs. 22,926/ha). Benefit cost ratio was maximum (1.47) in 50 % of nutrient source as organic manures + beejamrith, ghanajeevamrith, jeevamrith applied plots followed by 100 % nutrients through organic manures applied plots (1.46).

Keywords: *Pearl millet, organic, inorganic and integrated production systems*

Introduction

Pearl millet, *Pennisetum glaucum* L.R.Br. is cultivated in dry regions of arid and semi-arid tropics. India is the largest producer of millets in the world, harvesting about 11 million tons per year, nearly 36% of the world's output. Pearl millet, which accounts for about two thirds of millet production in India, is grown in the drier areas of the country, mainly in the states of Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, and Haryana. In India, pearl millet is the fourth most widely cultivated food crop after rice, wheat, and maize. It occupies an area of 6.93 million ha with an average production of 8.61 million tons and productivity of 1,243 $kgha^{-1}$ (Directorate of Millets Development, 2020).

Materials and Methods

Field experiment was carried out to evaluate organic, inorganic and integrated production systems in pearl milletin Eastern block farm, TNAU, Coimbatore. The experiment was laid out as non-replicated trial with treatment plot size of 50 m^2. Direct sowing of pearl millet variety CO (Cu) 10 was done with the recommended spacing of 45 x 15cm with six treatments.

Treatments details

- MP_1-I 100% organic (organic manures equivalent to 100% N requirement of the system) (50 % FYM + 50 % vermicompost)
- MP_1-II Supply of 50% nutrients through organic sources + Seed treatment with Beejamrit + application of Ghanajeevamrith @ 250 kg/ha, Jeevamrit @ 500 litres/ha / time twice a month with irrigation water and complete organic management as per NPOF
- MP_2-I 100% inorganic (No organic manures; RDF alone)
- MP_2-II State recommendation (FYM @ 12.5 t/ha + Azophos @ 2 kg/ha + RDF)
- MP_3-I 50% organic (50 % FYM + 50 % vermicompost) + 50% inorganic
- MP_3-II 25% nutrients through organic sources + 25% nutrients through inorganic sources + Seed/Seedling treatment with Beejamrit + application of Ghanjeevamrit @ 250 kg/ha, Jeevamrit @ 500 litres/ha/time twice a month with irrigation water

*MP - Management Practice

Results and Discussion

Growth parameters: Plant height at harvest (210.5 cm), number of productive tillers per hill (6.5), earhead weight (53.9 g), earhead length (35.9 cm) and earhead girth (32.6 mm) were recorded to be maximum in plots treated with state recommended management practices, followed by 50% organic (50 % FYM + 50 % vermicompost) + 50 % inorganic fertilizers applied plots (Table 1).

Yield and Economics:Plots maintained under state recommended management practices registered the maximum grain and straw yield of 2382 and 6734 kg/ha, respectively, followed by plots maintained under 50% organic (50 % FYM + 50 % vermicompost) + 50 % inorganic management practices (2102 and 6445kg/ha, respectively). Supply of 100 % nutrients through organic manures fetched the highest net return of Rs. 24876/ha followed by supply of 50 % nutrients through organic manures + beejamrith, ghanajeevamrith and jeevamrith applied management practices (MP_1-II) (Rs. 22,926/ha). Benefit cost ratio was maximum (1.47) in 50 % of nutrient source as organic manures + beejamrith, ghanajeevamrith, jeevamrith applied plots followed by 100 % nutrients through organic manures applied plots (1.46) (Table 2). Similar results were reported in tomato and brinjal (Manickam *et al.,* 2021).

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Table 1. Effect of treatments on growth and yield characters of pearl millet

Treatment	Plant height at harvest (cm)	No. of productive tillers / hill	Earhead weight (g)	Earhead length (cm)	Earhead girth (mm)
MP1-I	200.2	5.7	48.9	31.6	29.1
MP1-II	195.7	5.4	41.1	29.1	27.0
MP2 -I	198.5	5.6	47.3	31.1	28.8
MP2- II	210.5	6.5	53.9	35.9	32.6
MP3- I	203.6	6.1	51.3	33.3	31.8
MP3- II	196.4	5.6	43.3	30.7	27.0

Table 2. Effect of treatments on yield and economics of pearl millet

Treatments	Grain Yield (kg/ha)	Straw Yield (Kg/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
MP1-I	2030	6169	54531	79407	24876	1.46
MP1-II	1870	5116	48522	71448	22926	1.47
MP2-I	1985	5938	46026	65454	19428	1.42
MP2-II	2382	6734	59626	77370	17744	1.30
MP3-I	2102	6445	48597	69783	21186	1.44
MP3-II	1910	5540	45540	62460	16920	1.37

T2-32A

Studies on organic production practices for the management of fall armyworm, *Spodoptera frugiperda* (JE Smith) (Noctuidae: Lepidoptera) infesting maize

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Abstract

Maize (*Zea mays* L.) is one of the most important cereal crops being cultivated in an area of 180.63 m ha in 165 countries across the world with a production of 1134 million tonnes. Fall armyworm, *Spodoptera frugiperda* (J E Smith) is emerging as the most destructive pest of maize in India since its report during May 2018. Field experiments were conducted to evaluate organic management practices for the management of fall armyworm infesting maize in the Eastern Block, Tamil Nadu Agricultural University, Coimbatore from May, 2021 to August, 2021 with ten treatments replicated thrice with COHM 6 maize hybrid. Silicon powder was applied thrice at 20, 40 and 60 days after sowing (DAS) and silicon granules were applied in the leaf whorl thrice at knee high, tasseling and milking stage. Intensity of damage caused by fall armyworm was assessed using 1-5 scale developed by the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore. Pre-treatment damage intensity assessment at 15 DAS revealed that the damage was in the range of 3.7 to 4.1 scale in different treatments and was statistically non-significant. At 20 DAS, the damage was recorded to be in the range of 3.2 to 4.5 scale, with the lowest damage scale of 3.2 in the plots treated with foliar application of 5% neem leaf extract @ 15 DAS + use of pheromone traps + application of silicon powder @ 25 kg/ha + application of silicon granules @ 125 kg/ha (T_{10}), as against 4.5 in absolute control (T_1). At 40 DAS, the damage were recorded to be in the range of 2.1 to 4.4 scale, with the lowest damage of 2.1 scale in T_{10}, as against 4.4 scale in T_1. At 60 DAS, the damage were recorded to be in the range of 1.3 to 3.4 scale, with the lowest damage of 1.3 scale in T_{10}, as against 3.4 scale in T_1. Similar trend was observed at 80 DAS with the damage ranging from 1.0 to 2.1 scale. Plant height at harvest was recorded to be the maximum of 219.1 cm in T_{10} as against 165.8 cm in T_1. Maximum number of 15.7 leaves per plant was recorded in T_{10} as against 13.1 leaves per plant in T_1. Grain and straw yield were recorded to be the maximum in T_{10} (4905 and 6676 kg/ha, respectively) with the B:C ratio of 1.81 as against the lowest grain and straw yield of 3,653 and 4,694 kg/ha, respectively with the B:C ratio of 1.45.

Key words: *Maize, fall armyworm, organic management, silicon, damage assessment*

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops being cultivated in an area of 180.63 m ha in 165 countries across the world with a production of 1134 million tonnes (APEDA, 2019). Fall armyworm, *Spodoptera frugiperda* (J E Smith) is emerging as the most destructive pest of maize in India since its report during May 2018. Its rapid spread to more than 90 per cent of maize growing areas of diverse agro-ecologies of India within a span of 16 months presents a major challenge to smallholder maize farmers, maize-based industries as well as food and nutritional security (Suby *et al*., 2020). Fall armyworm is predicted to cause 21 to 53 per cent loss in annual maize production in the absence of control measures (Day *et al*., 2017). In agricultural systems, silicon is applied as a crop protection treatment and maize is one of the major crops that respond to silicon application (Liang *et al*., 2015). Hence, present study was undertaken to test the efficacy of silicon in the management of fall armyworm under organic maize production system.

Materials and Methods

Field experiment was conducted to evaluate organic management practices for the management of fall armyworm infesting maize with ten treatments replicated thrice with COHM 6 maize hybrid. Silicon powder was applied thrice at 20, 40 and 60 days after sowing (DAS) and silicon granules were applied in the leaf whorl thrice at knee high, tasseling and milking stage. Intensity of damage caused by fall armyworm was assessed using 1-5 scale developed by the Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore.

Results and Discussion

Pre-treatment damage intensity assessment at 15 DAS revealed that the damage was in the range of 3.7 to 4.1 scale in different treatments and was statistically non-significant. At 20 DAS, the damage was recorded to be in the range of 3.2 to 4.5 scale, with the lowest damage scale of 3.2 in the plots treated with foliar application of 5% neem leaf extract @ 15 DAS + use of pheromone traps + application of silicon powder @ 25 kg/ha + application of silicon granules @ 125 kg/ha (T_{10}), as against 4.5 in absolute control (T_1). At 40 DAS, the damage was recorded to be in the range of 2.1 to 4.4 scale, with the lowest damage of 2.1 scale in T_{10}, as against 4.4 in T_1. At 60 DAS, the damage was recorded to be in the range of 1.3 to 3.4 scale, with the lowest damage of 1.3 in T_{10}, as against 3.4 scale in T_1. Similar trend was observed at 80 DAS with the damage ranging from 1.0 to 2.1 scale. The results are in agreement with the findings of Ye *et al*. (2013) who have reported that silicon was able to prime jasmonate-mediated defense responses and rice defense against the rice leaf folder, *Cnaphalocrocis medinalis*.

Plant height at harvest was recorded to be the maximum of 219.1 cm in T_{10} as against 165.8 cm in T_1. Maximum number of 15.7 leaves per plant was recorded in T_{10} as against 13.1 leaves per plant in T_1. Grain and straw yield were recorded to be the maximum in T_{10} (4905 and 6676 kg/ha, respectively) with the B: C ratio of 1.81 as against the lowest grain and straw yield of 3,653 and 4,694 kg/ha, respectively with the B: C ratio of 1.45.

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Table 1. Evaluation of organic practices in the management of fall army worm in maize

Treat-ments	Damage caused by fall armyworm (1-5 scale)					Plant height (cm)	Number of leaves / plant	Grain yield (Kg/ha)	Straw yield (Kg/ha)	B:C ratio
	PTC	20 DAS	40 DAS	60 DAS	80 DAS					
T_1	4.0	4.5^{e}	4.4^{e}	3.4^{g}	2.1^{d}	165.8^{i}	13.1^{d}	3653^{i}	4694^{g}	1.45
T_2	4.1	4.2^{de}	4.0^{de}	3.4^{fg}	1.9^{cd}	189.9^{h}	13.8^{bcd}	3799^{h}	4974^{fg}	1.49
T_3	4.1	4.0^{cd}	3.8^{de}	3.3^{fg}	1.7^{bcd}	192.8^{g}	13.7^{cd}	4027^{g}	5068^{efg}	1.56
T_4	3.9	3.9^{cd}	3.8^{de}	3.1^{efg}	1.6^{bcd}	198.4^{e}	14.4^{abcd}	4103^{e}	5377^{def}	1.59
T_5	3.9	3.9^{cd}	3.6^{cde}	2.8^{def}	1.6^{bc}	196.6^{f}	14.6^{abcd}	4065^{f}	5439^{de}	1.53
T_6	3.7	3.8^{bcd}	3.5^{cd}	2.7^{de}	1.5^{bc}	198.7^{e}	14.6^{abcd}	4122^{e}	5496^{cd}	1.54
T_7	3.9	3.6^{abc}	3.2^{bcd}	2.4^{cd}	1.4^{abc}	209.4^{d}	14.9^{abcd}	4534^{d}	5909^{bc}	1.69
T_8	3.8	3.6^{abc}	2.8^{abc}	1.9^{bc}	1.4^{abc}	212.5^{c}	15.0^{abc}	4699^{c}	6073^{b}	1.73
T_9	3.8	3.4^{ab}	2.4^{ab}	1.6^{ab}	1.2^{ab}	218.3^{b}	15.2^{ab}	4864^{b}	6238^{b}	1.80
T_{10}	4.0	3.2^{a}	2.1^{a}	1.3a	1.0^{a}	219.1^{a}	15.7^{a}	4905^{a}	6679^{a}	1.81
S. Ed	**0.18**	**0.22**	**0.43**	**0.28**	**0.22**	**0.16**	**0.71**	**12.34**	**197.81**	**-**
CD (P=0.05)	**NS**	**0.46**	**0.91**	**0.59**	**0.47**	**0.34**	**1.50**	**25.92**	**415.59**	**-**

PTC - Pre-treatment count; DAS - Days after sowing

In a column, means followed by common letter(s) are not significantly different by LSD

T2-33

Evaluation of Hybrid castor-based millet intercropping system in Kalrayan hills of Salem District, Tamil Nadu

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Abstract

The Kalrayan hills measure 16 miles from North to south and 23 miles from East to west. Totally it extends over an area of 854.63 sq. km. The major crops grown in this area are cereals and millets (paddy, samai, tenai and varagu, horse gram) and cassava. In this area, samai being raised in 700 ha in Kalrayan hills alone. Improved varieties are not grown because of costly inputs involved and lack of proper management facilities. The tribal villages in these blocks were suffering from number of socio-economic constraints which affects productivity of crops. Depletion of natural resources coupled with degradation of land and water resources, lack of scientific approach to farming, growing low value high volume crops, post-harvest losses and resource poor farmers are posing serious threats to food, socio-economic livelihood and sustenance of the tribal farmers. The tribal farmers of the above mentioned blocks are growing wide variety of food crops among them minor millets occupy the major item, but the poor market prices coupled with low productivity incurs low income generation. In this situation, introduction of castor hybrid as an intercrop in samai in hilly areas can be recommended as a new intercropping system under rainfed condition. In this context, to evaluate hybrid castor YRCH 1 for castor + minor millet intercropping system under rainfed condition, field experiment was conducted in farmers field at Navampattu village of Kalrayan hills, during 2016 with two factors *viz*., Intercropping ratio and Nutrient management under split plot design. Among the treatments, higher net return of Rs. 27180/ha and BC ratio of 2.56 was recorded at intercropping of castor + samai (1:10) ratio along with 50% organic and 50% inorganic nutrient management practices when compare to other intercropping ratio and 100% organic nutrient management practice.

Key words: Hybrid Castor based millet intercropping, Samai equivalent yield, Net revenue, BCR, Kalrayan hills, Tamil Nadu.

Introduction

Castor is a valuable non-edible oilseed crop playing an important role in agricultural economy of arid and semi-arid regions. Castor is grown both as a sole crop and as a mixed crop/inter crop (Liv S Severino *et al*., 2012). Under irrigated high input management, sole cropping of castor is profitable. Castor is ideally suited for intercropping systems. In traditional areas, castor will form the base crop, while in non-traditional areas, castor will form a component crop with major crops of the region (Raghavaiah and Suresh, 2010). In Tamil Nadu, castor is grown mixed with groundnut and cotton.In hilly areas agriculture is mainly depends on seasonal rainfall. In recent years failure of monsoon, uneven distribution and amount of rainfall received is lower than the normal. Non adoption of improved cultivation methods and application of unbalanced fertilizers leads to micro nutrient deficiency ultimately resulted in poor crop yields.

The Kalrayan hills measure 16 miles from North to south and 23 miles from East to west. Totally it extends over an area of 854.63 sq. km. The major crops grown in this area are cereals and millets (paddy, samai, tenai and varagu, horse gram) and cassava.In this area, samai being raised in 700 ha in Kalrayan hills alone.

The farmers are raising only local strains under rainfed conditions. Improved varieties are not grown because of costly inputs involved and lack of proper management facilities. The tribal villages in these blocks were suffering from number of socio-economic constraints which affects productivity of crops. Depletion of natural resources coupled with degradation of land and water resources, lack of scientific approach to farming, growing low value high volume crops, post-harvest losses and resource poor farmers are posing serious threats to food, socio-economic livelihood and sustenance of the tribal farmers.

In this situation, introduction of castor hybrid as an intercrop in samai in hilly areas has been evaluated as a new intercropping system under rainfed condition due its good market value, drought tolerance and performs well in nutrient deficient soils and along with their native millets samai with improved varieties and technologies.

Materials and Methods

Field experiment was conducted byTCRS, Yethapur in the farmers field at Navampattu village of Kalrayan hills, Pethanaickanpalayam block, Salem district during September, 2016, with hybrid castor YRCH 1 and Samai Co 4 as per the following technical programme.

Treatment details

Factor A: Intercropping ratio

1. Castor + Samai (1:5)
2. Castor + Samai (1:10)
3. Castor + Samai (1:15)
4. Samai

Factor B: Nutrient management

1. 100 % Organic
2. 50 % Organic + 50 % Inorganic

Design :Split plot Design Replication :Four

Initial soil sample was collected and analysed for their physico-chemical properties and it was neutral (6.62) in reaction, non-saline (0.17), low in organic carbon (0.46%) and available nitrogen (246 kg ha^{-1}), high in available phosphorus (30 kg ha^{-1}) and potassium (334kg ha^{-1}).

A total of 116 mm, 80 mm and 280.9 mm rainfall received with 8 rainy days during the crop growth period at Kalrayan hills. At the time of sowing soil moisture content was 24.2%, at Kalrayan hills. Seed yield and economics *viz.,* net return and BCR were worked out.

Results and Discussion

In kalrayan hills, among the intercropping ratio, higher samai equivalent yield (1466 kg/ha) was recorded in intercropping of castor + samai (1:10) followed by intercropping of castor + samai (1:5) (1436 kg/ha). Among nutrient management practices, application of 50% organic and 50% inorganic recorded higher samai equivalent yield (863 kg/ha) over 100% organic nutrient management practices (828 kg/ha) (Table 1).

The reduction in seed yield of castor, in the intercropping system was mainly due to reduction in plant stand of castor in different intercropping treatment replacement type of intercropping system was followed in the present study. Minimum magnitude of reduction in seed yield of castor was observed with greengram because greengram seems to be less harmful for castor might be due to its short life span and also their growth peaks are never coincide with each other which reduced demand pressure and environmental resources are efficiently utilized by both the crops. These results are in conformity with the earlier findings of Sharma and Singh (2014) and Mohammed Mohsin *et al (*2020).

Among the treatments, higher net return of Rs. 27180/ha and BC ratio of 2.56was recorded at intercropping of castor + samai (1:10) ratioalong with 50% organic and 50% inorganic nutrient management practices when compare to other intercropping ratio and 100% organic nutrient management practice. In addition, intercropping of castor + samai (1:10) with 100% organic nutrient management practices recorded higher soil organic carbon content which was on par with 50% organic + 50% inorganic nutrient management practices (Table 2).

Based on the results it can be concluded that,

- Adoption of intercropping of castor + samai (1:10) ratio recorded higher samai equivalent yield of 1466 kg/ha under rainfed condition compare to other intercropping ratio.
- Higher net return of Rs. 27180/ha and higher BC ratio of 2.56 was recorded at intercropping of castor + samai (1:10) ratio along with 50% organic and 50% inorganic nutrient management practices when compare to other intercropping ratio and 100% organic nutrient management practice.

Hence, adoption of intercropping of castor + samai (1:10) with 50% organic + 50% inorganic nutrient management practice is the efficient resource management system for improving the productivity of castor and samai in hilly areas.The income from castor will improve their social status and samai will be the support for their stable food demand and overall economic status was improved.

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Table 1. Seed yield of Castor and Samai as influenced by different intercropping ratio and nutrient management practices

	Castor yield	Samai Yield	Samai Equivalent Yield
Main plot (M): Intercropping ratio			
M1: Castor+Samai (1:5)	1044	183	1436
M2: Castor+Samai (1:10)	947	330	1466
M3: Castor+Samai (1:15)	734	355	1236
M4: Samai	-	426	426
SEd	**-**	**7**	**-**
CD (P=0.05%)	**-**	14	**-**
Sub plot (S): Nutrient Management			
S1: 100% organic	449	289	828
S2: 50% organic + 50% inorganic	470	299	863
SEd	**-**	3	**-**
CD (P=0.05%)	**-**	6	**-**
Interaction (M x S)			
SEd	-	26	-
CD (P=0.05%)	-	NS	-

Table 2. Influence of castor and samai intercropping ratio and nutrient management practices on economics

Treatments	TCRS, Yethapur	
	Net returns (Rs./ha)	BCR
M1S1	16518	1.63
M1S2	24600	2.31
M2S1	18474	1.74
M2S2	27180	2.56
M3S1	12234	1.50
M3S2	20478	2.21
M4S1	1480	1.13
M4S2	3780	1.41

T2-34

Investigating the interaction effect of tillage system and different organic sources on growth, SPAD value and yield parameters of little millet

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Abstract

Millets, one of the important ancient food crops recognized as super cereals due to its climate resilience, superior nutritional profile and ability to support sustainable diet. The study reports the interactive effect of tillage systems and nutrient management practices on growth and yield parameters of little millet. An experiment was conducted in the research farm of Tamil Nadu Agricultural University, Coimbatoreduring2022. For conducting an experiment, strip plot design was laid out with tillage as the main plot and nutrient management practices as sub plot with 3 replications. The results showed that conventional tillage (Disc plough + Cultivator + Rotovator) with application of enriched vermicompost @ 1 t ha^{-1} followed by foliar spray of 3% *panchagavya* on 30th DAS and 5% of egg amino acid on 45th DAS had greater effect on growth parameters, SPAD value and yield parameters of little millet as compared to the other treatments. Similarly higher chlorophyll content was also noticed at earlier stage later decreased chlorophyll content at maturity stage.

Keywords: Tillage, organic sources, foliar spray, little millet

Materials and Methods

Site description: This study was performed during the year of 2022 at the experimental farm of Department of Agronomy, Tamil Nadu Agricultural University,oimbatore. The experimental site was located in the western zone of Tamil Nadu at longitutde of 76°97′E and latitude of 11°08′N with an elevation of 426 m above MSL. The soil of the experimental site was sandy clay loam in texture, slightly alkaline in nature.The experiment details consist oftwo factors *viz*., tillage and nutrient management practices.

Tillage practices (Vertical strips)

T_1- Conventional tillage (Disc plough + Cultivator + Rotovator)

T_2- Farmer's practice (Cultivator + Rotovator)

Nutrient management practices (Horizontal strips)

N_1 – FYM @ 12.5 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS + 3% vermiwash on 45th DAS ; N_2 – EFYM @ 1 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS +5% egg amino acid on 45th DAS ; N_3 –VC @ 2.5 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS + 3% vermiwash on 45th DAS ; N_4- EVC @ 1 t ha^{-1} + Foliar spray of 3% *panchagavya* on 30th DAS+ 5% egg amino acid on 45th DAS ; N_5 – GM @ 2.5 t ha^{-1} + Foliar spray of 3%

*panchagavya*on 30th DAS+ 5% vermiwash on 45th DAS ; N_6 – RDF of NPK fertilizers + Foliar spray of water on 30th & 45th DAS; N_7- Absolute control

* FYM- Farm yard manure; EFYM- Enriched farm yard manure; VC- Vermicompost; EVC- Enriched vermicompost; GM- Goat manure; RDF- Recommended dose of fertilizers;DAS- Days after sowing

Crop husbandry and field management: The field was well prepared as per the treatment schedule. The length and width of each plot was 7m x 5m whereaseach plot was separated by a buffer channel with the distance of 60 cm. Little millet (ATL 1) seeds were sown by line sowing method with inter-row distance of 25cm and intra row distance of 10cm respectively. Data on growth parameters and yield attributes of little millet were observed and statistically analysed.

Results and Discussion

The growth parameters viz., plant height, leaf area index, number of tillers and physiological character such as SPAD value of little millet were also significantly influenced by interaction effect of tillage and nutrient management practices. The result observed that application of enriched vermicompost @ 1 tha^{-1} followed by foliar application of *panchagavya* 3% on 30th DAS and 5% egg amino acid on 45th DAS increased in growth parameters and it remained on par with enriched farm yard manure @ 1 t ha^{-1} along with foliar spray of 3% *panchagavya* on 30th DAS and 5% egg amino acid on 45th DAS (N_7) was given in the table 1.These results are in accordance with the findings of Priyanka *et al*. (2019).The maximum chlorophyll content at early vegetative stage was observed in the treatment N_4 than harvest stage was expressed in the fig 1.Similarly, the highest yield attributing characters*viz*., productive tillers, panicle length and panicle weightwas observed under conventional tillage followed by farmer's practices [Fig 2. and Table 1]. It might be due to the interaction effect attributed greater availability of nutrients at the time of crop needs facilitating the translocation of photosynthates and better assimilation from source to sink,Naik *et al*.(2022) and Kumar *et al*.(2004).

From the result, it could be concluded that conventional tillage system with application of enriched vermicompost @1tha^{-1} followed by foliar spray of 3% *panchagavya* on 30th DAS and 5% egg amino acid on 45th DAS led to enhance the growth characters, SPAD value and yield attributes of little millet.

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Table 1. Effect of tillage and nutrient managementpractices on growth and yield parameters of little millet at maturity

Treatments	Plant height (cm)	Leaf area index	No. of tillers /plant	Panicle weight (g)
Tillage practices (Vertical strips)				
T_1	106.0	2.34	10.25	2.04
T_2	98.3	1.94	8.97	1.93
Sed	5.34	0.08	0.19	0.03
LSD(0.05)	11.58	0.18	0.42	0.06
Nutrient management practices (Horizontal strips)				
N_1	103.3	2.25	9.63	2.02
N_2	105.9	2.33	9.80	2.04
N_3	100.9	2.07	9.60	2.00
N_4	112.6	2.55	10.80	2.08
N_5	98.9	2.01	9.46	1.98
N_6	97.2	1.97	9.28	1.93
N_7	96.0	1.79	8.70	1.87
Sed	3.51	0.12	0.34	0.04
LSD(0.05)	7.62	0.26	0.74	0.09
Interaction effect				
T at N SEd	3.87	0.12	0.29	0.05
LSD (0.05)	8.40	NS	0.63	NS
N at T SEd	3.90	0.14	0.31	0.07
LSD (0.05)	8.46	NS	0.67	NS

Fig. 1. Effect of tillage and nutrient management practices on SPAD value of little millet

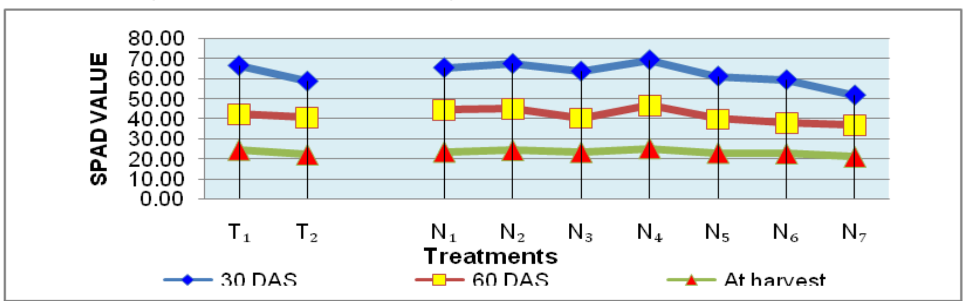
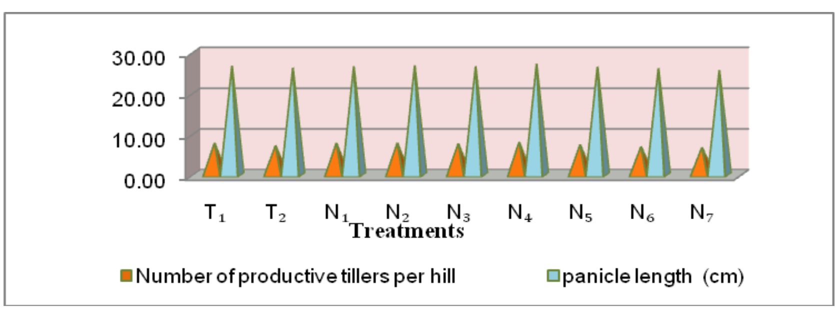


Fig. 2. Effect of tillage and nutrient management practices on yield parameters of little millet



T2-35
Assessment of multicut fodder sorghum varieties for rainfed condition in Vellore District

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Abstract

ICAR-KVK, Virinjipuram, Vellore district has conducted 10 on farm trials (OFT)on multicut fodder sorghum varieties during 2020-21 in three villages. The study revealed that the demonstrated technology recorded (CSV 33MF) a mean yield of 184.5 t/ha which was 29.1 % higher than farmers' practice multicut fodder variety CO (FS)- 29 (130.8 t/ha). The palatability was also significantly higher with CSV 33MF (91.8 %) as compared to CO (FS)- 29 (84.5 %) and similar trend was followed with respect to number of cuttings. Average extension gap, technology gap and technology index were found 53.7 t/ha, 40.5 t/ha and 18 % respectively. Higher net returns and Benefit: Cost ratio of Rs. 136020/ha and 4.56 was obtained with multicut fodder sorghum(CSV 33MF) in comparison to CO (FS)-29 (Rs.78084/ha and 3.03). Therefore, there is a need to disseminate the improved technologies among the farmers with effective extension methods like on and off campus trainings, OFT and demonstrations. The farmers should be encouraged to grow multicut fodder sorghum variety CSV 33MF under rainfed conditions to get higher green fodder yield and to realize higher returns.

Keywords: Multicut fodder sorghum, CSV 33MF, Green fodder yield

Introduction

Deficiency of feed and fodder accounts for half of the total loss in dairy farming therefore, forages are called as backbone of livestock industry. The scarcity of green forages and grazing resources in the country has made the livestock to suffer continuously with malnutrition resulting in their production potentiality at sub-optimum level as compared to many developed nations (Anonymous, 2012). Scarcity of feed and fodder is one of the major bottleneck which needs to be addressed urgently. Vellore district of Tamil Nadu has very limited number of fodder crops and farmers mainly depend on non-conventional and public grazing land. KVK Virinjipuram (Vellore district) has introduced multicut fodder sorghum in rainy season in the district purposefully to improve the fodder availability under organized dairy farming in Vellore district.

Materials and Methods

Multicut fodder sorghum varieties CO (FS)- 29, CSV 33MF and CO (FS) 31 was demonstrated during 2020-21 by ICAR- KVK, Virinjipuram in different locations of the Vellore district, Tamil Nadu. Ten on farm trials (OFT) were conducted in the selected villages of Vellore district. During meeting, receptive and innovative farmers were selected for technological intervention. Improved technologies released from TNAU, Coimbatore was adopted *viz.,* line sowing, integrated nutrient management and whole package was demonstrated. Economical assessment was done as per prevailing market prices. Cost of cultivation, Gross returns, net returns and B:C ratio were calculated. For the study, technology gap, extension gap and technology index were calculated as suggested by Samui, *et al*. (2000). The data was further analyzed by using simple statistical tools.

Present Increase Yield = Demonstration Yield - Farmers Yield / Farmers Yield

Technology gap = Potential Yield- Demonstration Yield

Extension gap = Demonstration Yield-Farmers Yield

Technology index (%) = Potential Yield - Demonstration Yield / Potential Yield X 100

Results and Discussion

Multicut fodder sorghum variety CSV 33MF has recorded significantly higher green fodder yield (184.5 t/ha) as compared to CO- (FS)-29 (130.8 t/ha) (Table 1). The yield enhancement was due to the introduction of improved multicut fodder sorghum variety CSV 33MF was to the tune of 29.1 per cent over the farmers' practice. Whereas, the palatability was also significantly superior in case of multicut fodder sorghum variety CSV 33MF (91.8%) than CO- (FS)-29 (84.5%). Dairy farmers were satisfied with growth and fodder yield from multicut fodder sorghum variety CSV 33MF were introduced in Vellore district. Palatability was good for cow as well as calf. During summer season yield less than monsoon season, it might be due to water scarcity and no application of fertilizers and manures.The average Net return was higher in CSV 33MF (Rs.136020/ha) as compared to CO- (FS)-29 (Rs. 78084/ha) because of additional input applied in demonstration. Similar trend was also observed with B:C ratio (Table-1). The higher additional return and effective gain obtained under demonstrations could be due to improved technology, non monetary factors, timely operations of crop cultivation and scientific monitoring (Chauhan *et al*., 2020). This substantially increased the income as well as rescues the livestock from scarcity of green fodder. Due to its drought tolerant and multicut nature fodder sorghum has created positive impact on livestock farmers in Vellore district of Tamil Nadu.

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Table 1. Yield and economic performances of multicut fodder sorghum varieties under rainfed condition

Particulars	CSV 33MF	CO- (FS)-31	CO- (FS)-29
Green fodder (t/ha)	184.5	151.8	130.8
Dry fodder (t/ha)	50.7	45.6	36.3
Net return (Rs.)	136020	99648	78084
BCR	4.56	3.21	3.03
Present Increase Yield	41.06	16.06	-
Technology gap	40.5	38	29
Extension gap	53.7	21	-
Technology index (%)	18	20	18

T2-36

Agronomic Biofortification of Barnyard Millet grain with iron: Path Analysis of iron fraction on grain iron content

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Abstract

Iron deficiency malnutrition is a most prevalent health problem worldwide. Enhancing the micronutrient in stable food crop the agronomic biofortification is an agricultural line of attack. Soil nourishment through fertilization is a major vehicle for changing plant mineral content and food quality. A field experiment was conducted to evaluate the effect of intergrated nutrient management for the biofortification of barnyard millet. The experiment was laid out in FRBD design and two genotypes were involved i.e. G1- High Fe containing genotype (Acm 17-353), G2- medium Fe containing genotype (MDU-1). Grain Fe content studies have shown that genotypes respond positively to external Fe application with enhanced uptake. In MDU-1 variety there is no increase under high soil Fe status, possibly owing to transporter saturation, while high iron genotype respond to the high soil Fe status. The plant NPK status deserves a special attention in efforts to biofortify food crops with Fe. Increasing the grain iron content also increases the limiting amino acids of cereals.

Keywords: Iron deficiency, biofortification, iron fertilization, grain iron, amino acids

Introduction

In the developing countries micronutrient malnutrition creates attention drawing problems. Globally, anemia is most commonly caused by iron deficiency. Fe deficiency anemia puts pre-school children and pregnant women under greatest risks. Agronomic biofortification is the application of micronutrient-containing mineral fertilizer to the soil and/or plant leaves (foliar), to increase micronutrient contents of the edible part of food crops. Developing the biofortified foods are the ongoing research and has mainly focused on enhance the Fe content of the most food crops including wheat [*Triticum sativum* (L.)] (Aciksoz *et al.,* 2011), maize [*Zea mays* (L.)] (Ortega-Blu and Molina-Roco 2007), common beans [*Phaseolus vulgaris* (L.)].

Materials and Methods

A field experiment was conducted in farmers's field at Tamilnadu, India with test crop of branyard during the year 2018-19 to evaluate the effect of intergrated nutrient management for the biofortification of barnyard millet. The experiment was laid out in FRBD design with three factors with unequal levels of factors. Factor G was genotype factor i.e. G1- High Fe containing genotype (Acm 17-353), G2- medium Fe containing genotype (MDU-1). Factor F was NPK levels (40:20:20 Kg/ha) i.e. F1- 75% NPK level and F2- 100% NPK level. Factor Fe was iron management Fe_1– No iron, Fe_2 – Foliar spray 0.5% $FeSO_4$ both vegetative and tillering stage, Fe_3– 100% $FeSO_4$ (@ 50 Kg/ha), Fe_4– 100% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$ at both stages,

Fe_4– 100% $FeSO_4$ + Foliar spray 0.5% $FeSO_4$ at both stages, Fe_5 – 125% $FeSO_4$ (@ 62.5 Kg/ha), Fe_6 – 125% $FeSO_4$ + foliar spray of 0.5% $FeSO_4$ at both stages. Total number of treatment was (2*2*6)=24 with two replication and each plot size were of 5*4 m^2.

Results and Discussion

The iron content in grain was influenced by iron fertilization and different NPK levels with a significant increase in both genotype of barnyard millet. The Fe content in grain ranged from 14.93 to 17.50 mg/100g. Among the two cultivars, ACM -15-353 cultivar recorded high iron content of 16.78 mg/100g than the MDU-1 variety (16.10 mg/100g). The above two genotypes possess different classes (low- and high-affinity) of transporters that operate under different Fe concentrations. Among NPK levels, 100% NPK recorded 4.73% higher Fe content than 75% NPK level. The balanced nutrition also enhanced the synergistic effect on uptake by plant nutrients. The results were in accordance with Nawaz et al., (2012) and Rana et al., (2005).

Path analysis to identify iron fraction contribution to grain iron: Initial and post harvest soil from the experimental soil were collected and the iron fraction are estimated using standard procedure. Path analysis was conducted to acquire the direct and indirect contribution of the soil iron fraction to the grain iron content. Totally five fraction were studied which contribute 0.63 towards the grain iron content. The residual value of 0.37 indicated the adequacy of the factors chosen for path analysis. The direct and indirect effects are depicted in the Fig.1.

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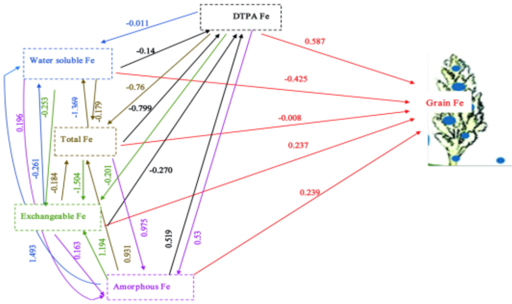
Fig.1. Path Analysis of grain iron vis different soil iron fraction



T2-37
Effect of crop geometry and nutrient management on the productivity of Barnyard Millet

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Abstract

The field experiments were conducted with an objective to study the impact of spacing on the productivity and to optimize the nutrient requirement for barnyard millet (*Kudiraivali*) under sodic soil condition using the short duration high yielding variety Co (KV) $_2$ during *summer* season of 2018 and 2019 at Anbil Dharma lingam Agricultural College and Research Institute, Trichy. The experiments were carried out in FRBD comprising two factors *viz.,* crop geometry and nutrient management. Factor one consist ofS_1 - 20 x 10 cm, S_2 - 15 x 10 cm and S_{3-} 25 x 10 cm. Nutrient management practices like N_1-100 % N + 100 % P, N_2-100 % N + 100 % P + FYM@ 12.5 t / ha, N_3-125 % N + 125 % P andN_4-125 % N + 125 % P + FYM@ 12.5 t / ha. The experiment was replicated thrice. Totally twelve treatment combinations were analyzed. Results revealed that spacing at 15 x 10 cm with 125 % RDF of N + P along with FYM recorded highest grain yield of 608 kg/ha with increased growth parameters like plant height, number of tillers and yield attributes *viz.*, number of panicles, length of panicle and weight of thepanicle.

Keywords: Crop geometry, nutrient management, barnyard millet, sodic soil

Introduction

In recent years, there has been increasing recognition of the importance of millets as a substitute for major cereal crops. Millets have the potentiality of contributing to increased food production both in developing and developed countries. In India *Kudiraivali*is an important dry land crop and cultivated over a wide array of environmental conditions even under poor soil conditions. It has the special feature of drought resistance and can withstand water logging up to 2 weeks. It has field duration of 70-90 days. Due to its quick growth, it can be grown as a short-term catchcrop. It is used as reclamation crops on land that is too saline for rice. It is the very quickest crop among all millets

One of the major reasons for low productivity of crops grown in salt-affected soil is the salt toxicity and poor soil properties. In India, 3.79 million ha and 0.35 million ha in Tamil Nadu have been affected by sodicity which affects productivity of the land directly. Extensive research work has been carried out on reclamation of sodic soil utilizing many inorganic and organic amendments either alone or in combination. However limited works have been carried out in the management of salt affected soils by altering the nutrient management particularly in millets.

Nitrogen is the most limiting nutrient for crop production in sodic soil as they are poor in N status and organic matter. Most of the crops grown in sodic soil invariably suffer from inadequate N supply. Various studies indicated that sodic soil requires additional N supply to increase the productivity of crops. Application of 25% extra N over the recommended dose of 150 kg ha^{-1} is essential for higher productivity of paddy. Keeping this in view, the field experiments were conducted at Anbil Dharmalingam Agricultural College and Research Institute, Trichywith an objective to enhance the productivity of barnyard millet (Kudiraivali) under sodic soil condition.

Materials and Methods

A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute during *kharif* season of 2018 – 19.The experiment was laid out in RBD and replicated thrice. Treatment comprising two factors. Factor I: crop geometryas *viz.*,S_1 – 20 x 10 cm, S_2 –15 x 10 cm, S_3 –25 x 10 cm. Factor II: N_1 - 100 % N + 100 % P, N_2 - 100 % N + 100 % P + FYM@ 12.5 t / ha**,** N_3 - 125 % N + 125 % P and N_4-125 % N + 125 % P + FYM@ 12.5 t / ha. Short duration Co $(KV)_2$ used as testvariety. Biometric observations were recorded and the data were statistically analyzed.

Results and Discussion

Plant population:

Among the various spacing adopted, S_2 (15 x10 cm) significantly recorded the highest plant population than other treatments. Thereis no significant difference found with regard to nutrient levels.

Plant height

With regard to factor 1, spacing @ 15 x10 cm significantly recorded the highest plant of106.2 cm followed by spacing @ 20 x10 cm. Similarly with respect to nutrient management factor N_4 significantly recorded the highest plant of 104.2 cm followed by N_3 which is on par with N_2. There is no interaction effect. The increase in plant height might be due to sufficient availability of sunlight, water and nutrition from soil to each crop under proper spacing. This finding was supported by the finding of Avasthe *et al.,* (2012).

Panicle weight (g)

Spacing @ 15 x10 cm significantly recorded the highest panicle weight of 4.75 g followed by spacing @ 20 x10 cm. Similarly with respect to nutrient management factor N_4 significantly recorded the highest panicle weight followed by N_3& N_2. There is no interaction effect.

Grain yield

There is a significant difference in the grain yield among thetreatments.The highest grain yield of 593 kg/ha was recorded by the spacing S_2 @ 15 x10 cm followed by the spacing @20 x10 cm. This might be due to more population of plants by close spacing and hence more yield per hectare. With respect to nutrient management N_4 -125 % N + 125 % P + FYM@ 12.5 t / ha significantly recorded the highest grain yield of 608 Kg /ha followed by N_3&N_2.This might be due to adequate spacing plant can gain sufficient sunlight, water and nutrition from soil, which can influence healthy yield and yield attributes.. Similar findings were reported by Manjunatha *et al.,* (2010) and Sridhar *et al.,* (2011).

From this study, it is concluded that crop geometry @15 x 10 cm was found to be the best spacing and N_4 - 125 % N + 125 % P + FYM@ 12.5 t / ha could be adopted as optimum dose of nutrients to get higher grain yield in barnyard millet under sodic soil condition.

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Table 1. Effect of crop geometry and nutrient management on Growth and yield

Treatments	Plant Population (m^2)	Plant height (cm)	No. of panicles / plant	Panicle weight (g)	Grain Yield (Kg/ha)
Factor 1 (Spacing)					
S_1 - 20 x 10 cm	29	98.3	6	4.27	517
S_2 - 15 x 10 cm	35	106.2	7	4.75	593
S_3- 25 x 10 cm	23	92.0	6	3.78	365
CD (0.05)	5	3.4	NS	0.3	71
Factor 2 (Nutrient management)					
N_1-100 % N + 100 % P (as per CPG)	29	93.7	5	4.01	465
N_2-100 % N + 100 % P + FYM@ 12.5 t / ha	30	96.8	4	4.36	472
N_3-125 % N + 125 % P	29	100.5	4	4.17	521
N_4-125 % N + 125 % P + FYM@ 12.5 t / ha	31	104.2	5	4.74	608
CD (0.05)	NS	3.9	NS	0.5	83

T2-38
Technologies for enhancing the productivity of barnyard millet in sodic soil

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Abstract

Barnyard millet is one of the hardiest, climate resilient and fast-growing crop that is bestowed with high nutrient content in grains. An experiment was carried out in barnyard millet under natural sodic soil condition to study the effect of different methods ofcrop establishment and to optimize the nutrient requirement for barnyard millet (Kudiraivali) under sodic soil condition using the short duration high yielding variety Co $(KV)_2$during *kharif* season in 2016 at Anbil Dharmalingam Agricultural College and Research Institute. The experiment was carried out in FRBD comprising two factors *viz.,* crop establishment techniques like line sowing at25 x 10 cm (E_1) and 35 x 10 cm (E_2) and transplanting at 25 x 10 cm (E_3) and 35 x 10 cm (E_4) and nutrient management practices of N_1at75%,$N_2$100% and $N_3$125 % recommended dose of fertilizers. The experiment was replicated thrice. Totally twelve treatment combinations were analyzed. Results revealed that transplanting of barnyard millet at 35 x 10 cm with 125 % RDF recorded higher grain yield of 980 kg/ha with increased growth parameters like plant height, number of tillers and yield attributes *viz.*, number of panicles, length of panicle and weight of the panicle in sodic soil.

Keywords: crop establishment, nutrient requirement, barnyard millet, sodic soil

Introdcution

Minor millets are a group of crops that are highly climate resilient and perform well even under adverse climatic conditions. Among the millet crops, barnyard millet (*Echinochloa frumentacea*) is a fast growing hardiest ancient millet crop grown in warm and temperate regions of the world and widely cultivated in Asia, particularly India, China, Japan, and Korea. It is the fourth most produced minor millet, providing food security to many poor people across the world. In India it is an important dry land crop and cultivated over a wide array of environmental conditions even under poor soil conditions. It has the special feature of drought resistance and can withstand water logging up to two weeks. It is equally important as a grain and fodder crop. Thus it deserves a greater importance than other millets. However, in reality the potentiality of this crop is not fully exploited.

The lower crop productivity is mainly due to poor crop management practices such as inadequate planting density and nutrition, high weed infestation, incidence of disease and insect pests. Keeping this in view,an experiment was conducted to find out the suitable crop establishment technique and to optimize the nutrient requirement for barnyard millet (kudiraivali) under sodic soil condition.

Materials and Methods

A field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute during *kharif* season of 2017 – 18.The experiment was laid out in RBD and replicated thrice. Treatment comprising two factors. Factor I: Method of crop establishment as *viz.*,E_1 – Line sowing with 25 x 10 cm, E_2 – Line sowing with 35 x 10 cm, E_3 – Transplanting with 25 x 10 cm, E_4 – Transplanting with 35 x 10 cm. Factor II: Nutrient management comprised ofN_1 - 75 % Recommended dose of fertilizer, N_2 - 100 % Recommended dose of fertilizer **,** N_3 - 125 % Recommended dose of fertilizer. Short duration Co $(KV)_2$used as testvariety

Biometric observations were recorded and the data were statistically analyzed.

Results and Discussion

The results revealed that transplanting at 35 x 10 cm with 125 % RDF (E_4N_3) recorded the highest plant population, the highest plant height and more number of tillers per hill. This might be due to wider spacing which resulted in lesser competition among the plants and also more photosynthesis activity as a result of better solar light inception on the leaves and also proper utilization of water and nutrients in a critical crop growth period. These findings are supported by the findings of Avasthe *et al.* (2012) where in rice lesser number of tillers and panicles per hill were recorded at closer spacing while wider spacing recorded higher number of tillers and panicles

Regarding the yield attributing characters transplanting at 35 x 10 cm with 125 % RDF (E_4N_3) significantly recorded more number of panicles per hill (7.60), panicle length (23.60cm) and grain yield of 997 Kg/ha. This might be due to adequate spacing plant can gain sufficient sunlight, water and nutrition from soil, which can influence healthy yield and yield attributes. Khan and Agrawal (1995) reported in ragi that the seed yield was highest with 2,60,000 plants per hectare compared to reduced populations

From this study, it is concluded that transplanting at 35 x 10 cm with 125 % RDF (E_4N_3) could be adopted to get higher grain yield in barnyard millet under sodic soil condition.

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Table 1. Effect of crop establishment techniques and nutrient management

Treatment	Plant population perquadrate (0.25 m^2)	Plant height (Cm)	No.of tillers per hill	Number of panicles per hill	Panicle length (Cm)	Grain Yield (Kg/ha)
Factor – 1 : Method of crop establishment						
E_1	6.32	137.8	3.68	3.55	21.61	736
E_2	7.11	145.2	5.11	3.63	21.50	783
E_3	7.64	153.9	6.23	4.20	22.26	873
E_4	8.15	162.5	6.96	5.83	20.33	917
SED	0.22	10.23	0.70	0.06	0.17	12.24
CD (0.05)	0.43	20.41	0.15	0.12	0.35	25.38
Factor – 2 : Nutrient management						
N1	6.18	142.4	5.29	3.37	20.30	793
N2	7.27	153.6	5.49	4.38	21.61	825
N3	7.81	165.8	5.71	5.16	22.38	864
SED	0.16	9.82	0.06	0.05	0.15	10.60
CD (0.05)	0.34	19.1	0.03	0.11	0.30	22.00

T2-39

Evaluation of sorghum varieties for their tolerance to sodicity level

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Abstract

A field experiment was conducted to assess the effect of different Exchangeable Sodium Percentage (ESP) levels of soil on yield of sorghum varieties and to fix optimum sodicity tolerance limits of sorghum varieties based on the performance under different soil sodicity levels. The experimental results revealed that the highest grain yield of 1340 kg/ha was recorded by Co 30 at 8 ESP level and the lowest grain yield of 22 kg/ha recorded by Irungu local at 48 ESP level. The results of grain yield revealed that the 50 per cent grain yield was recorded in the varieties *viz.,* Red local and K12 at the ESP of 32 per cent whereas, Co 30 and Irungu local recorded 50 per cent yield at 40 ESP level. However, 50 per cent grain yield was recorded in the varieties *viz.,* Co 30, Red local and Irungu local at the ESP of 32 per cent whereas in the variety K12 recorded 50 per cent yield at 24 ESP level which is clearly indicated that the varieties Co 30, Red local and Irungu local could be grown in the sodic soil having the ESP up to 32 per cent whereas the cultivar K12 can be recommended to the sodic soil having the ESP level up to 24 per cent. The stalk yield results clearly indicated that the variety Co 30, though it recorded the lowest stalk yield, it tolerance to 40 ESP while obtaining 50 per cent of maximum possible stalk yield. Although, the Irungu local recorded the lowest grain yield, it recorded the highest stalk yield among the variety which could suitably recommended for cultivation as fodder crop in the sodic soil up to 40 per cent ESP level.

Keywords: Sorghum, varieties, ESP level, grain yield, sodicity tolerance

Introduction

Sorghum (*Sorghum bicolour* L.) is the fifth prime cereal crop of the world, after wheat, rice, maize and barley. It is the staple food in 30 countries in the tropics and semi-tropics and in contrast to many other cereal grains, sorghum grains are gluten-free. About 6.73 million hectares in India are affected by salt. The sodic and saline soils accounts for 56 per cent (3.77 million hectares) and 44 per cent (2.96 million hectares) respectively, of the total salt-affected area. Almost in 11 states, sodicity poses a significant threat to the sustainability of agricultural crop production, in which Tamil Nadu occupies 9.41% (Singh *et al.*, 2010). High pH can impede the availability of essential plant nutrients over the entire soil profile (Sharma *et al.,* 2016). High pH (>8.5), high ESPs (>15) and variable electrical conductivity of soil saturation paste (EC, typically 4 dS/m) are some of the characteristics features of sodic soils. Sorghum has been reported to thrive well under moderately sodic soils and hence a field experiment was conducted to assess the effect of different Exchangeable Sodium Percentage (ESP) levels of soil on yield of sorghum varieties and to fix optimum sodicity tolerance limits of sorghum varieties based on the performance under different soil sodicity levels.

Materials and Methods

The field experiment was conducted at ADAC&RI, Trichy in strip plot design with three replications. Main plots consists of six ESP levels *viz.,* 8, 16, 24, 32, 40 and 48 whereas sub plots grown with four different sorghum varieties *viz.,* K12, Co 30, Local –Red and Local –Irungu (Black). Grain and stalk yields were recorded at harvest and expressed in kg/ha.

Results and Discussion

The highest mean grain yield of 818 kg/ha was recorded in the ESP of 8 followed by 16, 24, 32, 40 and 48 by recording 696, 519, 414, 101 and 63 kg/ha, respectively (Table 1). Among the different varieties evaluated the Co 30 recorded the highest mean grain yield of 735 kg/ha followed by K12, Red local and Irungu local by recording 462, 324 and 219 kg/ha, respectively. Among the interaction of ESP and varieties, the highest grain yield of 1340 kg/ ha was recorded by Co 30 at 8 ESP level. The lowest grain yield of 22 kg/ha recorded by Irungu local at 48 ESP level. In case of stalk yield among the different varieties evaluated the Irungu local recorded the highest mean stalk yield of 1293 kg/ha followed by K12, Red local and Co 30 by recording 977, 667 and 666 kg/ha, respectively (Table 2). However, the Red Local and Co 30 recoded significantly on par with each other with respect to haulm yield. Among the interaction of ESP and varieties, the highest haulm yield of 1640 kg/ha was recorded by Irungu local at 8 ESP level. The lowest haulm yield of 300 kg/ha recorded by K12 which was on par with Red local at 48 ESP level.

Based on the experimental results, it could be concluded that 50 per cent grain yield was recorded in the varieties *viz.,* Co 30, Red local and Irungu local at the ESP of 32 per cent whereas in the variety K12 recorded 50 per cent yield at 24 ESP level which is clearly indicated that the varieties Co 30, Red local and Irungu local could be grown in the sodic soil having the ESP up to 32 per cent whereas the variety K12 could be recommended to the sodic soil having the ESP level up to 24 per cent. The stalk yield results clearly indicated that the varieties Co 30, though it recorded the lowest stalk yield, it tolerance to 40 ESP while obtaining 50 per cent of maximum possible stalk yield. Although, the Irungu local recorded the lowest grain yield, it recorded the highest stalk yield among the varieties which could suitably recommended for cultivation as fodder crop in the sodic soil up to 40 per cent ESP level.

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Table 1. Effect of graded levels of Exchangeable Sodium Percent (ESP) on grain yield (Kg/ha) of sorghum varieties

ESP level/Varieties	S1 – K12	S2 – Co 30	S3 – Red local	S4 – Irungu local	Mean
M1 – 8	925	1340	582	425	818
M2 – 16	795	1092	568	330	696
M3 – 24	616	891	330	238	519
M4 – 32	320	791	317	228	414
M5 – 40	70	155	105	72	101
M6 – 48	46	138	45	22	63
Mean	462	735	324	219	-

	SEd	CD (0.05)
M	8.8	19.6
S	10.8	21.9
M at S	24.5	50.4
S at M	26.4	53.6

Table 2. Effect of graded levels of Exchangeable Sodium Percent (ESP) on stalk yield (Kg/ha) of sorghum varieties

ESP level/ Varieties	S1 – K12	S2 – Co 30	S3 – Red local	S4 – Irungu local	Mean
M1 – 8	1457	854	1025	1640	1244
M2 – 16	1290	785	894	1580	1137
M3 – 24	1257	754	758	1503	1068
M4 – 32	917	723	572	1270	870
M5 – 40	643	482	415	952	623
M6 – 48	300	397	340	810	462
Mean	977	666	667	1293	-

	SEd	CD (0.05)
M	22.6	50.3
S	15.6	31.6
M at S	40.1	83.8
S at M	38.2	77.5

T2-40

Studies on the influence of plant density and nutrient levels on nutrient uptake and yield of late maturity maize (*Zea mays*) hybrids

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Introduction

Maize is an important cereal crop grown in most parts of India due to its wide adaptability. Late maturity maize hybrids have higher yielding potential than medium and early maturity hybrids. The yield potential depends on its genetic makeup and environmental and edaphic factors. Therefore these hybrids have to be exploited to achieve higher yield through adoption of improved agro-techniques. Influence of plant density and nutrient levels on nutrient uptake and yield vary across locations. Hence, the experiments were conducted to study the influence of plant density and nutrient levels on nutrient uptake and yield of late maturity maize hybrids

Materials and Methods

Field experiments were conducted during *Rabi*,2019-20 and *Rabi*, 2020-21 at Department of Millets, Tamil Nadu Agricultural University, Coimbatore to study the influence of plant density and nutrient levels on nutrient uptake and yield of late maturity maize hybrids.The experiments were laid out in a split-split plot design. In the main plot, two planting densities *viz*.,60×25 cm(D_1) and 60×20 cm(D_2) and in the sub plot, three nutrient levels *viz*., 100% RDF:250:75:75 NPK kg/ha(N_1),90%RDF:225:68:68 NPK kg/ha(N_2) and STCR-IPNS:131:38:38 NPK kg/ha(N_3) and in the sub-sub plot, three late maturity maize hybrids from TNAU *viz*., CMH12-686(G_1), CMH15-005(G_2), COH (M) 6 (G_3) and one hybrid from private sector-NK6240(G_4) were tried in three replications in both the years. Observations on nutrient uptake and yield were recorded. The data on various characters studied during the investigation were statistically analyzed by Gomez and Gomez (2010) for split-split plot design. Wherever the treatment difference was significant, critical differences were worked out at 5 per cent probability level.

Results and Discussion

Effect of planting density and nutrient levels on NPK uptake in grain and stover (Table 1.) Experimental results revealed that planting density, nutrient levels and hybrids exerted significant influence on nitrogen uptake in grain and stover(Table1). Among the planting densities, spacing of 60×20cm recorded higher nitrogen uptake of 86.3 kg ha^{-1} in grain which was significantly superior to spacing of 60×25cm. The results confirm the findings of Golla et al.2018.With respect to nutrient levels, 100% RDF recorded higher nitrogen uptake of 88.1 kg ha^{-1} in grain which was comparable with 90% RDF but was significantly superior to STCR-IPNS. Among the late maturity maize hybrids, CMH12-686 recorded higher nitrogen uptake of 86.3 kg ha^{-1} in grain. This was comparable with CMH15-005 but was significantly superior to COH (M) 6 and NK6240.With respect to nitrogen uptake in stover, spacing of 60×20cm recorded higher nitrogen uptake of 57.3 kg ha^{-1} in grain which was significantly superior to spacing of 60×25cm. In respect of fertilizer levels, 100% RDF recorded higher nitrogen uptake of 59.4 kg ha^{-1} in grain which was comparable with 90% RDF but was significantly superior to STCR-IPNS. Among the late maturity maize hybrids, COH (M) 6 recorded higher nitrogen uptake of 55.9 kg ha^{-1} which was comparable withCMH12-686 and CMH15-005 but was significantly superior to NK6240. This was due to increase in N content and uptake by grain and stover of maize. The results confirm the findings of Begam et al.2018. The interaction effect was found to be non-significant.

Planting density failed to exert significant influence on phosphorus uptake in grain(Table 1). However, spacing of 60×20cm recorded higher phosphorus uptake of 22.4 kg ha^{-1} in grain. With respect to fertilizer levels, 100% RDF recorded higher phosphorus uptake of 23.6 kg ha^{-1} in grain which was comparable with 90% RDF but was significantly superior to STCR-IPNS. This was ascribed to high P content and improved dry matter production resulting in higher uptake. Similar findings were reported by Sharifi and Namvar, 2016. Among the late maturity maize hybrids, CMH12-686 recorded higher phosphorus uptake of 23.6 kg ha^{-1} in grain. This was comparable with CMH15-005 but was significantly superior to COH (M) 6 and NK6240.There was no significant influence of planting density on phosphorus uptake in stover. Nevertheless, spacing of 60×20cm recorded higher phosphorus uptake of 22.1 kg ha^{-1} in stover. With regard to fertilizer levels, 100% RDF recorded higher phosphorus uptake of 23.8 kg ha^{-1} in stover which was significantly superior to 90% RDF and STCR-IPNS. Among the late maturity maize hybrids, COH (M) 6 recorded higher phosphorus uptake of 22.2 kg ha^{-1} which was comparable with CMH12-686 and CMH15-005 but was significantly superior to NK6240. The interaction effect was not significant.

Though spacing of 60×20cm recorded higher potassium uptake (Table 1) of 35.7 kg ha^{-1} in grain, planting density failed to exert significant influence on potassium uptake in grain. In respect of fertilizer levels, 100% RDF recorded higher potassium uptake of 36.9 kg ha^{-1} in grain. This was comparable with 90% RDF but was significantly superior to STCR-IPNS. This was due to better dry matter production and enhanced K content resulting in higher uptake. The results confirm the findings of Haque et al.2001**.** Among the late maturity maize hybrids, CMH12-686 recorded higher potassium uptake of 37.3 kg ha^{-1} in grain which was comparable with CMH15-005 but was significantly superior to COH (M) 6 and NK6240. Potassium uptake in stover was significantly influenced by planting density and nutrient levels. Among the planting density, spacing of 60×20cm recorded higher potassium uptake of 117.8 kg ha^{-1} in stover which was significantly higher than spacing of 60×25cm.In respect of fertilizer levels, 100% RDF recorded higher potassium uptake of 121.8 kg ha^{-1} in stover which was comparable with 90% RDF but was significantly superior to STCR-IPNS. Among the late maturity maize hybrids, COH (M) 6 recorded higher potassium uptake of 114.5 kg ha^{-1} which was comparable with CMH12-686 and CMH15-005 but was significantly superior to NK6240.

Based on the results of experiments, it is concluded that among the late maturity maize hybrids, CMH15-005 and CMH12-686 recorded higher NPK uptake and yield under 60×20 cm with application of 100% recommended dose of fertilizer @250:75:75.

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Table 1. Effect of planting density and NPK levels on nutrient uptake of late maturity maize hybrids

Treatments	Grain			Stover		
	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
Main plot						
60×25 cm spacing	77.2	20.7	32.5	50.1	19.7	101.9
60×20 cm spacing	86.3	22.4	35.7	57.3	22.1	117.8
SEd	1.10	0.88	0.79	0.85	0.60	2.59
CD(P=0.05)	4.74	NS	NS	3.67	NS	11.2
Sub plot						
100% RDF	88.1	23.6	36.9	59.4	23.8	121.8
90% RDF	85.6	22.3	35.5	55.9	21.7	115.6
STCR-IPNS	71.5	18.8	29.8	45.7	17.1	92.3
SEd	1.91	0.92	1.63	1.79	0.84	3.09
CD(P=0.05)	4.40	2.13	3.76	4.15	1.93	7.14
Sub sub plot						
CMH12-686	86.3	23.6	37.3	54.1	21.3	111.6
CMH15-005	85.2	23.1	35.8	53.7	20.8	110.1
COH (M) 6	79.4	20.4	32.7	55.9	22.2	114.5
NK6240	76.1	19.2	30.4	50.8	19.1	103.5
SEd	1.78	1.37	1.64	1.73	1.04	4.18
CD(P=0.05)	3.61	2.78	3.32	3.52	2.1	8.47

T2-41

Efficient application of fertilizers for hybrid maize through STCR IPNS based fertilizer prescriptions under drip fertigation in Alfisol

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Abstract

Fertilizers and irrigation waters are two critical inputs and their efficiencies are inter linked. Application of fertilizers through fertigation based on crop requirement taking in to account the supplying capacity of soil and manure is attempted to attain the better fertilizer use. To achieve this, the STCR - IPNS based fertiliser prescription equations developed for hybrid maize on Palaviduthi series (Typic Rhodustalf) was validated by conducting six experiments at Coimbatore (Western Agro Climatic Zone) and Dindigul district (Southern Agro-climatic zone) during Kharif and Rabi seasons of 2021-22 and 2022-23. At all the six locations, the per cent achievement was within +/-10 per cent variation in STCR-NPK alone and STCR-IPNS treatments proving the validity of the equations. The highest mean grain yield was recorded in STCR-IPNS-10.0 t ha^{-1} (9.58 t ha^{-1}) followed by STCR-NPK alone-10.0 t ha^{-1} (9.38 t ha^{-1}). The highest response ratio of 15.14 kg kg^{-1} was recorded in STCR-IPNS-9 t ha^{-1}; however, the highest BCR of 2.40 was recorded in STCR-IPNS-10 t ha^{-1}. Hence, it would be ideal for targeting up to 10 t ha^{-1} for achieving better yield, efficient fertilizer use (RR) and BCR.

Keywords: Maize, Drip fertigation, STCR-IPNS, fertilizer prescription and hybrid maize

Introduction

The area under maize in India occupies 4% of the world maize area and 2% of the world production. This undermines the scope to increase the maize yield with better management practices. The shortage of irrigation water is steadily increasing and posing threat to food production and agriculture. The drip irrigation being used widely to better use the available irrigation water. Application of fertilizers along with irrigation water through drip fertigation enhances the water use efficiency and fertilizer use efficiency. The drip fertigation is becoming popular among the farmers due to increased efficiency of inputs and reduced labour cost. The fertilizer doses being adopted for the soil application is being followed for the drip fertigation. The scrupulous application of the fertilizer inputs without taking into account the soil supply leads to wastage of certain nutrients and deficiency of the certain nutrients.

Materials and Methods

In order to achieve better utilization of applied resources taking into account the capacity of the soil to nourish the crops and nutrient requirement of crops Soil test Crop response based fertilizer prescription equations for hybrid maize grown in the on red non-calcareous, sandy loam soil belonging to Palaviduthi soil series (Typic Rhodustalf) under drip fertigation were developed (Mohanapriya et al., 2020) by adopting the methodology developed by Ramamoorthy et al., (1967). Fertiliser Prescription Equations are as follows.

$FN = 3.15\,T - 0.68\,SN - 0.68\,ON$

$FP_2O_5 = 1.53\,T - 2.15\,SP - 0.62\,OP$

$FK_2O = 1.58\,T - 0.26\,SK - 0.51\,OK$

where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1} respectively; T = Grain yield target in q ha^{-1}; SN, SP and SK are available N, P and K in kg ha^{-1} respectively; ON, OP and OK are N, P and K supplied through FYM in kg ha^{-1}

To validate the fertilizer prescription equations developed through Soil Test Crop Response under Integrated Plant Nutrition System for hybrid maize grown under drip fertigation six numbers of field validations were undertaken on red non-calcareous, sandy loam soil belonging to Palaviduthi soil series (Typic Rhodustalf). The six locations were Thondamuthur, Coimbatore district and Pudhukkalarampatty, Viralipatty. C.K.Valasu, Poolampatti and Esakkampatti of Dindigul district spread in western and southern agro climatic zones of Tamil Nadu. Based on the initial soil test values of available N, P, K and yield targets aimed, fertilizer doses were calculated and applied for STCR treatments (Table .1). The fertilizer nutrients were supplied through urea, single super phosphate and muriate of potash. The whole dose of P_2O_5 was applied basally; micronutrient deficiencies were corrected in the experimental field by applying recommended dose of micronutrients. Fertiliser N and K_2O were applied through drip fertigation at an interval of six days and the entire quantities of fertiliser N and K_2O were split up into 13 fertigation with 25 % supplied during 6 to 30 DAS, 50 % during 31 to 60 DAS and 25 % during 61 to 78 DAS (Sampathkumar and Pandian, 2010). For IPNS treatments, 12.5 tonnes of FYM were applied basally and fertilizer N, P_2O_5, K_2O doses were adjusted accordingly.

Results and Discussion

The range and mean values of the six validation experiments indicated that the highest mean grain yield of maize was recorded with STCR-IPNS-10 t ha^{-1} (9.58 t ha^{-1}) followed by STCR-NPK-10 t ha^{-1} (9.38 t ha^{-1}). The highest response ratio of 15.14 kg kg^{-1} was recorded in STCR-IPNS-9 t ha^{-1}; however, the highest BCR of 2.40 was recorded in STCR-IPNS-10 t ha^{-1}. The mean increase of yield in STCR-IPNS-10 t ha^{-1} was 28.5 per cent over blanket (RDF alone), 16.1 per cent over blanket + FYM and the increase in BCR was 0.50 and 0.35 respectively. Farmer’s practice recorded relatively lower yield and response ratio as compared to blanket and STCR treatments while the STCR - IPNS treatments recorded the higher per cent achievement and response ratio among all the treatments.

The results of the validation experiments showed that the grain yield was within +/- 10% of the targeted yield in all the six experiments conducted in Coimbatore and Dindigul districts which confirmed the validity of fertilizer prescription equations developed for hybrid maize under drip fertigation on Palaviduthi series (Red non calcareous) and it would be ideal for targeting up to 10 t ha^{-1} for achieving better yield, efficient (RR) and economic (BCR) use of fertilizers.

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Table 1. Range and mean values of Results of validation experiments on drip fertigation in maize hybrid (Mean of six locations)

S. No.	Treatments	Fertiliser doses (kg ha^{-1})			Grain yield (kg ha^{-1})	Percent achieve-ment	RR (kg kg^{-1})	BCR
		FN	FP$_2$O$_5$	FK$_2$O				
1.	Blanket (RDF alone)	250	75	75	7.46	-	10.07	1.91
2.	Blanket(RDF+FYM@12.5 t ha^{-1})	250	75	75	8.26	-	11.26	2.06
3.	STCR- NPK alone 8.0 t ha^{-1}	149-162	47-73	61-90	7.72	96.4	14.78	2.04
4.	STCR - NPK alone 9.0 t ha^{-1}	181-194	62-88	77-106	8.65	96.1	14.78	2.22
5.	STCR - NPK alone 10.0 t ha^{-1}	212-225	78-104	92-113	9.38	93.8	14.38	2.34
6.	STCR-IPNS- 8.0 t ha^{-1}	125*	38*-55	38*-63	7.80	97.5	15.04	2.07
7.	STCR-IPNS- 9.0 t ha^{-1}	145-154	41-71	50-79	8.77	97.4	15.14	2.27
8.	STCR-IPNS- 10.0 t ha^{-1}	177-185	57-86	65-95	9.58	95.8	14.82	2.40
9.	Farmer's practice	100-207	40-60	38-56	5.42	-	9.05	1.50
10.	Absolute Control	0	0	0	3.43	-	-	1.05

STCR-IPNS: NPK+FYM @ 12.5 t ha^{-1}; *maintenance dose
Initial Soil Test Values: KMnO$_4$-N -132-151; Olsen-P- 23-35; 139-252 kg ha^{-1}; Zn- 0.63-1.62; Fe-3.85-6.47; Mn-5.86-7.24; Cu-0.97-1.23 mg kg^{-1}

T2-42

Effect of application of *Pongamia pinnata* leaf litter on weed, growth and yield of Baby Corn

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Abstract

Baby corn is the ear of maize (*Zea mays* L.) plant harvested young, especially when the silks have either not emerged or just emerged, and no fertilization has taken place, depending on the cultivar grown. Provides benefits to poor people from every walk of life and all disciplines. Farmers can grow four crops in a year. The demand for baby corn is rapidly increasing in urban areas in India. Can be effectively used a both a nutrious vegetable and as an export crop to earn valuable foreign exchange. After harvest the still young plants may be used as fodder for cattle. *Pongamia pinnata* is one of the few nitrogen fixing trees (NFTS) containing 30 - 40 % oil. The oil is used as bio diesel and leaves and flowers of pungam are high in nitrogen and it can be used to enrich soil. Pungam is the major tree species used in Agro forestry systems. Tree leaf litters contain higher amount of organic matter, N, P, K, Ca, Mg, S and other trace element can be applied for the production of agricultural crop. Recycling of tree litters is an important component of sustainable land use systems for production and maintaining productivity. Field experiment was conducted at Forest College and Research Institute, Mettupalayam to study the effect of *Pongamia pinnata* leaf litter on growth, yield of baby corn and on weed growth. Five treatments viz., Leaf litter of *Pongamia pinnata* @ 5 tonnes/ha, Leaf litter of *Pongamia pinnata* @ 10 tonnes/ha, Leaf litter of *Pongamia pinnata* @ 20 tonnes/ha, Hand weeding (No leaf litter applied), control (No leaf litter applied). Among the treatments Leaf litter of *Pongamia pinnata* @ 20 tonnes/ha recorded higher cob yield of baby corn. This was probably because of nutrient addition, minimum weed competition by the application of leaf litter.

Keywords: Baby corn, growth, yield, weed growth, *Pongamia pinnata* leaf litter

Introduction

Baby corn is the ear of maize (*Zea mays* L.) plant harvested young, especially when the silks have either not emerged or just emerged, and no fertilization has taken place. The demand for baby corn is rapidly increasing in urban areas in India. Can be effectively used a both a nutritious vegetable and as an export crop to earn valuable foreign exchange. After harvest the still young plants may be used as fodder for cattle. *Pongamia pinnata* is one of the few nitrogen fixing trees (NFTS) containing 30 - 40 % oil. The oil is used as bio diesel and leaves and flowers of pungam are high in nitrogen and it can be used to enrich soil. Incorporation of leaves improves soil fertility and favourable effect on growth and yield of many crops (Swaminathan, 2004) and decomposed flowers are valued in the tropics as rich in nutrition for plants (Savitha *et al.,* 2010). Pungam is the major tree species used in Agro forestry systems. Tree leaf litters contain higher amount of organic matter, N, P, K, Ca, Mg, S and other trace element can be applied for the production of agricultural crop. Hence, Field experiment was conducted to study the effect of *Pongamia pinnata* leaf litter on growth, yield of baby corn and on weed growth.

Materials and Methods

A field experiment was carried out to study the effect of application of leaf litter of *Pongamia pinnata* on the weed and crop growth in Baby corn at Forest College and Research Institute Farm, Mettupalayam with treatments viz., Leaf litter of *Pongamia pinnata* @ 5 tonnes/ha, Leaf litter of *Pongamia pinnata* @ 10 tonnes/ha, Leaf litter of *Pongamia pinnata* @ 20 tonnes/ha, Hand weeding (No leaf litter applied), control (No leaf litter applied). Baby corn variety COBC 1 was raised. Tree borne oilseed species *Pongamia pinnata* was taken for leaf litter. The dry leaf litter of *Pongamia pinnata* was collected and crushed firmly to apply in the field. Leaf litters were applied in the field at different doses as per the treatment before sowing of seeds. Weed control efficiency was calculated as per the methodology of Mani *et al*., (1973).

Results and Discussion

Leaf litter application had a marked effect on the growth and yield components and yield of the crop**.** Leaf litter of *Pongamia pinnata* @ 20 tonnes ha^{-1} recorded the highest plant height of 65 cm, 168cm and 181 cm at 15, 35 DAS and at harvest stages respectively. Leaf litter application at 20 tonnes ha^{-1} produced the highest dry matter. This could be ascribed to the higher availability of nutrients. Another reason is through the suppression of weeds by the application of mulches. The mulches can inhibit weed growth by providing a physical barrier to weeds. (Teasdale and Mohler 2000). The increased plant height provided opportunity for the plants to produce more number of cobs. The number of cobs plant^{-1} is uniform (2plant^{-1}) for all the treatments whereas the no leaf litter applied un weeded check recorded one cob plant^{-1}. Leaf litter applied at 20tha^{-1} had increased the cob weight (53.8gcob^{-1}) due to increased plant height, and DMP due to the availability of nutrients and weed suppression by the leaf litter. This ultimately reflected in increased yield of cobs(8025kgha^{-1}). Sarkar *et al* 2010 in an experiment with red amaranth, found that leaf litters showed its significant positive effect on yield and yield contributing characters. The lowest weed population (111.4m^{-2}) under hand weeding treatment. This was followed by Leaf litter of *Pongamia pinnata* @ 20 tonnesha^{-1}. The highest weed control efficiency was with the treatment Leaf litter of *Pongamia pinnata* @ 20 tonnesha^{-1}.

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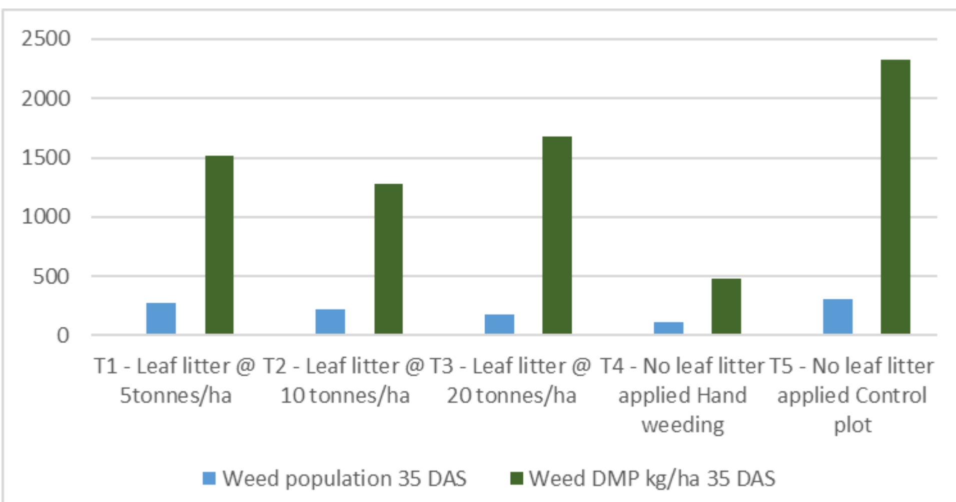
Table1. Effect of leaf litter of *Pongamia pinnata* on growth and yield of baby corn

Treatment	Plant height (cm) 35 DAS	DMP (kgha$^{-1)}$ 35 DAS	Cob length (cm)	Gob girth (cm)	Cob weight (gcob^{-1})	Cob yield (kgha^{-1})
T1 - Leaf litter @ 5tonnes/ha	131	1926	11	6.5	49.6	7643
T2 - Leaf litter @ 10 tonnes/ha	139	3259	12.5	6.9	50.0	7843
T3 - Leaf litter @ 20 tonnes/ha	168	4197	14.8	8.2	53.5	8025
T4 - No leaf litter applied Hand weeding	135	2716	8.7	6.0	45.9	7519
T5 - No leaf litter applied Control plot	123	1872	8.0	5.7	42.1	7155

Fig. 1. Effect of *Pongamia pinnata* leaf litter on weed



T2-43
HCN content and forage yield of multi-cut forage Sorghum under different organic manures and nitrogen levels

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Abstract

The treatments consisted of application of different organic manures viz., farmyard manure, goat manure and vermicompost along with 100% N (90 kg ha^{-1}) or 125% N through fertilizer nitrogen. In addition, recommended application of FYM @ 25 t ha^{-1} + 100% N was adopted for comparison. The results of this study showed that the higher HCN content was recorded under application of vermicompost 2.5 t ha^{-1} + 125% N and the lower HCN content was recorded under application of FYM 10 t ha^{-1} + 100% N. Higher level of green and dry fodder yield were recorded with application of FYM 10 t ha^{-1} with 125% N applied through fertilizer (38.7 and 16.9 t ha^{-1}, respectively).

Keywords: HCN, Forage sorghum, yield

Introduction

Sorghum is considered to be a good feed in ordinary conditions but when its normal growth is constrained by drought or imbalanced soil nutrients, hydrocyanic acid (HCN) content may develop to such an extent that the toxic level may reach lethal level when fed to animals (Fjell *et al*., 1991). Higher level of nitrogen application may increase prussic acid contents of forage sorghum and it gets readily absorbed into the blood stream of grazing ruminants, it causes cellular asphyxiation leading to illness of cattle eventually resulting in the death of animals. The farmers are generally not familiar with the optimum growth stage of forage sorghum that should be fed to the livestock. Hence, it was felt necessary to optimize the dose of FYM and nitrogen application and to study the effect of different organic manures on HCN content and yield of multi-cut forage sorghum.

Materials and Methods

A field experiment was conducted during rabi 2015 at New Area farm, Department of Millets, Tamil Nadu Agricultural University, Coimbatore. The soil of the experimental site was clay loam and was low in available nitrogen (229.6 kg ha^{-1}), high in available phosphorus (32.52 kg ha^{-1}) and high in available potassium (632.0 kg ha^{-1}). The experiment was laid out in randomized block design and replicated thrice using Co (FS) 31 as the test variety. The treatments consisted of application of FYM @ 25 t ha^{-1} + 100% N (T1), FYM @ 10 t ha^{-1} + 100% N (T2), FYM @ 10 t ha^{-1} + 125% N (T3), Goat manure @ 5 t ha^{-1} + 100% N (T4), Goat manure @ 2.5 t ha^{-1} + 125% N (T5), Vermicompost @ 5 t ha-1 + 100% N (T6), Vermicompost @ 2.5 t ha^{-1} + 125% N (T7). Recommended dose of 90: 40: 40 N, P_2O_5, K_2O kg ha^{-1} was applied treatment wise in the form of urea, single super phosphate and muriate of potash. 50% RDF of

45 kg N ha^{-1} and full dose of P_2O_5 and K_2O were applied at sowing. Remaining dose of 45 kg N ha^{-1} was top dressed at 30 DAS followed by the application of half the dose of 45 kg N ha^{-1} after every cut. After 4th cut, 100 % dose of PK fertilizer along with 50% dose of N is recommended to be applied.

Results and Discussion

HCN content: In the present study (Table 1), At 50 and 65 DAS, the lowest HCN content was recorded by application of FYM @ 10 t ha-1 + 100% N might be due to enzyme activity (CYP 79 A1 and CYP 76 E1) which gradually decreased at 50% flowering stage (Kumar and Devender, 2010). At 40, 50 DAFH the lowest HCN content was recorded through application of vermicompost @ 2.5 t ha-1 + 125% N and goat manure @ 5 t ha-1 + 100%. This might be due to decreased soil nitrogen availability which decreased nitrogen uptake this leads to lowest HCN content of forage sorghum.

Forage Yield : Green forage yield obtained in this treatment was 19% higher over application of FYM @ 25 t ha-1 + 100% N for both first cut and second cut (Table 2). Dry forage yield was also higher by 18 and 16% over FYM @ 25 t ha-1 + 100% N for first and second cut respectively. This might be attributed to sustained nutrient supply, which increased all the growth parameters like plant height and leaf stem ratio of the crop and the enhanced growth reflected on yield (Sumeriya and Singh, 2014).

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Table 1 Effect of organic manures and N levels on HCN content (ppm) of multi-cut forage sorghum at first and second cut

Treatment	First cut					Second cut		
	20 DAS	30 DAS	40 DAS	50 DAS	65 DAS	30 DAFH	40 DAFH	50 DAFH
T_1	489.3	378.5	408.1	188.0	145.6	230.3	209.1	88.5
T_2	484.3	209.1	272.6	156.2	103.3	204.9	156.2	72.6
T_3	568.9	213.4	293.8	166.8	145.6	272.6	219.7	92.7
T_4	496.2	219.7	314.5	272.6	130.8	336.1	198.5	71.6
T_5	568.9	236.6	336.1	251.6	166.8	293.8	200.7	82.1
T_6	526.6	230.3	441.9	336.1	236.6	255.7	160.4	103.3
T_7	547.8	312.8	463.1	378.4	251.5	304.4	149.9	124.5
SEd	52.4	26.5	35.9	24.2	16.6	26.6	19.0	9.1
CD(P=0.05)	NS	57.7	78.2	52.8	36.2	57.9	41.4	19.9

Table 2 Effect of organic manures and N levels on green and dry forage yield (t ha-1) of multi-cut forage sorghum at first and second cut

Treatment	Green forage yield		Dry forage yield	
	First cut	Second cut	First cut	Second cut
T_1	32.4	16.5	13.9	8.7
T_2	30.8	15.1	13.2	8.0
T_3	38.7	19.2	16.6	10.2
T_4	32.5	15.6	14.0	8.3
T_5	37.0	16.1	15.9	8.5
T_6	31.6	16.8	13.6	8.9
T_7	36.0	17.8	15.5	9.4
SEd	1.8	1.0	0.8	0.5
CD(P=0.05)	3.7	1.9	1.6	1.0

T2-44
Introduction of castor as intercropping in Samai in hilly areas

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Abstract

To assess the suitability of hybrid castor YRCH 1 for castor + minor millet intercropping system under rainfed condition and to improve the productivity of castor + samai intercropping system under rainfed condition through efficient resource management an experimental trial was conducted witht the following treatments such as Castor + Samai (1:5), Castor + Samai (1:10), Castor + Samai (1:15) as main plot treatment and 100 % Organic and 50 % Organic + 50 % inorganic as sub plot treatments. The results revealed that higher samai equivalent yield (1393 kg/ha) was recorded in intercropping of castor + samai (1:10) followed by intercropping of castor + samai (1:15) (1334 kg/ha). Among nutrient management practices, application of 50% organic and 50% inorganic recorded higher samai equivalent yield (1209 kg/ha) over 100% organic nutrient management practices (1177 kg/ha).

Introduction

Castor (*Ricinus communis*) is an important non-edible industrial oilseed crop. Oil content of castor kernel ranges from 46 to 50 per cent. The physical and chemical properties of castor oil are unique because of the presence of 12 hydroxy fatty acid with 18-carbon backbone called ricinoleic acid (RA) normally ranges from 85-95 per cent. It has wide range of uses in a variety of applications in the chemical industry including pharmaceuticals. Castor oil has greater demand across the globe throughout the year and highly valuable due its high content of ricinoleic acid (RA) and most importantly there is no synthetic substitute for recinoleic acid. Consequently, there is greater demand and steady market for castor kernel not only in domestic market but global market as well. Thus, it fetches premium price throughout the year unlike other crops. India is the largest exporter of castor oil and has a global market share of about 85-90% and generates Rs.7000 crore annually as foreign exchange. China and Brazil are the second and third largest producers of castor oil in the global market, contributing around 5-7% of the world exports, respectively.

Conservation agricultural (CA) technologies in castor cultivation are gaining momentum among farmers of semiarid tropics, resulted in higher productivity at less cost of production with significant benefits to the environment and more efficient use of natural resources. Surface crop residue management in CA practices has improved soil health by increasing microbial activity, soil organic carbon, mean weight diameter of soil aggregates which acts as a reservoir for nutrients and increases structural stability for enhancing infiltration. Relay on inter cropping with legumes is low cost strategy to ease the burden on commercial fertilizers (Rebafka et al.,1993). Crop intensification through inter cropping with legumes has been recognized as an effective strategy for achieving nutrition security, additional returns, poverty alleviation, judicious use of land and water resources. Thus, ultimately resulted in increase overall system productivity and profitability besides ensuring livelihood security.

Materials and Methods

To assess the suitability of hybrid castor YRCH 1 for castor + minor millet intercropping system under rainfed condition and to improve the productivity of castor + samai intercropping system under rainfed condition through efficient resource management an experimental trial was conducted witht the following treatments such as Castor + Samai (1:5), Castor + Samai (1:10), Castor + Samai (1:15) as main plot treatment and 100 % Organic and 50 % Organic + 50 % inorganic as sub plot treatments. Experiment was conducted in split plot design with three replications. Observations on plant growth parameters (Plant height, no. of branches), Yield parameters (No. of capsules/plant, test weight, seed yield) were recorded. Rainfall data was recorded during the crop growth period. Seed yield and economics *viz.,* gross return, net return, BCR were worked out.

Results and Discussion

In kalrayan hills, among the intercropping ratio, higher number of spikes/plant (41 nos.) was recorded in intercropping of castor + samai (1:5) ratio followed by intercropping of castor + samai (1:10) ratio (37). Among the nutrient management practices, higher number of spikes/plant was recorded in application of 50% organic and 50% inorganic nutrient management practices (40 nos.). With regard to samai, intercropping of castor + samai (1:10) ratio recorded significantly higher number of productive tillers per plant (7.4 nos.) and panicle length (42.7 cm). Also application of 50% organic and 50% inorganic nutrient management practices recorded significantly higher number of productive tillers per plant (5.4 nos.) and panicle length (40.1 cm). Among the intercropping ratio, higher samai equivalent yield (1393 kg/ha) was recorded in intercropping of castor + samai (1:10) followed by intercropping of castor + samai (1:15) (1334 kg/ha). Among nutrient management practices, application of 50% organic and 50% inorganic recorded higher samai equivalent yield (1209 kg/ha) over 100% organic nutrient management practices (1177 kg/ha). Among the treatments, higher net return of Rs. 45044/ha and BC ratio of 3.59 was recorded at intercropping of castor + samai (1:10) ratio along with 50% organic and 50% inorganic nutrient management practices when compare to other intercropping ratio and 100% organic nutrient management practice. In addition, intercropping of castor + samai (1:10) with 100% organic nutrient management practices recorded higher soil organic carbon content followed by 50% organic + 50% inorganic nutrient management practices.

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Table 1. Influence of different intercropping ratio and nutrient management practices on yield attributes of castor

Treatment	No. of spikes/ plant	No. of capsule/ spike	Test weight	No. of productive tillers/ plant	Panicle length (cm)	Castor yield	Samai Yield	SEY	BCR
Main plot (M): Intercropping									
M1: Castor+Samai (1:5)	41	115.5	28.9	5.1	37.2	1055	543	1264	3.52
M2: Castor+Samai (1:10)	37	89.5	28.1	7.4	42.7	950	744	1393	3.86
M3: Castor+Samai (1:15)	33	73.0	27.4	7.0	40.4	837	762	1334	3.68
M4: Samai	-	-	-	5.4	35.3	-	781	-	2.46
SEd	-	-	-	0.3	0.9	-	58	-	-
CD (P=0.05%)	-	-	-	0.6	1.8	-	117	-	-
Sub plot (S): Nutrient Management									
S1: 100% organic	38	109.3	27.8	5.2	37.8	703	697	1177	3.20
S2: 50% organic + 50% inorganic	40	112.6	28.2	5.4	40.1	718	718	1209	2.81
SEd	-	-	-	0.2	0.9	-	16	-	-
CD (P=0.05%)	-	-	-	NS	1.8	-	NS	-	-
Interaction (M x S)									
SEd	-	-	-	0.3	1.5	-	26	-	-
CD (P=0.05%)	-	-	-	NS	NS	-	NS	-	-

T2-45
Optimizing technology package for Tenai

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Abstract

To study the effect of different crop establishment techniques, inter cropping and foliar nutrition on the growth, yield and quality of Tenai, on station experimental trials were conducted at New Area Farm, Department of Millets, TNAU, Coimbatore, Regional Research Station, Paiyur and Centre of Excellence, Athiyanthal during Summer 2023 season. The experiments consisted of the following treatments such as Seed drill sowing (Pelleted seeds), Manual Broad casting (non-pelleted seed) and Manual Line sowing (non-pelleted seed) under mani plot treatments while Inter cropping with Tenai + Field Bean at 6:1ratio and Tenai +Red gram at 6:1ratio as sub plot treatments. Whereas, Foliar nutrition with Panchagavya @ 3% at and Fish amino acid @ 2% at Vegetative and Flowering stage were also given and these treatments were tested as sub-sub plot treatments. The results revealed that higher grain yield of both base and inter crop was higher under mechanized plot with less cost of cultivation which leads to higher net returns and benefit cost ration. The next beast treatment was manual line sowing and lowest yield was recorded under manual broadcasting which might be due to less population load per unit area. Regarding iner cropping field bean recorded higher productivity and gave higher net returns with short span of time as compared to redgram. Higher growth attributing characters, yield attributes and yield were higher under panchagavya @ 3.0 per cent sprayed field over FAA @ 2.0 per cent spray.

Keywords: minor millet, mechanization, yield, inter crop

Introduction

Millets are the ancient crops of the mankind and are important for rainfed agriculture. They are nutritionally rich and provide number of health benefits to the consumers. In recent times, the millets have become important owing to their good nutritional value, documented health benefits, versatile environmental adaptation, sustainability in low input agriculture and organic cultivation amenability. Gaps in Millet cultivation are paucity of agricultural laborers during peak period of millet cultivation causes delay in key operations like sowing, weeding, other intercultural operations, spraying, harvesting and processing, higher demand for labourers, enhanced labour wages leading to higher production cost thus, millet farming become non-viable and shift to non- agricultural avenues under labor scarce situation, low productivity owing to poor adoption of improved agronomic technologies and Non availability of quality critical inputs for millet cultivation. Paucity of agricultural laborers at peak period of millets cultivation causes delay in key operations like land preparation, timely sowing, intercultural operations like weeding, fertilizer application, irrigation, harvesting and processing.

Further, higher demand for labourers in peak cropping periods enhances labour wages leading to additional cost of cultivation.

All these factors leads to production losses, making millet farming become non-viable under labour scarce situations. The issue on labour scarcity is left unattended, it may potentially discourage millet farmers, who may leave their land fallow or cultivating other crops and shift to non-agricultural avenues for their livelihood. Farm mechanization is a viable avenue to address many of the issues arising due to shortage of agricultural laborers, speedup agricultural practices and saves time and labour in millet farming. It lowers millet production cost and improves farm income. Mechanization in millets with improved agronomic practices can shift millet agriculture from 'subsistence millet farming' to 'profitable commercial millet agriculture'.

Materials and Methods

To study the effect of different crop establishment techniques, inter cropping and foliar nutrition on the growth, yield and quality of Tenai, on station experimental trials were conducted at New Area Farm, Department of Millets, TNAU, Coimbatore, Regional Research Station, Paiyur and Centre of Excellence, Athiyanthal during Summer 2023 season. The experiments consisted of the following treatments such as Seed drill sowing (Pelleted seeds), Manual Broad casting (non-pelleted seed) and Manual Line sowing (non-pelleted seed) under mani plot treatments while Inter cropping with Tenai + Field Bean at 6:1ratio and Tenai +Red gram at 6:1ratio as sub plot treatments. Whereas, Foliar nutrition with Panchagavya @ 3% at and Fish amino acid @ 2% at Vegetative and Flowering stage were also given and these treatments were tested as sub-sub plot treatments. Seeds were sown on 06.02.2023 and the experiment was conducted in split-split plot design and replicated thrice with a net plot size of 40 m^2. All the treatments were imposed as per the technical programme.

Results and Discussion

The observations like germination, crop establishment rate, population density, plant height, No. of productive tillers per plant, ear head length and incidence of pests and diseases and days to reproductive stage were recorded. Currently, crop is at maturity stage. There was no significant variation among the treatments on germination percent. With respect to crop establishment rate seed drill sowing using pelleted seeds took 10 and 9.15 days for its establishment under vertisols at Coimbatore and Paiyur, respectively. While it was 5.75 days under alfisols at CoE, Athiyanthal. With respect to manual broad casting using non pelleted seeds took only 6.33, 5.35 and 5.0 days, respectively at Coimbatore, Paiyur and Athiyanthal. Under manual line sowing with non-pelleted seeds, complete emergence of radicle and plumule were taken place at 4.5, 4.75 and 4.5 days after sowing, respectively at Coimbatore, Paiyur and Athiyanthal. Regarding plant height, higher values were recorded under manual line sowing followed seed drill sowing (135 & 136.5 cm and 132 & 132.6 cm, respectively at Coimbatore and Paiyurcentre) while, taller plants with 138.7 cm was observed under seed drill sowing followed by manual line sowing (135.5 cm) and shorter plants were noticed under manual broad casting method of crop establishment at all the three centres. Regarding yield attributing characters, higher number of productive tillers per plant was noticed under broad casted method of crop establishment (8.0, 5.52 & 5.32) as compared to manual line sowing and seed drill sowing (5.25, 4.56 & 4.26). Similarly, lengthier ear head was observed (20.7, 19.3 & 20.3 cm) in manual broad casted method over rest of the treatments. Significant variation in ear head number and tillering efficiency was observed between foliar nutrition and inter cropping. Higher grain yield of both base and inter crop was higher under mechanized plot with less cost of cultivation which leads to higher net returns and benefit cost ration. The next beast treatment was manual line sowing and lowest yield was recorded under manual broadcasting which might be due to less population load per unit area. Regarding iner cropping field bean recorded higher productivity and gave higher net returns with short span of time as compared to redgram. Higher growth attributing characters, yield attributes and yield were higher under panchagavya @ 3.0 per cent sprayed field over FAA @ 2.0 per cent spray.

Table 1. Pooled data on the effect of crop establishment, inter cropping and foliar nutrition on growth characters of Tenai (ATL 1) during Summer 2023 season

Treatments	Germination (%)			Crop establishment rate (days)			Plant height (cm)		
	CBE	Paiyur	ATL	CBE	Paiyur	ATL	CBE	Paiyur	ATL
$M_1S_1F_1$	87.7	86.6	93.3	10.3	9.53	5.67	133	130.9	136.6
$M_1S_1F_2$	85.3	86.2	91.0	10.0	9.10	6.00	135	132.6	140.1
$M_1S_2F_1$	85.3	85.4	92.3	9.33	8.63	5.33	130	134.5	141.6
$M_1S_2F_2$	86.7	86.5	90.0	10.3	9.37	6.00	131	132.5	136.6
$M_2S_1F_1$	87.7	86.1	90.0	10.7	5.30	5.00	105	125.9	129.1
$M_2S_1F_2$	86.0	86.2	87.3	4.67	5.50	5.00	109	124.3	127.4
$M_2S_2F_1$	87.0	86.2	89.3	5.00	5.03	5.00	121	124.5	128.0
$M_2S_2F_2$	84.7	85.7	89.3	5.00	5.57	5.00	123	125.3	126.6
$M_3S_1F_1$	86.3	86.5	90.3	4.33	4.83	4.33	141	135.2	133.7
$M_3S_1F_2$	86.7	87.3	90.0	4.33	4.73	5.00	136	135.9	134.3
$M_3S_2F_1$	87.0	85.5	91.3	4.67	4.70	4.33	135	136.8	137.0
$M_3S_2F_2$	85.7	86.2	90.3	4.67	4.73	4.33	130	137.5	137.3
Mean									
SD (P)	86.3	86.15	9.16	10.0	9.15	5.75	132	132.6	138.7
MBC (NP)	86.3	86.05	89.0	6.33	5.35	5.00	114	125.0	127.7
MLS (NP)	86.4	86.37	90.5	4.50	4.75	4.50	135	136.5	135.5
T+FB	86.8	86.05	91.1	7.38	6.33	4.94	127	131.3	134.3
T+RG	85.8	86.35	89.6	6.50	6.50	5.22	127	131.3	133.7
PK	86.6	86.46	90.0	7.38	6.50	5.16	126	130.8	133.5
FAA	86.1	85.99	90.4	6.50	6.34	5.00	128	131.9	134.5
CD (p=0.05)									
Sowing	2.10	1.025	2.45	0.57	0.22	0.39	5.48	1.38	7.18
Inter crop	1.72	0.837	2.00	0.46	0.18	0.32	4.47	1.13	5.86
Foliar	1.45	0.574	2.02	0.32	0.20	0.29	4.38	0.67	4.01

Table 2. Pooled data on the effect of crop establishment, inter cropping and foliar nutrition on yield attributing characters of Tenai (ATL 1) during Summer 2023 season

Treatments	No. of tillers/plant			Ear head length (cm)		
	CBE	Paiyur	ATL	CBE	Paiyur	ATL
$M_1S_1F_1$	5.33	3.6	3.90	18.2	17.6	18.40
$M_1S_1F_2$	5.67	4.6	4.20	18.7	17.2	18.47
$M_1S_2F_1$	4.67	3.5	3.77	18.8	17.3	18.77
$M_1S_2F_2$	5.33	3.5	3.90	18.3	17.3	18.47
$M_2S_1F_1$	8.67	5.3	5.47	20.3	20.2	21.00
$M_2S_1F_2$	7.67	5.4	5.20	20.7	18.4	21.23
$M_2S_2F_1$	8.67	5.4	5.30	20.2	19.4	19.50
$M_2S_2F_2$	7.00	6.0	5.33	21.7	19.3	19.67
$M_3S_1F_1$	5.33	4.8	4.57	18.7	16.8	17.97
$M_3S_1F_2$	5.33	4.6	4.37	18.3	16.6	17.80
$M_3S_2F_1$	5.33	4.4	4.13	18.0	17.3	17.50
$M_3S_2F_2$	5.00	4.4	4.00	17.7	17.4	16.80
Mean						
SD (P)	5.25	3.80	3.94	18.5	17.3	18.5
MBC (NP)	8.00	5.52	5.32	20.7	19.3	20.3
MLS (NP)	5.25	4.56	4.26	18.2	17.0	17.5
T+FB	6.33	4.51	4.16	19.0	18.1	18.8
T+RG	6.00	4.75	4.40	19.2	17.7	18.7
PK	6.33	4.72	4.52	19.1	17.8	19.1
FAA	6.00	4.53	4.50	19.1	18.0	18.4
CD (p=0.05)						
Sowing	0.63	0.29	0.43	1.07	0.79	1.15
Inter crop	0.52	0.23	0.35	0.87	0.64	0.94
Foliar	0.57	0.24	0.29	0.63	0.51	0.60

T2-46
Enhancing the productivity of Tenai through dry farming techniques

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Abstract

An experiment was conducted at Dryland Agricultural Research Station Experimental Farm, Chettinad during *Kharif* 2014 season to find out the effect of soil moisture conservation to enhance the productivity of tenai variety CO 7 through reuse of rain water. The experiment consisted of following treatments *viz*., T1. Irrigation at Primordial Formation, T2. Irrigation at flowering, T3. Irrigation at Primordial Formation and flowering and T4.Control (without supplemental irrigation). The results revealed that that Irrigation at Primordial Formation and flowering stage had recorded the highest grain (1239 kg/ha) and fodder yield (2438 kg/ha) and gave maximum gross return (Rs.49560/ha), net return (Rs.27620/ha) and benefit cost ratio of 2.26 as compared to rest of the treatments.

Introduction

Foxtail millet (*Setariaitalica*) is one of the main antiquity crop mainly grown in semi arid region by disadvantaged groups including small and marginal holders for their livelihood security. It has the ability to withstand severe drought, matures earlier, require very minimum external inputs, free from biotic and abiotic stresses and produce the reasonable yield even under marginal resources. It is highly resilient in adapting to different agro ecological situations and ideal crop for climate change and contingency planting. Its grain has unique nutritional properties *viz*., high fibre, protein, minerals, vitamins and also possesses special health benefitting properties desired by people who suffering from life-style diseases like obesity and diabetes.

Materials and Methods

An experiment was conducted at Dryland Agricultural Research Station Experimental Farm, Chettinad during *Kharif* season to find out the effect of soil moisture conservation to enhance the productivity of tenai variety CO 7 through reuse of rain water. The experiment consisted of following treatments *viz*., T1.Irrigation at Primordial Formation, T2. Irrigation at flowering, T3.Irrigation at Primordial Formation and flowering and T4.Control (without supplemental irrigation). The trial was laid out in a Randomized block design with four replications. The short duration variety CO 7 was chosen for this study. The crop was sown on 27.08.2014 by manual pre monsoon seeding with a spacing of 22.5 cm X 10 cm. The biometric observations recordedduring the croppingperiodwere days to 50 % flowering, days to maturity, No. of productive tillers, ear head length (cm), grain yield (kg/ha), fodder yield (kg/ha), test weight (1000 g) besides recorded total rainfall (mm), soil moisture at fortnightly intervals, cost of cultivation (Rs/ha), gross income (Rs/ha) and benefit cost ratio (Rs/ha). The crop was harvested manually on 26.11.2015.

The soils of experimental field represent the red sandy loam type. The available nutrient status of the field was low in N (161 kg ha^{-1}), medium in phosphorus (21 kg ha^{-1}) and low in potash (149 kg ha^{-1}). The germination percentage of seed was 99 per cent. Soil moisture was measured using soil moisture pulse meter (Model MPM-160 B) at fortnight interval. The recommended doses of organic manure as FYM @ 5.0 t ha^{-1} and inorganic fertilizers were applied along the planting rows through Urea, DAP and Muriate of Potash and covered with soil. The plant protection measures were adopted as per the technical programme. The total number of productive tillers, ear head length, test weight from five plants were counted and mean arrived. Grains from each treatment were randomly selected and thrashed. The harvested grains from the net plot were sun dried, cleaned and the grain yield was recorded for the individual treatment after drying to 12 per cent seed moisture and expressed in kg ha^{-1}.

Yield and yield attributing characters:The results revealed that among the different supplementary irrigation evaluated, the highest growth parameters such as no. of productive tillers, ear head length (cm), grain yield (kg/ha), fodder yield (kg/ha) and test weight (1000 g) were higher with Irrigation at Primordial Formation and flowering followed by Irrigation at Primordial Formation. The lowest values of these parameters were observed in control (without supplementary irrigation). With respect to days to 50 % flowering and days to maturity, the crop attained 50 percent flowering at 45 DAS and matured 14 days earlier under the treatment Irrigation at Primordial Formation and flowering as compared to control (without supplementary irrigation). The next best treatment was Irrigation at Primordial Formation. The same trend was observed for gross return and benefit cost ratio.

From this study, it could be concluded that Irrigation at Primordial Formation and flowering stage had recorded the highest grain (1239 kg/ha) and fodder yield (2438 kg/ha) and gave maximum gross return (Rs.49560/ha), net return (Rs.27620/ha) and benefit cost ratio of 2.26 as compared to rest of the treatments.

Table 1. Effect of different *in situ* soil moisture conservation techniques on growth, yield attributes and yield of Tenai variety CO 7 under rainfed condition

Treatment details	Days to 50 % flowering	Days to maturity	No. of Productive tillers	Ear head length (cm)	Test weight (g)	Grain yield (kg/ha)	Fodder yield (kg/ha)
T1.Irrigation at Primordial Formation	48	85	12.1	21.8	2.73	1029	2195
T2. Irrigation at flowering	51	90	11.6	20.0	2.65	990	1974
T3.Irrigation at Primordial Formation and flowering	45	81	13.4	22.0	2.96	1239	2438
T4.Control (without supplemental irrigation)	56	95	7.4	17.6	2.56	749	1240
SEd.	-	-	0.36	0.53	0.17	88.3	117.8
CD ($P \leq 0.05$)	-	-	0.79	1.16	0.37	192.5	256.7

Table 2. Effect of different *in situ* soil moisture conservation techniques on economics of Tenai variety CO 7 under rainfed condition

Treatment details	Cost of Cultivation (Rs/ha)	Gross Income (Rs/ha)	Benefit Cost Ratio (Rs/ha)
T1.Irrigation at Primordial Formation	21595	41160	1.91
T2. Irrigation at flowering	21595	39600	1.83
T3. Irrigation at Primordial Formation and flowering	21940	49560	2.26
T4. Control (without supplemental irrigation)	21250	29960	1.41

T2-47

Effect of different land configuration on soil moisture, growth and yield of Foxtail Millet (*Setaria italica*) under rainfed alfisols

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Abstract

Experiment was conducted to study the effect of different moisture conservation practices on soil moisture, growth and yield of foxtail millet under rainfed alfisol during *Kharif* season. The experiment consisted of seven treatments *viz*., T_1 Broad Bed and Furrow, T_2 Compartmental Bunding, T_3 Ridges and Furrows, T_4 Tied Ridges, T_5 Basin Listing, T_6 Vertical Mulching and T_7 Flat Bed. The soil moisture content ranges from 0.4 per cent to 17.2 per cent and the highest soil moisture of 17.2 per cent was recorded during flowering stage of the crop growth under tied ridges followed by ridges and furrows (15.5 per cent).The results on yield attributing characters and yield revealed that crop grown under tied ridges followed by ridges and furrows attained fifty per cent flowering stage at 45 DAS and physiologically matured 10 days earlier as compared to other moisture conservation practices. Significantly higher productive tillers plant^{-1}(16.4), ear head length (22.2 cm)and test weight (3.06 g) were registered with tied ridges treatment and the next best treatment was ridges and furrows. Similarly, grain was significantly higher in tied ridges though it was at par with ridges and furrows and compartmental bunding. Whereas, green fodder yield was significantly higher in tied ridges (6654 kg ha^{-1}) and the next best treatments were ridges and furrows and compartmental bunding. Higher gross returns (Rs 84465 ha^{-1}), returns above variable cost (Rs. 60965 ha^{-1}) with a benefit cost ratio of 3.6 were recorded with tied ridges.

Keywords: Soil moisture, drought, in situ, grain and green fodder yield

Introduction

Recurrently, rainfall becomes an important constraint for crop production in Semi arid regions of India, this region has low rainfall, high evaporation and low water use efficiency. In order to reduce evaporation, conserving soil moisture and ensuring the crop productivity moisture conservation practices has been used as means of conserving soil and water resources for productivity enhancement of dry land crops. However, the effectiveness of conservation tillage depends on soil type, climate, and land slope (Lampurlanes *et al*., 2002). Foxtail millet (*Setaria italica*) is one of the main antiquity crop mainly grown in semi arid region by disadvantaged groups including small and marginal holders for their livelihood security. It has the ability to withstand severe drought, matures earlier, require very minimum external inputs, free from biotic and abiotic stresses and produce the reasonable yield even under marginal resources. It is highly resilient in adapting to different agro ecological situations and ideal crop for climate change and contingency planting. Its grain has unique nutritional properties *viz*., high fibre, protein, minerals, vitamins and also possesses special health benefitting properties desired by people who suffering from life-style diseases like obesity and diabetes.

However, the productivity in semi arid region is often limited by either early or terminal drought (Pan *et al*., 2012).The major reason for low productivity in foxtail millet is that it is being cultivated in marginal soils under scarcity conditions and non-adoption of improved management practices. Foxtail millet responds well to improved agronomic practices consisting of land configuration, timely sowing with optimum density and weeding and thus crop management strategies should be prioritized to identify the location specific crop production techniques. Hence, the present investigation was carried out to find out most efficient in-situ soil moisture conservation practices for maximizing the productivity of foxtail millet under rainfed condition.

Materials and Methods

Field experiment was conducted at Dryland Agricultural Research Station Experimental Farm, Chettinad during *Kharif* season to find out the effect of different in-situ moisture conservation techniques for enhancing the productivity of foxtail millet under rainfed condition. The experiment consisted of the following treatments such as T_1 Broad Bed and Furrow, T_2 Compartmental Bunding, T_3 Ridges and Furrows, T_4 Tied Ridges, T_5 Basin Listing, T_6 Vertical Mulching and T_7 Flat Bed. The trial was laid out in Randomized block design with four replications. The different soil moisture conservation practices such as broad bed and furrow (105 cm width and 50 cm furrow depth), compartmental bunding (8x5m), ridges and furrows (25x15cm), tied ridges (25x15 cm) at 60 cm intervals, basin listing (25x15 cm), vertical mulching (25x30cm) were formed on 26.08.2014 with residual soil moisture and these treatments were compared with flat bed. The soils of experimental field represent the red sandy loam type. The available nutrient status of the field was low in N (165 kg ha^{-1}), medium in phosphorus (22 kg ha^{-1}) and medium in potash (197 kg ha^{-1}).The seeds of short duration variety CO 7 were sown by manual pre monsoon seeding with a spacing of 22.5x10 cm. Required plant population was maintained by thinning at 15 days after sowing (DAS). Soil moisture was measured using soil moisture pulse meter (Model MPM-160 B) at fortnightly interval. The recommended doses of organic manure as FYM @ 12.5.0 t ha^{-1} including inorganic fertilizers (44:22 kg NP ha^{-1}) were applied along the planting rows as urea and diammonuim phosphate and covered with soil. Nitrogen was applied in two splits at 20 and 40 DAS and whole amount of phosphorus was applied as basal. All other plant protection measures were adopted as per the technical programme.

Results and Discussion

Effect of moisture conservation practices on productivity of foxtail millet: Moisture conservation practices had significant influence on days to fifty per cent flowering and days to maturity as evidenced from the results of the experiment which revealed that crop grown under tied ridges followed by ridges and furrows attained fifty percent flowering stage at 45 DAS and physiologically matured 10 days earlier as compared to other moisture conservation practices.

With reference to number of productive tillers $plant^{-1}$, significant difference was noticed among the moisture conservation practices and the highest productive tillers $plant^{-1}$ of 16.4 was registered with tied ridges treatment. The next best treatment was ridges and furrows which was observed to be on par with compartmental bunding. The lowest value of this parameter was noticed under broad bed and furrow treatment followed by flat bed. Among the different moisture conservation practices evaluated, tied ridges had the highest ear head length of 22.2 cm followed by ridges and furrows(20.2 cm) however, it was at par with compartmental bunding (19.8 cm) and vertical mulching treatments (19.6 cm).

Moisture conservation practices had exhibited significant variation on test weight and highest values of these parameters were registered with tied ridges though (3.06 g) it was observed to be at par with other insitu moisture conservation practices except flat bed and broad bed and furrow system. The better growth, yield attributing characters in tied ridges treatment was apparently due to favorable physical environment for the increased mineralization and mobility of applied fertilizers by reducing the runoff and enhancing the infiltration rate of the soil which resulted in higher moisture retention capacity as compared to other treatments (Singh *et al*., 2013).

Similarly, grain was significantly higher in tied ridges though it was at par with ridges and furrows and compartmental bunding. Whereas, green fodder yield was significantly higher in tied ridges (6654 kg ha^{-1}) and the next best treatments were ridges and furrows and compartmental bunding. This was mainly due to increased water holding capacity with increased availability of the applied nutrient in the soil which in turn increased the nutrient uptake and photosynthetic efficiency, thus leading to early flowering, higher productive tillers $plant^{-1}$, ear head length and test weight, resulted in higher grain and green fodder yield as envisaged in the investigation (Khurshid *et al*., 2006 and Yadav, 2010).

Effect of moisture conservation practices on profitability of foxtail millet: Cost of cultivation, gross returns, net returns and benefit cost ratio varied among the different moisture conservation practices (Table 4) and the results revealed that the lowest cost of cultivation of Rs. 23500 ha^{-1}, higher gross returns (Rs 84465 ha^{-1}), returns above variable cost (Rs. 60965 ha^{-1}) with a benefit cost ratio of 3.6 were recorded with tied ridges. The next best treatment was ridges and furrows which recorded cost of cultivation of Rs. 23000 ha^{-1}, gross returns of Rs 78570 ha^{-1}, net returns of Rs. 55570 ha^{-1} with a benefit cost ratio of 3.4. Lowest values of these parameters were noticed under broad bed and furrow and flat be system.

From this study, it could be concluded that soil moisture conservation practices such as tied ridges and ridges and furrowsproved to be the best agronomic management practices for higher productivity an economic returns besides conserving soil moisture.

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Table 1. Effect of different insitu soil moisture conservation techniques on growth and yield attributing characters of foxtail millet variety CO 7 under rainfed condition

Treatment	Days to 50% flowering	Days to maturity	Productive tillers plant^{-1}	Ear head length (cm)	Test weight (g)
Broad Bed and Furrow	54	91	8.4	17.2	2.57
Compartmental Bunding	49	91	14.4	19.8	2.95
Ridges and Furrows	45	80	14.8	20.2	2.99
Tied Ridges	45	80	16.4	22.2	3.06
Basin Listing	54	91	10.8	18.4	2.75
Vertical Mulching	52	91	11.3	19.6	2.85
Flat Bed	52	91	10.1	17.6	2.65
S.Em±	1.22	1.83	0.37	0.49	0.17
CD (P=0.05)	2.56	3.85	0.81	1.07	0.38

Table 2. Effect of different insitu soil moisture conservation techniques on yield and economics of foxtail millet variety CO 7 under rainfed condition

Treatment	Grain yield (kg ha^{-1})	Fodder yield (kg ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Gross Income (Rs ha^{-1})	Net Income (Rs ha^{-1})	BCR (Rs ha^{-1})
Broad Bed and Furrow	799	4412	23500	35955	12455	1.5
Compartmental Bunding	1737	5772	22750	78165	55415	3.4
Ridges and Furrows	1746	5982	23000	78570	55570	3.4
Tied Ridges	1877	6654	23500	84465	60965	3.6
Basin Listing	1426	4851	23000	64170	41170	2.8
Vertical Mulching	1447	4912	24500	65115	40615	2.7
Flat Bed	1140	4456	22750	51300	28550	2.3
S.Em±	86.8	200.9	-	-	-	-
CD (P=0.05)	189.2	437.8	-	-	-	-

T2-48

Crop diversification with short duration Tapioca (Vellayani Hraswa) in millet based cropping system for increasing the crop productivity and economic feasibility

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Abstract

Crop diversification within multiple-cropping and intercropping systems provides an alternate, sustainable crop production method with the potential to significantly reduce ecological impact and maximize productivity and nutritional security. Cassava is considered to be a “climate-smart” crop that can yield well in challenging environments. Cassava monocropping was shown to decrease soil organic matter (SOM) after 4 years and also resulted in decreased available soil phosphorus (P) levels. Since cassava is 10 to 11 months crop, no other crop can be grown in between due to less crop interval. With this background it was decided to go for diversification with short duration (6-7 months) cassava variety, vellayani hraswa in millet based cropping system in farmers field at Andipatti hills of Theni district during 2019-2021.

Keywords : Sorghum, Tapioca, Cropping system, productivity, economics

Introduction

The Hills of Andipatti is found towards the south of Palghat gap in the western ghats range in Theni district. With climate change fluctuations, the livelihoods of small and marginal farmers practicing subsistence agriculture have become highly vulnerable in this region (Anon,2012). The change in climate particularly in rainfall patterns and temperature has destabilized agricultural productivity, affecting the livelihoods, food security, income and health of the small farmers families.

The slopy upland which is mainly rainfed in this region is affected in many ways due to climate change in terms of delayed and untimely rains, long dry spells and deficit rainfall. Also, early exit of North east monsoon season which is the major source of rainfall also limits the scope of Rabi crops. The seasonal crops like vegetables *viz*., onion, tomato, brinjal and flower crops find place instead of crops high water requiring crops like rice, banana, sugarcane and cotton in the cropping pattern now a days. Owing to the reason of mixed culture with that of the adjoining regions of Kerala state where tapioca is being one of the principal food crops, inclusion of this crop as an edible crop either as vegetable or as snacks items is very common in this region. Farmers used to grow a bits of setts of traditional Tapioca varieties mostly taken from local types or from Kerala state which are low in yield, with long duration even though they are amenable for rainfed cultivation or with subsistence irrigation. Tapioca was found to be a better intercrop with finger millet (Dharam Singh Meena, 2017).

Though millet crops like maize, sorghumand small millets have been grown in this district since long back, introduction of vegetables has increased since last one to two decades. But, still there exist the cropping systems like sorghum - sorghum, maize-maize, especially for the purpose of meeting the demands of green and dry fodders for the growing dairy animal population in this region, since dairy rearing gives marked percentage of farm income. In this background, an attempt was made to introduce the short duration Tapioca variety *Vellayani Hraswa in the millet based cropping system as a* pioneer research programme to promote indtroduction of short duration Tapioca as a potential crop to get increased income income in sorghum based cropping system. The study was conducted in farmers holdings at Ethakovil village of Andipatti block in Theni district during 2019-2021.

Materials and Methods

This study was initiated in four farmers fields in Andipatti block of Theni district. These farm households largely depended on irrigated uplands which are partially depended on rainfall. The average size of landholding was1.0 acres to 2.0 ha which are low, medium and medium in the available N, P and K status of soil fertility, respectively. These farm holds were traditionally following sorghum- sorghum cropping system. Cultivation of short duration tapioca which have potential to cope with the climatic fluctuations and ensuring food and fodder requirements of these farm holds were studied. The performance of short duration cassava variety, Vellayani hraswa under sorghum based cropping system was evaluated for growth parameters and yield parameters and economics was worked out.

Results and discussion

The results revealed that the sorghum-tapioca system was produced comparatively more average sorghum equivalent yield (18,050 kg/ha) when compared to that of sorghum - sorghum system (8950 kg/ha). The net come (Rs.2,85,250/ha) and benefit cost ratio (BCR)(3.77) realized from sorghum-tapioca system were comparatively higher than that of sorghum-sorghum system which has given a net income of Rs. 1,37,500 /ha and BCR of 2.39.

Hence, it is concluded that short-duration (6-7 months) cassava provides opportunities to small holding farmers for effective utilization of resources such as land, moisture and nutrients with diversification of crops for increasing the crop productivity and economic feasibility of sorghum based cropping system in Andipatti hill area of Theni district.

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Table 1. Comparative performance of sorghum based sequential cropping systems (Mean of four farm holdings)

Treatments	Cassava yield (kg /ha)	Sorghum grain yield (kg/ha)	Sorghum grain equivalent yield (kg/ha)	Gross income (Rs./ha)	Cost of cultivation (Rs./ha)	Net income (Rs./ha)	BCR
Cassava cv. (Vellayani hraswa)-sorghum	28500	3800	18050	361000	75750	285250	3.77
Sorghum - Sorghum	-	8950	8950	195000	57500	137500	2.39

T2-49

Fertilizer Prescription for Targeted Yield of Hybrid Maize and Sustenance of Soil Fertility under Drip Fertigation

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Abstract

Applying excessive quantities of fertilizers ignoring the soil nutrient status and crop nutritional requirements had a negative impact on soil health. Maize is the most versatile crop with diversified uses. The present study was carried out to evaluate the effect of application of fertilizers and manures by adopting different approaches *viz.,* STCR-NPK alone and STCR-IPNS for different yield targets, blanket recommendation and farmer's practice on maize grain yield and post harvest soil fertility. Soil Test Crop Response Integrated Plant Nutrition System (STCR-IPNS) based fertilizer prescription equations developed for desired yield target of hybrid maize under drip fertigation on Palaviduthi soil series (Typic Rhodustalf) of Tamil Nadu were used for calculating fertilizer doses. Three field experiments were conducted at farmer's holdings in Dindigul District during 2022-23. Entire P was applied as basal, N and K were applied through fertigation using urea and muriate of potash. Plot wise grain yield was recorded and post harvest soil samples were analysed for soil available N, P and K. Mean grain yield of maize was highest with STCR-IPNS-10 t ha^{-1} (9.69 t ha^{-1}) and the increase of yield in STCR-IPNS-10 t ha^{-1} was 35.5 per cent over blanket (RDF alone), 15.1 per cent over blanket + FYM and 58.3 per cent over farmer's practice. Post harvest soil fertility status was maintained in STCR-IPNS as compared to STCR-NPK alone. STCR IPNS based fertilizer prescription for desired yield target not only increased the yield but also helps to maintain the post harvest soil fertility status.

Keywords : STCR IPNS equations, hybrid maize, drip fertigation, Palaviduthi soil series, grain yield, post harvest soil fertility

Introduction

Efficient utilization of resources including fertilizers is essential for sustainable crop production. Preventing the deterioration of soil health due to indiscriminate and imbalanced use of fertilizers is possible only when fertilizers are prescribed based on soil testing. Maize, known as the 'Queen of cereals' occupies third position in production next to wheat and rice in the world. It is grown in an area of 9.47 million hectares with a production of about 28.72 million tonnes and productivity of 3032 kg ha^{-1} in India. In Tamil Nadu, it is grown in an area of 0.34 million hectares with a production of 2.64 million tonnes and productivity of 7744 kg ha^{-1} (http://agricoop.nic.in).

Soil Test Crop Response Integrated Plant Nutrition System (STCR-IPNS) based fertilizer prescription for desired yield target of hybrid maize under drip fertigation was developed on Palaviduthi soil series (Typic Rhodustalf) of Tamil Nadu. The present study was carried out to evaluate the effect of application of fertilizers and manures by adopting different approaches *viz.,* STCR-NPK alone and STCR-IPNS for different yield targets, blanket recommendation and farmer's practice on maize grain yield and post harvest soil fertility.

Materials and Methods

Three field experiments were conducted with TNAU maize Hybrid CO 6 and maize hybrid ZEA-100 at farmer's holdings in C.K. Valasu (L1), Poolampatti (L2) and Esakkampatti (L3), Dindigul District during 2022-23. The experimental soils were red, non calcareous, sandy loam soils belonging to Palaviduthi series (Typic Rhodustalf). There were ten treatments viz., Blanket (RDF alone), Blanket (RDF+ FYM @ 12.5 t ha^{-1}), STCR - NPK alone - 8 t ha^{-1}, STCR - NPK alone - 9 t ha^{-1}, STCR - NPK alone - 10 t ha^{-1}, STCR - IPNS - 8 t ha^{-1}, STCR - IPNS - 9 t ha^{-1}, STCR - IPNS - 10 t ha^{-1}, Farmer's Practice and absolute control. Based on the initial soil test values of available N, P, K and yield targets aimed, fertilizer doses were calculated using the fertilizer prescription equations. For IPNS treatments, 12.5 tonnes of FYM were applied basally and fertilizer N, P_2O_5, K_2O doses were adjusted accordingly.

Fertilizer prescription equations used for calculating fertilizer doses

STCR – NPK alone	STCR – IPNS (NPK + FYM)
FN = 3.15 T – 0.68 SN	FN = 3.15 T – 0.68 SN – 0.68 ON
FP_2O_5 = 1.53 T – 2.15 SP	FP_2O_5 = 1.53 T – 2.15 SP – 0.62 OP
FK_2O = 1.58 T – 0.26 SK	FK_2O = 1.58 T – 0.26 SK – 0.51 OK

where, FN, FP_2O_5 and FK_2O - fertiliser N, P_2O_5 and K_2O in kg ha^{-1} respectively; T - Grain yield target in q ha^{-1}; SN, SP and SK - soil available N, P and K in kg ha^{-1} respectively; ON, OP and OK are N, P and K supplied through FYM in kg ha^{-1}, respectively.

Entire P was applied as basal, N and K were applied through fertigation using urea and muriate of potash as per the fertigation schedule. Plot wise grain yield was recorded and post harvest soil samples were analysed for soil available N, P and K.

Results and Discussion

The experimental soils in all three locations were low in available nitrogen (N), high in available phosphorus (P) and medium in available potassium (K). Range of fertilizer doses applied in three locations and maize grain yield obtained are furnished in Table 1.

The highest grain yield of maize 9.71, 9.88 and 9.48 t ha^{-1} was recorded with STCR-IPNS-10 t ha^{-1} at C.K. Valasu (L1), Poolampatti (L2) and Esakkampatti (L3), respectively. Mean grain yield of maize was highest with STCR-IPNS-10 t ha^{-1} (9.69 t ha^{-1}) and the increase of yield in STCR-IPNS-10 t ha^{-1} was 35.5 per cent over blanket (RDF alone), 15.1 per cent over blanket + FYM and 58.3 per cent over farmer's practice. Higher seed yield with STCR-IPNS treatment over blanket dose of fertilizers was reported in Glory Lily on Alfisol (Sellamuthu *et al*., 2020) in Pearl millet. Farmer's practice recorded relatively lower yield as compared to blanket and STCR treatments.

Despite higher removal of nutrients, the fertility status was maintained in STCR-IPNS as compared to STCR-NPK alone. This could be due to the prevention of losses of nutrients under IPNS. Maintenance of soil fertility by adopting soil test based fertilizer prescription was reported by Ramamoorthy and Velayutham (2011) and Santhi *et al*. (2011).

To conclude, STCR IPNS based fertilizer prescription for desired yield target not only increased the yield but also helps to maintain the post harvest soil fertility status.

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Table 1. Fertilizer doses applied and maize grain yield in three locations

S. No.	Treatments	Fertiliser doses (kg ha^{-1})			Grain yield (t ha^{-1})			
		N	P_2O_5	K_2O	L1	L2	L3	Mean
T_1	Blanket (RDF alone)	250	75	75	7.15	7.32	6.98	7.15
T_2	Blanket (RDF+FYM @ 12.5 t ha^{-1})	250	75	75	8.61	8.32	8.33	8.42
T_3	STCR-NPK alone - 8 t ha^{-1}	149-162	58-73	79-85	7.66	7.70	7.37	7.58
T_4	STCR-NPK alone - 9 t ha^{-1}	181-194	73-88	95-100	8.74	8.57	8.36	8.56
T_5	STCR-NPK alone - 10 t ha^{-1}	212-225	89-104	111-113	9.58	9.46	9.25	9.43
T_6	STCR-IPNS - 8 t ha^{-1}	125	39-55	46-54	7.78	7.88	7.58	7.75
T_7	STCR-IPNS - 9 t ha^{-1}	145-154	54-71	61-69	8.87	8.85	8.62	8.78
T_8	STCR-IPNS - 10 t ha^{-1}	177-185	70-86	77-85	9.71	9.88	9.48	9.69
T_9	Farmer's practice	155-207	40-60	38-56	6.13	6.25	5.98	6.12
T_{10}	Absolute control	0	0	0	4.11	3.95	3.82	3.96

Table 2. Post harvest soil fertility as influenced by treatments in three locations

S. No.	Treatments	C.K.Valasu (L1)			Poolampatti (L2)			Esakkampatti (L3)		
		SN	**SP**	**SK**	**SN**	**SP**	**SK**	**SN**	**SP**	**SK**
1	Blanket (RDF Alone)	150	23.2	152	134	23.5	163	153	20.4	176
2	Blanket (RDF+FYM @ 12.5 t ha^{-1})	159	27.3	166	140	26.8	177	161	23.9	187
3	STCR- NPK alone- 8 t ha^{-1}	144	22.8	155	127	21.5	164	145	20.2	177
4	STCR- NPK alone- 9 t ha^{-1}	145	23.7	159	129	23.4	169	151	21.7	181
5	STCR -NPK alone-10 t ha^{-1}	149	25.8	164	133	25.7	173	153	23.4	185
6	STCR- IPNS - 8 t ha^{-1}	148	24.9	159	132	23.7	169	151	21.8	181
7	STCR- IPNS -9 t ha^{-1}	151	25.3	165	135	25.6	174	157	23.5	186
8	STCR- IPNS - 10 t ha^{-1}	156	27.4	169	137	27.3	178	159	25.2	189
9	Farmers practice	143	21.6	148	125	21.7	158	149	19.3	169
10	Control	132	20.2	139	116	19.9	150	134	17.8	160
	ISTV	149	25	161	132	25	171	151	23	181

* SN, SP and SK - soil available N, P and K in kg ha^{-1}, respectively ; ISTV – Initial Soil Test Values

T2-50

Growth and yield of sorghum (*sorghum bicolor*) as influenced by natural farming practices

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Abstract

A field study was conducted at Eastern Block Farm, Tamil Nadu Agricultural University, Coimbatore, during the late rabi season of 2021-22 to compare the effects of natural and organic farming systems on sorghum growth and yield. The experiment included three farming practices: Integrated Crop Management (ICM), Organic Farming (OF), and Natural Farming (NF). The randomized block design was used with three replications. Results showed significant differences in growth and yield among the farming practices. ICM had the highest plant height (212.6cm), Leaf Area Index (6.66), Dry Matter Production (7705 kg/ha), and yield (2495 kg/ha), followed by organic farming. Among the natural farming practices, Complete NF had the highest plant height (197.8 cm), LAI (4.24), DMP (6742 kg/ha), and yield (1878 kg/ha), while the remaining NF practices performed similarly to Complete NF.

Keywords: Natural Farming, Organic Farming, Growth, Yield

Introduction

Sustainable farming and nutrient management practices are essential for productive agriculture, but modern high-yield methods reliant on chemical fertilizers can harm the environment and soil quality. This has led to a growing global interest in environmentally friendly and sustainable natural and organic farming systems known for their production stability and soil health benefits (Mageshwaran et al., 2019). In India, sorghum is extensively cultivated, covering 4.39 million hectares with an annual grain production of 4.81 million tonnes and productivity of 1099 kg/ha. Maharashtra, Karnataka, and Madhya Pradesh are the leading states in sorghum production. Tamil Nadu contributes with 4.05 lakh hectares of sorghum cultivation, producing 4.27 lakh tonnes of grain annually, with a productivity of 1054 kg/ha (indiastat, 2021). Consequently, a field trial was conducted to evaluate different farming systems for late rabi sorghum.

Materials and Methods

A field study was conducted at the Eastern Block Farm of Tamil Nadu Agricultural University in Coimbatore to examine the impact of different farming systems on the growth and yield of late rabi sorghum. The soil analysis showed 0.64% organic carbon and an N: P_2O_5: K_2O ratio of 219:17:920 kg/ha. The experiment used a randomized block design with three replications. The study involved three farming practices: Integrated Crop Management (ICM), Organic Farming (OF), and Natural Farming (NF). Complete NF included ghanajeevamirit (G) as basal treatment, Beejamirit (B) seed treatment, jeevamirit (J) applied through irrigation water, intercropping (I) with pulses, and crop residue mulching (M). ICM used a mix of 50% organic and 50% inorganic nutrients, with pest management through biopesticides & chemicals. Organic farming used 50% nutrients from farmyard manure and 50% from vermicompost. Sorghum variety CO 32 was sown on January 29, 2022, with a spacing of 60 cm X 15 cm. Crop growth parameters, including plant height, leaf area index, dry matter production, and grain yield, were recorded at 30 DAS, 60 DAS, and during harvest. Statistical analysis was performed using R Software (Gopinath et al., 2021) with the grapesAgri1 package, Version 1.0.0.

Results and Discussion

Different farming systems significantly influenced the growth and yield of sorghum (Table 1 & Fig 1). The integrated farming system showed significant improvements in plant height (212.6 cm), Leaf Area Index (6.66), Dry Matter Production (7705 kg/ha), and grain yield (2495 kg/ha) compared to other systems. This was due to a combination of 50% inorganic fertilizer and 50% organic manures. However, plant height, leaf area index, dry matter production, and grain yield were comparable to those achieved with organic farming practices. Complete natural farming practices showed significantly higher growth and yield parameters compared to other methods. The superior results in plant height, leaf area index, dry matter production, and yield in organic and NF systems were attributed to specific nutrient provisions such as beejamirit, ghanajeevamirit, and jeevamirit in NF plots, as well as the use of farmyard manure (FYM) and vermicompost in organic plots. These practices ensured the timely release of nutrients, supporting crop growth through mineralization. Control plots exhibited lower plant height, leaf area index, and dry matter production, while NF plots without beejamirit, ghanajeevamirit, and jeevamirit recorded second lower values due to slow growth at initial stages and limited nutrient availability. (Kudari and Babalad, 2021).

Beejamirit, jeevamirit, and ghanajeevamirit have beneficial effects due to growth-promoting substances such as IAA, GA, cytokinins, enzymes, and nitrogen compounds. These components impact chlorophyll content, leading to a higher leaf area index. Consequently, the plant produces and accumulates more photoassimilates (Esakkiammal *et al.*, 2015). This application also increases dry matter production (DMP), resulting in taller plants, improved yield attributes, and higher crop yield overall.

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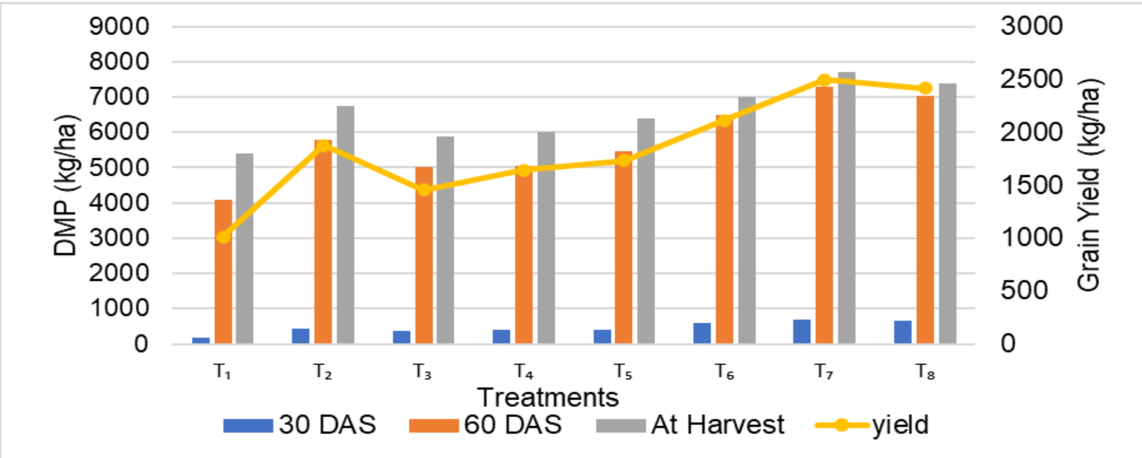
Table 1. Influence of Natural Farming Practices on Plant Height and LAI of Sorghum

Treatment	Plant height (cm)			Leaf Area Index		
	30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T_1- Control	33.8	135.1	160.5	0.37	3.85	2.53
T_2- Complete Natural Farming	43.3	160.4	197.8	0.47	4.85	4.24
T_3- NF (I+M)	39.2	156.5	171.3	0.43	4.19	2.81
T_4- NF (B+J+G+I)	40.4	154.3	170.3	0.46	4.47	3.39
T_5- NF (B+J+G+M)	41.5	156.3	197.5	0.46	4.72	3.50
T_6- Organic farming	45.6	175.0	201.6	0.48	5.20	5.15
T_7- ICM (organic pest management)	49.5	188.7	212.6	0.55	5.72	6.66
T_8- ICM (Chemical pest management)	48.3	182.7	207.8	0.54	5.61	6.23
SEd	3.75	17.38	16.55	0.04	0.43	0.43
CD (p=0.05)	8.04	30.44	35.50	0.09	0.92	0.91

Fig. 1. Influence of Natural Farming Practices on DMP and Grain Yield of Sorghum



T2-51

Response of groundnut –Finger Millet cropping system to applied nutrients and its impact on system productivity and profitability

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Abstract

In low rainfall zones, sustainable crop production method with the potential to significantly reduce ecological impact and maximize productivity and nutritional security. On farm research trials conducted to evaluate the response of groundnut- finger millet cropping system to applied plant nutrients in 12 farmers holdings at Mecheri block of Salem district showed that application of NPK +Zn recorded higher groundnut equivalent yield of 7,136 kg/ha/annum and the increase was 100 % over control in groundnut – finger-millet cropping system in low productive area of Mecheri block. This practice also recorded the highest net income of Rs.1,09,264/ha /annum.

Keywords: Groundnut, fingermillet, cropping system, productivity, economics

Materials and Methods

On farm research trials were conducted during 2020-21 to study the plant response to nutrients in groundnut -finger millet cropping system in 12 farmers holdings at Vellar, Bukkampatti and Olapatti villages of Mecheri Block in Salem District. The cropping system was Groundnut (*Kharif*) - finger millet (*Rabi*) in Mecheri block with the following set of treatments and fertilizer doses. The experiments were conducted in Randomized block Design replicated thrice. The treatments were $\mathbf{T_1}$ - Control (No NPK), $\mathbf{T_2}$ – Recommended level of N, $\mathbf{T_3}$ - Recommended level of N and P, $\mathbf{T_4}$ - Recommended level of N and K, $\mathbf{T_5}$ - Recommended level of N, P and K, $\mathbf{T_6}$ - Recommended level of N, P, K with Micro Nutrients and $\mathbf{T_7}$ - Farmers practice which was managed by the individual farmers. The dose of fertilizers adopted for component crops were, groundnut: RDF -25:50:75 kg/ha. Micronutrient - Borax: 10kg/ha, Farmer Practice (NPK) - 22:38:52 kg/ha and for fingermllet: Recommended Dose of NPK- 60:30:30kg/ha, Micro Nutrient- Zn SO_4: 37.5 kg/ha and Farmers practice - 55:23:26 kg/ha. The data on yield parameters were observed and economics of the cropping system was worked out.

Results and Discussion

In groundnut - Finger millet cropping sequence at Mecheri block, application of recommended dose of NPK (20:50:75 kg/ha for groundnut and 60:30:30 kg/ha for finger millet) along with micronutrient (Borax 10 kg/ha for groundnut and $ZnSo_4$ 12.5kg/ha (T_6) for finger millet) recorded the higher grain yields in both *kharif* and *Rabi* seasons due to the advantage of added macronutrients along with macronutrients as reported earlier(Christopher *et.al*., 2019; Vijayakumar, *et.al.,* 2020). This treatment recorded the highest total groundnut equivalent yield (7136kg/ha), Net return (Rs.1,09,264/-) and BC ratio of 7136 kg / ha and 1.41, respectively (Table 2).

The total N, P and K uptake were influenced by the treatments and balanced of N, P and K nutrients with micronutrients (Zn in maize and fingermillet and Borax in groundnut) recorded significantly higher uptake of N, P and K P and K) in both the seasons (Table 2).

From the results of this study, it was concluded that application of NPK +Zn recorded higher groundnut equivalent yield of 7,136 kg/ha/annum and the increase was 100 % over control in groundnut – finger-millet cropping system in low productive area of Mecheri. This practice also recorded the highest net income of Rs.1,09,264/ha /annum in groundnut-fingermillet cropping system.

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Table 1. Effect of nutrient application on grain yield and economics of Groundnut-Finger millet cropping system of Mecheri (Mean of 12 farmers)

Treatments	Grain Yield (Kg/ha)			Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	BC Ratio
	Kharif	Rabi *(GEY)	Total				
T_1 - Control	1033	2485	2474	69848	94566	24718	1.35
T_2 - N	1280	3088	3071	72983	116173	43190	1.59
T_3 - NP	1491	3819	3706	76037	138841	62804	1.83
T_4 - NK	1509	3905	3774	76873	145531	68658	1.89
T_5 - NPK	1786	4563	4433	80404	177485	97081	2.21
T_6- NPK + MN	1921	5010	4827	82608	195395	112787	2.37
T_7 - FP	1656	3972	3959	77626	159356	81730	2.05
CD p=0.05)	269	1269	846	-	-	-	

(GEY)- Groundnut Equivalent yield in terms of Finger millet crop, Groundnut pod- Rs. 54/kg, Finger millet grain- Rs. 29/ha

Table 2. Influence of Nutrient management practices on nutrient uptake (kg/ha) by crops under groundnut-fingermllet cropping sequence

Treatments	Groundnut (Kharif)			Fingermillet (Rabi)		
	N	**P**	**K**	**N**	**P**	**K**
Control	28.79	4.70	17.08	30.52	3.82	28.31
N	46.08	6.09	21.69	43.23	8.93	37.08
NP	58.74	10.95	26.18	53.20	8.38	54.64
NK	64.82	8.48	33.85	64.52	12.32	72.72
NPK	81.33	13.91	42.44	90.51	19.06	99.11
NPK + MN	91.68	15.70	48.92	96.82	18.49	97.76
FP	70.63	11.94	36.02	68.46	12.81	69.97
CD p=0.05)	9.90	1.83	6.62	20.91	3.05	19.93

T2-52

Potentials of agricultural residue derived smoke water on germination of Finger Millet (*Eleusine coracana L.*)

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Abstract

Plant derived smoke is a well-known agent for the promotion of plant growth and development. One pre-requisite for the application of plant derived smoke for enhancing seed germination and seedling growth is the use of smoke must be purely obtained from burning of plant material. It is a good substitute for traditional agricultural practices applied to enhance seed germination and plant growth as it is of low cost, easily approachable and of more useful method to obtain high yield. In this study, smoke water was collected from paddy straw in order to check the efficiency of seed gemination and growth of *Eleusine coracana.* (Variety TNAU *Ragi/Finger millet* Co 13).Gas Chromatography-Mass Spectrometry (GC-MS) analysis of smoke water revealed that the active compounds like9,12-Octadecadienoylchloride, (Z,Z), Hexadecanoic acid, methyl ester, Hexadecanoic acid, 1a,2,5,5a,6,9,10,10a-octahydro-5,5a-dihydroxy-4-(hydroxymethyl)-1,1,7,9-tetramethyl-11-oxo-1H-2, 8a methanocyclopenta[a] cyclopropa [e]cyclodecen-6-yl ester, [1aR-(1aa,2à,5á,5aá,6á,8aà,9à,10aà)], 9-Octadecenoic acid (Z)-, hexyl ester, Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester, Heptadecanoic acid, 16-methyl-, methyl ester, Oleic Acid, Glycidyl palmitate, Squalene, 9-Octadecenamide, (Z), Methyl stearate are present in the smoke water. The efficacy of paddy straw derived smoke water on finger millet germination was assessed through pot culture experiments. Among the various treatments imposed, the treatment which is having 1% of smoke water treatment (T_2) recorded the higher germination percentage (93%), root length (4.9 cm), shoot length (9.9cm) and vigor index (1376.40).Hence 1% of smoke water can be effectively utilized for treating the seeds to get higher yield.

Keywords: Agro-wastes derived smoke, seed germination, seedling vigour, Shoot &Root length

Introduction

Germination rate is significantly affected by several abiotic and biochemical factors. Plant derived smoke is a well-known agent for promoting plant growth and development and positively affects plant species from various habitats. The seed germination cues associated with fire or post-fire environments were identified as heat, temperature, chemicals, and smoke. On the other hand, smoke produced during fire was recognized as the major germination cue in post-fire environments. Despite its potential as a post fire cue for seed germination, burning of vegetation has many disadvantages. The negative impacts of the fire and smoke include killing the beneficial soil insects and microorganisms, loss of various minerals, and air pollution. The major factor contributing to air pollution due to vegetation burning is the addition of CO_2 to the environment. Compounds in smoke are stable at high temperatures, water soluble and very active even at low concentrations. The long lasting effectiveness of plant derived smoke solution ruled out the uncertainty about its storage period and made it more worthy in terms of its in time availability.

Plant derived smoke plays a vital role in enhancing the germination of many seeds of both agricultural and horticultural crops. One pre-requisite for the application of plant derived smoke for enhancing seed germination and seedling growth is the use of smoke must be purely obtained from burning of plant material (Elsadek and Yousef , 2019). This technology is a good substitute to traditional agricultural practices applied to enhance seed germination and plant growth in different plants and crops as it is of low cost, easily approachable and of more useful method to obtain high yield. In this study, smoke water was collected from paddy straw in order to check the efficiency of seed gemination and growth of finger millet(Variety TNAU *Finger millet* Co 13).

Materials and Methods

Smoke water was produced by burning 100 g of Paddy straw using the Bee smoker connected by a heater hose to the side arm flask containing 100 ml of distilled water. Side arm flask is further connected with vacuum aspirator for dissolving smoke into the water. The dried paddy straw was burnt in an opened smoker for 30 seconds, then the bee smoker lid was closed, and the tubing was attached to the opening of the smoker. The smoke was drawn through the water in the flask, dissolving the water-soluble compounds for 30 to 40 min. Once the process of burning the plant material was completed, the system was left to cool completely. After that, the smoke-water solution in the flask was ready to be used for further characterization and seed treatments. The efficacy of paddy straw derived smoke water on finger millet germination was assessed through pot culture experiments. Before sowing the seeds were treated with different concentrations of smoke water. The treatment details areT_1 – Control (Distilled water), T_2 - 1% smoke water, T_3 - 2% smoke water, T_4 - 4% smoke water, T_5 - 6% smoke water, T_6 - 8% smoke water and T_7 - 10% smoke water. The experiments comprise of 7 treatments, 3 replications under Completely Randomized Design (CRD).The germination percentage, Shoot length, Root length and ,Vigour index was recorded.

Results and Discussion

The pH of the smoke water is alkaline in nature (8.06) and Electrical Conductivity was non saline(0.01 dSm^{-1}).The Nitrogen content of the smoke water was 1.2% and Phosphorous and Pottasium content were 0.5% and BDL respectively. The total Magnesium, Sulphur, Lead, Sodium content was 0.98ppm, 1.2ppm, 0.2ppm, 0.92ppm respectively. Other total micronutrients like Calcium, Zinc, Copper, Chromium, Iron, Manganese, Cobalt was found to be Below Detectable Levels (BDL). Gas Chromatography-Mass Spectrometry (GC-MS) analysis of smoke water revealed that the active compounds like9,12-Octadecadienoylchloride, (Z,Z), Hexadecanoic acid, methyl ester, Hexadecanoic acid, 1a,2,5,5a,6,9,10,10a-octahydro-5,5a-dihydroxy-4-(hydroxymethyl)-1,1,7,9-tetramethyl-11-oxo-1H-2, 8a methanocyclopenta[a] cyclopropa [e]cyclodecen-6-yl ester, [1aR-(1aa,2à,5á,5aá,6á,8aà,9à,10aà)], 9-Octadecenoic acid (Z)-, hexyl ester, Hexadecanoic acid, 1-(hydroxymethyl)-1,2-ethanediyl ester, Heptadecanoic acid, 16-methyl-, methyl ester,Oleic Acid, Glycidyl palmitate, Squalene, 9-Octadecenamide, (Z), Methyl stearate are present in the smoke water.

Among the various treatments imposed, the treatment which is having 1% of smoke water treatment (T_2) recorded the higher germination percentage (93%), root length (4.9 cm), shoot length (9.9cm) and vigour index (1376.40) through germination and pot culture experiments respectively (Table.1).The application of low concentrations of smoke-water to stimulate germination seems to be positive as a result of the amounts of ethylene, gibberlic acid and butenolide in the smoke water. However, high concentrations of smoke water may have these same components of levels inhibitory to germination. Similar responce were recorded by Iqbal *et al.* (2016) who reported that smoke from burning plant material stimulated seed germination of numerous species worldwide. Furthermore, independent separation of promoting and inhibitory compounds is required for the explanation of their specific correlation with growth phenomena. Based on this information, plant-derived smoke applications should also be performed in the field condition before accepting them at a wide agricultural level to optimize their benefits.

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Table 1. Influence of smoke water on germination of finger millet under pot culture experiment

Treatments	Germination percentage	Root length (cm)	Shoot length (cm)	Vigour index
T_1 - Control	72.85	3.9	8.7	917.91
T_2 - 1% of smoke water	93.00	4.9	9.9	1376.40
T_3 - 2% of smoke water	90.24	4.6	9.5	1272.38
T_4 - 4% of smoke water	81.72	4.4	9.2	1111.39
T_5 - 6% of smoke water	75.36	4.2	9.0	994.75
T_6 - 8% of smoke water	72.20	3.8	8.6	895.28
T_7 - 10% of smoke water	69.17	3.4	8.4	876.20
Mean	79.2	4.2	9.0	1063.5

T2-53

Effect of quality seedlings produced through nutrient media in tray nursery and different level of nutrients on growth and yield of transplanted Finger Millet (*Eleusine coracana* L.)

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Abstract

Finger Millet, also known as Ragi is an important millet grown extensively in various regions of India and Africa. Finger millet Co (Ra) 15 variety was used for this experiment and the prime objective of the experiment was to find out the effect of nursery medium for the production of quality seedlings also, to determine the optimum age of seedlings and fertilizer level to attain maximum growth, yield attributes, yield and economics of transplanted finger millet. All the growth parameters and physiological parameters were significantly influenced by age of seedlings and different level of nutrients. On interaction effect, 15 days old seedlings raised from nutrient media with 125% RDF recorded higher growth and physiological parameters. Lower crop growth and physiological characters were obtained through planting of 21 days old seedlings raised from nutrient media combined with 75% RDF.It could be concluded that transplanting of 15 days old seedlings raised from nutrient media coupled with 100% RDF proved to be the most viable option for getting maximum productivity and profit in finger millet under irrigated condition.

Keywords: Nutrients, Seedlings, Growth parameters, Physiological parameters

Introduction

Finger millet popularly called as “the poor man’s crop”, is an annual and short-day plant for grain and fodder purposes. Method of sowing is critical for increasing the productivity of finger millet. The most practised crop establishment method in India is broadcasting and transplanting. Transplanted finger millet gives higher yield over the broadcasting and direct sown crop (Sarawale et al., 2016). The appropriate age of seedlings at transplanting is an important factor for increasing the performance and the yield of finger millet (Sarwar et al., 2011). The main reason for low productivity level of this crop is due to late transplanting of seedlings and little or no use of fertilizers (Ahiwale et al., 2011).Thus this study was undertaken to study the combined effect of nursery nutrient media along with age of seedlings and different levels of nutrients on growth and yield of transplanted finger millet.

Materials and Methods

To attain the objectives, field experiment was done by Co (Ra) 15 and laid out in split plot design with four main plots (Media with age of seedlings) and three subplots (Levels of inorganic fertilizers) and replicated thrice. The main plot consists of four different age of seedlings *viz*., 15, 18 and 21 days old seedlings raised from nutrient media (soil (70%) + well decomposed FYM (20%) + rice hull (10%) + DAP @ 7 g /tray + Azophos @14 g/tray +

vermicompost @100 g/tray) and simultaneously 17 days old seedlings also raised from conventional method. In subplot, three levels of RDF *viz*., 75, 100 and 125% were used.

Results and Discussion

The seedlings raised from nutrient media recorded higher germination percentage, shoot length, root length, shoot girth, root weight, root volume, fresh weight and dry weight of seedling than the seedlings raised from conventional method. Seedling vigour index was also higher in nutrient media seedlings. Among the different age of seedlings, 15 days old seedlings raised from nutrient media recorded higher growth and physiological parameters and it was on par with 18 days old seedlings raised from nutrient media. With regard to fertilizer levels, application of 125% RDF recorded higher crop growth and physiological parameters and it was statistically similar with 100% RDF. With respect to levels of fertilizer, higher yield attributes and yield were recorded with 125% RDF and it was par with 100% RDF. Consideration on interaction effect, higher yield attributes and yield were recorded with 15 days old seedlings raised from nutrient media along with 125% RDF which resulted in 15.4 percent increase in grain yield over farmers practice (17 days old seedlings raised from conventional method with 100% RDF). Transplanting of 15 days old seedlings raised from nutrient media noticed higher NPK uptake. On different age of seedlings, highest availability of nitrogen, phosphorus and potassium were observed at harvest with transplanting of 21 days old seedlings raised from nutrient media. Considering the integration of age of seedlings and different levels of fertilizer, 15 days old seedlings with 125% RDF showed higher growth and physiological parameters. Lower crop growth and physiological characters were obtained through planting of 15 days old seedlings raised from nutrient media combined with 75% RDF. Among the various treatments, 15 days old seedlings raised from nutrient media coupled with 125% RDF gave highest gross return (₹ 60514 ha^{-1}), net returns (₹ 40249 ha^{-1}) and B: C ratio (2.85).Lowest grass return (₹ 42027 ha^{-1}), net returns of (₹ 22566 ha^{-1}) and B: C ratio (2.13) was obtained with transplanting of 21 days old seedlings raised from nutrient media along with 75% RDF.

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Table 1. Different nutrient medium on seedling characteristics of transplanted finger millet

Seedling Characteristics	15 DAS		17 DAS		18 DAS		21 DAS	
	CM	NM	CM	NM	CM	NM	CM	NM
Germination Percentage	82	85	82	85	82	85	82	85
Shoot Length (cm)	12.5	13.8	13.2	14.8	15.1	15.2	15.9	17.1
Shoot girth (cm)	0.6	0.6	0.6	0.7	0.7	0.7	0.7	1.0
Root length (cm)	4.0	4.5	4.3	4.8	4.6	5.1	4.9	7.8
Root Weight (mg)	8.0	9.0	9.0	11.0	11.0	12.0	12.0	15.0
Root volume (cm^3)	0.5	0.8	0.7	1.0	1.1	1.3	1.6	1.9
Fresh weight of seedling (mg)	153	164	179	193	195	210	280	290
Dry weight of seedling (mg)	61	66	76	82	88	95	128	131
Seedling vigour index	1353	1556	1435	1666	1615	1726	1706	2117

NM- Nutrient media, CM- Conventional method.
*Data statistically not analysed

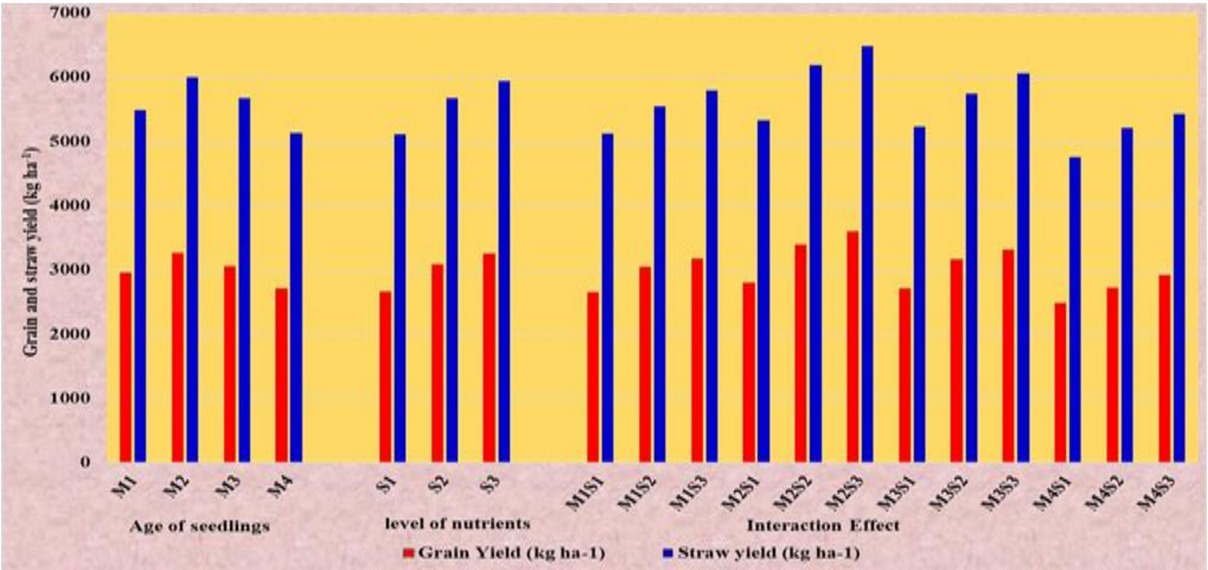

Fig 13. Age of seedlings and level of nutrients on grain and straw yield (kg ha^{-1}) of transplanted finger millet

T2-54
Effect of drip fertigation in Maize – Blackgram cropping system

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Abstract

Field experiments were carried out at Agricultural research Station, Tamil Nadu Agricultural University, Bhavanisagar to optimize the fertilizer level and form of fertilizers for maize – blackgram cropping system under drip fertigation. The experiment consisted of five treatments with two levels of recommended dose of fertilizer (RDF) viz., 100 per cent and 75 per cent by means of normal fertilizer and water soluble fertilizers (WSF) and drip irrigation with surface application of 100 per cent RDF. The experiment was laid out in Randomized Block Design with four replications. The cropping pattern followed was maize (*kharif*) – blackgram (rabi). Among the fertigation treatments studied, the drip fertigation with 100 per cent RDF as WSF recorded the highest yield parameters which were followed by drip fertigation with 75 per cent RDF as WSF and both the treatments were statistically on par. However, drip fertigation with 100 per cent RDF as WSF recorded significantly higher grain yield of 6144 kg ha^{-1} in maize and 807 kg ha^{-1} in black gram with total net income of Rs.50,473/- per ha for the cropping pattern as a whole.

Keywords: Maize – blackgram, cropping system, drip fertigation

Introduction

The demand for water is increasing in all sectors. More than 95 per cent of surface water and about 85 per cent of ground water are exploited in Tamil Nadu. Microirrigation has emerged as an appropriate water saving technique for row crops especially for wide spaced high value crops in water scarcity, undulated, sandy and hilly areas of India. By introducing drip with fertigation, it is possible to increase the yield potential by three times from the same quantity of water; and also by saving about 45 – 50 per cent of irrigation water and increasing the productivity of crops by about 40 per cent with saving of 30 per cent of fertilizers (Sivanappan, 2012). According to Agarwal (1973), multiple cropping was not only an important means of increasing food supply, but also an instrument for further economic utilization of available farm resources. Double cropping usually offers the potential to increase nitrogen (N) use efficiency in a multicrop sequence because the successive crops benefit from the residual N of the first crop (Clough *et al.*, 1990). Considering all these factors, the present study was conducted to determine the effect of different levels and form of fertilizers on productivity of maize-blackgram cropping system through drip fertigation.

Materials and Methods

Field experiments were carried out at Agricultural research Station, Tamil Nadu Agricultural University, Bhavanisagar to optimize the fertilizer levels and form of fertilizers for maize – blackgram cropping system under drip fertigation. The experiment was laid out in Randomized Block Design with four replications. The experiment consisted of five treatments *viz.*, drip Irrigation with surface application of 100 per cent RDF (T_1), drip fertigation with 100 per cent RDF – Normal fertilizers (T_2), drip fertigation with 100 per cent RDF – WSF (T_3), drip fertigation with 75 per cent RDF – Normal fertilizers (T_4) and drip fertigation with 75 per cent RDF – WSF (T_5). The cropping system followed was maize (kharif) – blackgram (*rabi)*.

Results and Discussion

Among the fertigation treatments studied, the drip fertigation with 100 per cent RDF as WSF (T_3) recorded the highest yield parameters which was followed by drip fertigation with 75 per cent RDF as WSF (T_5) and both the treatments were statistically on par. The lowest yield parameters were recorded by drip irrigation with surface application of 100 per cent RDF (T_1). Application of 100 per cent RDF and 75 per cent RDF as WSF through fertigation resulted in higher yield parameters. Better crop growth at recommended nutrient levels might have influenced the yield attributes favourably. Also, the nutrients were applied in adequate quantity and were in easily available form (WSF) which created more conducive environment for the roots to absorb the nutrients more effectively when compared to normal fertilizers. The growth parameters were also higher under these treatments which might have contributed to higher yield parameters. All these reasons coupled together and resulted in higher yield attributing characters in maize. This finding was in accordance with the findings of Narayanasamy *et al.* (1994).

The yield data of maize and blackgram showed the favourable effect of drip fertigation. Drip fertigation given based on 100 per cent RDF as WSF (T_3) produced higher yield (6144 kg ha^{-1} in maize and 807 kg ha^{-1} in blackgram) which was significantly superior to all the other fertilizer treatments. However, the stover yield of maize in T_3 was comparable with T_5. The lowest yield of maize and blackgram were recorded in drip irrigation with surface application of 100 per cent RDF (T_1). Recommended quantity of nutrients supplied at regular intervals as WSF (T_5) with favourable moisture status under drip irrigation resulted in better translocation of assimilates from source to sink. This might be the reason for higher yield in maize and blackgram. Similar findings of higher yield in maize with drip fertigation of 100 per cent RDF as WSF was obtained by Ramah (2008) and Anitta Fanish (2013).

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Table 1. Effect of drip fertigation on yield parameters and yield of maize – blackgram

Treatments	Yield parameters of maize		Yield of Maize		Balckgram Seed yield (kg/ha)
	Number of grains / cob	Cob weight (gm)	Grain Yield (kg/ha)	Stover yield (kg/ha)	
T_1 - DI with surface application of 100 % RDF	416.2	182.66	4462.0	8324	506.7
T_2 – DF with 100 % RDF – NF	474.4	207.75	5241.8	9065	660.0
T_3 - DF with 100 % RDF – WSF	512.4	227.82	6144.3	9586	806.7
T_4 - DF with 75 % RDF – NF	458.3	200.84	4676.8	8967	570.0
T_5 - DF with 75 % RDF – WSF	491.9	220.14	5367.5	9353	613.3
S.Ed.	11.89	7.53	106.22	158.34	11.12
CD (P=0.05)	27.69	16.40	231.45	325.76	24.24

T2-55

An alternate remunerative crop: Barnyard millet in Cauvery delta Improved production technologies and value addition through demonstrations, trainings, field days and exposure visits under SBGF project

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Abstract

In Cauvery delta region, paddy is a major crop grown throughout the year and it requires more water than many other crops. During *summer* and *kuruvai* seasons most of the lands are put on fallow due to non availability of enough irrigation water. It was observed that the farmers previously cultivated millets and cultivation of rice has replaced the millets during the last 4-5 decades and our objective is bringing back millets in the Cauvery Delta.Nowadays, the area under rice cultivation has become exponentially large and water stress conditions grew geometrically which has serious repercussions on the agriculture in the delta.The soil series present in Thiruvarur District *viz*., Alathur (36522 ha) and Madukkur (2967 ha) are highly suitable for growing millet crops. Barnyard millet (*Echinochloa* sp.) which requires very less quantity of water for its cultivation, lesser incidence of pest and diseases which reduces cost of cultivation and able to withstand drought besides helps in improving the nutrient status of the soil. A total of 20 demonstrations of barnyard millet cultivation with improved agronomic practices was conducted in 20 farmers field with one acre each in Koradachery block of Thiruvarur District during 2016-17 and2017-18 under State Balanced Growth Fund (SBGF) for increasing the per capita income of farmers through productivity enhancement and ensuring better nutrient security to them apart from effective utilization of available limiter water. It was found that highest yield of 2250 kg ha^{-1} and lowest yield of 2075 kg ha^{-1} with an average yield of 2133 kg ha^{-1} was recorded in demonstration fields. The average cost of cultivation was Rs.16780 ha^{-1} and average gross return was Rs.46921 ha^{-1} and the BCR was 2.80. Apart from demonstrations many trainings were conducted on high yielding technologies for millets cultivation, awareness was created through field days, exposure visits, All India Radio programmes and local newspapers. Hence, Barnyard millet is an ideal crop for Thiruvarur District during *summer* and *kuruvai* seasons where water availability is scanty and also it provides higher return to the farmers.

Keywords: *Barnyard millet, Summer season, Seed treatment, Value addition,*

Introduction

In Cauvery delta region, paddy a major crop grown throughout the year and it requires more water than many other cultivating crops. During *summer* and *kuruvai* seasons most of the lands are put on fallow without cultivation due to less availability of ground water and delayed release of cauvery water from Mettur dam. In order to effectively utilize the available land and limited water, an alternate crops like barnyard millet is reintroduced delta region with improved production technologies. In India, cultivation of barnyard millet is mainly confined to Tamil Nadu, Andhra Pradesh, Karnataka and Uttarakhand and is cultivated in an area of 1.46 lakh ha^{-1} with the production 1.47 lakh tonnes and the average productivity of 1034 kg ha^{-1} But yield potential of the popular released barnyard millet variety is more than 2500 kg/ha (IIMR, 2018). Barnyard millet (*Echinochloa* sp.) is high nutritional value crop with good source of protein, carbohydrate, fiber and rich in iron and zinc and cultivated mainly for human consumption as well as for livestock feed and most importantly, it is least susceptible to both biotic and abiotic stresses and requires less quantity of water for cultivation. It also helps in improving the nutrient status of the soil besides giving additional net revenue to the farmers of Thiruvarur District with less cost of cultivation. There is a huge demand for its grain and their value-added products and it fetches high price in the market now-a-days. But the availability of millets is very limited due to limited areas under millet cultivation in recent times. Few decades back, millets were cultivated along with other crops in delta region and later much importance were given to paddy crop. Even though, barnyard millet has nutritional value, less infestation of insect pests and less incidence of diseases and cultivated with less water and requires less cost of cultivation, still barnyard millet has remained an underutilized crop. Hence, this demonstartions was conducted to revive the millets cultivation in delta regions during *summer* and *kuruvai* seasons under State Balanced Growth Fund (SBGF) by effective utilization of available limiter water for increasing the per capita income of farmers through productivity enhancement and ensuring better nutrient security.

Materials and Methods

A total of 20 demonstrations of barnyard millet cultivation with improved agronomic practices was conducted in 20 farmers field with one acre each in Viswanathapuram, Koradachery, Paththur and Kilariyum villages of Koradachery block of Thiruvarur District during 2016-17 and 2017-18. The various improved agronomic practices like use of high yielding varieties like CO (KV) 2, soil application of biofertilizer *viz*., Azospirillum and Phosphobacteria each @ 2 kg ha^{-1} mixed with 25 kg of soil and 25 kg FYM was applied before transplanting, seed treatment with Azospirillum and Phosphobacteria each @ 600 g ha^{-1}, nutrient management with 40: 30: 50 kg N P_2O_5 K_2O per ha. Of that, 50 per cent of nitrogen and entire dose of P_2O_5 and K_2O was applied basally at the time of sowing, whereas remaining 50 per cent nitrogen was applied in two equal splits at 25-30 and 40-45 days after sowing were followed. In these demonstrations, no herbicides and insecticides were used by the farmers. The matured grains were harvested using paddy combined harvester with change of sieve alone to manage the small grain size. Trainings and demonstrations were conducted to use the grains for making biscuit, cookies and other value-added products.

Results and Discussion

Among four villages, the average highest yield of 2225 kg ha^{-1} was recorded in Viswanathapuram village whereas, the lowest yield was recorded in Kilariyum (2077.5 kg/ha) with an average yield of 2132.86 kg ha^{-1} was recorded in demonstration fields. The maximum gross return was obtained in Viswanathapuram (Rs.48950/ha) followed by Koradachery (Rs. 46618/ha). The minimum gross return was recorded in Kilariyum (Rs. 45705/ha) with average gross return was Rs.46923 ha $^{-1}$. The highest net return was also obtained in Viswanathapuram (Rs.30800/ha) followed by Koradachery (Rs. 32000/ha). The minimum net return was recorded in Kilariyum (Rs. 28955/ha) with average net return of Rs.30135 ha^{-1}. As far as BCR is concerned, the highest BCR was obtained in by

Viswanathapuram (2.89). The lowest BCR was obtained in Kilariyum (2.73) followed Paththur (2.80). The results are in confirmation with the reports of Renganathan *et al.,* (2020) and Jagadish *et al.,* (2008) also reported that millets are good remunerative crops and recorded very less infestation of pests. Apart from demonstrations, many on and off campus trainings were conducted on high yielding technologies for millets cultivation, awareness on millets cultivation was created among farmers through field days, exposure visits to various research station, All India Radio programmes and various technical information's were published in local newspapers. Hence, Barnyard millet is an ideal crop for Thiruvarur District during *summer* and *kuruvai* seasons where water availability is scanty and also it provides higher return to the farmers. The other advantages of cultivating millets like barnyard millet are not requiring any herbicide application and required five to six times irrigation.

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Table 1. Yield, Economics and BCR of Barnyard millet cultivation

Village	Yield (Kg/ha)			Gross Cost (Rs.)			Cost of cultivation (Rs.)			Net Return (Rs.)			BCR		
	2016-17	2017-18	Average	2016-17	2017-18	Average	2016-17	2017-18	Average	2016-17	2017-18	Average	2016-17	2017-18	Ave.
Viswanathapuram	2250	2200	2225	49500	48400	48950	17100	16800	16950	32400	31600	32000	2.89	2.88	2.89
Koradachery	2150	2088	2119	47300	45936	46618	16600	17100	16850	30700	28836	29768	2.85	2.69	2.77
Pathur	2120	2100	2110	46640	46200	46420	16450	16750	16600	30190	29450	29820	2.84	2.76	2.80
Kilariyam	2050	2105	2077.5	45100	46310	45705	16850	16650	16750	28250	29660	28955	2.68	2.78	2.73
Average	2142.5	2123.25	2132.86	47135	46711.5	46923.25	16750	16825	16787.5	30385	29886.5	30135.75	2.81	2.78	2.80

Fig.1. Yield obtained in barnyard millet cultivation

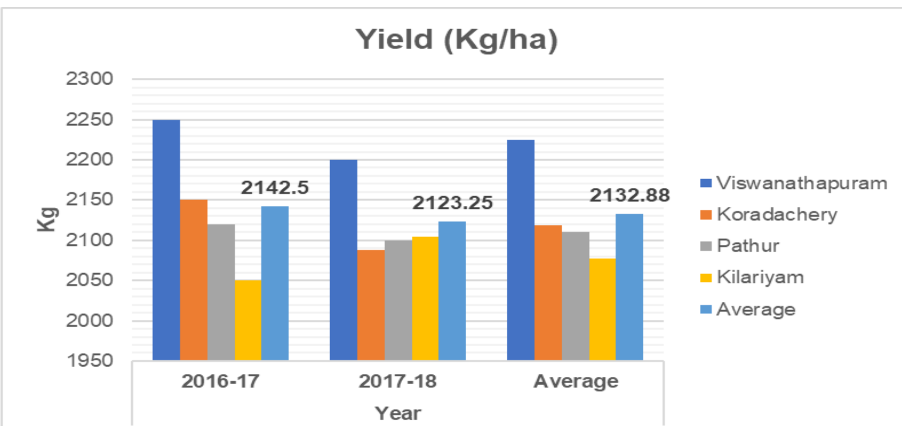
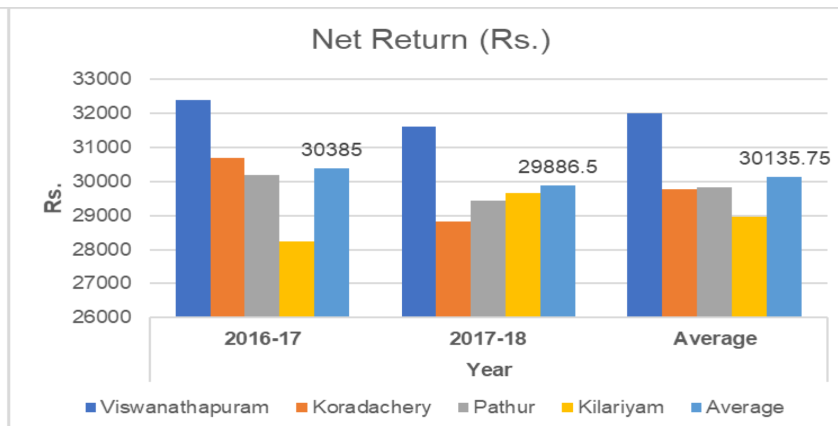


Fig. 2. Net return in barnyard millet cultivation



T2-56

Influence of weed management practices on weed dynamics and yield of transplanted Finger Millet

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Abstract

Field experiment was conducted at ADAC&RI, Tiruchirapalli to evaluate the weed management practices on weed dynamics and yield of transplanted finger millet under sodic soil. The experiment was laid out in Randomized Block Design (RBD) with ten treatments and three replications. The treatment comprised of weed management practices *viz.,* pre emergence (PE) application of pendimethalin at 750 g/ha, oxyfluorfen at 50 g/ha, bensulfuron methyl at 60 g/ha + pretilachlor at 600 g/ha, early post emergence (EPOE) application of bispyribac sodium at 25 g/ha, PE pendimethalin at 750 g/ha *fb* EPOE bispyribac sodium at 25 g/ha, PE oxyfluorfen at 50 g/ha *fb* EPOE bispyribac sodium at 25 g/ha, PE bensulfuron methyl at 60 g/ha + pretilachlor at 600 g/ha *fb* EPOE bispyribac sodium at25 g/ha, PE oxyfluorfen at 50 g/ha *fb* hand weeding at 30 DAT, hand weeding at 15 and 30 DAT and unweeded control. The results revealed that lower total weed density, dry weight and higher weed control efficiency (WCE) were registered in PE bensulfuron methyl 60 g ha^{-1} + pretilachlor 600 g ha^{-1} *fb* EPOE bispyribac sodium 25 g ha^{-1} and it was followed by HW on 15 and 30 DAT. The highest grain and straw yield were also registered in PE application of bensulfuron methyl at 60 g/ha + pretilachlor at 600 g/ha *fb* EPOE application of bispyribac sodium at 25 g/ha and it was on par with hand weeding at 15 and 30 DAT.

Keywords: Transplanted finger millet, weed management, weed dynamics, yield

Introduction

Finger millet is grown in many dry regions of the world mainly in Asia and Africa. It is the staple food crop for majority of people in South Asia and Africa. It can be grown in poor water supplying capacity and nutrient deficient soils due to its resilience and ability to withstand aberrant weather conditions. So, it is called as Climate Change Compliant Crop (CCCC). Among the millets, finger millet is ranked fourth globally in importance, after sorghum, pearl millet and foxtail millet. The area under finger millet cultivation in India is 1.19 m.ha with production of 1.99 mt and the average productivity of 1.66 tonnes/hectare.

In finger millet cultivation, weed menace has become a major threat for production and productivity. Finger millet due to its slow growth habit during initial stages, it favours weed growth and causes more competition for sunlight, nutrients and water which leads to lowering of crop productivity. However, finger millet production requires a lot of labour, particularly for weed management practices. Use of herbicides has been proved to be an economically viable option in controlling weeds (Shanmugapriya *et al.* 2019 and

Shanmugapriya *et al.* 2020). Thus, there is a need to develop weed management strategies that are profitable. Hence, the present investigation has been undertaken to evaluate different weed management practices on weed dynamics and yield of transplanted finger millet under sodic soil.

Materials and Methods

Field experiment was conducted during *Kharif,* 2018 at ADAC&RI, Tiruchirappalli, Tamil Nadu. The field experiment was laid out in RBD with three replications and ten treatments. The variety used for the experiment was TRY 1. The observations on total weed density, weed dry weight and WCE were recorded by adopting standard procedure. The grain and straw yields were recorded at harvest stage and expressed as kg/ha.

Results and Discussion

Weed flora:The major weed flora found in the experimental field consisted of *Cyperus iria, Cyperus rotundus* in sedges, *Echinochloa colona, Cynodon dactylon, Dactyloctenium aegyptium, Brachiaria mutica* in grasses and *Trianthema portulacastrum* in broad leaved weeds. Such broad spectrum of weeds was also reported by Ramesh and Rathika (2016).

Total weed density, weed dry weight and WCE: Adoption of different weed management practices has significantly influenced the total weed density, weed dry weight and WCE (Table 1). Among the different weed management practices, lower total weed density, dry weight and higher weed control efficiency (WCE) were registered in PE bensulfuron methyl 60 g ha^{-1} + pretilachlor 600 g ha^{-1} *fb* EPOE bispyribac sodium 25 g ha^{-1} and it was followed by HW on 15 and 30 DAT. Pre emergence herbicide along with post emergence herbicide effectively reduced the weed biomass. This is in line with the findings of Satish et al. (2018).

Yield: Adoption of different weed management practices produced distinct variations in grain and straw yields of transplanted finger millet (Table 3). The highest grain and straw yields were recorded with PE application of bensulfuron methyl at 60 g/ha + pretilachlor at 600 g/ha *fb* EPOE bispyribac sodium at 25 g/ha and it was comparable with HW at 15 and 30 DAT. Application of pre emergence herbicide controlled the weeds at early stage and early post emergence herbicide controlled weed growth at later stage which resulted in lesser competition by weeds and higher yield (Rathika and Ramesh, 2018).

PE application of bensulfuron methyl at 60 g/ha + pretilachlor at 600 g/ha *fb* EPOE application of bispyribac sodium at 25 g/ha was found to be best method for controlling weeds and increased yield of transplanted finger millet under sodic soil.

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Table 1. Influence of weed management practices on weed dynamics and yield of transplanted finger millet

Treatments		Total weed density (No./m²)	Total weed dry weight (g/m²)	WCE (%)	Grain yield (Kg/ha)	Straw yield (Kg/ha)
T_1	PE Pendimethalin at 750 g/ha	9.40 (87.80)	10.29 (105.30)	45.4	2556	4796
T_2	PE Oxyfluorfen at 50 g/ha	9.13 (82.80)	10.14 (102.22)	47.0	2720	4924
T_3	PE Bensulfuron methyl at 60 g/ha + Pretilachlor at 600 g/ha	8.73 (75.72)	9.74 (94.31)	51.1	2862	5065
T_4	EPOE Bispyribac sodium at 25 g/ha	8.76 (76.29)	9.57 (91.03)	52.8	2741	5160
T_5	PE Pendimethalin at 750 g/ha *fb* EPOE Bispyribac sodium at 25 g/ha	7.98 (63.24)	8.71 (75.41)	60.9	3022	5727
T_6	PE Oxyfluorfen at 50 g/ha *fb* EPOE Bispyribac sodium at 25 g/ha	7.20 (51.41)	7.92 (62.29)	67.7	3140	5838
T_7	PE Bensulfuron methyl at 60 g/ha + Pretilachlor at 600 g/ha *fb* EPOE Bispyribac sodium at 25 g/ha	5.48 (29.54)	5.06 (25.07)	87.0	3560	6617
T_8	PE Oxyfluorfen at 50 g/ha *fb* HW at 30 DAT	7.03 (48.91)	7.70 (58.82)	69.5	3222	6137
T_9	HW at 15 and 30 DAT	6.23 (38.31)	6.36 (39.92)	79.3	3443	6353
T_{10}	Unweeded control	12.60 (158.48)	13.91 (192.86)	-	1256	3144
CD (P=0.05)		0.67	0.76	-	256	469

T2-57

Yield and profit maximization in millets through demonstration of integrated crop management practices

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Abstract

Frontline demonstration in finger millet and little millet was taken up 120 ha area in farmers' holdings of Dharmapuri district during 2017-18 to 2019-20under Tamil Nadu Innovation Initiative (TANII) project to disseminate the integrated crop management technologies along with improved crop varieties for increasing the productivity in millets. The integrated crop management practices including cultivation of drought tolerant and short duration finger millet variety ML 365 and little millet variety CO 4, integrated nutrient management, integrated pest and disease management practices were demonstrated and compared with the existing farmers practice (FP). Results showed that demonstration of finger millet variety ML 365 with integrated crop management practices recorded higher mean grain yield of 2043 kg/ha and farmers practice recorded lower mean yield of 1687 kg/ha. Adoption of integrated crop management practices increased the grain yield of finger millet to the tune of 21.1 per cent compared to farmers practice. Farmers earned higher net income of Rs.15763/ha through the demonstration and Rs.11527/ha with farmers practice. Besides, farmers realized higher benefit cost ratio (1.61) through the demonstration compared to farmers practice (1.49). With regard to little millet, demonstration of CO 4 variety with integrated crop management practices recorded the higher mean grain yield of 912 kg/ha and farmers practice recorded the lower mean yield of 753 kg/ha. Higher net income (Rs. 10083/ha) and benefit cost ratio (1.70) was also realised in demonstration compared to farmers practice.

Keywords : Demonstration, Finger millet, Little millet, Grain yield, Net income, Benefit costratio

Introduction

Small millets, also known as nutri-cereals, are climate resilient and hardy crops. They have good adaption to wide range of environment especially heat, drought, marginal and degraded soils (Okalebo*et al.*, 1991). They are mainly grown for its grains and it is highly nutritious. They are small in size;its grains are rich in micronutrients, essential amino acids and vitamins. Due to lower glycemic index and higher fibre and antioxidants content it play vital role in managing diabetes in human beings.Out of 11 small millets, finger millet, foxtail millet, barnyard millet, little millet, proso millet, kodo millet are commonly grown in Tamil Nadu. In Dharmapuri district, small millets are cultivated in large-scale especially under rainfed condition. An average, finger millet and little millet are cultivated in 28,500 and 15,000 ha area, respectively. Farmers experiencing low yield due to non-adoption of improved variety and integrated crop management practices.

Materials and Methods

To disseminate the improved production technologies in millets for enhancing the productivity of millet crops front line demonstrations were conducted under the Tamil Nadu Innovation Initiative (TANII) project during 2017-18 to 2019-20 in 120 ha area in farmers holdings of Dharmapuri district. The demonstration was conducted both in finger millet and little millet under rainfed condition in Pennagaram, Dharmapuri and Palacodeblcksof Dharmapuri District. In the demonstration, integrated crop management practices such as improved variety (ML 365 in Finger millet and CO 4 in Little millet), seed treatment with bio-inoculants *Pseudomonas fluorescens* @ 10g/kg seed and *Trichodermaviride* @ 4 g/kg seed followed by bio-fertilizers *Azospirillum* and *Phosphobacteria*each @ 25 g/kg seed, soil application of millet micronutrient mixture @ 3 kg/ha, need based use of pesticides, etc. were followed and it was compared with the existing farmers practice. Yield data were collected from the beneficiary farmers and economics were worked out.

Results and Discussion

Results of the demonstration conducted on finger millet and little millet during the three years period is presented in Table 1. The pooled mean data on finger millet showed that cultivation of drought tolerant finger millet variety ML 365 with integrated crop management practices recorded the higher grain yield (2043 kg/ha) and farmers practice recorded the lower yield (1687 kg/ha) (Figure 1).The similar result of yield enhancement through front line demonstration of improved technologies has been reported by Anand Naik *et al*., (2016) in sorghum. Farmers earned the higher net income of Rs.15,763/ha and benefit cost ratio of 1.61 through the demonstration compared to farmers practice. It might be due to the higher grain yield recorded in demonstration compared to farmers practice. Similar results of increase in net income and benefit cost ratio due to adoption of improved technologies in the demonstrations were reported by Jat and Gupta (2015) in pearl millet.The pooled mean data on little millet indicated that demonstration of little millet variety CO 4 with integrated crop management practices recorded the higher grain yield (912 kg/ha), net return (Rs. 10083/ha) and benefit cost ratio (1.70). The lower grain yield (753 kg/ha), net return (Rs. 7708/ha) and benefit cost ratio (1.62) was recorded in farmers practice (Figure 2).The study indicated that demonstration of improved variety with integrated crop management practices enhanced the yield and income of the millet growers in Dharmapuri district.

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Table 1. Grain yield and economics of on finger millet and little millet under front line demonstration

Year	No. of Demonstration	Finger millet						Little millet					
		Grain yield (kg/ha)		Net return (Rs./ha)		BC Ratio		Grain yield (kg/ha)		Net return (Rs./ha)		BC Ratio	
		Demo	FP	Demo	FP	Demo	FP	Demo	FP	Demo	FP	Demo	FP
2017-18	100	2060	1670	15500	10650	1.60	1.47	975	775	11750	9000	1.67	1.63
2018-19	100	1920	1615	14040	10930	1.50	1.44	860	735	9000	6875	1.72	1.60
2019-20	100	2150	1775	17750	13000	1.73	1.57	900	750	9500	7250	1.71	1.63
Mean	-	2043	1687	15763	11527	1.61	1.49	912	753	10083	7708	1.70	1.62

Fig. 1. Grain yield and Net return of Finger millet

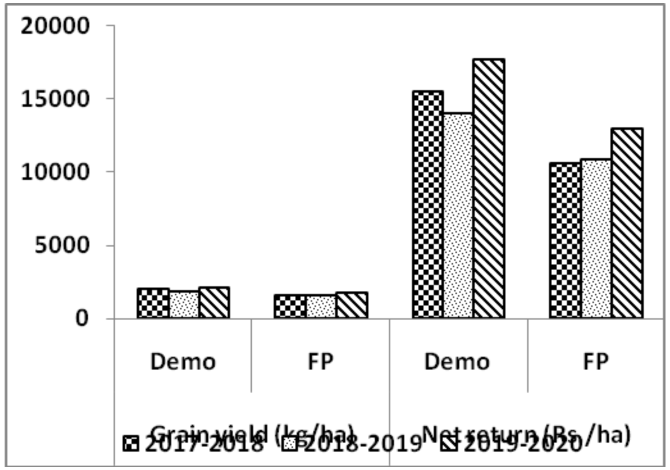
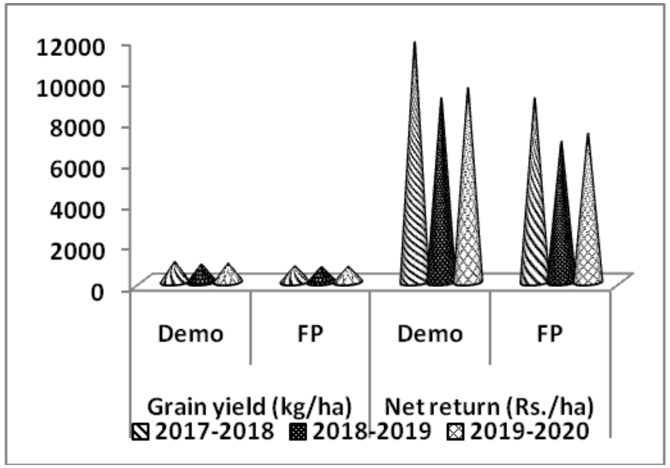


Fig. 2. Grain yield and Net return of Little millet



T2-58

Effect of Millet based cropping systems on profitability and economics

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Abstract

Millets are important sources of nutrients and can play a significant role in improving nutritional security and preventing diseases caused by imbalanced nutrition.In this present study, treatments included ten different millets based cropping systems among which first two treatments were the predominant cropping system of the zone, next two were to provide nutritional food grains in a balanced way, another two treatments for improving soil fertility status, then next two treatments with priority to fodder crops and last two with commercial value crops.Among the cropping systems, maize - chillies - radish system recorded the highest MEY (27.64 t/ha), system productivity (75.7 kg/ha/day), net return (Rs. 3,53,278/-) and B:C ratio (2.65) followed by beetroot - cotton- maize. Among the fodder crops, perennial fodder system Bajra Napier hybrid grass + Desmanthus recorded green fodder production to meet the fodder requirement.

Keywords: Millets, cropping system, productivity, economics

Introduction

In general, food security of a nation refers to a situation when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and Introduction healthy life (Food and Agriculture Organization, 1996). Millets, a group of hardy and drought-resistant cereal crops, have been incorporated in the cropping system to improve food and nutritional security. In this study, the millets were included in cropping system to combat food and nutrition insecurity of farm family.

Materials and Methods

A field experiment was carried out during 2020 to 2021under irrigated conditions, at the Eastern block of Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore with a view to study the effect of cropping systems on crop productivity and economics. The experiment was laid out in randomized block design with ten various cropping systems *viz*., T_1: sorghum - cotton- ragi; T_2: onion - cotton - maize; T_3: maize- bengalgram- cowpea; T_4: sorghum - horsegram - groundnut; T_5: gingelly - bengalgram - ragi; T_6: prosomillet - cowpea - sunflower; T_7: fodder maize + fodder cowpea (6:2); T_8: bajra napier hybrid + desmanthus (4: 2) (perennial); T_9: beetroot - cotton - maize; T_{10}: maize -chillies- radish. Plots were formed with a gross size of 5m x 4m. Observations were recorded from randomly selected 5 plants of each plot.System productivity was worked out by dividing the total maize equivalent yield (kg/ha/yr) of the cropping system with 365 days and expressed as kg/ha/day

Result and Discussion

Among the food crops, maize - chillies - radish cropping system registered highest Total Maize Equivalent Yield (TMEY) of 28 t $ha^{-1}yr^{-1}$ followed by onion - cotton - maize cropping system that produced TMEY of 26 t $ha^{-1}yr^{-1}$. On the other hand, the lowest TMEY of 7 t ha^{-1} yr^{-1} was recorded with the cropping system sorghum - horse gram - groundnut. Maize - chillies - radish cropping system registered the highest system productivity of 75.73 kg/ha/day and followed by onion - cotton - maize sequence with 72.52 kg/ha/day. However, the lowest system productivity of 19.97 kg/ha/day was registered with sorghum - horse gram - groundnut. Considering the economics of cropping sequence, among food cropping system, maize - chillies - radish recorded the highest annual net returns of Rs. 3,53,278/-per ha with the B-C ratio of 2.65. The next best system was beet root - cotton - maize cropping sequence which registered an annual net return of Rs. 3,47,994/-per ha and B:C ratio of 3.23. This might be due to the inclusion of vegetable crops which resulted in higher economic value. The Fodder system, BN hybrid grass CO (BN) 5 + *Desmanthus* registered higher net returns (Rs. 4,93,645/ha/yr) and B: C ratio (6.25). The highest system profitability was registered with BN hybrid grass CO (BN) 5 + *Desmanthus* (Rs. 1352 /ha/day) and Maize -Chillies -Radish (Rs. 968/ha/day) (Table 1). Oilseed and pulses including vegetable crops are receiving more attention owing to higher prices due to increased demand. Inclusion of these crops in sequence was found more beneficial than cereals alone (Annual Report, 2022). At present vegetables based which is not only productive and profitable but also stable over time and maintains soil fertility, is of great importance in present conditions (Pandey *et al*., 2018).

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Table 1. Effect of cropping system on productivity and economics

Trts	Cropping system	TMEY	System productivity (kg/ha/day)	Net Return (Rs./ha/yr)	B:C ratio
T_1	Sorghum - Cotton - Ragi	11	29.56	96447	1.78
T_2	Onion - Cotton - Maize	26	72.52	335637	2.64
T_3	Maize - Bengalgram - Cowpea (G)	11	31.41	116736	1.95
T_4	Sorghum - Horsegram - Groundnut	7	19.97	57280	1.57
T_5	Gingelly - Bengalgram - Ragi	8	21.42	61707	1.62
T_6	Prosomillet - Cowpea(G) - Sunflower	10	26.58	87152	1.75
T_7	Fodder Maize + Fodder Cowpea (6:2)(Twice)	10	27.39	71049	1.61
T_8	BN hybrid and *Desmanthus*(4:2)	29	79.48	493645	6.25
T_9	Beet root - Cotton - Maize	25	67.53	347994	3.23
T_{10}	Maize - Chillies - Radish	28	75.73	353278	2.65

T2-59

Effect of nutricereals intercropping in castor on weed control efficiency

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Abstract

Intercropping is the practice of growing two or more crops in proximity. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop. Field experiment was conducted during 2022 atTamil Nadu Agricultural University, Coimbatore to study theinfluence ofnutri cereals intercropping in castor onweed controlefficiency. The experimental results revealed thatlesser weed dry weight at 30, 60 and 90 DAS was recorded under solo little millet, prosomillet and foxtail millet followed by intercropping with castor + foxtail millet (1:3), castor + prosomilet (1:3) and castor + little millet (1:3) when compare to paired row cropping (2:4). Solo castor recorded higher weed density and total weed dry matter production at 30, 60 and 90 DAS. Castor intercropped with foxtail millet (1:3), proso millet (1:3) and little millet (1:3) recorded highest weed smothering efficiency when compared to paired row cropping.

Keywords: Castor,nurti cereals, weed density, weed smothering efficiency

Introduction

Castor is an important oil seed crop, in India's semi-arid low-rainfall regions are where castor *(Ricinus communis L.)* is produced as an indeterminate, non-edible oil seed crop. In agricultural cultivation, weeding has generally required a lot of labour. Due to the increased demand and high expense of human labour, manual weeding is rarely feasible. Because it allows for the possibility of a variety of crops obtaining a larger proportion of the available resources than in monocropping, intercropping holds potential as a weed control method (Ishaq *et al.,*2019). In this context, the present investigation was carried out to study the effect of nutri cereals intercropping in castor on weed control efficiency under irrigated conditions.

Materials and Methods

Field experiment was conducted at Eastern block farm of Tamil Nadu Agricultural University, Coimbatore during *summer* season, 2022. The study was conducted in Randomized Complete Block design.A total of thirteen treatments were used, and they are as follows T_1-castor + foxtail millet (1:3), T_2- castor + proso millet (1:3), T_3- castor + little millet (1:3), T_4- castor + kodo millet (1:3), T_5- paired row castor + foxtail millet (2:4), T_6-paired row castor + proso millet (2:4), T_7- paired row castor + little millet (2:4), T_8- paired row castor + kodo millet (2:4), T_9- sole castor, T_{10}- sole foxtail millet, T_{11}- sole proso millet, T_{12}-sole little millet, T_{13}- sole kodo millet.Weed dry matterproduction (TDMP)were taken on

30,60 and 90 DAS respectively and Weed Smothering Efficiency (WSE) was worked out. The weed dry weight was recorded and expressed in kg ha^{-1}. Weed Smothering Efficiency (WSE) was computed using the formula and expressed in percentage.

$$WSE\ (\%) = \frac{Mdw - Idw}{Mdw} \times 100$$

Where, Mdw - Mean dry weight of weeds in pure crop plot (kgha^{-1}), and Idw - Mean dry weight of weeds in intercropped plot (kg ha^{-1}).

Results and Discussion

Weed total dry matter production was significantly impacted by the intercropping strategy. Less weeds and weed total dry matter production were observed when intercropping systems were used.Lesser total weed dry weight at 30, 60 and 90 DAS was recorded under solo little millet, proso millet and foxtail millet followed by intercropping with castor + foxtail millet (1:3), castor + prosomilet (1:3) and castor +little millet (1:3) than compare to paired row cropping (2:4) and solo castor recorded higher total weed dry matter productionat 30 DAS, 60 DAS and 90 DAS because of wider spacing. This may have happened as a result of the intercropping system's full crop coverage and high plant density, which created intense competition with weeds and stunted their growth (Velayutham*et al.,*2002), reported that intercrops effectively cover the land, which inhibits the growth of weeds. In castor based nutri cereal intercropping the highest weed smothering efficiency at 30 DAS was observed in castor + little millet (46%) and castor+ proso millet (43%) and castor + foxtail millet (42%) respectively. At 60 DAS weed smothering efficiency was higher in castor + little millet (52%), followed by castor + foxtail millet (50%) castor + proso millet (41%). At 90 DAS Weed Smothering Efficiency was higher in castor + foxtail millet (46%) (Table 1). This might be because castor and intercrops grew vegetatively more successfully, increasing WSE and creating intense competition between the plants.

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Table 1. Effect of nutri cereals intercropping in castor on Weed dry weight and Weed Smothering Efficiency

Tr No.	Treatment	Weed dry weight (g/m^{-2})			Weed Smothering Efficiency (%)		
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
T_1	Castor + foxtail millet (1:3)	4.0 (15.8)	3.5 (11.8)	3.5 (11.9)	42	50	46
T_2	Castor+ proso millet (1:3)	4.0 (15.5)	3.6 (13.8)	3.8 (13.8)	43	41	37
T_3	Castor + little millet (1:3)	3.9 (14.4)	3.5 (11.2)	3.7 (13.0)	47	52	41
T_4	Castor+ kodo millet (1:3)	4.6 (20.8)	4.3 (17.5)	4.1 (16.2)	23	21	27
T_5	Paired row castor + foxtail millet (2:4)	4.1 (15.8)	3.8 (15.9)	4.0 (15.4)	42	32	30
T_6	Paired row castor + proso millet (2:4)	4.2 (17.5)	3.6 (13.7)	3.9 (14.9)	35	41	32
T_7	Paired row castor + little millet (2:4)	4.5 (19.4)	4.0 (15.8)	4.1 (16.4)	28	31	26
T_8	Paired row castor + kodo millet (2:4)	4.8 (22.7)	4.9 (22.6)	4.6 (20.8)	16	4.2	6.3
T_9	Solo castor	5.3 (27.3)	4.6 (23.6)	4.7 (22.2)			
T_{10}	Solo foxtail millet	4.0 (15.6)	4.0 (15.6)	3.8 (13.8)			
T_{11}	Solo proso millet	3.7 (12.9)	3.9 (15.0)	3.6 (12.7)			
T_{12}	Solo little millet	3.6 (12.4)	3.7 (14.0)	3.4 (11.1)			
T_{13}	Solo kodo millet	4.6 (20.4)	4.4 (22.5)	4.5 (20.1)			
	SEd	0.22	0.27	0.28			
	CD 5%	0.45	0.57	0.59			

Data in parentheses are original value. Data statistically analysed by $\sqrt{x + 0.5}$ transformation

T2-60

Evaluation of spacing and fertilizer doses for multicut Forage Sorghum under Irrigated Condition

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Abstract

A field experiment was conducted to evaluate the spacings and fertilizer doses on multicut forage sorghum (SPV 2242) under irrigated condition at Tamil Nadu Agricultural University, Coimbatore during July-December, 2016. The experiment was laid out in split plot design replicated thrice using SPV 2242 as the test variety. The treatments consisted of four different spacings (30 x 10 cm, 30 x 15 cm, 30 x 20 cm and 30 x 25 cm) along with three fertilizer doses (75% RDF, 100% RDF and 125% RDF). In addition, recommended application of FYM @ 12.5 t/ha was followed. The results revealed that increased plant population with highest rate of fertilizer application increases the green and dry forage yield and improved the fodder quality. Higher level of green and dry forage yield were recorded under 30 x 10 cm spacing with 125% RDF (38.9 and 20.3 t ha^{-1}), respectively. Economic analysis showed that the higher gross return (₹86850/ha), net return (₹116007/ha) and B C ratio of 1.72 were recorded with 30 x 10 cm spacing with 125% RDF.

Keywords: Foragesorghum, green forage yield, dry forage yield, fertilizer dose

Introduction

Global trend in animal production indicates a rapid increase in the consumption of livestock products. India supports nearly 20 per cent of the world livestock population on a land area of only 2.3 per cent. It is a leader in cattle (16 per cent) and buffalo (55 per cent) population and has world's second largest goat (20 per cent) and fourth largest sheep (5 per cent) population, respectively. But, the country has only 4.4 per cent of the cultivated area under fodder crops with an annual total forage production of 833 MT (390 MT green and 443 MT dry). In Tamil Nadu, the area under fodder crops is 1.72 lakh ha producing 340 lakh tonnes of fodder annually as against the requirement of 486 lakh tonnes. It is estimated that the deficit will increase over 64.2 and 24.8 per cent of green and dry fodder, respectively by 2020 (Handbook of Agriculture, 2013).

Amongst the annual forage crops, sorghum occupies nearly 2.5 m ha area. Cultivation of sorghum over other forage crops is widely practiced due to its high tolerance and suitability to wide variation in soil and climatic conditions and having many advantages like quick growth, high biomass accumulation, high dry matter content and wide adaptability besides drought withstanding ability. It is also suitable for silage and hay making. The green fodder availability from single cut sorghum is seasonal while multi-cut sorghum helps to supply green fodder throughout the year. Multi-cut forage having shorter cutting interval of 40-45 days, requires adequate nutrients in available form to produce sufficient foliage in a limited period of time.For higher yields, an adequate plant population is a pre-requisite. This is again decided by the fertility of soil and the space required for the plant to develop healthily. The present study was taken up to find out the optimum population with optimum fertilizer doses for increasing the forage yield.

Materials and Methods

The experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during July-December 2016. The experiment comprised of four different spacing along with three different fertilizer doses *viz*., 30 x 10 cm, 30 x 15 cm, 30 x 20 cm, 30 x 25 cm and 75% RDF,100% RDF and 125% RDF. The variety used was SPV 2242 and seeds sown on the two sides of ridge formed 60 cm apart to achieve 30 cm spacing between the rows. The recommended dose of N, P_2O_5, and K_2O kg/ha was applied treatment wise. Fifty percent of the recommended dose of nitrogen and full dose of P_2O_5, and K_2O were applied at the time of sowing. Remaining fifty percent dose of nitrogen was top dressed at 30 DAS. After each cut of 45 kg N/ha was applied. The data were statistically analyzed using ANOVA with critical difference at 5% level of significance (Gomez and Gomez, 1984).

Results and Discussion

Green forage yield and Dry forage yield Forage yield is a function of growth parameters, *viz*., plant population, plant height, leaf to stem ratio, leaf area, and leaf area index. Forage yield is a function of genetic as well as environmental factors which plays a vital role in plant growth and development. The green forage and dry forage yield was significantly influenced by different spacings during first, second and third cut of forage sorghum. The narrow spacing of 30 x 10 cm recorded significantly higher green forage yield of40.8 t/ha, 35.9 t/ha and 23.9 t/ha, respectively at first, second and third cut. Higher dry forage yield was recorded with the treatment combination of 30 x 10 cm spacing with fertilizer dose of 125% RDF during first, second and third cut of forage sorghum (Figure 1). This might be attributed to the low plant density at wider plant spacing and high plant density at narrow plant spacing. The higher yield was obtained from the highest seed rate and narrow row spacing and increased row spacing reduced yield (Mokadem *et al*., 2002). With respect to fertilizer doses, highest fertilizer dose (125% RDF) recorded higher green forage yield of 38.9 t/ha, 34.2 t/ha and 22.5 t/ha at first, second and third cut, respectively. Higher dose of fertilizer resulted in higher availability of N and accelerating the process of cell division, enlargement and elongation. This in turn showed luxuriant vegetative growth and resulted in higher green forage yield. Similar results were also obtained by Sujathamma *et al*. (2015).

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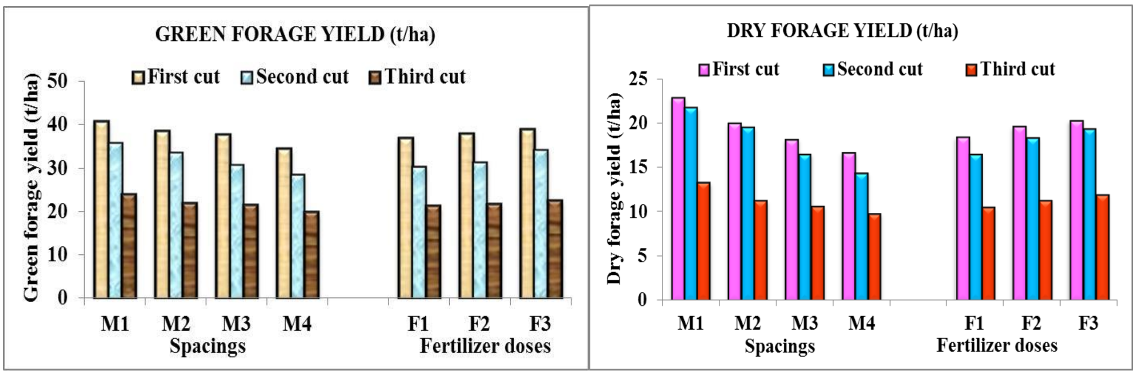
Table 1. Treatment details

MainPlot: Spacings	SubPlot:FertilizerLevels
M1 - 30 x 10 cm (3, 33,000 plants /ha)	S1 - 75% RDF (67.5:30:30 Kg NPK/ha)
M2 - 30 x 15 cm (2, 22,000 plants /ha)	S2 - 100% RDF (90:40:40 Kg NPK/ha)
M3 - 30 x 20 cm (1, 66,000 plants /ha)	S3 -125%RDF (112.5:50:50 kg NPK/ha)
M4 - 30 x 25 cm (1, 33,333 plants /ha)	
(Recommended spacing: 30 x 10-15 cm)	

Fig. 1. Effect of spacings and fertilizer doses on (a) green forage yield (t/ha) and (b) dry forage yield (t/ha) - first, second and third cut



(a) Green forage yield (t/ha) (b) Dry forage yield (t/ha)

T2-61
Nanoemulsion seed coating for ameliorating heat stress in Maize

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Abstract

An experiment was conducted to find out the effect of methyl cellulose nanoemulsion seed coating in maize (CO HM 6) to enhance the germination and seedling growth under heat stress condition. The properties of nanoemulsion was characterised by particle size analyzer, Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM). The bioefficasy of nanoemulsion was tested on maize where the seeds were coated with nanoemulsion at the rate of 20ml/kg and placed in plant growth chamber where the temperature and relative humidity were maintained at 40^0C and 50% respectively for a duration of 0, 3, 5, 7, 9, 11 and 13 days along with uncoated seeds. The seeds subjected to heat stress were evaluated for their heat stress tolerance through pot culture study. The results revealed that, the nanoemulsion coated seeds recorded higher rate of germination, speed of emergence, seedling length, vigour index and root volume, irrespective of the period of exposure to high temperature as compared to untreated seeds. The study concludes that the methyl cellulose nanoemulsion coating protect the seeds under high temperature stress as insulator and disintegrate when seeds get adequate soil moisture.

Keywords*:* Maize, Nanoemultion, Seed germination, Seed vigour

Introduction

Maize is one of the fundamental and predominant cereal crop next to rice and wheat because it is used as a staple food for human and animals. Globally it is known as queen of cereals. Preparing the seeds to withstand various level of heat stress for a longer period which is expected in pre-monsoon, without the loss of seed viability and vigour that will assure the performance of crop under rainfed condition. In this way nanoemulsion seed coating with polymeric substances or materials is a promising technique which protects the seeds against heat stress. With this background, the study was conducted to find out the suitability of methyl cellulose nano emulsion seed coating in maize for providing resistance and improving seedling emergence and growth under high soil temperature stress prevailed under rainfed cultivation.

Materials and Methods

The present study was carried out at Department of Seed Science & Technology, Department of Nano Science &Technology and Department of Crop Physiology ,Tamil Nadu Agricultural University, Coimbatore Hybrid seeds of maize (COHM 6) obtained from Department of Millets, Tamil Nadu Agricultural University, Coimbatore, formed the base material for the study.

The impact of methyl cellulose nanoemulsion seed coating on physiological and biochemical quality attributes was studied by exposing the seeds to high temperature regime. Maize seeds were coated with methyl cellulose nanoemulsion @ 20ml/kg of seed. For the induction of heat stress, the seeds were kept in plant growth chamber in which the temperature and relative humidity were maintained at 40^0 C and 50% RH respectively. The nanoemulsion coated seeds along with uncoated seeds were kept in plant growth chamber for the duration of 3, 5 7, 9, 11 and 13 days. The temperature and relative humidity were fixed based on the summer soil temperature and relative humidity in dry areas. The uncoated and coated seeds were kept and spread uniformly in the plant growth chamber separately for each exposure period. After completion of the specific exposure period, the uncoated and coated seeds were removed from plant growth chamber and evaluated for the following seed quality parameters under pot culture experiment with four replications. The experiment was designed in Factorial Completely Randomized Design (FCRD). The seedquality characteristics viz.,speed of germination (Maguire,1962),germination (ISTA, 2013), root length, shoot length, dry matter production and vigour index were observed.

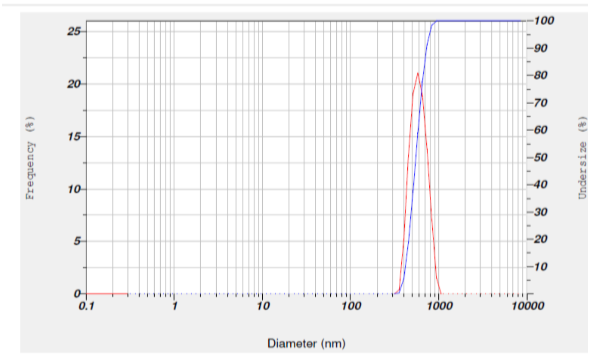
Results and discussion

In this study, the nanoemulsion was prepared by oil in water concept using methyl cellulose, vitamin E and Tween 80 surfactant. Nanoemulsion prepared by using high energy homogenizer was characterized for particle size (droplet) and morphology. The particle size analysis data revealed the size of 565.4 nm. In earlier report, it was observed that the methyl cellulose was stable upto 250°C (Surendhiran *et al*., 2019). The reduced particle size at high energy level is due to rupturing of particles where the shear forces acting upon emulsion droplets which leads collision and disrupts the interfacial membrane. The fine particle size with excellent stability may be due to the molecular structure of Tween 80 wherein the presence of hydrophobic chain in tail (C18 = 1, a mono oleate tail) induces the mobility of particles that prevents the agglomeration (Hasani *et al*., 2015).The surface topography of nanoemulsion analysed under SEM reported that methyl cellulose nanoemulsion had a core shell shaped particles with size ranges from 400 to 900nm (Figure 2). Further, the results of TEM images confirmed the morphology of nanoemulsion ascore shell structure with size ranges from 300 to 800 nm.

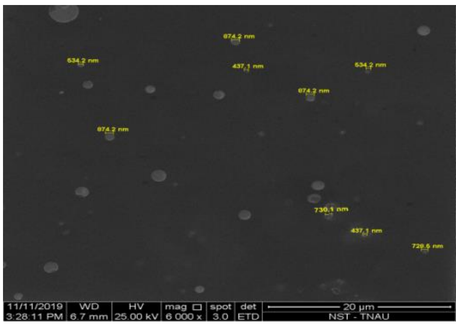
The significant and notable difference was observed for speed of emergence due to nanoemulsion coating compared to uncoated seed. Increases in the stress exposure period reduced the speed of emergence in both coated and uncoated seeds, however speed of emergence was maximum for coated seeds compared to uncoated seeds after 13 days of exposure. Coated seeds recorded the increased percentage of 6.28% over uncoated seeds for speed of emergence even after the exposure of 13 days to high temperature. Similarly, the same trend of results was observed for germination, root and shoot length, drymater production, seedling vigour and root volume Compared to uncoated seeds, coated seeds recorded the percent increase of 12.5% (root length), 8.87% (shoot length), 14.7% (dry matter production), 36.63% (vigour index I)41.17% (vigour index II) and 38.23% (root volume) (Figure 4) The positive effect nanoemulsion seed invigouration on germination and seedling vigour of maize seed under high temperature arrtibuted to phase transition behaviour of methyl cellulose which forms a film on seed coating and acts as thermal barrier that protects the seeds against high temperature stress, and when the polymer reaches the ambient temperature it changes its structure and allow the water for facilitating the seeds to imbibe and germinate. Methyl cellulose form films including different additives (alpha tocopherol) for biodegradability and anti oxidative properties which become an excellent barrier against ultra violet radiation and high temperature (Pauline *et al*., 2015). According to Kumar *et al*. (2007) methyl cellulose could be used as potential seed coating agent for protecting the seeds against abiotic stress. In the present investigation, higher seedling vigour and biomass is due to the maximum root and shoot growth

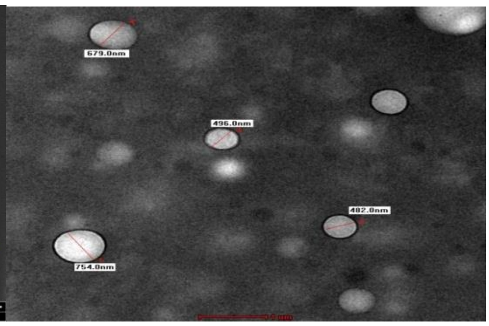
The result of the present study clearly indicated that methyl cellulose nanoemulsion coated seeds recorded better performance than the uncoated seeds under high temperature stress condition. The maize seeds exposed to high temperature stress condition for 5 days recorded the germination of 88% (below IMSCS) and the seeds coated with nanoemulsion maintained 90% of germination even after 9 days of exposure. Thus the result clearlyindicated that, methyl cellulose nanoemulsion coated seeds of maize had the ability to withstand the high temperature stress under rainfed condition without reduction in seed quality.Hence, the methyl cellulose nanoemulsion seed coating @ 20ml/kg of seeds could be recommended for the enhancement seed vigour and seedling establishment for pre-monsoon sowing of maize.

Particle size analysis of nanoemulsion



SEM images of nanoemulsionTEM images of nanoemulsion





T2-62
Nutrient response on growth and yield of Maize under farmers household condition

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Abstract

Maize(*Zea mays* L.,) is important crop not only because of its great adaptability to widely varying conditions but also because of its high responsiveness to better management practices particularly irrigation and fertilizers. On - farm field experiments were conducted at Maize Research Station, Vagaraiduring *Rabi* 2022-23 season to study the response of nutrients N, P & K and $ZnSO_4$ in maize cropunder farmers' field condition. The experiments were conducted with different nutrient combination treatments such as control (No NPK), N alone, NP, NK, NPK, NPK along with micronutrient (Zn SO_4) and farmers' practice. The results revealed that the balanced application of N, P, K (250: 75: 75 kg NPK/ha) along with $ZnSO_4$ @ 37.5 kg/ha registered maximum plant height (197.4 cm), cob length (20.8 cm), cob weight (183.4 g) and hundred grain weight (51.8 g). Grain and stover yields of maize were higher with the recommended dose of fertilizer N, P, K (250: 75: 75 kg NPK/ha) along with $ZnSO_4$ @ 37.5 kg/ha with 6542 and 8760 kg/ha respectively. The lowest growth, yield attributes,grain yield and stover yields were recorded in the control plots (No N, P & K).

Keywords: Nutrient response, Recommendeddose of fertilizer, Split application,Zinc sulphate, maize yield.

Introduction

Maize (*Zea mays* L.,)is placed in third position among the cereals in terms of its importance, after rice and wheat. Maize is important crop not only because of its great adaptability to widely varying conditions but also because of its high responsiveness to better management practices particularly irrigation and fertilizers. Maize shares a major contribution in farmers economy of developing countries. Apart from providing staple diet for the population, maize is also an important crop in industrial and livestock production in India. Maize being a high nutrient mining crop it needs a higher amount of NPK for its economic production (Adhikari *et al.*, 2021). Zinc element is essential for normal, healthy growth and reproduction of plants. Nutrient deficiency is one of the important yields limiting factors includes delayed sowing, high weeds infestations, water shortage at critical growth stages. The universal deficiency of nitrogen and phosphorus is followed by Zn deficiency. Almost 50% of the world soils used for cereal production is Zn deficient (Gibbson, 2006). Keeping this in view, the present investigation was therefore conducted to evaluate the effect of NPK and Zinc on growth and yield of maize under farmers holdings.

Materials and Methods

On Farm field experiments were conducted during *rabi* 2022-23 in twelve farmers' fields atAyakudi, Kanakkanpatti and Erramanaickenpatti villages of Palani block of Dindiguldistric.The soils of the experimental fields were red sandy to red loam with low in organic carbon (0.34 %), low in nitrogen (235 kg ha^{-1})and phosphorus (9.3 kg ha^{-1})and medium in potash (245 kg ha^{-1}). The field experiment was conducted in 12farmers' fields considered as 12 replications with randomized block design. The experiment consisted of seven treatments comprising different nutrients combination *viz.*,T_1- Control (No NPK);T_2 - RDF of N @ 250 kg /ha;T_3-RDF of N and P @ 250: 75 kg /ha;T_4-RDF of N and K @ 250: 75 kg /ha;T_5-RDF of N, P and K @250:75:75 kg /ha;T_6-RDF N, P, K& $ZnSO_4$250:75:75:37.5 kg /ha andT_7-Farmers practice . The farmers practice treatment was managed by the individual farmer with their own fertilizer schedule. Recommended dose of fertilizer N, P, K & $ZnSO_4$250: 75: 75:37.5 kg /ha were applied as follows. Full dose of P, K, Zn SO4 and25 % of N as basal, split application of remaining 50 % N at 25DAS and 25 % N at 45 DAS.The net plot size of on farm experimental trials was 100 sq.m and the maize hybrids which were used for these experiments are Pioneer 3401, Cauvery and NK 6668.Maize sowing was done in the farmers' field with 60 x 25 cm spacing.

Results and Discussion

Growth and yield attributes: Recommended dose of fertilizerapplication of N, P, K (250: 75: 75 kg NPK/ha) along with $ZnSO_4$ @ 37.5 kg/ha registered higherplant height (197.4 cm), cob length (20.8 cm), cob weight (183.4 g) and 100 grain weight (51.8 g).(Table 1). It was followed by application of N, P and K nutrients @ 250:75:75 kg/ha (T_5). The lowest plant height, cob length, cob weight and 100 grain weight were observed in the control plots (No N, P & K).Higher growth and yield attributesin recommended dose of fertilizer along with zinc application might be due to the stimulatory effect of zinc on most of the physiological as well as metabolic processes of plant. The results are also reported by those of Jagdeep Sing *et al.,* (2021). Azab (2015) was also noticed that combined application of NPK fertilizer and Zn gave significant increase in plant height, leaf area and dry weight of corn.

Grain yield and Stover yield: Balanced nutrient application of N, P, K (250: 75: 75 kg NPK/ha) along with $ZnSO_4$ @ 37.5 kg/ha produced significantly highermaize grain and stoveryields of 6542and 8760 kg/harespectively. (Table 1). It was followed by application of N, P and K nutrients @ 250:75:75 kg/ha (T_5). The lowest grain and stoveryields(3530 and 5356 kg/ha)were realized in the control plots (No N, P & K). Higher grain and stoveryields of maize in recommended dose of fertilizer application with zinc might be due to the fact that zinc plays an important role in biosynthesis of IAA and initiation of primordial for reproductive part which have favored the metabolic reaction within plant. These findings are in agreement with the results obtained by Kumar *et al.,*(2018).Maximum maize yield was recorded with 150 kg N + 25 kg ZN , which was 52 % higher than control has been reported by Reddy *et al.,* (2019).

The results of the present study indicated that balanced application of N, P and K nutrients @ 250:75:75 kg/hawith $ZnSO_4$ @ 37.5 kg/ hacould be the best nutrient management practice for getting maximum yield of maize under farmers household condition at Dindigul district.

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Table 1. Effect of plant nutrients on the growth and yield of maize under farmers household condition

Treatments	Plant height at harvest (cm)	Cob length (cm)	Cob weight (g)	Hundred grain weight (g)	Grain yield (Kg/ha)	Stover yield (Kg/ha)
T_1 - Control (No NPK)	165.3	12.4	155.5	47.7	3530	5356
T_2 -RDF of N @ 250 kg /ha	174.1	14.5	163.3	48.4	4582	6780
T_3 -RDF of N and P @ 250: 75 kg /ha	177.4	15.3	168.2	49.1	4812	6945
T_4 -RDF of N and K @ 250: 75 kg /ha	183.6	16.7	174.6	49.3	5276	7442
T_5 -RDF of N, P and K @250:75: 75 kg /ha	191.3	18.1	180.1	51.2	5975	8074
T_6 -RDF of N, P, K & Zn @ 250:75:75: 37.5 kg/ha	197.2	20.8	183.4	51.8	6542	8760
T_7 -Farmers practice	185.7	17.6	178.8	50.5	5738	7961
SED	2.6	0.8	1.1	2.4	132	166
CD (0.05)	5.4	1.9	2.5	NS	268	372

T2-63
Effect of chemical weed management in hybrid Maize

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Abstract

Field experiment was carried out at Maize Research Station, Tamil Nadu Agricultural University, Vagarai, during *kharif,* 2021 season, to develop and identify economically viable best possible weed management options for maximizing the weed control vis-à-vis productivity of maize. The experiment was conducted in a Randomized Complete Block Design (RCBD) with the following weed management treatments *viz*., T_1 - Weedy check/Control, T_2 - Weed free check, T_3 - Atrazine 1.0kg/ha Pre-Emergence (PE) *fb* Hand Weeding (HW) at 25 DAS, T_4 - Atrazine 0.75kg/ha (PE) *fb* Topramezone 25.2g/ha at 25 DAS, T_5 -Atrazine 0.75kg/ha (PE) *fb*Tembotrione 120 g/ha at 25 DAS, T_6 -Atrazine 1.0kg/ha (PE) *fb* Topramezone 25.2g/ha at 25 DAS, T_7 - Atrazine 1.0kg/ha (PE) *fb*Tembotrione 120 g/ha at 25 DAS, T_8 - Topramezone 25.2g/ha + Atrazine 0.75kg/ha at 15 DAS and T_9 - Tembotrione 120g/ha + Atrazine 0.75kg/ha at 15 DAS and replicated thrice.Integrated Weed Management (IWM) practices comprising of pre-emergence application of atrazine @ 1.0kg/ha as pre-emergence on 3 DAS *fb* one hand weeding at 25 DAS, registered significantly the higher growth parameters, yield attributes and grain and straw yield of hybrid maize. In labour scarcity condition, weed management practices comprising wither sequential application of atrazine @ 1.0kg/ha (PE) *fb*Tembotrione herbicide @ 120 g/ha at 25 DAS (or) sequential application of atrazine @ 1.0kg/ha (PE) *fb* topramezone @ 25.2g/ha herbicide @ 120 g/ha at 25 DAS could be explored as alternate options.

Keyword: Maize, weed management,

Introduction

Maize (Zea mays L.) is the third most important cereal food crop in the world and it is called as queen of cereals. After rice and wheat, maize (*Zeamays* L.) is India's most significant crop. Maize is utilizednot only for human food and animal feed, but also for starch and oil production.Weed competition is one of the major biotic constraints in reducing productivity under irrigated conditions due to wider spacing and application of fertilizers. Farmers control the weeds effectively by adopting cultural methods but it also poses limitations like labor intensity, unfavorable soil and climatic conditions for effective weed control. Further, non-availability of labour with high rate of wages during peak periods of agricultural operations are the problems in cultural methods of weed control. In this context, the chemical method of weed management is gaining importance. Use of herbicides will provide completely weed free condition to the crop from its early growth period whereas, manual or mechanical weeding can be done only after the emergence of weeds (Selvakumar*etal*., 2018).

Materials and Methods

Field experiment was carried out at Maize Research Station, Tamil Nadu Agricultural University, Vagarai, during *kharif,* 2021 season, to develop and identify economically viable best possible weed management options for maximizing the weed control vis-à-vis productivity of maize. The experiment was conducted in a Randomized Complete Block Design (RCBD) with the following weed management treatments *viz*., T_1 - Weedy check/Control, T_2 - Weed free check, T_3 - Atrazine 1.0kg/ha Pre-Emergence (PE) *fb* Hand Weeding (HW) at 25 DAS, T_4 - Atrazine 0.75kg/ha (PE) *fb* Topramezone 25.2g/ha at 25 DAS, T_5 -Atrazine 0.75kg/ha (PE) *fb*Tembotrione 120 g/ha at 25 DAS, T_6 -Atrazine 1.0kg/ha (PE) *fb* Topramezone 25.2g/ha at 25 DAS, T_7 - Atrazine 1.0kg/ha (PE) *fb*Tembotrione 120 g/ha at 25 DAS, T_8 - Topramezone 25.2g/ha + Atrazine 0.75kg/ha at 15 DAS and T_9 - Tembotrione 120g/ha + Atrazine 0.75kg/ha at 15 DAS and replicated thrice.

Results and Discussion

Application of pre-emergence herbicide, early post emergence herbicide, hand weeding and integrated weed management practices significantly influenced weed density, as well as growth and yield attributes and productivity of the hybrid maize. Among the various weed management treatments experimented, integrated weed management practices involving application of atrazine @ 1.0kg/ha as pre-emergence on 3 DAS *fb* one hand weeding at 25 DAS (T_3) significantly registered minimum density of grassy weeds, sedges and broadleaved weeds at 50 DAS, followed by sequential application of atrazine @ 1.0kg/ha (PE) *fb*Tembotrione herbicide @ 120 g/ha at 25 DAS (T_7) and sequential application of atrazine @ 1.0kg/ha (PE) *fb* topramezone @ 25.2g/ha herbicide @ 120 g/ha at 25 DAS (T_6). Both the early post emergence herbicides *viz*., Tembotrione and topramezone were highly effective in controlling of all the weed species in general and broadleaved weeds in specific.

With regard to yield attributes and yield of grain and straw, practicing integrated weed management practices by application of atrazine @ 1.0kg/ha as pre-emergence on 3 DAS *fb* one hand weeding at 25 DAS (T_3), significantly accounted the higher cob length, cob girth, grain rows/cob, number of grains/row, grain yield (7836 kg/ha) and straw yield (10814 kg/ha), however it was on par with the sequential application of atrazine @ 1.0kg/ha (PE) *fb*Tembotrione herbicide @ 120 g/ha at 25 DAS (T_7) and sequential application of atrazine @ 1.0kg/ha (PE) *fb* topramezone @ 25.2g/ha herbicide @ 120 g/ha at 25 DAS (T_6). The lowest yield attributes, grain and straw yield was recorded in weedy check ((T_1). A pigment synthesis inhibitor tembotrione (42% SC), which is a post-emergent broad-spectrum systemic herbicide of triketone group has been tested and proved to be successful in managing all the categories of weeds infesting the maize fields during later stages (Dharam *et al*. 2018). Singh *et al*., (2012) also reported that post-emergence application of tembotrione 120 g ha^{-1} along with surfactant (1000 ml ha^{-1}) was found most effective to control the grassy as well as non-grassy weeds.

In term of economics, Integrated Weed Management (IWM) practices comprising of pre-emergence application of atrazine @ 1.0kg/ha as pre-emergence on 3 DAS *fb* one hand weeding at 25 DAS (T_3), registered significantly the maximum gross return (Rs. 1, 17,545/ha), net return (Rs. 35,876/ha) and B: C ratio (1.44).In labour scarcity condition, weed management practices comprising wither sequential application of atrazine @ 1.0kg/ha (PE) *fb*Tembotrione herbicide @ 120 g/ha at 25 DAS (or) sequential application of atrazine @ 1.0kg/ha (PE) *fb* topramezone @ 25.2g/ha herbicide @ 120 g/ha at 25 DAS could be explored as alternate options.

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Table 1. Effect of weed management practices on growth, weed density, yield attributes and yield of maize

Treatments	Plant height at harvest (cm)	Grain rows/ cob	No. of grains / row	100 seed weight (g)	Yield (kg/ha)		BCR
					Grain	Stover	
T_1	189.8	14.1	26.3	36.7	4053	6294	0.87
T_2	227.2	15.1	34.4	38.7	7959	10964	1.33
T_3	222.3	14.9	33.5	38.5	7836	10814	1.44
T_4	206.7	14.7	30.7	38.1	6736	9523	1.31
T_5	214.6	14.7	30.7	37.8	6748	9535	1.33
T_6	216.8	14.8	31.2	38.2	7039	9715	1.37
T_7	219.1	14.8	31.7	38.2	7192	9933	1.42
T_8	201.8	14.4	30.0	37.6	6145	9324	1.22
T_9	204.2	14.4	30.1	37.4	6297	9381	1.27
CD at 5%	21.4	NS	3.5	NS	1051	1493	
CV (%)	5.9	3.4	6.6	3.7	9.1	9.1	

T2-64
Grain cum fodder production in maize based intercropping system under irrigated condition

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Abstract

The green fodder requirement for ever-increasing livestock population, the production as well as productivity of fodder needs to be increased.The Field experiment was conducted during 2022-23 at MRS, Vagarai, ARS, Bhavanisagar and ARS, Vaigaidam under irrigated condition in randomized block design with three replications.The experiment consisted of the following treatments *viz*., T_1- Grain maize alone (100 % RDF), T_2-Grain maize + fodder maize with 100 % RDF, T_3-Grain maize + fodder maize with 125 % RDF, T_4-Grain maize + fodder maize with 150 % RDF, T_5-Grain maize + fodder cowpea with 100 % RDF, T_6- Grain maize + fodder cowpea with 125 % RDF and T_7- Grain maize + fodder cowpea with 150 % RDF. Both the fodder crops *viz*., fodder maize and fodder cowpea were raised between the maize crops. All other agronomic management practices were followed as regular irrigated crop.Between the intercrops, the fodder maize recorded higher fodder yield than fodder cowpea in all the intercropping situations. Regarding fodder maize, grain maize + fodder maize with 150 % RDF of NPK recorded higher fodder yield (16.97 t/ha) (T4) . Grain maize alone (T_1) recorded higher grain yield (6816 kg/ha). This was on par with grain maize and fodder maize with addition of 125 % RDF (6636 kg/ha) (T_3) and the same trend was observed in maize stover yield also.Among the maize based intercropping situation, Grain maize with fodder maize with addition of 125 % recommended dose of NPK recorded higher net return of Rs. 76,510 and the B:C ratio of 1.97. The lowest net return and BCR was recorded in the treatment grain maize with fodder cowpea with of 150 % RDF.

Keywords: Maize, Fodder, Intercropping

Introduction

Integration of animal component is one of the key factor to sustain agriculture production at farm level. Availability of quality green fodder is very important for the success of animal component in profitable way. At present, thereexists around 63 % deficiency of green fodder and 23.5 % deficiency of dry fodder in India (Singh, 2009). Now a days, Maize became one of the most suitable fodder crop for making silage. Thus, maize has become a major constituent of ruminant rations in recent years, where its inclusion in dairy cow diets improves fodder intake, increases animal performance and reduces production costs (*Anil et al.*, 2000). In this situation to satisfy the green fodder requirement for ever-increasing livestock population, the production as well as productivity of fodder needs tobe increased. Intercropping system has been recognized as an effective strategy in intensive agriculture as well as better management practices for effective utilization of natural resources. Hence this study was proposed to find out the influence of intercropping fodder maize and fodder cowpea on the yield of grain maize and green fodder with level of fertilizer.

Materials and Methods

The Field experiment was conducted during 2022-23 at MRS, Vagarai, ARS, Bhavanisagar and ARS, Vaigaidam under irrigated condition in randomized block design with three replications. The experiment consisted of the following treatments *viz*., T_1- Grain maize alone (100 % RDF), T_2-Grain maize + fodder maize with 100 % RDF, T_3-Grain maize + fodder maize with 125 % RDF, T_4-Grain maize + fodder maize with 150 % RDF, T_5-Grain maize + fodder cowpea with 100 % RDF, T_6- Grain maize + fodder cowpea with 125 % RDF and T_7- Grain maize + fodder cowpea with 150 % RDF. Both the fodder crops *viz*., fodder maize and fodder cowpea were raised between the maize crops. All other agronomic management practices were followed as regular irrigated crop.

Results and Discussion

The intercropping practices exhibited significant effect on growth and yield characters of maize. Plant height was maximum (32.5 cm) in the treatment of Grain maize + fodder maize with 150 % RDF (T_4). This was on par with the treatments of grain maize with fodder maize and addition of 125 % RDF and Grain maize alone. With regard to DMP at harvest, the same trend was observed. The treatment, Grain maize + fodder cowpea with 150 % RDF registered lowest growth attributes.The cob weight was maximum in grain maize alone (219.7 g) (T_1) and it was on par with the treatments of Grain maize + fodder maize with 125 % and the lowest cob weight was observed in the treatment Grain maize + fodder cowpea with 150 % RDF (T_7).

Regarding grain yield, grain maize alone (T_1) recorded higher grain yield (6816 kg/ha). This was on par with grain maize and fodder maize with addition of 125 % RDF (6636 kg/ha) (T_3) and the same trend was observed in maize stover yield also.All the leas yield parameters, maize grain yield and maize stover yield were recorded in the treatment Grain maize + fodder cowpea with 150 % RDF (T_7).This mightbe because intercropping fodder crops exertedcompetition with maize for growth resources,thereby affecting grain formation anddevelopment. Similar finding was reported byGetachew *etal*., (2013).

Between the intercrops, the fodder maize recorded higher fodder yield than fodder cowpea in all the intercropping situations. Regarding fodder maize, grain maize +d fodder maize with 150 % RDF of NPK recorded higher fodder yield (16.97 t/ha) (T4) . This was on par with 125 % RDF of NPK (17.3 t/ha). In fodder cowpea, grain maize with fodder cowpea with of 150 % RDF of NPK registered the maximum fodder yield (12.9 t/ha).The green fodder yield of maize linearlyincreased with increased fertilizer levels. Thismight be due to increased nutrient uptakeassociated with increased fertilizer applicationand better growth which resulted in enhancedaccumulation of photosynthates which reflects on fodder yield and accordance with the findings of Mahdi *etal*., (2010) and Mohamed Amanullah and Nivethitha (2020).

Among the maize based intercropping situation, Grain maize with fodder maize with addition of 125 % recommended dose of NPK recorded higher net return of Rs. 76,510 and the B:C ratio of 1.97. The lowest net return and BCR was recorded in the treatment grain maize with fodder cowpea with of 150 % RDF.

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Table 1. Influence of intercropping fodder maize and cowpea on Hybrid maize

Treatments	Plant height (cm)	DMP (t/ ha)	Cob weight (g)	Grain yield (kg / ha)	Stover yield (kg / ha)	Fodder yield (t/ ha)	Net income (Rs / ha)	BCR
T_1	232.4	14.4	219.7	6816	8732	-	60146	1.90
T_2	221.5	13.3	203.3	6171	8085	14.2	66590	1.88
T_3	226.6	14.2	211.6	6636	8494	15.9	76510	1.97
T_4	232.5	13.9	204.0	6436	8251	17.3	73005	1.90
T_5	220.9	13.0	201.8	5738	7713	12.2	54362	1.73
T_6	221.1	13.0	194.9	5958	7834	12.5	57324	1.73
T_7	216.7	12.6	190.3	5679	7731	12.9	49374	1.63
S.E.d	4.8	0.2	3.8	123	222			
CD (0.05)	10.5	0.5	8.3	268	484			

T2-65
Effect of drip fertigation system on high value Maize based cropping system

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Introduction

Maize is the third most important grain crop in India, after rice and wheat with respect to area and productivity. In Tamil Nadu, Maize is cultivated under irrigated condition during *kharif* season in Perambalur, Salem, Cuddalore, Erode, Villupuram and Ariyalur districts. Maize crop mostly cultivated under ridges and furrow method by adopting surface irrigation method. Water is increasingly becoming a major limiting factor for agriculture in Tamil Nadu and hence, efficient utilization of available water resources is most important. Drip irrigation system has substantially high irrigation efficiency (80 to 90%) when compared to surface irrigation method (Ramulu*et al.,* 2010). In order to, increase the water use efficiency and water productivity in maize grown districts during *kharif* season in Tamil Nadu it can be cultivated under raised bed system by using drip irrigation method. Maize is nutrient exhaustive crop and hence, application of fertilizer in right time, right quantity and right stage is more important. It should be easily addressed by adopting the drip irrigation system (Kadasiddappa and Praveen Rao, 2018). In Tamil Nadu, Perambalur, Salem, Cuddalore, Erode, Villupuram and Ariyalur districts maize crop is cultivated under irrigated condition during *kharif* season. In these districts high value prevailing vegetable crops can be grown during *rabi* season.Now-a-days, vegetable crops *viz*., onion fetching higher monetary returns. In sandy loamy soil condition, mostly onion is cultivated during *rabi* season in above mentioned districts of Tamil Nadu. Hence, drip irrigation system is most suitable for precise use of water and fertilizer, increasing water use efficiency and water productivity in system basis. With the above background, this study was conducted for enhancing the water use and water productivity under Maize – Onion cropping system.

Materials and Methods

A field experiment was conducted during the year 2017-18ineastern block farm at Tamil Nadu Agricultural University, Coimbatore,The experimental trial was laid out in randomized block design with four replications. Treatments imposed are drip fertigation @ 50% pan evaporation (T_1), drip fertigation @ 75% pan evaporation (T_2), drip fertigation @ 100% pan evaporation (T_3), drip fertigation @ 125% pan evaporation (T_4) and conventional method of irrigation (T_5). Maize crop was raised during *Kharif* season and Onion crop was raised during *rabi* season. Variety chosen for the study were for maize crop CO H(M) 6 and for onion crop CO (On) 5. For drip irrigation treatments, drip system was installed in raised bed (width of 90 cm) and the distance between two laterals 120 cm, the water discharge rate of emitters 4 lph. In conventional method, ridges and furrows were formed with a spacing of 60 cm. Irrigation was given once in3 days through drip system as per the pan evaporation value for the treatment. For conventional method, irrigation was given once in 7-10 days depending upon the soil moisture condition. The effective rainfall amount was added along with irrigation water for the calculation of total water applied in each treatment. The recommended fertilizer schedule for hybrid maize is 250:75:75 kg N, P, K ha^{-1}. For drip irrigation treatments T_1& T_2, P source (SSP) was applied fully as basal, N and K (urea and white potash) was applied in split through drip irrigation as per schedule. All the recorded data were analysed statistically as per the method suggested by Gomez and Gomez (1984).

Results and Discussion

Based on the study the result revealed that, growth and yield attributes were recorded higher in drip fertigation at 125 % pan evaporation when compared to conventional irrigation method in Maize and Onion crop (Table 1). Drip fertigation at 125 % pan evaporation regime in Maize recorded higher grain yield of 6882 kg/ha with a water saving of 29.3 % when compared to conventional irrigation method in Maize. Drip fertigation at 125 % pan evaporation regime in Onion registered higher bulb yield of 16337 kg/ha with a water saving of 28.8%when compared to conventional irrigation method. Drip fertigation at 100% pan evaporation registered higher water use efficiency in maize (16.7 kg/ha mm) and onion (43.5 kg/ha mm) when compared to surface irrigation method (Table 2).

Drip fertigation methods performed better than conventional irrigation method in Maize – Onion cropping system. Drip fertigation at 125 % pan evaporation regime in Maize recorded higher grain yield of 6882 kg/ha with a water saving of 29.3 % when compared to conventional irrigation method. Drip fertigation at 125 % pan evaporation regime in Onion recorded higher grain yield of 16337 kg/ha with a water saving of 28.8 % when compared to conventional irrigation method.In both the crops, drip fertigation at 100% pan evaporation registered higher water use efficiency and water productivity in Maize - Onion cropping system.

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Table 1. Influence of irrigation regimes on yield attributes and yield of Maize – Onion cropping system

Treatments	Maize crop			Onion crop		
	Cob length (cm)	Cob girth (cm)	Grain yield (kg/ha)	Clump weight (g /plant)	Bulb number / clump	Bulb yield (kg /ha)
Drip fertigation @ 50% pan evaporation (T_1)	10.2	9.1	3217	34.5	2	7562
Drip fertigation @ 75% pan evaporation (T_2)	13.7	11.7	4894	51.5	3	11093
Drip fertigation @ 100% pan evaporation (T_3)	17.8	14.3	6456	63.3	4	15766
Drip fertigation @ 125% pan evaporation (T_4)	18.6	15.9	6882	63.8	4	16337
Conventional method of irrigation (T_5)	16.3	14.1	5463	48.2	3	11358
S.Ed.	0.6	0.3	118	1.3	0.1	255
CD (0.05)	1.0	0.8	248	2.8	0.2	521

Table 2. Influence of irrigation regimes on total water use, WUE and water productivity

Treatments	Maize crop		Onion crop	
	Total Water used (mm)	WUE (kg/ha mm)	Total water used (mm)	WUE (kg/ha mm)
Drip fertigation @ 50% pan evaporation (T_1)	205	15.6	194	38.9
Drip fertigation @ 75% pan evaporation (T_2)	312	15.7	284	39.1
Drip fertigation @ 100% pan evaporation (T_3)	388	16.7	362	43.5
Drip fertigation @ 125% pan evaporation (T_4)	416	16.5	412	39.6
Conventional method of irrigation (T_5)	588	9.3	578	19.6

T2-66

Studies on finding suitable crop geometry and seedling age for getting maximum yield in transplanted Sorghum

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Abstract

Field experiment was conducted during 2018-19 at agricultural research station, kovilpatti to find the optimum spacing and seedling age for getting maximum yield in transplanted sorghum. experiment was laid out in split-plot design with three replications.the treatment combinations comprised of three spacing *viz.*, s_1 - 45 × 15 cm, s_2 - 45 × 30 cm, s_3 - 45 × 45 cm in main plot with four different age of seedlings *viz.,*t_1- transplanting with 15 days aged seedling, t_2- transplanting with 18 days aged seedling, t_3- transplanting with 21 days aged seedling, t_4- control (normal sowing)in sub plot. The results of the experiment revealed that transplanting of sorghum variety K 12 with 18 days old seedling with spacing of 45 X 15 cm registered highest yield of 3506 kg ha^{-1} followed by transplanting of 21 days old seedlings with the spacing of 45 X 30 cm (2961 kg ha^{-1}) under irrigated vertisol condition. Higher gross return and B:C ratio ofRs. 66605/- and 2.93 were recorded by transplanting of sorghum variety K 12 with 18 days old seedling with spacing of 45 X 15cm**.**

Keywords*:* Sorghum, Spacing, Age of seedlings, Transplanting and Yield

Introduction

Sorghum ranks third in the major food grain crops in India, whereas it is the fourth food grains of the world. Millions of people in Africa and Asia depend on sorghum. In addition, the fodder and stover is fed to millions of cattle. In India, sorghum is cultivated in 6.16 million ha with production of 5.45 million tonnes during the year 2014 - 15 (Agricultural Statistics at a glance 2016). In Tamil Nadu it is cultivated over an area of3.39 lakh hectares with an annual production of 4.39lakh tones and a productivity of 1301 kg/ha of grain (2015-16).

IN TAMILNADU SORGHUM IS BEING CULTIVATED IN TWO SEASONS *VIZ.,* EARLY MONSOON (SOUTH-WESTMONSOON) IN JUNE-JULY AND LATE MONSOON (NORTH-EASTMONSOON) IN SEPTEMBER – OCTOBER. IN CERTAIN ISOLATED POCKETS LIKE, THE POLLACHI AREA OF COIMBATORE DISTRICT AND THE TENKASI TRACT (KADAYANALLUR) OF TIRUNELVELI DISTRICT, THE RAINFED CROP IS SOWN AS EARLY IN APRIL OR MAY AND THE CROP MATURES WITH THE HELP OF SUMMER SHOWERS AND THE EARLY MONSOON RAINS. WHEREAS THE IRRIGATED SORGHUM IS RAISED UNDER TWO WELL DEFINED SEASONS *VIZ.,* 'THAIPATTAM' (JANUARY - FEBRUARY) AND 'CHITRAIPATTAM' (MARCH - APRIL). NEARLY 20 TO 25 PER CENT OF THE AREA UNDER SORGHUM IN THE STATE IS CROPPED IN SUMMER SEASON UNDER ASSURED WATER SUPPLY.

The main challenges for farmers in semi-arid and arid areas of the tropics and sub tropics are poor food security, yield instability and risk of crop failure due to erratic and unreliable rainfall resulting in shortage of water. Under this condition, there is a considerable risk of failure of crops, patchy stands and high re-planting costs. In semi-arid areas, crop stands is improved by filling gaps with seedlings from overcrowded parts of the field. Transplanting sorghum and pearl millet varieties grown in nurseries has improved establishment in the field (Mapfumo, 2002).

Age of seedlings is an important factor in the transplanted crops. Onset of the rainy season in **semi-arid** tropics is highly variable. If nurseries are established early and the late arrival of rains, seedlings may be too old to be transplanted. Old transplants have high transpiration rates due to greater leaf area and this may affect establishment. Delayed sowing or transplanting in sorghum led to lower grain yield. However, transplanting had less depressive effects than late sowing for both cultivars (Tenkouano *et al*., 1997). Basu*et al.* (2003) opined that transplanting of 21-day old seedlings gave identical grain yield with direct sown crop and matured 8-10 days earlier. Badran (2001) stated that under late planting conditions, transplanting of maize may be a possible alternative to direct sowing. Therefore, transplanting of sorghum may be advantages in this specific location like Tenkasi area of Tamil Nadu. Narrow row spacing (30 cm) and low seeding rate (5 kg ha^{-1}) produced the maximum grain yield consistently while lower yields were recorded in the treatments having greater row spacing (60 cm) and higher seed rates (7.5, 10, 12.5 & 15 kg ha^{-1}) (Gondal et al., 2017)

Hence, the present study is undertaken to evaluate the performance of transplanted sorghum with different age of seedlings and spacing considering yield, yield attributes compared with direct sown sorghum

Materials and Methods

Experiment was conducted in black soil farm of Agricultural Research Station, Kovilpatti and it was laid out in split plot design and replicated thrice. The treatment combination comprised of

Main plot: Spacing

S_1 - 45 × 15 cm

S_2 - 45 × 30 cm

S_3 - 45 × 45 cm

Sub-plot : Transplanting

T_1- Transplanting with 15 days aged seedling

T_2- Transplanting with 18 days aged seedling

T_3- Transplanting with 21 days aged seedling

T_4- Control (Normal sowing)

Design : Split plotReplication : ThreeVariety : K 12

Season : Summer irrigated - March - April

Nursery and main field were laid out at black soil farm of Agricultural Research Station, Kovilpatti and sowing of sorghum variety K12 was done in nursery and main field on 22.03.19 and transplanting of seedlings were done as per the approved technical program.

Data on plant height, LAI, DMP, number of grains per panicle (nos.), 100 seed weight and seed yield were recorded replication wise. The data on growth and yield attributes and yield were statistically analyzed and presented below.

Results and Discussion

The crop received 75.4 mm of rainfall in 6 rainy days. The average maximum and minimum temperature was 39.3 and 25.2 °C and sun shine hours was 8.2 hrs. Among different spacing tried, higher survival percentage of 81 was recorded by 45 X 15 cm. Among the age of seedlings, higher survival percentage was recorded by direct sowing of seeds in main field (96%), followed by transplanting of 18 days old seedlings (78%). There is no significant difference was found in shoot fly incidence among different spacing and age of seedlings tried (Table 1).

Treatments failed to influence plant height of sorghum but leaf area index was influenced by different spacing and age of seedlings. Increased LAI was recorded by wider spacing of45 × 45 cm (5.78) and transplanting of 18 days old seedlings (5.48). Higher number of seeds panicle^{-1} was recorded by wider spacing of 45 × 45 cm (2122 nos.) and transplanting of 21 days old seedlings (2063 nos.) may be due to lesser competition between plants. While 100 grain weight (2.32 g) and yield of sorghum (2705 kg ha^{-1})was significantly higher in closer spacing of 45 × 15 cm and transplanting of 18 days old seedlings(2.32 g and 2705 kg ha^{-1}) respectively(Table 1).

With regard to economics, higher gross return (Rs. 66,605/-), net return (Rs.43,853/-) and B:C ratio (2.93) was recorded by transplanting of 18 days old seedling with closer spacing of 45 x 15 cm. This was followed by direct sowing of seeds in 45 x 15 cm (Table 1).

Table 1. Influence of spacing and age of seedling on survival % and shoot fly incidence

Treatments	Survival%	Shoot fly incidence (%)	Plant height (cm)	LAI	No.of seeds panicle^{-1}(Nos.)	100 seed weight (g)	Grain yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Netreturns (Rs. ha^{-1})	B : C ratio
Main plot : Spacing										
S_1 : 45× 15 cm	81	8.5	207.4	4.76	1476	2.32	2705	54108	31402	2.40
S_2: 45 × 30 cm	70	8.5	201.9	5.18	1890	2.22	2297	45943	24316	2.12
S_3: 45 × 45 cm	74	8.5	202.2	5.78	2122	2.23	1878	37551	16540	1.79
Sed	5	0.4	12.2	0.31	105	0.11	138	-	-	-
CD (5 %)	NS	NS	NS	0.87	290	0.32	382	-	-	-
Sub plot: Age of seedlings										
T_1:Transplanting of 15 days seedling	64	8.7	204.4	4.83	1452	2.24	1944	38887	16533	1.74
T_2: Transplanting of 18 days seedling	78	8.3	204.7	5.48	1949	2.31	2505	50096	28161	2.26
T_3: Transplanting of 21 days seedling	61	9.0	202.5	5.31	2063	2.21	2458	49165	26811	2.20
T_4:Normal sowing as control	96	8.0	203.8	5.33	1852	2.27	2266	45321	24839	2.20
Sed	7	0.4	10.2	0.26	99	0.11	115	-	-	-
CD (5%)	14	NS	NS	0.55	209	0.22	241	-	-	-
M at S Sed	12	0.8	14.7	0.40	182	0.20	214	-	-	-
M at S CD (5%)	NS	NS	NS	NS	423	0.46	505	-	-	-
S at M Sed	12	0.8	12.9	0.35	172	0.18	192	-	-	-
S at M CD (5%)	NS	NS	NS	NS	362	0.39	404	-	-	-

T2-67
Assessment of suitability of minor millets in Vellore District

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Abstract

Minor millets are high energy, nutritious foods comparable to other cereals and some of them are even better with regard to protein and mineral content. They are particularly low in phytic acid and rich in dietary fibre, iron, calcium and B vitamins. For a water-starved district like Vellore, cultivation of millets is suitable, say experts. For the suitability of small millets in Vellore district was assessed in hills and plain of Anaicut block of Vellore and for this samai, tenai, varagu and panivaragu were demonstrated in the farmers field. Among selected millets samai ATL 1 found to more suitable in terms of yield (1650 and 1315 kg/ha, respectively for hills and plain) followed by tenai, varagu and panivaragu.The yield difference in the selected millets might be due to climatic condition and soil types.The Krishi Vigyan Kendra (KVK), Vrinjipuram, is encouraging farmers to take up millet cultivation.

Keywords: Minor millets, Samai, Tenai, Varagu and Panivaragu

Introduction

Millets are cereals from the Poaceae grass family and are considered one of the oldest cultivated crops. Millets are also believed to have nutraceutical health benefits. As the millets are consumed by the poor, they guard them against food and nutritional insecurity imposed by various agronomic, socio economic and political factors. Minor millets can thus act as a shield against nutritional deficiency disorders and provide nutritional security (Dayakar Rao*et al*.. 2017; Hassan*et al*. 2021). These include but are not limited to, an increase in digestive system well-being, a reduction in cholesterol, the prevention of heart disease, protection against diabetes, the lowering of cancer risks, and an increase in energy levels and improvement of the muscular system. These characteristics ought to place such grains in the right position in terms of alternative crops; however, due to a lack of attention, millet was termed the ‘lost crop. Given the current challenges regarding sustainable food production, climatic changes, and water scarcity, coupled with overpopulation, an interest has been developed regarding millet. This has provided an opportunity for farmers, nutritionists, and food and feed manufacturers to engage in research in order to understand the nutritional and functional characterisation of millet grains. The present study focuses on the suitability of minor millets were assessed in Vellore district.

Materials and Methods

The small millet variety of Samai (ATL 1),tenai (ATL 1), vargau (ATL 1) andpanivaragu (ATL 1) crops trails were conducted at two different locations (Hills and plains) of Anaicut block, Vellore district. The crops are raised in September-October (Puratassipattam) season. All the good agricultural practices were followed as per TNAU crop production guide. The crops (samai, tenai,varagu and panivaragu)wereharvested 85-90, 80-85,110 and 70 days after sowing, respectively.

Results and Discussion

Crop suitability analysis in Vellore District was carried for three small millet crops viz., samai, tenai, varagu and panivaragu.The average grain yield of samai, tenai,varagu and panivargauwere1312, 1015,1051 and 901kg/ha, respectively in the hills, where as in the plains it was, 1015, 760, 852 and 665 kg/ha, respectively (Table 1). Similarly, when compared to ATL varieties with local type, the ATL varieties were gave more yield than local (Table 2) and among four minor millets samai ATL 1 found to be suitable in Vellore district in terms of yield compared to other millets. The difference in the selected millets might be due to climatic condition and soil types.Millets grown and matured under conditions of low rainfall and soil fertility, with little or no attention. The temperature range for growth is 16-32 ºC. Millets requires a well drained, aerated, depth (0.5 m to 2.0 m) with red loamy soil type and optimum pH 5.6-7.6.

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Table 1. Grain yield of small millets in Vellore district

Locations	Average grain yield (Kg/ha)			
	Samai	**Tenai**	**Varagu**	**Pannivargu**
Hills	1312	1025	1051	901
Plain	1015	760	852	665

Table 2. Comparison of local and small millets ATL varieties yieldin Vellore district

Locations	Average grain yield (Kg/ha)							
	Local	**Samai ATL 1**	**Local**	**Tenai ATL 1**	**Local**	**Varagu ATL 1**	**Local**	**Pannivargu ATL 1**
Hills	974	1650	726	1324	845	1258	751	1052
Plain	718	1315	540	1015	654	985	420	915

T2-68

Assessment of seed dormancy duration of small millet varieties in seed supply chain

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Abstract

Small millets are a group of grassy plants having short slender culm categorized under coarse cereals which belong to the family poaceae. In most of the grass species, seeds possess post-harvest dormancy and needs some period of storage for release of dormancy. To assess the duration of dormancy in small millets varieties, an experiments was conducted at Centre of Eexcellence in Millets, Athiyandal during 2022-23.Freshly harvested small millets seeds of Foxtail millet Co (Te)7, Kodo millet (CO 3), Little millet Co (Sa)4 , Proso MilletCO 5 and Barnyard Millet CO (KV) 2seeds were collected and seed quality parameters were evaluated. Among the millets, proso millet CO 5 had the dormancy up to 28 daysand Barnyard millet CO (KV) 2 had the dormancy up to 35 days. In foxtail millet Co (Te) 7, Kodo millet (CO 3) and little millet CO 3 (Sa)4 no seed dormancy was observed immediately after harvest.

Keywords: Small millets, seed dormancy, germination, vigour

Introduction

The Millets are rich source of Protein, Fibre, Minerals, Iron, Calcium and have a low glycemic index. To create domestic and global demand and to provide nutritional food to the people, Government of India had proposed to United Nations for declaring 2023 as International Year of Millets (IYoM). Through the efforts made by the Government, the production of millets has increased from 14.52 million tonnes in 2015-16 to 17.96 million tonnes in 2020-21 (Maddipoti*et al*., 2022). Knowledge on the duration of seed dormancy is very much useful to the farmers who take up crop production immediately after harvest and to find out cost effective dormancy breaking methods. Based on these aspects, an experiment is proposed to assess the seed dormancyduration of TNAU released small millet varieties in seed supply chain .

Materials and Methods

Freshly harvested small millets seeds *viz.*, Foxtail millet Co (Te)7, Kodo millet (CO 3), Little millet Co (Sa)4 , Proso MilletCO 5, Barnyard Millet CO (KV) 2seeds were collected from Department of Millets, TNAU, Coimbatore and Centre of Excellence, Athiyanthal, Tiruvannamalai. To assess the seed dormancy duration, seeds were evaluated for seed quality parameters viz., germination, seedling length and vigour parameters. Germination test was carried out in paper media using 400 seeds with four replications @ 100 seeds per replication. Final count on normal seedlings was recorded on tenth day and percent germination was computed. The vigour index value was calculated and expressed in whole number and dry weight of the seedlings were assessed and expressed as mg 10 seedlings $^{-1}$.

Results and Discussion

Five different small millets were evaluated for presence of dormancyat different days after harvest. Among the millets, proso millet CO 5 had the dormancy up to 28 days. As per IMSCS, the recommended germination is 75%. In proso millet, immediately after harvest the germination was only 14% and it reached to 83% after 28 days after harvest and 96% after 35 days of harvest (Table1). Barnyard millet CO (KV)2 also had the dormancy up to 35 days. In barnyard millet, immediately after harvest the germination was only 7% and it reached to 82% after 35 days after harvest and the maximum of 96% was noticed after 42 days of harvest (Table 2). In foxtail millet Co (Te)7, Kodo millet (CO 3) and little millet CO 3 (Sa) 4no seed dormancy was observed and Immediately after harvest, the germination was 90%,86% and 85%, respectively. Similar result was observed in green foxtail seed which exhibits complete dormancy when freshly harvested(Vanden Born, 1970). Naturally occurring gases (oxygen, nitrogen, carbon monoxide) cause dormancy in giant foxtail (*Setariafanerii*) under favorable temperature and moisture conditions (Dekker and Hargrove, 2002). In small millets, the testa and pericarp, which cover the embryos of seeds, acted as a barrier to the diffusion of oxygen to the embryo.

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Table 1. Evaluation of seed quality parameters of proso millet and Barnyard millet

Seed stage	Proso millet CO 5				Barnyard millet CO (KV)2			
	Germination (%)	RL (cm)	SL (cm)	DMP (mg 10 seedling^{-1})	Germination (%)	RL (cm)	SL (cm)	DMP (mg 10 seedling^{-1})
Initial	14	9.23	8.58	28.34	7	8.86	7.23	30.12
7 DAH	35	10.50	8.87	32.10	22	9.34	7.56	33.45
14 DAH	57	11.42	9.45	35.65	40	10.23	8.17	35.32
21DAH	72	12.11	9.82	40.13	58	11.12	9.25	42.67
28 DAH	83	12.45	9.90	42.25	69	12.44	10.22	43.76
35 DAH	96	13.34	10.43	45.54	82	12.67	11.26	46.26
42 DAH	96	13.52	10.55	45.65	93	13.78	11.85	46.87
SEd	2.45	0.56	0.62	0.07	2.21	0.63	0.85	0.16
CD (P=0.05)	4.92	1.04	1.25	0.15	4.44	1.28	1.72	0.34

DAH- Days after harvest , RL- Root length, SL- Shoot length

T2-69

Effect of different production factors on yield and economics of Pearl Millet

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Abstract

Field experiments were conducted during *Kharif* seasons 2021, 2022 in Randomised Block design with three replications. Pearl millet hybrid HHB 299 was used. Soil was sandy clay loam, slightly alkaline pH (8.53), non-saline nature (EC 0.37 dS/m) with low organic carbon content (0.40 %). Treatments were, T_1 - Full package & practices of location [RDF + $ZnSO_4$ @25 kg/ha + $FeSO_4$ @ 0.5-0.75% at 20-25 DAS + bio-inoculant seed treatment (*Azoteeka*) + thinning & gap filling + weeding & hoeing (3-5 WAS) + irrigation], T_2 - T_1 – RDF, T_3 - T_1 - $ZnSO_4$ @25 kg/ha, T_4 - T_1 - $FeSO_4$ @ 0.5-0.75% at 20-25 DAS, T_5 - T_1 - bio-inoculant seed treatment, T_6 - T_1 – thinning & gap filling, T_7 - T_1 - weeding & hoeing (3-5 WAS), T_8 **-** T_1 - irrigation. Experimental result, revealed significant difference among treatments for different growth parameters, yield attributes, grain and stover yields of pearl millet hybrid. Pearl millet cultivation with full package of practices viz., RDF + $ZnSO_4$ @ 25 kg/ha + $FeSO_4$ @ 0.5-0.75 % at 20-25 DAS + bio-inoculant seed treatment (*Azoteeka*) + thinning & gap filling + weeding & hoeing (3-5 WAS) + irrigation (T_1) recorded taller plants (192.5 cm), more total tillers plant^{-1} (4.9 nos.) and effective tillers plant^{-1} (4.4) and highest grain yield (33.56 q/ha). The contribution of individual agronomic factors revealed no weeding and hoeing (3-5 WAS), no RDF recorded 39.0% yield reduction and it was followed by no thinning and gap filling accounting to 23.27% yield reduction. No application of ZnSO4 (11.44%), no irrigation (9.06%), $FeSO_4$ @ 0.5-0.75% at 20-25 DAS (9.03 %) and bioinoculant seed treatment (5.23%) also exhibited their individual contribution towards productivity of pearl millet. Full package of practices (T_1) recorded highest gross returns (Rs.61687), net returns (Rs. 27902), B:C ratio (1.83) and lowest with no weeding and hoeing (3-5 WAS) (T_7).

Keywords: Bioinoculants, Micronutrients, Irrigation, Weeding, RDF (Recommended dose of fertilizers), Agronomic factors, productivity

Introduction

"Pearl millet" is a small seeded millet belonging to grass family with special characteristics of drought tolerance and establishes well in arid and semi-arid ecosystems. It is mostly grown as a rainfed crop under low soil fertility and moisture deficit conditions on marginal lands. Pearl Millet is resilient to high temperatures and drought prone environments requiring only 350 mm water. Pearl millet is highly nutritious and has high proportion of slowly digestible starch (SDS) and resistant starch (RS) contributing to low glycemic index (GI) and is the need of the transforming diets, food habits and the food industry (Satyavati, 2021). Hence, it gains importance in increasing the production for which its contributing factors has to be identified so that it can be worked upon to increase the yield. A study was proposed with an objective of quantification of individual production factors of management towards productivity and economics in pearl millet.

Materials and Methods

Field experiments were conducted experiment at Field No. 2B, New Area farm of Department of Millets, TNAU, Coimbatore during *Kharif* season of 2021 and 2022 in

Randomized Block design with three replications. The treatments were, T_1 - Full package & practices of the location [RDF + $ZnSO_4$ @25 kg/ha + $FeSO_4$ @ 0.5-0.75% at 20-25 DAS + bio-inoculant seed treatment (*Azoteeka*) + thinning & gap filling + weeding & hoeing (3-5 WAS) + irrigation], T_2 - T_1 – RDF, T_3 - T_1 - $ZnSO_4$ @25 kg/ha, T_4 - T_1 - $FeSO_4$ @ 0.5-0.75% at 20-25 DAS, T_5 - T_1 - bio-inoculant seed treatment, T_6 - T_1 – thinning & gap filling, T_7 - T_1 - weeding & hoeing (3-5 WAS), T_8 **-** T_1 - irrigation. Pearl millet hybrid, HHB 299 was sown with spacing of 45 cm x 15 cm, recommended dose of fertilizer (80:40:40). Soil was sandy clay loam in texture with slightly alkaline pH (8.53), non-saline nature (EC 0.37 dS/m) with low organic carbon content (0.40 %). Initial soil nutrient status of the experimental field recorded low available nitrogen (208 kg/ha), medium available phosphorus (12 kg/ha) and high available potassium (507 kg/ha). Biometric observations on growth parameters were recorded at different growth stages while yield parameters and yield were recorded at harvest.

Results and Discussion

Plant population recorded with full package of practices viz., RDF + $ZnSO_4$ @ 25 kg ha^{-1} + $FeSO_4$ @ 0.5 - 0.75 % at 20-25 DAS + bio-inoculant seed treatment (*Azoteeka*) + thinning & gap filling + weeding & hoeing (3-5 WAS) + irrigation (T_1), full package of practices without $ZnSO_4$ @ 25 kg/ha (T_3), full package of practices without $FeSO_4$ @ 0.5-0.75% at 20-25 DAS (T_4), Full package of practices without irrigation (T_8) were highest and comparable with each other. The lowest plant population was observed in full package of practices without weeding & hoeing (3-5 WAS) (T_7). Pearl millet cultivation with full package of practices (T_1) and full package of practices without irrigation (T_7) registered taller plants of 192.5 cm and 189.0 cm, respectively.

Higher total tillers per plant were recorded with full package of practices (T_1) (4.9), full package of practices without $FeSO_4$ @ 0.5-0.75% at 20-25 DAS (T_4) (4.3), full package of practices without thinning & gap filling (T_6) (4.2), Full package of practices without irrigation (T_8) (4.6) and were comparable with each other. Higher number of effective tillers per plant were registered with full package of practices (T_1) (4.4) and full package of practices without irrigation (T_8) (4.1). Treatments with full package of practices without RDF (T_2) and weeding & hoeing (3-5 WAS) (T_7) recorded lowest total number of tillers (3.6 and 3.1) and effective tillers (2.8 and 2.6), respectively.

Highest grain yield and stover yield (kg/ha) were observed with full package of practices (T_1) (3356 kg/ha), full package of practices without $FeSO_4$ @ 0.5-0.75% at 20-25 DAS (T_4) (3053 kg/ha), full package of practices without bio-inoculant seed treatment (T_5) (3177 kg/ha), Full package of practices without irrigation (T_8) (3052 kg/ha) and were comparable with each other. Similar trend was observed in stover yield. Lowest grain and stover yield (kg/ha) was recorded with full package of practices without RDF (T_2) and weeding & hoeing (3-5 WAS) (T_7) recorded (2047 and 2047 kg/ha) and (3220 and 3266 kg/ha), respectively. Similar results were reported by Deshveer (2005) for weed management and Sanjana *et al.*, 2023. All the economic indicators worked out were higher for the full package of practices (T_1) with gross returns (Rs.61687), net returns (Rs. 27902), B:C ratio (1.83) while they were lower for the treatment T_7 with no weeding and hoeing (3-5 WAS). Impact of Production factors on Yield: The contribution of individual agronomic factors was assessed and it revealed that no weeding and hoeing (3-5 WAS) and with no RDF recorded 39.0% yield reduction and it was followed by no thinning and gap filling accounting to 23.27% yield reduction. Sharma and Jain (2003) have also reported upto 40 % loss in grain yield due to weed competition in pearl millet. No application of ZnSO4 (11.44%), no irrigation (9.06%), $FeSO_4$ @ 0.5-0.75% at 20-25 DAS (9.03 %) and bioinoculant seed treatment (5.23%) also exhibited their individual contribution towards the productivity of pearl millet. Pearl millet cultivation with full package of practices (RDF+$ZnSO_4$+$FeSO_4$+ Bio-inoculant seed treatment + thinning and gap filling, weeding and hoeing and irrigation) produced the highest grain yield, stover yield and economic returns. No weed management, fertilizer management highly influence on the yield of pearl millet by reducing it. Thinning and gap filling is also having higher impact on yield with a sizable yield reduction. Micronutrient application or seed treatment with biofertilizers had the least influence on production of pearl millet.

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Table 1. Influence of different agronomic factors on pearl millet productivity (2021 and 2022) (Pooled mean of 2 years)

Treatments	Plant population ('000/ha)	Plant height (cm)	Total tillers/ plant (No.)	Effective tillers / plant (No.)	Test weight (g)	Grain yield (kg/ha)	Dry fodder yield (kg/ha)
T_1	151.0	192.5	4.9	4.4	11.23	33.56	46.41
T_2	132.6	170.1	3.6	2.8	8.85	20.47	32.20
T_3	145.9	176.7	4.1	3.4	10.72	29.72	41.81
T_4	145.6	175.4	4.3	3.5	10.55	30.53	42.76
T_5	144.7	176.6	4.1	3.4	10.36	31.77	44.73
T_6	135.3	173.3	4.2	3.6	9.14	25.75	37.15
T_7	124.8	165.7	3.1	2.6	8.12	20.47	32.66
T_8	148.7	189.0	4.6	4.1	10.90	30.52	42.40
SEd	2.74	7.09	0.33	0.34	0.86	1.77	2.24
CD (p=0.05)	5.88	15.21	0.71	0.73	1.84	3.80	4.80

Table 2. Economics of the treatments (2021 and 2022) (Pooled mean of 2 years)

S. No.	Treatments	Gross returns (Rs./ha)	Total Cost (Rs./ha)	Net returns (Rs./ha)	BCR
1	T_1	61687	33785	27902	1.83
2	T_2	38019	28776	9243	1.32
3	T_3	54705	30110	24595	1.82
4	T_4	56171	32165	24006	1.75
5	T_5	58477	33405	25072	1.75
6	T_6	47490	32585	14905	1.46
7	T_7	38065	30785	7280	1.24
8	T_8	56118	32785	23333	1.71

T2-70
Identification of Groundnut + Small millets inter cropping system for alfisols under irrigated condition

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Abstract

To maximise the net return realised by the groundnut farmers intercropping with millets is the best option. By keeping this in mind present study was carried out with the objective to optimize the row proportion of groundnut + small millet intercropping system under irrigated condition and economic feasibility of the intercropping system. The experiment was conducted at Agricultural College and Research Institute, Eachangkottai, during *rabi* season 2020-21 and 2021-2022 under irrigated condition. Groundnut equivalent yield was recorded under Groundnut paired row + Varagu in two years of study. The higher net return was realised in the Groundnut paired row + Varagu in two yearsof study. Among the intercrop system Groundnut paired row intercropped with varagu (2:1) was recorded highest Groundnut (kernel) equivalent yield, net return and B:C ratio than other intercropping system in both the years of experiment. Among the sole millets (intercrop) varagu recorded highest yield than the sole samai.

Keywords: Groundnut, Intercrop, Varagu, Samai, GEY, Net reurn.

Introduction

Groundnut is a principal oilseed crops of south India. But area under groundnut is declining in the past decade. Various factors responsible for this. Among them low return realised by the farmers is key factor. This can be overcome by intercropping system. Hence the present study was carried out with the objective to optimize the row proportion of groundnut + small millet intercropping system under irrigated condition and economic feasibility of the intercropping system. Intercropping of millets like little millet (ATL 1), kodo millet (TNAU 86) with groundnut (VRI 8) on red soils was studied

Material and Methods

The experiment was conducted at Agricultural College and Research Institute, Eachangkottai, during *rabi* season 2020-21 and 2021-2022 under irrigated condition. The soil of the experimental site is slightly acidic pH (5.5) and with the organic carbon (3.8 g/kg). Intercropping of millets like little millet (ATL 1), kodo millet (TNAU 86) with groundnut (VRI 8) on red soils was studied. The treatments included in the experiment were T1: Sole groundnut, T2: paired row groundnut, T3: Groundnut + Samai (2:1), T4: Groundnut + Varagu (2:1), T5: Groundnut paired row + Samai, T6: Groundnut paired row + Varagu, T7: Farmers practice (Mixed sowing of groundnut and samai) T8: Farmers practice (Mixed sowing of groundnut and Varagu) T9: Sole samai and T10: Sole Varagu The experiment was laid out in a randomized block design with three replications.

Results and Discussion

The growth parameters were recorded higher in the paired row groundnut than the sole groundnut system in both years of the study. Regarding plant height, the higher was recorded under T_2 -paired row groundnut (34.1 cm) than the T1 -sole groundnut system (33.0 cm) in 2021. In 2022 the significantly superior plant height was recorded under T2 -paired row groundnut (34.6 cm) than the T1 -sole groundnut system (33.4 cm). In both the years lower plant height was recorded under T7 -Farmers practice of mixed sowing of Groundnut with Samai. Regarding, dry matter production significantly superior DMP was recorded under T2 -Paired row groundnut (7963 kg/ha in 2021 and 8254 kg/ha in 2022) than the T_1 -Sole groundnut system (6956 kg/ha in 2021 and 7041 kg/ha in 2022) in both the years. In both the years lower DMP was recorded under T_7 - Farmers practice of mixed sowing of Groundnut with Samai (Table 1)

With respect to yield attributes the no. of matured pods/plant was recorded significantly superior under T2 - Paired row groundnut than the T1 - Sole groundnut system in both the years. In both the years lower no. of matured pods/plant was recorded under T7 -Farmers Practice of mixed sowing of Groundnut with Samai.100 seed weight was recorded higher under T2- paired row groundnut than the T1 -Sole groundnut system in both the years. During 2021 and 2022. Lower 100 seed weight was recorded under T7 -Farmers practice of mixed sowing of Groundnut with Samai. Dry pod yield was recorded significantly superior under T2 Paired row groundnut (2682 kg/ha in 2021 and 2758 kg/ha in 2022) than the T1 Sole groundnut system (2550 kg/ha in 2021 and 2642 kg/ha in 2022) in both the years. In both the year lowest dry pod yield was recorded under T7 - Farmers practice of mixed sowing of Groundnut with Samai. Significantly superior shelling percentage was recorded under T2 -Paired row groundnut than the T1 sole groundnut system in both the years. (Table 1).

Significantly superior higher haulm yield was recorded under T2 -Paired row groundnut than the T1 sole groundnut system in 2021. Haulm yield was recorded higher under T2 - Paired row groundnut than the T1 -Sole groundnut system in 2022. Lower haulm yield was recorded under T7 -Farmers practice of mixed sowing of Groundnut with Samai in both the years. Kernel yield was recorded higher under T2 -Paired row groundnut than the T1 -Sole groundnut system in both the years. Lower kernel yield was recorded under T7- Farmers practice of mixed sowing of Groundnut with Samai during 2021 and 2022 (Fig 1 and 2)

Significantly superior Groundnut equivalent yield was recorded under Groundnut paired row + Varagu (Shwethanjali et al., 2018). in both the years (2100 kg/ha in 2021 and 2489 kg/ha in 2022). Lowest Groundnut equivalent yield was recorded under sole samai in both the years (378 in 2021 and 779 in 2022). (Table 2). The higher net return was realised in the Groundnut paired row + Varagu in both the years (Rs.1,34,265/ha in 2021 and Rs.1,13,2632/ha in 2022). The lower net return was realised under T7 -Farmers practice of mixed sowing of Groundnut with Samai in both the years. The higher benefit cost ratio was recorded under Groundnut paired row + Varagu in both the years (3.94 in 2021 and 3.34 in 2022). Lower benefit cost ratio was recorded under T7 - Farmers practice of mixed sowing of Groundnut with Samai in both the years (Table 2).

Among the intercrop system Groundnut paired row intercropped with varagu (2:1) was recorded highest Groundnut (kernel) equivalent yield, net return and B:C ratio than other intercropping system in both the years of experiment. Among the sole millets (intercrop) varagu recorded highest yield than the sole samai.

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Table 1. Effect of groundnut +millet on growth and yield attributes of Groundnut

Treatments	Plant height (cm)		DMP (Kg/ha)		No. of matured pods/plant		100 seed weight (g)		Shelling percentage (kg/ha)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T_1	33.0	33.4	7635	7953	21.3	22.8	45.2	45.6	73.80	72.2
T_2	34.1	34.6	7963	8254	22.5	23.9	45.6	46.0	74.52	73.4
T_3	28.6	29.1	7142	7503	17.0	18.1	43.0	43.2	69.80	70.3
T_4	29.5	29.9	7209	7562	17.4	18.7	43.4	43.7	71.00	71.4
T_5	30.8	33.0	7428	7809	18.8	19.1	44.1	44.3	71.90	72.6
T_6	31.7	32.1	7271	7894	20.1	21.4	44.6	44.8	72.60	72..8
T_7	26.3	26.7	6956	7041	15.5	16.7	42.1	42.3	67.73	70.0
T_8	27.4	27.8	6840	7253	15.9	17.2	42.5	42.7	68.60	70.2
SEd	0.7	0.33	55	65	0.3	0.4	0.4	0.2	0.40	0.3
CD (P=0.05)	2.1	1.01	167	198	0.8	1.0	1.3	0.7	1.31	1.0

Table 2: Effect of groundnut +millet on dry pod yield, groundnut equivalent yield, Land equivalent ratio, net returns and B:C ratio of the system

Treatments	Dry pod yield (kg/ha)		GEY (kg/ha)		Net return (Rs/ha)		B:C ratio	
	2021	2022	2021	2022	2021	2022	2021	2022
T_1	2550	2642	1635	1902	92,608	77,130	3.05	2.66
T_2	2682	2758	1690	2013	1,00,168	84,367	3.21	2.81
T_3	1674	1763	1221	1493	61,254	54,823	2.49	2.30
T_4	1750	1831	1409	1750	84,290	71,528	3.05	2.69
T_5	2292	2375	1776	2088	1,00,001	89,020	3.20	2.91
T_6	2420	2510	2100	2489	1,34,265	1,13,263	3.94	3.34
T_7	1483	1516	1144	1457	56,944	53,427	2.42	2.29
T_8	1600	1705	1175	1471	64,811	54,337	2.61	2.32
T_9	-	-	378	779	4182	24,113	1.16	1.91
T_{10}	-	-	767	1060	32,233	41,222	2.22	2.49
SEd	43	30	53	27	-	-	-	-
CD (P=0.05)	131	90	158	79	-	-	-	-

T2-71

Effect of sowing window and crop geometry on growth and yield of Sorghum

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Abstract

A field experiment was carried out during the summer season of 2022 in the Eastern block farm (37F) of Tamil Nadu Agricultural University in sandy loam soil to study the effect of sowing window and crop geometry on growth and yield of sorghum. The experiment was laid out in strip plot design with three different sowing windows (D_1 - First fortnight of February, D_2 - First fortnight of march and D_3 - First fortnight of April) as Factor A and six different crop geometries as factor B (S_1 - 45 x 15 cm, S_2 – 45 x 10 cm, S_3 – 45 x 5 cm, S_4 – 30 x 15 cm, S_5 – 30 x 10 cm and S_6 – 30 x 5 cm) and replicated thrice. It was observed that grain yield was significantly higher in April sown crop (2602.81 kg/ha) and respective increase was 9 percent over February sowing.The second highest yield was observed in march (2484.53 kg/ha) sown crop followed by February (2394.53 kg/ha) sown crop. Among different spacing 45 cm x 15 cm recorded highest yield.

Introduction

Sorghum (*Sorghum bicolor*) is an important food and feed source in mixed crop-livestock production systems where its dual usage is a preferred option, with key characteristics being wide adaptability across environments and tolerance to biotic and abiotic stresses especially among the resource poor small-scale farmers. Despite the importance of sorghum, its cultivation areas have witnessed a remarkable decline by an estimated 0.15 million hectares annually, starting from the mid-eighties, which is the peak of its production until the present time due to climatic changes and lack of interest in this crop. Therefore, it is important to study the planting date development of new varieties suitable for adopting to the changing climate. Most of the farmers of Tamil Nadu are practicing broadcasting method of sowingunder rainfed situation and there is no standardized method of sowing till now. Therefore, crop geometry and sowing window were taken into consideration as apart of research work.

Materials and Methods

The experiment was conducted in the Eastern block farm (37F) of Tamil Nadu Agricultural University, Coimbatore. The experimental site is at an altitude of 420.7 m above mean sea level and is situated at 10°54' N latitude and 74°56' E longitude (MSL). The experiment was laid out in strip plot design with three different sowing windows (D_1 - First fortnight of February, D_2 - First fortnight of march and D_3 - First fortnight of April) as Factor A and six different crop geometries as factor B (S_1 - 45 x 15 cm, S_2 – 45 x 10 cm, S_3 – 45 x 5 cm, S_4 – 30 x 15 cm, S_5 – 30 x 10 cm and S_6 – 30 x 5 cm) and replicated thrice. All the necessary package of practices are followed as per the crop production guide TNAU 2020. A minimum temperature of 19°C to 25.2 °C, maximum temperature of 31°C to 36.5 °C, Bright sunshine hours upto 10.3 hrs and a rainfall of 148.4 mm has been recorded during the growing season.

Results and Discussion

Sowing window and crop geometry has significant influenceon the grain yield and leaf area index. The data regarding leaf area grain yield and leaf area index was presented in the Fig.1 and table.1. It was observed that grain yield was significantly higher in April sown crop (2602.81 kg/ha) and respective increase was 9 percent over February sowing. the second highest yield was observed in march (2484.53 kg/ha) sown crop followed by February (2394.53 kg/ha) sown crop. Among different spacing 45 cm x 15 cm recorded highest yield (2950.07 kg/ha. At all the stages of observation i.e 30 DAS, 60 DAS and harvest leaf area index was significantly higher when the crop is sown during I FN of April. In case of crop geometry leaf are index is more in case of closer spacing (30 cmx 5 cm) compared to the optimum spacing because the land area of closer spacing is three times lower than that of optimum spacing land area. Optimum temperature and rainfall during the growing season led to increased biological activity in April 1stFN sown crop which ultimately resulted in higher yieldThavaprakash *et al.* (2007), Azrag and Dagash (2015).

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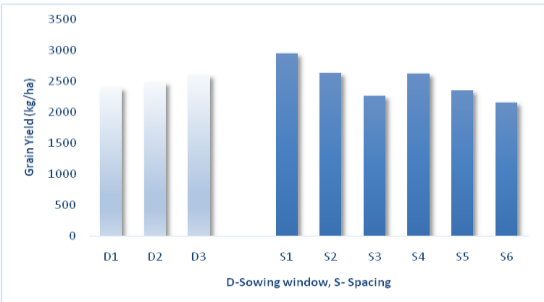
Table 1. LAI during different stages of crop growth

Treatment	**Leaf Area Index**		
Sowing Window	**30 DAS**	**60DAS**	**HARVEST**
D_1 - First FN of February	2.35	7.29	6.63
D_2 - First FN of March	2.61	8.36	7.80
D_3 - First FN of April	2.70	9.77	8.16
SEd	0.04	0.21	0.31
CD	0.11	0.58	0.88
CROP GEOMETRY			
S_1 - 45 x 15 cm	1.67	6.64	5.87
S_2 – 45 x 10 cm	2.10	7.90	6.88
S_3 – 45 x 5 cm	3.44	9.61	8.28
S_4 – 30 x 15 cm	2.11	7.59	6.67
S_5 – 30 x 10 cm	2.40	8.13	7.52
S_6 – 30 x 5 cm	3.59	10.98	9.96
SEd	0.05	0.17	0.41
CD	0.11	0.38	0.93

Fig.1. Grain yield under different sowing window and crop geometry



T2-72
Role of intercrops in Small millets production

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Abstract

The experiment was conducted at Centre of Excellence in Millets, Athiyandal on various intercropping systems in small millets during the years 2020, 2021 and 2022. Due to climate change the average annual rainfall is decreasing and occurring without regular intervals. Therefore, better utilization of available resources is essential. In this study small millet crops like, Foxtail millet, kodo millet and finger millet were intercropped with pulses and oilseed crops. Result revealed that kodomillet intercropped with black gram in 1: 1 ratio recorded higher kodomilletequivalent yield (3158 kg/ha), Foxtail millet intercropped with niger in 4 : 1 ratio register higher equivalent yield of (2737 kg/ha) and Finger millet intercropped with blackgram 4 : 1 ratio recorded higher finger millet equivalentyield (2928 kg/ha). This study helps to grow small millets crops without any yield loss and also indirectly influences the small millet production.

Keywords: kodomillet, foxtail millet, finger millet, equivalent yield

Introduction

Small millets were intertwined in the lives of our ancestors. It can withstand severe drought and higher heat and its cultivated much by the people who lived in hills. Small millets are important crops of rainfed areas in semi-arid regions. Currently, they are grown on a limited area representing a small portion of global millet production, because of the shift from traditional crops to cash crops. Some of small millets are considered as weeds, particularly the wild forms. However, they are the crops of local importance that provide reliable yields on marginal lands, and contribute significantly to the food security. Because of growing sedentary lifestyle and its associated health issues, consumers are seeking more nutrient-rich foods that are both tasty and healthy. Small millets fit the bill as a healthy food choice because they provide high energy, high dietary fibre, protein with balanced amino acid profile, many essential minerals, vitamins, antioxidants, and have a low glycemic index (GI). Because of these features, they are called as 'Smart-Food Crops' and 'nutri-cereals'. Hence, satisfy the needs of today's growing population. We have to increase overall small millet production. There are many potential factors to achieve maximum yield in small millet cultivation. However, farmers having mindset of small millet crops are less yielded, less remunerative and possibility of loss of yield during rainfed condition.To overcome this problem introduction of Intercropping is one of the sure ways of increasing production without much increase in the application of inputs (Bhagat *et al*., 2019). Intercrops also supports weed control, soil fertility improvement and yield loss due to rainfall.

Materials and Methods

This experiment was conducted at Centre of Excellence in Millets, Athiyandal with the treatment set of Kodomillet intercropping : T_1 – Kodomillet sole crop T_2 – Kodomillet +

Blackgram (1 :1) T_3 – Kodomillet + Green gram (1 :1) ; under Foxtail millet intercropping T_1 – Foxtail millet sole crop, T_2 – Foxtail millet + Sesame (4 :1), T_3 – Foxtail millet + Niger (4 :1); under Finger millet intercroppingT_1 – Finger millet sole crop, T_2 – Finger millet + Blackgram (4 :1) and T_3 – Finger millet + Redgram (6 :1). The experimental plots have low N and medium P and low K content, pH ranges from 7.2.The following observations recorded during the cropping period. As per the crop production guide crop management practices were made on time.

Results and Discussion

All the growth and yield parameters of Kodo millet, Finger millet and foxtail millet were significantly high in sole crop compared to intercropping (Table-1,2 ,3). In kodo millet intercropping system maximum plant height, number of tiller and higherequivalent yield (3158 kg/ha) were obtained in the treatment kodo millet intercropped with blackgram (1 :1) ratio. Which helps to improve the soil fertility (Table 1). In foxtail millet intercropping system maximum plant height (1146 cm) Number of tillers (42), harvest index (328 percent) and yield (2737 kg/ha) were obtainedin foxtail millet and niger intercropping in 4:1 ratio. It controls the weeds at the right time. Good price of sesame increases net profit (Table 2). In finger millet cropping system, Plant height of finger millet intercropped with black gram was on par with plant height in sole crop. Finger millet plant height was reduced in intercropping with redgram due to the competition offered by intercrops. However, finger millet equivalent yield was significantly high when intercropped with Blakgram followed by Pigeon pea (Table 3). Intercropping with root nodule crops can reduce the use of external inputs due to the complementary use of nutrient and water resources by the intercrop components. Legumes improve the soil health by fixing atmospheric N and may partially supplement the use of inorganic fertilizers and also improve the production of cereal crops by adding much needed organic matter in the soils and by improving physical properties of soils (Triveni*et al*., 2017).

From this study the result concluded that small millets cultivated with intercrops gives more income and alsoreduction of yield loss during rainfed season. This result will be useful for farmers who are not willing to cultivate small millets as main crop, they grow with some intercrops which helps indirectly to increase the small millet area and production.

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Table 1. Effect of intercrops in kodo millet production

Treatments	Plant height (cm)	No. of productive tillers (No.)	Grain yield (kg/ha)	Straw yield (kg/ha)	Kodo millet equivalent yield (kg/ha)	B:C ratio
Kodo millet sole crop	71.0	19.3	2270	4815	2004	2.45
Kodomillet + Blackgram (1 :1)	67.3	19.3	1990	4307	3158	3.53
Kodomillet + green gram (1 :1)	64.3	18.0	1895	4350	2950	3.28

Table 2. Effect of intercrops in foxtail millet production

Treatments	Plant height (cm)	Length of panicle (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)	FMEY (kg/ha)	B:C ratio
Foxtail millet sole crop	123.3	16.4	2200	4847	2200	2.36
Foxtail milelt + Sesame (4 :1)	114.6	14.6	1990	4080	2737	2.93
Foxtail milelt + Niger (4 :1)	110.3	15.4	2023	4560	2314	2.48

Table 3. Effect of intercrops in finger millet production

Treatments	Plant height (cm)	No. of productive tillers No.)	Grain yield (kg/ha)	Straw yield (kg/ha)	FMEY (kg/ha)	B:C ratio
Finger millet sole crop	91.4	5.0	2420	3876	2420	2.34
Finger millet + Blackgram (4 :1)	91.3	4.5	2006	3248	2928	2.82
Finger millet + Redgram (4 :1)	82.0	5.2	2098	3345	2925	2.45

T2-73
Effect of Boron Nutrition on growth and yield attributes of grain Sorghum *(Sorghum bicolor L)*

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Abstract

A field Experiment was conducted of New area, Department millets, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during rabi season 2022 on Sandy clay loam. Seven treatments were followed with boron nutrition. T_1 Recommended fertilizer (N,P,K,S,Zn), T_2 Recommended fertilizer + 1.0 kg/ha boron soil application, T_3Recommended fertilizer + 2.0 kg/ha boron soil application, T_4 Recommended Fertilizer + 1.0 kg/ha boron soil application +0.1 ppm foliar spray at panicle initiation and flowering stage, T_5 Recommended fertilizer + 1.0 kg/ha boron soil application + 0.2 ppm foliar spray at panicle initiation and flowering stage, T_6 Recommended fertilizer dose + 0.1 ppm foliar spray at panicle initiation and flowering stage, T_7 Recommended fertilizer dose + 0.2 ppm foliar spray at panicle initiation and flowering stage and were tested in randomized block design with tree replications. Results indicated that application of recommended fertilizer dose + 2kg/ha boron soil application (T_3) registered higher plant height, Number of grains per panicle, 1000 grains weight, bio mass yield, Grain yield and stoves yield over the control (T_1).

Keywords: Boron Nutrition, Panicle imitation flowering, Sorghum bicolour L.

Introduction

Sorghum (Sorghum bicolour L) is the fifth most important cereal in the world after rice (Oryza sativa) consecutive wheat (Tritiumaestivum L), Maize (-2ea mays L) and barley (hordeum vulgare L). Sorghum belong to the family poace with chromosome number 20 (20=20). The world wide Sorghum cultivated area is around 42.7 m ha (2020 - 21) which yield around 61.96 million metric tons. In production, India contribute about 16 percent of the total world Sorghum production. In India Sorghum was he staple food forthe in majority of the people during the 1950's and understandably, the occupied area was more than 18 m/ha, but currently the area had come down to 7.69 m ha.

The deficiency of boron was also more prominentduring thought periods as their root activity decreased generally boron deficiencies are related to acidic soil condition and high rainfall, which leads to leaching of boron due to greater watersolubility in acidic soil condition. It can be related to lower absorption andsolubility under alkaline soil conditions. In crop production boron deficiency is considered as one of the major constraints (Sillanpaa, 1982). Boron deficiency has been responded in more than 80Countries and for at least 132 crops during the last 60 years (Shorocks, 1997).Deficiencies of Boron in India are common in Laterite and Lateric Soil.Soil which are developed from calcarious alluvial soil or has high leaching tendency are generally accounted as boron deficient soil (Borkakati and Takkar, 2000)

Materials and Methods

A field experiment was conducted at new area, Department of millets, Agricultural College and Research Institute, Tamil Nadu Agricultural University at Coimbatore. During rabi season 2022 – 23 which is situated at 11'N latitude an L 76^0 E longitude at an elevation of 440 m above the mean sea level in the North western Agro climatic zone of Tamil Nadu. The field experiment was comprised of seven treatments of boron nutrition T_1 Recommended dose fertilizer (N,P,K,Zn) T_2 Recommended dose fertilizer +1kg/ha^{-1} boron soil application, T_3 Recommended dose + 2 kg/ha boron soil application +1.0 kg/ha boron soil application +0.1 ppm foliar spray at panicle initiation and flowering stage T_6 Recommended dose fertilizer +0.1 ppm foliar spray at panicle initiation and flowering stage T_7 Recommended dose of fertilizer +0.2 ppm foliar spray at panicle initiation and flowering stages under randomized block design with three replications. The crop Sorghum Co32 variety was used for the experiments. The recommended dose of 80:16.7:27, 20 -5 kg/ha NPK, S,Zn was applied as urea, single super phosphate and murate of potash respectively.Foliar application of Boron was done @ 1.0 and 0.2 ppm at panicle initiation and flowering stage.

Result and Discussion

Sorghum growth Characteristics were significantly higherover control by the application of boron. Application of RDF + 2.0 kg boron soil application recorded significantly higher plant height at panicle and flowering stages. Similarly, Maximum sunflower plant height 160.6 cm was achieved with the application of micronutrients like boron and zinc (Baloch *etal*., 2015).Results indicated that application of recommended fertilizer dose + 2kg/ha boron soil application (T_3) registered higher plant height, Number of grains per panicle, 1000 grains weight, bio mass yield, Grain yield and stoves yield over the control (T_1).

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T2-74
Weed dynamics of cotton influenced by intercropping of minor millets

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Abstract

The wider interspace available with cotton husbandry can be effectively used by intercropping with short duration pulses and millets to enhance the input use efficiency and sustainability. Field experiment was conducted at Department of Agronomy, Agriculture College and Research Institute, Madurai under summer irrigated condition (2023) to study the feasibility of minor millet intercropping in cotton. The experiment was laid out in randomized complete block design with ten treatments and were replicated thrice. The treatments consisted of intercropping of barnyard millet, foxtail millet and finger millet at 1:1 ratio under normal geometry (T_1-T_3), 1:2 ratio under paired row system (T_4-T_6) and at 1:3 ratio under replacement series (T_7-T_9) along with cotton sole cropping as control (T_{10}). The soil of the experimental field is sandy clay loam in nature with low, medium and high in N, P and K status. The results showed that cotton intercropped with barnyard millet at 1:2 ratio under paired row system (T_4) registered the lower weed density (60.9 and 31.25 m^{-2}) and lower weed dry weight (49.5 and 25.72 g m^{-2}) at 25 and 50 DAS which was followed by cotton intercropped with barnyard millet at 1:3 ratio (T_7). Higher weed control efficiency due to smothering effect of millet intercropping was also observed in (T_4) cotton + barnyard millet at 1:2 ratio (33.0 per cent at 25 DAS and 60.2 per cent at 50 DAS).
Keywords*:* Cotton, minor millet, weed density, dry weight, weed control efficiency.

Introduction

Cotton is one of the major commercial cash crop and also known as white gold or king of fibre. It plays a vital role in national and international economy especially, known for textile fibre and accounts for 35 per cent of world total annual fibre demands. India accounts for 41.3 per cent area under cotton cultivation in world. In Tamil Nadu, cotton is cultivated in an area of 1.55 lakh ha with production of 5.0 lakh bales and productivity of 548 kg ha^{-1}, which is below the world average yield of 768 kg ha^{-1} (Anonymous, 2021). To increase the resource utilization in cotton cultivation, intercropping has been recognized as a potential way and economic system of crop production in cotton. Minor millets are getting popular in recent years due to their tremendous nutraceutical potential thus called as “nutricereals or nutraceutical crops”. Intercropping of minor millets with compatible crops will pave the way for augmenting the cropping area under minor millets and to sustain their productivity (Maitra 2019). The relatively longer duration with slow growing habit of cotton during the initial stages, intercropping is possible in cotton. Therefore, an attempt was made to study the feasibility of inter cropping of minor millets with cotton.

Materials and Methods

The field experiment was conducted at Agriculture College and Research Institute, Madurai under during summer, 2023. This experiment was carried out in a randomized complete block design with three replications. The treatments consisted of cotton intercropped with barnyard millet at 1:1 ratio (T_1), foxtail millet at 1:1ratio (T_2), finger millet at 1:1 ratio (T_3), barnyard millet at 1:2 ratio (T_4), foxtail millet at 1:2 ratio (T_5), finger millet at 1:2 ratio (T_6) under additive series, cotton + barnyard millet at 1:3 ratio (T_7), foxtail millet at 1:3 ratio(T_8), finger millet at 1:3 ratio(T_9) under replacement series and cotton sole crop as control (T_{10}). The varieties used in this study were SVPR-6 (cotton), MDU-1 (barnyard millet), CO-7 (foxtail millet), CO-15 (finger millet). The recommended spacing of 75 x 30 cm was followed for cotton under normal system, 90/60 × 30 cm was adopted for paired row system. The spacing of 30 × 10 cm was followed for all the minor millets. The fertilizer recommendation of 80: 40: 40 kg NPK ha^{-1} was applied for cotton and no additional fertilizers were applied to intercrops. The data on weed density and weed dry weight were recorded on 25 and 50 DAS and weed control efficiency was computed as per the standard procedure.

Results and Discussion

Cotton intercropped with minor millets had a significant impact on weed density and weed dry weight (Table 1). Weed density was lowest under cotton intercropped with barnyard millet at 1:2 ratio (60.92 and 31.25 m^{-2} on 25 and 50 DAS) and it was followed by cotton + barnyard millet intercropping at 1:3 ratio (69.75 and 38.95 m^{-2} at 25 and 50 DAS) which was statistically on par with cotton + barnyard millet at 1:1 ratio (73.50 and 39.25 m^{-2} on 25 and 50 DAS, respectively).

Weed dry weight was also significantly influenced by intercropping minor millets in cotton. It was found to be lowest in cotton + barnyard millet intercropping at 1:2 ratio (49.75 and 25.72 g/m^2 at 25 DAS and 50 DAS, respectively) and this was followed by cotton + barnyard millet at 1:3 ratio. A similar reduction in weed biomass was reported earlier in intercropping of cotton with cluster bean and coriander (Sankaranarayanan *et al.,* 2012).

Weed control efficiency (WCE) of intercropping due to smothering effect also followed the similar trend as that of weed dry weight. Higher WCE was recorded in cotton + barnyard millet intercropping at 1:2 ratio (32.98 % at 25 DAS and 60.17 % at 50 DAS). The next best intercropping system in terms of WCE was cotton + barnyard at 1:3 ratio which recorded 23.26 and 50.35 percent on 25 DAS and 50 DAS. The lower weed density, dry weight and higher WCE was achieved in cotton + barnyard millet intercropping system due to the high tillering capacity of barnyard millet which might have reduced the light interception into the ground surface suppressed the weed growth. Veeraputhiran and Sankaranarayanan (2021) also observed higher WCE of cotton + cluster bean intercropping under paired row planting system than sole cropping of Bt cotton.

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Table 1. Effect of minor millets intercropping with cotton on weed parameters

Treatments	Weed density (no./m2)		Dry weight (g/m2)		Weed control efficiency (%)	
	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS
Cotton + Barnyard millet (1:1) under additive series	73.50 (8.60)	39.25 (6.30)	56.90 (7.58)	30.25 (5.55)	19.14	49.96
Cotton + Foxtail millet (1:1) under additive series	78.33 (8.88)	49.21 (7.05)	60.72 (7.82)	35.25 (5.98)	13.82	37.27
Cotton + Finger millet (1:1) under additive series	85.25 (9.26)	45.87 (6.81)	68.91 (8.33)	34.67(5.93)	6.21	41.53
Cotton + Barnyard millet (1:2) under additive series	60.92 (7.84)	31.25 (5.64)	49.75 (7.09)	25.72 (5.12)	32.98	60.17
Cotton + Foxtail millet (1:2) under additive series	82.75 (9.12)	44.24 (6.70)	65.24 (8.11)	34.29 (5.90)	8.96	43.60
Cotton + Finger millet (1:2) under additive series	74.12 (8.64)	42.71 (6.57)	55.56 (7.49)	29.69 (5.49)	18.46	45.56
Cotton + Barnyard millet (1:3) under replacement series	69.75 (8.38)	38.95 (6.20)	52.10 (7.25)	28.56 (5.39)	23.26	50.35
Cotton + Foxtail millet (1:3) under replacement series	79.17 (8.92)	49.86 (7.10)	71.05 (8.46)	37.98 (6.20)	12.09	36.44
Cotton + Finger millet (1:3) under replacement series	86.37 (9.31)	42.75 (6.58)	75.26 (8.70)	33.19 (5.80)	4.98	45.50
Sole cotton	90.90 (9.54)	78.45 (8.90)	88.34 (9.43)	44.25 (6.69)	0	0
SEd	1.83	1.12	4.77	0.79	-	-
CD (P=0.05)	5.85	3.58	1.49	2.51	-	-

*Figures in parentheses indicate transformed into $\sqrt{x+0.5}$ values

It can be concluded from the present study that intercropping of barnyard millet at 1:2/1:3 ratios is a suitable intercrop for effective weed management in cotton.

Theme 2

System of Millet Intensification, Advanced management technologies and Farm mechanization

Abstract

T2-75

Effect of organics and foliar spray on common Millet

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Abstract

Panicum miliaceum(common millet)is a grain crop with many qualities, such as its extremely short life cycle, low water requirements, high nutritional content, producing grain more efficiently per unit of moisture than any other grain species.A field experiment was carried out during the *Kharif* season of 2022 under irrigated conditions, at the Eastern block of Agricultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore with a view to study the effect of organics and foliar spray on Common Millet on variety ATL 1 and to study the economics of the treatment given. As of organics basal application of (100 % and 75%) vermicompost and (100 % and 75%) enriched vermicompost were used and for foliar sprays, 3% humic acid, 3%seed weed extract, 3%panchagavya, 3%vermiwash and 3% PPFM were given on 30 DAS and 45 DAS. There was significance increase in the vegetative and reproductive efficiency of prosomillet. Among the treatments, these are found to be best.

Keywords: Prosomillet, Foliar spray, Vermicompost, Sea weed Extract, Panchagavya

T2-76

Upscaling of pearl millet variety co10 in Virudhunagar district through front line demonstration

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Abstract

Front line Demonstration was conducted in the Virudhunagar district, Tamil Nadu, India during *Rabi* 2020-21 and 2022-23 under rainfed vertisol condition. To create awareness among the farmers and to showcase the improved production technologies in Pearl millet. The improved crop management practices *viz*., promotion of drought tolerant, high yielding and short duration pearl millet variety CO 10, integrated nutrient management, integrated pest and disease management technologies were demonstrated and compared with the farmer's practice (local variety) in pearl millet cultivation. Results indicated that demonstration of pearl millet variety CO 10 with improved crop Management practices recorded more higher grain yield of 29.5q/ ha and farmers practice recorded lower yield of 18.9q/ha. Adoption of improved crop management practices increased the grain yield of pearl millet to the tune of 56 per cent compared, to farmer's practice. Farmers earned higher net income of Rs.62,750/ha through the demonstration and Rs.25650/ha with farmers practice. Besides, farmers realized higher benefit cost ratio (2.5) through the demonstration compared to farmer's practice (1.6). Thus, the demonstration of improved variety CO 10 with crop management practices increased the grain yield and net income of the farmers growing pearl millet under rainfed condition (Table 1). In the present study, potential of the new variety and technologies were demonstrated systematically and scientifically in the farmer's field along with farmers practice for further adoption by farming community in large scale.

T2-77

Effect of sowing windows and Nitrogen levels on yield and economics of Sorghum *(Sorghum bicolor)*

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Abstract

Sorghum is the fifth most significant crop, cultivated in the semi-arid tropics. It is also grown for a range of purposes, including food, feed, fodder, fuel and also providing nutritional and health security to all. Sorghum yield is extremely influenced by crop management practices, growing season and other climatic conditions. The field experiment was conducted at agricultural college and research institute, Coimbatore during summer season to find out the suitable sowing date and level of nitrogen on yield and economics of dual purpose K12 sorghum under summer irrigated conditions. The experiment was laid out in split plot design and replicated thrice. The main plot consists of five dates of sowing windows *viz.,* D_1–First fortnight of April, D_2–Second fortnight of April, D_3–First fortnight of May, D_4–Second fortnight of May, D_5–First fortnight of June. The sub plot consists of three levels of nitrogen *viz.*, N_1–75% RDN, N_2–100% RDN, N_3–125% RDN. The observation on sorghum yield was observed and the economics were worked out. The experimental results revealed that sowing on the second fortnight of May with increased level of Nitrogen (125% RDN) recorded higher the grain yield (4360.8 kg ha^{-1}), higher the gross return (130824 Rs. ha^{-1}), net return (86500 Rs. ha^{-1}) and Benefit cost ratio (2.95) of sorghum.

Keywords: Sorghum, Sowing windows, Nitrogen levels, Yield, Economics.

T2-78

Intercropping competition and yield advantage of varagu with blackgram under irrigated and rain-fed condition

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Abstract

Effective use of resources like land, solar radiation, water, nutrients, and more agricultural resources for both time and space allows for the growth of two or more crops in the same area, which improves the efficiency of the use of both land and water. Growing dissimilar crops simultaneously on the same field that may be with annual intercrop or

perennial intercrops grow with the least amount of competition. Millets are nutrient depleting crops that collect nutrients from the top soil layer. Millets with legume intercropping enhance soil fertility by fixing atmospheric nitrogen. Intercropping systems prevent rainfall from hitting bare soil, which blocks surface pores, stops water from penetrating the soil, and increases surface drainage. This reduces soil erosion. Planting uniformly or nearly uniformly over the land to reduce early interplant competition and increase the rate of solar radiation interception. By supplying organic matter to the soil (SOM), legume crops encourage air circulation, water retention, and buffering of restrictions. This makes the soil more cultivable and helps maintain the proper balance of soil aggregates, air circulation, water retention, and buffering constraints. At the Centre of Excellence in Millets, Athiyandal, Tiruvannamalai, a field experiment was carried out to determine the effects of intercropping varagu with greengram and blackgram cropping systems under a rain-fed and irrigated condition on photosynthetic efficiency, growth analysis, and productivity. It was done in Kharif, 2018 and 2019. Randomized block design was used to conduct this experiment. It has three replications. The aim of this study was to evaluate and compare varagu with greengram and blackgram inter cropping effects on rainfed and irrigated ecosystem.Sole varagu intercropped with blackgram and greengram in 1:1 ratio recorded reduced weed density compared to paired row varagu under both the rainfed and irrigated condition. Sole varagu intercropped with blackgram in 1:1 ratio recorded more no of productive tillers, total chlorophyll content, relative water content under irrigated and rain-fed conditions. Similarly, increased grain yield and straw yield were identified in Sole varagu intercropped with blackgram 1:1 ratio.

Keywords: Varagu, Greengram, No.of productive tillers, Chlorophyll content, Grain yield and Straw yield.

T2-79

Co-application of organic amendments: A stimulant for soil microbial metabolism to improve soil health and yield in maize-legume intercropping system

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Abstract

Long-term application of mineral fertilizers is associated with a decrease in soil quality and microbial activities. Organic amendments such as farmyard manure (FYM) and poultry manure (PM) were known to improve nutrient availability and soil water-holding capacity. Legume intercropping releases diverse phytochemicals that modify the root architecture, enhanced nutrient uptake, and influence crop agronomic traits. To assess the optimal nutrient management strategy for sustainable maize production, field experiments were conducted in the South farm of the Karunya Institute of Technology and Sciences, Coimbatore, which is situated in the Western Agro-climatic zones of Tamilnadu (10.934º N latitude and 76.75º E longitude at an altitude of 467 MSL), during the *Kharif* and *Rabi* seasons of 2022-’23. Maize hybrid COH (M) 6 was the predominant crop intercropped with black gram (VBN8) in both seasons. Under Randomised Block Design (RBD), ten treatments were formulated and replicated thrice, as T_1 - Absolute control, T_2 -RDF alone, T_3 - RDF + Poultry Manure (4t ha^{-1}), T_4 - RDF + FYM (12.5 t ha^{-1}), T_5 - RDF + Poultry Manure (4 t ha^{-1}) +

Black gram intercropping, T_6 - RDF + FYM (12.5 t ha^{-1}) + Black gram intercropping, T_7 - 75 % RDF + Poultry Manure (4 t ha^{-1}) + Black gram intercropping, T_8 - 75% RDF + FYM (12.5 t ha^{-1}) + Black gram intercropping, T_9 - 50% RDF + Poultry Manure (4 t ha^{-1}) + Black gram intercropping, T_{10} - 50% RDF + FYM (12.5 t ha^{-1}) + Black gram intercropping. The treatments were imposed one week before sowing, and at optimum moisture level, the maize seeds were sown at a spacing of 60 x 25 cm. Black gram was sown adjacently at a 15 cm distance from maize. The observations for agronomic traits were recorded at different phenological stages in both seasons. From the results, it was inferred that the treatment amended with PM (T_5) performed more significantly in terms of grain yield (6.69 t ha^{-1}) which is 35% higher than the control (T_1), followed by T6(6.42 t ha^{-1}). However, in the subsequent seasons, the treatments with 75% RDF amended with PM and FYM (T_7 and T_8) registered increased yield when compared with the first season.The mean growth and yield characteristics were also significantly higher in T_5 and T_6 followed by T_7 and T_8. While unravelling the soil microbial dynamics, the bacterial population was predominant followed by fungi. Exopolysaccharide (EPS) producing bacterial colonies were identified in the treatments supplemented with organic amendments. The FDA activity was higher in T_6 (RDF + FYM @12.5 t ha^{-1} + Black gram intercropping) which represents significant microbial activity. Dehydrogenase and acid phosphatase were registered maximum in the treatments T_6 and T_5 respectively. The soil enzyme activities were positively correlated with the grain and stover yield, where the PM enhances phosphorus uptake from the soil. The results suggest that organic amendments especially FYM and PM could be a suitable nutrient management strategy for achieving sustainable maize production, due to the increased soil enzyme activities in the subsequent seasons. It can be concluded that the recommended doses of chemical fertilizers could be sequentially reduced with the co-application of PM and FYM in the subsequent seasons. The EPS producers and their role in shaping soil structure will be explored further.

Keywords: maize, organic amendments, sustainable production

T2-80

Assessment of high yielding ragi varieties in virudhunagar district

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Abstract

Ragi (*Eleusine coracana*) is the major staple food crop cultivated 66.13 ha in the Virudhunagar of Tamil Nadu. Ragi is rich in carbohydrates, calcium, fibre, proteins and vitamins, contains slow releasing carbohydrates and provides continuous energy and is being promoted as food for diabetics. However the productivity is quite low. An attempt was made to identify suitable high yielding varieties for this region through on farm trials in Virudhunagar District during 2022-23. The study revealed that ATL 1 recorded higher grain yield of 2812 kg/ha, Plant height (98 cm), Number of finger/ earhead (9 Nos) and high number of tillers 8.2 compared to other variety ragi VL376. Higher net return of Rs. 31605/ha and benefit cost ratio of 2.26 was recorded in ATL 1 compared to the other varieties. Farmers satisfied with ATL 1 due to its high tillering, non lodging nature, suitable for machine harvest and yielding nature. Considering the above facts, ATL 1 would be a better option to the farming community for enhancing the productivity of ragi in rainfed condition.

T2-81

Review on mechanized seed ball production through low- cost drum granulator in Pearlmillet

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Abstract

Seed is considered as one of the most critical inputs necessary for agricultural productivity. The sentence "Life cycle of a plant begins with seed and ends with seed" shows the significance of seed. Certain physical modifications in seeds such as process of seed pelleting are proven to be scientifically important approach in improving the production potential of many crops specially. Seed granulation or seedball making is a seed-pelleting technique, using locally available natural materials for improve the crop establishment and early biomass production. In the dry regions, the nutrient status of soil is often very poor and the soil has low water holding capacity which leads to reduction in crop establishment and yield. Previous experiments described that seedballs promotes plant development, especially during the seedling establishment phase (Nwankwo et al, 2018)

The primary challenge in manual seedball production is the labour demand to mix and mould the raw material. Therefore, The drum granulator was built by Romuli at al., 2023 to mechanize production should ensure proper and fast mixing, which can substantially increase. production capacity while sustaining seedball quality in terms of germination rate. In the African region, the significant staple food crop is pearl millet (*Pennisetum glaucum* [L.] R. Br.) Pearl millet is drought tolerant and responds well to the fertilizers. Therefore, pearlmillet was used this study. The major design ideas for the machine are cheap cost and ease of manufacture and operation.

Seed granulating raw materials such as sand, loam, water, and seeds are needed. Nutrient additives are mandatory and other additives are optional (60% sand, 35% loam, (2% of wood ash or 1% NPK mineral fertilizer and 4 %). The materials are mixed into a substrate to which water is added and then molded into seedballs with a minimum diameter of 20 mm. (Fig .1). The production capacity was higher under drum granulator compare to the manual method. Comparison of manual and mechanized seedball production was shown in Table 1.

In addition to that, the study results reported that loam amount and drum rotating speed proved to be the most influential parameters on seedball production and quality. The machine-made seedballs were also of high quality, exceeding 98% germination rate under greenhouse conditions. Besides pearl millet, the machine can be potentially used for other small-sized seeds, such as cotton or sesame.

Based on above view, The drum granulator (seedball machine) technology (Fig 2.) has shown to be a feasible concept for mechanised seedball production. Further there is need to enhancement of substrate composition with biochar, pesticide, commercial fertilizers.

T2-82

Magical millets: An evolution towards food security, rural self-sufficiency, and nutrition

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Abstract

Millets, often regarded as "magical grains," have gained attention as a promising solution to address pressing global challenges such as food security, rural self-reliance, and nutrition. Millets possess exceptional nutritional qualities, rich in fiber, protein, vitamins, and minerals. Their gluten-free nature and low glycemic index make them suitable for individuals with dietary restrictions and those seeking healthier alternatives. By integrating millets into diets, communities can mitigate malnutrition and reduce the risk of chronic diseases. Furthermore, millets exhibit remarkable climate resilience and adaptability, thriving in harsh conditions with limited water and poor soil fertility. As a result, they offer a sustainable solution for smallholder farmers in marginalized regions, reducing their vulnerability to climate change impacts and improving agricultural productivity. The cultivation of millets can foster rural self-reliance, empowering farmers to meet their own food needs and enhance their economic well-being. To harness the transformative power of millets, it is crucial to establish supportive policies and comprehensive value chains. Governments and stakeholders must prioritize investment in millet research, development, and infrastructure, including access to quality seeds, training, and market linkages. Strengthening the millet value chain will enable farmers to maximize their yields, improve post-harvest handling, and expand market reach, thus enhancing food security and income generation. Moreover, promoting millet-based entrepreneurship and innovation can unlock opportunities for value addition, such as millet processing, product development, and culinary diversification. In conclusion, the pivot towards millets represents a promising pathway to achieve food security, foster rural self-reliance, and improve nutrition. Through collaborative efforts among policymakers, researchers, farmers, and consumers, millets can unlock their magical potential and pave the way for a healthier, more sustainable, and resilient future.

Keywords: Food security, Nutrition, Climate change.

T2-83

Improved dryland technologies in millets

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Abstract

One of the major concerns at the global level is the abrupt changes in the earth's environment, which have had a devastating effect on the earth's ecology. Currently, we are in the age of an agrarian crisis, which has necessitated for crop improvement to tackle the negative effects of climate change. Under the water stress conditions, varieties with a high harvest index, low rate of water loss and more roots in the upper soil layer generally produce a high yield. Millets are nutrient-rich and capable to resist variety of harsh environmental conditions, including lack of moisture. Millet crops have evolved dynamically in terms of

morphology, physiology, and biochemically that allow them to flee and/or adapt to adverse environmental situations. This paper highlights the latestagronomic practices followed in millets to improve the yield during water stress conditions.

Keywords: climate change, drought, dryland, millets, technologies

T2-84

Effect of different organic manure on growth and yield of Sorghum (*Sorghum biocolor* L)

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Abstract

A field experiment was conducted at new area, Department of millets, Agricultural college and Research Institute, Tamil Nadu Agricultural University at Coimbatore. During Rabi season 2022-2023 sandy clay loam, The treatments were block design (RBD) and Three replications. T_1 unfertilized unmannured control T_2 Azospilillum + PSB+KSB+ ZnSB (Bio - fertilizers) T_3 FYM application equivalent in recommended dose of nitrogen T_4 Vermicompost (VC) application equivalent to RDN T_5 Bio – fertilizer + FYM T_6 Bio – fertilizer + Vermi compost T_7 ZBNF (based on 4 (irrigation) principles beejamrita (Seed Treatment) jeevamrita, acchadana (mulching) waaphasa. The effect of application of Bio fertilizer + vermicompost higher value of plant height number of grains per panicle, 1000 grains weight, grain yield net plot and stover yield (kg net plot) $T_{6,}$ The lowest value of all physiological parameter in unfertilized and unmanure control plot.

Keywords :Azospinillium, Bio-fertilizer, FYM, Vermicompost

T2-85

Influencing of foliar nutrition growth and yield of rabi Sorghum (*Sorghum Bicolour* L.)

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Abstract

A field experiment was conducted at new area, Department of millets Agri cultural college and Research Institute Tamil Nadu Agricultural University, Coimbatore during Rabi 2022 – 23 On sandy clay 10 am. Fifteen treatments and two replication were followed by T_1 Recommended dose g NPK Zn Fe B fertilizers (Basal) as per practice T_2 T_1 + Nano urea C_4 ml of water spray at panicle initiation stage T_3 T_1 + Nano urea 4ml per litter of water spray at FL. Stage T_4 T_1 + Nano urea (4ml/Litter water) Spray at PI and FL T_5 T_1 + DAP (2%) Spray at PI T_6 T_1 + K (2% KCC) Spray at PI T_7 T_5 + K (2% KCC) Spray at PI T_8 T_7 + Zn spray (0.5 % Zinc Sulphate) at PI T_9 T_8 + Fe spray (0.5 Sulphate at PI T_{10} T_9 + B) Spray 0.1 ppm sodium boron at PI T_{11} T_1 with top dressing of 50 % N out of total N T_{12} unfertilized control grained T_{13} T_1 with irrigation T_{14} T_{13} with top dressing of 50 % N The effect of T_{10} T_9 0.5 furrows sulphate T 0.1 ppm sodium based at panicle initiation stages height value of plant height, Number of grains per Panicle, 1000 grains weight (gram) grain Yield (Net plot) and stolen yield (Net plot). The lover value of T_{12} unfertilized control.

T2-86

Enhancing sorghum productivity: Effective weed management strategies

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Abstract

Sorghum (*Sorghum bicolor* L.) is the world's fifth most important food crop, widely consumed as a dietary staple. In India, sorghum productivity faces challenges, particularly due to weed infestation. Weeds have a detrimental impact, causing a loss of around 33% of potential production. Manual hand weeding has traditionally been the preferred and effective method, but it is labor-intensive, time-consuming, and economically unfeasible due to high wage rates. To address this, mechanical equipment offers time-saving alternatives, increasing productivity per worker and reducing costs. Chemical weed control is a valuable supplement, but its efficacy depends on factors like weed emergence patterns, timing of application, and crop growth stage. Care must be taken to avoid excessive herbicide use, as it can lead to weed resistance, making control more challenging. Cropping system strategies, such as crop rotation, intercropping, and mulching, influence weed composition in cultivated fields. These strategies impact weeds through factors like feeding habits, allelopathic effects, excretion, physical interference (e.g., shading), and altered ecological dynamics. Some of these elements directly contribute to pest management through predatory behavior, indirectly suppress weeds serving as alternative hosts, and promote faster and more robust crop growth. Intercropping, increasingly practiced in intensive agriculture, maximizes land use and effectively reduces weed growth compared to monoculture systems. Integrated weed management (IWM) involves combining multiple strategies to suppress weeds effectively. This comprehensive approach integrates various components of the weed management system to achieve acceptable levels of control. Therefore, adopting diverse weed management techniques in sorghum cultivation is crucial, focusing on methods that are efficient, cost-effective, and environmentally safe.

Keywords: Weed infestation, Cropping system strategies, Mulching, Intercropping

T2-87

Influence of Organic Amendments and Bioinoculants to enhance the Productivity of fox tail millet under rainfed condition

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ABSTRACT

Minor millets, which are high in nutrients such as calcium and iron, are grown primarily in hilly, arid areas of India where, because of their high tolerance to drought, they are often more productive than other grains. The experiment trial was conducted at Agricultural College and Research Institute, Vazhavachanur during 2016 with the following treatments T1-PPFM @ 500 ml / ha on 30, 45 and 60 days after sowing, T2- Panchakavya @ 3 % on 30, 45 and 60 days after sowing, T_3-ArbuscularMycorrhiza @ 50 kg / ha as basal, T_4-Weed Mulching @ 5t / ha and in-situ composting and T_5- Recommended dose of fertilizer (Control). The plant biometrics Plant height and tiller population was recorded maximum with PPFM application on 30, 45 and 60 days after sowing with 25.4 cm, 48.5 cm and 65.0 cm at 30th ,60th DAS and at harvest stage respectively. Similar trend was observed in the tiller population. The maximum grain yield was recorded with the application of PPFM @ 500ml/ha with 1802 kg/ha, application of Arbuscular Mycorrhiza @50 kg /ha as basal with 1345 (kg/ha). The minimum grain yield was recorded with the application of control with 433(kg/ha). The proline accumulation was highest at grain development stage in all the small millets and the maximum was observed in foxtail millet at grain development stage. This shows that the foxtail millet cultivars able to tolerate under stress and proline accumulation is the highest at grain development stage. With regard to B:C ratio it was revealed that application of PPFM (2.61) followed by the application of Arbuscular mycorrhiza (2.03). A positive synergistic effect of *Azospirillum* and phosphobacteria is responsible for the higher accumulation of N and higher yield. PPFM under drought conditions, it produces an enzyme ACC Deaminase (1- Amino cyclopropane 1- carboxylate) which inhibits ethylene production. This ethylene hormone is only responsible for senescence in the plant. By inhibiting this ethylene production, can protect the plant from senescence. This PPFM is cost effective and eco-friendly. It mitigates drought and also helps to increase yield by 10%.

T2-88

Bacillus velezensis LLB10, a drought tolerant leaf associated endophytic plant growth promoting bacteria for little millet (*Panicum sumatrense* L.)

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Abstract

Little millet, the least water-demanding crop is one of the important small millet indigenous to the Indian subcontinent, well known for its drought tolerance. A decline in little millet productivity under drought due to climate change necessitates the finding of sustainable solutions. In order to isolate drought tolerant microbes associated with little millet, the present study was carried out in little millet crop ATL-1 variety for their ability to tolerate drought by limiting field capacity. Plants were able to tolerate osmotic stress about 10 bars and endophytic bacterial isolates were isolated from leaf of little millet plants grown under stressed condition. A total of 3 isolates (LLB2,LAB6, and LLB10) were selected based on their ability to tolerate drought up to 36 bars on PEG infused agar plates and further screened for Phosphorous, and Zinc solublization, IAA production, ACC deaminase activity, siderophore production, exopolysachride production, and biofilm activity. The isolate LLB10 was identified as potential bacteria and was closely related to Bacillus velezensis. Invitro germination experiments yielded promising results in germination percentage and plant growth promoting attributes under induced stress conditions. Metabolomics study on the strain Bacillus velezensis LLB10 under stress and non stress revealed top metabolites like like Proline, oleic acid, Fumaric acid, Gibberellic acid, yielded promising results in drought tolerance and plant defense. *Bacillus velezensis* LLB10, a leaf associated bacteria, can be further extrapolated as a newer bio inoculant for abiotic stress mitigation and plant growth promotion in little millet.

Theme 3

Biotic and abiotic stress management
Extended summaries

T3-01
Effect of neem cake against bio stages of maize fall armyworm *Spodoptera frugiperda* (J.E. Smith)

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Abstract

Neem (*Azadirachta indica*) is a native to the Indian subcontinent. Its seeds are the source neem cake.The neem cake is recommended to apply in the last plough to contain the invasive maize fall armyworm (FAW) pest *Spodoptera frugiperda* (J.E. Smith). The experiment was laid out in the Insectary, Department of Agricultural Entomology, TNAU, Coimbatore for improving soil health through neem cake using popular maize hybrid (CoH8) with six treatments and five replications in Complete Randomized Design (CRD). In the first experiment, after 14 days, the survival of FAW 2nd instar larvae was 32.00 per cent and 3rd instar larvae was 34.62 per cent, respectively. In second experiment 49 mg of neem cake (T_1) recorded 3 nos. and 96 mg of neem cake (T_2) recorded 2 nos. of adult emergence as against in control (T_6) (5 nos. of adult).

Introduction

Neem (*Azadirachta indica*) popularly called as margosa, neem, nim tree or Indian lilac, belongs to the mahogany tree of family Meliaceae. It is one of two species in the genus *Azadirachta* and is a native to the Indian subcontinent, but is naturalized and grown around the world in tropical and subtropical areas. Its seeds are the source of neem oil, neem seed powder and neem cake.The neem cake is being applied in the last plough to enrich the soil nutrients and to contain the pests.

The invasive fall armyworm (FAW) is a major threat to maize production in recent days. The fall armyworm, *Spodoptera frugiperda* (J.E. Smith), is a polyphagous migratory insect pest that is able to cause considerable economic losses in over various types of crops. The pest is native to the tropical and sub-tropical regions. To manage this new keypest and to overcome health, environmental, and resistance problems related to the indiscriminateuse of insecticides, effective and sustainable alternative pest control approaches are need of the hour. Aiming to solve this catastrophe more sustainably, neem cake (250 kg/ha) was used in this study. In this paper, the neem cake is used against various bio stages of *Spodoptera frugiperda* development and the impact of neem cake in the larval growth, pupal formation and emergence of adult is studied in depth with soil as base medium.

Materials and Methods

The experiment was laid out in the Insectary, Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore using the popular maize hybrid (CoH8) with six treatments and five replications in Complete Randomized Design (CRD).

Larval survival rate of second and third instar larvae grown in the potted plants after application of neem cake at standard quantity of 49 mg of neem cake/10 kg of pot soil and 30 numbers of each second and third instar larvae released separately in the maize plants grown in neem cake treated pots. Feeding bioassay test was conducted using the method as detailed by Meagher and Nagoshi (2012). Regular observations were recorded in the growth and observed till cessation of feeding.

In the second experiment the final instar (sixth instar) larvae are used after cessation of feeding and allowed to pupate in small tumbler cups with neem cake treated soil at different doses *viz*., 49 mg of neem cake (T_1), 96 mg of neem cake (T_2), 147 mg of neem cake (T_3), 196 mg of neem cake (T_4), neem cake recommended dose in wet condition (T_5), without neem cake as control (T_6). The percent pupation by sixth instar larvae and adult emergence from each treatment was recorded from the third day after pupation and the per cent adult emergence was recorded.

During the trial period, data were recorded before treatments (pretreatment count) and daily counts were recorded till the larvae stop feeding in the first experiment. Regular observations were recorded and trial data were analyzed in AGRES package.

Results and Discussion

In the first experiment the initial survival of fall armyworm 2nd instar larvae was 86.67 per cent and 3rd instar larvae was 93.33 per cent, respectively. After 14 days, the survival of FAW 2nd instar larvae was 32.00 per cent and 3rd instar larvae was 34.62 per cent, respectively. In the second experiment, only 49 mg of neem cake (T_1) (6nos. of larvae) and 96 mg of neem cake (T_2) (5 nos. of larvae), treatments permitted pupation. 49mg of neem cake (T_1) recorded 3 nos. and 96 mg of neem cake (T_2) recorded 2 nos. of adult emergence as against (T_6) (5 nos. of adult) in control.

Neem is a key ingredient in non-pesticidal management providing a natural alternative to synthetic pesticides. Neem does not directly kill insects. It acts as an anti-feedant, repellent and oviposition deterrent and thus protects the crop from damage. The insects starve and die within a few days. Neem also suppresses the subsequent hatching of their eggs. Neem-based fertilizers have been effective against southern armyworm. Neem cake may be used as a fertilizer. Neem-based products can, therefore, be recommended as an important component for any integrated pest management scheme to fight FAW.

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T3-02

Impact of calcium silicate with other ecofriendly approaches on borer pests of Barnyard Millet

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Abstract

The effect of various silicon sources against the borer pests *viz.,* shoot fly and stem borer of barnyard millet was assessed. The lowest percent incidence of both dead heart (5.72%) and white ear (5.25%) was recorded in the treatment with basal application of 60 kg of silica as calcium silicate/ha which was on par with the application of 50% calcium silicate with neem formulation and release of *Trichogramma*. The yield recorded was higher in basal application of 75% of 60 kg of silica/ha along with application of azadirachtin 300 ppm and release of *Trichogramma* (1.82 t/ha) which was on par with basal application of 50% of 60 kg of silica/ha along with application of azadirachtin 300 ppm and release of *Trichogramma* (1.80 t/ha) against the untreated check (0.65 t/ ha) with BC ratio of 2.20.

Keywords: calcium silicate, neem, *Trichogramma,* borer pests, barnyard millet

Introduction

Barnyard millet is one of the most important small millet crops in Asia, showing a firm upsurge in world production. It is richest source of fibre compared to wheat and rice. Among the insect-pests harbouring barnyard millet crop, shoot fly, *Atherigona falcata* and pink stem borer, *Sesamia inferens* are the most damaging insect pests and causes significant yield loss. As per the status report on millets, priorities should be given to evolve IPM module for effective management of shoot fly and stem borer in different small millets. For management of shoot fly and stem borer, farmers never use insecticides which in turn led to poor yield. The most reliable and basic method to control insects is host plant resistance. In the absence of heritable host plant resistance, the insect population could be contained by nutritional manipulation (Sharma *et al*., 2002). This has necessitated the use of silicon fertilizers against certain insect pests. Silicon application significantly enhances insect pest resistance in plants with yield increase

Silicon deposition in the plant may reinforce plant insect resistance by providing a mechanical barrier against insect pests. Silicon promotes plant resistance in two ways: first, through physical resistance, and second, through chemical defense by inducing resistant factor in it (Alhousari and Greger, 2018). Potassium silicate (18% Si), sodium silicate (23% Si), and calcium silicate (24% Si) are reported to be readily available silica fertilizers that can be used for pest management either through soil or foliar applications (Murali Baskaran *et al*., 2021).

Keeping the global concern with special reference to environmental pollution due to continuous usage of insecticides, human health and toxic residues of chemicals the present work is planned with the use of environmentally friendly management strategies. For management of shoot fly and stem borer, farmers never use insecticides which in turn lead to poor yield. For its management, a variety of environmentally friendly management strategies must be created. Induced host plant resistance is one strategy that might be used to control shoot fly and stem borer.

Material and Methods

A confirmatory field experiment was conducted during September 2022 to November 2022 at Agricultural College and Research Institute, Madurai. The design adopted was Randomized block design (RBD) using the Kuthiraivali variety MDU 1 with following nine treatments and replicated thrice. The plot size was 5 x 4m and all the agronomic practices were followed uniformly in all the plots. The treatments comprised of T_1- Soil application of calcium silicate at 60 kgs/ha, T_2 - 75 % of T1/ha + azadirachtin 300 ppm 5 ml/l, T_3 - 75 % of T_1 + *Trichogramma 5*cc /ha, T_4- 75 % of T_1 + azadirachtin 300 ppm 5 ml/l + *Trichogramma* 5cc/ac, T_5 - 50 % of T_1 + azadirachtin 300 ppm 5 ml/l, T_6- 50 % of T_1 + *Trichogramma* 5cc/ha, T_7 - 50 % of T_1 + azadirachtin 300 ppm 5 ml/l + *Trichogramma* 5 cc/ha, T_8 - Farmers practice, T_9 - Untreated check. In each plot the incidence of shoot fly and stem borer *viz.,* dead heart and white ear per cent were recorded in randomly selected plants at regular intervals.

Results and Discussion

Observation on dead heart damage due to shoot fly was recorded on 10 DAT. The per cent damage ranged from 4.16 to 7.67 among the treatments. All the treatments were on par with each other except untreated check where the per cent damage was 7.67 (Table). The dead heart damage on 40 DAT due to stem borer ranged from 5.53 to 14.47 % among treatments. The lowest incidence of dead heart was recorded in the treatment with basal application of 75% of 60 kg of silica / ha along with application of neem formulation and release of *Trichogramma* (5.53%) which was on par with both and 50 % of 60 kg of silica /ha along with application of azadirachtin 300 ppm 5 ml/l and release of *Trichogramma* (5.57%) and basal application of 60 kg of silica as calcium silicate alone (5.72%). Similarly, the white ear incidence ranged from 4.97 to 13.86% among treatments. The lowest incidence of white ear was recorded in the treatment with 75% of 60 kg of silica/ha along with application of azadirachtin 300 ppm 5 ml/l and release of *Trichogramma* (4.97%) which was on par with 50 % of 60 kg of silica /ha along with application of azadirachtin 300 ppm 5 ml/l and release of *Trichogramma* (5.16%) and basal application of 60 kg of silica as calcium silicate alone (5.25%).

The results are in agreement with the findings of Arivuselvi and Chandramani (2014) who reported that the incidence of yellow stem borer, *Scirpophaga incertulas* damage was significantly less in the basal application of calcium silicate 200 kg/ha with foliar spray of 0.25% SMS sprayed during the critical stages of rice crop. This is in endorsement with finding of Indhumathi *et al*., (2019) who found that the maximum reduction of sugarcane early shoot borer was observed in basal application of calcium silicate 1000 kg/ha + SSB @ 2 kg/ha as 71.30 % and over untreated check. The mean per cent damage of internode borer was significantly less in sugarcane treated with calcium silicate 1000 and 500 kg/ha + SSB @ 2 kg/ha (6.41 and 6.92 %). The maximum per cent reduction of sugarcane top shoot borer was recorded in baggase ash at 500 kg/ha and 1000 kg/ha + SSB @ 2 kg/ha as 66.82 and 66.42 as against 0.00 in untreated sugarcane plant.

In Kuthiraivali, yield varied from 0.65 to 1.82 t/ ha. It was maximum in the treatment with basal application of 75% of 60 kg of silica /ha along with application of azadirachtin 300 ppm 5 ml/l and release of *Trichogramma* (1.82 t/ ha) with BC ratio of 2.20 which was on par with 50% of 60 kg of silica /ha along with application of azadirachtin 300 ppm 5 ml/l and release of *Trichogramma* (1.80 t/ha) with BC ratio of 2.16 followed by basal application of 60 kg of calcium silicate (1.78 t/ha) with BC ratio of 2.06 and 75 % of 60 kg of calcium silicate and azadirachtin 300 ppm 5 ml/l (1.75 t/ha) with BC ratio of 1.91.

The present study on the effect of calcium silicate on borer pests of barnyard millet revealed that 50 % of 60 kg of silica/ha along with application of azadirachtin 300 ppm 5 ml/l and release of *Trichogramma* can be recommended to minimise the borer pests.

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Table 1. Effect of silicon with other ecofriendly approaches on borer pests of barnyard millet

Treatments		Shoot fly	Stem borer		Yield (t/ha)	BC ratio
		Dead heart (%)	Dead heart (%)	White ear (%)		
T_1	Basal application of calcium silicate at 60 kgs/ha	4.42 (12.14)^a	5.72 (13.74)^a	5.25 (13.24)^a	1.78 (1.31)^b	2.06
T_2	75 % of $T_{1/ha}$ + Azadirachtin 300 ppm 5 ml/l	4.63 (12.43)^a	6.63 (15.10)^b	5.98 (14.15)^b	1.75 (1.32)^b	1.91
T_3	75 % of T_1 + *Trichogramma* 5cc /ha	4.16 (11.65)^a	7.21 (15.45)^c	5.81 (13.95)^b	1.62 (1.27)^{cd}	1.89
T_4	75 % of T_1 + Azadirachtin 300 ppm 5 ml/l + *Trichogramma* 5cc/ha	4.91 (12.40)^a	5.53 (13.57)^a	4.97 (12.88)^a	1.82 (1.35)^a	2.20
T_5	50 % 0f T_1 + Azadirachtin 300 ppm 5 ml/l	4.20 (11.79)^a	7.50 (15.73)^c	5.52 (13.59)^b	1.65 (1.28)^c	1.62
T_6	50 % of T_1+ *Trichogramma* 5cc/ha,	4.94 (12.84)^a	6.32 (14.54)^b	5.79 (13.92)^b	1.60 (1.26)^{cd}	1.54
T_7	50 % of T_1 + Azadirachtin 300 ppm 5 ml/l + *Trichogramma* 5 cc/ha	4.34 (11.93)^a	5.57 (13.64)^a	5.16 (13.13)^a	1.80 (1.32)^a	2.16
T_8	Farmers practice	4.82 (12.68)^a	8.96 (16.27)^d	6.92 (15.25)^c	0.82 (0.90)^e	1.52
T_9	Untreated check	7.67 (16.08)^b	14.47 (22.34)^e	13.86 (21.86)^d	0.65 (0.80)^f	1.21
SEd		0.119	0.166	0.17490	0.014	
CD p= (0.05)		0.238	0.339	0.357	0.032	

Values in a column are arcsine transformed values. In a column mean followed by same letter are not significantly different at P= 0.05 level as per LSD.

T3-03

Influence of cold storage on Fall Armyworm, *Spodoptera frugiperda* egg parasitoid, *Telenomus remus* Nixon emergence *vis~a~vis* its shelf life

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Abstract

Telenomus remus is a highly specialized egg parasitoid of Fall Armyworm (FAW), *Spodoptera frugiperda*. Determining the shelf life to provide a consistent supply of parasitoids for the biological control of FAW is need of the hour. In this context, to ascertain the effect of cold storage of parasitized FAW eggs on the fitness of *T. remus* was studied under refrigerated conditions at 3˚C. The results revealed that the cold storage of five days old parasitized FAW eggs of *T. remus* recorded comparatively maximum parasitoid emergence in 2 days storage period (58.56 %) followed by 4 days (49.05%), 6 days (43.34%), 8 days (36.32%) and 10 days (32.54%), respectively. Both female and male parasitoid emergence was found to be maximum in 2 days (32.41 and 23.15%) followed by least emergence (21.23 and 11.29%) in 10 days storage period. The *T. remus* parasitized FAW eggs kept at room temperature (control) yielded more parasitoids with highest female, male proportions indicating the stress inflicted by the cold storage on the parasitized eggs which reflected in the adult emergence. However, based on the demand, 5 days old *T. remus* parasitized FAW eggs can be stored for 6 days with reasonable emergence.

Keywords: *Telenomus remus,* Fall Armyworm, Cold storage, Parasitoid fitness

Introduction

Telenomus remus Nixon (Hymenoptera: Scelionidae) stands out as a highly specialized egg parasitoid of FAW (Cave, 2000). *Telenomus remus* is noted for its effective action on FAW eggs which are oviposited in superimposed layers. Determining the shelf life to provide consistent supply of parasitoids for the biological control of FAW is need of the hour. Cold storage of parasitoids can enables us for the coordinated field releases of natural enemies and also increases the parasitoid availability to consumers (Venkatesan *et al*., 2000). In view of the above fact, investigations were carried out to find out the storability of *T. remus* parasitized FAW eggs.

Materials and Methods

Freshly laid FAW egg masses were stacked in a paper strip with gum Arabic glue and subjected to parasitization by *T. remus*. After parasitization, the egg cards at one day after parasitization were refrigerated at 3˚C for different storage periods (2, 4, 6, 8, and 10 days). Similarly, the *T. remus* parasitized eggs at 2, 3, 4, 5 and 6 days after parasitization were also subjected to storage at 3˚C for the above mentioned periods. Six treatments with four replications were followed for each age group. Observations on the per cent parasitism (no. of parasitized eggs (blackened eggs)/ total no. of egg's exposed), adult emergence (no. of emerged adults/ no. of parasitized eggs) and male female proportion were recorded. The percentage data were subjected to arcsine transformation with AGRES software and the means were separated by LSD (Least Significant Difference).

Results and Discussion

Laboratory experimentsconducted to study the effect of cold storage on the fitness parameters of *T. remus* at 3˚C resulted in reduced per cent adult emergence in one day old parasitized FAW eggs stored for 2 days (15.47%) followed by 4 days (11.68%), 6 days (10.67%), 8 days (8.67%) and 10 days (5.45%), respectively. However, cold storage of five days old parasitized FAW eggs recorded comparatively more parasitoid emergence in 2 days storage period (58.56 %) followed by 4 days (49.05%), 6 days (43.34%), 8 days (36.32%) and 10 days (32.54%), respectively. Both female (32.41%) and male (23.15%) parasitoid emergence was found to be maximum in 2 days storage period followed by least emergence (21.23 and 11.29%) in 10 days (Fig.1). The *T. remus* parasitized FAW eggs kept at room temperature (control) yielded more parasitoids with highest female, male proportions indicating that the stress inflicted by cold storage on the parasitized eggs which reflected in the adult emergence. Reduction in the parasitoid emergence in cold stored parasitized eggs could be due to the effect of cold shock on the developing embryos (Olaye *et al*., 1997). Also, gradual decrease in female parasitoid emergence with the increased storage period observed in the present study was in accordance with those of Mohamed and El-Heneidy (2020). However, considering the demand, the 5 days old parasitized FAW eggs of *T. remus* can be stored for a period of 6 days with reasonable parasitoid emergence.

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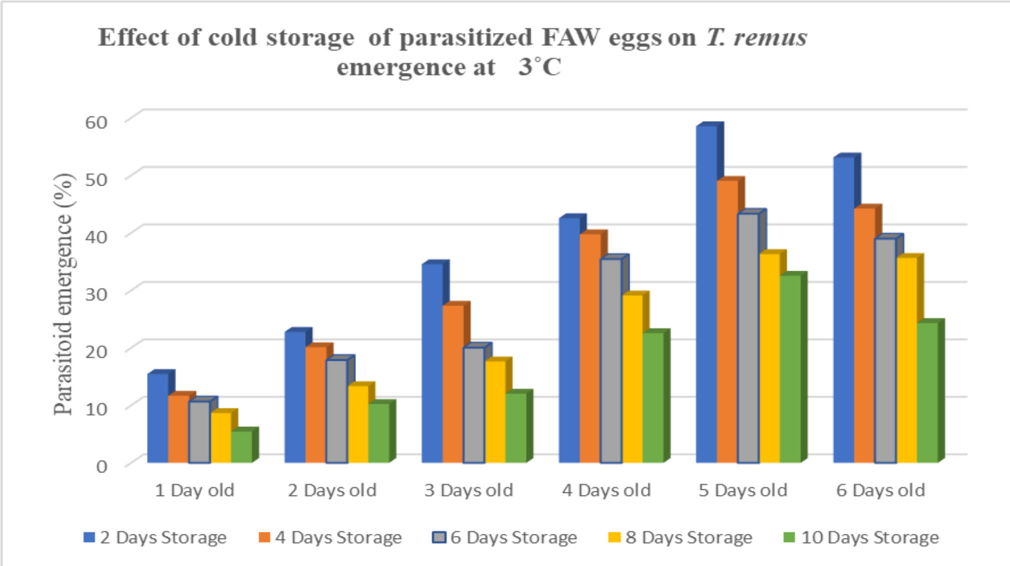
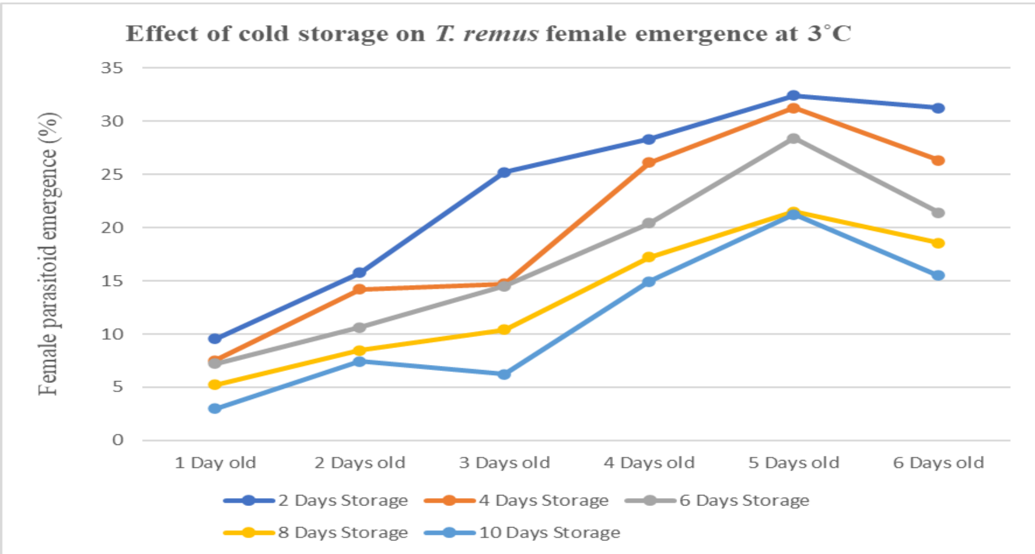
Fig. 1. Effect of storage of *T. remus* parasitized FAW eggs at 3°C





T3-04

Standardization of artificial diet for mass culturing Fall Armyworm, *Spodoptera frugiperda* Smith to accomplish research needs of management strategies

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Abstract

Development of management strategies for the invasive alien, Fall Armyworm (FAW), *Spodoptera frugiperda* requires extensive screening of insecticides and mass production of parasitoids under laboratory conditions. To meet out the research needs, large quantities of FAW have to be produced under laboratory for which designing of a proper diet is mandatory. To standardize the artificial diet, thirty different diet compositions were tried and sixteen were shortlisted. Among the sixteen diets tested, the diet composition added with lablab bean soaked + maize leaf powder – Wesson's salt recorded highest per cent adult emergence (95.0%) followed by lablab bean soaked + maize leaf powder + wesson's salt (92.50%) and lablab bean powder + maize leaf powder - Wesson's salt (92.50%) (Table 1a & 1b). Based on the results, the diet with the ingredients *viz.,* lablab bean soaked + maize leaf powder + wheat germ (25.00 g) + brewer's yeast (23.00 g) + ascorbic acid (2.50 g) + sorbic acid (1.50 g) + methyl para hydroxy benzoate (dissolved in 10 ml of Ethanol) (2.00 g) + distilled water (480 ml) + agar agar (13.0 g) + formalin (1.00 ml) + tetracycline (1.25 g) + multivitamin syrup (2.00 ml) is standardized as the best diet for the mass production of FAW in large quantities so as to carry out the bioefficacy testing of various components of integrated pest management (IPM) under laboratory conditions.

Keywords: Fall Armyworm, *Spodoptera frugiperda*, Artificial diet, Mass culturing

Introduction

Maize is the third most important cereal crop after rice and wheat in India. Maize cultivation was affected by numerous biotic factors including insect pests which cause significant yield reduction. The Fall Armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is one of the recent alien pests reported by Sharanabasappa *et al*. (2018) for first time in India on maize poses a serious threat to maize production and cause significant global yield loss up to 80 per cent (Overton *et al*., 2021). Management of this pest is a challenging task owing to its cryptic, polyphagous and migratory behaviour. The key to minimize the losses caused by FAW lies in the framework of integrated pest management which involves the combination of cultural, chemical, biological control, resistant and tolerant varieties. Being an invasive pest, identification of effective insecticides requires bioefficacy testing under laboratory and also production of biological control agents like parasitoids requires large quantities of FAW eggs / larvae. To meet out the various research needs, FAW larvae has to be produced in enormous quantity under laboratory for which designing of an artificial diet is mandatory. With this view, the present investigation was carried out to standardize an artificial diet for FAW.

Materials and Methods

To standardize the artificial diet, thirty different diet compositions were tried and 16 were shortlisted and compared for its efficiency on the basis of larval weight, pupal weight and larval survivability by addition and deletion of few ingredients. The ingredients *viz.,* wheat germ (25.00 g), brewer's yeast (23.00 g), ascorbic acid (2.50 g), sorbic acid (1.50 g), methyl para hydroxy benzoate (dissolved in 10 ml of Ethanol) (2.00 g), distilled water (480 ml), agar agar (13.0 g), formalin (1.00 ml), tetracycline (1.25 g) and multivitamin syrup (2.00 ml) were common for all the 16 diets and the ingredients *viz.,* maize leaf powder (25 g) and wessons's salt (2 g) were either added or deleted. In addition, maize grain (88.0 g) or lablab bean (88.0 g) either soaked or as powder were added. Based on the efficiency, artificial diet for the mass production of FAW larvae was standardized. The data were analyzed with AGRES software and the means were separated by LSD (Least Significant Difference).

Results and Discussion

Among the sixteen diets tested, the diet composition added with lablab bean soaked + maize leaf powder – Wesson's salt recorded highest per cent adult emergence (95.0%) followed by lablab bean soaked + maize leaf powder + Wesson's salt (92.50%) and lablab bean powder + maize leaf powder - Wesson's salt (92.50%) (Table 1a & 1b). Based on the result, the diet having the ingredients *viz.,* lablab bean soaked + maize leaf powder + wheat germ (25.00 g) + brewer's yeast (23.00 g) + ascorbic acid (2.50 g) + sorbic acid (1.50 g) + methyl para hydroxy benzoate (dissolved in 10 ml of Ethanol) (2.00 g) + distilled water (480 ml) + agar agar (13.0 g) + formalin (1.00 ml) + tetracycline (1.25 g) + multivitamin syrup (2.00 ml) is standardized as the best diet for the mass production of FAW in large quantities so as to carry out the bioefficacy testing of various components of integrated pest management (IPM) under laboratory conditions. This is in confirmation with the results of Ge *et al.* (2022) except for the ingredient soybean which was replaced by lablab bean in the present investigation.

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Table 1a. Standardization of diet for the mass production of FAW

Table 1a. Evaluation of diet without maize leaf powder

Diet	Larval weight (g)*		Larval duration (days)*	Pupal weight(g)*	Pupal duration (days)**	Adult emergence
	5th day	7th day				
T1	0.1362^{a}	0.3601^{a}	20.00^{d}	0.2515^{a}	-	0.00
T2	0.0742^{bc}	0.2147^{b}	19.00^{c}	0.2432^{b}	-	0.00
T3	0.0069^{d}	0.0402^{e}	20.73^{e}	0.2083^{e}	-	0.00
T4	0.0314^{d}	0.0974^{d}	20.56^{de}	0.2247^{d}	-	0.00
T5	0.1295^{a}	0.3807^{a}	18.00^{b}	0.2029^{f}	11.40^{b}	65.0^{b}
T6	0.0866^{bc}	0.2194^{b}	16.50^{a}	0.2520^{a}	10.25^{a}	72.50^{a}
T7	0.1134^{ab}	0.2720^{b}	17.82^{b}	0.2331^{c}	12.05^{c}	52.50^{d}
T8	0.0763^{c}	0.1645^{c}	18.00^{b}	0.2036^{f}	10.09^{a}	55.00^{c}
SEd	0.014	0.027	0.27	0.0018	0.19	0.85
CD (0.05)	0.029	0.055	0.56	0.0037	0.39	1.71

Table 1b. Evaluation of diet with maize leaf powder

Diet	Larval weight (g)*		Larval duration (days)*	Pupal weight(g)*	Pupal duration (days)	Adult emergence
	5th day	7th day				
T1	0.0149^{e}	0.0460^{d}	18.14^{c}	0.2095^{b}	19.14^{cd}	35.00^{g}
T2	0.0186^{e}	0.0522^{d}	19.34^{cd}	0.2039^{b}	18.94^{c}	42.50^{e}
T3	0.0323^{d}	0.0975^{c}	18.91^{c}	0.2198^{a}	19.86^{d}	37.50^{f}
T4	0.0411^{cd}	0.1118^{c}	18.09^{c}	0.2279^{a}	20.11^{e}	45.00^{d}
T5	0.0821^{a}	0.2343^{a}	14.47^{a}	0.2223^{a}	11.03^{b}	92.50^{b}
T6	0.0543^{b}	0.1485^{b}	16.71^{b}	0.2107^{a}	10.03^{a}	95.00^{a}
T7	0.0462^{cd}	0.1119^{c}	16.80^{b}	0.1915^{b}	10.34^{a}	90.00^{c}
T8	0.0513^{bc}	0.1046^{c}	16.81^{b}	0.2159^{a}	10.66^{ab}	92.50^{b}
SEd	0.006	0.007	0.275	0.019	0.22	1.05
CD (0.05)	0.012	0.015	0.552	0.039	0.45	2.11

*Mean of three replications; Means followed by the common letter (s) are not significantly different at 5 % level. ** - No pupation in T1 – T4

T1 - Maize grain soaked + Wesson's salt; T2 - Maize grain soaked - Wesson's salt;
T3 - Maize grain powder + Wesson's salt; T4 - Maize grain powder - Wesson's salt;
T5 - Lab lab bean soaked + Wesson's salt; T6 - Lab lab bean soaked - Wesson's salt;
T7 - Lab lab bean powder + Wesson's salt; T8 - Lab lab bean powder - Wesson's salt

T3-05
Farmers demonstration of TNAU fall armyworm capsule on Maize in Krishnagiri District

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Abstract

The frontline demonstrations (FLDs) on Maize were conducted at Regional Research Station, Paiyur 635112 Krishnagiri (Tamil Nadu) during *Kharif* and *Rabi* 2021-2022 on 15 farmer's field of different villages of Krishnagiri district, Tamil Nadu. The results revealed that during Kharif 2021, the incidence of Fall Armyworm (FAW) was low in demonstration plot on 15 – 25 DAE (23.90 %) and 30 - 40 DAE (12.46 %) over the farmer practice (35.25% and 23.65 %). During *Rabi*, 2022 also minimum incidence of FAW was recorded on 15- 25 DAE (21.24%) and 30-40 DAE (11.82%) when compared to farmer practice. The average higher yield (5690 kg /ha and 5635 kg/ha) was recorded in demo plots compared to farmer practice (4375 kg/ha and 4415 kg/ha) with highest BCR (2.37and 2.35) compared to farmer practice (1.67 and 1.69). By conducting frontline demonstrations of TNAU FAW intervention practices, the maize productivity was enhanced to a great extent which increased in the income level of farmers and improved livelihood of farming community.

Introduction

The fall armyworm (FAW) (*Spodoptera frugiperda*) is one of the devastating insect pest belonging to the family Noctuidae and falls in the Lepidoptera order. It is a polyphagous pest (Baudron *et al.*, 2019)) causing damage to economically important cultivated cereal crops such as maize, rice, sorghum, cotton and various vegetable crops and eventually impacts on food security (FAO, 2019). This pest is native to the Americas and invaded into Asia during May 2018 and it was first reported on maize in Karnataka, India. Since then, it has spread to other states viz., Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Odisha. Considering the economic loss caused by FAW and its widespread across the countries, Food and Agriculture Organization (FAO) has declared FAW as food security threat and trying to find out effective solutions for the management of FAW. With this background, demonstration of TNAU Capsule technology was conducted in Vellore district of Tamil Nadu for maize growing farmers.

Material and Methods

The frontline demonstrations (FLDs) on maize were conducted by Regional Research Station, Paiyur, Krishnagiri during *Kharif* and *Rabi* 2021-2022 on 15 farmer's field of Uthankarai block and different villages viz., Karapattu, Kannanur, Kathavani and Karumandapathi in Vellore district of Tamil Nadu. Observation of fall armyworm incidence and also Economics in Maize field was recorded.

Results and Discussion

During *kharif* 2021, the incidence of fall armyworm (FAW) was low in demonstration plot on 15 – 25 DAE (23.90 %) and 30 - 40 DAE (12.46 %) compared to farmer practice

(35.25% and 23.65 %). During *Rabi*, 2022 also, FAW incidence was minimum on 15- 25 DAE (21.24%) and 30-40 DAE (11.82%) in demonstration plots. The average higher yield (5690 kg /ha. and 5635 kg/ha.) was observed in demo plots compared to farmer practice (4375 kg/ha and 4415 kg/ha.) with highest BCR (2.37and 2.35) as agianst 1.67 and 1.69 in farmers practice. Similar findings were reported by Ganiger *et al.* (2018) who recorded the occurrence of fall armyworm, in Bangalore Rural and Chikkaballapur district during kharif and Rabi season 2018.

As per findings, the incidence of Fall Armyworm (FAW) was low in demonstration plot on 15 – 25 DAE and 30 - 40 DAE over the farmer practice during *Kharif* and *Rabi* seasons 2021-2022 with higher yield (5690 kg /ha. and 5635 kg/ha) compared to farmer practice (4375 kg/ha and 4415 kg/ha.) with highest BCR (2.37and 2.35) compared to farmer practice (1.67 and 1.69).

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Table 1. Demonstration of Fall army worm incidence in Maize during Kharif and Rabi season 2021-2022 in Krishnagiri District

Treatment	FAW infestation (15-25 DAE)			FAW infestation (30-40 DAE)			FAW infestation @ Harvest			TOTAL COST	Yield (kg/ha.)	Amount from feed	Gross return	BC ratio
	% infestation	Score	NE/ 10 plants	% infestation	Score	NE/ 10 plants	% infestation	Score	NE/ 10 plants					
Khari season 2021*														
Demonstration	23.90	1.78	5.69	12.46	1.58	5.83	10.59	1.63	2.66	43481	5690	15567	129360	2.37
Farmer practice	33.25	3.15	1.23	25.56	2.62	0.96	22.65	2.45	0.54	30895	4375	9250	81000	1.67
Rabi season 2021-2022*														
Demo plot	21.24	1.65	5.70	11.82	1.44	6.46	7.72	2.67	2.86	43710	5635	15500	127900	2.35
Farmer practice	43.26	3.2	1.04	24.95	2.18	1.02	23.21	2.36	1.06	28870	4375	8625	80875	1.69

***Mean of 15 farmers**

T3-06

Bio Efficacy of various plant powders on the mortality of rice weevil, *Sitophilus oryzae* L. in stored sorghum

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Abstract

The experiment was conducted to evaluate the efficacy of insecticidal plants against rice weevil, *Sitophilus oryzae* in terms of percent mortality at different exposure period. The black pepper, *Piper nigrum* 2 per cent seed powder caused 100 percent weevil mortality at 1 day after treatment (DAT). The toxicity level of plant powders at 6 DAT was *C. annum* (91.11%) > *A. indica* (85.55%) > *S. grandiflora* (85.55%) > *L. camara* (74.44%) > *Clitoria ternatea* (73.33%) as compared untreated (46.66%).

Keywords*:* Plant powders, *Sitophilus oryzae*, Sorghum.

Introduction

Sorghum, *Sorghum bicolor* L is the fifth most important crop in the world after rice, wheat, corn and barley (Selva Rani *et al.,* 2019). Grater losses are inflicted during storage. Varying levels of losses of food grains have been repoted in Tamil Nadu viz., sorghum (16%), rice (12.9%) pearl millet (14%) and maize (12. 7%) (Suleiman and Rugumamu, 2017). The rice weevil, *Sitophilus oryzae* L. (Colepotera: Curculionidae) is a serious pest of various food grains like rice, wheat and maize under storage. At present, pest control measures in storage rely on the use of synthetic insecticides and fumigants, which is the quickest and surest method of pest control but it is also not advised to mix the insecticides with food grains. The present study has been focused to investigate the comparative effectiveness of different insecticidal plants against the rice weevil *S. oryzae*

Materials and Methods

Laboratory studies were conducted at Department of Crop Protection, Agricultural College and Research Institute, Vazhavachanur, Thiruvannamalai District during 2017 - 2018. Ten insecticidal plants, Black pepper seed, Chilli fruit and leaves of Neem, Sankupuspam, Akathi, Senna, Tulasi, Lantana were taken. Twenty grams of stored sorghum seeds were taken in plastic container powder of various plant parts at the rate of 2:100 (w/w) was added to sorghum seeds and shaken thoroughly. An untreated check was maintained. Thirty newly emerged adult weevils were released in to each plastic container and kept in laboratory. Mortality (lack of locomotion and/ or response to repeated probing) was recorded at one day interval for up to seven days. The experiment was laid out in Completely Randomized Design (CRD) with three replication (Suleiman and Rugumamu, 2017).

Results and Discussion

The rice weevil per cent mortality was compared to untreated control (Table 1). Among the plant powders, *P. nigrum* 2 % seed powder registered 100.00 per cent mortality at 1 DAT while in control no mortality was observed. Similar results were reported by Oguntola *et al.,* (2019). At 7 DAT, highest mortality (95.55%) was observed in *C. annum* which was followed by *A. indica* (89.99 %) and *S. grandiflora* (89.99 %). Among the plant powders, minimum per cent mortality was observed in *C. angustifolia* (45.55 %) as compared to untreated control (49.99%).

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Table 1. Effect of plant powders on the mortality of rice weevil, *Sitophilus oryzae* in stored sorghum

Treatments	Adult mortality (%) – Days after treatments (DAT)*							MEAN
	1 DAT	2 DAT	3 DAT	4 DAT	5DAT	6 DAT	7 DAT	
Piper nigrum 2 %	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)	100.00 (89.47)
Capsicum annum 2 %	5.55 (13.47)	31.11 (33.89)	54.44 (47.55)	62.21 (52.09)	77.77 (61.88)	91.11 (72.72)	95.55 (77.99)	59.67 (51.37)
Azadirachta indica 2 %	4.44 (11.49)	42.22 (40.52)	49.99 (45.00)	67.77 (55.82)	78.88 (63.73)	85.55 (68.24)	89.99 (72.31)	59.87 (51.09)
Clitoria ternatea 2 %	5.55 (13.47)	15.55 (23.19)	27.77 (31.76)	36.36 (37.25)	46.66 (43.08)	73.33 (58.93)	82.22 (65.08)	14.10 (38.97)
Abutilon indicum 2 %	4.44 (11.99)	19.99 (26.51)	26.66 (31.06)	38.88 (38.57)	49.99 (44.99)	66.66 (54.75)	75.55 (60.44)	40.31 (38.33)
Sesbania grandiflora 2 %	12.22 (20.32)	28.88 (32.47)	44.44 (41.80)	81.10 (64.37)	83.33 (65.97)	85.55 (67.68)	89.99 (71.72)	60.78 (52.02)
Cassia angustifolia 2 %	2.22 (7.18)	19.99 (26.42)	19.99 (26.51)	31.11 (33.89)	38.88 (38.57)	42.22 (40.52)	45.55 (42.44)	28.56 (30.79)
Ocimum canum 2 %	7.77 (16.11)	11.11 (19.42)	19.99 (26.51)	29.97 (33.17)	43.33 (41.11)	59.99 (50.77)	73.33 (58.93)	35.07 (35.15)
Leucas aspera 2 %	4.44 (11.99)	18.88 (25.68)	27.77 (31.76)	44.44 (41.80)	47.77 (43.72)	53.33 (46.91)	65.65 (54.06)	37.45 (36.56)
Lantana camara 2 %	4.44 (11.99)	24.44 (29.25)	47.77 (43.72)	59.99 (50.77)	69.69 (56.87)	74.44 (59.67)	83.33 (65.97)	52.05 (45.46)
Untreated control	0.00 (0.52)	16.66 (24.0	25.44 (30.21)	32.24 (34.53)	39.99 (39.22)	46.66 (43.08)	49.99 (44.99)	30.14 (30.94)

*Mean of three replication, DAT- Days After Treatment,
Figures in parentheses are transformed arcsine values

	SED	CD (0.05)
Treatment	0.87	1.81 **
Period	0.64	1.36**
Treatment x period	2.06	5.00**

T3-07

Insecticidal effect of Chitosan O Arginine (CS – O - Arg) against Fall Armyworm, *Spodoptera frugiperda* JE Smith (Lepidoptera: Noctuidae) on Maize

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Introduction

The fall armyworm (FAW), *Spodoptera frugiperda* (J.E.Smith) (Lepidoptera: Noctuidae), the recently invaded insect pest, has caused a threat to grain/ fodder production. It was first discovered in India's Karnataka district in July 2018 and spread throughout the country (Kalleshwaraswamy *et al*. 2019)**.** Damage potential varied from 9.0 to 62.5% depending on seasonal variations (Shylesha *et al*. 2018) and different geographic regions. High damage has been recorded in maize (77.2%), followed by sorghum (60.1%) and pearl millet (41.4%) (Suby *et al*. 2020). Farmers are applying synthetic chemical insecticides to reduce the damage caused by FAW infestation. However, synthetic chemical insecticides have adverse effects, including residues in food and water (Tulashie *et al*. 2021). With this view, research was carried out to find eco-friendly solutions for this destructive pest. This study evaluated Chitosan O Arginine for its toxicity against second-instar larvae of *S. frugiperda*.

Materials and Methods

The synthesized CS – O - Arg was evaluated for its toxicity against second instar larvae of *S. frugiperda* by leaf dip bioassay with eight treatments *viz*., 200 ppm, 400 ppm, 800 ppm, 1600 ppm, 3200 ppm of CS - O – Arg, solvent alone (Glacial Acetic acid 0.1%), adjuvant alone (Tween 80 0.05%), crude chitosan 1600 ppm and untreated check. The leaf bits (2.5 cm dia), were prepared from young maize leaves and were used for bioassay. Each treatment was replicated thrice and 10-second instar larvae were released for each replication. Observations were recorded at 24, 48, and 72 h intervals on larval mortality (Abbott, 1925) (Badawy and El- Aswad, 2012). Leaf dip bioassay was performed in the laboratory to determine LC_{50} CS-O-Arg against *S. frugiperda* (IRAC method no. 018) (IRAC, 2019).

Results and Discussion

Results revealed that CS - O - Arg at 3200 ppm caused the highest mortality (73.33 %) of *S. frugiperda* after 72 hours of treatment. Uddin *et al.* (2021) reported that the unmodified chitosan was active against *S. litura* larvae, with 62.72 per cent mortality after seven days of treatment. Similar findings have been reported for 1000 ppm of CS O Arg, which caused 90.0 per cent mortality of *P. xylostella* after 72 HAT (Selva Rani *et al*. 2022). The second instar *S. frugiperda* larva exposed to different doses of Chitosan O Arginine (CS - O - Arg) recorded an LC_{50} value of 1438.54 ppm at 72 HAT. Rabea *et al.* (2014) showed that the derivatives of chitosan were more toxic to the Mediterranean fruit fly, *Ceratitis capitata* and N-(4-propylbenzyl) chitosan (LC_{50} = 7434 mg/L) was found to be the most active after 24 h of treatment, while the highest activity after 48 h of treatment was exhibited by N-(2-nitrobenzyl) chitosan (LC_{50} = 4923 mg/L). The insecticidal activity was time-dependent with high toxicity after 48 h. Selva Rani *et al*. (2022) reported that the LC_{50} value of CS-O-Arg was 688.64 ppm against *P. xylostella*. Zheng *et al.* (2021) reported that the higher concentration of Chitosan / Carboxymethyl chitosan –Nanoparticles suspension caused a higher mortality rate, and it had the behavior of water absorption and swelling under the acidic environment of the middle intestine of red ant fire ants and decreased intestinal digestive enzyme activity, finally leading to death.

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Table 1. Toxicity of Chitosan O Arginine against *S. frugiperda* second instar larva

Treatment	**Cumulative Mortality (%) #**		
	24 HAT	**48 HAT**	**72 HAT**
T1 – C S O Arg 200 ppm	0.00±0.00 (4.05)c	6.66±0.47 (6.04)e	13.33±0.57 (7.72)e
T2 – C S O Arg 400 ppm	0.00±0.00 (4.05)c	13.33±0.47 (7.72)d	16.66±0.57 (8.40)d
T3 – C S O Arg 800 ppm	3.33±0.57 (5.04)b	26.66±0.94 (10.14)c	40.00±1.00 (12.19)c
T4 – C S O Arg 1600 ppm	6.66±0.57 (6.04)ab	40.00±0.81 (12.19)b	60.00±0.82 (14.74)ab
T5 - C S O Arg 3200 ppm	20.00±1.00 (8.97)a	60.00±0.81 (14.74)a	73.33±0.57 (16.24)a
T6 – GAA1% + T80 0.05%	0.00±0.00 (4.05)c	0.00±0.00 (4.05)f	0.00±0.00 (4.05)f
T7 – Crude Chitosan 1600 ppm	0.00±0.00 (4.05)c	6.66±0.57 (5.73)ab	13.33±0.47 (7.72)e
T8 – Control	0.00±0.00 (4.05)c	0.00±0.00 (4.05)f	0.00±0.00 (4.05)f

SED	0.88	1.27	0.81
P value	<0.0001**	<0.0001**	<0.0001**

#Mean values of three replications are represented as mean± standard deviation
Figures in the parentheses are arc sine transformed values (x+0.5)
Means followed by the same letter are not significantly different from each other by Tukey's test ($p \leq 0.05$)
SED: Standard Error of the Difference; ** Highly Significant; HAT- Hours After Treatment

Table 2. Dosage mortality response of *S. frugiperda* second instar larva to Chitosan O Arginine

Test sample	χ^2	***df*** (n-2)	LC_{50} (ppm) at 72 HAT	Fiducial Limits (50%)		LC_{95} (ppm)	Fiducial Limits (95%)		Slope
				UL	LL		UL	LL	
CS O Arg	7.71^{ns}	3	1438.54	1622.17	1269.42	4393.54	2118.11	3330.19	3.78

Control - Nil mortality
ns = Not Significant at $p < 0.05$ level
LC_{50} =Lethal Concentration that kills 50 percent of the exposed larvae
LC_{95}= Lethal Concentration that kills 95 percent of the exposed larvae
χ^2 = Chi Square; *df* = Degrees of freedom; UL = Upper Limit; LL = Lower Limits
HAT – Hours After Treatment; CS-O- Arg - Chitosan O Arginine

T3-08

Seasonal Occurrence of American fall armyworm, *Spodoptera frugiperda* J.E. Smith (Noctuidae: Lepidoptera) in maize in Pudukkottai District, Tamil Nadu

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Abstract

Maize is the third largest cultivating crop next to rice and wheat globally. Maize is generally cultivated for human consumption as well as for preparation of cattle and poultry feed. There are 141 insect pests are known to infest maize from sowing to harvest of the crop and the new invasive pest American fall armyworm, *Spodoptera frugiperda,* causes considerable yield losses. Roving survey was conducted in major maize growing blocks of Pudukkottai district during 2020-21 and 2021-22. During survey, whorl damage and cob damage due to fall armyworm and presence of larvae were recorded in randomly selected 25 plants in three different places in the field and per cent infestation and number of larvae per plant were worked out. Based on the level of damage, TNAU FAW score was assigned from 1 to 5 and presence of natural enemies were also recorded in randomly selected 10 plants. The Geo-coordinate were recorded during the entire survey programme. The per cent infestation of fall armyworm was ranged between 3.33 and 26.67 in whorl 2.67 and 3.33 and 12.0 in the tassel stage in Pudukkottai district during 2020-21 and 2.67 and 16.00 in whorl during 2021-22. The average per cent infestation of fall armyworm was 8.25 and average TNAU FAW score was 1.81 during 2020-21 and 8.18 and 1.67 respectively during 2021-22. As far as natural enemies, coccinellids and spiders were dominant during both the years. The average natural enemies population per plants were coccinellids (0.51), hymenopterans (0.38), cricket (0.21) and spider (0.69) during 2020-21 and 2.83, 0.67, 0.80 and 1.37 respectively during 2021-22. The main objective of this study was to continuously monitor the infestation of fall armyworm in maize growing areas to assess the damage level and presence of natural enemies population for formulating successful management strategies against fall armyworm.

Keywords: Maize, fall armyworm, roving survey, coccinellids, spiders

Introduction

Maize is the third largest cultivating crop next to rice and wheat globally. Maize is generally cultivated for human consumption as well as for preparation of cattle and poultry feed. In India, the area under maize cultivation was 9.38 million hectares with a total production of 28.75 million tonnes and the productivity was 3065 kg ha^{-1} during 2017-18 (Agricultural Statistics at a Glance, 2019). In Tamil Nadu, maize was cultivated in an area of 4.02 lakh hectare with production of 25.65 lakh tonnes and the productivity was 6409 kg ha^{-1} during 2020-21.There are 141 insect pests are known to infest maize from sowing to harvest of the crop (Reddy and Trivedi, 2008). The American fall armyworm, *Spodoptera frugiperda,* an invasive pest is native to tropical and subtropical regions of the America and was first reported in Shivamogga district of Karnataka state on 18th May 2018 (Sharanabasappa *et al.,* 2018) and subsequently it was reported in other southern states of India (Padhee and Prasanna, 2019). It is a polyphagous pests reported to cause damage to 353 host plants from 76 families (Montezano *et al.,* 2018) surpassing 180 species reported earlier. It mainly feeds on maize, rice, sorghum, millet, sugarcane, cowpea cotton, potato, soybean, groundnut vegetable crops, cruciferous crops and cucurbits. As this is a new pest, farmers are applying inorganic insecticides without knowing the efficacy against this pest and the level of its infestation. Under these circumstances, continuous monitoring of fall armyworm in maize growing areas is of paramount importance to assess the damage level and presence of natural enemies population for formulating successful management strategies against fall armyworm.

Material and Methods

Roving survey was conducted in major maize growing blocks of Pudukkottai district *viz*., Thiruvarankulam Arimalam, Gandarvakottai, Pudukkottai and Karambakudi along with State Department of Agriculture officials during 2020-21 and 2021-22. During survey, whorl damage and cob damage due to fall armyworm and presence of larvae were recorded in randomly selected 25 plants in three different places in the field and per cent infestation and number of larvae per plant were worked out. Based on the level of damage, TNAU FAW score was assigned from 1 to 5 (1- Nil damage to pin hole damage; 2- Circular or elongated holes with less than 1 inch on whorl leaves; 3- Elongated holes with more than 1 inch size on whorl leaves; 4-Elongated holes with 1 to 2 inch size and mild shredding on whorl leaves and 5- Severe shredding and defoliation of whorl and furl leaves) and presence of natural enemies were also recorded in randomly selected 10 plants. The Geo-coordinates were recorded during the entire survey programme.

Results and Discussion

During this study, 15 to 70 days old maize crop was surveyed. The per cent infestation of fall armyworm ranged between 3.33 and 26.67 in whorl 2.67 and 3.33 & 12.0 in the tassel stage in Pudukkottai district during 2020-21 and 2.67 & 16.00 in whorl during 2021-22 (Table 1). The level of damage based on TNAU FAW score was ranged from 1.0 to 3.2 during 2020-21 and 0.26 to 2.67 during 2021-22. The damage percent was very minimum in all surveyed area except Suranviduthi of Thiruvankulam block where the infestation was high (26.67%). During the vegetative stage, minimum larval population of 0.12 per plant was observed in Dhathchinapuram of Thiruvankulam block followed by Kanniyankollai of Karambakudi block with 0.3 larva per plant during 2020-21 and 0.24 in Keelapanaiyur during 2021-22. The average per cent infestation of fall armyworm was 8.25 and average TNAU FAW score was 1.81 during 2020-21 and 8.18 and 1.67 respectively during 2021-22 (Table 1). As far as natural enemies, coccinellids and spiders were dominant during both the years. In Vettikadu of Arimalam block, the maximum of 1.00 coccinellids per plant was recorded during 2020-21 and 5.00 during 2021-22. With respect to spiders, Vettikadu of Arimalam block recorded the maximum of 1.4 spider per plant during 2020-21 and 2.67 in Sokkanathanpatti during 2021-22. The average natural enemies population per plant was coccinellids (0.51), hymenopterans (0.38), cricket (0.21) and spider (0.69) during 2020-21 and 2.83, 0.67, 0.80 and 1.37, respectively during 2021-22. Vijayaakshaya Kumar *et al*., (2020) also reported infestation of fall armyworm in maize in Perambalur district.

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Table 1. Roving survey on fall armyworm infestation and its natural enemies in Pudukkottai District

Sl. No.	Village	Block	Age of Crop	Damaged parts	FAW infestation			Natural enemies/ plant			
					% infestation	TNAU FAW score	Larvae/ plant	Coccinellid	Hymeno pterans	Cricket	Spiders
	2020-21										
1.	Kothakottai	Thiruvarankulam	35	Leaf	4.50	1.2	0.70				
2.	Dhathchinapuram	Thiruvarankulam	15	Leaf	3.33	1.0	0.12		0.20		
3.	Suranviduthi	Thiruvarankulam	35	Leaf	26.67	3.2	0.74				1.30
4.	Manganur	Gandarvakottai	30	Leaf	10.00	1.8	1.33				0.60
5.	Manganur	Gandarvakottai	40	Leaf	6.67	2.4	0.67	0.60	0.50		
6.	Vanakkankadu	Karambakudi	32	Leaf	12.00	2.3	1.30	0.80		0.20	
7.	Kanniyankollai	Karambakudi	28	Leaf	10.00	1.26	0.25				0.60
8.	Mullankuruchi	Karambakudi	24	Leaf	4.00	1.1	0.30	0.50	0.30		0.40
9.	Kottaikadu,	Karambakudi	22	Leaf	8.00	1.26	0.30	0.30		0.10	0.30
10.	Vettukaadu	Arimalam	65	Cob	4.60	2.6	0.82	1.00	0.60		1.40
11.	Keelapanaiyur	Arimalam	70	Cob	3.33	-	0.60	0.50	0.30		
12.	N.Pudupatti	Gandarvakottai	62	Cob	3.33	-	0				
13.	N.Pudupatti	Gandarvakottai	65	Cob	3.33	-	0			0.33	
14.	Vettaikadu	Karambakudi	60	Cob	12.00	-	0.12	0.20			
15.	Mullankuruchi	Karambakudi	65	Cob	12.00	-	0.12	0.20			0.20
				Average	**8.25**	**1.81**	**0.49**	**0.51**	**0.38**	**0.21**	**0.69**
	2021-22										
16.	Keezhapaniyur	Arimalam	40	Leaf	8.00	1.82	0.47	2.67			1.33
17.	Veeradipatti	Gandarvakottai	30	Leaf	5.33	1.25	0.56	3.67		0.33	1.33

18.	Kallur	Arimalam	36	Leaf	6.67	1.60	0.44	2.33	0.33		1.67
19.	N.Pudupatti	Gandharvakottai	18	Leaf	12.60	2.02	1.67	1.67			0.33
20.	Sokkanathanpatti	Gandharvakottai	24	Leaf	6.67	1.21	0.47	4.33			1.33
21.	Koththakottai,	Thiruvarankulam	18	Leaf	4.00	1.37	0.28	5.00			1.67
22.	N.Pudupatti	Gandharvakottai	20	Leaf	14.66	2.1	0.88	3.67			2.00
23.	Koththakottai,	Thiruvarankulam	24	Leaf	5.30	1.22	0.34	3.00		0.67	1.00
24.	Vannarapatti	Gandharvakottai	15	Leaf	10.67	1.88	0.71	2.33	0.33		1.67
25.	Sokkanathanpatti	Gandharvakottai	23	Leaf	8.60	1.76	0.45	2.33			2.67
26.	N.Pudupatti	Gandharvakottai	34	Leaf	12.67	2.31	1.66	1.67			1.67
27.	Valavampatti,	Pudukkottai	14	Leaf	9.33	1.97	0.68	2.67	0.67		1.33
28.	Kulathur,	Gandharvakottai	18	Leaf	16.00	2.46	2.67	2.33		1.0	1.00
29.	Kothakottai	Thiruvarankulam	20	Leaf	3.40	1.17	0.43	3.67			1.67
30.	Thatchinapuram	Thiruvarankulam	32	Leaf	5.33	1.35	0.31	3.00			2.00
31.	Vadakku	Thiruvarankulam	31	Leaf	2.67	1.02	0.26	3.67	0.67		1.67
32.	Maramadakki	Thiruvarankulam	35	Leaf	12.00	1.90	1.33	2.33		1.33	1.33
33.	Keelapanaiyur	Arimalam	40	Leaf	6.77	1.65	0.24	2.67			1.67
34.	K.Rayavaram	Arimalam	28	Leaf	5.33	1.60	0.31	2.33	1.33	0.67	0.33
35.	Vennavalkudi	Thiruvarankulam	32	Leaf	9.33	1.74	0.93	1.33			0.37
				Average	**8.18**	**1.67**	**0.55**	**2.83**	**0.67**	**0.80**	**1.37**

T3-09
Evaluation on millets based Integrated Pest Management Module for major insect pests of groundnut

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Abstract

Field trial was conducted during *Kharif* 2019 to evaluate the millets based IPM module against major insect pests of groundnut in comparison with farmer's practice and untreated control by adopting large field plot of 2000m^2 with the spacing of 30 x 30 cm. After the treatment, the mean population of different pests *viz., S. litura* (0.18 larva/plant), *H armigera* (0.25 larva/plant), groundnut leaf miner (3.50%/ plant), leafhopper (1.15 numbers/ leaflet), and thrips (1.75 numbers/ leaflet) was low in IPM module plot. Highest seed yield of 1620 kg/ha with favourable B:C ratio of 3.18 was recorded from IPM module plot, while lowest seed yield of 870 kg/ha with B:C ratio of 1.78 was recorded from untreated control plots.

Keywords: Groundnut, Millets, IPM module

Introduction

Groundnut is an important oil seed crop, which is grown mainly across the tropical and subtropical parts of the world. India is one of the major groundnut producing countries with annual production of (5.3 mt) from an area of (6.9 mha) with productivity of 1176 kg per ha (Anon, 2011). The crop is known to be attacked by several insect pests and among them, *Aproaerema modicella* Deventer, *Spodoptera litura* Fabricius and *Thrips palmi* Karny are considered as important destructive pests on this crop (Amin and Mohammad, 1980). Under these situations intercropping can play a significant role to enhance the productivity and profitability per unit area and time through more efficient use of land, water and solar energy, besides assuring insurance against crop failure. With this background, the present study was undertaken to know the impact of intercrops based IPM module on insect pest incidence on groundnut crop.

Materials and Methods

Field trial was conducted at farmers field at Ayyansalai village of Sathyamangalam, Erode district during *Kharif* 2019 - 20 in VRI 2 to evaluate the IPM module in groundnut by adopting large field plot of 2000m^2 with the spacing of 30 x 30 cm. In IPM module plot the treatments consists of application of neem cake @ 250kg/ha, installation of light trap @ 1/ha, trap crop (castor or cowpea), mass trapping with pheromone trap @ 12/ha, spraying of *Metarhizium rileyi* @ 4g/lit , spraying of *Beauveria bassiana* @ 4g/l, cumbu as intercrop (6:1) and cowpea as border crop, spraying of azadirachtin 1% @ 1.5 ml/l and need based application of novaluron 10EC @ 2ml/l. In farmers practice 4 sprays of acephate was given for pest management. In untreated control plots VRI 2 was planted under unprotected conditions. Observation were recorded on pest population *viz., Spodoptera litura*, leafminer, *Helicoverpa armigera*, leafhopper, thrips, and natural enemies in treatments imposed plots of IPM module plot, farmers practice and untreated control plots besides natural enemies count at 15 days interval on 10 plants each in 8 locations along with yield data at the time of harvest to work out the economics

Results and Discussion

In IPM module plot the *S. litura* population ranged from 0.19 to 0.25 larva/ plant, *H armigera* population ranged from 0.20 to 0.30 larva/ plant, groundnut leaf miner population ranged from 5.00 to 6.00 per cent/ plant, leafhopper population was 1.20 to 1.90 numbers/plant, thrips population was 1.90 to 2.50 thrips/ leaflets before adopting treatments. After the treatment, there was a reduction in the pest population *viz., S. litura* (0.18 larva/ plant), *H armigera* (0.25 larva/ plant), groundnut leaf miner (3.50 %/ plant), leafhopper (1.15 numbers/ leaflet) and thrips (1.75 numbers/ leaflet) in IPM module plot as compared to unprotected and farmers practice plots (0.68 and 0.63 *S. litura* larvae/ plant; 0.78 and 0.38 *H. armigera* larvae/ plant; 8.50 and 7.50 groundnut leaf miner infestation/ plant; 5.00 and 3.25 leafhopper numbers/ plant; 6.93 and 5.60 thrips/ leaflet in farmers practice plots and untreated control plots, respectively (Table 1).

Highest (0.65 cocoons/ plant) *Apanteles* parasitization was recorded in untreated control plots followed by IPM module plot (0.48 cocoons/plant) and farmers practice (0.10 cocoons/plant). Highest seed yield was recorded in IPM module plot over unprotected plot (Table 2). The data revealed that a higher seed yield of 1620 kg/ha with favourable B:C ratio of 3.18 was recorded from IPM module plot, while lowest seed yield of 870 kg/ha with B:C ratio of 1.78 was recorded from untreated control plots . The findings of the present study was in conformity with the findings of Girija *et al.,* (2015).

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Table 1. IPM module for the management of defoliators in groundnut (*Kharif*, 2019 - 20)

Module	*S litura (No. of larvae/plant)*						*H armigera (No. of larvae/plant)*					
	PTC	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**Pooled**	**PTC**	**15 DAG**	**30 DAG**	**45 DAG**	**60 DAG**	**Pooled**
IPM	0.25	0.20	0.10	0.30	0.10	**0.18**	0.30	0.10	0.20	0.10	0.60	**0.25**
Farmer's Practice	0.20	0.60	0.20	1.20	0.50	**0.63**	0.25	0.20	0.40	0.60	0.30	**0.38**
Untreated control	0.19	0.70	0.30	0.80	0.90	**0.68**	0.20	0.60	0.70	1.00	0.80	**0.78**
CD(0.05)	0.0029	0.0274	0.045	0.059	0.036		0.0050	0.024	0.023	0.042	0.024	
	Gnut leafminer (% infestation)						**Leafhopper (No. /leaflets)**					
IPM	5.00	5.00	2.00	4.00	3.00	**3.50**	1.20	0.40	1.90	1.60	0.70	**1.15**
Farmer's Practice	5.50	7.00	5.00	10.00	8.00	**7.50**	1.90	0.80	2.70	6.60	2.90	**3.25**
Untreated control	6.00	9.00	6.00	12.00	7.00	**8.50**	1.50	1.20	2.90	8.80	7.10	**5.00**
CD(0.05)	0.0319	0.116	0.158	0.237	0.423		0.049	0.038	0.050	0.349	0.307	
		Thrips (No. /leaflets)					***Aphanteles* (cocoon/plant)**					
IPM	2.00	0.90	2.10	1.80	2.20	**1.75**	0.20	0.10	0.30	0.40	0.30	**0.28**
Farmer's Practice	2.50	1.70	4.40	9.90	6.40	**5.60**	0.25	0.10	0.40	0.00	0.00	**0.13**
Untreated control	1.90	2.30	5.50	12.30	7.60	**6.93**	0.20	0.60	0.60	1.10	0.40	**0.68**
CD(0.05)	0.0160	0.097	0.1559	0.1284	0.0679		0.0160	0.0091	0.0239	0.0435	0.0340	
	Predators (No/plant)											
IPM	0.60	0.60	0.40	0.70	0.20	**0.48**						
Farmer's Practice	0.50	0.10	0.10	0.20	0.00	**0.10**						
Untreated control	0.50	0.70	0.60	0.80	0.50	**0.65**						
CD(0.05)	0.0055	0.0309	0.0241	0.0300	0.023							

Table 2. Yield and economics of IPM module for the management of defoliators in groundnut (*Kharif*, 2019 - 20)

	Seed yield (Kg/ha)	**Gross return (Rs/ha)**	**Cost of cultivation (Rs/ha)**	**Net return (Rs/ha)**	**CB ratio**
IPM	1620	97200	30500	66700	1: 3.18
Farmer's Practice	1120	67200	34150	33050	1 : 1.96
Untreated control	870	52200	29300	22900	1 : 1.78
CD (0.05)	36.1724				

T3-10
Study the efficacy of bioagents on root knot nematode in Maize

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Abstract

The root knot nematode *Meloidogyne incognita* is an emerging problem in Maize growing areas in Tamil Nadu. A pot culture experiment was conducted to evaluate the efficacy of different biocontrol agents *viz., Purpureocillium lilacinus* (10g/pot)*, Pochonia chlamydosporia* (10g/pot), AM fungi (10 g/pot) for the management of root knot nematode *Meloidogyne incognita* in maize along with untreated control. The experiment results were revealed that all the biological agents were found to inhibit the root knot nematode development and shows the potential to increase the plant growth significantly. The maximum plant growth was recorded in AM fungi treated plants (32%) followed by *P. lilacinus* (21%) and are significantly different from untreated control. The root knot nematode *M. incognita* alone treated plants recorded lowest vegetative growth. The population of root knot nematode *M. incognita* in soil and roots were significantly lower in all biological agents treated plants compared to untreated control. The lowest nematode population in soil and root was recorded in AM fungi (10 g/plant) compared to untreated control. The percent reduction in nematode population in soil, adult female nematode/g and egg mass/g was maximum in AM fungi treated plants with 44.55, 47.2 and 50 percent respectively over untreated control.

Keywords: Maize, root knot nematode, *Meloidogyne incognita,* AM fungi, *Purpureocillium lilacinus, Pochonia chlamydosporia*

Introduction

The root knot nematode *Meloidogyne incognita* is an emerging nematode problem in Maize in growing areas of Tamil Nadu. Damage symptoms of root knot nematode infested maize showing of yellowing, stunting, drying of leaf margin and plants.

Maize damaged by root-knot nematodes often is stunted and has the appearance of moisture and nutrient deficiencies. Severe infestations can result in the death of younger plants. Affected plants typically occur in patches in the field and symptoms typically are more common and most damaging to plants in light, sandy-textured soils. Belowground symptoms include roots that are galled, stunted and discolored. Sometimes the maize root system may appear healthy and galls may be small and difficult to notice even though root-knot nematode numbers may be very high. In field, root knot nematodes may also cause stubby root symptoms because they stop the growth of root tips. The soil and root samples of from stunted maize plants collected at Pudukkottai district on preliminary observations revealed that presence root-knot nematode, *Meloidogyne incognita* which was found to be responsible for growth decline. Even though chemical nematicides are having good for nematode management, it will not encouraged for field application due to residues problems, environmental pollution, and health hazards. To avoid these problems, biological control agents were used to manage root knot nematode. The present study was undertaken to evaluate the biocontrol potential of talk formulation on nematode under shade net house condition.

Materials and Methods

The experiment was conducted to evaluate the efficacy of different biocontrol agents *viz., Purpureocillium lilacinus* (10 g/pot), *Pochonia chlamydosporia* (10 g/pot), AM fungi (10 g/pot) under shadenet house condition on nematode management in maize along with carbofuran 3G chemical check and untreated control. Pot mixtures were prepared and filed in the pots (10 kg capacity), arranged in row and sowing the maize seeds at the rate of 5 seed per pot. After seedling emergence, all the above said bioagents were applied near the root zone of maize plants. The experiment was laid out in completely randomized block design with five treatments and four replications. The experiment was terminated 110 days after sowing. Observation such as plant height, nematode population, root gall index, number of adult female/g of root and number of egg masses/g of root were recorded at the time of termination of experiment.

Results and Discussion

The results revealed that in all the treatments were influenced significantly on plant growth and nematode population reduction compared to untreated control. The maximum plant growth was recorded in AM fungi treated plants (32 per cent) followed by *P. lilacinus* (10 g/plant) significantly different from untreated control. The root knot nematode *M. incognita* alone treated plants recorded lowest vegetative growth. The population of root knot nematode *M. incognita* in soil and roots were significantly lower in all biological agents treated plants compared to untreated control. The lowest nematode population in soil and root was recorded in AM fungi (10 g/plant) compared to untreated control. The percent reduction in nematode population in soil, adult female nematode/g and egg mass/g was maximum in AM fungi treated plants over untreated control. The present study was designed to determine the efficacy of biocontrol agents on nematode management in maize. In general, all the bio agents are capable of reducing the nematode population in soil. The AM fungi can protect their host plant by suppression of root knot nematode population (Nele Schouteden *et al.* 2012). Plant growth is higher in AM fungi treated plant compared to untreated control, since these fungi are known to increase the uptake of water and mineral nutrients for their host plant, such as phosphate and nitrogen (Baum *et al*. 2015); altered the root morphology, quantity and quality of root exudate (Sood, 2003). Hence it was concluded that the application of AM fungi may be a promising practice in management of root knot nematode in maize cultivation.

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Table 1. Effect of biocontrol agents on root knot nematode population in maize

Treatments	Plant height (cm)	Nematode population (250g soil)	No. of female /g of root	No. of egg mass/g of root	Gall Index
T1 - *Purpureocillium lilacinus* (10 g/pot)	121	155	13	7	1
T2 - *Pochonia chlamydosporia* (10 g/pot)	113	145	12	8	2
T3 - AM fungi (10 g/pot)	132	104	5	5	1
T4 – Carbofuran 3G 1 kg a.i./ha	118	128	12	9	1
T5 – Untreated control	110	393	17	16	5
CD (0.05)	10.34	11.05	1.07	1.15	

T3-11
Population distribution of plant parasitic nematodes associated with Millets in Pudukkottai district

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Abstract

A survey was conducted to explore the presence of plant parasitic nematodes associated with millet crops in Pudukkottai District. Nine genera of plant parasitic nematodes were recorded in this study. Soil samples were collected, processed and community analysis were done. The results revealed that the *Meloidogyne* sp. was the most frequently occurring nematode having an absolute frequency of 34.40% followed by *Hoplolaimus* sp. (23.50%), *Helicotylenchus* sp. (22.50%), *Pratylenchus* sp. (18.40%), *Tylenchorynchus* sp. (13.60%), *Heterodera* sp. (10.20%), *Criconemoides* sp. (7.50%), *Rotylenchulus* sp. (3.90%) and *Trichodorus* sp. (2.10%). The maximum absolute density was recorded for *Meloidogyne* sp. *Heterodera* sp. followed by *Helicotylenchus* sp. with 256, 178 and 137 nematodes per 200cc of soil respectively. The highest prominence value was recorded in *Meloidogyne* sp. (42.50) followed by *Hoplolaimus* sp. (31.2), *Helicotylenchus* sp. (26.50) and *Pratylenchus* sp. (21.75). The root-knot nematode *Meloidogyne* sp. is a major nematode presence in all the blocks followed by cyst nematode *Heterodera* sp.

Introduction

Indian millets are a group of nutritiously rich, drought tolerant and mostly grown in a variety of agro-ecological situations viz., plains, coast and hills as well as in diverse soils and varying rainfall. They constitute an important source of food and fodder and play a vital role in ecological and economic security of India. Indian Millets are nutritionally superior to wheat and rice as they are rich in protein, vitamins and minerals. Millet cultivation facing many biotic and abiotic stress and influence production. Among the biotic stress, plant parasitic nematodes are widely spread in millet growing areas of the world. The estimated annual yield loss based on the international survey of crop losses due to nematodes in millet was assessed as 11.8%. Incidence of the plant parasitic nematodes associated with millets was reported from different part of the world including southern part of India (Seshadri, 1970 and Bridge, 1978) by several workers. However, work on the community structure of the nematodes associated with millet crops of Tamil Nadu is inadequate. Hence, this present study was conducted for community structure of the plant parasitic nematodes associated with millet crops in Pudukkottai district.

Materials and Methods

A survey was conducted to study the occurrence of plant parasitic nematodes associated with millet crops viz., maize, sorghum, samai, varagu, thinai and ragi in Pudukkottai District. Soil samples (215) were collected from Pudukottai, Aranthangi, Annavasal, Viralimalai, Avudayarkovil, Gandarvakottai, Arimalam blocks of Pudukkottai District. Soil samples were collected from the rhizosphere of millet crops to a depth of 10-15 cm at the rate of 5 composite samples obtained from four corners and centre of the field per field. The soil samples were collected in polythene bags labelled properly and processed same day to avoid loss of nematodes. The nematodes present in the suspension were identified up to generic level and population data were recorded for community analysis. Community analysis were done following the methods of Norton (1978).

Results and Discussion

In maize, nine genera of plant parasitic nematodes were recorded in the rhizosphere of maize crop viz., *Meloidogyne, Heterodera, Helicotylenchus, Hoplolaimus, Criconemoides, Pratylenchus, Rotylenchulus, Tylenchorynchus, Trichodorus*. Among them, *Meloidogyne, Tylenchorynchus,* and *Heterodera,* was found more frequent and abundant. All other genera were neither frequent not abundant.

In sorghum, six genera of parasitic nematodes were recorded in the rhizosphere of sorghum. Among them, *Heterodera, Helicotylenchus* and *Meloidogyne* was found more frequent and abundant than *Criconemoides*.

Five genera of plant parasitic nematodes were encountered in the rhizosphere of samai crop viz., *Meloidogyne, Helicotylenchus, Hoplolaimus*, *Criconemoides* and *Trichodorus*. Among them, *Meloidogyne* and *Helicotylenchus* was more frequent and abundant. All other genera were neither frequent not abundant.

Similarly, five genera of plant parasitic nematodes were encountered in the rhizosphere of varagu crop viz., *Meloidogyne, Helicotylenchus, Hoplolaimus*, *Tylenchorynchus* and *Trichodorus*. Among them, *Meloidogyne* and was more frequent and abundant. All other genera were neither frequent not abundant.

Only four genera were encountered in thinai crop. Among them, *Hoplolaimus. Helicotylenchus* and *Trichodorus* were neither frequent nor abundant while, *Meloidogyne* was abundant but not frequent.

Six genera of plant parasitic nematodes, *Meloidogyne, Helicotylenchus, Hoplolaimus, Criconemoides, Trichodorus* and *Tylenchorynchus* were found in ragi crop. Only *Meloidogyne* and *Helicotylenchus* genera were both frequent and abundant. *Trichodorus* and *Tylenchorynchus* common but not abundant (Table 2).

Community analysis

The results of nematode community analysis (table2) revealed that the *Meloidogyne* sp. was the most frequently occurring nematode having an absolute frequency of 34.40% followed by *Hoplolaimus* sp. (23.50%), *Helicotylenchus* sp. (22.50%), *Pratylenchus* sp. (18.40%), *Tylenchorynchus* sp. (13.60%), *Heterodera* sp. (10.20%), *Criconemoides* sp. (7.50%), *Rotylenchulus* sp. (3.90%) and *Trichodorus* sp. (2.10%). The maximum absolute density was recorded for *Meloidogyne* sp. *Heterodera* sp. followed by *Helicotylenchus* sp. with 256, 178 and 137 nematodes per 200cc of soil respectively. The highest prominence value was recorded in *Meloidogyne* sp. (42.50) followed by *Hoplolaimus* sp. (31.2), *Helicotylenchus* sp. (26.50) and *Pratylenchus* sp. (21.75). per 200cc soil respectively.

Among the nine nematode genera associated with millets, the root knot nematode, *Meloidogyne* sp. registered the highest absolute, relative frequency and density was considered as predominant nematode of millets grown in seven blocks of Pudukkottai district. The cyst nematode *Heterodera* sp., spiral nematode *Helicotylenchus* sp., stunt nematode *Tylenchorynchus* sp. lance nematode *Hoplolaimus* sp. and lesion nematode *Pratylenchus* sp. were recorded followed by *Meloidogyne* sp. in all blocks Pudukkottai district.

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Table 1. Community analysis of plant parasitic nematodes associated with millets in Pudukkottai district

Nematode Genera	Average no. of nematodes/200cc soil	Absolute frequency	Relative frequency	Relative density	Absolute density	Prominence value
Meloidogyne	512	34.4	27.5	32	256	42.5
Heterodera	357	10.2	5.2	7.3	178	14.25
Helicotylenchus	275	22.5	11	17	137	26.5
Hoplolaimus	138	23.5	12.5	19	69	31.2
Criconemoides	86	7.5	3.75	3	43	11
Pratylenchus	129	18.4	8.4	10.5	64	21.75
Rotylenchulus	42	3.9	1.57	2	21	6.3
Tylenchorynchus	165	13.6	6.5	9.5	83	15.8
Trichodorus	53	2.1	1	3.8	26	4.25

T3-12
Impact of millets and other intercrops on the relative incidence of insect pests of castor

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Abstract

A field experiment was conducted at Tapioca and Castor Research Station, Tamil Nadu Agricultural University, Yethapur (Tamil Nadu) during *Kharif* 2018 to study the population dynamics of insect pests and natural enemies in different castor intercrops. Defoliator population was significantly lesser in castor + redgram + cumbu intercropped treatments than in the sole castor crop which was served as control. The cumulative mean number of sucking pest population was found to be lesser in (castor + red gram), followed by castor + redgram + cumbu intercrop system. Capsule borer percentage infestation was significantly lesser in castor + redgram + cumbu intercropped treatments with increased percentage parasitization by *Microplitis maculipennis* and *Apanteles angaleti .*

Keywords: Cumbu, Castor, Defoliators, Intercrop

Introduction

Castor (*Ricinus communis* L.) is an industrially important non-edible oilseed crop of the world. Among the biological constraints in castor production, insect pests dominate the scenario. The most important ones are the defoliators including semilooper (*Achaea janata*), tobacco caterpillar (*Spodoptera litura*), hairy caterpillars (*Euproctis* spp. and *Ergolis merione*) and castor shoot and capsule borer (*Conogethes punctiferalis*). Management of defoliators and capsule borer relies heavily on insecticides when other management strategies of pest control do not give satisfactory control under high pest infestation level. The average productivity is low (309 kg/ha) in Tamil Nadu and other states in Southern and Central India where the crop is cultivated mostly as rainfed with low input management. Adoption of intercropping methods offer an opportunity to protect the crops by natural pest management. There is also a strong need to develop pest management practices that are affordable for resource–poor farmers. With these considerations in view, the present study was aimed to examine how the incidence of insect pests differ in an intercropping system compared to a castor monocrop.

Materials and Methods

To evaluate the population dynamics of insect pests and natural enemies in different castor intercrops, field experiments was conducted at Tapioca and Castor Research Station, Yethapur (Tamil Nadu) during *Kharif* 2018. The castor hybrid DCH 519 was sown in plots of 5.4m x 6.0m with a spacing of 90 cm x 90 cm. The experiment was conducted in a randomized block design with eight treatments and replicated thrice with a large plot size of 500 m^2 per replicate. Intercrops were sown in between rows of castor in an additive manner to keep the population of castor plants constant across the eight cropping systems. All other intercrops were sown in two rows 30 cm apart from each other and 30 cm away from castor rows on either side. Routine agronomic practices such as application of recommended doses of fertilizers to castor, intercrops, and intercultural operations were taken up at appropriate growth stages of the crops. No pest control measures were undertaken during the entire crop growth period.

Statistical analysis

The data were analysed by OPSTAT (Sheoran *et al*., 1998). Population data were square root transformed and the percentage infestation data were arcsine transformed.

Results and Discussion

The results of the experiment carried out during *kharif* 2018 revealed that the combination of castor with intercrops exhibited significant differences with each other (Table 1). Defoliator population was significantly lesser in castor + redgram + cumbu intercropped treatments (T3) than in the sole castor crop which served as control (T8). The cumulative mean number of sucking pest population was found to be lesser in T1 (castor + red gram), followed by treatments T3 (castor + redgram + cumbu). Capsule borer infestation was significantly lesser in castor + redgram + cumbu intercropped treatments (T3). Thus, the sole crop T8 had the more defoliators, sucking pest population and capsule borer damage during *kharif* 2018. It has been shown that, castor main crop, when raised with green gram as intercrop significantly increased the percentage parasitization by *Microplitis maculipennis* and *Apanteles angaleti* by 53.0 and 21.0 per cent, respectively. Rao et al. (2012) reported that the intercropping systems *viz.,* castor + pigeon pea recorded significantly lower population levels of *A. janata* (0.89) *as compared to* higher level of *A. janata* population in castor monocrop (1.12 to 1.29 / plant) Results of the present study was also in concurrence with the report of Midega and Khan (2003). They reported that border crops increased the abundance of natural enemies like *Cheilomenes* sp., *Chrysoperla sp*, ants, ear wigs and spiders concurrently with reducing target insect pests in main crop. Similarly the sucking pest population during *Kharif* 2018 revealed lesser population in treatments T1, T2, T3 (redgram, cumbu) as against the highest population in sole castor crop T8. The treatment with tall crop as intercrops recorded lesser population of sucking pests than short crops in T4, T5, T6 (groundnut, greengram). Alegbejo and Uvah (1986) reported that high, tall, barrier crops may act as mechanical barriers that impede insect colonization on the protected crop. Diversity in the crop field may have a profound effect on colonization by insects, and has been well–documented in the case of intercropping (Risch *et al*., 1983). Baliddawa (1985) observed that up to 30 per cent of pest reduction in intercropping systems could be due to the “natural enemy effect”. From the above results, it is concluded that castor crop intercropped with taller, pollen yielding, fast growing cereals and pulse crops like cumbu and redgram reduce the pest population and increase the activity of natural enemies with increased yield in castor.

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Table 1. Population dynamics of insect pest and natural enemies of castor under different intercrops - *Kharif* 2018

Treatments	Defoliators (No. of larvae/plant) *			Sucking pest population*		Capsule borer * (% damage) #	Parasitoids *	
	Semilooper **	Tobacco caterpillar **	Hairy caterpillar **	Leafhopper (No./3 leaves/plant) **	Thrips (No./spike) **		*Microplitis maculipennis % parasitization #*	*Apanteles angaleti % parasitization #*
T1 Castor + Red gram	3.6(2.14)	4.6(2.36)	3.3(2.07)	8.6(3.09)	18.3(4.38)	5.3(2.50)	71(62.73)	25(4.34)
T2 Castor + Cumbu	4.3(2.29)	3.3(2.07)	2.6(1.89)	9.3(3.20)	17.6(4.30)	4.6(2.36)	56(46.13)	23(3.45)
T3 castor + Redgram + Cumbu	3.3(2.07)	2.3(1.81)	2.3(1.81)	10.3(3.35)	11.3(3.49)	3.3(2.07)	73(59.08)	30(4.11)
T4 Castor + Groundnut	6.3(2.69)	15.6(4.06)	4.6(2.36)	18.3(4.38)	20.3(4.60)	6.6(2.75)	60(44.39)	24(2.64)
T5 Castor + Greengram	4.3(2.29)	10.3(03.35	3.6(2.14)	19.6(4.52)	15.6(4.06)	5.6(2.56)	53(46.13)	21(3.86)
T6 castor + Gnut + Greengram	5.6(2.56)	12.6(3.67)	4.3(2.29)	22.3(4.81)	22.3(4.81)	6.3(2.69)	57(44.97)	29(4.23)
T7 Castor + Daincha	8.3(3.04)	8.3(3.04)	5.6(2.56)	18.6(4.41)	16.3(4.14)	7.3(2.87)	63(52.64)	31(4.57)
T8 Castor	10.3(3.35)	11.3(3.49)	6.6(2.75)	26.3(5.21)	29.3(5.49)	9.6(3.24)	60(48.46)	25(3.15)
CD	0.38	0.47	0.31	0.67	0.71	0.38	12.38	0.60
SEd	0.17	0.21	0.14	0.31	0.33	0.18	5.72	0.28
CV%	8.39	8.93	7.87	9.26	9.16	8.35	13.85	9.02

* Mean of three replication
** Figures in parentheses are square root transformed values
\# Figures in parentheses are ARC sine transformed values

T3-13

Impact of frontline demonstrations on IPM technology against fall armyworm and yield parameters in maize

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Abstract

The front line demonstrations on Integrated Pest Management of fall armyworm conducted at Salem district revealed that raising border crop like fodder sorghum , collection and destruction of egg masses , monitoring using pheromone trap installation, spraying neem based insecticides , *M. anisopliae* @ 2ml/lt and spraying of insecticides on different stages on need basis reduced the damage of fall armyworm, *S. frugiperda* by 83.50 per cent and recorded highest yield (79.60 q/ha) followed by farmer's practice (58.75 q/ha). The net return and benefit-cost ratio was also in new technology (Rs. 66900.00 /ha and 1:2.27) followed by farmer's practice (Rs. 23125.00 /ha and 1:1.36). The technology is cost effective and environmentally safe, since the number of sprayings was less and need based.

Key words: Maize, Fall armyworm, IPM, Demonstration

Introduction

Maize (*Zea mays* L) is one of the most versatile crop having wider adaptability under varied agro-climatic conditions. Globally, maize is known as queen of cereals because of its highest genetic yield potential among the cereals. In spite of this, climate change and global warming increase frequency of invasive pest attacks in maize crops. In this context, Fall armyworm, *Spodoptera frugiperda* (J E Smith), an economically important pest native to America has recently invaded India, causing substantial damage to maize and other crops. It was first reported in Karnataka on maize (Sharanabasappa *et al.,* 2019) which was later reported from Tamil Nadu, Andhra Pradesh, Telangana and West Bengal. Farmers' rely on spraying of various insecticides and applied them at frequent intervals. This leads to resistance, and pest resurgence of maize fall armyworm and hence productivity of maize was found to be very low per unit. So frontline demonstrations (FLDs) were carried out to create awareness among on the farmers on improved pest management management practices for fall armyworm for further adoption.

Materials and Methods

The Integrated Pest Management (IPM) package for management of fall armyworm in maize was demonstrated with the farmer participation during kharif 2021 through Krishi Vigyan Kendra, Sandhiyur, Salem under irrigated condition. Each demonstration was conducted along with a check plot (farmer's practice of application of insecticides only up to five rounds) of 0.4 ha for the comparison. The demonstrations were conducted in ten fields of Gengavalli block of Salem district. The selected farmers were trained on seed treatment, installation of traps and spraying of insecticides and were provided with all the essential inputs. Data on fall armyworm incidence and yield parameters were recorded from both the demonstrated and check plot for the comparison.

Technology Interventions

- Border crop with *para grass /* fodder sorghum / fodder maize in 2-4 rows all around the maize field
- Seed treatment with Cyantraniliprole +Thiamethoxam @ 4ml/kg of seed
- Setting up of *S. frugiperda* pheromone traps @ 10 per acre
- Prophylactic foliar spray of Neem oil (5 ml/l)
- Foliar insecticidal spray during 21-28 days using Emamectin Benzoate (0.4 g/l) and One spray with *Metarhizium anisopliae* @ 2ml/lt

Results and discussion

The demonstrations on Integrated Pest Management of fall armyworm which includes border crop like fodder sorghum , collection and destruction of egg masses , monitoring using pheromone trap installation, spraying neem based insecticides , *M. anisopliae* @ 2ml/lt and spraying of insecticides on different stages on need basis reduced the damage of fall armyworm, *S. frugiperda* by 83.50 per cent and recorded highest yield (79.60 q/ha) followed by farmer's practice (58.75 q/ha) (Table 1). The net return and benefit-cost ratio was also in new technology (Rs. 66900.00 /ha and 1:2.27) followed by farmer's practice (Rs. 23125.00 /ha and 1:1.36). The recorded yield and calculated benefit cost revealed that improved integrated pest management technologies of maize increases the yield compared to farmers practice (Ram *et al*., 2013).Thus new technology was found to be effective in reducing the incidence of fall armyworm. The technology is cost effective since the number of sprayings was less and need based. Due to the reduction in fall armyworm damage there was increases in the yield in maize.

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Table 1. Effect of IPM technology demonstration on incidence of fall armyworm and yield parameters in maize in Salem district

Farming situation	No. of Demo.	FAW incidence (%)		% reduction	Yield (q/ha)		% Increase	Economics of demonstration (Rs./ha)			Economics of check (Rs./ha)		
		Demo	Check		Demo	Check		Gross Cost	Net Return	BCR	Gross Cost	Net Return	BCR
Irrigated	10	10.65	64.50	83.50	79.60	58.75	35.50	119400	9400	2.27	88125	23125	1.36

T3-14
Occupational exposure of emamectin benzoate 5 SG sprayed in maize ecosystem

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Abstract

Field trials were conducted to assess the occupational exposure and dislodgeable foliar residues of emamectin benzoate 5 SG from maize agro ecosystem under high volume (HV), low volume (LV) and ultra-low volume (ULV) spraying system. Method validation was done in UHPLC with PDA Detector. LOD and LOQ for emamectin benzoate in UHPLC with PDA is 0.015 and 0.05 ppm respectively. Total hourly dermal exposure (HDE) to spray man, helper and bystander involved in spraying of emamectin benzoate were 1160.29, 818.29 and 13.69 µg/h, respectively for HV, 2004.06, 1018.62 and 23.93 µg/h, respectively for LV and 1740.77, 406.00 and 27.78 µg/h, respectively for ULV. Fore arms, thighs and ankle of spray man involved in HV, LV and ULV spraying were highly exposed to emamectin benzoate with an average of 11.40, 42.50 and 22.90 per cent, when applied to the maize crop. For helper, the most contaminated part was hand with an average of 86.50 per cent and least exposed parts were head and neck. For bystander, arms, chest, thigh and calves were exposed more to insecticides. Spray man had more amount of exposure when compared to helper and bystander. The exposure was more in LV spraying when compared to other spraying systems. Dislodgeable foliar residues of emamectin benzoate were 4.50, 5.16 and 4.73 ng/cm^2 from HV, LV and ULV sprays, respectively on the day of application and the half-life of 0.64 days. The higher initial deposit and longer persistence of dislodgeable residues were noticed in LV spray, when compared to HV and ULV spray.

Keywords: Pesticide, Exposure, Assessment, Residues, Validation

Introduction

Maize (*Zea mays*), known as queen of cereals is the third most important cereal in India next to rice and wheat in terms of both area and production. The major pests of maize include shoot fly, stemborer, pink stemborer, earworm, aphid and shoot bug. The recent invasion of fall armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) drastically increased the pesticide usage in maize agro ecosystem. Assessment of occupational exposure of insecticide to maize farm workers in developing countries is of special interest for the estimation of potential health risks, specifically when there is a lack of occupational hygiene regulations. The term occupational exposure refers to a potentially harmful exposure to hazards chemicals in the workplace. Exposure to pesticides results in acute and chronic health problems. The evaluation of the occupational exposure of farm workers to pesticides is an essential part of the risk assessment.

Materials and Methods

Field trial was conducted at Periyanaickenpalayam and Thondamuthur block, Coimbatore during 2021 to determine potential dermal and inhalation exposure to the working population (spray man, helper and bystander) and dislodgeable foliar residue of emamectin benzoate 5 SG @ 12.5 g ai/ha from maize agro ecosystem under high volume (HV), low volume (LV) and ultra-low volume (ULV) spraying system. Method validation for emamectin benzoate in absorption pads and maize leafs were done in UHPLC. Sampling for occupational exposure were collected from absorption pads tied in the body region *viz.,* head, neck, chest, back, upper arm, fore arm, thigh and calf of sprayman, helper and bystander. Sampling for inhalation exposure were collected using portable battery powered modified impinger / air sampler carried by drone operator, helper and bystander. Samples were collected on 0 (1 hr after spray), 1, 3, 5, 7 and 10 days after spray for dislodgeable residues. Samples were processed, residues extracted and detected in UHPLC with PDA Detector.

Results and Discussion

Good linearity for the different concentration *viz*., 0.05, 0.1, 0.2, 0.4, 0.8, 1.6 and 3.2 ppm of were obtained for emamectin benzoate by recording R^2 value 0.999. Instrument was very specific to the target analytes (RSD for area is < 5; RT is < 2). Recovery of emamectin benzoate from absorption pads and maize leaf discs ranged from 80 to 100 percent. LOD and LOQ for emamectin benzoate in UHPLC with PDA is 0.015 and 0.05 ppm respectively. Total hourly dermal exposure (HDE) to spray man, helper and bystander involved in spraying of emamectin benzoate were 1160.29,818.29 and 13.69 µg/h, respectively for HV, 2004.06, 1018.62 and 23.93 µg/h, respectively for LV and 1740.77, 406.00 and 27.78 µg/h, respectively for ULV. Fore arms, thighs and ankle of spray man involved in HV, LV and ULV spraying were highly exposed to emamectin benzoate with an average of 11.40, 42.50 and 22.90 per cent, when applied to the maize crop. For helper, the most contaminated part was hand with an average of 86.50 per cent and least exposed parts were head and neck. For bystander, arms, chest, thigh and calves were exposed more to insecticides. The hourly respiratory exposure (HRE) of spray man, helper and bystander for emamectin benzoate in HV spray was 0.122, 0.049, and 0.028 µg/h, respectively, while in LV spray it was 0.137, 0.064 and 0.038 µg/h, respectively and in ULV spray it was 0.089, 0.035 and 0.034 µg/h, respectively. Dislodgeable foliar residues of emamectin benzoate were 4.50, 5.16 and 4.73 ng/cm^2 from HV, LV and ULV sprays, respectively on the day of application and disappeared by 5th day with half-life of 0.64 days, respectively. The above results are in agreement with the findings of An *et al.* (2014) in maize, who reported that, the crop height of 61.8 cm led to leg and feet exposure of 85.6 per cent of the total exposure of chlorpyrifos. The sprayman's arms and hands highly exposed to the spray cloud. Ganesan (2004) observed that helper hands received more deposit than applicators. According to Gao *et al.* (2014) chlorpyrifos exposure was more were to forearms and thighs when applied to maize crop of more than 80 cm height. To conclude, spray man had more amount of dermal exposure when compared to helper and bystander. The dermal exposure was more in LV spraying when compared to other spraying systems. The power sprayer resulted in higher respiratory exposure to farm workers compared to HV and ULV spray. The higher initial deposit and longer persistence of dislodgeable residues were noticed in LV spray, when compared to HV and ULV spray.

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Table 1. Total hourly dermal and respiratory exposure of emamectin benzoate to field workers by different spraying system

Spraying system	Workers	Exposure	
		HDE (µg/h)	HRE (µg/h)
High volume spray	Sprayman	1160.29	0.122
	Helper	818.29	0.137
	Bystander	13.69	0.089
Low volume spray	Sprayman	2004.06	0.049
	Helper	1018.62	0.064
	Bystander	23.93	0.035
Ultra low volume spray	Sprayman	1740.77	0.028
	Helper	406.00	0.038
	Bystander	27.78	0.034

T3-15
Demonstration of TNAU Fall Armyworm Capsule on Maize in Vellore District of Tamil Nadu

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Abstract
The frontline demonstrations (FLDs) on Maize were conducted by Krishi Vigyan Kendra, Virinjipuram, Vellore District of Tamil Nadu during *Kharif* and *Rabi* 2021-2022 on 10 farmer's fields of different villages of Vellore district of Tamil Nadu. The results revealed that during *Kharif* 2021, the incidence of Fall Armyworm (FAW) was low in demonstration plot at 15 – 25 DAE (14.82%) and 30 - 40 DAE (11.11 %) compared to farmer practice (26.56 % and 23.65 %). During *Rabi*, 2022 also, minimum incidence of FAW was recorded at 15- 25 DAE (23.75%) and 30-40 DAE (13.69%) when compared to farmer practice. The highest yield (5520 kg /ha and 5630 kg/ha) was recorded during *Kharif* and *Rabi* seasons, when compared to farmer practice (4120 kg/ha and 4125 kg/ha). The BCR was also higher in FLD plots (2.24 and 2.25 during *Kharif* and *Rabi* seasons, respectively) when compared to farmers practice (1.72 and 1.79). The frontline demonstrations of TNAU FAW proven IPM module in farmer's field revealed an increase in the income level of farmers and improved the livelihood of farming community.

Introduction
The fall armyworm (FAW) (*Spodoptera frugiperda*) is one of the devastating insect pest belonging to the family Noctuidae and falls in the Lepidoptera order. It is a polyphagous pest (Baudron *et al.*, 2019) causing damage to economically important cultivated cereal crops such as maize, rice, sorghum, cotton and various vegetable crops and eventually impacts on food security (FAO, 2019). This pest is native to the Americas and invaded into Asia during May 2018 and it was first reported on maize in Karnataka, India. Since then, it has spread to other states viz., Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra and Odisha. Considering the economic loss caused by FAW and its widespread damage across the countries, Food and Agriculture Organization (FAO) has declared FAW as food security threat and focussing to find out effective solutions for the management of FAW. With this background, demonstration of TNAU Capsule was conducted in Vellore district of Tamil Nadu for maize growing farmers.

Materials and Methods
The frontline demonstrations (FLDs) on Maize were conducted by Krishi Vigyan Kendra, Virinjipuram, Vellore District (Tamil Nadu) during *Kharif* and *Rabi* during 2021-2022 on 10 farmer's fields of different blocks of Kaniyambadi, Anaicut, Gudiyatham in Vellore district of Tamil Nadu. Observation of Fall armyworm infestation and economics of IPM module was also recorded.

Results and Discussion

During *Kharif* 2021, the incidence of fall armyworm (FAW) was low in demonstration plot at 15 – 25 DAE (14.82 %) and 30 - 40 DAE (11.11 %) compared to farmer practice (26.56 % and 23.65 %). During *Rabi* 2022 also, minimum incidence of FAW was recorded on 15- 25 DAE (23.75%) and 30-40 DAE (13.69%) when compared to farmer practice (Table 1). Higher yield (5520 kg /ha and 5630 kg/ha) was obtained during *Kharif* and *Rabi* seasons when compared to farmer practice (4120 kg/ha and 4125 kg/ha) with comparatively higher BCR (2.24 and 2.25) compared to farmer practice (1.72 and 1.79) (Table1). Similar findings have been reported by Ganiger *et al.,* (2018) in Bangalore Rural and Chikkaballapur district where FAW damage was devastating during *kharif* and *Rabi* season 2018.

The incidence of fall armyworm (FAW) was low in demonstration plots when compared to farmer practice during *Kharif* and *Rabi* season 2021-2022 with higher yield and higher BCR.

The Director (CPPS), TNAU, Coimbatore, is gratefully acknowledged for facilitating the conduct of demonstration through Government of Tamil Nadu sponsored project GoTN F 36OT.

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T3-16
Survey and Surveillance of major insect pests of Barnyard Millet in Madurai District

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Abstract

The present investigation was carried out at Agricultural College and Research Institute, Madurai during two consecutive seasons of Rabi, 2021 and 2022. In addition, roving survey was conducted at various millet growing blocks namely Kallikudi, Kallupatti and Sedapatti. The roving survey results revealed that pink stem borer was the major pest observed in various locations and the damage was less than 5.0 per cent. Fall army worm damage was also observed in minimum proportions. Fixed plot survey results revealed that, dead heart and white ear due to pink stemborer was maximum to the tune of 12 and 20 per cent, respectively. Fall army worm damage was also noticed to the extent of 8.0 percent in fixed plot surveys.

Introduction

Barnyard Millet (*Echinochloa crusgalli, E. colona*) is a short duration crop that can grow in adverse environmental conditions with almost no input and can withstand various biotic and abiotic stresses. In addition to these agronomic advantages, the grains are valued for their high nutritional value and lower expense as compared to major cereals like rice, wheat, and maize. It contains a rich source of protein, carbohydrates, fiber, and, most notably, micronutrients like iron (Fe) and zine (Zn) that are related to numerous health benefits. These features make barnyard millet an ideal supplementary crop for subsistence farmers and also as an alternate crop during the failure of monsoons in rice/major crop cultivating areas. Barnyard millet is ravaged by several insect pests like defoliators, stem borers and sap feeders. Among these, the pink stem borer *Sesamia inferens* Walker (Noctuidae: Lepidoptera) is a serious pest in barnyard millet (Gahukar and Reddy, 2019). In peninsular India, pink stem borer causes more damage throughout the year (Santhosh *et al.,* 2008). Limited works are available for the diversity of insect pests in barnyard millet and its influence on weather parameters, hence this experiment was conducted

Materials and Methods

During the cropping season of 2020-2021 and 2021-2022, roving surveys were performed at major millet growing blocks of Madurai District namely Kallikudi, Kallupatti and Sedapatti. Fixed plot survey was also conducted during Rabi season at AC&RI, Madurai. During the surveillance programme the pest population and its extent of damage was assessed at fortnightly intervals and expressed with respect to standard weeks.

Results and Discussion

The survey results revealed that the major insect pest observed in barnyard millet was pink stemborer, fall army worm and aphids. The damage was less than 5 per cent in the roving survey, while in fixed plot survey conducted during 2020-22, the results revealed that the dead heart and white ear due to pink stemborer was maximum to the tune of 12.0

and 20.0 per cent respectively. Fall army worm damage was also noticed to the extent of 8.0 percent in fixed plot. The results of the influence of weather parameters on the major insect pests in barnyard millet showed that the population of aphids was negatively correlated with minimum temperature and rainfall. Dead heart due to pink stemborer was negatively correlated with minimum temperature (r= -0.90) and rain fall (r = - 0.678). The per cent white ear was negatively correlated with evening RH and positively correlated with maximum temperature and minimum temperature. Fall armyworm damage was positively correlated with maximum temperature and negatively correlated with evening RH (Table 1 and 2).

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Table 1. Influence of weather parameters on the population of major insect pests in Barnyard millet (2020-21)

Parameters	Correlation (r =value)				
	Thrips	Aphids	Dead heart	white ear	FAW
Max. temp	0.364 NS	-0.040 NS	-0.368 NS	0.637 **	0.535 *
Min. temp	0.024 NS	-0.569 *	-0.900 **	0.560 *	0.242 NS
Morning RH	-0.493 *	-0.288 NS	-0.159 NS	0.175 NS	0.296 NS
Evening RH	-0.152 NS	0.136 NS	-0.027 NS	-0.746 **	-0.578 *
Rainfall	0.774 **	-0.618 **	-0.678 **	-0.265 NS	0.118 NS

* significance at 5 % level ; ** significance at 1 % level

Table 2. Influence of weather parameters on the population of major insect pests in Barnyard millet (2021-22)

Parameters	Correlation (r =value)				
	Thrips	Aphids	Dead heart	white ear	FAW
Max. temp	-0.144 NS	0.704 **	0.356 NS	0.449NS	-0.119 NS
Min. temp	-0.35 NS	0.423 NS	0.369 NS	0.574 *	-0.341NS
Morning RH	0.662 **	-0.241 NS	-0512NS	-0.573*	0.134 NS
Evening RH	0.106NS	-0.694**	-0.613*	-0.598 *	-0.29 NS
Rainfall	0.031NS	-0.578*	-0.451 NS	-0.347 NS	-0.26 NS

* significance at 5 % level ; ** significance at 1 % level

T3-17
Impact of management module for fall army worm in Maize through frontline demonstrationi in Tiruvallur

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Abstract

Fall armyworm, *Spodoptera frugiperda* is found to be an important invasive pest of maize. This study was conducted to evaluate the performance of TNAU refined integrated pest management capsule for the management of fall armyworm in Tiruvallur district. Farmers who grow maize were selected randomly and demonstration was conducted in 10 locations. The results revealed that leaf and whorl damage due to FAW was 11.40 per cent and 12.62 per cent in demonstration plots as against 24.58 per cent and 23.40 per cent in farmers' practice. With reference to cob damage, minimum level of incidence (12.62%) was observed in demonstration plots as against 37.60 per cent in farmers' plots. Yield increase of 45.90 per cent was noticed in demo plots compared to farmers' practice. Hence, refined IPM capsule was well accepted by the farmers and performed well at Tiruvallur district against fall armyworm incidence in Maize.

Keywords: IPM capsule, fall armyworm in maize, Tiruvallur

Introduction

In India, the incidence of fall armyworm, *Spodoptera frugiperda* was detected during 2018 in maize fields at Shivamogga (Deole, 2018). Thereafter it made its appearance in six other states of the country, including Tamil Nadu, Andhra Pradesh, Odisha, Chhattisgarh and Gujarat. Their spread was alarming and has raised a national concern all over. Fall armyworm is polyphagous in nature with more than 85 host species. They are responsible for leaf damage (Bessin, 2019) and major damage is done by younger larvae. Mainly young larvae feed on the leaf tissue making holes on them which (Sesay *et al*., 2019). Generally feeding on the young plant by fall armyworm through whorl may lead to dead heart. Older larvae can cause greater damage and defoliation leaving only ribs and stalk of corn plant giving torn or ragged appearance (Capinera, 2017). In Tiruvallur district, maize is being cultivated in 20 to 25 hectares of area during *Kharif* and *Rabi* season. Integrated pest management (IPM) is the one of most preferred and effective management for fall armyworm (Day *et al*., 2017). Hence it was proposed to conduct frontline demonstration on TNAU refined IPM capsule for fall armyworm management in maize during 2020-21.

Materials and Methods

The main objective of the study is to demonstrate recently standardised crop protection technology, as well as their management practices, in a farmer's field. In Tiruvallur district, demonstration on TNAU refined IPM capsule for FAW management in maize was conducted in ten locations of farmers' field at Avichery and Thirukananjeri villages during 2020 - 2021. Farmers were provided with major critical inputs and trainings were conducted to familiarize and popularize the technology among the farmers. The TNAU refined IPM capsule includes the application of neem cake @ 250 kg/ha at the time of last ploughing; seed treatment with cyantraniliprole 19.8% + thiamethoxam 19.8%FS @ 4 ml/kg seed; border cropping with cowpea, gingelly/ redgram or sunflower; pheromone traps @ 12/ha; window based application of insecticides during early whorl stage (15 – 20 DAE) *viz*., application of chlorantraniliprole 18.5 SC @ 0.4 ml/ lit (or) flubendiamide 480 SC @ 0.5 ml/lit followed by azadirachtin 1500 ppm @ 5 ml/lit on need basis and during late whorl stages (35-40 DAE): application of emamectin benzoate 5 SG @ 0.4 g/lit (or) novaluron 10 EC @ 1.5 ml/lit or spinetoram 11.70 SC @ 0.5 ml/lit and during tasseling and cob formation stage (only if required) spraying of spinetoram 11.70 SC @ 0.5 ml/lit (or) emamectin benzoate 5 SG @ 0.4 g/lit (which was not sprayed at late whorl stage). Fortnightly observations were made on leaf damage, whorl damage, tassel damage, cob damage and also natural enemy complex *viz.*, spiders, and coccinellids in the demo trials, farmers' practice plots and untreated check plots and the mean damage infestation was arrived and analysed with one way ANOVA.

Results and Discussion

Front line demonstration on refined IPM capsule for fall armyworm (*Spodoptera frugiperda*) management in maize was conducted in ten locations at Avichery and Thirukananjeri villages of Tiruvallur district. The farmers were facilitated with critical inputs and fortnightly observation on leaf damage, whorl damage, tassel damage, cob damage and also natural enemy complex *viz*., spiders, and coccinellids were recorded in the trials, farmers' practice fields and untreated check plots from July to December and mean damage was arrived and analysed.

In IPM plots, leaf and whorl damage due to *S. frugiperda* was 11.40 per cent and 12.62 per cent as against 24.58 per cent and 23.40 per cent in farmers' practice. With reference to cob damage, minimum level of incidence (12.62%) was observed in refined IPM plots against 37.60 per cent in farmers' practice plots. Occurrence of natural enemies in IPM plot was 0.75 numbers plant as against 0.45 numbers per plant. Maximum yield was recorded in refined IPM plots (4.45 t/ha) as against farmers practice (3.05 t/ha). Net income of Rs. 43,730 and BCR of 2.9 was realised in refined IPM capsule plots as against a net income of Rs. 20,700 and BCR of 1.8 in farmers' practice plot (Table 1.). An yield increase of 45.90 per cent over farmers' practice was observed due to reduction in pest incidence. Refined IPM capsule was well accepted by the farmers and performed well at Tiruvallur district against fall armyworm incidence in maize. The Front line demonstration intervention is highly effective among maize farmers with increased net returns due to reduced FAW incidence.

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Table 1. Performance of refined IPM capsule for Fall Army Worm in Maize

Treatments	Yield t/ha	Net Income (Rs./ha)	Leaf damage %	Whorl damage%	Cob damage%	BCR
FAW -Refined IPM capsule	4.45	43730	11.40 (19.54)	12.62 (20.67)	8.61 (16.78)	2.90
Farmers' Practice	3.05	20700	24.58 (29.63)	23.39 (28.81)	37.6 (37.71)	1.80
Untreated Check	1.82	17900	42.50 (40.67)	37.50 (37.66)	52.4(46.41)	1.10
SED	0.186	1187.69	1.308	0.935	1.838	-
CD (0.01)	0.391	2495.5	2.748	2.777	3.861	-

Values in parantheses are arcsine transformed values

T3-18

Efficacy of newer molecules of fungicides on management of *turcicum* leaf blight incited by *Helminthosporium turcicum* (Pass.) in Maize

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Abstract

Maize is one of the important cereal crops in India. It is affected by various biotic factors. Among these, *Turcicum* leaf blight is major threat in maize cultivation and caused severe yield loss. Hence, the present study are undertaken to test the efficacy of newer fungicide molecules against *Turcicum* leaf blight. Field trials were conducted to test the effectiveness of various newer molecules of fungicides for the management of *Turcicum* leaf blight in different seasons during 2015-16 in a randomized block design. The treatments comprised of eight new molecules of fungicides along with a control and replicated thrice. Observations on disease incidence and yield were recorded. The results revealed that derosol (0.1%) and folicure (0.05%) recorded the lowest percent disease incidence of *turcicum* leaf blight 13.29 % and 16.71%, respectively, followed by mancozeb M 45 (0.2%) (20.63%) and mancozeb Z 78 (0.2%) (20.82%) against control which recorded 46.90%. Derosol (0.1%) recorded the least lesion length of 1.79 cm followed by folicure (0.05%) (2.08cm), mancozeb M 45 (0.2%) (0.2%) (2.61) and mancozeb Z 78 (0.2%) (2.69) compared to control which recorded 15.16 cm of lesion lentht. The lesion width was also very much reduced by all the treatments when compared to control. Derosol (0.1%) recorded the highest yield of 6760 kg/ha followed by folicure (0.05%) (6683 kg/ha).

Keywords: *Turcicum* leaf blight, Newer molecules, Fungicides, Maize, Yield.

Introduction

Maize (*Zea mays* L.) is the third most important cereals next to rice and wheat, in the world as well as in India. It is a versatile crop and can be grown in diverse environmental conditions and has multiple uses. It has got immense potential and is therefore called as “**miracle crop**” and also “**queen of cereals”**. Maize, being a C_4 plant is an efficient converter of carbon and absorbed nutrients into food. In India area and productivity of maize were 9.9 million hectares and 30 million tonnes respectively in 2020-21 (agricoop.nic.in).

The demand for maize is increasing day by day in India with the increase in demand for poultry and cattle feed. With the introduction of high yielding indigenous and exotic hybrids and use of fertilizers, there has been a phenomenal increase in area and production. However, at the same time the crop is prone to several foliar diseases. Among the foliar diseases affecting maize, the *turcicum* leaf blight also called as northern leaf blight caused by *Exserohilum turcicum* (Pass.) leonard and suggs. (Syn. *Helmithosporium turcicum* Pass.) is of worldwide importance (Carlos 1997). *Turcicum* leaf blight of maize is considered to be one of the most devastating diseases as its occurrence and incidence assumes greater significance resulting in reduction of grain yield by 28 to 91 percent (Harlapur *et al*., 2007). There are limited reports on breeding approaches for disease resistance to this disease in maize production systems. Due to non-availability of stable sources of resistance to the diseases, control by chemical means is important to avoid crop losses. With these ideas in view, attempts were made in the present study to find out the suitable chemical control measures for effective management of *turcicum* leaf blight in maize

Materials and Methods

Field trials were laid out during *Kharif* 2015, *Rabi* 2015, *Kharif* 2016 and *Rabi* 2016 with recommended general package of practices. The experiments were laid out in a randomized block design with three replications. The treatments comprised of eight new molecules of fungicides along with a control. The hybrid CoHM 6 was used as the test hybrid. *Helminthosporium turcicum* culture was artificially inoculated into the plants in the testing fields. Newer molecules of fungicides were applied 10 days after artificial inoculation of pathogen and also repeated once after 20 days. The observations *viz.,* plant height, cob height, lesion length and lesion width and per cent disease incidence and grain yield were recorded. The leaf blight severity was recorded at silk drying stage following 1-5 rating scale. Pooled analysis was done with all the three season data.

Results and Discussion

The pooled mean data revealed that, derosol (0.1%) and folicure (0.05%) recorded the lowest percent disease incidence of *turcicum* leaf blight (13.29 % and 16.71%, respectively), followed by mancozeb M 45 (0.2%) (20.63%) and mancozeb Z 78 (0.2%) (20.82%) compared to control which recorded 46.90%. Derosol (0.1%) recorded reduced lesion length of 1.79 cm followed by folicure (0.05%) (2.08 cm), mancozeb M 45 (0.2%) (0.2%) (2.61 cm) and mancozeb Z 78 (0.2%) (2.69 cm) against control which recorded 15.16 cm. The lesion width was also very much reduced by the above treatments when compared to control. Derosol (0.1%) recorded the highest grain yield of 6760 kg/ha followed by folicure (0.05%) (6683kg/ha), mancozeb Z 78 (0.2%) (6381 kg/ha) and mancozeb M 45 (0.2%) (6328 kg/ha) (Table 1). The least yield of 4983 kg/ha was recorded under control.

The results of the experiments revealed that derosol (0.1%) recorded the least disease incidence and the highest yield followed by folicure.

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Table 1. Efficacy of newer molecules of fungicides on *turciucm* leaf blight and yield of maize (Pooled mean)

Treatments	Disease incidence %	Lesion length (cm)	Lesion width (cm)	Yield (kg/ha)
T1- Folicure 25 EC(0.05%)	16.71	2.08	1.11	6683
T2- Derosol 50 WP (0.1%)	13.29	1.79	0.99	6760
T3- Mancozeb M 45 (0.2%)	20.63	2.61	1.52	6328

T4- Mancozeb Z 78 (0.2%)	20.82	2.69	1.71	6381
T5- Cholorothalanil 75 WP (0.1%)	24.18	3.09	1.28	5822
T6- Copper hydroxcide 77 WP (0.05%)	24.73	3.10	1.29	6082
T7- Penconozole 10 EC(0.05%)	24.19	3.26	1.39	5918
T8- Propiconozole 25 EC(0.05%)	25.58	3.79	2.08	5836
T9- Control	46.90	15.16	4.45	4983
CD (P=0.05%)	**1.83**	**0.75**	**0.19**	**313**

T3-19

Influence of essential oils and neem products on management of *turcicum* leaf blight caused by *Helminthosporium turcicum* (Pass.) in Maize

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Abstract

Field trials were conducted to test verify the effectiveness of various essential oils and neem products for the management of *Turcicum* leaf blight (TLB) in different seasons during 2015-16. The experiments were laid out in a randomized block design replicated thrice. The treatments comprised of six essential oils, three neem products along with a control. The *turcicum* pathogen multiplied in the laboratory conditions were inoculated in the fields. Observations on disease incidence and grain yield were recorded. The results revealed that palamrosa oil (0.05%) recorded the lowest TLB incidence of 18.94% followed by eucalyptus oil (0.1%) (21.05%), lemon grass oil (0.05%) (22.09%) and geranium oil (0.05%). The lesion length and width was also reduced by the above oils when compared to control. With regard to grain yield, palmarosa oil (0.05%) recorded the highest yield of 6466 kg/ha followed by eucalyptus oil (0.1%) (6356 kg/ha), lemongrass oil (0.05%) (6285 kg/ha) and geranium oil (0.05%) (6098 kg/ha).

Introduction

Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat. It is grown in diverse environmental conditions and has multiple uses. The demand for maize is increasing day by day in India with the increase in demand for poultry and cattle feed. But, biotic and abiotic factors are major limiting factor in maize production. Among the biotic factors infecting maize, the *turcicum* leaf blight caused by *Exserohilum turcicum* (Pass.) leonard and suggs. (Syn. *Helmithosporium turcicum* Pass.) is a major threat in maize cultivation (Carlos 1997). Yield losses caused the turcicum leaf blight ranged from 28 to 91 per cent (Harlapur *et al*., 2007). Most of the commercial varieties and other breeders' materials are vulnerable and susceptible to the northern leaf blight (Muriithi, 1992).

Even though various plant protection measures are available, about one third of the crops produced are destroyed by pests and diseases. The discovery of synthetic chemicals has contributed, greatly to the increase in food production by controlling pests and diseases. But, the use of pesticides and fungicides has been causing serious environmental problems and human health problems, thus encouraging the search for alternative products that could substitute these chemical components (Sarmento Brum *et al*., 2014).

Use of plant products in disease management is a contemporary eco-friendly approach and gaining popularity considering that of its benefits over chemical compounds. These plant extracts are easily biodegradable, without any residue, non-phytotoxic and are easily absorbed by the plants and cost effective. The presence of naturally occurring substances in plants with antifungal properties had been stated and tested toward wide range of fungi infecting many commercially important crops. However, studies on control of *turcicum* leaf blight of maize with the aid of plant extracts are meager.

Essential oils have been presented in research as having great potential for phytopathogen control, thus reducing the incidence of pathogenic microorganisms that cause prejudice both in the agriculture and food industries (Bakkali *et al*., 2008). The presence of naturally occurring substances in plants with antifungal properties have been reported and tested against wide range of fungi infecting many commercially important crops. Jayalaxmi and Seetharaman (1998) reported that palmarosa oil was effective in reducing the fruit rot and die back of chilli followed by *Ocimum sanctum* leaf. With all these ideas in view, this experiment was planned and conducted to find out the influence of essential oils for ecofriendly management of *turcicum* leaf blight of maize

Materials and Methods

Field trials were laid out during *Kharif* 2015, *Rabi*, 2015, *Kharif* 2016 and *Rabi* 2016 with regular package of practices. The experiments were laid out in a randomized block design and replicated thrice. The treatments comprised of six essential oils, three neem products along with a control. The hybrid CoHM 6 was used as the test hybrid. *Helminthosporium turcicum* culture was artificially inoculated in the plants in the fields. The periodical sub culturing of fungus in the laboratory was made for further inoculation on plants. Essential oils were applied 10 days after artificial inoculation of pathogen and also repeated once after 20 days. The observations *viz.*, plant height, lesion length and lesion width and the disease incidence observation were made and recorded. The leaf blight severity was recorded at silk drying stage following 1-5 rating scale. The pooled analysis was done for all the three season data.

Results and Discussion

The pooled mean data of all the experiments revealed that palamrosa oil (0.05%) recorded the lowest TLB incidence of 18.94% followed by eucalyptus oil (0.1%) 21.05%, lemon grass oil (0.05%) (22.09%), geranium oil (0.05%) (24.47%), neem oil 3%) (24.85%), NCE 3% (25.70%) and NSKE 5% (26.11%). The lesion length and width were also significantly reduced by the above oils compared to control. With regard to cob yield, palmarosa oil (0.05%) recorded the highest of 6466 kg/ha. followed by eucalyptus oil (0.1%)(6356 kg/ha), lemongrass oil (0.05%) (6285 kg/ha), geranium oil (0.05%) (6098 kg/ha). The least yield was recorded with control which recorded 4879 kg/ha.

The results revealed that all the essential oils and neem products recorded lesser incidence of TLB and higher grain yield than control. The least TLB incidence and the highest yield were recorded with palmarosa oil (0.5%).

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Table 1. Efficacy of essential oils on *turciucm* leaf blight of maize

Treatment	Disease incidence %	Lesion length (cm)	Lesion width (cm)	Yield kg/ha
T1- Palamrosa oil (0.05%)	18.94	2.88	1.34	6466
T2- Eucalyptus oil (0.1%)	21.05	3.14	1.59	6356
T3- Lemon grass oil (0.05%)	22.90	3.23	2.14	6285
T4- Geranium oil (0.05%)	24.47	3.85	2.32	6098
T5- Mahua oil (0.1%)	40.12	7.88	3.37	4763
T6- Neem oil (3.0%)	24.85	3.71	1.69	5967
T7- Pungam oil (3.0%)	39.97	12.35	3.88	4739
T8- NSKE (5%)	26.11	4.07	1.64	5966
T9- NCE (5%)	25.70	3.75	1.96	5878
T10- Control	49.15	16.79	5.20	4879
CD (P=0.05%)	**1.91**	**0.81**	**0.20**	**310**

T3-20
Effect of BPCL Super Absorbent Polymer Variants on the Performance of Millets under Dry land Condition

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Abstract

Super Absorbent Polymers (SAP) are the high molecular weight mostly monomers produced largely using acrylic acid by de-polymerization. It is largely used in agriculture for increasing the water holding and release capacity of the soil and their by crop production. Hence in the present study, the efficiency of the selected Agri-SAP variants produced by BPCL, Noida viz., ASAP 2 (AA and KOH) and ASAP 6 (AA, Cellulose and NaOH) at two rates of application (15 and 20 kg/ha) on influencing the maize and sorghum performance under dryland condition was evaluated. It was seen that the rate of ASAPs didn't showed much variation on grain yield and straw yield production and were however superior over control. The ASAPs increased the maize grain yield by 10-21 percent and sorghum grain yield by 12-23 percent and increased the moisture retention at different period of growth by 3-16 and 5-6 percent compared to control in maize and sorghum grown soil.

Keywords: Dry land, Maize, Sorghum, Super Absorbent Polymer (SAP), Water saving

Introduction

The acrylic acid (AA) is one of the six Niche Petrochemicals product produced by the Propylene Derivatives Petrochemical Complex at BPCL Kochi Refinery which are predominantly being imported to the country. Hence, the production of acrylic acid, in India by BPLC will substitute its import and saves foreign exchange besides benefitting the industries across a variety of business segments such as specialty chemicals, plasticizers and Paints & Adhesivesetc (BPCL, 2021).While major quantity of the acrylic acid is used in hygienic medical products, detergents, wastewater treatment chemicals, plastics, coatings, adhesives, elastomers, paints and polishes, etc., BPCL is also extending its R&D in producing biodegradable and environmental friendly Super Absorbent Polymer (SAP) variants from acrylic acid by depolymerization for enhancing the water retention property of soil and increasing the water use efficiency in agriculture.

Materials and Methods

The field experiments were conducted under dryland condition in Agricultural Research Station, TNAU, Kovilpatti, Tamil Nadu to evaluate the performance of the two Agri-SAP variants viz., ASAP 2 (AA and KOH) and ASAP 6 (AA, Cellulose and NaOH) at two rates (15 and 20 kg/ha)on increasing the water use efficiency and crop performance. Experiments were laid out during rabi season (Oct, 2022-Jan, 2023) using maize (Hybrid CO-6) and sorghum (K-8) as test crops. The experimental field soil is high in pH (8.23), low in EC (0.41 dS/m), low in available N (135 kg/ha), and P (14.5 kg/ha) and medium in organic carbon (0.68 %) and high in available K (326 kg/ha). Experiments were conducted as non replicated trial and each treatment plot was sized to 7 m x 20 m. Samples were collected and observations were recorded in four replicates and data were statistically analyzed using RBD design. The ASAPs were applied before sowing by mixing with field soilto cover entire area and then small cultivator was used to cover and mix the SAP up to 10 cm depth approximately. Then the crop was sown and other cultivation practices were followed as per the crop production guide (CPG, 2020) of TNAU. Fertilizer was applied as per the recommendation. Soil samples were collected at different interval and gravimetric moisture content was determined. At the time of physiological maturity stage, the growth and yield parameters were recorded in both the crops and the yield was recorded at the time of harvest.

Results and Discussion

As the crop was raised completely dependent on rainfall, 100 % germination was not achieved. The germination of maize and sorghum was about 64 and 68 % in control respectively and above 70% in all ASAP applied plots with highest value in the ASAP 2 @ 20 kg/ha plot for both the crops.Significant effect of ASAP variants on yield parameters in maize and sorghum crops were observed.The grain and straw yield was significantly varied by the ASAP variants and their rates. Both the ASAPs produced significantly higher grain and straw yields over control and were comparable between them. Increased rate of ASAP application decreased the yields however, it was non significant (Figure 1). Grain and straw yield increase by the ASAP variants over control was calculated. Itwas found to be 17-21 and 10-14 percent by ASAP 2 and ASAP 6, respectively for grain yield of maize and 21-23 and 12-17 percent by ASAP 2 and ASAP 6, respectively for grain yield of sorghum.

The moisture retained in soil on 30, 50 and 90 days after sowing given in Figure 2. The ASAPs applied plots retained more moisture when compared to control during different period of crop growth. The moisture retention increase over control was higher at low rate of application irrespective of ASAP variant and period of determination. It was found to be 4-16, 3-11, 3-9 and 3-8 percent for ASAP 2 @ 15 kg/ha, ASAP 2 @ 20 kg/ha, ASAP 6 @ 15 kg/ha and ASAP 6 @ 60 kg/ha respectively under maize crop. Similarly, it was observed that both the ASAP variants (ASAP 2 and ASAP 6) retained comparable moisture in sorghum grown soil at different times irrespective of application rates with the average increase of 5 to 6 percent over control irrespective of time of measurement. Similar increase in moisture retention due to SAP was also reported by Abrisham*et al*. (2018) in *Salvia rosmarinus* cultivated soil.

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Fig 1. Effect of ASAP variants and its rate of application on increasing the yield over control in maize and sorghum under rainfed condition

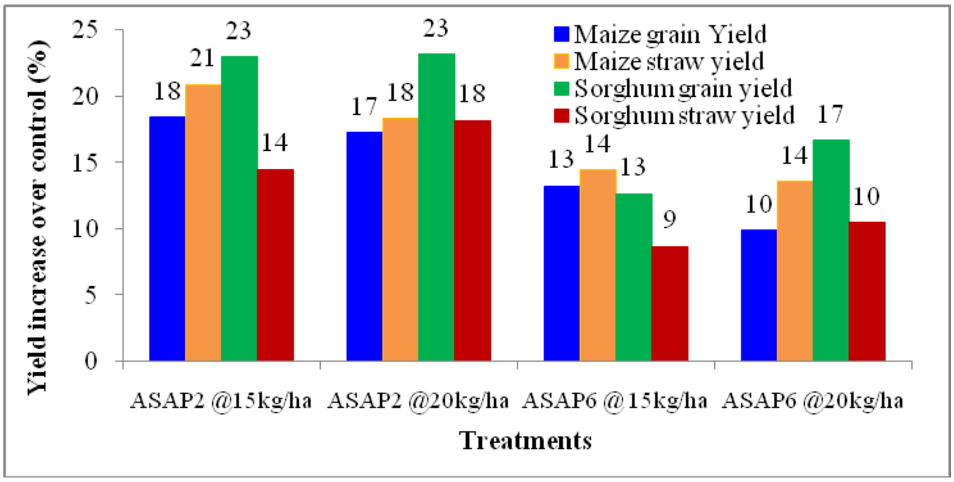
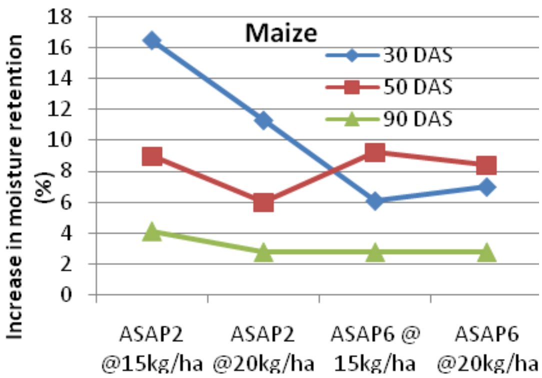
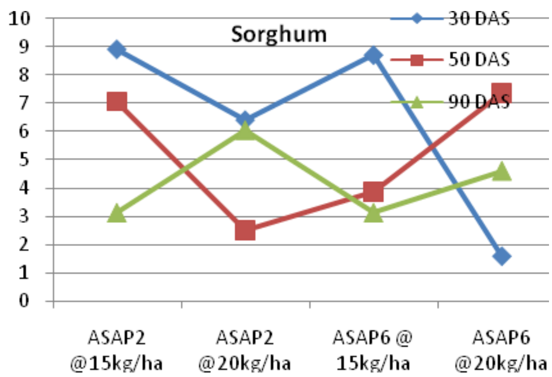


Fig 2. Effect of ASAP variants and its rate of application on increasing moisture retention over control in maize and sorghum grown soil under rainfed condition





T3-21

North-Eastern zone-specific Forewarning system for Ragi Blast Disease management by adjusting time of sowing in Tamil Nadu

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Abstract

Ragi (*Eleusine coracana* L.) is originally native of the Ethiopian highlands and cultivated widely in East Africa and tropical Asia, mainly in the rainy slopes. India is the largest cultivator of ragi, which is primarily grown in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Uttar Pradesh, Bihar, Orissa and Gujarat. Of the several fungal diseases blast caused by *Pyricularia grisea* is an important disease in almost all the ragi growing regions of India. The early sown and after 16th January sown crops were free from all the blast incidences. It recorded minimum temperature of 24.84^{0}C and maximum 32.87^{0}C, relative humidity of 73.27 per cent and a very high amount of rainfall. Information on the incidence and occurrence of blast in ragi sown at different dates can help to adjust the sowing time to harvest high yields in North-Eastern zone of Tamil Nadu.

Keyword: Ragi, Blast disease, Forecasting

Introduction

Ragi (*Eleusine coracana* L.) is originally native of the Ethiopian highlands and was introduced into India approximately 4000 years ago. It is cultivated widely in East Africa and tropical Asia, mainly in the rainy slopes. It is also cultivated in the upland area of the Himalayas at an elevation of 2,300 m. India is the largest cultivator of ragi, which is primarily grown in the states of Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Uttar Pradesh, Bihar, Orissa and Gujarat. Of the several fungal diseases blast caused by *Pyricularia grisea* is an important disease in almost all the ragi growing regions of India. The disease is known to occur almost every year during rainy season in all major ragi growing areas and is perceived as one of the major diseases causing recurring yield losses in all the states of India (Seetharam, 1983). Information on the incidence and occurrence of blast in ragi sown at different dates can help to adjust the sowing time to harvest high yields. Therefore, keeping this in mind the field experiments were conducted at Centre of Excellence in Millets, Athiyandal during 2016 to 2021 to assess the impact of planting dates and varieties on the resultant incidence of blast disease of ragi in the field.

Materials and Methods

Trials were established under rainfed conditions for two consecutive years, 2016-17 to 2020-21 in a randomized block design in 3m X 2m plot at a spacing of 25cm X 10cm with three replications of each treatment in all the years, variety CO14 was sown in at least on fortnightly from 1st June to 16th February. The crop was raised as per the recommended package of practices and no spray application of any chemical was given for the management of disease. The data on neck and finger blast were recorded at dough stage of the crop was recorded. Neck blast was recorded as the percentage of ears showing infection on the peduncle and finger blast as the percentage of fingers affected (Nagaraja *et al*., 2007).

Results and Discussion

The incidence of leaf blast was recorded from 1st September to 16th January, neck blast recorded in 16th August to 16th November and finger blast incidence recorded in 1st August to 16th November of every year. The early sown and after 16th January sown crops were free from all the blast incidences. which recorded minimum temperature of 24.84^{0}C and maximum 32.87^{0}C, relative humidity of 73.27 per cent and a very high amount of rainfall (Table1). Patro and Madhuri (2014) recorded the highest incidence of neck blast of 72.67 and 67.00 per cent was noticed in the susceptible genotypes VR-708 and KM-252 respectively in June 16th sown crop, where minimum temperature of 26.1^{0}C, maximum temperature of 32.36^{0}C, relative humidity of 89.9 per cent and a very high amount of rainfall prevailed. Highest finger blast severity of 58.32 and 51.37 per cent in genotypes VR-708 and KM-252 respectively in June 16th sown crop. Similarly highest incidence of leaf blast (Grade-4) was recorded in June 16th sown VR-708.

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Table1. Metrological data and blasts (Leaf, Neck & Finger) incidence recorded during experimentation at Centre of Excellence in Millets

S. No.	Date of Sowing	Temperature (^{0}C)		RH (%)	Rain fall (mm)	Leaf blast (G)*	Neck blast (%)*	Finger blast (%)*
		Max.	Min.					
1.	1st Jun. 2019	35.54	27.10	54.64	32.80	0	0	0
2.	16th Jun. 2019	36.67	27.25	52.68	4.00	0	0	0
3.	1st Jul. 2019	34.18	25.88	60.31	96.80	0	0	0
4.	16th Jul. 2019	34.30	27.68	59.26	122.20	0	0	0
5.	1st Aug. 2019	36.27	27.60	68.30	0.00	0	0	3.00
6.	16th Aug. 2019	35.38	27.10	56.80	140.00	0	4.00	8.00
7.	1st Sep. 2019	36.30	27.47	63.51	122.00	3.00	9.50	9.50
8.	16th Sep. 2019	32.87	24.84	73.27	171.00	6.00	11.50	10.00
9.	1st Oct. 2019	33.62	25.92	74.11	90.00	6.33	17.50	19.00
10.	16th Oct. 2019	31.22	23.95	72.73	96.00	6.00	14.50	20.50

11.	1st Nov. 2019	30.14	25.07	73.66	7.70	6.67	9.00	16.00
12.	16th Nov. 2019	27.38	25.42	69.30	53.00	6.33	4.00	10.50
13.	1st Dec. 2019	29.30	24.76	60.31	36.80	7.00	0	0
14.	16th Dec. 2019	28.15	22.10	59.26	0.00	5.67	0	0
15.	1st Jan. 2020	29.50	22.25	68.30	0.00	5.00	0	0
16.	16th Jan. 2020	29.40	23.10	56.80	0.00	3.00	0	0
17.	1st Feb. 2020	31.26	23.10	63.51	0.00	0	0	0
18.	16th Feb. 2020	33.50	23.45	63.27	0.00	0	0	0

* Mean of three replications

T3-22

Yield assessment of cultural mixtures of the Ragi [*Eleusine coracana* L. Gaertn.] for blast [*Pyricularia grisea* (Cooke) Sacc.] disease management under *in vivo* conditions

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Abstract

Mixtures of cultivars play an important role in managing plant diseases by impediment disease epidemics especially airborne pathogens. The aim of this study is to evaluate the effect of different combinations of mixtures of cultures on finger millet blast epidemics devoid of yield reduction. The treatments were constituted by mixtures of pre-released cultures and commercial variety with resistant cultivar in 1:1 and 2:1 ratios against blast disease. Their performances were compared with monoculture performance also with fungicide treatment. Pre-released cultures (TNEc 1285 + TNEc 1294 + TNEc 1310) pooled with resistant cultivar (GE4449) at 1:1 ratio had recorded sustainable yield. That treatment on par with fungicide (Tricyclazole 75% WP) sprays in both trials on (2020 and 2021) *rabi*season. The mixture of cultures witnessed that without much additional input cost and fungicidal exposure, the sustainable yield was recorded in both trials.

Keywords: Blast resistance, Culture composite, Ragi

Introduction

Ragi[*Eleusinecoracana* L. Gaertn.] is grown in more than 25 nations of Africa and Asia continent, it makes around 12% of the world's millet area (Babu*et al*., 2015). Even though, ragi is known to be one of the hardiest crops, it is affected by numerous diseases, including fungal diseases like blast, brown spot, sheath blight, foot rot, green ear and smut disease afflict ragi (Preethi*et al*., 2020). Nearly all phases of a ragi plant's growth are infected by *M. grisea*, which causes an up to 80-100% reduction in crop grain output and biomass (Dida *et al*., 2021). The fungusinfects leaves, necks and fingers also discolour the grains. Variety mixtures can provide functional diversity that limits pathogen epidemics and to increase yield stability (Zhu *et al*., 2000). In this point of view, the workswerecarried out and makes evidence for the functional diversity concept against pathogens.

Materials and Methods

Totally eleven treatments were constituted as mixtures and monoculture. The mixtures contain commercial variety (CO15) in Tamil Nadu with resistant culture (GE4449), pre-released cultures (TNEc 1285, TNEc 1294, TNEc 1310) with resistant culture (GE4449) in 1:1 and 2:1 ratio, Monoculture for released and pre-released cultures, resistant and susceptible varietytested against ragi blast. Finally, cultural composite treatments were compared with fungicide recommendations (Two sprays of tricyclazole 75% WP @ 500 g/ha at maximum tillering and heading stages).

Treatment details

T_1	-	Released variety (CO15) + GE4449 (Resistant Check) 1:1 ratio
T_2		Released variety (CO15) + GE4449 (Resistant Check) 2:1 ratio
T_3	-	Pre-released cultures (TNEc 1285 + TNEc 1294 + TNEc 1310) + GE4449 1:1 ratio
T_4		Pre-released cultures (TNEc 1285 + TNEc 1294 + TNEc 1310) + GE4449 2:1 ratio
T_5	-	GE4449 sole crop (Resistant Check)
T_6	-	*Udaramallike* (Susceptible Check)
T_7	-	CO15 sole crop
T_8	-	TNEc 1285 sole crop
T_9	-	TNEc 1294 sole crop
T_{10}	-	TNEc 1310 sole crop
T_{11}	-	Two spray of fungicide tricyclazole75% WP @ 0.2%

A randomized block design was used with three replicates per treatment. Crops were sown during *rabi,* 2020 and *rabi*2021 with a spacing of 25x10 cm, which was comparable to common practices in the region. A single nitrogen application took place at the beginning of tillering, around the vegetative growth stage. No fungicide treatment was applied during the entire crop growth period except comparison check.

Results and Discussion

The mean of two trials, higher grain yield of 2304 kg/ha recorded in Tricyclazole 75% WP two spray (T_{11}) treatment on par withPre-released cultures (TNEc 1285 + TNEc 1294 + TNEc 1310) + GE4449 at 2:1 ratio (T_4) treatment (2291 kg/ha) and 1:1 ratio(Table 1). In this study the mean of two trials, higher grain yield and biomass recorded both fungicide treatment and mixture of cultures at 2:1 ratio on par with each other. Ragi seed treatment to resistant variety with either Carbendazim @ 2 g/kg or *Pseudomonas flourescens* 6g/kg reduced blast disease incidence by two and a half times over control besides recording high mean yield of 2567and 2498 kg/ha as against 2106 kg/ha in susceptible variety (Nagaraja*et al*., 2012). In winter barley (*Hordeumvulgare*), Creissen*et al.* (2016) explained that the varietal mixtures have the capacity to stabilise productivity even when environmental conditions and stresses are not predicted in advance. Varietal mixtures provide a means of increasing crop genetic diversity without the need for extensive breeding efforts. They may confer enhanced resilience to environmental stresses and thus be a desirable component of future cropping systems for sustainable arable farming.

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Table 1. Effect of treatment on grain and fodder yield ofragi under field condition during *Rabi* 2020 and 2021

Trt. No.	*Rabi* 2020		*Rabi* 2021		Mean		Yield increase over susceptible check (%)
	Grain yield (kg/ha)	Fodder yield (kg/ha)	Grain yield (kg/ha)	Fodder yield (kg/ha)	Grain yield (kg/ha)	Fodder yield (kg/ha)	
T_1	2340	4721	2135	4412	2238	4567	18.26(25.29)
T_2	2355	4710	2075	4316	2215	4513	17.07(24.40)
T_3	2410	4913	2150	4437	2280	4675	20.51(26.92)
T_4	2398	4896	2184	4465	2291	4681	21.09(27.33)
T_5	2230	4640	2026	4192	2128	4416	12.47(20.67)
T_6	1980	4121	1804	4015	1892	4068	00.00(0.77)
T_7	2195	4574	2019	4246	2107	4410	11.36(19.69)
T_8	2295	4676	2108	4197	2202	4437	16.36(23.85)
T_9	2285	4670	2087	4208	2186	4439	15.54(23.21)
T_{10}	2290	4650	2149	4215	2220	4433	17.31(24.58)
T_{11}	2418	4930	2189	4505	2304	4718	21.75(27.79)
S. Em ±					84.50	168	3.46
CD at 5%					179.00	351	7.06

Figures in the parentheses are arcsine transformed values

T3-23

Exploration of AM fungi from soils of minor millet ecosystem and their seed coating in improvement of yield under water deficit condition

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Abstract

Arbuscular Mycorrhizal fungi (AMF) are an important group of soil microorganism, associated with most of the terrestrial plants. In the last 10 decades, extensive research on various aspects of arbuscular mycorrhizal fungi has resulted in the discovery of the role of mycorrhizal associations in increasing nutrient uptake, tolerance to biotic and abiotic stresses and increased photosynthetic and reproductive capacity in plants. Understanding the diversity can be used to regulate these fungi for enhanced land and crop management practices and agricultural production.In the present study, the AM fungal diversity was assessed in three different soil types of finger millet, foxtail millet, little millet, kodo millet and barnyard millet of minor millet growing regions of Tamil Nadu and physico-chemical properties of sampling sites were analysed. The maximum spore density was observed in soils of sandy loam and kodo millet and *Glomus fascicultum, Rhizophagusintraradices* and *Funneliformismosseae* were most frequently present in minor millet ecosystem.Furtherseed coating of native AM spores showed significant increase in plant growth, yield and physic-chemical properties under 50 % moisture stress condition.

Introduction

Arbuscular mycorrhiza fungi are a group of soil microorganisms that benefit a wide range of terrestrial plants by forming a mutualistic association. However, there is lack of information about diversity of AM fungi in different ecosystems. Also, only little literature has addressed the problem of lowering the cost of AM fungi application. Such high quantity increases the cost of production per crop and per unit area cultivation. Therefore, the use of AM fungi in agricultural crops, especially for field crops, is currently restricted. One effective strategy for lowering the AM fungal inoculum and providing crops with precise delivery is seed coating (O'Callaghan 2016).This coating promotes early colonisation of AM fungi on germination-stage seeds and helps the symbiosis establish more successfully. In the present study, diversity of AM fungi in millet ecosystem and standardization of AM fungal inoculum for seed coating under water deficit condition was studied.

Materials and Methods

Sixteen samples were collected from five different minor millet crops *viz*., finger millet, foxtail millet, little millet, barnyard millet and kodo millet grown in different regions of Tamil Nadu. The samples were pooled by quartering method and used for analysis of physiochemical properties and assessment of AM spore density. The root samples of different minor millet crops were collected and gently washed under tap water to remove the adhering soil particles. The roots were then cut into 1 cm bits and preserved in FAA (Formalin: Acetic acid: Alcohol) till they are used for estimation of AM fungal colonization.The spores from millet ecosystem were identified by PCR amplification of ITS region from genomic DNA as per the method described by Manian *et al*., (2001). Then the identified spores were evaluated for their efficiency as seed inoculants.

Results and Discussion

A total of 24 AM species were identified from soil types and crop types of minor millet growing regions. The soil samples collected from sandy loam soil and sandy clay loam soil had maximum species richness. The species *Rhizophagusintraradices*, *Funneliformismosseae* and *Glomus fascicultum* were frequently isolated from different soil types. Relative abundance results showed that among 11 genera, the genus *Glomus* was dominantly present (Fig 1). Among the 24 species identified, *Rhizophagusintraradices* was abundantly present in all soil samples followed by *Funneliformismosseae*and *Glomus fascicultum* (Fig 2). The Physico-chemical characteristics of the collected sixteen soil samples were analyzed. All the soil samples were slightly acidic to moderately alkaline and had EC value less than 1. All soil samples are low to medium in N content and medium to high in P, K and organic carbon content. This was in agreement with Negrete-Yankelevich *et al.,*(2013)who reported positive correlation between spore density and soil available phosphorous. Seed coating of AM fungi with carboxymethyl cellulose using AM inoculum sieved through 500 µm sieve showed better vigour index and infectivity potential followed by the seeds coated with polymer biosticker using 500 µm sieve. The seed coating of AM fungi significantly increased shoot length, root length, leaf number, glomalin, acid phosphatase and alkaline phosphatase activity than soil application. Protein content, proline content, catalase activity and yield parameters were also increased in seed treatment over uninoculated control and soil application under 50% water deficit condition.Rocha *et al.,* (2019)studied the effectiveness of AM fungi by coating chickpea seeds with single and combinations of AM fungal inoculum and reported that seeds treated with the AM fungal combination were most effective and displayed maximum root colonization.

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Fig. 1. Diversity analysis of AM fungi from different minor millet

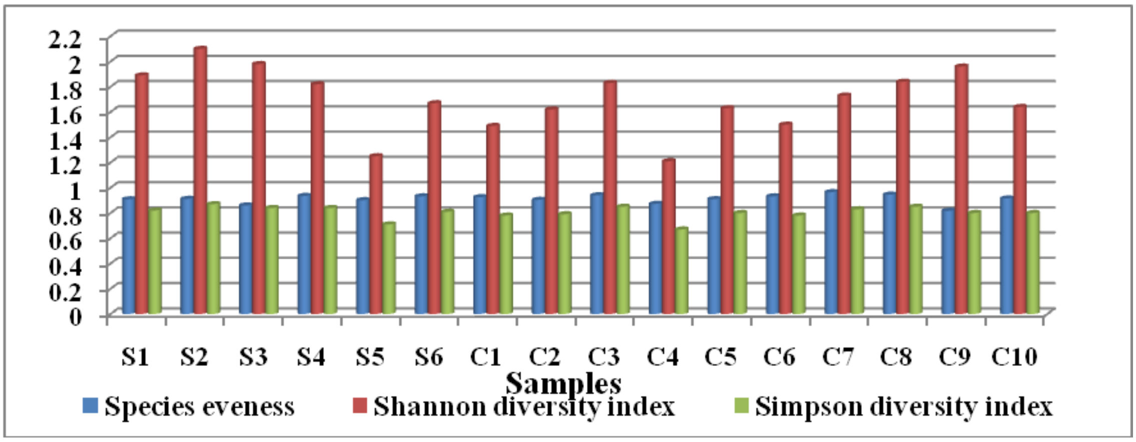

Fig. 2. AM fungal spores isolated from soils of minor millets

Rhizophagus intraradices ***Funneliformis mosseae***

T3-24

Maize Shank is an ideal substrate for on farm multiplication of *Trichoderma viride*

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Abstract

Trichodermaviride is promising biocontrol agent against major soil borne plant pathogens like *Macrophomina ,Fusarium, Sclerotium, Fusarium* and *Rhizoctonia*spp which are causing significant crop loss ranged from 25 – 45 Per cent. The availability of the viable spore inoculum at on farm level condition is a major constraints for effective management. To explore substrate for on farm production of *T. viride*, an investigation was made for the effectiveness of maize shank for on farm multiplication of *T. viride*. The studies on spawning technique for multiplication of *T. viride* using different sizes of shank such as 2, 4, 6, 8 10 cm and powdered shank revealed that the powdered shank inoculated with *T. viride @10* gram of talc (20 x 10^6cfu / g) in 200 shank based spawn with 40 % W/V was found to be effective for the colonization of *T. viride* on 28 days after inoculation.

Keywords: Maize shank, *Trichodermaviride* and Spawn

Introduction

Maize (*Zea mays* L) is one of the most versatile and multi utility crops, having wider adaptability in diverse ecologies. Globally, it is known as queen of cereals because of its highest genetic potential. It is the major source of food, feed, fodder and industrial raw material and provides enormous opportunity for crop diversification, value addition and employment generation (Kumar *et al*., 2013). To date, the abusive use and indiscriminate release of parental pesticides and their metabolites has prevailed to be a detrimental ecological concern, due to the great tendency to exist indefinitely, streaming, and pseudo-persistent properties over the food chain (Ferreira *et al*., 2015).

After the maize grain has been harvested, the maize stalks are used to feed animals, maize cobs which are produced in large numbers in the country find very minimal use in our homesteads, low percentage ofthe maize cobs are used as fuels and the rest are found in large piles in our homesteads.

Another more general use of corn cobs is for industrial cleaning purposes. Corn cobs are ground and used for sandblasting, polishing, paint removal, and grease removal (Grit O’Cobs, 2011). To our knowledge, this is the first attempt on enrichment of maize shank for the multiplication of *T. viride*. Hence the present investigation was made to study the maize shank based medium for the multiplication of *Trichodermaviride.*

Materials and Methods

Optimisation of maize shank size for faster multiplication of *T. viride*

i) Collection of the shank :

After removal of the maize grain from the cob, the shank was collected from the Department of Millets, TNAU, Coimbatore and dried with sun light for one week. Then the collected shanks were broken in to small pieces with the different sizes such as 2, 4, 6, 8 and 10 cm and whole shank also was used.as a check. The powdered shank was also taken for the preparation of the spawn packet. The Polypropylene bag (Autoclavable) with the size 8" X 5" X 19",0.5 Micron Filter was used to prepare the spawn with 200 gram quantity.

ii) Sterilisation of Maize Shank

The different size broken shank with the quantity of 200 gram was filled in the Polypropylene bag and moistened with sterile water with different ratio of 20 , 40 and 60 W/Vol was added. Then the substrate of spawn was sterilised in Autoclave with 121 ºC at 15 lb pressure for 30 min.

iii) Inoculation:

The talc based T. viride inoculum (20 x 10^6cfu / g) was taken and inoculated with two different dosage of 5 g and 10 gram/spawn bag and incubated at room temperature. The periodical observations on colonisation of *T. viride* spawn ruining was recorded

Results and Discussion

Since the moisture in the spawn is playing critical role for the multiplication of *T. viride*, the efficacy of the colonisation of *T .viride* with the dosage (10 gram/spawn) with 20 and 40% moistened substrate was studied. The results revealed that the powdered shank with *T .viride* inoculum of 10 gram/spawn with 40 % of moisture was recorded the maximum colonisation of 94.67 % spawn running on 28 days after inoculation was recorded.

The growth and sporulation of *T.viride*in spawning technique with maize shank results aregiven in Table 1. The highest growth was recordedon 28 daysafter inoculation in powdered maize shank with spawn coverage of 94.67%. The results of the present study supported with locallyavailable liquid substrates such as Black gram soaked water, Coconut water; rice mill effluent, Palmyrahjaggery solution and Palmyrah fruit pulp extract can be used for the mass multiplication of *T. viride* by small scale farmers. (Emerson and G. Mikunthan. 2015). Another study reveals that pulses are the potentialsources for maximum biomass production of *Trichoderma* spp. (Khandelwal, *et al.* 2012).

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Table 1 . Standardisation of different size of maize shank for *Trichodermaviride*multiplication with 40% Moisture and 10 g of inoculum

Treatment (Shank size)	Spawn Growth of *T. viride* @10 gram/spawn (%)/ Days after inoculation			
	7	**14**	**21**	**28**
0.50 cm	60.33^{f} (50.98)	70.33^{d} (57.04)	80.00^{b} (63.60)	80.00^{b} (63.60)
2cm	50.33^{gh} (45.19)	60.67^{f} (51.18)	69.67^{d} (56.66)	80.33^{b} (63.82)
4 cm	60.33^{f} (50.97)	69.67^{d} (56.62)	66.33^{e} (54.57)	76.00^{c} (60.73)
6 cm	10.00^{q} (18.30)	20.33^{o} (26.75)	30.33^{m} (33.39)	50.00g^{hi} (45.00)
8 cm	20.00^{o} (26.49)	48.00^{hij} (43.85)	41.00^{k} (39.80)	52.00^{g} (46.14)
10 cm	16.00^{p} (23.51)	38.67^{l} (38.43)	47.67^{ij} (43.65)	46.67^{j} (43.08)
(<1 cm)	50.00^{ghi} (45.00)	69.67^{d} (56.66)	79.67^{b} (63.33)	62.33^{f} (52.16)
Powder	28.00^{n} (31.86)	41.33^{k} (39.99)	47.67^{ij} (43.66)	94.67^{a} (76.89)
SED	0.336			
CD	0.673			
T X W	1.34			

T3-25

Studies on hydrophilic bio polymer seed coating on seedling vigour of Barnyard Millet (*Echinochloa frumentacea*)

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Abstract

Investigations were carried out to study the effect of hydrophilic bio polymers seed coating on seedling vigour of barnyard millet. Seed coating experiment consists of Six Hydrophilic polymers (Xanthan Gum, Iota Carrageenan, Kappa Carrageenan, Agar Agar, Food grade Agar and Gellan Gum), two different dosages (*viz.,*10 g and 20 g /kg of seeds) and two dosages of sticking agents (*viz.,* 5ml and 10 ml) with a control and exposed to seed germination studies under lab conditions. The results revealed that Barnyard Millet seeds coated with Xanthan Gum 10 g + 10ml Water /kg of seeds recorded the maximum germination, Seedling length and vigour index I & II (83%, 21.01cm, 10.47 mg1744 and 869) and control recorded the minimum values of 75%, 13.79cm ,9.81mg,1034 and 736 for germination %, Seedling length, dry matter production, Vigour Index I and II. Hence, it is concluded that Barnyard Millet seeds coated with Xanthan gum @ 10 g + 10 ml water /kg may be recommended as pre sowing seed treatment for improving the seed germination and seedling vigour of Barynyard millet under rainfed conditions.

Keywords : Barnyard Millet, Hydrophilic bio polymers, Seed coating, Water holding capacity and Polymerization potential, Seed germination and seedling vigour

Introduction

Barnyard millet is an ancient millet crop grown in warm and temperate regions of the world and widely cultivated in Asia, particularly India, China, Japan, and Korea. It is the fourth most produced minor millet, providing food security to many poor people across the world. Globally, India is the biggest producer of barnyard millet, both in terms of area (0.146 m ha^{-1}) and production (0.147 mt) with average productivity of 1034 kg/ha during the last 3 years (IIMR, 2018)**.** It contains a rich source of protein, carbohydrates, fiber, and, most notably, micronutrients like iron (Fe) and zinc (Zn). Millets are adapted to a wide range of ecological conditions and are often grown on skeletal soils that are less than 15 cm deep. It does not demand rich soils for their survival and growth. Because of these reasons millets are highly cultivated in rainfed ecosystems where less rain, more heat and reduced water availability (Millet network of India) and reduced productivity. In this Juncture technology interventions will help to overcome drought stress during seed germination paving way to adequate crop stand could help to increase the productivity and expand millets cultivation in dry tracks of Tamil Nadu. With this view the present study was formulated in Barnyard Millet.

Materials and Methods

Six organic hydrophilic polymers namely Xanthan Gum, Iota Carrageenan, Kappa Carrageenan, Agar agar, Food grade agar and Gellan gum were used in this study.The barnyard millet seeds (MDU 1) with 75 % germination and 12 % moisture was used as the base material for the study

The experiments were conducted at Agricultural College and Research Institute, Kudumiyanmalai, Pudukkottai, Tamil Nadu during 2022. Organic hydrophilic polymers exposed for polymerization potential and water holding capacities. Among the six bio polymers the polymerization potential and water holding capacities were recorded maximum in Xanthan gum 38.27 ml/g of polymer and in Iota Carageenan 34.17 ml/g of polymer and the Identified polymers were taken for the seed coating experiments. The barnyard millet seeds (MDU 1) with 75 % germination and 12 % moisture were coated with different dosages of hydrophilic polymer dry powders (*viz.,*10 g and 20 g /kg of seeds) with various dosages of water as sticker (*viz.,* 5ml and 10 ml) and exposed to seed germination studies under lab conditions against the uncoated seeds.

Results and Discussions

The results revealed that barnyard millet seeds coated with Xanthan gum 10 g + 10ml water /kg of seeds recorded the maximum germination, seedling length and vigour index I & II (83%, 21.01cm, 10.47 mg1744 and 869) and control recorded the minimum values of 75%, 13.79cm ,9.81mg,1034 and 736 for germination %, seedling length, dry matter production, Vigour Index I and II. The % Increase over the control was 8% for seed germination, 52 % for seedling length (cm), 7% for dry matter production (mg) ,67% for seedling vigour index I and 18% for seedling vigour index II (Fig.1). From the studies, it could be concluded that barnyard millet seeds coated with 10 g Xanthan gum + 10 ml water may be recommended as pre sowing seed treatment for improving the seed germination and seedling vigour. The results were in agreement with Maya Hotta *et al.,(*2016) who reported that super absorbent polymer coatings on seeds provide more efficient imbibition of water speed up germination and improved seedling growth. Polymer coating absorbs water from the surrounding soils and holds it at the seed surface, thus increasing both the germination speed and the total number of germinated seeds.

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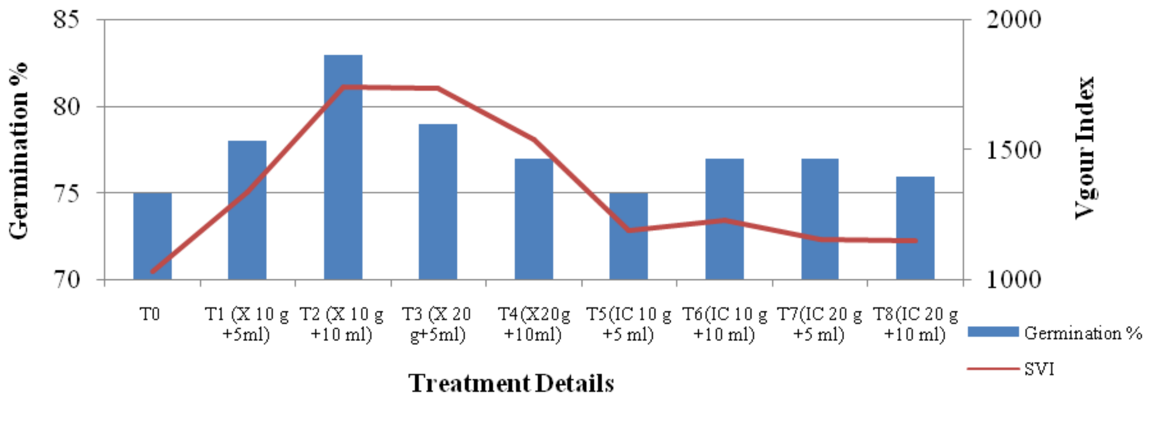
Fig. 1. Effect of HP seed coating on Seed Germination %and Seedling Vigour Index in Barnyard Millet



T3-26

Effect of hydrophilic polymers seed coating on seed germination and seedling vigour of Finger Millet (*Eleusine coracana* L.)

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Abstract

Experiments were conducted to study the Effect of Hydrophilic polymers Seed Coating on Seed Germination and Seedling Vigour of Finger millet. Six Hydrophilic polymers namely Xanthan Gum , Iota Carrageenan, Kappa Carrageenan, Agar Agar, Food grade Agar and Gellan Gum were studied for their polymerization potential and water holding capacities. Based on the polymerization potential and water holding capacities the following polymers Xanthan gum and Iota Carageenan recorded the maximum water Holding capacities of 38.27 ml/g and 34.17 ml/g and forwarded Seed coating experiment with different dosages of polymer powders (10g, and 20g /kg) and sticking agent (water 5ml and 10 ml) and studied for seed quality parameters against uncoated seeds. Results revealed that Finger millet seeds coated with 20 g Xanthan gum + 10 ml water recorded the maximum values for seed quality parameters and the % increase over the control was 7 for seed germination, 56 for seedling length (cm), 21 for dry matter production (mg) ,69 for seedling vigour index I and 31for seedling vigour index II. From the studies it could be concluded that Finger millet seeds coated with the xanthan gum @20 g can be recommended as pre sowing seed treatment to withstand the rain fed conditions.

Keywords: Finger Millet, Hydrophilic bio polymers, See coating, Water holding capacity and Polymerization potential, Seed germination and seedling vigour

Introduction

Finger millet (*Eleusine coracana* L.) is one of the important minor millets, extensively cultivated in India with a total area of 2.5 million hectares producing 2.2 million tonnes. It is a rich source for Ca (300-350mg/100g), P(283 mg/100g) and Fe (3.9 g/100g) ,vitamin B_1, B_2, folic acid and niacin .Millets are adapted to a wide range of ecological conditions and are often grown on skeletal soils that are less than 15 cm deep. It does not demand rich soils for their survival and growth. All these qualities of millet farming system make the climate change portends less rain, more heat, reduced water availability and reduced productivity (Millet network of India). Moreover the area under millet cultivation is continuously declining, that too the crop is majorly cultivated in rainfed /drought prone ecosystems in India. The productivity and profitability of millets cultivation is also affected due to absence of quality seed supply chain and improper crop management.

It is a high time to develop and enhance the productivity of rainfed crops by using the quality seeds and adopting technological interventions to mitigate water stress. Technological intervention to overcome drought stress during seed germination paving way to adequate crop stand could help to increase the productivity and expand millets cultivation in dry tracks of Tamil Nadu.

Soil addition of Hydrophilic polymers has great potential in restoration and reclamation and can hold 400 – 1500 g of water /g (Wood house and Johnson, 1991;

Bowman, and Evans, 1991). In ideal situations they can store and provide 95% water for plant absorption (Johnson and Veltkamp, 1985). Blodgett *et.al.,* (1993) found that adding superabsorbent polymers to the soil matrix increased the water holding capacity and also increased the water availability to plants. The superabsorbent polymers also prolonged water availability for plant use when irrigation stopped (Huttermann *et al.,*1999). Nevertheless, studies on organic hydrophilic polymers application through seed treatment is very meager or nil. By seed treatment the quantity of polymer required can be minimized and also the labour and time required for field application can be reduced. With this background the present study was initiated.

Materials and Methods

Six organic Hydrophilic polymers namely Xanthan Gum, Iota Carrageenan, Kappa Carrageenan, Agar Agar, Food grade Agar and Gellan Gum were collected from the market.The Finger Millet seeds (ATL 1) with 80 % germination and 12 % moisture was used as the base material for the study

The experiments were conducted at Agricultural College and Research Institute, Kudumiyanmalai, Pudukkottai, Tamil Nadu during 2022. Organic hydrophilic polymers exposed for polymerization potential and water holding capacities. Among the six bio polymers the polymerization potential and water holding capacities were recorded maximum in Xanthan gum 38.27 ml/g of polymer and in Iota Carageenan 34.17 ml/g of polymer and the Identified polymers were taken for the seed coating experiments. The Finger Millet seeds were coated with different dosages of hydrophilic polymer dry powders (*viz.,*10 g and 20 g /kg of seeds) with various dosages of water as sticker (*viz.,* 5ml and 10 ml) and exposed to seed germination studies under lab conditions against the uncoated seeds.

Results and Discussion

The results revealed that finger millet seeds coated with Xanthan Gum 20 g + 10ml Water /kg of seeds recorded the maximum germination, Seedling length and vigour index I & II (87%, 26.23cm, 12.47 mg 2282 and 1084) which was followed by seeds coated with Iota Carrageenan 20 g + 10ml Water /kg of seeds (85 %, 25.51cm ,11.76mg, 2168 and 999) and control recorded the minimum values of 80%, 16.86cm ,10.29mg,1348 and 823 for germination %, Seedling length, dry matter production, Vigour Index I and II. The % Increase over the control was 7% for seed germination, 56 % for seedling length (cm), 21% for dry matter production (mg) ,69% for seedling vigour index I and 31% for seedling vigour index II (Fig.1 to Fig.3.). From the studies it could be concluded that Finger millet seeds coated with 20 g Xanthan gum + 10 ml water may be recommended as pre sowing seed treatment for improving the seed germination and seedling vigour of Finger millet.

The results were in agreement with Maya Hotta *et al., (*2016) they reported that Super Absorbent Polymer coatings on seeds provide more efficient imbibition of water speed up germination and improved seedling growth. Polymer coating absorbs water from the surrounding soils and holds it at the seed surface, thus increasing both the germination speed and the total number of germinated seeds.

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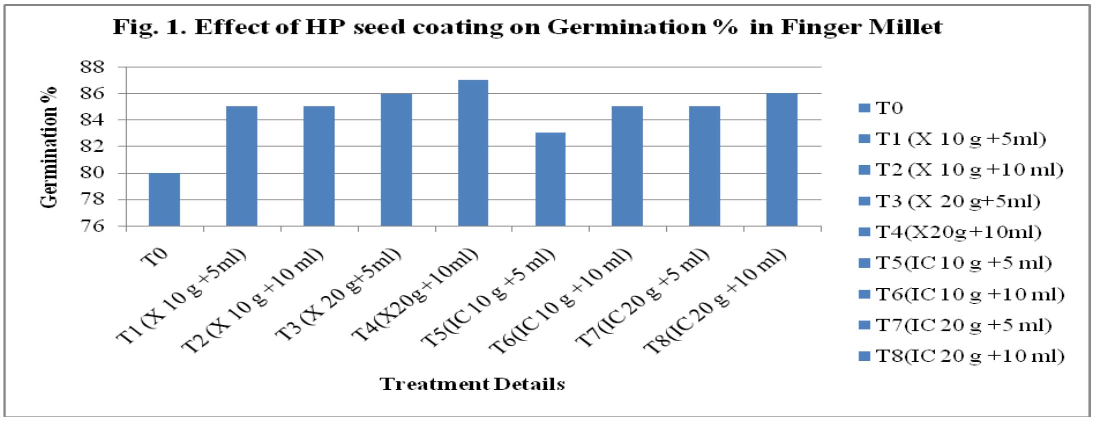

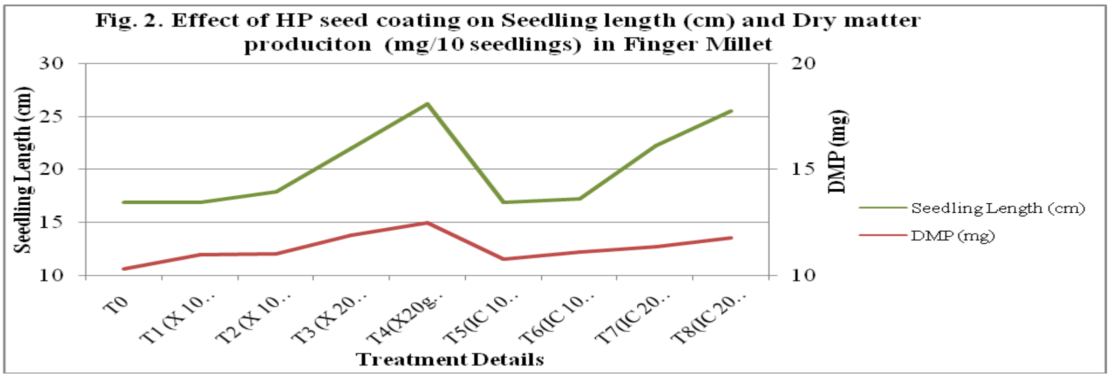

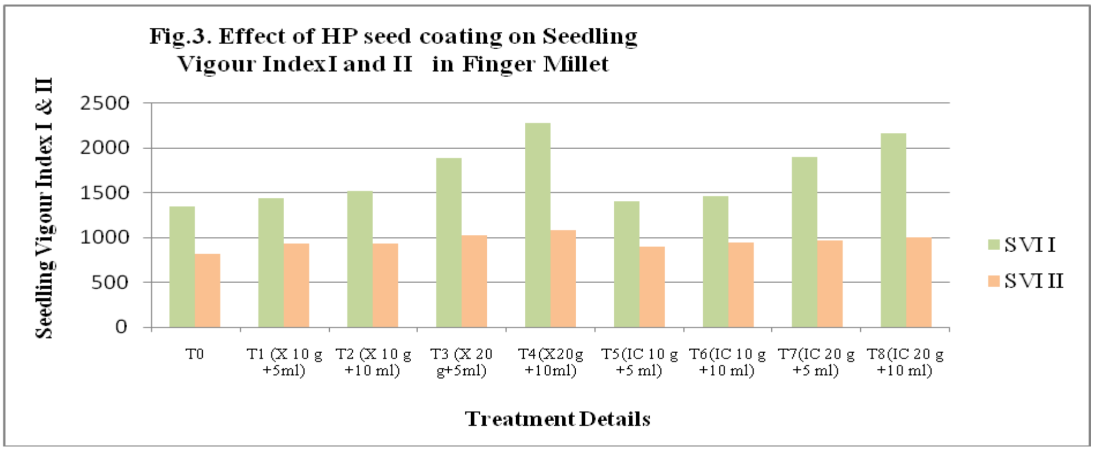

T3-27
Chilling sensitivity and tissue response in Foxtail Millet genotypes

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Abstract

The ability of a plant to survive the average minimum temperature of a region without harm or death is known as resilience. Temperature is an extremely important growth limiting factor because it regulates plant physiological and biochemical activity throughout the growth cycle. Low temperature may have an effect on plant processes such as photosynthesis, respiration, water absorption, chlorophyll stability and yield. Temperature stress, particularly high or low temperatures, can disrupt plant metabolism and shorten the time of distinct plant growth phases. Plants' responses to low temperature exposure can have a significant impact on various growth parameters such as leaf area, leaf area index, crop growth rate, relative water content, photosynthetic efficiency, days to 50% flowering, number of tillers, number of grains per tiller, total dry matter production, and yield.The present study was conducted to determine the low temperature effect on growth analysis and yield of tenai genotypes screening at Agricultural College and Research Institute, Vazhavachanur, Tiruvannamali district and Jawathu hill region of Vellore district.

Keywords: Foxtail millet, Growth analysis, Membrane stability, Photosynthetic efficiency and Productivity

Introduction

Chilling harm can be obvious or unseen. Plant vigour may be diminished or crop flowering may be delayed by chilling. Apart from other environmental stresses, low temperature is an important environmental factor in limiting plant survival, metabolism, and productivity. Low temperature disturb all the physiological processes like, photosynthesis, chlorophyll content, respiration, crop growth rate and total dry matter production of plants (Rahul kumar*et al*., 2018). Chilling injury is defined as an injury produced by a temperature drop below 15°C but above the freezing point. Rapid wilting of the leaves and the development of water soaked areas are characteristics of chilling injury. Foxtail millet, in particular, decreases growth and development at low temperatures. When compared with conventional cultivation, total dry matter production is very low at cold temperature. As a result, yield loss is severe.

Materials and Methods

A field experiment on foxtail millet was conducted with 7 genotypes viz., TNSi 337, TNSi 354, TNSi 356, TNSi 375, TNSi 376, TNSi379 and check variety ATL 1 in two locations viz., Agricultural College and Research Institute, Vazhavachanur, Tiruvannamali district and Jawathu hills at Vellore district. The cardinal temperature of foxtail millet is 9.3°C for base, 37.0°C for optimum and 46.0°C ceiling temperature (Kamkar *et al*., 2006).

Results and Discussion

Genotypes TNSi 375, TNSi 376 , TNSi 337 and ATL 1 had maximum no of tillers, leaf area at 12 to 24 °C, therefore these genotypes are good for *Rabi'* cultivation, since the have low temperature tolerance. Since, the most sensitive stage for chilling harm is the flowering stage, which occurs 10-15 days prior to grain filling stage, the cold stress was assessed in flower initiation period. The genotypes with least percentage of chlorophyll reduction (3.565) and average yield of (1397) is TNSi 375 genotype and the most sensitive genotype is TNSi 356 at Tiruvannamali and Jawathu hills. Plant species native to tropical and subtropical places often exhibit injury signs at temperatures below 12 degrees Celsius (Esmaili and Salehi, 2012). Chilling stress frequently causes decreased leaf area, crop growth rate and photosynthetic efficiency and chlorosis, cellular membrane damage, and oxidative stress in plants (Suzuki and Mittler, 2006). Plant adaptive process involves a number of biochemical and physiological changes, including increased levels of proline and membrane stability index to the adverse environmental conditions (Holaday, 1992). Based on the results obtained in this study, it is concluded that the culture TenaiTNSi 375 and TNSi 376 were found to be suitable for low temperature tolerance

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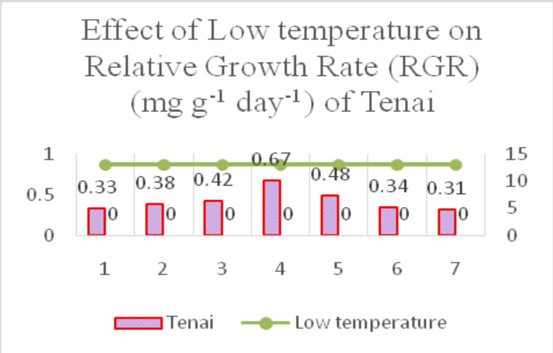
Table 1. Effect of low temperature on Crop Growth Rate (g m^{-2} day^{-1}), Total chlorophyll content (mg g^{-1}), 1000 grain weight (gm) and Grain yield (kg/ha) of foxtail millet genotypes at Tiruvannamaiand Jawathu hills.

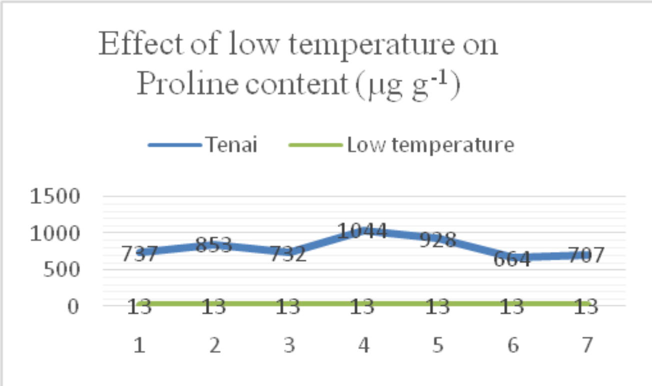
Treatments	Crop Growth Rate (g m^{-2} day^{-1})		Total chlorophyll content (mg g^{-1})		1000 grain weight (gm)		Grain yield (kg/ha)	
	TVM	Jawathu hill	TVM	Jawathu hill	TVM	Jawathu hill	TVM	Jawathu hill
TNSi 337	4.20	3.63	2.606	2.981	3.29	3.26	1233	1200
TNSi 354	4.82	3.51	1.368	2.957	3.20	3.28	1005	997
TNSi 356	4.74	3.61	1.397	3.047	3.56	3.36	962	948
TNSi 375	4.93	3.91	3.565	3.157	3.66	3.39	1397	1230
TNSi 376	4.68	3.68	3.226	3.023	3.48	3.32	1275	1255
TNSi 379	4.90	3.50	2.957	2.976	2.84	3.16	943	1125
ATL 1	5.12	3.55	2.829	2.658	2.91	3.34	1290	1150

SEd	0.36	0.310	0.09	0.227	0.068	0.201	69.43	62.43
CD (P=0.05)	1.11	0.683	0.26	0.499	0.150	0.443	152.95	137.53

Fig.1. Effect of low temperature on relative growth rateof foxtail millet genotypes at Tiruvannamali and Jawathu hill.

Fig.2 Effect of low temperature on prolineof foxtail millet genotypes at Tiruvannamali and Jawathu hill.





T3-28

Reproductive responses of Foxtail (*Setaria italica* L.) and Barnyard Millet (*Echonochloa frumentacaea* L.) genotypes to drought and heat stress

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Abstract

Minor millets are moderately tolerant to abiotic stresses (drought and heat stress) but beyond the threshold level, it is severely affected by multiple stress, especially at the reproductive stage. Foxtail and barnyard millets are nutri-cereals, widely grown in Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Bihar, Madhya Pradesh and Maharashtra. The present study was undertaken to evaluate the foxtail and barnyard millet genotypes under drought combined heat stress at anthesis to assess the reproductive responses of foxtail and barnyard millets of selected genotypes under drought and heat stress. Among the genotypes of foxtail (Assam local 1, GS 77, GS/15/1, TNAU 159, GS 199, GS 474/1 and CO7) and barnyard millet (ESLG 104, ESLG 94, ESD 83, SEJ 194, ELB 32, ESD 102 and CO 2), selected genotypes were studied under microscopic examination for anther length showed a significant reduction in anther size due to drought and heat stress. The genotype TNAU 159 and ESLG 94 was observed to maintain larger anther length compared to other genotypes of foxtail and barnyard millet respectively. Under the combined drought and heat stress, pollen viability was observed to be higher in TNAU 159 followed by GS 77 genotype of foxtail millet and ESLG 94 followed by ESD 83 genotypes of barnyard millet at the anthesis stage. It is concluded that the present study unfoldedthe way to identify the tolerant genotypes under drought and heat stress in foxtail (TNAU 159 and GS 77) and barnyard millet (ESLG 94 and ESD 83) genotypes. Further, it can be exploited for the future breeding programme of drought-combined heat stress.

Keywords: Foxtail and barnyard genotypes, Combined stress, Pollen length, Pollen viability,

Introduction

Minor millets play an important role in global agriculture and have been growing from ancient times in traditional agricultural systems (Begum *et al*., 2013). Foxtail and barnyard millets are grown widely in Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Bihar, Madhya Pradesh and Maharashtra. Minor millets are moderately tolerant to abiotic stresses (drought and heat stress) but beyond the threshold level, it will severely be affected by multiple stress, especially at the reproductive stage. Heat and drought may affect crop yield and gas exchange at any developmental stage while, the early reproductive stage is found to be one of the most susceptible phases of a crop to drought stress (Liu et al., 2005). Hence, the present study was undertaken to evaluate the foxtail and barnyard millet genotypes under drought combined heat stress at anthesis to assess the reproductive responses of foxtail and barnyard millets of selected genotypes under drought and heat stress.

Materials and Methods

Anther length: Anthers were collected from the spikelets early in the morning before anthesis. These anthers were fixed in a fixative FAA (50% absolute ethanol, 5 % acetic acid, 27% formaldehyde, and 18% sterilized water) following the procedure of Jagadish *et al.* (2010). The length was measured using an image analyser and the measurements were taken using the capture pro software version 4.1.

Pollen viability: The pollen grains from anthers of randomly selected spikelets were collected and taken on cavity slides and stained with Iodine-potassium iodide solution (0.44 g Iodine + 20.08 g potassium iodide in 500 ml of 70% alcohol). The viability percentage was calculated from the mean of three microscopic field counts for each genotype (Jensen, 1962).

$$Viability\ (\%) = \frac{Number\ of\ viable\ pollen\ grains}{Total\ number\ of\ pollen\ grains} \times 100$$

Results and Discussion

The study reported that exposure of plants to combined stresses could lead to more acute damage than individual stress. Combined stresses, particularly during the stress-sensitive reproductive stages, causes short pollen length. Even though, the genotypes TNAU 159 and ESLG 94 registered lengthiest anther of 1.45 mm in Foxtail Millet and Barnyard Millet respectively (Table 1). The cultivars with large anthers are tolerant to heat and drought stress because of a large number of pollen grains per anther, which compensates for the reduction in the number of pollen grains that germinate under high temperatures (Bheemanahalli *et al.,* 2021).Pollen viability is considered an important parameter of pollen quality. The present investigation revealed that the dark colour-stained pollens are viable, semi-viable are light in colour and non-stained pollens are unviable pollens. Foxtail TNAU 159 and barnyard ESLG 94 recorded higher pollen viability while foxtail GS 199 and SEJ 194 recorded poor viability under combined stress conditions (Figure 1). Decreased longevity of pollen under drought and heat could be a result of disruption of carbohydrate accumulation in pollen grains and/or change in the ultrastructure of pollen grains at high temperatures. In addition, we believe that the quick loss of moisture from pollen due to high temperature and high vapour pressure deficit may result in a quick loss of viability.

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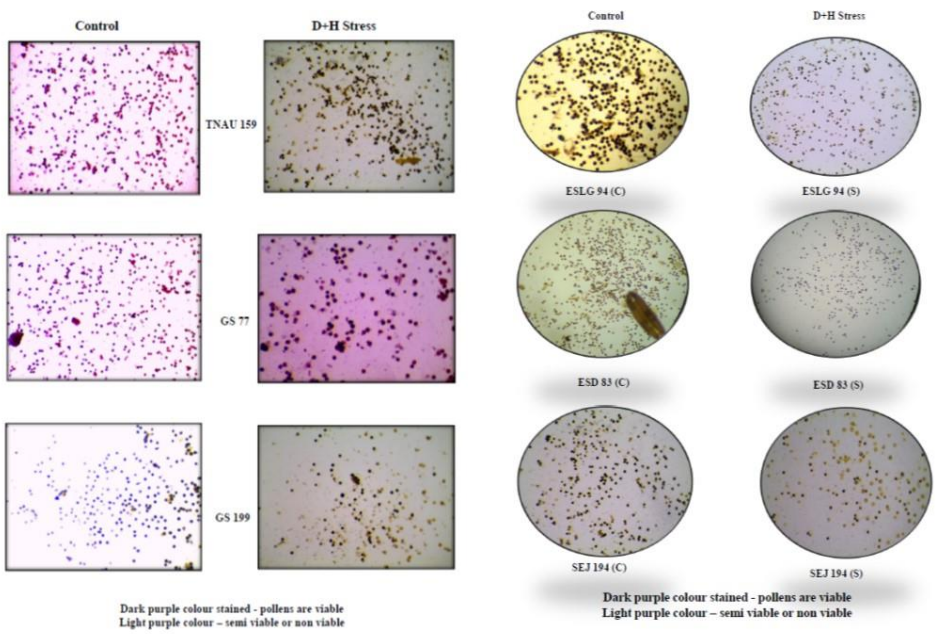
Table 1. Effect of drought and heat stress on anther length (mm) in foxtail and barnyard millet genotypes

Genotypes	Foxtail Millet		Barnyard Millet		
	Control	D + H	Genotypes	Control	D + H
Assam local 1	1.46	1.32	ESLG 104	1.53	1.36
GS 77	1.49	1.38	ESLG 94	1.53	1.45
GS/15/1	1.49	1.38	ESD 83	1.50	1.43
TNAU 159	1.52	1.45	SEJ 194	1.54	1.32
GS 199	1.48	1.27	ELB 32	1.52	1.34
GS 474/1	1.47	1.30	ESD 102	1.51	1.39
CO7	1.45	1.32	CO 2	1.47	1.37
Mean	1.480	1.346	Mean	1.514	1.380
	S.Ed	CD ($p \leq 0.05$)		S.Ed	CD ($p \leq 0.05$)
G	0.026	0.053**	G	0.026	NS
T	0.014	0.028**	T	0.014	0.028**
GxT	0.037	NS	GxT	0.037	NS

Significant*, Highly significant**, NS - Non-Significant; D: Drought, H: Heat stress

Fig. 1. Combined stress effect on Pollen viability of foxtail and barnyard millet genotypes



T3-29
Germplasm identification for combined heat and drought stresses in Foxtail Millet

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Abstract

Millets offer nutritional security and there is a need for promoting millets as they are rich in protein, fibre, iron, minerals, B-complex vitamins and calcium. The most widely grown millets are finger millet, proso millet and foxtail millet especially wherever annual rainfall is below 350 mm, perhaps no other cereal crop can be grown under such moisture stress. But due to adverse environmental conditions the productivity of millets is declining. Furthermore, IPCC has predicted that there will be a risk of high temperature combined with drought stress in millet growing regions. So, there is a need to identify the tolerant foxtail millet germplasm line to be used in breeding programs. The 45 foxtail millet germplasm lines including checks were collected from Centre of Excellance, Athiyandal and IIMR, Hyderabad. The plants were exposed to natural stress under field conditions during grain filling stage. The parameters such as panicle length and panicle weight were recorded. Among the 45 foxtail millet genotypes, 1982 IC04 79445 was found to be tolerant that performed well for both panicle length and panicle weight.

Keywords: Millet, nutrient rich, field evaluation, panicle length, panicle weight

Introduction

Millets are a group of highly variable small-seeded grass, widely grown around the world as grain crops for human food and animal fodder. In recent years, there has been an increasing recognition of the importance of millets as a substitute for major cereal crops (Nandhini and sridhara, 2019). Millets are known for their climate-resilient features including adaptation to a wide range of ecological conditions, less irrigational requirements, better growth and productivity in low nutrient input conditions (Kole *et al.,* 2015). Also, millets are nutritionally superior to other major cereals as they are rich in dietary fibers, resistant starches, vitamins, essential amino acids, storage proteins and other bioactive compounds (Amadou *et al.,* 2013). These attributes have made millets a crop of choice for cultivation in arid and semi-arid regions of the world; however, the less attempt has been made to study the climate-resilient features of millets compared to other major cereals. Among millets, foxtail millet (*Setaria italica*) and its wild progenitor, green foxtail (*S. viridis*) are extensively studied since they are considered as models for studying the traits related to C4 photosynthesis, stress biology, and bioenergy characteristics (Muthamilarasan and Prasad, 2015). The objective of this study was framed as i) Genetic variability for yield components in thenai under natural high temperature and drought conditions and identify the promising genotypes to be grown under heat and drought environments.

Materials and Methods

A field experiment was conducted in Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore to evaluate the performance of foxtail millet germplasm lines including checks under natural heat and drought conditions. The germplasm lines were collected from Centre of Excellence, Aathiyandhal, TNAU and Indian Institute of Millet Research, Hyderabad (Table 1). Foxtail millet plants were grown with a spacing of 22.5cm x10cm and recommended dose of fertilizer 44:22 kg of N:P. Plants were grown under well-watered conditions from sowing to grain filling. From grain filling stage water was withdrawn and grown under natural high temperature stress until maturity.

Panicle length and panicle weight

The plants were harvested and dried in hot air oven under 60 ℃ for two days and panicle length was measured from top to bottom of the panicle where the grains were located and expressed as cm. Once panicle length was taken the panicles were cleaned and the grains alone were separated and weighed to measure the panicle weight and expressed as gram.

Results and Discussion

Panicle length was highest (30cm) in ISE- 128/1genotype followed by 1982 IC04 79445, ISE -213/1, 3358 IC04 04133. The lowest panicle length was recorded by SEA -8 (4.5cm) followed by E2 56 (8.3 cm) and SEA 12 (11.7 cm) (Fig. 1). Panicle weight was highest (13.8g) in 1982 IC04 79445 followed by ISE – 254 and EN 54. The lowest panicle wight was recorded by SEA -8 (0.63g) followed by E2 56 (2.5g) and SEA 12 (3.9g) (Fig. 1).

Panicle length of foxtail millet germplasm lines under rainfed conditions was recorded to be 15 cm to 20 cm similarly panicle weight was recorded to be 6 to 10 g (Deva *et al.,* 2019). When foxtail millet was grown under different water regimes the panicle length was found to be 10 to 16 cm and panicle weight as 2.84 to 4.46 g (Nandhini & Sridhara, 2019).

The genotype 1982 IC04 79445 was screened as tolerant line that performed well for both panicle length and panicle weight under field evaluation of foxtail millet germplasm for combined drought and high temperature stress.

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Fig. 1. Panicle length and panicle weight of foxtail millet germplasm lines exposed to drought and high temperature stress

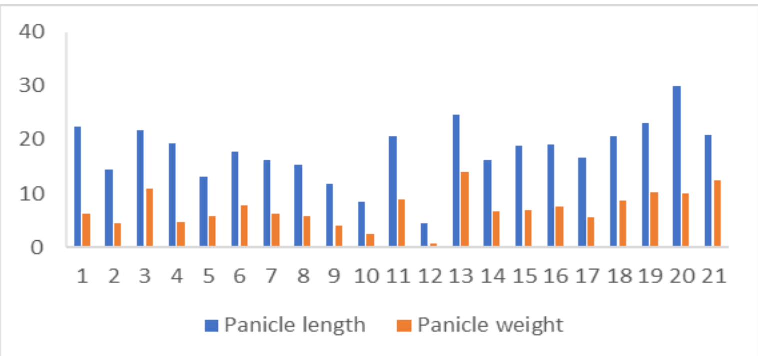

Table 1. List of genotypes/ Checks used in this study

S. No	Genotypes/ Checks	S. No	Genotypes/ Checks	S. No	Genotypes/ Checks
1.	3358 IC04 04133	16.	2057 IC04 03470	31.	ATL 1
2.	SIA 3156	17.	2734 IC0403470	32.	CO (TE) 7
3.	EN 54	18.	ER 101	33.	Tenai 2201
4.	3990 IC04 26732	19.	SEA 12	34.	Tenai 2202
5.	4266 IC0538945	20.	3821 ICO321168	35.	Tenai 2203
6.	ERP 90	21.	SEJ 166	36.	ISE - 15
7.	E2 81	22.	SIA 3222 garuda	37.	ISE - 26
8.	2706 IC0403440	23.	E2 56	38.	ISE - 2/3
9.	2063 IC0480408	24.	2750 IC0403487	39.	ISE - 183/1
10.	2001 IC04 79711	25.	SEA -8	40.	ISE - 213/1
11.	3519 EC0529793	26.	ELS 36	41.	ISE - 57/A
12.	3191 IC04 03951	27.	DHFT 109- 3	42.	ISE - 128/1
13.	3376 IC04 04151	28.	3115 IC04 03900	43.	ISE - 23
14.	Suryanandhi	29.	1926 E8D03	44.	ISE - 365
15.	SIA 326, Prasad	30.	1982 IC04 79445	45.	ISE - 254

T3-30

Multi-trait novel rhizobacteria for drought mitigation in Sorghum [*Sorghum bicolor*(L.) Moench]: isolation and characterization

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Abstract

Drought is a major constraint throughout the world, and it creates a major yield loss by changing the plant metabolic process. However, the negative effects of drought on plant growth and development were alleviated by using plant growth-promoting bacteria. With these backgrounds, the study was conducted to identify the drought-tolerant endophytic bacteria and their plant growth promotion (PGP) traits under drought conditions. A total of ten bacterial isolates were obtained and showed normal growth at −0.5 MPa; whereas, increasing the osmotic potential to −1 MPa, only six isolates *viz.,* VR2 (A. pittii), VR4, SR1 (*Bacilluslichiniformis*), SR2 (*Bacillus* sp.), SR3 (*P. intermedius*), and SR5 (*Acinetobacter baumannii*) showed normal growth. Among the strains, only five promising isolates *viz.,Acinetobacter pittii*, *Bacillus lichiniformis*, *Bacillus* sp., *Pseudacidovorax intermedius*, and *Acinetobacter baumannii* were characterized through partial 16S rRNA sequencing. These strains had higher levels of production in exopolysaccharides (EPS), and 1-aminocyclopropane-l-carboxylic acid deaminase(ACCd) under normal and moisture stress conditions.

Keywords: *Pseudacidovorax intermedius*, Rhizobacteria, Drought, Sorghum

Introduction

Drought stress causes a major problem around the world especially in the agriculture sector and it reduces crop growth, which in turn, affects crop production. Plant growth-promoting rhizobacteria (PGPR) play an important role in the maintenance of plant growth, nutrient management, and hormonal balance(Vurukonda*et al.,* 2016). Sorghum is the fourth most important cereal followed by maize and it has been used for a variety of purposes, including grain, forage, syrup, and bioethanol production. Naturally, sorghum is a very hardy and drought-tolerant crop. However, it reducing the growth, development and grain yield of sorghum in the semi-arid agro-ecologies. Functional characterization of sorghum-associated microbial resources and their field application can be a better agronomic option to mitigate drought stress. Therefore, we postulate that rhizobacterial endophytes connected to the sorghum genotype that can withstand drought would promote stress tolerance by their PGP activities. Accordingly, the objective of the present work was formulated to identify the drought tolerant novel rhizobacterial endophytesin sorghum.

Materials and Methods

The aim of isolating bacterial isolates from sorghum root (Vellacholam and COFS 29) was achieved using the method outlined by Marequeet *et al.* (2015). Drought stress was induced via two methods: PEG diffusion and broth inoculation, both at various PEG 6000 concentrations (− 0.2, − 0.4, − 0.6, − 0.8, − 1, and − 1.2 MPa) (Michel and Kaufmann 1973). An Exopolysaccharide (EPS) production was determined by the estimation of total carbohydrates content (Dubois *et al.,* 1956) and expressed as mg/ml. The quantitative assessment of ACC deaminase activity was done spectrophotometrically in terms of α-ketobutyrate production at 540 nm by comparing it with the standard curve of α-ketobutyrate and expressed as nmoles mg^{-1} protein h^{-1}**.**

Results and Discussion

A total of all ten isolates showed normal growth at −0.5 MPa; whereas, increasing the osmotic potential to −1 MPa, only six isolates *viz.,* VR2 (A. pittii), VR4, SR1 (*Bacilluslichiniformis*), SR2 (*Bacillus* sp.), SR3 (*P. intermedius*), and SR5 (*Acinetobacter baumannii*) showed normal growth. Finally, there was no bacterial growth was observed in −1.2 MPa of increased osmotic potential. Among the strains only five promising isolates *viz.,Acinetobacter pittii* (MN744689), *Bacillus lichiniformis* (MN744694), *Bacillus* sp. (MN744707), *Pseudacidovorax intermedius* (MN508430), and *Acinetobacter baumannii* (MT138561) were characterized through partial 16S rRNA sequencing. The synthesis of exopolysaccharide (EPS) was greater in drought-stressed endophytic isolates than in normal circumstances. Among the isolates, SR3 (*P. intermedius*) produced the highest amount of EPS (0.80±0.012 mg/mL) under osmotically stressed condition (−1 MPa). The result indicated that EPS production happens as a response to stress and it helps the bacteria from a desiccated environment and dried out slowly (Hepper 1975). Based on quantifying the amount of α-KB production, ACC deaminase enzyme activity was examined in the presence of PEG 6000 (−1 MPa), SR3 (*P. intermedius*) had the highest level of ACC deaminase activity (1.16-fold). ACC deaminase hydrolyses ACC into α-ketobutyrate and ammonia instead of ethylene (Glick,2014).

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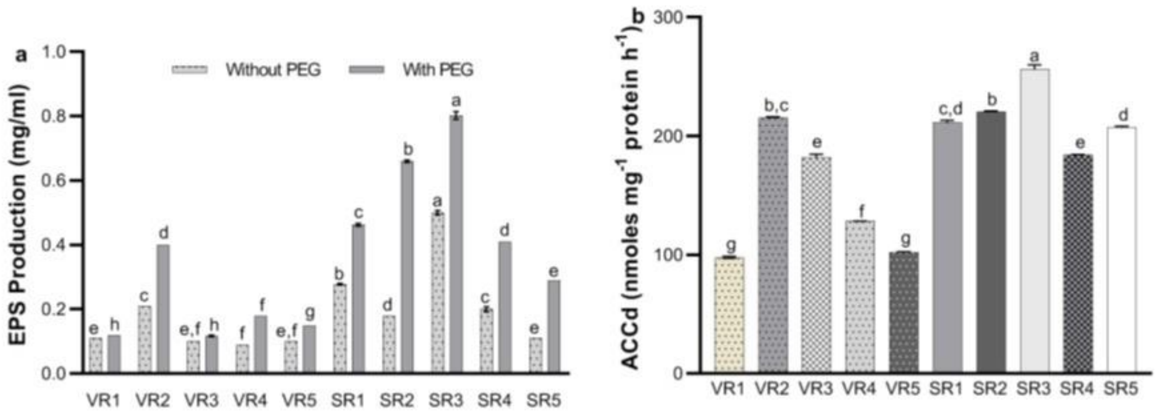
Table 1. Growth of bacterial strains under different concentrations of polyethylene glycol (PEG 6000)

Isolates	PEG Concentration 6000		
	-0.5 MPa	-1 MPa	-1.2 MPa
VR1	+++	++	-
VR2	+++	+++	-
VR3	+++	++	-
VR4	+++	+++	-
VR5	+++	++	-
SR1	+++	+++	-
SR2	++	+++	-
SR3	+++	+++	-
SR4	++	++	-
SR5	+++	+++	-

+++Normal growth, ++ Poor growth, - No growth

Fig. 1. a. EPS production under normal and moisture stress condition.b. ACCdeaminase under moisture stresscondition. Values with different letters aresignificantlydifferentat *p*≤0.05.



T3-31
Impact of land surface temperature and vegetation variations on Groundnut during the growing season in Perambalur district of Tamil Nadu

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Abstract

Groundnut (Arachis hypogaea L.), is an important crop grown in many parts of the world, particularly in semi-arid tropics. This study focused on analyzing environmental stress factors between Normalized Difference Vegetation Index and Land Surface Temperature during Groundnut's growing season from June to August over an eight-year period (2015-2022) in Perambalur district, Tamil Nadu. The data was obtained through MODIS-based procedures which showed that there was variability observed in NDVI but minimal variation noted for LST. In conclusion, different growing seasons had varying effects on Groundnut production due to complex relationships between LST and NDVI across various years; however correlation coefficient R of regression equations ranged from 0.54 to 0.82 suggesting that use of estimation methods based on MODIS NDVI and LST data can suitably be applied even amidst complexities such as diverse topography or soil/vegetation types.

Keywords: LST, Vegetation, MODIS, Groundnut, Perambalur

Introduction

Groundnut, also known as *Arachis hypogaea* L., is a significant crop worldwide that provides protein and oil for human consumption and animal feed. It grows in semi-arid tropics but often experiences high air and soil temperatures above 35°C during the reproductive period, leading to yield losses. Environmental stress factors such as temperature changes and varying vegetation throughout the growing season can significantly affect groundnut's growth, development, and productivity.

The study examined the correlation between urban tree canopy structure and land surface temperature in Nanjing City, China (Chen *et.al*., 2020). This was done through the use of a detailed vegetation map, LiDAR data and statistical analysis techniques. The aim of this research was to analyze environmental factors that affect crop growth during June - August from 2015 to 2022 in Perambalur district located in Tamil Nadu by examining the relationship between Normalized Difference Vegetation Index and Land Surface Temperature.

Materials and Methods

Perambalur district is located in the southern Indian state of Tamil Nadu and has an area of 3691 square kilometres spread geographically lies from 10º 53’ to 11º 31’ North Latitudes and from 73º 38˙ to 79 º 31˙ East Longitudes and is divided into four taluks: Veppanthattai, Alathur, Perambalur, and Kunnam. The region is known for the cultivation of crops such as paddy, sugarcane and groundnut. Black cotton soil, clay loam and red sandy soil are the predominant soil types. Maize, Cotton, Sorghum, Onion, Tapioca, Paddy, and Groundnut are the major cultivated crops.

The linear regression fitting was used to establish multiple linear regression equations between the time series the MODIS LST and NDVI. The NDVI dataset was the MOD13Q1 V6 product from 1 June 2015 to 31 August 2022. The product was the 16-day composite with a total of 48 images. The NDVI time series data were used to detect abnormally high and low values to reflect seasonal changes in the vegetation index. The seasonal NDVI was consistent with the growth pattern of the vegetation. The selected LST dataset was the MOD11A2 product from 1 June 2015 to 31 August 2022, which was an eight-day composite product with a total of 96 images. The eight-day LST dataset was converted to a 16-day LST images to match the NDVI temporal resolution.

Results and Discussion

Results of the study conducted between 2015 and 2022, indicate a slight decline in mean land surface temperature and vegetation. However, an analysis of Fig.1 reveals that from 2015-2018 there was an increase in both the mean LST temperature (29.48°C), Normalized Difference Vegetation Index score of 0.65; whereas for years spanning from 2019 to 2022, recorded higher LST levels at around 31.60°C with correlating impact on groundnut output shown as increased yield rates respectively. The outcomes obtained through linear regression showed non-stationarity within the LST range while vegetative components depicted no significant negative coefficient correlation among factors. Innovations suggested by (Liu *et. al*., 2020). Improved separation techniques via multi-pixel and multi-temporal data for effective distinction between soil temperatures from vegetation component temperatures based on one pixel land surface measurements which provide better opportunities to obtain more accurate readings.

Plants of each cultivar were exposed to a factorial combination of two LST (optimum: 29°/26 °C and high: 39°/24 °C) and NDVI (low: 0.37 and high: 0.83) until final harvest at 90 DAP (Fig 2). The effects of high LST and NDVI imposed from start of flowering or podding were similar. Exposure to high LST and NDVI significantly reduced total dry matter production, partitioning of dry matter to pods, and pod yields in both the cultivars. Based on time series datasets for the Bashang Plateau and northern North China's mountainous region from 1998 to 2015 (Wang *et. al*., 2020) use trend analysis, partial correlation analysis, and univariate linear regression to investigate the sustainability of vegetation variations and to determine the driving mechanisms of climatic and anthropogenic factors in vegetation dynamics at the regional scale.

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Fig. 1. Time series variations of NDVI between 2015-2022

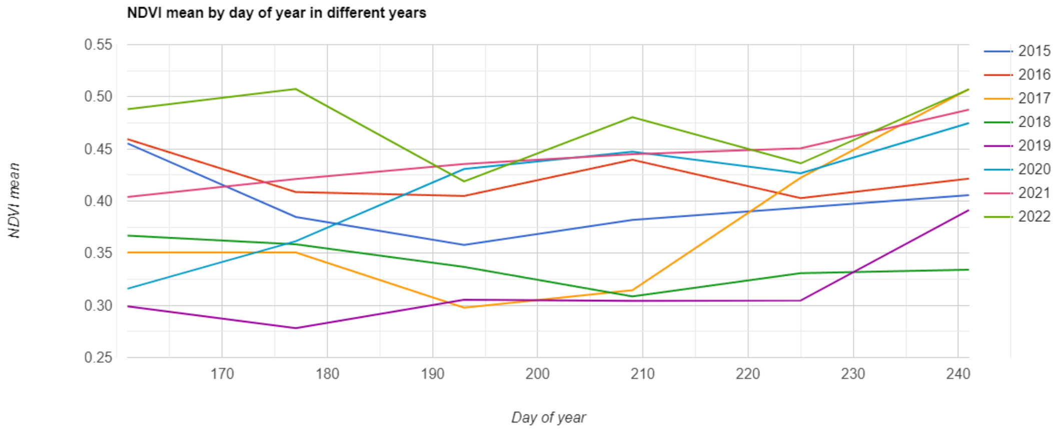
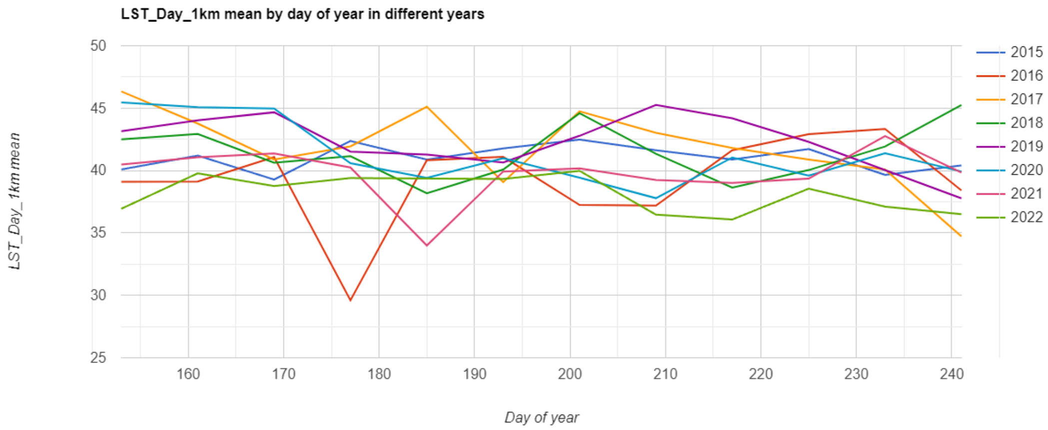


Fig. 2. Time series variations of Temperature between 2015-2022



T3-32

Physiological evaluation of finger millet (*Eleusion coracana (L.) Gaertn*) for sodicity tolerance and mitigation through growth promoters and nutrients

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Abstract

Feeding the fast-growing human population with balanced nutritional diet under unpredictable severe weather events is a challenging task globally.The *In vitro* screening and field experiement was conducted with five finger millet varieties viz., TRY 1, Paiyur 1,Paiyur 2, CO (Ragi) 14 and ATL 1 were screened for tolerance to sodicity stress.From this study it is concluded that Paiyur II and ATL I identified as tolerant varieties and Paiyur I and Co14 as susceptible for sodicity stress. The susceptible varieties-Paiyur I and Co 14 showed significant improvement in physiology and grain yield due to foliar spray with nutrient mixture (Calcium nitrate (0.5%) + K_2SO_4 (0.5%) +$ZnSO_4$(0.5%) +Boric acid (0.2%) at flowering and grain filling stage .

Keywords: Finger millet, Sodicity ,Mitigation and Nutrient management.

Introduction

Fingermillet crop covers 12 percent of millets that are in the world and is ranked fourth after sorghum, pearl millet and foxtail millet.Millets are native of semi arid tropics, where salinity and drought are most common phenomena. Feeding the fast-growing human population with balanced nutritional diet under unpredictable severe weather events is a challenging task globally. The climate change crisis is expected to cause shifts in food production and yield loss, causing a severe threat to food security. A key strategy to adapt to a changing climate is to develop and promote elite germplasms with stable yields that can survive under changing weather conditions. There exist great potential in underutilized crops such as finger millet that are well adapted to extreme weather conditions and can act as an alternative food resource towards ensuring food and nutritional security (Mabhaudhi et al., 2019).Therefore, the present investigation was conducted to identify finger millet variety with enhanced tolerance to salt stress based on morpho-physiological traits with the intention to be used in future breeding programmes to develop improved salt tolerant cultivars and identify cost effective management practices.

Materials and Methods

The*In vitro* screening was conducted with five finger millet varieties viz., TRY 1, Paiyur 1,Paiyur 2, CO (Ragi) 14 and ATL 1 were screened for tolerance to various levels of sodicity stresses using sodium bicarbonate ($NaHCO_3$) solution at 0, 25, 50 and 75 mM, based on germination per cent, seedling growth, Vigour index and stress tolerance index.

Seeds were allowed to germinate in Petri dishes with the design of FCRD with five replication.

The field experiment was carried out in Factorial Randomized Block Design with five finger millet varieties viz., TRY I, Paiyur I, Paiyur II, Co (Ra) 14 and ATL 1 with three replications during July 2021 in Anbil Dharmalingam Agricultural college and Research Institute. The pH of soil is 8.5. The foliar spray treatments include DAP (1%), BR (1 ppm), SA (100 ppm) and Nutrient mixture ((Calcium Nitrate (0.5%)+K_2SO_4(0.5%)+$ZnSO_4$(0.5%)+Boric acid (0.2%)) were applied at flowering and grain filling stages was compared with control. The morpho-physiological parameters were recorded at flowering stage and yield and yield parameters were recorded. The data were analysed using the standard procedure described by Gomez and Gomez (1984)

Results and Discussion

In *in vitro* screening high sodicity level of 75 mM, the varieties paiyur 2 and Paiyur 1 registered more than 80 per cent germination. Shoot length of 15 days old seedlings was measured and a significant reduction was noticed in all the varieties subjected to different sodicity levels. Among the varieties, CO (Ra) 14 registered the highest reduction of 73 per cent over control followed by Paiyur 1 (60 per cent). The lowest reduction of 40 per cent was noticed in Paiyur 2 followed by ATL 1 (50 per cent). Highest STI was recorded by Paiyur 2 value of 65 showing their tolerance to sodicity stress. Whereas the poor performing variety CO (Ra)14 recorded significantly lower STI of 48 indicating their susceptibility to sodicity stress. In field experiment among the varieties Paiyur II recorded highest plant height of 98.03cm at flowering stage. Variety ATL1 recorded more SPAD(35.60) which is on par with TRY 1(35.39). Among the treatments BR (1ppm) (35.44) recorded more SPAD value which is on par with nutrient mixture spray (34.92) compared to control. The physiological parameters like soluble proteinand LAI was recorded at flowering stage. Among the treatments nutrient mixture spray recorded more soluble protein (11.22 mg/g) compared to control. Significant increase in yield and yield parameters was observed. Among the varieties paiyur II recorded higher grain yield of 2495 kg/ha compared with check variety of TRY 1 (2462) followed by ATL 1 recorded grain yield of 2431 kg/ha. With regards to foliar spray of nutrient mixture recorded more grain yield of 2304 kg/ha compared with control 2016 kg/ha.From this study it is concluded that Paiyur II and ATL I identified as tolerant varieties and Paiyur I and Co14 as susceptible for sodicity stress. The susceptible varieties-Paiyur I and Co 14 showed significant improvement in physiology and grain yield due to foliar spray with nutrient mixture (Calcium nitrate (0.5%) + K_2SO_4 (0.5%) +$ZnSO_4$(0.5%) +Boric acid (0.2%) at flowering and grain filling stage .High grain yields observed in finger millet can be directly associated with high number of fingers, finger length, number of productive tillers and early flowering. In a similar study, improved performance for agronomic traits under drought stress was positively correlated with grain yield was observed by Shanker and Shanker, 2016.

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Fig.1. Effect of nutrient mixture on yield parameters in finger millet varieties

Fig. 2. Field view

Table 1. Effect of growth promoters and nutrients on physiologicalparameters and yield of finger millet varieties under sodicity

Table 1a. Individual effect

Varieties & Treatments	LAI	SPAD	Soluble Protein (mg/g)	Pt.ht	Grain yield (kg/ha)
Varieties					
M_1-TRY I	2.34	35.39	10.49	89.52	2462
M_2-Paiyur I	1.93	31.16	9.90	83.60	1788
M_3-Paiyur II	2.41	33.07	10.19	98.03	2495
M_4-Co14	2.08	33.75	9.24	83.11	1750
M_5-ATL I	2.53	35.60	11.06	95.60	2431
Mean	2.26	33.79	10.17	94.37	2185
SED	0.05	0.77	0.23	2.16	50
CD (P= 0.05)	0.10	1.55	0.46	4.35	101
Treatments					
S_1-Control	2.05	31.53	9.13	85.65	2016
S_2-DAP(1%)	2.25	32.26	9.63	92.20	2167
S_3- BR (1ppm)	2.27	35.44	10.57	100.14	2230
S_4-SA(100 ppm)	2.24	32.82	10.31	91.77	2211
S_5-NM	2.48	34.92	11.22	102.09	2304
Mean	2.26	33.79	10.17	94.37	2186
SED	0.05	0.77	0.23	2.16	50
CD (P= 0.05)	0.10	1.55	0.46	4.35	101

Table 1b. Interaction effect

Varieties& treatments	LAI	SPAD	Soluble Protein (mg/g)	Pt.ht	Grain yield (kg/ha)
TRY I + control	2.11	34.7	9.48	85	2350
TRY I + DAP(1%)	2.48	35.9	10.33	95	2455
TRY I + BR (1ppm)	2.20	36.0	11.21	102	2500
TRY I + SA(100 ppm)	2.37	34.3	10.24	94	2480
TRY I + NM	2.55	36.6	11.35	98	2567
Pai I + control	1.64	31.3	8.21	82	1754
Pai I + DAP (1%)	2.04	33.6	9.54	99	1800
Pai I + BR (1ppm)	1.77	32.9	10.33	100	1820
Pai I + SA(100 ppm)	1.99	27.2	9.48	82	1690
Pai I + NM	2.20	30.8	11.92	105	1880
Pai II + control	2.17	37.4	9.18	80	2400
Pai II + DAP(1%)	2.62	29.8	9.86	99	2550
Pai II + BR (1ppm)	2.27	34.9	11.23	101	2590
Pai II + SA(100 ppm)	2.45	27.8	9.92	93	2450
Pai II + NM	2.70	37.6	11.45	119	2660
Co14+ control	1.89	31.8	8.58	80	1663
Co14+ DAP(1%)	2.44	38.8	9.53	98	1864
Co14+ BR (1ppm)	2.15	35.7	10.43	95	1910
Co14+ SA(100 ppm)	2.22	33.5	9.86	95	1798
Co14+ NM	2.49	37.2	10.52	104	1980
ATL I + control	2.29	34.0	10.14	91	2438
ATL I + DAP(1%)	2.73	35.8	10.92	103	2453
ATL I + BR (1ppm)	2.32	33.7	11.83	98	2598
ATL I + SA(100 ppm)	2.48	37.0	10.41	95	2410
ATL I + NM	2.83	37.3	11.88	97	2690
SED	0.12	1.73	0.51	4.83	112
CD (P= 0.05)	0.23	3.47	1.04	9.72	225

T3-33
Changes in physiological and biochemical behaviour in Maize (C_4) crop under enriched CO_2

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Abstract

An experiment was conducted at Department of Soil Science & Agricultural Chemistry, TNAU, Coimbatore to know the effect of elevated CO 2 on physiological and biochemical characteristics of maize crop under open top chamber (OTC) condition. The crop was grown in Palaviduthi (S 1) and Periyanaickenpalayam (S 2) soil series under three CO 2 levels viz., 376 µ mol mol -1 CO 2 (C 0), 550 µ mol mol -1 CO 2 (C 1) and 650 µ mol mol -1 CO 2 (C 2). The results revealed that, Chlorophyll 'a'content, chlorophyll 'b' content, Peroxidase, catalase activity and soluble protein content were constantly increasing from KH stage to HT stage. Transpiration rate increased upto CI stage and thereafter it started to decline. Considering CO 2 levels, transpiration rate decreased with increasing levels CO 2 levels in all stages of crop growth, but no significant difference was observed.

Keywords: Open Top Chamber, soil series, CO 2 levels, Maize, Physiological and biochemical behaviour.

Introduction

The CO_2 concentration has increased approximately 25 % from ~ 280 ppm to 350 ppm, since the beginning of the industrial revolution and continues rising at a rate of approximately 0.5% per year. The Intergovernmental Panel on Climate Change Projects, based on climate model results show that the global mean temperature may increase by about 0.3 ºC per decade over the next century and the precipitation and possibly wind patterns may be altered as well. These projected climate change and increases in CO_2 could have significant impact on agriculture. C3 crops indicated that the benefits of growth of elevated CO2 are greatest for CO2 fertilization, lower the productivity and least for yield. Like wise, in an irrigated sorghum elevated CO2 stimulated CO2 fertilization by 9% but did not enhance total biomass or grain yield. A thorough understanding of vast potential of elevated CO_2 concentration on responses of C_4 crops is a pre requisite to develop soil and land use management plans for building up soil carbon for long term perspective in a region.

Materials and Methods

The experiment was conducted in an Open Top Chamber (OTC) at the Department of Soil Science and Agricultural Chemistry, Tamil Nadu Agricultural University, Coimbatore. The experiment was conducted in Factorial Completely Randomized Design (FCRD) with three repetitions. There are totally six treatments three replications.The details on the treatment schedule adopted are given below:

Factor 1: Soil type

a) S_1 – Palaviduthi series
b) S_2 – Periyanaickenpalayam series

Factor 2: CO_2 levels

a) C_0 – 376 μ mol mol^{-1} CO_2

b) C_1 – 550 μ mol mol^{-1} CO_2

c) C_2 - 650 μ mol mol^{-1} CO_2

The crops were kept inside the chamber and subjected to elevated CO_2 at 25 Days after Sowing (DAS). Palaviduthi soil series was sandy 1oam in texture, taxonomically classified as Typic Rhodustalf. The soil was neutral (pH 7.05) with low level of soluble salts (EC 0.03 dS m^{-1}), medium in organic carbon (0.59 per cent), low in $KMnO_4$-N (229.3 kg ha^{-1}), medium in Olsen – P (12.9 Kg ha^{-1}) and NH_4 OAC – K (253.1 Kg ha^{-1}). Periyanaickenpalayam series was sandy clay loam in texture, taxonomically classified as VerticUstropept. The soil was alkaline in reaction (pH 8.21) with medium soluble salts (0.53 dS m^{-1}), medium in organic carbon (0.61 per cent), medium in $KMnO_4$-N (241.6 Kg ha^{-1}) and medium in Olsen –P (15.4 kg ha^{-1}) and NH_4OAC – K (269.5 kg ha^{-1}). Fertilizers were applied according to the general recommendations given in Crop Production Guide (135 kg N, 62.5 kg P_20_5 as SSP, 50 kg K_20 as MOP / ha).

At each growth stage viz., Knee high stage (30 DAS), Tasseling stage (45 DAS), Cob initiation (65 DAS) and Harvest (95 DAS) of maize crop, fully opened 3rd leaf from the top were sampled and used for estimations viz., Chlorophyll content, Soluble protein, Peroxidase and Catalase, Transpiration rate also recorded using Steady State Porometer at each growth stages of the crop. The data on various parameters were analysed statistically using Agres statistical software (Pascal Intel Software Sollutions).

Results and Discussion

The mean values of chlorophyll 'a' content was found to be varied from 1.22, 1.30, 1.36 and 1.44 mg g-1 in KH, TA, CI and HT stages respectively. Among the soil series, crops grown in Periyanickenpalayam soil series (S_2) recorded significantly higher chlorophyll 'a' content than crops grown in Palaviduthi soil series (S_1) in all stages of crop growth. Chlorophyll 'b' content varied from 1.57 in KH stages, 1.62 in TA stage, 1.66 in CI stage and 1.69 in HI stge. Periyanaickenpalayam (S_2) soil series registered higher chlorophyll 'b' content than Palaviduthi soil series (S_1) in all stages of crop growth.

The mean value of soluble protein content varied from 1.17, 1.29, 1.54 and 1.83 mg g^{-1} in KH, TA, CI and HT stages, respectively. Among the soil series, Periyanaickenpalayam soil series (S_2) registered slightly higher soluble protein content than Palaviduthi soil series (S_1) in all stages of crop growth except HT stage but it was not significant. Chlorophyll 'a'content, chlorophyll 'b' content and soluble protein content were constantly increasing from KH stage to HT stage.

The mean value of peroxidase activity was found to be range from 1.19, 1.42, 1.57 and 1.89 Δ 430 nm g^{-1} min^{-1} at KH, TA, CI and HT stage, respectively. Peroxidase activity increased from KH stage to HT stage. Catalase activity was varying from 1.94, 2.10, 2.18 to 2.31 µg H_2O_2 g^{-1} min^{-1} at KH, TA, CI and HT stage, respectively. Peroxidase activity and catalase activity increased from KH stage to HT stage.

The mean value of transpiration rate varied from 1.63, 2.39, 3.45 to 2.96 m mol m^{-2} S^{-1}, KH, TA, CI and HT stages respectively. Transpiration rate increased upto CI stage and thereafter it started to decline. Considering CO_2 levels, transpiration rate decreased with increasing levels CO_2 levels in all stages of crop growth, but no significant difference was observed.

Chlorophyll pigments of maize crop were higher in enriched CO_2 level than ambient CO_2 concentration. But it was not significant. If any of the CO_2 effect on C_4 photosynthesis occurred in this experiment, it might be evident in chlorophyll pigments at any of the four developmental stages assessed by the physiological analysis (Leakey *et al.*, 2006).

Soluble protein is the indirect measure of RUBISCO. 50 per cent of soluble protein is occupied by RUBISCO. The results indicated that, enriched CO_2, did not increase the soluble protein and RUBISCO content in maize crops significantly. There was no evidence of significantly increased soluble protein content even during the vegetative stage of crop development, when sink capacity in maize is relatively low compared to sink capacity during grain filling. It is also possible that lower water use, lower stomatal conductance, might reduce nitrate uptake by mass flow, reduce leaf nitrogen, amino acid, protein and counteract any enhancement of photosynthesis by elevated CO_2 (Leakey *et al.*, 2006).

The activities and amount of antioxidants *viz*., peroxidase and catalase were not significantly affected by the CO_2 concentration. Similar trend was reported by Baczek – Kwinta and Koscielniak (2003). In Maize tissues, H_2O_2 a product of O_2 dismutation, is scavenged by catalase in mitochondria, peroxysomes, glyoxysomes and cytosol and by peroximdase, present mainly in chloroplast and cytosol. Thus, if elevated CO_2 produces high amount of H_2O_2, the scavenging enzymes concentration will also rise. But it was not observed in the present study. This implies that due to enriched CO_2 the crop has not met any biotic or abiotic stress.

Transpiration rate was less in enriched CO_2 plants than in control plants. This reduced transpiration rate was due to lower stomatal conductance. This lower stomatal conductance and transpiration rate may have counteracted the development of water stress under elevated CO_2. Reduced transpiration rate due to elevated CO_2 was also observed by Leakey *et al.* (2004).

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T3-34

Effect of terminal heat stress mitigation treatments on seed yield and quality in sorghum (*Sorghum bicolor*)

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Abstract

Sorghum yield potential is often limited by short high temperature stress occurring primarily during the reproductive period. To overcome the terminal heat stress effect in sorghum, an experiment was conducted at KVK, Pongalur, Tamil Nadu Agricultural University, Coimbtore during 2021-2022 under AICRP on seed (Crops) operating at Seed Centre, TNAU, Coimbatore.The mitigation treatments *viz.,* salicylic acid (400 ppm and 800 ppm), ascorbic acid (10 ppm), KCl (500 ppm) and cycocel (50 ppm) were imposed as foliar spray at vegetative stage (40 DAP), anthesis stage and both combination of vegetative + anthesis stage. The results revealed that in **sorghum, f**oliar spray with salicylic acid @ 400ppm during both vegetative and anthesis stage increased the plant physiological parameters and yield up to 15.2 % (3750 kg/ha) with the maximum 1000 seed weight (28.4 g) and resultanr seed germination (94 %) over control (3255 kg/ha, 27.8g and 86 %, respectively)

Introduction

High temperature stress during floret development alters pollen morphology and results in an abnormal exine wall, degeneration of tapetum cells, and membrane damage, leading to pollen sterility in grain sorghum (Djanaguiraman *et al.*, 2014). Similarly, high temperature stress during anthesis decreases seed set in many cereal crops including sorghum (Singh *et al*., 2015), resulting in lower grain numbers and grain yield. High temperature stress during anthesis causes poor anther dehiscence and impairs pollen tube growth and hampers fertilization, resulting in lower seed set (Jagadish et al., 2007). Although studies have shown that in grain sorghum high temperature stress (>36°C; daytime maximum temperature) decreases floret fertility (Jain *et al*., 2010), the relative sensitivity of various reproductive growth stages (panicle emergence, anthesis, and grain filling) on yield and resultant seed quality have not been studied.Based on these background, the present experiment was conducted to assess the effect of mitigation treatment to overcome the heat stress effect at different growth stages and resultant seed quality in sorghum.

Materials and Methods

An experiment was conducted at KVK, Pongalur, Tamil Nadu Agricultural University, Coimbtore by adopting Factorial Randomized Block Design (FRBD) with four replications during 2021-2022 under AICRP on seed (Crops) operating at Seed Centre, TNAU, Coimbatore. Sorghum variety K12 was raised in an area of 0.4 ha at KVK, Pongalur during February 2021 for exposing the crop at high temperature during anthesis stage (April -May 2021). The mitigation treatments *viz.,* salicylic acid (400 ppm and 800 ppm), ascorbic acid (10 ppm), KCl (500 ppm) and cycocel (50 ppm) were imposed as foliar spray at vegetative stage (40 DAP), anthesis stage (70 DAP) and both in combination of vegetative + anthesis stage. Plant physiological and yield parameters were recorded. Immediately after harvest, germination test was conducted in the resultant seeds.Germination, vigour index andseedling dryweight were estimated. The data were subjected to an Analysis of Variance and treatment differences tested (test) for significance ($P \geq 0.05$) (Gomez and Gomez ,1984). Wherever necessary, the percentage values were transformed to arc sine values.

Results and Discussion

Foliar spray of Salicylic acid @ 400ppm at both vegetative (40 days after sowing) and anthesis stage (70 days after sowing) induces ear formation at 6 days earlier and the maximum plant height (232 cm) than the control (224 cm). The foliar treatment with Salicylic acid induced the early maturity *ie.* 7 days earlier than the control and produced the maximum number of seeds per ear (1545), yield per plant (41.3g), yield (3750kg/ha) over control (1458 nos, 38.5g and 3255kg/ha) (Table 1). The yield increase due Salicylic acid @ 400ppm foliar spray at vegetative and anthesis stage was 15.2% higher than the control and other treatments. After harvesting, the seeds obtained from foliartreatmentwith Salicylic acid @ 400ppm recorded the maximum germination (94%), vigour index I (3412) and II (4925) over the control (86%, 2812 & 4925, respectively) (Table 2).During anthesis stage, the temperature prevailed was >37^{0}C at KVK Pongalur.

In sorghum, foliar spray with salicylic acid @ 400ppm at both vegetative and anthesis stage increased the yield up to 15.2 % and the resultant seeds recorded the maximum germination of 94%.

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Table 1. Effect of heat stress mitigation treatment on plant physiological parameters in sorghum K12

Treatments/Stage of spraying	Days to ear formation			Plant height at physiological maturity (cm)		
	Vegetative stage	Anthesis stage	Vegetative +Anthesis	Vegetative stage	Anthesis stage	Vegetative +Anthesis
Control	60	59	58	215	218	224
Salicylic acid 800 ppm	58	59	56	218	220	228
Salicylic acid 400 ppm	55	53	52	224	227	232
Ascorbic acid10 ppm	57	55	54	220	224	227
KCl 500 ppm	58	56	55	216	222	225
Thiourea 400 ppm	57	55	53	218	225	229
Cycocel 50 ppm	56	55	54	216	219	223
Mean	57	56	55	218	222	227
	T	S	TXS	T	S	TXS
SEd	1.7	0.8	2.0	1.2	0.7	1.8
CD (p=0.05)	3.5	1.7	4.1	2.5	1.5	3.6

Table 1. Effect of heat stress mitigation treatment on yield parameters in sorghum K12

Treatments/Stage of spraying	Total number of seeds /ear			Yield (kg /ha)		
	Vegetative stage	Anthesis stage	Vegetative +Anthesis	Vegetative stage	Anthesis stage	Vegetative +Anthesis
Control	1157	1245	1458	2780	3054	3255
Salicylic acid 800 ppm	1235	1328	1478	2875	3240	3457
Salicylic acid 400 ppm	1280	1425	1545	3125	3550	3750
Ascorbic acid 10 ppm	1200	1327	1450	3050	3254	3386
KCl 500 ppm	1245	1289	1358	2856	3145	3367
Thiourea 400 ppm	1189	1300	1421	2980	3245	3456
Cycocel 50 ppm	1268	1342	1358	2886	3347	3420
Mean	1225	1322	1438	2936	3262	3442
	T	S	TXS	T	S	TXS
SEd	1.7	0.8	2.0	1.2	0.7	1.8
CD (p=0.05)	3.5	1.7	4.1	2.5	1.5	3.6

T3-35
Physiological effects of cerium nanoparticles on sorghum under drought stress

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Abstract

Cerium oxide nanoparticles have been utilized in various fields of science due to their exemplary phenomena but in less exploited in agricultural science. The objectives of this study are to (i) examine whether there are differences in toxicity potential among different concentrations of nanoceria to each organism representing each trophic level, (ii) quantify the effect of nanoceria on the transpiration rate of sorghum plants under drying soil, and (iii) understand the mechanism associated with alleviation of drought stress by nanoceria. The toxicity potential of nanoceria to phosphobacteria, azolla, microalgae, sorghum leaves, and sorghum pollen were quantified. The different organisms were exposed to different concentrations of cerium nanoparticles namely 0, 5, 10, 25, 50, 100, 200, 400, 500, and 1000 mg L^{-1}. In conclusion, the toxicity assays performed using organisms showed that nanoceria is not toxic to terrestrial plants, aquatic organisms, and soil microbes at a lower concentration, up to 25 mg L^{-1}. A progressive soil drying experiment was conducted using CO 30 sorghum variety. Drought stress was imposed at the five-leaf stage for five days, and the treatments included foliar spray of bulk cerium nitrate, nanoceria, and unsprayed control. Results evidenced that nanoceria and bulk ceria spray have resulted in high FTSW thresholds. Under drought stress, foliar application of nanoceria had protected the photosynthetic rate and pollen germination, resulting in sustained carbon assimilation and higher seed-set percentage and it could be associated with osmotic adjustment caused by nanoceria and efficient scavenging of ROS produced under drought.

Keywords: Sorghum, drought, nanoparticles, cerium, FTSW

Introduction

Nanoparticles have potential applications in several sectors of science like medical science, engineering, and biotechnology, including agriculture, where through nano technology, synthesize of nano fertilizers, carriers of agrochemicals and nanoparticles to mitigate abiotic stress are synthesized and used (Prasad *et al*., 2017). Nanotoxicology explains the interaction effects between the nanoparticle and a living organism. In general,toxicology depends on the dose, but in the case of nanoparticles, it depends on size, number, surface activity and aggregation (Paramo *et al*., 2020).Any morphological, biochemical or molecular changes in the test organism due to exposure to nanomaterial is said to be their effects; if the effects are positive and enhance growth, then the nanomaterial has a positive influence. In contrast, if the material has an adverse impact on morphology, function, and growth, then it is negatively influenced. The significant aftermath of the nanoparticle toxicity in most organisms is associated with increased concentration of reactive oxygen species (ROS), which can cause loss of membrane integrity and oxidation of biomolecules (Klaine *et al.,* 2008).

In the recent past, cerium oxide nanoparticles have gained attention for various uses like exhibiting redox activities, free radical scavenging, inhibition of biofilms and the like. Foliar application of silicon nanoparticle under salinity stress to cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) has improved the photosynthesis rate, mesophyll conductance, and plant water use efficiency compared with unsprayed control (Haghighi *et al*., 2013). Application of $nTiO_2$ to chickpea (*Cicer arietinum* L.) exposed to low-temperature stress has improved the membrane integrity in both tolerant and susceptible genotypes (Mohammadi *et al*., 2013). Foliar application of copper nanoparticles against the *Fusarium* sp. was more effective than the commercially available fungicides (Brahmanwade *et al*., 2015).Therefore, experiments were conducted to (i) examine whether there are differences in toxicity potential among different concentrations of nanoceria to each organism representing each trophic level, (ii) quantify the effect of nanoceria on the transpiration rate of sorghum plants under drying soil, and (iii) understand the mechanism associated with alleviation of drought stress by nanoceria.

Materials and Methods

Ecotoxicity experiment:The phosphobacteria, azolla, microalgae, sorghum leaves, and sorghum pollenwere exposed to different concentrations of cerium nanoparticles namely 0, 5, 10, 25, 50, 100, 200, 400, 500, and 1000 mg L^{-1}.

Quantifying the effects of nanoceria on the transpiration rate of sorghum under drying soil:A pot-culture experiment was conducted in a completely randomized block design with four replications.Plants were grown under the natural sunlit condition at a photosynthetic photon flux density (PPFD) of 800-900 μmol m^{-2} s^{-1} from sowing to the five-leaf stage at 80% pot capacity.Three treatments namely foliar spray of water (T_1), bulk ceria (T_2) and nanoceria (T_3) were imposed. The soil moisture content was measured using FTSW procedure.The various physiological traits like chlorophyll index, canopy temperature, minimum fluorescence yield (Fo), maximum fluorescence yield (Fm), photosynthetic rate, transpiration rate, stomatal conductance, and intercellular CO_2 concentration were recorded at FTSW of 0.4, which occurred on 4^{th} day of stress. The data was analysed using SAS programs version 9.4 (SAS Institute 2003).

Results and Discussion

The effect of nanoceria on phosphobacteria growth was assessed by counting colony-forming units (CFU), and there were significant (P<0.01) differences among the treatments. The result indicated that increasing the concentration of nanoceria in the growth medium decreased the colony-forming units, and a severe decrease was observed from 200 mg L^{-1}. The azolla and microalgae dry biomass were significantly decreased in media amended with 200 mg L^{-1} to 1000 mg L^{-1} of nanoceria (Fig. 1). The growth of microalgae decreased at a higher level than azolla growth.Among the various nanoceria concentrations, Fv/Fm ratio started to decrease from 50 mg L^{-1} to 1000 mg L^{-1}. *In-vitro* pollen germination of sorghum pollen grains decreased on exposure to nanoceria from the concentration of 50 mgL^{-1}. It was evident that increasing the concentration of nanoceria in the medium significantly reduced the pollen germination percentage from 62% (0 mg L^{-1}) to 6.4 % (1000 mg L^{-1}).Overall, the impact of nanoceria on sorghum seed germination was very low. However, nanoceria treatment had a profound effect on seedling vigour, as evidenced by a significant decrease in seedling vigour from 50 mg L^{-1} of nanoceria. The decrease in seedling vigour was associated with decreased root length from 50 mg L^{-1} to 1000 mg $L^{-1}$of nanoceria treatment, and not with germination percentage and shoot length. Azolla and microalgae dry biomass were significantly decreased from 200 mg L^{-1} to 1000 mg $L^{-1}$of nanoceria. It is possible to predict that at higher concentrations, nanoceria may induce the production of ROS due to its size, surface charges, and chemical reactivity (Auffan *et al*., 2010), which might have decreased the growth of aquatic organisms like azolla and microalgae (Hoecke*et al.,* 2009).Xue *et al.*(2011) provided direct experimental evidence that cerium nanoparticles can efficiently scavenge •OH based on nanoparticle size and Ce^{3+} surface levels or surface charge level.

The fraction of transpirable soil water (FTSW) varied significantly (P<0.05) for days of drying, foliar sprays, and interaction of days of drying and foliar sprays. In contrast, the transpiration rate varied significantly (P<0.05) for days of drying and foliar sprays only (Table 1). Also, there were significant differences (P<0.001) among the foliar spray treatments for chlorophyll index (SPAD units), canopy temperature (°C), stomatal conductance (mol m^{-2} s^{-1}), intercellular CO_2 concentration (μmol mol^{-1}), transpiration rate (mmol m^{-2} s^{-1}), and leaf photosynthetic rate (μmol m^{-2} s^{-1}).

There were significant differences in transpiration rate among the treatments from day 0 to day 8. The value for breakpoint ranged between 0.63 and 0.64 FTSW. The lowest breakpoint was observed in nanoceria treatment (0.61 FTSW), followed by bulk ceria (0.63 FTSW). The highest breakpoint was observed in water spray plants. The r^2 for the two-segment regression for control, bulk ceria and nanoceria were 0.93, 0.89 and 0.84. The linear regression slope below the breakpoint (Slope 1) ranged between 0.205 to 0.288 FTSW, and there was a positive relationship between breakpoint and slope 1. The slope of transpiration response to FTSW above the breakpoint (Slope 2) was much less than Slope 1. There was no relationship between Slope 2 and breakpoint.In this study, nanoceria and bulk ceria sprayed plants had high FTSW thresholds than water sprayed plants. In other words, nanoceria treated plants had exhibited a restricted transpiration rate compared with water sprayed plant at high FTSW content. However, the difference between nanoceria and water sprayed plant was very meagre. The possible hypothesis to explain decreased transpiration rate in nanoceria treatment than other treatments may be associated with limitation in hydraulic conductance (Sinclair *et al.,* 2005).

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Fig. 1. Effect of different concentration of nanoceria on growth of azolla and microalgae

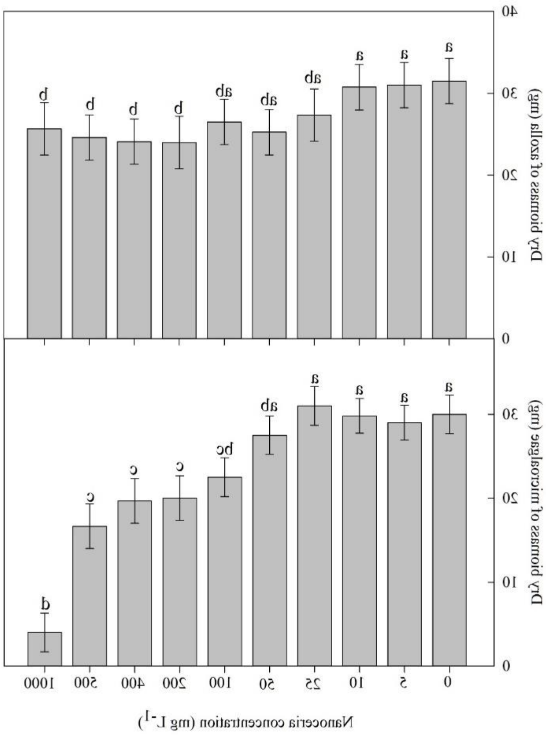
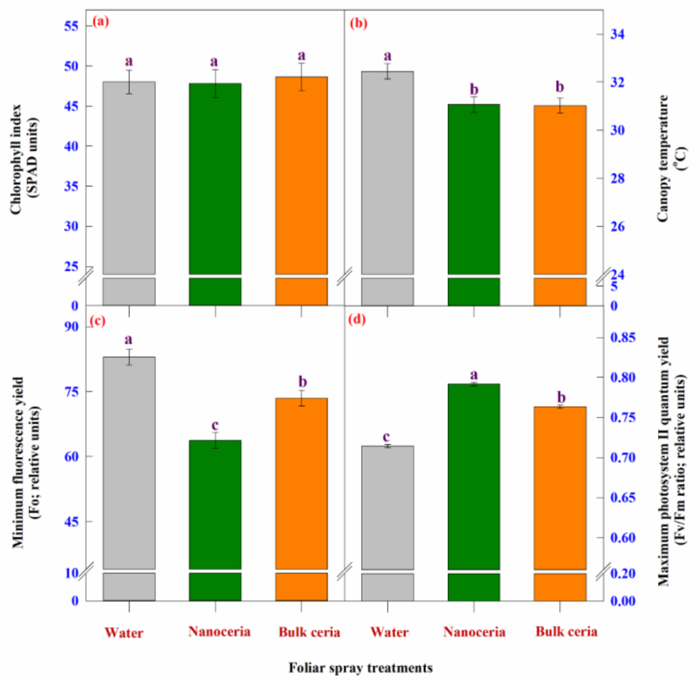


Fig. 2. Effect of nanoceria, bulk ceria and water spray on chlorophyll index (SPAD units), canopy temperature (°C), minimum fluorescence yield (Fo; relative units) and maximum photosystem II quantum yield (Fv/Fm ratio; relative units) of sorghum grown in drying soil. Each data point is the average of four replications.



T3-36

Effect of high temperature stress on pollen characters of Maize (*Zea mays* L.) inbreds

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Abstract

Climatic change has a strong influence on agriculture. Maize (*Zea mays* L.) is the most widely cultivated cereal grain in the world. Developing maize cultivars with high temperature stress tolerance is a major goal around the world. Based on this background, a pot culture experiment was conducted during January to April, 2021 (*rabi* season) in the Department of Crop Physiology, TNAU, Coimbatore to explore about the physiological and biochemical changes in two maize genotypes (UMI 1230 and CBM-DL-322) under elevated temperatures *viz*., T_1: Ambient temperature (37ºC), T_2: Ambient temperature + 4ºC (41ºC) and T_3: Ambient temperature + 6ºC (43ºC) under open top chamber (OTC) for ten days during reproductive stage and various parameters were recorded and analyzed under factorial completely randomized design with seven replication. Results revealed that, the pollen viability and germination were affected negatively in both maize inbreds. Comparing two temperature treatments, ambient temperature + 6ºC, recorded more per cent reduction than ambient temperature + 4ºC in both UMI 1230 and CBM-DL-322 inbreds. The similar trend was followed in pollen grain size and tube length of the pollen.

Keywords: Maize, High temperature, pollen characters

Introduction

After rice and wheat, maize is the important cereal in India and it is called as 'Queen of cereal'. As reported by United Nations of Food and Agriculture Organization (FAO), in developing countries, among cereal crops maize and wheat contribute 2/3 of food requirement. Maize is one of most widely produced crops in the world, being the first in grain production with a yield that exceeded 1.1 billion tons in 2021 (Serna, 2022). According to the United Nations body in charge of evaluating climate change science, the Intergovernmental Panel on Climate Change, global air temperatures was forecast to rise by 0.2°C per decade, reaching temperatures that are 1.8–4°C higher than current levels by 2100 (Conrow, 2020). According to the Naveed *et al.* (2014b) plants exposed to high temperature at reproductive stage for long time adversely affects the pollen viability, germination and tube growth rate.

So the occurrence of any abiotic and biotic stress during this critical period registers a significant negative impact on yield. Hence, this study was proposed to understand and quantify the impact of elevated temperatures occuring during the reproductive stage on the pollen characters (pollen germination, pollen tube length and pollen viability) of selected maize inbreds.

Materials and Methods

Pollen characters *viz*., Pollen viability (Potassium Iodide), pollen germination percentage (Walden, 1994) and pollen grain size (Naveed *et al.* , 2014a) was analyzed in laboratory by using the glass slide. The fresh pollen was collected in the early morning from the tassel cover. The wrapped plant's tassel which represents the treatment and collected the pollen by tapping method. The collected pollens were observed under optical microscope at magnification 40X.

Results and Discussion

Pollen viability percentage (%)

Irrespective of the inbred lines, maximum pollen viability percentage was observed in ambient temperature treatment, followed by ambient+4ºC and least in ambient+6ºC (Figure 1). Irrespective of the treatment the genotype CBM-DL-322 showed significantly higher pollen viability (75.57 %) than UMI 1230 (69.05 %) inbred. This could be due to, high temperature stress occurs during pollen development, which cause early tapetal cell degeneration due to poor source translocation to growing pollen grains, resulting in loss of pollen viability (Lizaso *et al.*, 2018).

Pollen germination percentage (%)

Pollen from CBM-DL-322 inbred line showed maximum germination percentage (65.54%) than UMI 1230 (58.03%) inbred. Pollen collected from ambient + 6ºC (37.84%) plants showed significant reduction germination than other temperature treatments. This could be due to a number of factors, such as delayed maturation, heat induced to enzymes inactivation , denaturation of protein, nucleic acids involved in the germination process and heat-induced improper dehydration (Ogolla, 2019).

Pollen grain size (µm)

Among the two genotypes, CBM-DL-322 inbred showed significantly increased pollen size (115.79 µm) than the UMI 1230 (107.58 µm) inbred. Among the temperature treatments ambient condition (122.36 µm) showed significantly higher pollen size compared to ambient +4ºC and ambient + 6ºC of 113.35and 99.33µm respectively. This might be the result of increased temperature stress during pollen development, which tends to result in early tapetal cell degeneration resulting from poor source translocation to growing pollen, leading to reduced pollen grain size (Wang *et al.*, 2016).

When comparing both genotypes under high temperature stress, maize inbred line CBM-DL-322 performed better under both high temperature treatments conditions compared to UMI 1230 inbred. Within the temperature treatment, ambient temperature+4ºC showed less percentage reduction in pollen viability, pollen germination percentage and pollen grain size. Therefore, CBM-DL-322 inbred can be used in the region where high temperatures are predominant, or it can be used as a parent in a breeding programme for developing high temperature-tolerant varieties.

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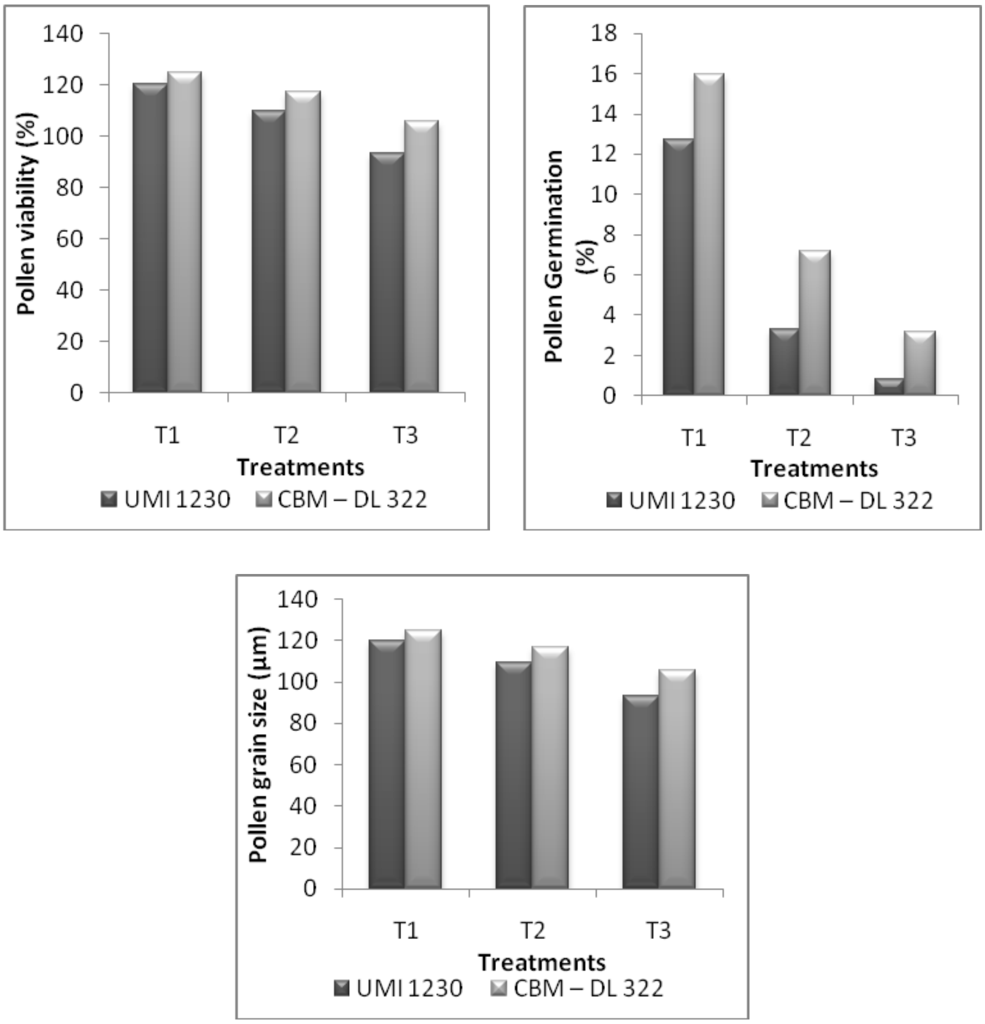
Fig. 1. Effect of High Temperature Stress on Pollen Germination Percentage (%), pollen viability percentage (%) and pollen grain size (μm)



T3-37
Influence of AM fungi on physiological character and yield of sorghum under rainfed condition

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Abstract

Field trial was conducted during 2019-20 to study the effect of AM fungi on the physiological character and yield of sorghum under rainfed condition. Experiment was laid out in Randomized block design with three replications. The treatment combination comprised of T_1 : Un inoculated control, T_2 : Seed treatment with AM Fungi @ 20 g ha^{-1} of seed, T_3 : Seed treatment with AM Fungi @ 25 g/ ha^{-1} of seed, T_4 : Seed treatment with AM Fungi @ 30 g/ ha^{-1} of seed, T_5: Soil application with AM Fungi @ 37.5 kg ha^{-1}, T_6 : Soil application with AM Fungi @ 50 kg ha^{-1}, T_7 : Soil application with AM Fungi @ 62.5 kg ha^{-1}. The result of the experiment revealed that the yield characters, yield, root characters, physiological characters and microbial infection were higher in soil application of AM fungi @ 62.5 kg ha^{-1} which was followed by soil application of AM fungi @ 50 kg ha^{-1}.

Keywords: Sorghum, AM fungi, Root infection, Enzymes and Yield

Introduction

Drought is still a serious agronomic problem and one of the most important factors contributing to crop yield loss. For sorghum grown in India, water resources are very limited with drought stress often occurring during the growth season. Drought influencing grain production and quality, with increasing global climate change making the situation more serious. Drought stress isone of the most important environmental factors limiting growth and development of the crop plants (Kramer, and Boyer, 1997). Vesicular – arbuscularmycorrhizal (VAM) fungi are known to enhance the ability of the plants to establish and cope with stress situations (nutrient deficiency, drought, etc.). The useof these fungi as plant inoculants, was investigated to help plants to thrive in degraded arid/semiarid areas (Allen and Allen, 1980). While drought responses in mycorrhizal crop plant species have received considerable attention (Alguacil, 2003) yet, physiological responses during drought recovery are still poorly studied.

These fungi have been considered as keystone species in increasing ecosystem productivity and have the potential to affect plant diversity by providing increased access to immobile soil nutrients, water, and also by increasing root pathogen resistance (Rillig, 2004).The effect is often more pronounced in plants grown under drought stressed conditions than under well-watered conditions (Sanchez-Diaz and Honrubia, 1994).In other words, AMs are able to alter plant physiology in a way that confers the plant ability to more efficiently grow under stressful conditions and cope with stresses (Miransari, *et al*., 2008).

In addition, Auge, (2001) suggested that mycorrhizal soil itself could somehow directly influence the water relations of plants associated with them. So the goal of this research is investigating the effect of mycorrhiza on yield and yield component of sorghum in drought condition.

Materials and Methods

Experiment was conducted in black soil farm of Agricultural Research Station, Kovilpatti and it was laid out in Randomized block design and replicated thrice. The treatment combination comprised of

Treatments (Foliar spray)

T_1 : Un inoculated control
T_2 : Seed treatment with AM Fungi @ 20 g ha^{-1} of seed
T_3 : Seed treatment with AM Fungi @ 25 g/ ha^{-1} of seed
T_4 : Seed treatment with AM Fungi @ 30 g/ ha^{-1} of seed
T_5 : Soil application with AM Fungi @ 37.5 kg ha^{-1}
T_6 : Soil application with AM Fungi @ 50 kg ha^{-1}
T_7 : Soil application with AM Fungi @ 62.5 kg ha^{-1}
Design : RBD
Replication : Three
Variety: Sorghum K 12

The crop was sown with spacing of 45 x 15 cm. The soil was clay in texture with sub angular blocky in structure with WHC of 65%, EC: 0.32 dSm^{-1}, pH: 8.45, Available N: P: K is 160: 16.1: 350 kg ha^{-1} respectively. The seeds are pre-soaked in 2% potassium dihydrogen phosphate solution for 6 hours in equal volume and then dried back to its original moisture content in shade and are used for sowing. The common farm yard manure (12.5 t / ha) and fertilizer doses (40:20:0 kg NPK / ha) were adapted to all the treatment combination uniformly.

The Atrazine 0.25 kg/ha was given on 3rd day after soaking rain to control the initial weed growth. Hand weeding was done on 30 DAS to control weeds. Various observations like plant height, dry matter production, root length, root biomass, number of seeds per panicle, 1000 grain weight and yield, plant stress, microbial infection %, soil dehydrogenase Soluble protein, NRase, Proline and Catalase were recorded replication wise.

Result and Discussion

The crop received 146.1 mm rainfall in 9 rainy days. Plant height was higher in soil application of AM fungi @ 62.5 kg $ha^{-1.}$ The crop received higher morning relative humidity (more than 90%) from vegetative to grain development stage leads to severe midge and smut damage. Hence yield of crop was lesser than normal yield. Significantly higher grain yield (500 kg ha^{-1}) and straw yield (7000 kg ha^{-1}) were recorded by soil application of AM fungi @ 62.5 kg ha^{-1} which was followed by soil application of AM fungi @ 50 kg $ha^{-1.}$ Treatments failed to influence root length of sorghum plant. Root biomass was significantly higher in soil application of AM fungi @ 62.5 kg ha^{-1} at all the stages of crop growth. Plant physiological characters *viz*., soluble protein, proline content and catalase activity was significantly higher in soil application of AM fungi @ 62.5 kg ha^{-1} than control while treatment failed to influence NRase activity. Mycorrhizal infection % and soil dehydrogenase was higher in soil application of AM fungi @ 62.5 kg ha^{-1} at all the stages of crop growth (Table 1). This may be due to different species of AM have the ability for adaptation to different conditions and being synergistic with indigenous soil microorganisms and helped the plant to survive adverse stress condition.

Soil application of AM fungi @ 62.5 kg ha^{-1} helped the plant to tolerate adverse climatic condition. Hence for getting higher yield in sorghum under drought situation, soil application of AM fungi @ 62.5 kg ha^{-1} may be followed.

Table 1. Influence of AM fungi on growth parameters, yield parameters and yield of sorghum under rainfed condition during 2019-2020

Treat ments	Plant height (cm)	Grain yield (kg/ha)	Straw yield (kg/ha)	Root length (cm)	Root biomass (kg/ha)	Soluble protein (mg/g)	NRase (µg/NO_2 /g/h)	Proline (mg/g)	Catalase (µg H_2O_2 g^{-1} min^{-1})	Mycorrhizal infection %	Soil dehydro -genase (mg TPF g^{-1} day)
T1	159.0	380	5800	25.3	19	7.1	68.4	320	3.4	30.0	4.43
T2	156.8	410	6000	25.4	20	7.8	70.3	392	3.7	46.7	4.96
T3	168.9	440	6700	25.9	36	8.1	72.5	414	4.3	53.3	5.55
T4	158.1	415	6150	25.4	27	7.9	72.8	432	4.8	46.7	4.62
T5	160.9	425	6200	25.6	33	8.2	70.1	545	6.5	53.3	4.91
T6	172.4	460	6800	26.2	47	9.3	75.3	564	7.3	53.3	5.89
T7	178.3	500	7000	26.9	67	9.5	78.5	572	7.8	56.7	6.12
S.Ed.	10.0	27.4	389.4	1.5	4	0.5	4.4	31.6	0.4	3.2	0.34
CD	NS	82.3	1168.2	NS	11	1.6	NS	94.8	1.3	9.6	1.01

T3-38

Upsurging the media for optimal growth and sporulation of *Sphaerellopsis paraphysata*

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Abstract

Several biotic and abiotic factors distress the pearl millet and significantly influence the production. Leaf rust, caused by *Puccinia substriata*, is the most important disease among the biotic factors, which reduced the yield up to 76 percent. *Sphaerellopsis paraphysata* is a rust mycoparasite with a wide host range that inhibits rust spore germination which could be cultured and could be grown on potato dextrose agar media. The effect of different carbon and nitrogen sources on the growth of *S. paraphysata* TNAU Sp1 showed that the dextrose and sodium nitrate supported the maximum mean mycelial growth and recorded 60.00 and 58.67 mm, respectively.

Keywords: Pearl millet rust, Mycoparasite, *Sphaerellopsis paraphysata*, Artificial media, Growth and sporulation

Introduction

Pearlmillet (*Pennisetum glaucum*) is an important food grain crop and widely grown millet throughout the world. The major pearl millet producing states of India are Rajasthan, Gujarat and Tamil Nadu. Among the diseases of pearl millet, the leaf rust caused by *Puccinia substriata* is the most destructive causing yield loss up to76% (Wilson *et al*. 2000; Thakur *et al*., 2011). *Sphaerellopsis spp*. is a hyper parasitic fungi which parasitizes the rust pathogen and thus reduces the incidence. Hence, attempts were made to standardize the parameters required for optimum growth of *Sphaerellopsis paraphysata*.

Materials and Methods

The pycnidia of *S.paraphysata* in the rust infected leaves were scrapped and the pycnidia were dipped in sodium hypochlorite for 30 sec and then mixed with water agar medium, after the solidification of the media the pycnidia dispersed randomly in the water agar were marked with a marker under stereo zoom microscope and incubated at 25ºC for 48 hours and then the germinated spores were located and marked which are transferred to another Petri dish containing V8 juice agar (Asmitha Sri *et al*., 2019).Streptomycin was added to prevent the bacterial contamination.

Potato dextrose agar medium was used as a basal medium by adding different carbon and nitrogen sources to study their influence on the radial mycelial growth of *S. paraphysata.* The sources were added separately to the basal medium at 20g per litre. Every treatment was replicated thrice and the radial mycelial growth was measured 25 days after incubation (Behera and Makhija, 2001).

Results and Discussion

The results showed that the maximum mycelial growth (58.8 mm) and mycelial dry weight (9.85g) were observed when dextrose was used a carbon source followed by cellulose which recorded 54.5 mm and 9.28 g as mean mycelial growth and dry weight, respectively besides inducing more pycnidial production. Among the tested nitrogen sources, sodium nitrate had recorded maximum mean mycelial growth (58.8 mm) and mycelia dry weight (3.70g) which statistically on par with potassium nitrate and urea. The least mycelial growth was obtained in ammonium nitrate (38.8 mm). The maximum mycelial growth and dry mycelial weight of *S. paraphysata* was obtained when dextrose used as carbon source while, Rambo and Bean, (1970) had reported that the fructose followed by sucrose were responsible for the growth and development of *S. paraphysata*.

Among the nitrogen sources, sodium nitrate obtained the maximum growth and the results obtained was similar to Parthasarathy, (2018), who reported that peptone and yeast extract had yielded maximum mycelial growth for *A. quisqualis.* In liquid media the highest dry mycelial weight was obtained with sodium nitrate while ammonium nitrate recorded the least growth. This was in accordance with Parthasarathy, 2018, who stated that maximum mycelial growth of *A. quisqualis* was obtained in peptone. Hence, the *S. paraphysata*- a myco parasite on pearl millet rust pathogen *Puccinia substriata* could be commercially mass multiplied and potentially exploited as a biocontrol agent.

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Effect of different carbon sources on the growth of S. *paraphysata*

Treatments	Mycelial growth (mm)	Dry Weight of Mycelia (g)	Pycnidial production
Carbon sources			
Sucrose	46.0^{c}	8.48^{c}	+
Cellulose	54.5^{b}	9.28^{b}	++
Starch	54.0^{b}	8.43^{c}	+
Mannose	28.0^{d}	2.25^{e}	+
Maltose	45.0^{c}	5.08^{d}	+
Dextrose	58.8^{a}	9.85^{a}	+
Nitrogen sources			
Peptone	46.8^{b}	2.48^{c}	+
Urea	56.5^{a}	2.95^{bc}	-
Potassium nitrate	56.3^{a}	2.65^{c}	++
Beef Extract	55.0^{a}	3.40^{ab}	++
Ammonium nitrate	38.8^{c}	1.38^{d}	++
Sodium nitrate	58.8^{a}	3.70^{a}	++

Values are mean of three replications; Means in a column followed by the same alphabet are not significantly different according to DMRT at $p<0.01$

T3-39

Effective management of *Fusarium verticilloides* causing Maize (*Zea mays* L.) ear rot by Phyllosphere antagonistic bacteria

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Abstract

Maize (*Zea mays* L.) is the third most important cereal crop next to rice and wheat in the world and in India. It is known as “Queen of cereals”. Maize ear rot is a fungus-induced ear disease that occurs widely in Europe, America, Africa, Asia and Oceania. In 1977, maize ear rot swept through the state of Meghalaya and India. Several biocontrol microorganisms have been isolated from rhizosphere and used for the management of soil borne fungal and bacterial pathogens. Their use on the management of foliar diseases / phyllosphere diseases is not successful. Because the rhizosphere antagonistic microorganisms may not survive in the phyllosphere region due to erratic temperature variation, exposure to direct sunlight, UV irradiation and low availability of moisture and nutrient in the phyllosphere region. Investigating the presence of native antagonistic bacteria from the phyllosphere and to evaluate their ability to suppress *Fusarium verticilloides (F. verticilloides)* in maize is very essential. Six bacterial strains were isolated from *calotropis*, *opuntia*, and *Acalypha phyllosphere* and screened *in vitro* antagonism against *Fusarium verticilloides*. Out of these, four strains showed significant levels of antagonism against *F. verticilloides* and promoted enormous germination of maize. Field study was conducted with mass multiplied bacteria with seed treatment, foliar and soil application which demonstrates the effectiveness of *Pseudomonas stutzeri* strains isolated from the phyllosphere in the management of the ear rot of maize and shows that Phyllosphere can harbor bacterial strains with antagonistic activity against *F. verticilloides.*

Keywords: *Fusarium verticilloides*, *Pseudomonas stutzeri*, Phyllosphere, PDI, PROC, yield attributes

Introduction

Biocontrol is environmentally safe, and in some cases, it is the only option to protect plants against pathogens. Recently, attention has been focused on finding the phyllosphere colonizing anti-microbial agent for controlling foliar/phyllosphere pathogens (Innerebner *et al*. 2011). The disease symptoms of Fusarium ear rot appears on kernels as moldy growth which may be initially white, pink or salmon colored. Later the infected kernels may turn to tan or brown in colour. Other symptom like “Starburst” symptom is more prevalent and is characterized by white streaks beneath the pericarp, radiating basipetally from the kernel silk scar (Fig 1A). It should be wise to find phyllosphere colonizing antagonistic microbes that could better survive in the dynamic atmospheric conditions of the phyllosphere region compared to the rhizosphere region. Development of control measures for fumonisins producing *F.verticillioides* in maize is still at an early stage. There has been little success with these fungicides, and pesticide residue and phytotoxicity are major problems leading to environmental pollution and human health hazard. In addition, they are expensive. Therefore, finding an alternative control practice for Fusarium ear rot disease management in maize is necessary.

Materials and Methods

Based on 16S rDNA gene sequence analysis, the four bacterial strains were identified (*Pseudomonas stutzeri-1*, *Pseudomonas stutzeri-2*, *Bacillus amyloliquefaciens* , *Pseudomonas aeruginosa)* with 27F +1115R and 27F+1525R primers, remaining two strains were identified through biochemical and colony morphology as *Bacillus subtilis*1 and *Bacillus subtilis* 2. The mass multiplication of effective bacterial strains was initially prepared through a procedure given by Vidhyasekaran and Muthamilan (1995). A loop full of effective bacterial Isolates were inoculated separately into sterilized and cooled King's B and NA broth, respectively, and incubated for 48 hours at 28$\pm$ 2°C. Forty eight hour old bacterial culture in their respective medium with a population of 9 x 10^8 cfu/ml were mixed with 1 kg of talc containing 15 g of $Caco_3$ and 10 g of carboxy methyl cellulose (CMC) under sterile conditions. While applying the population of bacterium in talc formulation was checked to be 2.5 to 3 x 10^8cfu/g. A field experiment was conducted at AC & RI, Killikulam, Vallanad, Thoothukudi district on the management of ear rot disease with the designed treatments (Table 1) in RBD replicated thrice with a plot size of 8.0 x 4.0 sq.m. The maize hybrid CoH (M) 6 was used in the study. Seeds were sown in the field in the recommended spacing (60 x 25 cm) and fertilizer dosage of (250:75:75 kg of NPK/ha). Seed treatment at 10g/kg of seed at the sowing, soil application at 2.5 kg/ha at 30 days after sowing, and foliar application at 0.2 % talc formulation during boot leaf, anthesis, and milky stage were applied. The observation on PDI and germination percentage was recorded.

Results and Discussion

The PCR amplification produced a amplicon size at 1100bp with 27F +1115R primers and 1500bp with 27F+1525R primers (Fig 1C and Fig 1D). The effective bacterial antagonists *P. stutzeri-1*, *P. stutzeri-2*, *B. amyloliquefaciens* , *P. aeruginosa, B. subtilis*- 1, and *B. subtilis- 2* were tested for their efficacy against ear rot disease under field condition. Among the treatments, *P. stutzeri*-1, applied as seed treatment, soil application and foliar spray (fig.1B) recorded the minimum PDI of 10.13, which accounted for 76.06 % Percentage reduction over control (PROC). Similarly, *P. stutzeri-2* also recorded a minimum PDI of 11.97, which accounted for a 71.70 PROC. The chemical check, carbendazim (0.1 per cent), recorded a PDI of 15.24, resulting in a 64.98 PROC. The untreated control significantly registered the maximum disease index of 43.52 percent (Table 1). Nayaka *et al*. (2008) reported that seed treatment and foliar spray in maize with *P. fluorescens* reduced the incidence of *F. verticillioides* under field conditions. Similarly, the application of *B. amyloliquefaciens* and *Microbacterium oleovorans* reduced the level of population load of *F. verticillioides* and fumonisin accumulation in maize seeds (Pereira *et al*. 2007).

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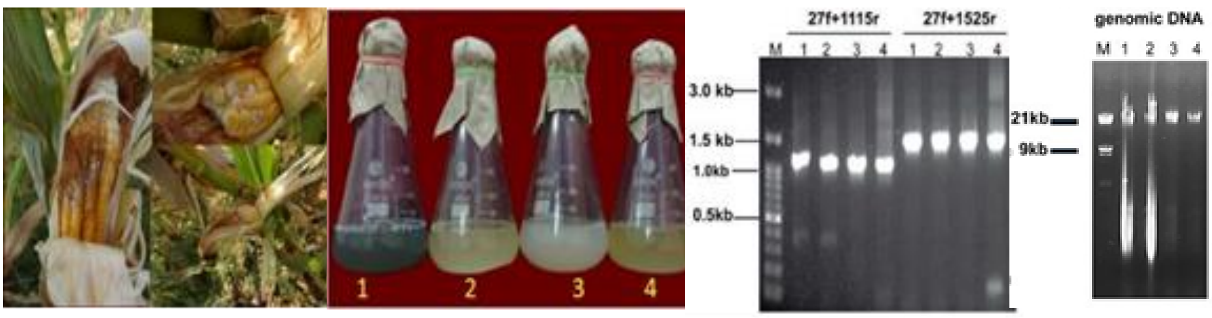
Table 1. Effect of Phyllosphere antagonistic bacteria on maize ear rot under field conditions (DMRT*)

S. No	Treatments	Germination (%)	PDI	PROC
1	*Pseudomonas stutzeri -1*	83.86^{a}	10.13^{e}	76.06
2	*Pseudomonas stutzeri- 2*	77.71^{ab}	11.97^{de}	71.70
3	*Bacillus amyloliquefaciens*	71.39^{a}	13.79^{de}	67.42
4	*Bacillus subtilis -1*	57.29^{bc}	25.64^{c}	39.39
5	*Bacillus subtilis -2*	48.87^{d}	29.95^{b}	29.22
6	*B. amyloliquefaciens + P. stutzeri -1*	61.33^{b}	24.27^{c}	42.64
7	*Pseudomonas aeruginosa*	75.15^{a}	21.67^{c}	48.79
8	Carbendazim	65.69^{bc}	15.24^{d}	64.98
9	Control	62.00^{b}	43.52^{a}	-
	CD 5 % (p=0.05)	17.23	4.11	-



A. B. C. D.

A. Symptoms of *Fusarium* ear rot of image. B. 1-*Pseudomonas aeruginosa* ; 2-*Pseudomonas stutzeri* 1*,* 3- *Pseudomonas stutzeri*; 4- *Bacillus amyloliquefacieans;*; C. PCR Amplification showed genomic DNA at 1100bp and 1500bp with bacteria specific primers D. Genomic DNA of phyllosphere bacterial isolates identified through gel electrophoresis C& D. Lane M-Marker; 1- *Pseudomonas stutzeri* 1; 2–*Pseudomonas stutzeri* 2; 3- *Bacillus amyloliquefacieans;* 4- *Pseudomonas aeruginosa*

T3-40

Characterization of Important Disease of Indian barnyard millet (E*chinochloa frumentacea* (roxb)

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Abstract

Barnyard millet is a highly nutritious crop affected by several pathogens, of which leaf spot is an important disease hindering productivity. Larger cultivation of kuthiraivali in climate changes the Helminthosporium leaf blight incidence was high (47.80%), Grain smut (5%) and Curvularia leaf blight (28.50%) for the three years (2017-2020). Small yellow-brown spots on leaves expand to oblong lesions. Center of lesions change to brown and margins remain yellow. Lesions are more common on leaf margins Indian barnyard millet TamilNadu, India. The resulting 550-bp sequence was submitted to GenBank with Accession No. OP604146, the leaf blight pathogen is Curvularia *lunata* and grain smut identified with ITCC for (HCIO 1304), the sample submitted IARI, herbarium collections.

Keywords: Barnyard millet, symptoms, Helminthosporium, Grain Smut, Curvularia leaf spot

Introduction

Early symptoms appeared as brown circular spots on the leaves. These spots increased in size and coalesced to form oblong lesions. Entire fields were severely affected by the disease. Pathogen isolations were made on Potato dextrose Agar (PDA) media. Symptomatic leaf samples were cut into 4 to 6 mm2 pieces, surface sterilized (10%bleach for 1 min, 90% ethanol for 30 sec) and rinsed in sterilized water three times, followed by air drying. These samples were plated onto PDA media and incubated at 25°C for 6 days in the dark.

Materials and Methods

The isolates were grown in Petri dishes in a potato-dextrose-agar medium (PDA). Subsequently, the characteristics of the colonies and the conidia were observed. The analyzed colonies morphological characteristics were as follows: thin mycelium, border shape irregular, colony coloration black, colony reverse side with dark pigmentation) and fungus of dark brown colony, bearing large stroma, appeared on the media. Conidiophores were brown, septate, geniculate, simple or unbranched, with dark brown scar. PDA after ten days of incubation in a chamber at a temperature of 25 °C ± 2 °C and a 12-hour photoperiod. The conidia were collected with a platinum loop and transferred to slides, where conidia were using an optical microscope (40X) coupled to a camera, conidia measuring Conidia were brown, straight to pyriform, with 3 to 4 cells, with large and curved central cells, smooth walled, ranging in size from 5.3 to 19.56 μm, and produced apically in a sympodial manner. Based on morphological characteristics, the pathogen was identified as

Curvularia lunata (Wakk.) For pathogenicity testing, a conidial suspension (10^6conidia ml−1) from a 7-day-old culture of C.lunata was used to inoculate ten leaves of Barnyard millet (CO (Kv2) variety, followed by incubation in a controlled environment chamber at 25 °C with 70–80% humidity.

As a control, ten leaves of Barnyard millet (CO (Kv2) variety were inoculated with sterile distilled water. Two weeks after inoculation, symptoms were observed only on the leaves inoculated with conidia and the fungus was consistently re-isolated.*C.lunata* was observed on Barnyard millet in,

The fungus was further identified by amplifying internal transcribed spacer region sequence DNA extraction was carried out by scraping the mycelium and reproductive structures formed in monocultures of the Curvularia sp. DNA extraction was carried out according to the CTAB-based protocol , To amplify the DNA from the isolates, primers ITS1 (forward: 5'- TCCGTAGGTGAACCTGCGG-3') and ITS4 (reverse: 5'TCCTCCGCTTATTGATATGC-3').

The field survey was conducted the sorghum crop is more affected maturity stage, the pathogen isolated and sent ITCC for identification.

Results and Discussion

The resulting 550-bp sequence was submitted to GenBank with Accession No. OP604146 *Curvularia lunata*.

Curvularia leaf spot diseases, caused by different Curvularia species (iftikhar 2016), Silva et al. (2014) presented evidence regarding the transmission of Curvularia sp. from seeds of other species of grass, Brachiaria, rice, sorghum and millet. To our knowledge, this is the first report of *C. lunata* leaf blight on *Echinochloa frumentacea* India.

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T3-41

Epidemiological influence of weather factors on occurrence and management of major diseases of Foxtail Millet (*Setariaitalica*(L)Beauv.)

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Abstract

A study was conducted on influence of weather parameters on the major diseases of foxtail millet and its management. An elaborate survey was conducted in foxtail millet growing areas in the Northern districts of Tamil Nadu. The diseases *viz*., blast (*Pyriculariagrisea*), brown spot (*Helminthosporiumnodulosum*) and rust (*Ustilagosetariae*) observed in Salem, Thiruvannamalai, Thirupattur and Vellore districts. A field experiment was conducted to study the effect of weather parameters on the occurrence of major diseases of foxtail millet during, 2021-22 and 2022-23, in which the crops were cultivated without any plant protection measures. Maximum temperature (℃), minimum temperature (℃), relative humidity (%) and rainfall (mm) were recorded from observatory available in the Centre of Excellence in Millets, Athiyandal during the above period. The correlation of weather factors and disease incidence indicated that all the weather parameters except maximum temperature influences the blast disease development and relative humidity (%) and rainfall (mm) influence the disease development as positively, whereas minimum temperature influences the disease development negatively. The studies on regression co efficient analysis shows that only minimum temperature influences the disease development as negative for blast disease during the both years. Whereas RH and rainfall positively influences the rust as well as brown spot. Seed treatment with *B. subtilis* at 10g/ kg of seed and foliar spray of azoxystrobin at 0.5% on 35 days after sowing (DAS) and 50 DAS effectively reduces the all the diseases in foxtail millet crop sown during first week of august of every year. The same treatment also recorded more grain yield and high benefit cost ratio when compared to other treatments in the experiments.

Keywords: Foxtail millet, disease occurrence, weather variables, influence, management

Introduction

Foxtail millet(*Setariaitalica* (L.) Beauv.)is one among the small millets commonly called as highly resilient to drought, physiologically very efficient and reliable for harvest. The grains are highly nutritious and even well superior to major cereals with respect to certain constituents (Upadhyaya et al. 2011) The Changes in Climate is one of the undesirable phases whichcan intensely influence agricultural production. The most serious threats that occur due to climate change are biotic and abiotic stress. Diseases play a risk factor for its production and the diseases viz. blast (*Pyriculariagrisea*), rust (*Uromycessetariae-italica*), brown spot (*Drechslerasetariae*), downy mildew (*Sclerosporagraminicola*), udbatta (*Ephelis* sp.), and bacterial leaf blight (*Pseudomonas avenae*) are reported in foxtail millet (Das, 2017). Among the diseases, blast is one of the severe and important one whichoccurs in severe form and may cause grain loss of up to 60% during favourable condition (Karthikeyan and Gnanamanickam 2008). Management practices developed for blast disease and spraying of fungicides like carbendazim 50 WP @ 1 g/l, edifenphos 50 EC @ 1 ml/l, or a combination product of carbendazim + mancozeb @ 1 g/l of water contains the disease development (Konda *et al*. 2016). Chemical methods for disease management are followed in high-disease-pressure-prone areas. Many fungal and bacterial diseases have been successfully controlled through biocontrol agents worldwide. Many of the beneficial bacterial genera like *Bacillus* spp. (Chen *et al*. 2019) and *Pseudomonas* spp. and also few yeast species, like *Streptomyces* spp. (Law *et al*. 2017), were found to beeffective in the management of rice and finger millet blast diseases caused by *Pyriculariaoryzae* and *Pyricularia grisea*, respectively. In case of foxtail millet blast, few studies showed *in vitro* potential of *Trichoderma* spp. and *Bacillus* spp. against *P. setariae,* however, not many studies have been reported on the field performance. Hence, experiments have been conducted to find out suitable control measures for the management of major diseases of foxtail millet.

Materials and Methods

Initially, a survey was conducted to find out the occurrence and severity of major diseases in foxtail millet from Salem, Thiruvannamalai, Thirupattur and Vellore districts. The diseases recorded using standard scale used for blast, brownspot and rust diseases. Simultaneously, field trial was conducted during 2021-22 and 2022-23 at CEM, Athiyandal to study the influence of weather factors on the diseases of foxtail millet in which the crops were maintained without any plant protection measures. The diseases were recorded and the weather factors were recorded from observatory located at CEM, Athiyandal. In order to study the effect of management practices on disease incidence, field trials were conducted during the same period with six treatments. The disease incidence and growth parameters were recorded from the trials.

Results and Discussion

From the survey, it was found that the diseases *viz*., blast, brown spot and rust observed in Salem, Thiruvannamalai, Thirupattur and Vellore districts. The incidence of rust is more at Elathur, Thiruvannamalai district during the two years of period (15.21 in 2021-22 and 17.95 in 2022-23). The brown spot observed as maximum at Karumandurai hills (19.5 PDI) of Salem District. The correlation of weather factors and disease incidence indicated that all the weather parameters except maximum temperature influences the blast disease development and relative humidity (%) and rainfall (mm) influence the disease development as positively, whereas minimum temperature influences the disease development negatively. The studies on regression co efficient analysis shows that only minimum temperature influences the disease development as negative for blast disease during the both years. Whereas RH and rainfall positively influences the rust as well as brown spot. In order to develop a management practice for the disease, a field experiment was conducted during 2021-22 and 2022-23 with treatments of biocontrol agents and fungicides. The trials were conducted with two times of sowing *ie* August and September. Seed treatment with *B. subtilis* at 10g/ kg of seed and foliar spray of azoxystrobin at 0.5% on 35 days after sowing (DAS) and 50 DAS effectively reduces the all the diseases in foxtail millet crop sown during first week of august of every year. The same treatment also recorded more grain yield and high benefit cost ratio when compared to other treatments in the experiments. The seed treatment and spray of *Bacillus* recorded low incidence of blast of foxtail millet (Karthikeyan and Gnanamanickam, 2008).

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Table 1. Effect of biocontrol agents and chemicals on diseases of foxtail millet

S.No	Treatments	Blast incidence (PDI)	Rust (PDI)	Brown spot (PDI)	Yield (kg/ha)
1	Seed treatment (ST) with *Bacillus subtilis* @10g/kg of seed	8.68	9.15	4.37	781.0
2	ST with *B. subtilis* @10g/kg of seed + foliar spray of B. subtilis at 1g/lit tillering stage as well as boot leaf stage	4.68	7.24	3.05	815.0
3	ST with *Bacillus subtilis* @10g/kg of seed + Foliar spray of Azoxystrobin 23% SC @ 1ml/l at tillering stage as well as boot leaf stage	1.50	1.82	0.95	863.0
4	ST with *B. subtilis* @10g/kg of seed+ Foliar spray of Propiconazole 25 % EC @ 1ml/l at tillering stage as well as boot leaf stage	1.81	2.12	1.05	860.0
5	Foliar spray of Mancozeb 75 % WP @ 2.5g/L after 45 DAS	6.12	4.02	1.48	832.0
6	T6: Control	15.17	17.25	12.63	685.0
	SEd	0.31	0.37	0.29	7.19
	CD (5%)	0.37	0.28	0.26	15.33

T3-42
Integrated management of blast disease in Finger Millet

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Abstract

The effect of bacterial biocontrol agent (*Pseudomonas*-TNAU-Pf1) and fungicide was evaluated individually and their integration as seed treatment and foliar spray for the management of finger millet blast under field conditions during 2016-17 and 2017-18. The results revealed that seed treatment with talc-based formulation of *Pseudomonas* (10g/kg) plus two sprays of tricyclazole (0.1%) one at maximum tillering phase and another at heading phase was significantly most effective in reducing leaf, neck and finger blast in both the seasons. The treatment recorded lesser incidence of leaf blast (1.00 PDI), neck blast (0.61%) and finger blast (0.99%) with higher grain yield of 2418 kg/ha and the BC ratio of 1:3.75.

Keywords: Finger millet, Blast, *Pseudomonas*, Fungicide, IDM

Introduction

Finger millet (*Eleusine coracana* Gaertn.) popularly known as ‘Ragi’ is one of the most important cereal crops supporting the lives of millions of people across the globe and particularly in the developing countries. The crop is grown under rainfed conditions by small and marginal farmers of India ensuring their food security. Although, finger millet is known to cope up with abiotic and biotic stresses, nevertheless, under vulnerable conditions some of the diseases cause heavy losses and can damage entire crop. Of the several fungal diseases that affect finger millet crop, blast disease caused by *Pyricularia grisea* is by far the most important disease. The average loss due to finger millet blast has been reported to be around 28% and has been reported as high as 80-90% in endemic areas. In India, the disease was first reported from Tanjore delta of Tamil Nadu. Since then, the disease is known to occur almost every year during rainy season in all major finger millet growing areas and is perceived as one of the major disease causing recurring yield losses in all the states of India. Although, fungicides are found to be highly effective against leaf, neck and finger blast disease however, information on use of fungicides with bioagents is lacking. Keeping these facts in view, studies were conducted to manage leaf, neck and finger blast of finger millet through fungicides with bioagents.

Materials and Methods

A field experiment was conducted at Regional Research Station farm, Paiyur during November 2016 to February 2017 and December 2017 to March 2018 to evaluate the efficacy of talc-based formulation of bioagent (*Pseudomonas*) and a fungicide (Tricyclazole) individually and their integration as seed treatment and foliar spray for the management of finger millet blast with five treatments and four replications under randomized block design using a variety Paiyur 2. The seeds were treated with talc-based formulation of *Pseudomonas* @ 10 g/kg and tricyclazole @ 2g/kg of seeds. Foliar application of bioagent (1%) and fungicide (0.1%) was given during maximum tillering and heading phase using high volume backpack knapsack sprayer. The incidence of leaf blast was recorded after first spray by visual observation following 0-5 scaleand the per cent disease index (PDI) was calculated. Percent neck and finger blast were recorded as the percentage of ears showing infection on the peduncle and percent of fingers with infection, respectively, at dough stage of the crop. The data on plant height (cm) and number of productive tillers/hill was recorded at heading phase. At crop maturity, the ears were harvested, dried, thrashed, cleaned and per plot yield was recorded from which yield per hectare was computed.

Results and Discussion

The results revealed that seed treatment with talc-based formulation of *Pseudomonas* (10g/kg) plus two sprays of tricyclazole (0.1%) one at maximum tillering phase and another at heading phase was significantly most effective in reducing leaf, neck and finger blast and increasing grain yield in both the seasons. The treatment recordedlesser incidence of leaf blast(1.00 PDI),neck blast (0.61%) and finger blast (0.99%) with higher grain yield of2418 kg/ha and the BC ratio of 1:3.75. Whereas untreated control recorded 18.25, 11.13 and 10.82% incidence of leaf, neck and finger blast and grain yield of 1831 kg/ha, respectively (Table 1 and 2). Similarly, Kumar and Kumar (2011)and Prajapati *et al*. (2020) also reported that seed treatment with bioagent plus its two foliar sprays followed by two sprays of ediphenphos (0.1%) were significantly most effective in reducing the incidence of blast disease and also increased the grain yield.

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Table 1. Effect of bioagent and fungicide on the incidence of finger millet blast (Pooled mean of two trials)

Treatments	Leaf blast (PDI)	Neck blast (%)	Finger blast (%)
T1: ST with TNAU-Pf1@ 10g/kg +two sprays of TNAU-Pf1@ 10g/l	3.88	3.36	3.52
T2: ST with Tricyclazole @ 2 g/kg of seed + two sprays of Tricyclazole @ 1 g/l	2.87	2.26	2.85
T3: ST with TNAU-Pf1@ 10g/kg + two sprays of Tricyclazole @ 1 g/l	1.00	0.61	0.99
T4: ST with Tricyclazole @ 2 g/kg of seed + two sprays of TNAU-Pf1@ 10g/l	5.00	4.09	4.33
T5: Untreated control	18.25	11.13	10.82
CD (0.05%)	1.15	1.32	1.40
S ED	0.57	0.60	0.69

Values are mean of four replications

Table 2. Effect of bioagent and fungicide on the growth and yield attributes of finger millet (Pooled mean of two trials)

Treatments	Plant height (cm)	No. of productive tillers/hill	Grain yield Kg/ha	BCR
T1: ST with TNAU-Pf1@ 10g/kg +two sprays of TNAU-Pf1@ 10g/l	86.03	4.53	2217	1:3.20
T2: ST with Tricyclazole @ 2 g/kg of seed + two sprays of Tricyclazole @ 1 g/l	80.04	4.68	2290	1:3.14
T3: ST with TNAU-Pf1@ 10g/kg + two sprays of Tricyclazole @ 1 g/l	88.34	5.22	2418	1:3.75
T4: ST with Tricyclazole @ 2 g/kg of seed + two sprays of TNAU-Pf1@ 10g/l	80.44	4.22	2156	1:2.97
T5: Untreated control	71.66	3.25	1831	-
CD (0.05%)	2.44	0.45	65.34	-
S ED	1.21	0.22	32.09	-

Values are mean of four replications

T3-43

Determination aflatoxin contaminationin Maize based poultry feeds of Tamil Nadu

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Abstract

In India, maize is emerging as third most important staple food crop after rice and wheat. Its importance lies in the fact that it is not only used for human food andalsoutilizing as animal feed. According to Indian Institute of Maize Research (IIMR) 2021, out of total maize production in India, 47% has been utilized for the purpose of poultry feed. Contamination of poultry feed with mycotoxins such as aflatoxin is a major concern for the poultry industry, which results in a significant economic loss in turn directly, affects consumers. Monitoring the aflatoxin levels in poultry feed is crucial for controlling economic loss and decreasing the health hazards to the population. This study was conducted to examine the occurrence of total aflatoxin in poultry feed in a high consumption area. The raw materials such as maize kernels, maize gluten, soybean meal, broken rice,paddy husk, groundnut cake, rapeseed pellet, sunflower pelletand four different processed poultry feeds, i.e., pre starter, starter, finished and layer mash were assessed by Reverse phase HPLC.Overall incidence of AFB1 was recorded as 86.00% (n=43/50); whereas, in the feed ingredients, it was 96.66% (n=29/30), and in the finished feeds, the incidence of AFB1 was 70.00% (n=14/20). Maize, maize gluten meal, soybean meal, sunflower pellet, groundnut cake pellet were found to be highly (100%) contaminated with AFB1.Layer mash feed recorded the highest frequency (100%) of aflatoxin contamination with a mean value of 30.18 µg/kg.

Keywords: Aflatoxin, Maize, Poultry feed, Poultry feed ingredients

Introduction

Mycotoxins are often found as natural contaminants in raw ingredients of poultry feed (Khan *et al*., 2011). Poultry birds are highly susceptible to mycotoxicoses caused by aflatoxins (Anjum*et al*., 2011) that decreases hatchability, body mass ratio, growth rate, meat and egg production, vaccination efficiency, impairing the feed conversion ratio, discolored liver and increasing the susceptibility of birds to diseases and mortality. Toxigenic *Aspergilusflavus*isolates generally produces aflatoxins B1, B2, G1 and G2 (Davis and Diener, 1983). The reports from epidemiological studies have demonstrated that AFB1 is a hepatocarcinogenic mycotoxin and the primary contributor to the high rate of Hepatocellular carcinoma (HCC). The International Agency for Research on Cancer has classified AFB1 as a Group1 carcinogen for HCC. As per the European regulation (EC), poultry feed should not get more than 20 µg/kg of aflatoxin contamination for birds consumption.

In India, different poultry feed ingredients are likely to be contaminated mainly with aflatoxin producing fungi. Most commercial feed mills in India provides suitable environment condition for fungal growth during harvest and storage. The unhygienic method of processing and production and suitable environmental condition paves the way for the fungal contamination. Therefore, regular monitoring of total aflatoxin in poultry feeds is an important precondition to check toxins buildup in poultry feeds. The present study was undertaken to quantify total aflatoxincontent in poultry feed raw materials and finished feed collected from various commercial poultry farms of Tamil Nadu, India.

Materials and Methods

A total of 50 samples comprising of different types of raw feed materials (n=30), and finished feed (n=20) were collected directly from poultry farms and poultry feed production sites ofwestern zone of Tamil Nadu, India during February to April (Pre- monsoon season), 2023. Twenty- five grams of finely ground sample was mixed with 5g of sodium chloride and 100 ml of methanol (80%, w/v). Further, it was vigorously shaken under orbital shaker at 150 rpm for 30 minutes and the sample extract was filtered through Whatmanno 4-filter paper. Four ml of filtrate (equivalent to 1g) was diluted with 16 ml of PBS buffer and passed slowly through the immuoaffinity column (Aflarhone, R-biopharm, USA) with flow rate of 1ml/min. then, the column was washed with 20 ml of PBS buffer with a speed of 5ml/min. Finally, the elution of aflatoxin was carried out with 1ml of 50% methanol followed by 1 ml of deionized water by back flushing to ensure the toxin removal.

Aflatoxin was determined by reverse-phase (RP) HPLC using an Agilent 1200 HPLC system (Agilent Technologies, USA).Aflatoxinswere separated in HPLC column with a mobile phase of water: methanol (60:40 v/v) containing 350 µl of 4M nitric acid and 119 mg of potassium bromide. Fluorescence detection was at an excitation wavelength of 365 nm an emission wavelength of 425 nm (Lee *et al*., 2014). Aflatoxin retention times with 1 ml/min flow rate were 5.4-6.4 min for AFG2, 6.5-7.8 min for AFG2, 8.0- 9.5 min for AFB2 and 10.0-11.8 min for AFB1. Total run time was 15 min.

Results and Discussion

A total of 50 poultry feed samples were collected from major feed manufacturing companies in Tamil Nadu during pre monsoon season.Out of 50 samples tested, 17 recorded the maximum aflatoxin contamination exceeding the regulatory limit of 20 µg/kg and 33 samples showed aflatoxin contamination ranged between 1 to 20µg /kg.

Aflatoxin B1 contamination level in these samples ranged from Non-Detected (ND) to 75.18 µg/kg and the total incidence of AFB1 in feed ingredients and finished feed samples was almost 86.00%. Out of total 30 different poultry feed ingredients analyzed, overall incidence of 96.66% of AFB1 was observed, with maximum and minimum contamination levels recorded as 75.18 µg/kg and 1.48 µg/kg, respectively. Maize kernel is the most commonly used feed ingredient in poultry diets, in which 100% AFB1 incidence was recorded. The average contamination and maximum level of AFB1 recorded as 25.63 µg/kg and 75.18 µg/kg, respectively. Corn is more susceptible for aflatoxin production throughout the world as compared to soybean, groundnut and rapeseed (Firdous, 2003).

Among different vegetable protein sources, maize gluten meal (30% & 60%), soybean meal, sunflower pellet, rapeseed pellet and groundnut cake were tested, maize gluten meal 30% showed the highest AFB1 contamination with an average level of 38.59 µg/kg, and maximum level of 70.16 µg/kg which was almost equal to the AFB1 contamination observed in maize kernel. Soybean meal is the next most frequently used feed ingredient in poultry diet. For all soybean meal samples tested, concentration of AFB1 toxin was relatively high (mean 25.17 µg/kg and maximum level 23.08 µg/kg). Similarly, the average concentration and maximum level in sunflower pellet was observed as 25.86 and 36.50 µg/kg, respectively. In the current study, mean values of AFB1 in all feed ingredients (except rapeseed pellet, rice broken and oil removed rice husk) were found higher than safe limit of 20 µg/kg, as recommended by European regulations for bird consumption.

The results revealed that AFB1 incidence in finished poultry feed was about 70.00%. The average contamination and maximum level of AFB1 were noted as 21.08 µg/kg and 59.32 µg/kg. This study showed that incidence and average concentration of AFB1 were less in the finished feed samples as compared to feed ingredients. Maximum AFB1 value (59.32 µg/kg) was observed in layer mash II followed by finished crump (36.00 µg/kg). The less incidence and mean values of AFB1were observed in broiler pre starter and chick starter I and II feed as compared to other mash feeds. This might be due to low moisture content, as recorded in crumb feed. Even though, the study was conducted during pre monsoon season (March – May) having low humid environment and elevated temperature that is less conducive for the growth of fungi producing mycotoxins, the amount of AFB1 recorded in most of the samples was above the permissible limit.

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Table 1. Aflatoxin contamination in poultry feed ingredients (n=32) and finished feed (n=18)

Ingredients/ Feed	Samples analyzed (n)	Positive samples (n;%)	Mean Amount of AFB1 µg/kg	Maximum AFB1 level µg/kg	EU Permissible limit (+/-)
Feed ingredients					
Maize Kernels	10	10 (100)	25.63	75.18	+
Maize gluten meal I (30%)	2	2 (100)	38.59	70.16	+
Maize gluten meal II (60%)	2	2 (100)	16.18	22.00	+
Soybean meal	3	3 (100)	25.17	23.08	+
Rice broken	2	2 (100)	9.12	12.76	-
Rice husk	1	1 (100)	15.38	15.38	-
Oil removed rice husk	1	1 (100)	1.48	1.48	-
Groundnut cake	3	3 (100)	20.62	33.00	+
Rapeseed pellet	3	2 (66.66)	2.78	11.76	-
Sunflower pellet	3	3 (100)	25.86	36.50	+
Processed feed					
Pre starter (1-12 days)	3	1 (33.33)	4.10	4.10	-
Starter I (13-20 days)	3	2 (66.66)	18.45	26.90	+
Starter II (20-28 days)	3	1(33.33)	25.10	25.10	+
Finished crumb (>28 days)	3	2 (66.66)	30.66	36.00	+
Layer mash I (Layer breed)	4	4 (100)	17.99	25.09	+
Layer mash II (Layer breed)	4	4 (100)	30.18	59.32	+
Total	30*+20** =50	29# + 14## =43			

* = total number of feed ingredients, ** = total number of processed feeds, # = total positive feed ingredients, ## = total positive processed feeds.

T3-44

Influence of meteorological variables on bacterial leaf blight in paddy

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Abstract

Rice (*Oryza sativa L.*) is a cereal crop that is consumed as a staple food by half of the world's population. Rice disease outbreaks threaten both local and global food security. The Gram-negative bacterium *Xanthomonas oryzae pv. oryzae*, which enters the rice plant by wounds or hydathode water pores, colonises the xylem arteries, and forms tannish-gray to white lesions along the veins, is the cause of bacterial leaf blight (BB). The objective of this study was was used to assess the influence of meteorological variables using evapotranspiration, temperature, rainfall and vegetation dataset and GLDAS-2.1 product from 1 January 2010 to 31 December 2022. Results revealed that, Maximum temperature, moisture and the number of rainy days were major meteorological variables that significantly influenced the increase in the percentage of disease severity.

Keywords: Weather, Paddy, Impact, Leaf blight, Monsoon

Introduction

Climate change is major threat in recent times and brings new diseases and challenges ahead. To overcome these challenges and achieve the food security for all, effective planning and management will be needed. Rice (*Oryza sativa L.*) is the best cereal, staple food crop of the world's population and major cash crop in India. Abnormal changes of weather factors such as temperature, relative humidity and rainfall are favours the development of pest and disease and farmers also lose the large amount of their production.The disease has spread to rice-growing regions throughout the world. It has been discovered to be pandemic in rainy areas such as Assam, West Bengal, the Malabar Coast, and the Himalayas. The disease has also been identified in Africa, Asia, South America, and the United States (Cohen and Leach, 2020).

Materials and Methods

Perambalur district is located in the southern Indian state of Tamil Nadu and has an area of 3691 square kilometres spread geographically lies from 10º 53’ to 11º 31’ North Latitudes and from 73º 38˙ to 79 º 31˙ East Longitudes and is divided into four taluks: Veppanthattai, Alathur, Perambalur, and Kunnam. The region is known for the cultivation of crops such as paddy, sugarcane and groundnut. Black cotton soil, clay loam and red sandy soil are the predominant soil types. Maize, Cotton, Sorghum, Onion, Tapioca, Paddy, and Groundnut are the major cultivated crops.

The GLDAS-2.1: Global Land Data Assimilation System was used to assess the influence of meteorological variables using evapotranspiration, temperature, rainfall and vegetation dataset and GLDAS-2.1 product from 1 January 2010 to 31 December 2022.

Results and Discussion

Effects of meteorological factors on bacterial leaf blight disease: The weather factors influence the yield quality and quantity. The temperature has a direct relationship with crop growth. Temperature increases have an impact on nutrition, while temperature decreases have an impact on crop development, resulting in a poor yield. The incidence of plant diseases is greatly influenced by variations in temperature, which might modify the distribution and prevalence of such diseases.Temperature changes because complicated responses in plant pathogens. Thermal stresses have been found to influence the growth, manufacture of cell-degrading enzymes, and infection structure development of fungal plant diseases, resulting in pathogenicity alterations.

For instance, the rice false smut pathogen *Villosicla Vavirens* can develop smut balls and sclerotia at a moderately low nighttime temperature (13°C). Temperature variations have a substantial impact on the *Magnaporthe oryzae* rice blast fungus's ability to generate appressoria quickly. Years of field research have shown that rice blast outbreaks are more likely to occur when the temperature is between 23°C and 27°C or lower, rather than when it is between 28°C and 31°C. Haque *et al*., (2022) were conducted bacterial blight in the thirty agro-ecological zones of Bangladesh to know the influence of weather parameters in paddy. The results shows that when mean temperature more than 28°C, relative humidity ranges from 69-74 percent, rainfall more than 560 mm, little sunshine and strong winds coincide, this disease appear in the form of epidemic during the rice growing seasons from 2010 to 2022. However, rainfall, maximum temperature, morning relative humidity, and evening relative humidity were shown to be favourably correlated, whereas wind velocity was found to be significantly positively correlated with BB infection. According to Abrol *et al.,* (2022), relative humidity (morning) is positively correlated with brown spot severity. Temperature and disease severity, on the other hand, were shown to be adversely correlated with the formation of brown spot of rice.

Environmental variables primarily influence the severity and spread of plant diseases, therefore understanding epidemiology can assist the management of the disease. Maximum temperature, moisture and the number of rainy days were major meteorological variables that significantly influenced the increase in the percentage of disease severity.

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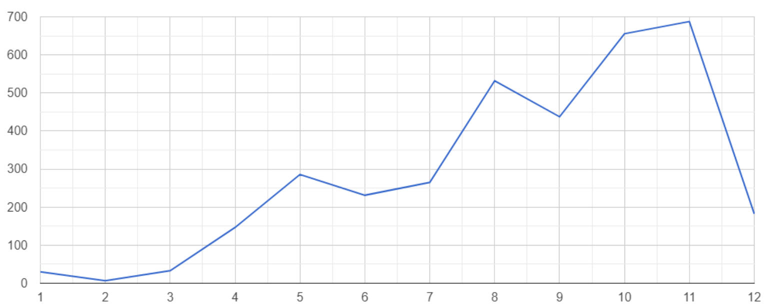
Fig. 1. Time series variations of Evapotranspiration in Paddy between 2010-2023



T3-45
Study the efficacy of bioagents on root knot nematode in Maize

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Abstract

The root knot nematode *Meloidogyne incognita* is an emerging problem in Maize growing areas in Tamil Nadu. A pot culture experiment was conducted to evaluate the efficacy of different biocontrol agents *viz., Purpureocillium lilacinus* (10g/pot)*, Pochonia chlamydosporia* (10g/pot), AM fungi (10 g/pot) for the management of root knot nematode *Meloidogyne incognita* in maize along with untreated control. The experiment results were revealed that all the biological agents were found to inhibit the root knot nematode development and shows the potential to increase the plant growth significantly. The maximum plant growth was recorded in AM fungi treated plants (32%) followed by *P. lilacinus* (21%) and are significantly different from untreated control. The root knot nematode *M. incognita* alone treated plants recorded lowest vegetative growth. The population of root knot nematode *M. incognita* in soil and roots were significantly lower in all biological agents treated plants compared to untreated control. The lowest nematode population in soil and root was recorded in AM fungi (10 g/plant) compared to untreated control. The percent reduction in nematode population in soil, adult female nematode/g and egg mass/g was maximum in AM fungi treated plants with 44.55, 47.2 and 50 percent respectively over untreated control.

Keywords: Maize, root knot nematode, *Meloidogyne incognita,* AM fungi, *Purpureocillium lilacinus, Pochonia chlamydosporia*

Introduction

The root knot nematode *Meloidogyne incognita* is an emerging nematode problem in Maize in growing areas of Tamil Nadu. Damage symptoms of root knot nematode infested maize showing of yellowing, stunting, drying of leaf margin and plants.

Maize damaged by root-knot nematodes often is stunted and has the appearance of moisture and nutrient deficiencies. Severe infestations can result in the death of younger plants. Affected plants typically occur in patches in the field and symptoms typically are more common and most damaging to plants in light, sandy-textured soils. Belowground symptoms include roots that are galled, stunted and discolored. Sometimes the maize root system may appear healthy and galls may be small and difficult to notice even though root-knot nematode numbers may be very high. In field, root knot nematodes may also cause stubby root symptoms because they stop the growth of root tips. The soil and root samples of from stunted maize plants collected at Pudukkottai district on preliminary observations revealed that presence root-knot nematode, *Meloidogyne incognita* which was found to be responsible for growth decline. Even though chemical nematicides are having good for nematode management, it will not encouraged for field application due to residues problems, environmental pollution, and health hazards. To avoid these problems, biological control agents were used to manage root knot nematode. The present study was undertaken to evaluate the biocontrol potential of talk formulation on nematode under shade net house condition.

Materials and Methods

The experiment was conducted to evaluate the efficacy of different biocontrol agents *viz., Purpureocillium lilacinus* (10 g/pot)*, Pochonia chlamydosporia* (10 g/pot), AM fungi (10 g/pot) under shadenet house condition on nematode management in maize along with carbofuran 3G chemical check and untreated control. Pot mixtures were prepared and filed in the pots (10 kg capacity), arranged in row and sowing the maize seeds at the rate of 5 seed per pot. After seedling emergence, all the above said bioagents were applied near the root zone of maize plants. The experiment was laid out in completely randomized block design with five treatments and four replications. The experiment was terminated 110 days after sowing. Observation such as plant height, nematode population, root gall index, number of adult female/g of root and number of egg masses/g of root were recorded at the time of termination of experiment.

Results and Discussion

The results revealed that in all the treatments were influenced significantly on plant growth and nematode population reduction compared to untreated control. The maximum plant growth was recorded in AM fungi treated plants (32 per cent) followed by *P. lilacinus* (10 g/plant) significantly different from untreated control. The root knot nematode *M. incognita* alone treated plants recorded lowest vegetative growth. The population of root knot nematode *M. incognita* in soil and roots were significantly lower in all biological agents treated plants compared to untreated control. The lowest nematode population in soil and root was recorded in AM fungi (10 g/plant) compared to untreated control. The percent reduction in nematode population in soil, adult female nematode/g and egg mass/g was maximum in AM fungi treated plants over untreated control. The present study was designed to determine the efficacy of biocontrol agents on nematode management in maize. In general, all the bio agents are capable of reducing the nematode population in soil. The AM fungi can protect their host plant by suppression of root knot nematode population (Nele Schouteden *et al.* 2012). Plant growth is higher in AM fungi treated plant compared to untreated control, since these fungi are known to increase the uptake of water and mineral nutrients for their host plant, such as phosphate and nitrogen (Baum *et al*. 2015); altered the root morphology, quantity and quality of root exudate (Sood, 2003). Hence it was concluded that the application of AM fungi may be a promising practice in management of root knot nematode in maize cultivation.

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Table 1. Effect of biocontrol agents on root knot nematode population in maize

Treatments	Plant height (cm)	Nematode population (250g soil)	No. of female /g of root	No. of egg mass/g of root	Gall Index
T1 - *Purpureocillium lilacinus* (10 g/pot)	121	155	13	7	1
T2 - *Pochonia chlamydosporia* (10 g/pot)	113	145	12	8	2
T3 - AM fungi (10 g/pot)	132	104	5	5	1
T4 – Carbofuran 3G 1 kg a.i./ha	118	128	12	9	1
T5 – Untreated control	110	393	17	16	5
CD (0.05)	10.34	11.05	1.07	1.15	

Theme 3

Biotic and abiotic stress management
Abstract

T3-46

Biological management of sorghum leaf anthracnose (*Colletotrichum sublineolum*) disease

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Abstract

Sorghum [*Sorghum bicolor* (L.)], a diploid photosynthesis efficient C4 crop is one of the most important cereals serving as a staple food for over 500 million people globally, used as animal feed, and is increasingly important source of biomass for cellulosic ethanol production. It is predominantly produced by subsistence farmers in the developing world significantly contributing to food security. However, biotic and abiotic stresses are causing significant yield losses across all its growing areas. B*ecause* of its wide distribution and ability to infect all above ground parts of the plant, anthracnose caused by the destructive fungal pathogen *Colletotrichum sublineola* is one the most important diseases of sorghum. Agronomic practices alone are not effective to reduce infections and yield losses due to anthracnose. Although the overuse and high frequency use of chemical pesticides could induce resistance, residue and environmental pollution risk, it is not economically and practically feasible for small-scale farmers. Application of biocontrol agents is considered the most efficient and is a core in integrated strategy for anthracnose management. Hence, the study aimed to mitigate leaf anthracnose disease using biocontrol agents *Streptomyces rochei* and *Bacillus subtilis* (Bbv 57). Field experiment was conducted at TRC, Bhavanisagar. Sorghum seeds (Local red) were sown (F.No C9/; Latitude N 11.46 6575: Longitude E 77.13 733) with six treatments, 4 replications, RBD design. Biocontrol agents *Streptomyces rochei* and *Bacillus subtilis* (Bbv 57) @ 0.2% were sprayed at 30 and 45 days after sowing (DAS) and other cultivation practices were followed as per the Crop production Guide. Foliar disease intensity was recorded at 30, 45 and 60 DAS and yield attributes were also recorded. The results revealed that foliar spray with *Streptomyces rochei* 0.2% (30 and 45 DAS) were significantly mitigated the sorghum leaf anthracnose (19.44 PDI) compared to control which recorded 49.72 PDI. Therefore, *Streptomyces rochei* gaining interest as environmentally friendly alternatives to synthetic fungicides for management of leaf anthracnose of sorghum.

Keywords: Sorghum, Anthracnose, Biocontrol, *Streptomyces rochei*

T3-47

Identification of sources of resistance to blast disease in foxtail millet germplasm

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Abstract

Blast, caused by *Magnaporthe grisea*, is an economically important disease of foxtail millet in India. Host plant resistance is the most economical and effective means of managing this disease, as this crop is predominantly grown by resource-poor farmers. To identify sources of blast resistance, 374 foxtail millet germplasm along with three susceptible checks (CO (Te) 7, SiA 326 and SiA 3156) were evaluated for two seasons at two different hotspot locations, Athiyandal and Vriddhachalam. The percent disease index (PDI) of foxtail millet accessions varied from 7.56 to 86.00 PDI. The lowest disease severity among the accessions was observed in SEJ 19 (7.56 PDI), followed by ESD 90 (8.79 PDI) and TNAUF00700350 (9.23 PDI). Sixty accessions showed moderately resistant response and the rest of the accessions showed moderately susceptible to highly susceptible response. However, the maximum disease severity (86.00 PDI) was recorded in CO (Te) 7. The mean apparent rate of infection varied from 0.042 to 0.167 among foxtail millet accessions. It was lowest in SEJ 19 (0.042), followed by ESD 90 (0.066) and TNAUF00700350 (0.073). The highest infection rate was observed in genotype CO (Te) 7 (0.167). The result clearly shows that among the 374 accessions, three accessions (SEJ 19, ESD 90 and TNAUF00700350) exhibited high levels of resistance to leaf blast infection. These blast resistant accessions would be useful in foxtail millet disease resistance breeding programmes.

Keywords: Blast disease, foxtail millet, host plant resistance, germplasm, *Magnaporthe grisea*

T3-48

Occurrence of banded sheath blight disease in small millets in Tamil Nadu

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Abstract

Achieving sustainable food production in India is largely dependent on reviving the cultivation of small millets. However, the emergence or recurrence of fungal diseases under changing environmental conditions poses a serious threat to millet cultivation in India. Banded sheath blight, caused by the soil-borne necrotrophic fungus *Rhizoctonia solani*, has

become a serious problem in small millets in recent years. The disease occurs as a re-emerging disease in finger millet, while it occurs as an emerging disease in foxtail millet, barnyard millet and kodo millet. During the study conducted between 2017 and 2020 in Tamil Nadu, the disease severity or percent disease index (PDI) ranged from 8.31 - 15.43 PDI in finger millet, 7.13 - 13.22 PDI in foxtail millet, 8.55 - 15.62 PDI in barnyard millet and 3.73 - 7.25 PDI in kodo millet. The study suggests that this disease used to occur sporadically, but recently it is emerging or re-emerging as a serious problem and needs detailed studies on etiology and management aspects.

Keywords: Banded sheath blight, small millets, emerging and re-emerging disease, *Rhizoctonia solani*

T3-49

Impact of silicon and growth regulator against maize fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

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Abstract

A microplot field experiment was conducted during February 2022 - May 2022 at Thoppur village of Kariyapatti block of Virudhunagar district to evaluate the effect of silica nutrition and growth regulator on fall armyworm of maize. The experiment was laid out in a Randomized block design using the variety Maize Co H(M) 6 with three replications and sixteen treatment combinations with spacing of 60 25 cm and plot size of 6 × 2 m. Foliar application of silicic acid and potassium silicate was done at 15 and 30 DAS and gibberellic acid at 45 and 60 DAS. All foliar sprays were applied by a 10 L volume knapsack sprayer. The mean leaf and cob damage score per plant (TNAU scoring method) was assessed. Leaf and cob damage score/plant was calculated in ten randomly selected plants per each treatment. The results revealed that the treatment with basal application of 150 kg of calcium silicate/ha + 0.2 % silicic acid at 15 DAS + 50 ppm GA at 30 DAS was found to be most effective and significantly superior over all other treatments by recording lowest mean leaf damage score of 1.63/plant and mean cob damage score of 1.13/plant followed by the treatment with 75 kg of calcium silicate/ha + 0.2 % silicic acid at 15 DAS + 50 ppm GA at 30 DASwith 1.66 leaf score/plant and 1.35 cob score/plant.

Keywords : *Spodoptera frugiperda*, Silicon, Gibberellic acid,Leaf and Cob score

T3-50

Evaluation of bio-efficacy, phytotoxicity and bio-safety of thiamethoxam 30 % w/w FS (CRUISER 35 FS) as seed treatment against early crop stage pests posing threat to Maize

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Abstract

Maize (*Zea mays*) originated in Central mexico, and globally, it is cultivated on nearly 20.6 million hectares in about 245 countries having wider diversity of soil, climate, biodiversity and management practices that contributes 121 million tonnes in the global grain production (FAO, 2021). About 250 species of insect pests damage maize (Sreelatha *et al*., 2022) causing about 25 – 45 % yield loss (Neupane *et al*., 2022). The present study was conducted to evaluate the bio-efficacy, phytotoxicity, and biosafety of thiamethoxam 30 % w/w FS (CRUISER 35 FS) as seed treatment against early crop stage insect pests *viz*., Shoot fly and Aphids in corn. Among the treatments, thiamethoxam 30 % w/w FS (CRUISER 35 FS) application @ 2.4 g.ai/ha improved the plant growth and it was found to be effective against shoot fly, *Atherigona orientalis* with lowest dead heart of 2.30 per cent. The aphids, *Rhopalosiphum maidis* incidence was also lowest (10.18 nos/plant) besides recording the higher grain yield (5.88 t/ha) and relatively safer to natural enemies *viz*., coccinellids and spiders 7.03 and 2.53 nos/ 10 plants, respectively, as against 7.38 and 3.40 nos/ 10 plants in untreated control. There was no phytotoxicity symptoms on maize crop (epinasty, hyponasty, yellowing, necrosis, leaf injury, vein clearing and stunting) when treated with thiamethoxam 30 % w/w FS (CRUISER 35 FS) 2.4 g.ai/ha.

Keywords: Maize, thiamethoxam 30 % w/w FS, bio-efficacy, shoot fly, Aphids

T3-51

Evaluation of phytotoxicity and biosafety of chlorantraniliprole 9.3% w/w + lambdacyhalothrin 4.6% w/w ZC (Ampligo 150 ZC) in corn through drone application

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Abstract

Maize (*Zea mays L*.) is the world's leading crop and is widely cultivated as cereal grain that was domesticated in Central America. Globally, maize is known as queen of cereals because of its highest genetic yield potential. Maize is the only food cereal crop that can be grown in diverse seasons, ecologies and uses. Though maize has encountered with number of insect pests insecticide spraying to manage insect pests in maize was minimal until the invasion of fall armyworm in India during 2018. The use of unmanned aerial vehicle (UAV) in agriculture is increasing especially for the application of insecticides. The biological

efficacy of insecticides may vary when applied using different spray systems. The quantity of spray fluid used will be much lesser but with the same quantity of active ingredients. In this regard it is necessary to evaluate the efficacy of any molecule in newer delivery systems. With this background, a field experiment was conducted during *rabi* in a randomized block design to assess the phytotoxicity of chlorantraniliprole 9.3% w/w + lambdacyhalothrin 4.6% w/w ZC (Ampligo 150 ZC) in Corn through Drones. The studies on phytotoxicity effect of chlorantraniliprole 9.3% w/w + lambdacyhalothrin 4.6% w/w ZC (Ampligo 150 ZC) @ 35 g ai/ha using knapsack sprayer and 35 and 70 g ai/ha by using drone revealed that there was no phytotoxicity *viz*., leaf injury on tips and leaf surface, wilting, vein clearing, necrosis, epinasty and hyponasty etc. The crop was free from phytotoxic symptoms for the all the evaluated doses besides being safety to natural enemies *viz*., coccinellids and spiders 5.16 and 6.02 nos/ 10 plants, respectively as against 5.4 and 6.3 in control.

Keywords: Corn, Ampligo 150ZC, unmanned aerial vehicle, phytotoxicity, biosafety

T3-52

Evaluation of bio-efficacy, phytotoxicity and bio-safety of isocycloseram 20% + emamectin benzoate 5% w/v SC against *Spodoptera frugiperda* in Maize

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Abstract

Maize is one of the important cereal crops grown throughout the world and has the highest production among the cereals. About 20.6 mha land area is under maize cultivation and contributes 121 million tones around the globe (FAOSTAT, 2021). India is one among the top ten leading maize producing countries with 31.64 million tonnes produced from 9.9 mha (Indiastat, 2021). Insect pests pose a heavy threat to crop and causes major yield loss. The invasive pest fall armyworm resides on maize crop from seedling to cob maturity, thus necessitating spraying of insecticides at multiple times. The present study was conducted to evaluate the bio-efficacy of isocycloseram 20%+emamectin benzoate 5% w/v SC against corn pests. Among the treatments, isocycloseram 20%+emamectin benzoate 5% w/v SC applied @ 62.5(50+12.5) g. ai/ha was found to be superior in population reduction of fall armyworm (0.63 nos/plant) besides recording the higher grain yield (6.45 t/ha) and safety to natural enemies *viz*., coccinellids and spiders 4.33 and 4.78 nos/ 10 plants, respectively as against 4.55 and 5.13 nos/plant in untreated control. There was no phytotoxicity symptoms on maize crop (epinasty, hyponasty, yellowing, necrosis, leaf injury, vein clearing and stunting) treated with Isocycloseram 20%+Emamectin benzoate 5% w/v SC @ 62.5 (50+12.5) g. ai/ha and 125 (100+25) g.ai/ha.

Keywords: Maize, Isocycloseram 20% + Emamectin benzoate 5% w/v SC, bio-efficacy, phytotoxicity, relative safety

T3-53

Bioefficacy of insecticides for the management of Maize fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

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Abstract

The invasive fall armyworm, *Spodoptera frugiperda* was reported for the first time in thee Indian subcontinent in 2018 (Sharanabassapa *et al.,* 2018). The pest is capable of causing huge crop losses (Prasanna *et al.,* 2018) in monocot and dicot crops and has an extensive host range in the Americas. There is need to develop an effective management strategy to contain this pest. The first line of defence for any invasive pest is usage of insecticides, through which the heavy infestation is drastically reduced followed by exploring IPM measures.

An experiment with nine treatments and three replications has been taken up in the Dept. of Millets, TNAU, Coimbatore during *Kharif* 2022 using TNAU hybrid Co(H)M8 in a randomized block design at a spcing of 70 x 20 cm maintaining a plot size of 12 m^2. Two sprays were taken up, first at 25 days after emergence (DAE) and the second at 40 DAE. Observations on per cent infestation by FAW was recorded besides recording the FAW leaf injury rating following Davis and Williams (1992) scale 10 days after each spraying and cob infestation and score were also recorded at the time of harvest. The yield per plot was also recorded at the time of harvest. The pretreatment infestation ranged between 63.3 to 73.3 per cent in different treatments. After the first round of spraying, the least infestation (16.7%) was recorded in in flubendiamide 480SC and chlorantraniliprole 18.5SC treated plots as against 60.0 per cent in control. After second round of spraying, chlorantraniliprole 18.5SC spraying recorded the least infestation (3.3%) followed by chlorantraniliprole 9.3% + lambda cyhalothrin 4.6% ZC (10.0%) as against 68.3 per cent in untreated control. However, in terms of score, chlorantraniliprole 18.5SC and flubendiamide 480SC treated plots registered least score (1.1). With respect to cob infestation, flubendiamide 480SC followed by chlorantraniliprole 18.5SC spraying registered the least infestation (21.7 and 23.3%, respectively) as against 46.7 per cent in control. The yield was also maximum in chlorantraniliprole 18.5SC and flubendiamide 480SC treated plots (5117 kg/ha and 4987 kg/ha, respectively) as against 2931 kg/ha in untreated control. Thus, insecticides *viz*., chlorantraniliprole 18.5SC 0.4 ml/l and flubdendiamide 480SC 0.3 ml/lit are effective in reducing the invasive fall armyworm infestation, besides increasing yield when compared to control.

Keywords: Maize, Fall armyworm, bioefficacy, insecticides, management

T3-54
Evaluation of sorghum land races for resistance to sorghum shoot fly, *Atherigona soccata*

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Abstract

Sorghum is one of the important dryland crops grown in sub-saharan Africa and Asia serving as a source of food, feed, fodder and biofuel besides being a livestock feed, for poor farmers in rural areas. The crop is relatively drought tolerant and comes up well in adverse climatic conditions. The crop is cultivated in an area of 3.39 lakh ha in Tamil Nadu with an annual production of 4.4 lakh tonnes and productivity of 1.3 tonnes/ha (Dept. of Economics and Statistics, 2019-20). Sorghum is infested by more than 150 insect pests, of which shoot fly, *Atherigona soccata* is of serious concern which can result in complete plant loss at times (Aher *et al.,* 2022). It is a key pest of sorghum and attacks the crop during early crop growth stage i.e. 10 – 25 days after planting. The larva (maggots) thrive in the innermost whorl causing wilting of the growing point and drying of central leaves referred to as “dead heart”. The affected whorl exhibits a bad odour and can be pulled out easily. Losses due to sorghum shoot fly alone have been reported to the tune of 22.0 – 84.0 per cent (Mote *et al.,* 1982).

Host Plant Resistance is considered one of the important components in mitigating the shoot fly menace in sorghum and sorghum land races offer good donors for shoot fly resistance. A field study was conducted at the Department of Millets, Tamil Nadu Agricultural University, Coimbatore during *Kharif* 2021 to assess the levels of resistance in sorghum land races for sorghum shoot fly in comparison with cultures and cultivated varieties. A total of ten land races, five cultures, three cultivars and one resistant and one susceptible checks were subjected to evaluation. In order to increase the population of shoot fly, Interlard – fishmeal technique was followed wherein moistened fishmeal was sprinkled in the interlards (inter-rows) of the different land races and other cultures and varieties within a week after germination (Sharma, 1992). The shoot fly damage was recorded on 14 days after germination (DAE) and 21 DAE. The shoot fly infestation was categorised as Resistant (< 20 % dead heart), Moderately Resistant (21-50% dead heart) and Susceptible (> 50 % dead heart). All the land rces registered less than 20 per cent shoot fly infestation with least infestation (9.5%) in Kottathur Local 6. The cultivated varieties registered shoot fly infestation in the range of 18.2 to 41.6 per cent, while the resistant (IS18551) and susceptible check (DJ6514) registered 8.0 and 22.0 per cent shoot fly infestation, respectively. Two cultures *viz*., TNS 661 and TNAU 2519 were also exhibiting relatively lesser levels of shoot fly infestation (8.2 and 9.7 %, respectively). Thus, sorghum land races are a source of promising donors for resistance breeding programmes especially with respect to sorghum shoot fly.

Keywords: Sorghum, land races, shoot fly, *Atherigona soccata*, host plant resistance

T3-55

Impact of maize fall armyworm refined integrated pest management module in maize growing districts of Tamil Nadu

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Abstract

In India, maize production has increased from 17.8 million tonnes in 1950 to 29 million tonnes in 2018-19 with a corresponding increase in area. A new threat to maize cultivation came in the form of invasive fall armyworm, (FAW), *Spodoptera frugiperda* (JE Smith) in 2018 (Deshmukh and Kalleshwaraswamy, 2018). An Integrated Pest Management Capsule has been formulated by Tamil Nadu Agricultural University during 2021-22 based on a multi-centered, multi disciplinary approach involving TNAU entomologists across the state under the Government of Tamil Nadu sponsored Research and Development project on “Developing Integrated Pest Management Module for Maize Fall Armyworm and Validation Under Area Wide Integrated Pest Management (AWIPM) through Farmers Participatory Approach in Tamil Nadu”.

The awareness of TNAU’s IPM capsule in terms of adoption of different IPM components *viz.,* seed treatment, neem cake, pheromone traps, border cropping, botanicals, biocontrol agents and window based insecticide spraying was studied. The impact of IPM adoption on the number of sprays, type of sprayers used and the yields obtained were studied based on feedback questionnaires distributed to farmers during State and Regional Level farmers Workshops and awareness programmes. About 717 farmers took part in this survey representing 18 districts of Tamil Nadu.

The results of the state wide survey revealed that, the farmers were capable of spotting the FAW infestation at about 14 days after emergence. However, in some of the districts like Pudukottai, Tenkasi and Tirunelveli the incidence was first spotted at around 8.0 days while in Madurai and Tiruvannamalai farmers spotted the incidence around 20.0 days.

Regarding the awareness among the farmers on the TNAU IPM capsule, almost in all the districts, 56.1 % of the farmers got the capsule information from TNAU, followed by 17.6 per cent from State Department of Agriculture. TNAU is closely associated with State Department of Agriculture for dissemination of technology throughout the state and thus, TNAU and State Department of agriculture together contributed for 74.1 per cent technology transfer while 16.4 per cent of the farmers relied upon their own friends and 5.4 per cent farmers sought the help private input dealers.

With regard to adoption of different components of IPM capsule, about 56.2 per cent of the farmers incorporated neem cake in their fields. Similarly, 57.2 per cent of the farmers placed pheromone traps. Majority of the farmers felt that, both these inputs are a bit costly and hence demanded subsidised inputs for the adoption of neem cake and pheromone traps. Only 21.2 per cent of the farmers went for neem based insecticides and farmers were

of the view that, neem based insecticides are comparatively less effective than the chemical insecticides. With respect to seed treatment, only 46.1 per cent of the farmers resorted to treating the seeds. In this case, majority of the farmers were of the opinion that, the seeds were already treated. However, TNAU insisted on looking at the label and advised the farmers to go for seed treatment with cyantraniliprole + thiamethoxam 19.8% @ 4 ml/kg seed, if they were not treated with insecticides *a priori*.

The window-based insecticide spray advocated by the TNAU reduced the number of insecticide sprays to 2.3 sprays and the farmers realised satisfactory levels of control. This should be compared with the invasive phase of the pest, when farmers went up to 5-6 rounds of insecticide sprays. Reduction in number of sprays is having multiple benefits *viz.,* reduction in the cost of plan protection, reduced residues in the final produce, reduced toxicity to non-target organisms, conservation of natural enemies, etc. As per the TNAU recommendation, about 62.4 per cent of the farmers went for knapsack sprayer and realised satisfactory levels of FAW control. An average yield of 1746 kg/ac was realised by the farmers before adoption of refined IPM practices which reached an average of 2684 kg/ac upon adoption. This corresponds to additional yield of 900 kg/ac approximately, adding a monetary benefit of Rs. 18,000 per acre under current maize market price.

At the outset, the transfer of technology through the triple platform *viz*., TNAU, State Department of Agriculture and Private Input Dealers worked well for the betterment of farmers. With policy initiatives like providing neem cake and pheromone traps at subsidised rates, the adoption rates of these technologies can be improved. Similarly, providing good quality legume seeds in small sachets along with maize seeds at seed distribution outlets can be thought of to increase the border cropping proportion. Still persistent efforts on the part of TNAU and State Department of Agriculture are needed for continued transfer of the TNAU IPM capsule to manage maize fall armyworm to reach larger masses.

Keywords: Maize, fall armyworm, *Spodoptera frugiperda*, adoption rate of IPM, Tamil Nadu

T3-56
Biocontrol of leaf rust disease of sorghum under field condition

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Abstract

Sorghum (*Sorghum bicolor* L. Moench) is the economically most important millet crop worldwide. Considerable loss caused by the phytopathogenic fungi is one of the most important challenges affecting the global crop production. Leaf rust, caused by *Puccinia purpurea*is one of the most destructive sorghum diseases. Under favourable environmental conditions, it can destroy millions of hectares of sorghum crop in less than a month, causing full economic loss. Many researchers have studied the chemical fungicides against sorghum leaf rust. However, their uses are undesirable due to health concerns, the hazard effects they inflict on the environment and their high cost. In contrast, the biological control is a potential, economical, and eco-friendly approach to control the disease. However, some biocontrol agentshave been reported to be as effective against the rust diseases. Hence, the attempt was made to contain the disease using bacterial and actinobacterial formulation (Talc) for rust disease management in Sorghum.

The trial was conducted with six treatments viz., *Streptomyces rochei* 0.2% (30DAS) + *Bacillus subtilis* (Bbv57) 0.2% (45DAS), *Bacillus subtilis*(Bbv57) 0.2% (30DAS) + *S. rochei* 0.2% (45DAS), *S. rochei* 0.2% (30 & 40 DAS), *Bacillus subtilis* (Bbv57) 0.2% (30 & 40 DAS), Mancozeb 0.2% (30 & 40 DAS) along with control during Rabi season 2022-23 and the

results indicated that the mancozeb (0.2%) recorded least rust incidence (4.77 PDI) and maximum grain (1992.75 kg/ha) and straw (2520.63 kg/ha) yield, followed by the application of *Streptomyces rochei* 0.2% (30 DAS) + *Bacillus subtilis* (Bbv57) 0.2% (45 DAS) and *Bacillus subtilis* (Bbv57) 0.2% (30 & 40 DAS) at 0.2%, which recorded 5.90 PDI and 6.84 PDI, with a grain yield of 1907.55 kg/ha and 1870 kg/ha, respectively. The delayed initiation of the first symptom was noticed in mancozeb (0.2%) spraying on 58 DAS, followed by *Streptomyces rochei (*0.2% on 30 DAS) and *Bacillus subtilis* (Bbv57) (0.2% on 45 DAS) spraying on 58 DAS. The highest BC ratio of 1.72 was obtained for mancozeb (0.2%), followed by spraying of *Streptomyces rochei at* 0.2% (30 DAS) and *Bacillus subtilis* (Bbv57) at 0.2% (45 DAS), which showed a BC ratio of 1.72.

Keywords: Sorghum, Leaf Rust, *Puccinia purpurea*, Biological Control

T3-57

Deciphering novel endophytic bacterial consortia for the management of blast disease in finger millet

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Abstract

Finger millet [*Eleusine coracana* (L.) Gaertn. subsp*. coracana*] is aclimate-resilient crop of Poaceae familygrown in arid and semiarid region and is an allotetraploid (AABB) species with 2n=4x=36 chromosomes. Its low Glycemic Index (GI) value, high nutraceutical properties and superior malting quality makes it a preferred choice for diabetics. It is challenged by a number of biotic and abiotic factors that affect the ultimate yield. Among the biotic factors, Blast disease is a major constraint in finger millet cultivation. The blast disease in finger millet is caused by *Magnaporthe grisea* (Hebert) Barr. (Anamorph: *Pyricularia grisea* Sacc.), which is highly devastating and adversely affects productivity. The pathogen infects all aerial parts causing leaf, neck and finger blast resulting in yield losses, whichoften exceed 50% annually. Its control relies on three broad management strategies through application of chemical and biological agents and breeding of blast resistant varieties. Conventional breeding strategies *viz.,* development of resistant varieties using oligo-genes and application of fungicides often leads to the development of resistance in blast pathogens.Thus, biological control of blast disease has been considered as a sustainable alternative method to synthetic chemical fungicides. However, in recent decades thenovel research on endophytic bacterial consortiaasbioinoculantsto enhance crop yield has been proposed which offerswith multifunctional attributessuch as the production of quality grains, protection of crops against biotic and abiotic stresses; soil fertility enhancement and are environmentally safe.The mixture of endophytic bacterial species in a formulation is an emerging technology in the present era because of its multiple benefits throughPGP traits, nutrient solubilisation, high PEG tolerance, extracellular hydrolytic enzyme production and antagonistic potential.Metagenome sequencing of fingermilletassociated microbial consortia provides unique diversity of endophyteslike *Bacillus cereus,B. amyloliquefaciens, Enterobacter* sp., *Pseudomonas* sp. and *Paenibacillus* sp. could be used as putative PGPR cum potential bio-control agents in reducing the incidence of blast disease. However, no effective bioinoculant has been formulated and widely adopted for effective biological control of blast disease. Thus, bioformulation with endophytic bacterial consortiahas been proposed as sustainable approach to alleviate multiple stressand confers blast disease resistance in finger millet.

Keywords: Finger millet, Blast pathogen, Endophytic bacterial consortia, Bioformulation.

T3-58
Effect of sowing dates on the incidence of downy mildew in Sorghum

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Abstract

Sorghum downy mildew is a disease that has potential to cause yield loss to susceptible hybrids if there is a high incidence in the field. The seedling stage, about 3 to 4 weeks after planting, is a good growth stage to determine the incidence of disease in the field, since the initial infections occurring in soil that lead to systemically-infected plants occur before then, and do not occur thereafter. Though field survey gives some idea about natural incidence of the disease it is better to have separate field experiment under natural field (non-sick) conditions to assess downy mildew incidence on present day cultivars. With this objective field experiments were conducted in two seasons at Coimbatore. One hybrid (CSH30) and one red grain line susceptible to downy mildew (DMS652) were sown on four windows starting from June to August. The experiment was laid out in split plot design with sowing window as main-plot and genotype as sub-plot. Each genotype was sown in 6 rows of 4 m length and replicated 3 times. Downy mildew incidence was recorded at vegetative (30 DAS) and reproductive (60 DAS) stages. Other parameters like grain yield and seed mass were also recorded. In 2020, there was gradual but significant increase of downy mildew as sowing date advances from 1st week of July to 3rd week of August. Trend was same during vegetative and reproductive growth stage on both the cultivars. In 2021, the trend was same during vegetative and reproductive growth stage on the susceptible genotype DMS652 only. There was decrease in grain yield and increase in downy mildew incidence as sowing advances from 1st week of July to 1st week of August which partly may be due to effect of downy mildew. On the hybrid CSH30 there was no downy mildew incidence in July and thereafter increasing trend was noted. The incidence was increased due to weather factors viz., day and night (19-22) temperature, RH (80-90%) and rainfall (30-35mm) prevailed during August. Early sowing before july may reduced the downy mildew incidence.

Keywords: Sorghum, Downy mildew, Sowing windows, Cultivars, Weather parameters

T3-59
Volatile Compound-Mediated Recognition and Inhibition Between *Streptomyces rochei* and Grain mould pathogens of Sorghum

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Abstract

The organic approach to the management of the disease is essential and will increase consumer demand. Bioactive molecules like mVOC (volatile organic compound) identification are used to unravel the molecules responsible for

antifungal activity. Numerous pathogens have been found to be potential antagonists of the *Streptomyces rochei* strain (ASP). The goal of the current research was to examine *S. rochei*'s ability to suppress pathogens that cause sorghum grain mold through the use of a dual culture approach and the formation of microbial volatile organic compounds (mVOCs). The mVOCs reduced the mycelia development of *Fusarium moniliforme* and *Curvularia lunata* by 63.75 and 68.52 per cent, respectively, in the inverted and paired plate test. By changing the structure of the mycelium, the mVOCs prevented spore generation and decreased mycelial growth. *Streptomyces rochei's* interactions with these two pathogens throughout the current study resulted in the profiling of 45 mVOCs altogether. We investigated the (mVOCs) produced by *S. rochei* alone and how they interacted with *F. moniliforme* and *C. lunata*. In the current investigation, *S. rochei* modulated the levels of numerous chemicals, including 2-methyl-1-butanol, methanoazulene, and cedrene. When *S. rochei* interacted with *F. moniliforme* and *C. lunata*, it released brand-new terpenoids with peak regions including myrcene (1.14), cymene (6.41), and ç-terpinene (7.32). These metabolites play a role in the biosynthesis of sesquiterpenoids, alkanes, and the pathway for the breakdown of oxalic acid. An understanding of the different ways that *S. rochei* manifests mechanisms such hyperparasitism, competitions, and antibiosis via mVOCs is provided in the current work. In addition to their antibacterial properties, these metabolites may promote plant development.

Keywords: Antifungal, Grain mold, interaction, mVOCs, Sorghum, *S. rochei*

T3-60
Pre and Post-harvest practices for preventing aflatoxin contamination in maize

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Abstract

Maize is a vital food and feed grain worldwide. Aflatoxin produced primarily by the fungi *Aspergillus flavus* and *Aspergillus parasiticus*, are very potent carcinogens in both humans and livestock and can readily contaminate maize grain in the field and in storage. Earlier work suggested that proper harvesting management practices as well as efficient postharvest drying and storage practices should significantly reduce aflatoxin contamination. However, developments of Aflatoxin during maize crop growth periods were not addressed. Curbing of Aflatoxin development and ramification are essential to reduce exposure to aflatoxins by consumers and producers dependent on maize for food and income generation.Pre- and post-harvest aflatoxin contamination of maize caused by *Aspergillus flavus*is a major problem in the tropics. Sound crop management practices are an effective way of avoiding or at least diminishing, infection by *Aspergillus flavus*and subsequent aflatoxin contamination. Adopting recommended cultivation practices *viz*., application of biocontrol agents, insects and drought management and harvesting at maturity stage are found to reduce aflatoxin contamination. Postharvest management of aflatoxin was conducted by using four plant product viz., *Adhatodavasica*Nees, *Andrographispaniculata* (Burm. f.) Wall. ex Nees, *Trachyspermumammi*, Zimmu (Interspecific hybrid of *Allium sativum* and *Allium cepa*)with three packing technique viz., Jute bag, Fertilizer bag, cloth bag. The packing methods viz., Jute bag, Fertilizer bag and cloth bag treated with the plant products was found to free from aflatoxin contamination in the properly dried maize samples (Moisture content <10%) up to six months observation. In artificially inoculated condition (*A.*

flavus x10^5 CFU ml^{-1}), high moisture content (>12%) with *Andrographispeniculata* plant product (3%) treated maize seeds packing in jute bag has found to be free from contamination up to six months observation. The results showed that using recommended cultivation practices followed by packing with jute bag treated with *Andrographispeniculata* plant product (3%) was found to free from aflatoxin contamination.

Key Words: Aflatoxin, Agronomic practices, Plant Product,*Andrographis,* Packing method, Jute bag.

T3-61
Survey of important disease of Nutricerarls diseases in southern TamilNadu

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Abstracts

Millets are also rich in phytochemicals including phyticacid. Southern district of TamilNadu survey of important disease for Kuthiraivali leaf blight(*Helminthosporium*) and Ragi blast increasing trends for 2017-2021 in Sivagangai district followed by Madurai and Virthunagar district, In 2021 Cumbu important diseases like blast-*Pyricularia* and leaf blight *severe* cause heavy yield losses and posing threads to Small millet production. its severe form causes upto 30 - 40 per cent loss in grain yield

Keywords: Survey, Kuthiraivali, leaf blight, Ragi, Cumbu, Tenai blast

T3-62
Management of Indian barnyard millet leaf blight by Plant extracts and chemical methods

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Abstracts

The management of leaf blight pathogen with nineteen plant extracts tested under *in vitro* conditions. Among nineteen plant extracts the 5v (Vilvum, Vembu (neem), Vanni, Vagai and Vengai) plants extracts (10%) effectively inhibited mycelial growth (84.81, 64.77, 63. 26, 61.36 and 48.56 per cent reduction over control) of Leaf blight pathogens. The field experiments carnbendazim +mancozeb @2gm/lit, followed by *Bacillus subtilis* seed treatment 10gm/kg and foliar spray @1gm/lit these were onpar with each other followed by vembu leaf extracts (10%) to controlling of disease. the effective extracts, all of which are readily available to the farmers, should be promoted instead of the synthetic fungicides, which are in limited supply and invariably expensive for millet farmers in TamilNadu

T3-63
Millet-Associated Seed-Borne Mycoflora and Their Management

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Abstract

Millet crops are an important staple food source for millions of people worldwide. However, the production and yield of millet can be significantly affected by seed-borne fungal pathogens, also known as seed-borne mycoflora. These pathogens can lead to reduced germination rates, seedling vigor, and overall crop health. Therefore, understanding the diversity and management of seed-borne mycoflora in millet is crucial for sustainable millet production. The mycoflora associated with millet seeds can comprise various fungal species, including *Fusarium, Aspergillus, Penicillium*, and *Alternaria.* These fungi can colonize the seed surface, internal tissues, or both, leading to seed deterioration and subsequent crop losses. Furthermore, some seed-borne fungi can produce mycotoxins, posing risks to human and animal health if consumed. Several management strategies have been developed to control seed-borne mycoflora in millet. These strategies include cultural practices, such as crop rotation, seed selection, and field sanitation, which aim to minimize the presence of fungal pathogens in the soil and on crop residues. Seed treatments, including chemical and biological agents, are also employed to reduce fungal infection during storage and planting. Additionally, advancements in molecular techniques have facilitated the identification and characterization of seed-borne fungi, enabling more targeted and effective management strategies. Molecular methods, such as polymerase chain reaction (PCR) and DNA sequencing, can assist in early detection and monitoring of fungal pathogens, leading to timely interventions. In conclusion, the seed-borne mycoflora of millet can significantly impact crop productivity and quality. Effective management strategies, including cultural practices, seed treatments, and molecular techniques, play a vital role in minimizing the incidence and spread of seed-borne fungal pathogens. Further research is warranted to explore novel approaches for sustainable and environmentally friendly management of seed-borne mycoflora in millet production systems.

Keywords: Millet, Seed-borne mycoflora, Fungal pathogens, Management strategies, Cultural practices, Seed treatments.

T3-64
Strategies to mitigate abiotic stresses in millets

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Abstract

Millets are extremely important cereal crops in the agricultural sector. They hold particular significance in the semiarid tropical regions of Asia and Africa with their beneficial properties like food intends for human and livestock consumption. Millets are grown in areas

that are not ideal for cultivation.Although millets have many benefits and are tolerant to stresses, their production is constrained by a number of environmental issues and impending effects of climate variability.By making use of contemporary genetic, genomic and agronomic techniques we can mitigate abiotic stressors and improve the yield stability of millets under climate change conditions. In order to solve the issue, it is essential to employ modern breeding techniques and omics tools to improve physiological as well as agronomical traits of millets. High-throughput methods such as TILLING, mutation breeding, transgenesis, and genome editing (CRISPR/Cas9) methodology are highly effective and precise that concurrently target several locations. These techniques were successful in creating millet crops that are tolerant to abiotic stress by manipulating signaling pathways or regulatory processes involved in protecting crops. After obtaining candidate lines with appropriate abiotic stress tolerance, hybridization can be used to gain higher tolerance to various abiotic stressors or increased production.

Keywords: Millets, abiotic stress, adaptive strategies

T3-65
Physiological studies for yield improvement in Finger Millet under drought condition

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Abstract

The pot culture experiment was conducted to study the effect of nutrients and PGRs on finger millet in the Glass house, Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore during 2019. The experiment was conducted in variety CO15, comprising of eight treatments viz., T_1- Absolute control (Irrigated), T_2- seed treatment with Brassinosteroid (0.1 ppm), T_3- foliar spray of All 19:19:19 (1%), T_4- Urea (0.5%)+ KCl (1%), T_5-Salicylic acid (100 ppm), T_6- Brassinosteroid (0.3 ppm), T_7 - Chlormequat chloride (200 ppm) and T_8 - Drought Control. Drought was imposed by withholding irrigation at vegetative stage. The treatment was imposed at vegetative stage and the soil moisture data were recorded by using moisture meter (Data Devices, Theta Probe). Foliar application of 0.3 ppm Brassinosteroid application showed highest photosynthetic rate, stomatal conductance, transpiration rate, catalase activity and superoxide dismutase activity followed by application of 100 ppm Salicylic acid. Among the treatments, the maximum yield was recorded in 0.3 ppm brassinosteroid treated plants than control under drought condition.Therefore, foliar spray of brassinosteroid (0.3 ppm) and salicylic acid (100 ppm) were found to be effective in improving the physiological and biochemical aspects by exhibiting better yield and yield attributes under drought condition in finger millet.

Keywords: Finger millet, drought, foliar application and yield

T3-66
Melatonin enhances membrane integrity and plant water status of Finger Millet under drought stress

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Abstract

Drought stress is considered as the most devastating abiotic stress that impairs the stability of cell membranes and plant water status, hence, photosynthesis and other metabolic processes are severely affected which leads to drastic reduction in yield in food crops. Finger millet (*Eleusinecoracana* L.) is an important food crop after cereals and it is grown extensively in rainfed areas because of its adaptive characters. But, the yield potential observed to be low than the actual potential due to drought that occurs during critical stages of the crop. Alleviation of effect of drought through plant growth regulating compounds is one of the options to sustain the yield of finger millet growing extensively under drought prone areas. Melatonin is one such compound, acts as an antioxidant and promotes the tolerance of plant against abiotic stresses. To assess the efficacy of melatonin in ameliorating the consequences of drought in finger millet, an experiment was laid out with four treatments *viz.,* irrigated control, drought control, drought with melatonin treatment and drought with 0.2 ppm brassinosteroids, each with three replications under pot culture condition. Separate set of plants were maintained for imposing vegetative (35-40 DAS) and reproductive stage (55-65 DAS) drought by withholding of water for a period of 10 days. The melatonin @ 60 μM was given as foliar spray at 3 days after the imposition of drought, when the plant water status (RWC) reduced to below 90%. Melatonin treatment had significantly influenced the traits related to the cell membrane stability like MDA, electrolyte leakage and activities of catalase, superoxide dismutase, ascorbate peroxidase. Also, melatonin application helps to maintain high plant water status under drought condition by regulating the stomatal conductance, enhancing the osmotic potential, osmotic adjustment and relative water content and thereby photosynthetic activity. The yield was also increased in melatonin treated plants than the untreated plants under drought condition owing to higher plant water status, gaseous exchange and photosynthetic rate.

Keywords: Drought, Finger millet, Melatonin, Membrane stability, Yield.

T3-67
Development of new foliar formulations for yield enhancement in Finger Millet

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Abstract

Pot culture and field experiments were conducted at Dept. of Crop Physiology, TNAU, Coimbatore to test different foliar formulations for enhancing the yield in finger millet under irrigated and drought condition. Foliar spray of different formulations were applied at flowering stage under irrigated condition in pot culture and the observations were recorded ten days after foliar application. The physiological parameters *viz.*, chlorophyll index, relative water content (RWC) and soluble protein content were recorded. Among the different foliar formulations, foliar spray of Formulation II recorded higher SPAD (47.1) value, RWC (80.8) and soluble protein content (14.0) than other treatments. The yield and yield attributes were recorded significantly higher in Formulation II than control. Similarly, an experiment was also conducted under drought condition to test the foliar formulations in finger millet. The stress was imposed at flowering stage and after that foliar different formulations wereapplied. In this study,the physiological traits*viz.*, chlorophyll stability index, chlorophyll index, RWC,proline content and antioxidant enzymes were recorded. It was observed that all the foliar formulations recorded more SPAD value, better RWC and CSI as well as higher proline content than drought control. Among the different foliar formulations, Formulation II exhibited significant results in physiological traits and yield attributes than other treatments under drought condition.Based on these findings, a field experiment was conducted under irrigated condition where foliar application of formulation II recorded higher yield with the yield increment of 12% than control.

Theme 4

Post-harvest management, value addition and therapeutic foods in millets

Extended summaries

T4-01
Development and evaluation of Tomato Pomace enriched gluten-free pasta from Finger millet

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Introduction

It is generally difficult to bring about changes in our eating patterns. Millets are underutilized in our daily diets and therefore their consumption needs to be increased. Hence, to promote the consumption of millets in the daily diets of north Indians, it is pertinent to introduce them in the form of convenient food, which appeals to the palate of local people and does not disrupt their dietary pattern. Finger millet (*Eleusine coracana* L.) is the most consumed small millet and accounts for 85% of all millet produced in India. It is an excellent source of calcium with a relatively better-balanced protein composition (Antony et al. 2018). Being gluten-free, it is the perfect choice for developing convenience products to increase its consumption and cater to the demand of the celiac disease population. The processing of tomatoes results in generation of 2-5% of tomato pomace of the initial weight of tomatoes processed, which is a rich source of nutrients, dietary fibre and oil (Botinestan et al. 2015). Therefore, efforts are underway to utilize it in food products to ensure better returns to the growers. Pasta is an easy to cook popular snack of all age groups with the added advantage of good storability. The present work was hence undertaken to develop gluten free pasta with optimal utilization of tomato pomace to achieve sustainable goals, and to study the acceptability, quality and nutritional parameters of the developed product

Materials and Methods

The work was carried out in the Department of Food Science and Technology, Punjab Agricultural university, Ludhiana. Finger millet (Acc. IC0475677) was procured from the Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana while fresh tomato pomace (variety Punjab Ratta), was obtained from the Food Industry and Business Incubation Centre, Punjab Agricultural University, Ludhiana. The raw materials were processed further to get finger millet flour (FMF) and tomato pomace powder (TPP). FMF was replaced with TPP at 5, 10, 15 and 20% level and mixed thoroughly, followed by sieving, to make a uniform blend for pasta preparation. The pasta was prepared in pasta extruder (le monferrina Masoero, Italy) in macaroni shape (die No. 82), dried and packed in polypropylene (PP) bags for storage at 4°C till further analysis. Samples were evaluated on 9 point hedonic scale from extremely liked (9) to extremely disliked (1). The cooking quality, color, texture and nutritional profile of the most acceptable sample and control were then analyzed following standard protocols. Sensory evaluation was conducted to find the most acceptable formulation which was then further analyzed and characterized for its proximate, phytochemical, mineral, fatty acid and amino acid composition and compared with the control sample having no tomato pomace to know about the effect of addition of tomato pomace to the formulation. The data were inspected by one-way analysis of variance (ANOVA) and means were compared through Posthoc Tukey's test at ($p<0.05$). The data were subjected to statistical analysis using SPSS Statistical Software version 18.0 (SPSS Inc., USA).

Results and Discussion

- The pasta supplemented with 15% of TPP was adjudged best with 8.15 score on a 9-point hedonic scale pasta. It had higher protein, crude fiber, and possesses higher lycopene content (5.92 mg/100g) along with good amount of minerals (iron, calcium, phosphorus) fatty acids (oleic, linoleic, palmitic) and amino acids (valine, leucine, lysine, and histidine). The enriched pasta also showed significant increase in dietary fibre, total phenolic content, and the DPPH radical scavenging activity
- Enrichment with TPP resulted in a reduction in the cooking time but an increase in the gruel solid loss. The texture values also see a decrease with the addition of TPP in the pasta base.
- Supplementation of tomato pomace in finger millet flour pasta helps to enhance its color characteristics and textural properties in comparison to control pasta.
- The study thus showed that waste generated through tomato processing can be successfully utilized as a functional ingredient in the preparation of novel gluten free pasta from finger millet possessing enhanced protein, dietary fiber, bioactive compounds, minerals, fatty acids and amino acid profile
- This gluten-free pasta product will help in increasing the daily consumption of finger millet by both the celiac disease affected people and general population and at the same time help in sustainable utilization of tomato pomace, a food industry by-product.

The convenience food, Pasta, developed from finger millet and tomato pomace, is gluten-free with enhanced nutritional profile and functional benefits and hence will cater to the needs of people with celiac disease and general population as well. The convenience food will help to popularize the adoption/ incorporation of finger millet in diet and in valorization of tomato pomace.

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Table 1. Proximate and phytochemical composition of Finger Millet based Gluten-free Pasta

Parameter	**Control pasta (0% TPP)**	**TPP supplemented pasta (15% TPP)**
Moisture (%)	6.1±0.18^{b}	6.9±0.20^{a}
Fat (%)	1.62±0.01^{b}	2.66±0.02^{a}
Protein (%)	6.13±0.17^{b}	8.32±0.21^{a}
Ash (%)	2.01±0.02^{b}	2.47±0.03^{a}
Crude fibre (%)	3.49±0.25^{b}	8.65±0.42^{a}
Total carbohydrates (%)	80.65±1.98^{a}	71.00±1.62^{b}
Dietary fibre (%)	8.91±0.2^{b}	17.66±0.58^{a}
Energy (kcal)	361.70±3.78	341.22±3.42
Total phenolic content (mg GAE/100 g)	293.76±6.4^{b}	311.2±7.1^{a}
DPPH radical scavenging activity (%)	59.2±0.96^{b}	72.7±1.01^{a}
Lycopene (mg/ 100 g)	-	5.92±0.04

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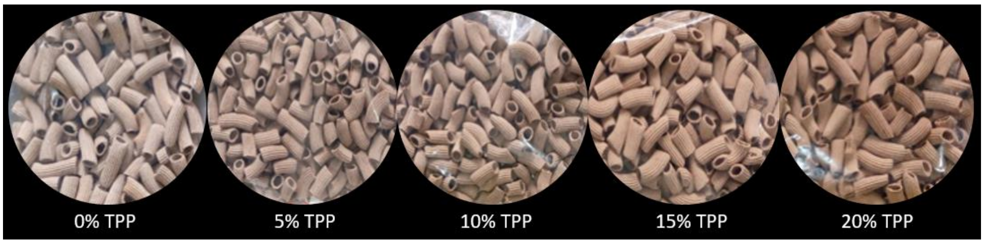
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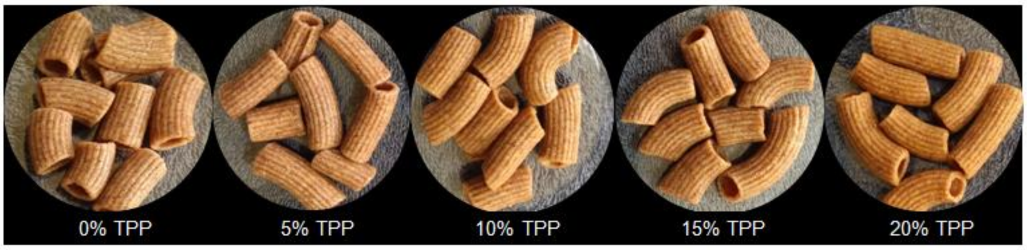
5% TPP
10% TPP
15% TPP
20% TPP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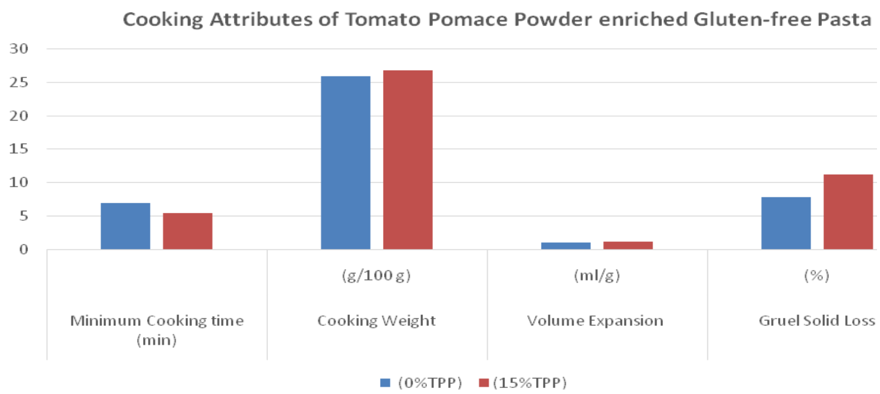
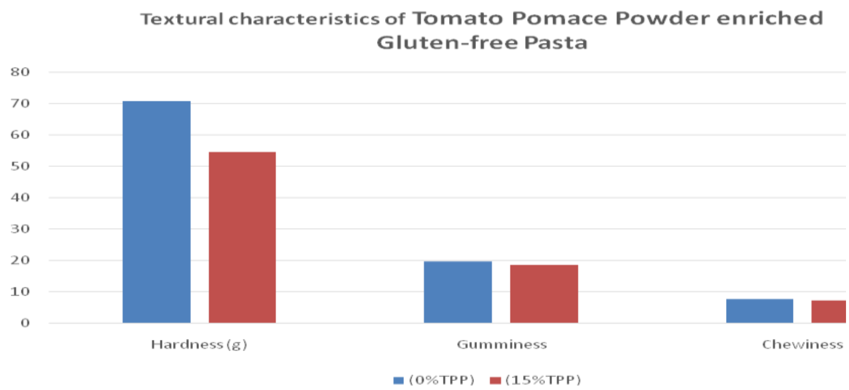

Cooking Attributes of Tomato Pomace Powder enriched Gluten-free Pasta
30
25
20
15
10
5
0
(g/100 g)
(ml/g)
(%)
Minimum Cooking time (min)
Cooking Weight
Volume Expansion
Gruel Solid Loss
(0%TPP)
(15%TPP)


Textural characteristics of Tomato Pomace Powder enriched Gluten-free Pasta
80
70
60
50
40
30
20
10
0
Hardness (g)
Gumminess
Chewiness
(0%TPP)
(15%TPP)

T4-02

Effect of modified starch on glycemic index of millet based pasta product

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Abstract

The study aimed at investigating the appropriate technology for development of modified starch and to standardize the millets based pasta products incorporated with modified starch. Further the nutritional and sensory qualities of the developed pasta products were measured. We attempted physical modification technique i.e. autoclave-cooling and was found to be optimum for development of modified starch. The optimum flour blend for pasta products were whole wheat flour (50%), millet flour (25 and 50%) and cassava modified starch (15 and 25%) and green ram flour (10%) and it was found to be acceptable without affecting its sensory attributes.

Introduction

Health and nutrition is the most demanding and challenging field in this era and would continue to be in the future as well. Diet and lifestyle - related diseases include coronary heart disease, certain cancers (e.g. large bowel), inflammatory bowel diseases (IBD) and diabetes. Functional foods have two general types of beneficial effects: to reduce the risk of a disease, and to enhance a specific physiological function. The incidence of *diabetes mellitus* is increasing in an exponential manner globally (International Diabetes Federation, 2009). Pasta products are also basic foodstuffs having an important role in the human food consumption. But research has showed that sugars are progressively liberated from pasta foods during digestion, leading to low postprandial blood glucose and insulin response. Epidemiological studies consistently show that the risk for type 2 *diabetes mellitus* is decreased with the consumption of whole grains (Dam *et al*., 2003 and Murtaugh *et al*., 2003). Utilization of wholegrain cereals in food formulations is increasing worldwide, since they are rich sources of dietary fiber.

Materials and Methods

Standardisation of low glycemic functional pasta products (Noodles): Among the three modified starch, cassava modified starch, was utilized for the development of low glycemic functional pasta products because of its ease in starch extraction, per cent recovery (yield), low cost and for its abundant availability. To standardize the formula for the preparation of pasta products like noodles, spaghetti and macaroni various combinations of treatment schedule as trial was experimented. The various treatments whole wheat flour (50%) and replaced with whole wheat flour with combinations of kodo millet / barnyard millet flour and green gram dhal flour at different levels incorporated with modified/resistant starch (from 5% up to 25%) to formulate low glycemic functional flour for pasta products production were carried out. To improve the quality of the low glycemic pasta products such as strength, elasticity and to avoid disintegration and also to reduce solid loss the Sodium Alginate (NDL) / Guargum, a food stabilizer which also acts as a dietary fiber was added.

Results and Discussion

Chemical characteristics of low glycemic functional pasta product (Noodles): Chemical characteristics of low glycemic functional pasta product (Noodles) were presented in Table 6.The initial moisture content of experimental products (T_1 to T_7) ranged from 8.08 - 8.17 per cent was noted to be less when compared to control (T_1) as 8.20 per cent. Even though the substitution with millet flour (50% and 25% kodo / barnyard millet) and cassava modified starch for the formulation of low glycemic functional pasta products reduced the protein content because of the reduction in gluten but with the addition of gum (sodium alginate) has the tendency to improve the protein content. The highest protein content was noticed in T_4 (11.20 g/100g). Fat content of all the treated pasta samples were found to be low to that of the control (2.10g/100g). This is due to the fact that the low fat content of kodo millet and barnyard millet. The barnyard millet incorporated samples showed a very little higher fat content than the kodo millet but lower than that of the control samples. Significant increase in fiber content of pasta products (noodles) was observed with increase in the level of incorporation (50 and 25 per cent) of kodo millet flour and barnyard millet flour compared to the control. The highest fiber content was noted in T_3 and T_6 samples as 5.83 and 6.91 g/100g. Incorporation of millet flour and pulse flour, due to modified starch (increased resistant starch content) imparts low digestible starch content, thus products with indigestible compounds leads to slow, low rate for the enzymatic hydrolysis of carbohydrates was observed.

The barnyard millet samples (41.70 – 50.12 g/100g) produced samples with lower starch content than the kodo millet flour (43.92 – 54.60 g/100g) samples. The high amylose content was noticed in T_3, T_4, T_6 and T_7 of noodles, as modified starch was added but was less in T_2 and T_5 samples due to the reduction in starch content with accordance to the incorporation of millet flour than the control. The dietary fiber of the millet and modified starch substituted product revealed an improvement in the TDF when compared to the other samples. Soluble dietary fiber was higher in the kodo millet flour substituted samples when compared to barnyard millet flour substituted samples those had higher insoluble dietary fiber. The highest total dietary fiber was noted in T_3 (19.15g/100g) and T_4 and T6 respectively. The calcium (37 to 43mg/100g), iron (3.20 to 8.01) and phosphorus (195.50 to 297.00, mg/100g), content of all the treatments for noodles respectively.

The amylase and total dietary fiber content was had found maximum in millet and modified starch substituted pasta products. The glycemic index of the developed millet based modified starch substituted pasta was found to be low.

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Murtaugh, M.A., Jacobs, D.R., Jacob, B., Steffen, L.M. and Marquart, L.: Epidemiological support for the protection of whole grains against diabetes. Proceedings of the Nutrition Society, **62**, 143–149 (2003).

Table 1. Proportion of functional flour used for low glycemic pasta products (noodles) formulation

<table>
<tr><th>Treatment</th><th>Whole Wheat flour</th><th>Kodo millet Flour (%)</th><th>Barnyard millet flour (%)</th><th>Cassava modified Starch (%)</th><th>Green Gram flour (%)</th><th>Sodium alginate (%)</th></tr>
<tr><td>T_1 (Control)</td><td>100</td><td>---</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td>T_2</td><td>50</td><td>50</td><td>---</td><td>---</td><td>---</td><td rowspan="6">2</td></tr>
<tr><td>T_3</td><td>50</td><td>25</td><td>---</td><td>25</td><td>---</td></tr>
<tr><td>T_4</td><td>50</td><td>25</td><td>---</td><td>15</td><td>10</td></tr>
<tr><td>T_5</td><td>50</td><td>---</td><td>50</td><td>---</td><td>---</td></tr>
<tr><td>T_6</td><td>50</td><td>---</td><td>25</td><td>25</td><td>---</td></tr>
<tr><td>T_7</td><td>50</td><td>---</td><td>25</td><td>15</td><td>10</td></tr>
</table>

Particulars	T1	T2	T3	T4	T5	T6	T7
Moisture (%)	8.20± 0.15	8.17±0.09	8.15± 0.13	8.13±0.03	8.15±0.10	8.11±0.13	8.08± 0.13
Protein (%)	11.14±0.13	10.82±0.21	9.26±0.22	11.20±0.05	11.12±0.23	9.34±0.23	11.45±0.22
Fat (%)	2.10±0.007	1.92± 0.01	1.72± 0.04	1.70± 0.02	2.0± 0.03	1.75± 0.02	1.73± 0.03
Fibre (%)	2.00±0.04	5.21±0.12	5.83±0.08	5.60±0.10	6.62±0.14	6.91±0.17	6.84±0.12
Starch (%)	54.60± 1.40	43.92± 0.89	51.58±1.20	45.28± 1.06	41.70±1.01	50.12± 1.04	42.72± 0.88
Amylose (%)	21.40±0.30	16.45± 0.27	25.34± 0.32	21.60±0.32	17.10±0.15	26.10± 0.62	22.11± 0.39
Soluble Dietary Fibre (%)	2.20± 0.01	4.16± 0.04	4.04± 0.03	4.11± 0.10	2.30±0.02	2.00±0.001	2.19± 0.01
Insoluble Dietary Fibre (%)	8.20±0.13	11.09± 0.05	15.11± 0.21	14.74± 0.02	11.61± 0.13	15.63± 0.33	15.14 0.29
Total Dietary Fibre (%)	10.40± 0.19	15.25± 0.14	19.15± 0.47	18.85± 0.07	13.91± 0.18	17.63± 0.02	17.33± 0.22
Calcium (mg)	38.0± 0.91	41.00± 0.08	37.00± 0.01	43.00±1.09	37.50± 0.01	33.00± 0.49	40.00±0.33
Iron (mg)	4.42± 0.05	3.73± 0.04	3.20±0.01	4.07± 0.04	8.01±0.02	5.11± 0.011	6.13± 0.15
Phosphorus (mg)	297.0±0.52	242.5± 1.38	195.5± 2.03	245.0± 4.20	288.5± 2.10	218.5± 0.11	294.4±2.91

T4-03

Vitamin D fortified millet milk beverage

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Introduction

Micronutrient malnutrition is a global phenomenon that affects developing and industrialized countries, with serious health and economic implications especially Vitamin D deficiency nearly 3 out of 4 population nearly 76 % of the Indian population were affected by vitamin D deficiency (National Institute of Health Database 2022).Millets are most important because of its high nutritional value. Ragi (Finger Millet) *(Eleusine coracana*) is one of the important cereals occupies highest area under cultivation among the small millets and it is a good source of magnesium and dietary fiber. It contains slowly digestible and resistant starch.Bajra (*Pennisetum glaucum*) is a profoundly nutritious and easy to digest cereal grain. These millets are power-packed with carbohydrates, essential amino acids, antioxidants, multiple vitamins like thiamine, riboflavin, folic acid, niacin, beta carotene, and minerals like iron, phosphorus, magnesium, and zinc.

Plant based milk may resemble consistency and appearance of cow's milk. Plant based milk lacks vitamin A, vitamin D, Vitamin B12, Omega 3 fatty acids which is one of the draw back of consuming plant based milk and to be corrected by food fortification technique. Food fortification is an important, continuous, self-sustaining strategy to improve the health and nutrition status of millions of people. Plant based milk are inexpensive and consumed in moderate amounts and so are an obvious vehicle for dietary mineral and vitamin fortification. Fortification of milk products is beneficial to consumers and provides opportunities for marketing for the non dairy product industry.

Cow milk allergy, lactose intolerance, calorie concern and more preference to vegan diets has influenced consumers towards choosing cow milk alternatives. It is inexpensive and alternate to poor economic group of developing countries, under nourished children, infants and also to address the triple burden of malnutrition, lactose, intolerance, osteoporosis, patients and post menopausal syndrome women.

Materials and Methods

The matured (whole grains) of local variety Ragiand Bajrawere purchased from local market of Madurai district of Tamil Nadu. Selected ragi and bajra were sorted by removing broken kernels and other unwanted materials. It was cleaned and rinsed with tap water twice. Hundred grams of each millet were weighed and soaked in water for 18 - 20 hrs.Soaked grains were drained and tied tightly with a muslin cloth and kept in dark for germination. The germination process was carried out a room temperature for about 24 hours for ragi and bajra. The germinated millet grains were dried at 45ºC for 8 hours to obtain the final moisture content of about 7-8 %. It was pulverized into flour and sieved. Millet flour was mixed with water 1: 6

ratio and it was ultra sonicated at 20 KHz for 2 seconds and it was filtered. Separated slurry and millet milk were extracted. The product was pasteurized at 85ºC for 7 mins and stored at 4ºC.The chemical form of Cholecalciferol D3 were added as fortificant in the ragi and bajra milk at 5µg to7.5 µg per liter as per FSSAI (2021) recommendation level.

Selected ragi and bajra grains are analyzed for proximate composition such ascarbohydrates, protein, fat, fiber and calcium by using methods AOAC (2000). Developed ragi and bajra millet milk are analyzed for physicochemical property such as pH, acidity, viscosity, protein, fat, fiber, calcium and sedimentation rate following the methods of Jeske*et al*., (2017). Vitamin D fortified ragi and bajra milk organoleptic characteristics were analyzed by using nine point hedonic rating scale.

Proximate composition of selected ragi and bajra grains

Ragi and bajra grain contain 68.92 and 62.36 (g/100g) of carbohydrates,8.72 and 12.12g/100g) of protein, 2.68 and 5.40 (g/100g) of fat, 5.45 and 5.27(g/100g) of crude fiber and calcium as 362 and 54.87 (mg/100g) respectively. Ragi grains contains higher amount of calcium. (Table 1)

Physico chemical properties of ragi and bajra milk

The physico chemical properties of ragi and bajra milk were analyzed. Ragi and bajra milk had pH value as 5.92 and 5.85; Acidity (%/100 ml) as 0.59 and 0.48; Viscosity as (cP/100ml) 2.89 and 3.74; protein as (g/100ml) 1.89 and 3.92; fat as (g/100ml) 1.02 and 2.57; fiber as (g/100ml) 1.78 and 0.28; calcium as (mg/100ml) 142.72 and 12.9; and sedimentation rate (g/40 ml) 0.97 and 1.02 respectively. (Table 2) Ragi milk had lower sedimentation rate and higher calcium content and also other nutritional content.

Organoleptic characteristics like colour and appearance, flavour, consistency, taste and overall acceptability were analyzed in both vitamin D fortified ragi and bajra milk. Both ragi and bajra milk R2 and B2 (5.5 cholecalciferol fortified) had higher sensory score and overall acceptability. (Table 3) But there is very slight difference occurs between both unfortified and different treated fortified milk.

The ragi milk had higher calcium content and good physico chemical property and other nutritional value when compared to bajra milk. Ragi milk is more suitable vehicle for vitamin D fortification. Sensory analysis of fortified and unfortified ragi and bajra milk had only slight changes occurs regarding organoleptic characteristics (by using nine point hedonic rating scale).

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Table 1. Proximate composition ofragi and bajra seeds (100g)

Parameters	Ragi grain	Bajra grain
Carbohydrate (g)	68.92	62.36
Crude protein (g)	8.72	12.12
Fat (g)	2.68	5.40
Crude fiber (g)	5.45	5.27
Calcium (mg)	362	54.87

Table 2. Physico chemical properties of ragi and bajra milk

Parameters	Ragi Milk	Bajra Milk
pH	5.92	5.85
Acidity (% / 100ml)	0.59	0.48
Viscosity (cp / 10ml)	2.89	3.74
Protein (g / 100ml)	1.89	3.92
Fat (g / 100ml)	1.02	2.57
Fiber (g / 100ml)	1.78	0.28
Calcium (mg / 100ml)	142.72	12.98
Sedimentation rate (g / 40ml)	9.97	1.02

Table 3. Organoleptic evaluation of vitamin D fortified ragi and bajra millet milk beverage

Parameters	Vitamin D fortified ragi milk				Vitamin D fortified bajra milk			
	Control	R1	R2	R3	Control	B1	B2	B3
Colour and appearance	8.2	7.9	8.2	7.5	8.0	7.4	8.0	7.3
Consistency	8.3	8.2	8.3	8.2	7.9	8.0	8.1	8.0
Taste	8.1	7.5	8.4	7.3	7.8	7.3	8.2	7.1
Falvour	8.3	8.1	8.2	8.1	8.0	7.9	8.0	7.9
Overall acceptability	8.7	8.5	8.8	8.6	8.4	8.3	8.6	8.0

Control	Unfortified ragi milk	Control	Unfortified bajra milk
R1	5µg choiecalciferol fortified ragi milk per liter	B1	5µg choiecalciferol fortified bajra milk per liter
R2	5.5µg choiecalciferol fortified ragi milk per liter	B2	5.5 µg choiecalciferol fortified bajra milk per liter
R3	6µg choiecalciferol fortified ragi milk per liter	B3	6 µg choiecalciferol fortified bajra milk per liter

T4-04
Studies on sensory evaluation, chemical analysis and cost configuration of burfi developed from finger millet flour with standard cattle milk

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Abstract
Millet based snacks are widely accepted in recent days and are fascinating specifically to children. Burfi was made by adding finger millet flour in the ratio of 100:0 (T1), 90:10 (T2), 85:15 (T3), 80:20 (T4), and 75:25 (T5), along with 30% sugar by weight of khoa. The milk was standardised to contain 6% fat. In a completely randomised design (CRD), the data were statistically analysed for five treatments and four replications. Evaluation of the taste, body, texture, colour, and general acceptability using a 9-point hedonic scale with five finger millet burfi treatments and four replications. The highest scores for flavour, body and texture, colour and appearance, and overall acceptability went to the burfi made with 15 parts finger millet flour (T3), which received scores of 8.85, 8.76, 8.95, and 8.89, respectively. Fat, protein, total solid, SNF, moisture, ash, and acidity were all at 22.98, 15.95, 81.03, 56.23, 18.97, 3.7, and 0.21 percent, respectively, in burfi made with the inclusion of 15 parts of finger millet flour (T3). Burfi's price was reduced at the same time that finger millet flour production rose. Production of burfi cost Rs 243.95, 229.95, 224.2, 215.95, and 207.7 per kg at ratios of 100:0 (T1), 90:10 (T2), 85:15 (T3), 80:20 (T4), and 75:25 (T5) khoa to finger millet flour, respectively. Burfi's production cost was Rs. 224.2 per kg when made with 15 parts finger millet flour (T3), the maximum allowable level. Therefore, it can be determined that adding 15 parts of finger millet flour will result in superior quality burfi.

Keywords: Burfi, Finger millet flour, Hedonic scale, Khoa

Introduction
Burfi comes in a variety of flavours, including plain, mawa, fruit, cashewnut, almond, besan, and khajoor, among others. Due to burfi's allure and widespread acceptability throughout India, a variety of flavours and ingredients have been added to it (Amrita Poonia and Sonika Pandey. 2020). Because of its nutritional power in terms of dietary and functional fibre, starch pattern, and high calcium and iron levels, finger millet has become more significant in recent years. In the Indian states of Karnataka, Tamil Nadu, Andhra Pradesh, and some of the north, finger millet is widely grown. Ragi production as a percentage of total production is highest in Karnataka, where it accounts for 512,000 tonnes, or 63.23 percent. Tamil Nadu is next with 800.4 thousand tonnes, or 8.91 percent, followed by Uttarakhand with 694 thousand tonnes, or 7.73 percent, Maharashtra with 622.6 thousand tonnes, or 6.93 percent, and Andhra Pradesh with 368,000 tonnes, or 4.11 percent. Madhya Pradesh has the lowest share (0.5 thousand tonnes at 0.006 percent). (Sankaran.,2017).

Materials and Methods

The market was used to source the complete, fresh, clean buffalo milk. The milk sample underwent an analysis for the presence of ash, acidity, moisture, total solids, fat, and protein. The Pearson's formula set the threshold for milk at 6%. Sugar was bought from the Madurai local market and, so the finger millet flour. Burfies with different combinations was prepared by addition of finger millet flour in the proportion of 100:0 (T1), 90:10 (T2), 85:15 (T3), 80:20 (T4) and 75:25 (T5) with 30 per cent sugar by weight of khoa was added.

Results and Discussion

The data from Table 1 demonstrated that the inclusion of finger millet flour greatly changed the flavour of burfi. Burfi made with 15 parts finger millet flour (T3) obtained the noticeably highest score (8.85 out of 9). It shown that as the amount of finger millet flour increased, the flavour rating of burfi increased up to a certain point and then decreased proportionally. Ramteke (2018) reported a similar outcome, stating that 10% potato flour (T3) in burfi received the highest point 44 and 20% potato flour scored the lowest point 40.25 for burfi.

The data from Table 1 revealed that, among all the treatments, the burfi made with 15 parts of finger millet flour (T3) had the highest score, 8.89, followed by T4 (20 parts), T2 (10 parts), T1 (0 parts), and T5 (25 parts), in that order. Burfi produced without the addition of finger millet flour cost Rs. 243.95 per kg (T1 control). In the proportions of 90:10 (T2), 85:15 (T3), 80:20 (T4), and 75:25 (T5), khoa to finger millet flour, the average total cost of burfi was Rs. 229.95, 224.2, 215.95, and 207.7 per kg, respectively. Thus, it was concluded that adding 15% finger millet flour (T3) might yield burfi of higher quality and fetch a higher price on the market. It may be assumed that the best finger millet flour burfi, which is nutritious and therapeutic in nature, can be made by mixing 15% finger millet flour and 85% buffalo milk khoa with 30% sugar. (Priced at 224.2 Rs/Kg)

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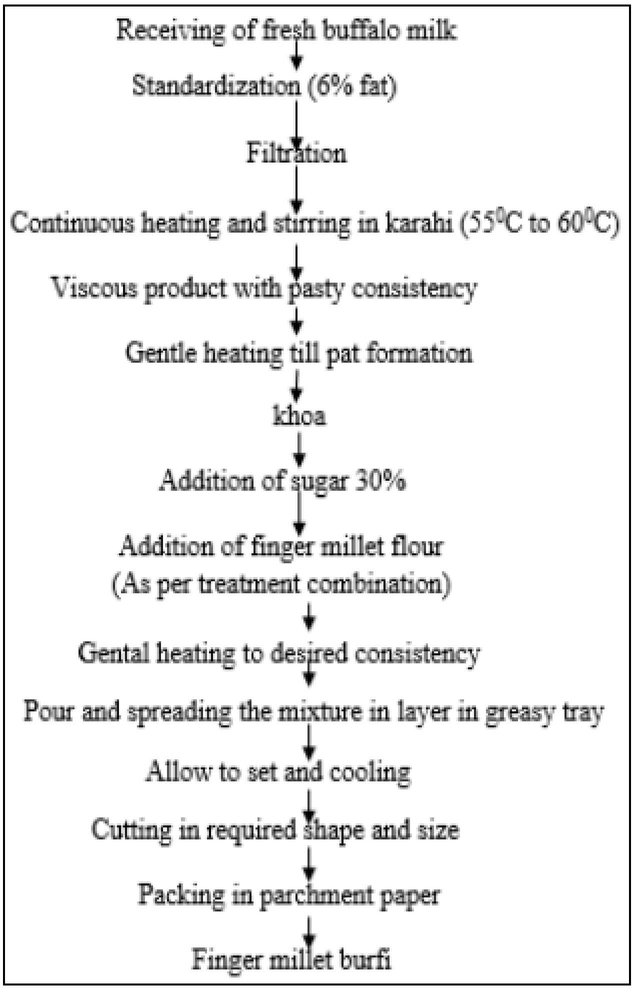
Ramteke VM, *et al.,.* 2018. Studies on preparation, sensory evaluation and cost configuration of potato flour burfi. *Intr. J Microbiol App Sci*. 7(8):1610-1615.

Table 1: Effect of finger millet flour on sensory evaluation and overall acceptability of burfi

Treatments	Parameters			
	Flavour	Body & Texture	Colour & Appearance	Overall acceptability
T_1	8.43^c	8.18^c	8.43^c	8.03^c
T_2	8.60^b	8.50^b	8.66^b	8.38^b
T_3	8.85^a	8.76^a	8.95^a	8.89^a
T_4	8.13^d	7.78^d	8.00^d	7.33^d
T_5	7.70^e	7.50^e	7.33^e	6.44^e
S.E. (m) ±	0.049	0.041	0.046	0.082
C.D.	0.148	0.124	0.141	0.25
Result	Sig.	Sig.	Sig.	Sig.


Receiving of fresh buffalo milk
Standardization (6% fat)
Filtration
Continuous heating and stirring in karahi (55⁰C to 60⁰C)
Viscous product with pasty consistency
Gentle heating till pat formation
khoa
Addition of sugar 30%
Addition of finger millet flour
(As per treatment combination)
Gental heating to desired consistency
Pour and spreading the mixture in layer in greasy tray
Allow to set and cooling
Cutting in required shape and size
Packing in parchment paper
Finger millet burfi

T4-05

Changes in the nutrient composition upon malting, hydrothermal treatment and fermentation of sorghum grains

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Abstract

Sorghum, also known as great millet, is an important cereal crop widely cultivated across the arid and semi-arid parts of the world. Besides being highly nutritious, the crop possesses several agronomic advantages to survive under harsh environmental conditions and are regarded as climate- smart crops. Elucidating the changes in nutritional composition upon processing is important for the food-based industrial applications of sorghum grains. In this study, the changes in nutrients *viz*. protein, fat, ash and mineral content of sorghum grains upon processing including malting, hydrothermal treatment fermentation was estimated for the sorghum genotypes including PYPS-2 (yellow), CSV 20 (white) CSV-41 (white), SPV 2612 (red). Estimation of the protein of the raw and treated sorghum showed the content varied between different processing methods and found to be ranged between 8.87 ± 0.50 to 11.83 ± 0.13 %, with fermented grains showing higher content. Crude fat content of the raw and treated sorghum grains ranged from 0.93 ± 0.035 to 4.40 ± 0.41 %. The fat content decreased upon malting. The total ash content varied from 0.98 ± 0.05 to 1.85 ± 0.03 %. The calcium was found to be 70. 66 ± 4.60 ppm in the raw CSV-41 to 153.74 ± 5.53 ppm in hydrothermally treated SPV-2612. Further, the iron and zinc contents slightly varied between the samples. Understanding the nutrient content in finger millet may enable improved food application and consumption of this climate-smart, nutri-cereal.

Keywords: Sorghum grains, processing methods, protein content, ash content,

Introduction

Sorghum (*Sorghum bicolor (L.)* Moench), belonging to *Poaceae*, is one among the widely cultivated millets across the arid and semi-arid parts of the world. It is the fifth most produced crop in the world and is a staple especially in south Asia and Africa. In 2020, worldwide production of sorghum amounted up to around 62 million tonnes (USDA, 2020). The grains are highly nutritious and the crop possesses several agronomic advantages to survive under harsh environmental conditions. Hence, sorghum is regarded as a promising crop for sustainable nutritional security. Owing to enhanced awareness regarding the nutritional as well as nutraceutical value of sorghum, there is a recent upsurge in the utilization of these grains.

Sorghum grains are subjected to various processing techniques which is often required to convert them into edible form. Germination, malting, fermentation, cooking, thermal treatments, popping *etc* are among the important processing techniques employed upon sorghum grains (Saleh et al., 2013). These processing methods improve the sensory and functional attributes as well as consumption convenience of these grains. The changes in nutritional composition upon processing is an important aspect, especially for the food-based applications of sorghum. Hence, this study was aimed at estimating the changes in nutritional composition upon processing of sorghum grains.

Materials and Methods

The sorghum grains samples including CSV 20, CSV 41 and SPV 2612, are obtained from ICAR-IIMR. PYPS-2 grains were obtained from RARS, Palem. The processing methods of malting, hydrothermal treatment and fermentation were carried out as per the standard protocols and then nutritional composition was estimated.

The proximate analysis of the treated and raw grain samples was carried out as per AOAC protocols (AOAC, 2005). For crude protein determination by Kjeldahl method**,** involving digestion, distillation and titration. Fat content of the sample was determined by Soxhlet extraction method. Ash content of the sample was calculated using muffle furnace method. The important minerals *viz*. Ca, Fe, Zn were determined using microwave digestion followed by atomic absorption spectrometry.

Results and Discussion

The protein content of sorghum as determined by Kjeldahl method and ranged between 8.87 ± 0.50 to 11.83 ± 0.13 %. The values varied between different processing methods (Fig. 1). In the raw grains, the contents (in % wet basis) were PYPS-2 (10.7 ± 0.19), CSV-20 (9.8 ± 0.25), CSV-41(9.0 ± 0.47), SPV-2612(10.8 ± 0.1). For malted sorghum: PYPS-2 (11 ± 0.10), CSV-20 (9.9 ± 0.42), CSV-41 (8.9 ± 0.50), SPV-2612(10.8 ± 0.28). For Hydrothermal sorghum: PYPS-2 (11.3 ± 0.10), CSV-20 (10.3 ± 0.45), CSV-41(9.3 ± 0.31), SPV-2612 (12.1 ± 0.13). For Fermented sorghum: PYPS-2 (11.8 ± 0.13), CSV-20 (10.6 ± 0.38), CSV-41(9.7 ± 0.51), SPV-2612 (11.8 ± 0.52). The fermented sorghum had higher protein content.

The crude fat content, as determined by Soxhlet extraction is presented in Fig. 2. The fat content of the raw and treated samples was found to be ranged between 0.93 ± 0.03 to 4.40 ± 0.41 % and the values varied between different processing methods. In the raw grains, the contents (in % wet basis) were PYPS-2 (4.04 ± 0.044), CSV-20 (3.54 ± 0.14), CSV-41(3.65 ± 0.26), SPV-2612(3.55 ± 0.16). For Fermented sorghum: PYPS-2 (4.40 ± 0.41), CSV-20 (3.14 ± 0.06), CSV-41(3.14 ± 0.06), SPV-2612 (2.84± 0.17).

The ash content of raw and processed sorghum grains is presented in table 1. It was found that the ash content of the samples was in the range of: raw: PYPS-2 (1.38 ± 0.06), CSV-41(1.50 ± 0.01), CSV-20 (1.12 ± 0.03), SPV-2612 (1.69 ± 0.02), while for malted sorghum, PYPS-2 (1.52 ± 0.18), CSV-41(1.41 ± 0.05), CSV-20 (0.98 ± 0.05), SPV-2612 (1.58 ± 0.04). The changes in the mineral contents are presented in table 2. Calcium content were found to be higher in the processed samples. The calcium was found to be 70. 66 ± 4.60 ppm in the raw CSV-41 to 153.74 ± 5.53 ppm in hydrothermally treated SPV-2612. Further analysis is required for a deeper understanding of nutritional quality of the grains upon processing.

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Table 1. Total ash content of raw, malted, hydrothermally treated and fermented sorghum grains

Grain samples	Raw	Malted	Hydrothermal	Fermented
PYPS-2	1.38 ± 0.06	1.52 ± 0.18	1.47 ± 0.06	1.50 ± 0.02
CSV 41	1.12 ± 0.03	0.98 ± 0.05	1.08 ± 0.00	1.30 ± 0.01
CSV 20	1.50 ± 0.01	1.41 ± 0.05	1.48 ± 0.04	1.55 ± 0.12
SPV 2612	1.69 ± 0.02	1.58 ± 0.04	1.71 ± 0.06	1.85 ± 0.03

Results are presented in wet basis

Table 2. Mineral content (Ca, Fe and Zn) in the raw and treated sorghum grains

Treatment	Sorghum variety	Ca (ppm)	Fe (ppm)	Zn (ppm)
Raw grains	PYPS-2	75.21 ± 0.63	34.33 ± 1.74	17.82 ± 0.51
	CSV-20	74.94 ± 3.41	35.67 ± 0.71	18.34 ± 0.12
	CSV 41	70.66 ± 4.60	37.29 ± 3.31	16.76 ± 0.77
	SPV-2612	94.95 ± 0.45	35.97 ± 0.79	20.92 ± 0.96
Malted	PYPS-2	102.45 ± 6.25	35.24 ± 1.10	18.78 ± 0.81
	CSV-20	133.85 ± 7.46	33.60 ± 0.55	20.39 ± 0.88
	CSV 41	94.86 ± 92.46	24.60 ± 0.14	16.70 ± 1.54
	SPV-2612	124.72 ± 11.01	30.42 ± 0.41	21.27 ± 0.64
Hydrothermally treated	PYPS-2	93.54 ± 6.58	36.10 ± 0.64	19.09 ± 0.22
	CSV-20	115.86 ± 4.19	31.67 ± 0.87	20.42 ± 0.29
	CSV 41	89.74 ± 4.97	27.16 ±1.71	16.35 ± 0.65
	SPV-2612	153.74 ± 5.53	29.24 ± 0.84	22.13 ± 0.89
Fermented	PYPS-2	97.25 ± 1.26	42.43 ±1.12	19.35 ± 0.55
	CSV-20	97.14 ± 9.85	48.61 ± 2.51	20.93 ± 2.08
	CSV 41	82.71 ± 3.97	52.38 ±4.59	16.98 ± 0.88
	SPV-2612	110.71 ± 9.25	44.96 ± 2.18	23.57 ± 1.90

The results are presented in wet basis

Fig. 1. Total protein content (%) of raw and treated sorghum grains

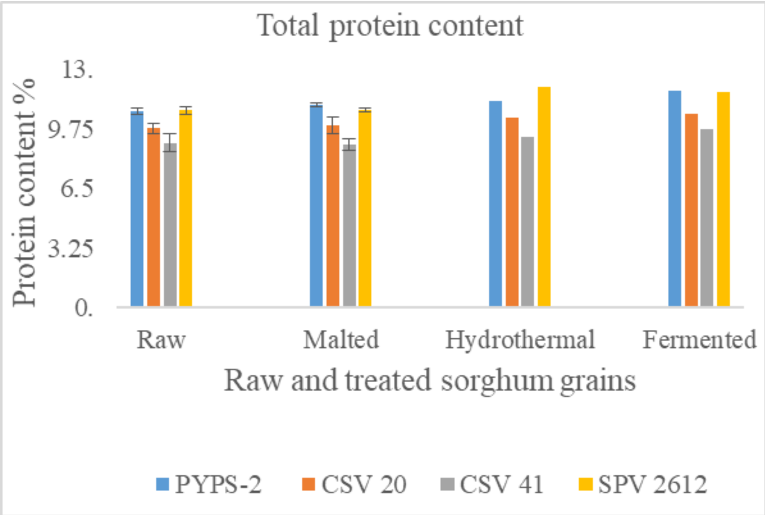
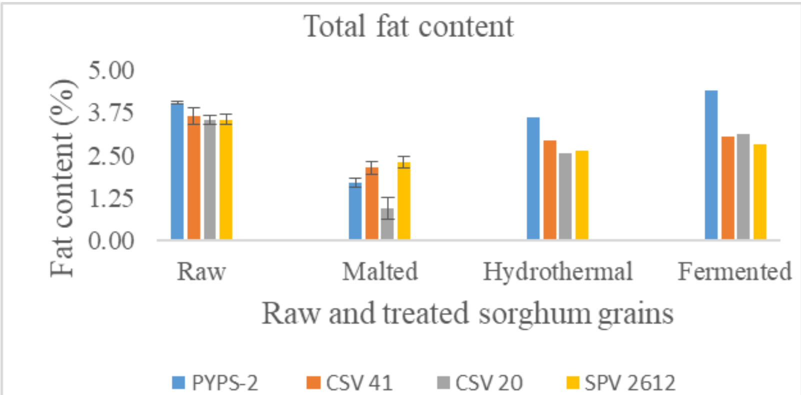


Fig. 2. Crude fat content of raw and treated sorghum grains



T4-06
Modelling the process optimization of barnyard millet incorporated vermicelli

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Abstract

Millet contains more fiber, minerals and vitamins, which are normally deficient in the Indian diet and has eight times more calcium than other cereals. Millets are generally converted to flour for the preparation of various food products. They can also be exploited for their nutritional benefits and value added nutritive health foods. In terms of nutritive value, barnyard millet is superior to major and minor millets. Barnyard millet grains are a rich source of dietary fiber, iron, zinc, calcium, protein, magnesium, fat, vitamins, and some essential amino acids. Hence the present study was undertaken to enhance and formulate barnyard millet flour incorporated vermicelli and to determine the optimal level incorporation of barnyard millet flour, black gram flour and fenugreek in acceptable level of vermicelli considering with its nutritional and sensory quality parameters as a response variables. Response Surface Methodology (RSM) was applied for optimized process conditions. Desirable values of Protein, Fiber and Rehydration ratio was obtained for corresponding optimum condition of barnyard millet flour as X_1, black gram as X_2 and as X_3. Optimal nutritional properties and rehydration ratio from a developed product can be obtained when carefully prepared under the following conditions: barnyard flour (41.61 g), black gram flour (12.2 g) and fenugreek 2.96 (g). Based on the response surface 3D plot of the optimum processing parameter of the developed vermicelli had maximum of protein (22.43 g), fibre (0.96 g) and rehydration time (2.96).

Keywords: Barnyard millet, RSM, Nutritional Quality

Introduction

Millets are the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes. Millet contains more fibre, minerals and vitamins, which are normally deficient in the Indian diet and has eight times more calcium than other cereals. Pearl millet is one of the important cereal grown in the tropics and is rich in iron and zinc, contains high amount of antioxidants and these nutrients along with the antioxidants may be beneficial for the overall health and wellbeing. With regard to nutritional quality, bajra is at least equivalent to maize and generally superior to sorghum in protein content/quality and metabolizable energy levels, as well as digestibility.

Materials and Methods

Bajra (CO 10) variety was obtained from Tamil Nadu Agricultural University, Coimbatore, other dry ingredients viz., black gram, semolina, fenugreek were procured from the local market, Madurai. Grains were thoroughly cleaned, washed, dried and grounded in the pulverized to make fine flour and sieved by 80 - 100 mesh sieve. Bajra flour, semolina, black gram dhal flour and fenugreek seed flour were mixed and passed through a 100 mesh sieve to obtain a fine powder. The flour blends were weighed followed by addition of salt and was mixed well. For pre moistening, the flour blend with hot water (70ºC) was added and mixed well, followed by pre steaming in an steamer for 5 min. Then, the blend was post moistened with of hot water (70ºC) and was mixed thoroughly in the extruder by the shaft in the extruder. The mass was kneaded for 15 min to ensure thorough distribution of moisture. After extrusion, the vermicelli products were post steamed for 20 min using steamer. The post steamed vermicelli products were cooled and dried in a cabinet drier for four hours at 60°C. Physico chemical parameters such as rehydration characteristics, protein and crude fiber from the developed products were investigated.

Results and Discussion

The experimental results on theincorporation of various ingredients such as bajra flour (X1), black gram flour (X2), and fenugreek (X3) for the development of bajra based vermicelli are shown in Table 1. The quality of the developed vermicelli was evaluated as the responses for the factors studied. The quality of vermicelli based on nutritional profile and rehydration ratio was rated based on the protein (Y1), fibre (Y2) and also the rehydration ratio (Y3) of the vermicelli were measured throughout the optimization process. Both the manipulated variables and responses were fitted to the quadratic model by performing the analysis of variance (ANOVA). The experimental results were analyzed to determine the lack of fit and the significance of the quadratic model and the effect of interaction between the manipulated variables and responses. According to Gan et al. (14), the lack of fit test is a measurement of the failure of a model to represent the experimental data at the point excluded in the regression while Lima et al. (25), is covered that the goodness-of-fit of the model was identified by the coefficient of determination (R_2) and it should be at least approximately 80%The p-value is a tool to check the significance of each coefficient. Greater F-value and smaller p-value represent better significance of the corresponding coefficient. The results obtained from the ANOVA analysis are shown in Table 1&2.

The F and p-values of <0.05 indicate that the quadratic model of the bajra vermicelli development was statistically significant at 95% confidence interval. The lack of fit for each response is insignificant. The R^2 values for the protein, fiber and rehydration ratio are 74, 63 and 75 per cent indicating that only 26, 37 and 25 per cent of the data cannot be interpreted by the model while protein showed high values of R^2 exceeding 73 per cent, which indicates that a high proportion of variability is well explained by the model.

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Table 1. Analysis of variance of the response variables

Response	Source	Sum of square	DF	Mean square	F value	Prob>F	R^2 (%)
Protein	Model	206.18	9	22.90	3.15	0.044	73.95
	Lack of fit	72.62	5	14.52	*	*	
	Pure error	0.00	5	0.00			
	Total	278.80	19				
Fibre	Model	0.182	9	0.020	1.89	0.167	66.17
	Lack of fit	0.097	5	0.019	*	*	
	Pure error	0.00	5	0.00			
	Total	0.287	19				
Rehydration ratio	Model	6.50	9	0.722	3.40	0.035	75.37
	Lack of fit	2.12	5	0.424	*	*	
	Pure error	0.00	5	0.00			
	Total	8.62	19				

Table 2. Regression model adjusted to the experimental

Parameters	Regression equation	R^2
Protein	Y_1 = 21.2595 – 0.5824 + 1.2750 + 0.5408 – 0.0853 – 0.0007 + 2.1158+ 108713+ 3.1638+ 0.5562	73.95
Crude fibre	Y_2=0.828871+0.055790-0.002788+ 0.071480+ 0.01.69+ 0.067724-0.016195-0.0000-0.00000-0.00000	66.16
Rehydration ratio	Y_3=2.55291+0.6662-0.25957-0.31713+0.02723-0.07492+0.37420+0.02625+0.41125-0.08625	75.37

Table 3. Criteria of optimum value for the response of bajra vermicelli

Process variable	Optimum value	Response	Optimum value
Bajra flour	41.61	Protein	22.43
Black gram flour	13.25	Fibre	0.96
Fenugreek	1.60	Rehydration ratio	2.96

T4-07
Formulation of aprobiotic millethealthy snack bar for children

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Abstract

Millets are veritable storehouses of health and nutrition. It is high in fiber, protein, iron and calcium, making it essential for children to consume. The consumption of fast food and snacks increased significantly in recent years. In this study, millets being highly nutritious were used in the development of bars instead of cereals. Standardization of millet bar were carried out with different millets. Fruit bars were inoculated with probiotic cultures such as *Lactobacillus delbrueckii*, *Lactococcus fermentum*, *Streptococcus thermophilus*, *Bifidobacterium bifidum* and *Lactobacillus acidophilus*. They were tested for acid and bile tolerance. The cultures were inoculated in the mango fruit bar and is placed on the millet bar. The bars were packed in MPP covers and stored at room temperature. *S thermophilus* tolerated well at pH 2.0 and exhibited maximum growth 0.241 after four hour of incubation compared to *L delbrueckii* and *L acidophilus*. The moisture content of the millet fruit bar was 6.32 which was within the safe level for storage. The protein content of the bar was 14.58 g/100g. The fat content of the bar was less which was found to be 6.72g% which is ideal for those who prefer low fat snack. The calcium and iron content of the millet fruit bars were 1.73 and 35.15mg%. All the parameters like colour and appearance, texture, flavour, taste and overall acceptability were above 8.50 during initial day of storage indicating the product was highly acceptable. The probiotic microbes did not influence the organoleptic properties of the bars. The increase in microbial population was minimum during the storage.

Keywords: Cereal bars, millets, fruit bars, probiotic, nutrient content

Introduction

The demand for food with health benefit beyond their basic nutrition is increasing all over the world. As a result, the market for functional foods, or foods that promote health beyond providing basic nutrition, is flourishing. Within the functional foods, is the small but rapidly expanding arena of probiotics – live microbial food supplements that beneficially affect an individual by improving intestinal microbial balance (Granato et al., 2010). Scientific work on the properties and functionality of living micro-organisms in food have suggested that probiotics play an important role in immunological, digestive and respiratory functions, and that they could have a significant effect on the alleviation of infectious diseases in children and other high-risk groups (FAO, 2001). This study is intended to develop a healthy probiotic millet bar incorporating beneficial microbiota.

Materials and Methods

The sorghum grains were cleaned, soaked, conditioned and puffed. The bajra and ragi flakes were roasted slightly and made to grits. Groundnut and roasted Bengal gram were roasted until crispy and grounded coarsely. The jaggery syrup was made and all the ingredients were mixed until reaching the soft ball stage. They were then poured on trays and shaped. Probiotic cultures such as *L delbrueckii*, *L fermentum*, *S thermophilus*, *B bifidum* and *L acidophilus* were obtained from NDRI, Karnal. Bacterial cultures were mass multiplied in nutrient broth, MRS and Lactobacillus medium. The acid and bile tolerance of the cultures were tested as described by Khalil et al., 2007.

The cells were harvested by centrifugation at 10,000 rpm at 4°C for 10 min. The cells were washed twice with saline (0.85% NaCl) by centrifugation as above. The washed bacterial cells were suspended in 7 ml saline. Five hundred micro litre of saline suspended bacterial cells (10^8 CFU/ g of dry fruit bar) was smeared over mango bar. Mango fruit bar was dried at 30°C in oven for 24 h, and left at room temperature for 20-30 min. Viability of probiotic bacteria was determined by plate count method. The moisture AOAC (1995), protein, fat, β-carotene, calcium and iron (Ranganna, 1995), crude fiber (Maynard, 1970), carbohydrate, ascorbic acid Sadasivam and Manickam (2008) were analysed in the stored bars. The changes in the organoleptic scores and probiotic microbial population were analysed.

Results and Discussion

There was a gradual increase in moisture content during the storage but were within the safe level to inhibit microbial growth. The protein content of the fruit bar during the initial day was 3.65 g% which reduced to 3.61 g% during the 90th day of storage. The fat content of the bar was 1.68g%. The calcium and iron content of the millet fruit bars were 1.73 and 35.15mg% which did not change during storage. There was a 20.81% reduction of β-Carotene content of the stored millet fruit bar. The energy content of the millet fruit bar was calculated as 137 kcal and 25.83g% per 100g. All probiotic bacteria tested showed a steady loss in viability when exposed to acidic conditions initially there was an average of 5.54 log cfu/ ml of viable probiotic bacteria but after 1h of exposure the average viability of cells was reduced to an average of 4.39 log cfu/ml after 2 h of exposure.*Lactobacillus acidophilus* and *Streptococcus thermophilus* were most acid tolerant strains survived after 2 h incubation. There was a minimum change in the organoleptic characteristics except the colour and appearance. There was no microbial population during the initial day and was minimum increase during the storage. The millet fruit bars could be stored in metalized polyethylene packages The cost of 25 g of the millet fruit bar was calculated as Rs.9.00.

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Table 1. Changes in chemical parameters of the stored millet fruit bar

Chemical parameters	Days of storage			
	Initial	30th	60th	90th
Moisture (%)	6.32	6.875	7.43	7.47
Protein (g%)	14.58	14.52	14.50	14.46
Fat (g%)	6.72	6.68	6.67	6.65
Ash (g%)	4.50	4.28	4.55	4.45
Crude fiber (g%)	1.24	1.19	1.16	1.15
Iron (mg%)	1.73	1.73	1.73	1.73
Calcium (mg%)	35.15	35.15	35.15	35.15
β-Carotene (µg%)	218.70	218.62	218.50	218.46
Total Phenol (mg/100g)	112.22	119.62	119.53	119.50

T4-08
Standardization of pearl millet incorporated Ready-to-Use idli mix

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Abstract

An attempt was made to develop a minor millet incorporated idli ready mix using pearl millet. Pearl millet flour was incorporated for the standardization of idli ready mix at the level of 0, 5, 10, 15, 20, 25 and 30 per cent. Pearl millet powder incorporated at the level of 20 per cent for idli ready mix was found to be highly accepted for all the sensory attributes.Further, the standardized pearl millet incorporated idli ready mixes were packed in stand up pouch (P_1) and metalized polypropylene pouch (P_2) and stored for 120 days to study their storage stability at room temperature. There was a gradual reduction in the nutrient content of the minor millet incorporated idli ready mix in both the packaging materials during storage. There was no microbial load observed at the initial day of storage and was found to be slightly increased towards the end of the storage.The sensory score value for the the control (T_0) and pearl millet incorporated idli mixes were found to be decreased gradually packed in stand up pouch (P_1) and metalized polypropylene pouch (P_2) during the storage period for 120 days

Keywords: Minor millet , idli ready mix, Pearl millet , stand up pouch, metalized polypropylene pouch

Introduction

Millets referred as coarse cereals, are a variety of small edible grains belonging to the grass family, that are cultivated as grain crops, primarily on marginal lands of dry areas in temperate, subtropical and tropical regions (Yenagi *et al*., 2010).Millets are more than just an interesting alternative to the more common grains. The millet grains are also rich in phytochemicals, including phytic acid, which are believed to lower cholesterol and associated with reduced risk of cancer (Bhat *et al*., 2018). The millets are good source of antioxidants, such as phenolic acids and glycated flavonoids. Millet foods are characterized to be potential prebiotic and can enhance the viability or functionality of probiotics with significant health benefits. Millets are the major source of energy and protein for millions of people across the world. It has been reported that millet has many nutritious and medical functions (Obilana and Manyasa, 2002a).Millets have no characteristic flavour and hence can blend well with other ingredients. In this context, formulation of acceptable, easy to consume, user friendly, natural food products with good shelf life under ambient conditions and having optimum combination of nutrients to promote the general health of the diverse Indian population is the need of the hour (Nazni and Shalini,2010). Hence, an attempt was made to develop to develop pearl millet incorporated Ready - To – Use idli mix.

Materials and Methods

Parboiled rice, black gram and minor millet (pearl millet) were soaked separately drained and dried. The dried parboiled rice, black gram and pearl millet were separately ground to powder. The ground powders were mixed together.Salt was add into the ground powder and mixed well.The control idli mix was processed with rice and black gram dhal.Idli mix was packed in packaging materials and stored at room temperature.

Hundred gram of the mix was taken and curd (15 ml) and water (50 ml) were added. They were mixed well to a batter consistency. The batter was allowed to ferment for 30 minutes at room temperature. The fermented batter was poured into idli mould and steamed for 20 minutes. The end point of idli was checked and removed from fire.

Results and Discussion

The carbohydrate content of the control idli mix (T_0) and pearl millet incorporated idli mix (T_1) was 52.66 g/100g and 46.85 g /100g respectively at the initial day of storage. Then carbohydrate content decreased to 51.50 g/100g, 51.67 g/100g and 45.00 g/100g, 45.07 g/100g respectively for T_0 and T_1 packed in P_1 and P_2 at the end of the storage (120 days).The initial protein, fat and fibre contents T_0 and T_1 was 5.30 g/100g and 10.23g/100g and 1.92 g/100g and 3.98 g/100g and 0.96 g/100g and 3.71 g/100g were found to be reduced to 4.50 g/100g and 4.64 g/100g and 9.79 g/100g and 9.84 g/100g and1.46 g/100g and 1.52 g/100g and 3.73 g/100g and 3.75 g/100g and 0.73 g/100g and 0.81 g/100g , 3.71 g/100g and 0.38 g/100g and 3.49 g/100g respectively packed (P_1) and (P_2) after 120 days of storage. The initial calcium, iron and phosphorus content of the control (T_0) and pearl millet incorporated idli mixes (T_1) was 26.93 mg /100g and 40.87 mg /100g and 1.62 mg/100g and (T_1) 4.68 mg/100g and 110.73 mg/100g and 132.27 mg /100g was found to be reduced 26.71 mg /100g and 26.67mg/100g and 40.68 mg /100g and 40.71 mg /100g and to1.27 mg/100g and 1.29 mg/100g and 4.31 mg/100g and 4.43 mg/100g respectively and 110.41 mg/100g and 110.48 mg /100g and 132.01 mg/100g and 132.12 mg /100g respectively packed in P_1 and P_2 respectively. There was no microbial load observed at the initial day of storage and was found to be slightly increased at the end of the storage. The sensory score value for the the control (T_0) and pearl millet incorporated idli mixes were found to be decreased gradually packed in stand up pouch (P_1) and metalized polypropylene pouch (P_2) during the storage period for 120 days

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T4-09
Studies on rheological properties of millet based dough for 3D food printing

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Abstract

3D food printing, as the name suggests, is a 3-dimensional printing technology that prints food. 3D food printing is an emerging technology and has vast scope in providing the right nutrition to the right people. 3D printing is mainly based on additive manufacturing technology where food is printed in form of layers and deposited one over the other. Millets are being considered as nutri-cereals, which can supplement calcium, protein, niacin, and many other essential compounds to improve the malnutrition status of India. An optimized formulation of millets will be a good source of various micro and macro nutrients if it’s delivered in the right manner. This work presents a comparative study on the rheological properties of millet based dough for its printability using 3D printing. The dynamic viscoelastic properties such as storage modulus (G'), loss modulus (G") and loss factor (tanδ) in interaction with angular frequency were studied. The linear viscoelastic range for oscillation test was selected at a strain rate of 0.05 per cent. The values of G' and G" show an increase with an increase in angular frequency for all the millet-based dough irrespective of xanthan gum addition.

Keywords: Millet, Rheological properties, 3D printing, functional food

Introduction

Millets are indigenous crops of India and are rich in calcium, protein, niacin, and many other essential compounds. Though they are high valued crops, their cultivation percentage dropped from 40% to 20% after the green revolution *(ICRISAT).* Many of the minor millets are extinct or hardly grown. But now, millets are gaining importance as people not only look for fast and convenient food but also for healthy alternatives. So, there is a pertinent need to develop technology that produces healthy food in a fast and convenient manner without affecting the nutritional quality of millets and protecting the health of the consumer. India takes 107th place in case of malnutrition, i.e., nearly 40% of the youngsters are deprived of essential nutrients. So, it’s necessary to develop a product that contains all the essential nutrients to make up for a balanced diet. Most of the technology or processing methods either destroy essential nutrients or show a reduction in the bioavailability of essential nutrients. Therefore, developing a technology that increases the bioavailability of the material is essential.

Materials and Methods

Millets will be purchased from a local farmer and will be ground to form fine powders. These powders will be sieved to get uniform particle size, and which are suitable for printing. These flours are combined with eggs, fat, sugar and required micronutrients to form batter. Batter will be formulated using various active ingredients. In batter formulation, Millets and their combination in different ratio will be used. Micronutrients lost during the process will also be enriched. The formulated batter is tested for its rheological properties.

Dynamic viscoelastic measurements

Oscillatory frequency sweep test

The dynamic viscoelastic properties of the millet baseddough was measured using a rheometer (MCR 92 series, Anton Paar Co.Ltd., Austria) using small amplitude oscillatory frequency sweep test. The linear viscoelastic range (LVR) of the samples was initially determined using strain sweeps (0.1 to 100 rad/sec) at a fixed frequency of 1 Hz. The frequency sweep test was carried out at 0.05 per cent of strain in the viscoelastic linear region with frequency ranging from 0.1 to 100 rad/s at 25 °C. The dynamic rheological parameters of the millet based dough were recorded using the software RheoCompassTM (Anton Paar, Graz, Austria) such as the shear storage modulus (G'), which defines the elastic behaviour of the samples and the shear loss modulus (G''), which explains the viscous behaviour of the sample. The loss factor ($tan\delta$) was calculated (Ronda et al., 2011).

Temperature sweep test

A temperature sweep test was conducted utilizing a temperature-controlled rheometer (MCR 92 series, Anton Paar Co. Ltd. Austria) in the temperature ranges from 25 °C to 180 °C at a heating rate of 5 K/min using an angular frequency of 5 rad/s. Measurement of dynamic viscoelasticity was carried out. Using the software RheoCompassTM (Anton Paar, Graz, Austria), the storage modulus (G') and loss modulus (G'') were recorded (Bozdogan et al., 2019).

Results and Discussion

The dynamic viscoelastic properties such as storage modulus (G'), loss modulus (G'') and loss factor (tanδ) interaction with angular frequency was measured. The linear viscoelastic range for oscillation test was selected at a strain rate of 0.05 per cent. The values of G' and G'' were increased with the increase in angular frequency for all the millet based dough irrespective of xanthan gum addition. It reveals that the millet-based dough behave as an elastically active gel-like structure favourable for the printing objects to maintain its shape (Huang et al., 2019). The control millet-based dough has the lowest moduli values of G' (10.37 kPa) and G'' (3.712 kPa), whereas millet-based dough added with xanthan gum (0.5 – 2 %) has the high G' and G'' in the range of 18.4 to 25.36 kPa and 5.8 to 9.82 kPa, respectively. Additionally, it was found that the G' was higher than G'' for all the millet-based dough, then the millet-based dough exhibits gel-like structure with elasticity (Yang et al., 2018).

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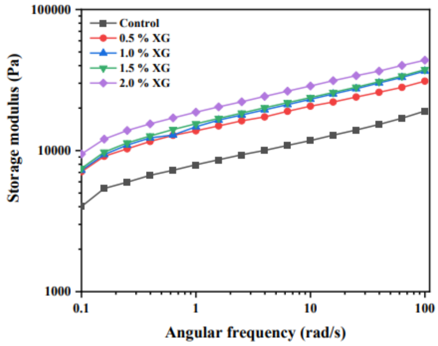

T4-10

Development of on-farm hermetic storage for de-hulled millets

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Abstract

A study was conducted to enhance the shelf life of de-hulled little millet using hermetic storage. The storage bin with a capacity of 1000 kg was developed using stainless steel (SS 304). The engineering properties such as bulk density, true density, porosity, thousand-grain mass, coefficient of friction and angle of repose were studied for de-hulled little millet to design a hermetic storage bin. The storage study was conducted for 72 days and the changes in gas composition, temperature, relative humidity, moisture content, colour value, protein content, starch content, free fatty acid content, total phenol, peroxide value, crude fibre content were studied. A commercially available hermetic bag was used as a control. A lab-scale hermetic bin was developed to determine the insect mortality at different pressure and moisture content of de-hulled little millet.

Keywords: Hermetic Storage, de hulled little millet, Biochemical quality

Introduction

India is the largest cultivator and producer of millet in the world with around 10 million tonnes annually. Millets are highly nutritive grains that can grow in drought conditions. Millets should be stored in proper condition to ensure supply throughout the year. Due to improper storage facilities in India, it accounts for 6% loss. Mostly millets are consumed after de-hulling. The de-hulled millet has poor shelf life due to rancidity. The millet contains oil in the bran layer which reacts with atmospheric oxygen to produce off flavour. Fumigation was the most common method used to store the grains. The fumigated grains contain chemical residues which may cause health problems. Hermetic storage is an airtight non-chemical storage technology that can be an alternative to fumigation. Hermetic storage is an alternate, effective method and a cheap, affordable, eco-friendly technology where the availability of oxygen in the storage environment is minimized. The lack of availability of oxygen prevents the growth of insects during storage.

Materials and Methods

For storing 1000 kg of de-hulled little millet, the dimension of hermetic bin was made with certain initial assumption of height and diameter (H/D) ratio. Hermetic bin was fabricated using stainless steel (SS 304) sheet with thickness of 2 mm. The bin consists of two sections namely cylindrical section and hopper section. The dimension of cylindrical section was about 1.80 m height and 0.96 m diameter which consist of twelve ports. Two hopper sections were fabricated with dimensions of 0.25 m height, 0.96 m and 0.20 m as top and bottom diameter respectively. The fabricated stainless steel hermetic bin was shown in Fig. 1.

The engineering properties such as bulk density, true density, porosity, thousand- grain mass, coefficient of friction and angle of repose were studied for de-hulled millet. The effect of hermetic storage on gas concentration moisture content and biochemical quality were carried out in de-hulled little millet.

Results and Discussion

The bulk density, true density, porosity, thousand-grain mass, coefficient of friction and angle of repose were found on be 832.83 kg/m^3, 1362.4 kg/m^3, 38.9%, 2.21 ± 0.02g, 0.35 and 27º. Janssens theory was used for grain pressure calculation inside the hermetic bin. Vertical and lateral pressure exerted on bin wall by the de-hulled little millet was found to be 661.750 kg/m^2 and 15.20 kg/m^{2}respectively. Surcharge load and surcharge pressure on hopper bottom were also calculated as 651.46 kg and 225.12 kg/m^{2}respectively. The minimum thickness of stainless steel sheet for fabrication of a bin was found to be 0.8218 mm. Hermetic bin experienced the lowest average temperature of 26.1 ℃ compared to hermetic bag (27.8 ℃). After 72 days of storage, O_2 concentration decreased to 14.9 %, whereas CO_2 concentration was increased to 6.0 % (Fig. 2). According to Villers et al. (2006) in hermetic storage, there was a general development of low O_2 and elevated CO_2 content, which was related to the product's respiration rate. The moisture content of the de-hulled little millet was increased from 10% to 11% (w.b.) in the hermetic bin and 12.4% (w.b.) in the hermetic bag.

After 72 days of storage, the starch content, protein content, total phenol and crude fibre content were decreased to 59.1%, 9.36%, 19.6 mg/100g and 1.47% in hermetic bin, 55.2%, 9.1%, 17.2 mg/100g and 1.4% in hermetic bag (Fig. 3). The free fatty acid content and peroxide value were increased to 0.50 % and 4.1 mEq/kg in the hermetic bin, 0.99% and 4.99 mEq/kg in hermetic bag respectively. Kim loan el al., (2022) reported the decrease in protein, total phenol and crude fibre content may also be influenced by the moisture content of grain during storage. In the hermetic bin, FFA content showed a minimal increase compared to the hermetic bag. It revealed that the hermetic bin was the best method of storage system to store the de-hulled little millet. The emergence of *Tribolium casteneum* adult was found at 64th day of storage in hermetic bag. Among various pressure level, the mortality of insects was higher in 200 mm Hg and 100% mortality in 3 days. The mortality of insects was faster in 12% (w.b.) compared to 10.5% (w.b.). 100% mortality of insects was achieved in 18 days at 12% (w.b.) It has been demonstrated that the low partial pressure of oxygen, which results in hypoxia, is the primary cause of insect death when exposed to low pressure. Prasantha et al., (2020) reported the vacuum pressure 10 kPa has higher mortalitythan 20 kPa vacuum pressure.

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Fig. 1. Stainless steel (SS 304) Hermetic storage bin

Fig. 2. Effect of gas concentration during storage

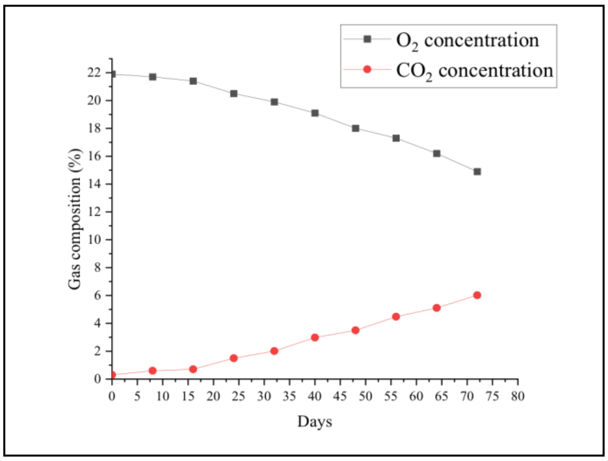
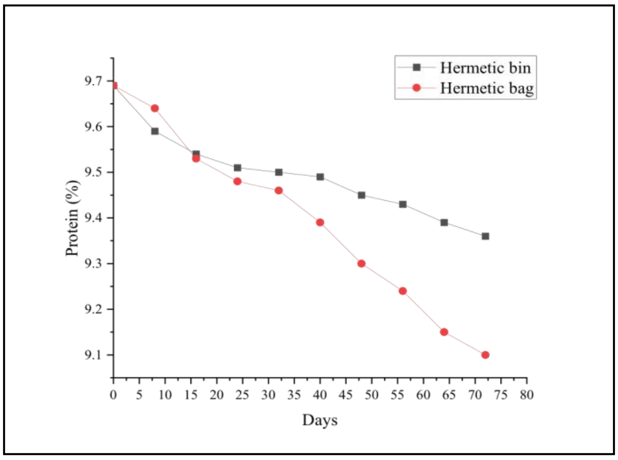


Fig. 3. Effect on protein content during storage



T4-11
Optimization of texturized whey protein concentrate incorporated multimilletnutri-bar using response surface methodology

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Abstract

Millet contains more fibre, vitamins and minerals which are normally deficient in the Indian diet and has eight times more calcium than other cereals. Millets are generally converted to flakes for the preparation of various food products. They can also be exploited for their nutritional benefits and value added nutritive health foods. Hence the present study was undertaken to modify the whey protein concentrate by enzymatic texturization method and analyzed the functional properties. The texturized whey protein concentrate has improved functional properties compared to non-texturized whey protein concentrate. The texturized whey protein concentrate incorporated multimilletnutri-bar was optimized using Response Surface Methodology and Artificial Neural Network. Results revealed that nutri-bar containing 13 % incorporation of millet flakes and 10 % incorporation of texturized whey protein concentrate was found to be best according to sensory evaluation. The nutri-bar was found to have moisture content of 11.38 percent, Protein 14.97 g/100g, carbohydrate 53.96g/100g, fat 11.22 g/100g, crude fibre 1.68g/100g and the iron and calcium content were 2.90 and 139.11 mg/100g respectively. The texturized whey protein concentrate incorporated multimilletnutri-bar has improved textural properties compared to control nutri-bar.

Keywords: Millet flakes, whey protein concentrate, nutri-bar

Introduction

Consumers are seeking for wholesome, ready-to-eat foods in modern society because it is difficult to sit down for a meal. Snack foods like potato chips, extruded products, and chocolate bars available in market cannot fulfil the requirements of a balanced diet (Estevez *et al.,* 2000). Food producers have been motivated by rising consumer demand for nutrient-dense snacks to create food bars that combine convenience and nutrition (Izzo *et al*., 2001).

Millets are a small-seeded crop that has a number of health advantages. Traditional millet grains are being used in the development of newer processed products for health reasons, and they are potential future crops because they are a gluten-free alternative that also contains high amounts of dietary fibre, micronutrients, essential fatty acids, and sulphur containing amino acids (Datta Mazumdar et al., 2022). In this study, millet flakes (Sorghum, Pearl, Finger, Kodo, and Little millet) were utilized for the development of nutri-bar incorporated with texturized whey protein concentrate and optimized using Response Surface Methodology (RSM).

Materials and Methods

Whey protein concentrate (90%) was texturized by enzymatic texturization method the process flow chart was given in Figure 1. The texturized whey protein concentrate was grounded and sieved after freeze drying. Millets and Traditional landrace chithiraikar rice were processed into flakes the process flow chart was given in Figure 2. The pitted dates, raisins, almonds were chopped to fine pieces. After the preparation of raw materials, the syrup was prepared using ghee, brown sugar, the other ingredients (texturized whey protein concentrate, millet flakes, traditional land race chithiraikar rice flakes, chopped dates, raisins, almonds, sesame seeds, choco chips, Cardamom, honey and salt) were added to the syrup and mix thoroughly to distribute uniformly and make bar. The developed bars was packed and stored for further analysis.

Results and Discussion

The texturized whey protein concentrate using enzymatic texturization method has improved functional properties as given in Figure 1. The texturized whey protein concentrate incorporated multimilletnutri-bar was analyzed for nutritional composition and given in Table 1. The nutri-bar was found to have a moisture content of 11.38 percent. Protein content was found to be 14.97 g/100g, carbohydrate content was 53.96g/100g, fat content was 11.22 g/100g, crude fibre 1.68g/100g and the iron and calcium content was 2.90 and 139.11 mg/100g respectively. The appearance, flavour and texture of multimilletnutri-bar was found to be good. Hence, based on the sensory scores, the product was ranked as 8.7 like very much/9.0. The texturized whey protein concentrate incorporated multimilletnutri-bar has improved textural properties compared to control nutri-bar.

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Table 1. Nutritional composition of texturized whey protein concentrate incorporated nutri-bar

Parameters		Texturized whey protein concentrate incorporated nutri-bar
Moisture (%)	:	11.38
Protein (g/100g)	:	14.97
CHO (g/100g)	:	53.96
Fat (g/100g)	:	11.22
Crude fibre (g/100g)	:	1.68
Iron (mg/100g)	:	2.90
Calcium (mg/100g)	:	139.11

Fig 1. Functional properties of non-texturized and texturized whey protein concentrate

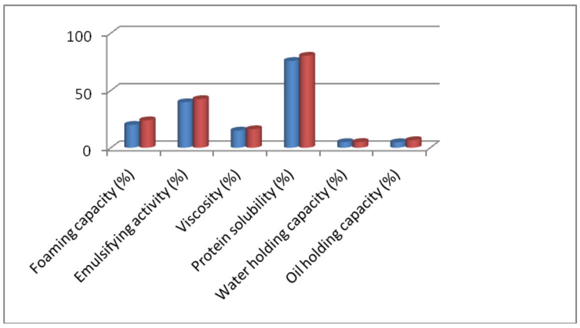


Fig 1. Enzymatic texturization of whey protein concentrate: (Banach J.C. *et al*., 2013)

Whey protein concentrate (90%)- Mixed into Millipore water

↓

Agitated by an overhead mixer or magnetic stirrer

↓

The protein dispersion was then stored overnight at 4ºC

↓

Equilibrated to room temperature

↓

Adjust pH to 7.8-8.0 using HCL or NaOH

↓

Temperature was equilibrated to 37ºC-40ºC

↓

Prepare trypsin solution and add to protein dispersions (1:100)

↓

Agitate in incubator at 37-40ºC fir 10 min

↓

To cease the reaction, the protein dispersions were placed in 90ºC water bath for 10 min

↓

Freeze dried and Ground the samples and sieved through - 250µm

Fig 2. Process of flaking Millets and traditional landrace chithiraikar rice: (Takhellambam*et al.*, 2016)

Dehulled the grains

↓

The grains were tempered at 10-15%

↓

Gelatinized in rotary steamer at 180°C under the pressure of to 24 lbs. /psi for 25 min

↓

Air cool the grains for surface dryness

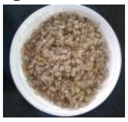
↓

Rolled the grains to flakes with an aperture size of 0.25mm

↓

The flakes were dried in cabinet drier for 4-6 hours (moisture content of about 10.5%) and stored for further analysis

Sorghum Flakes



Pearl millet Flakes

Finger Millet Flakes

Little millet Flakes

Kodo millet flakes

T4-12
Probiotic Bacteria from Fermented Millets for post harvest management of aflatoxins

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Abstract

The research on lactic acid bacteria confirmed how specific strains possess probiotic properties and have unique characteristics like flavour, aroma softness etc, to food products. The probiotic lactic acid bacteria (LAB) were used in many food products, thus conferring various health benefits to humans when they are frequently consumed in adequate amounts. The advent of functional food or the concept of nutraceuticals objectively places more emphasis on seeking alternatives to limit the use of medications thus promoting the regular consumption of fermented foods. Study was undertaken on the isolation and characterization of probiotics from fermented millets grains and their application in post harvest management. Of the 40 LAB isolates, three isolates *viz*., FM1, BM6 and LM4 were found to be tolerant to low pH and low temperature.

Keywords: Probiotic bacteria, health benefits, millet, fermentation

Introduction

Present scenario people are focusing on getting nutritional, healthy and safe food. Here the heroes of probiotics are entered into scientist mind and research has been started. Probiotics are defined as “living micro-organisms, which upon ingestion in certain numbers, exert health benefits beyond inherent basic nutrition” (Guarner *et al.,*2005) but interest in this area was initiated by Metschnikov 100 years ago. Most probiotic microorganisms belong to Lactic Acid Bacteria (LAB), such as *Lactobacillus sp, Bifdobacterium sp and Enterococcus sp***.** and commonly used in foods. It is well known that probiotics have a number of beneficial health effects in humans and animals. They play an important role in the protection of the host against harmful microorganisms and also strengthen the immune system. Biological decontamination by using bacteria especially lactic acid bacteria (LAB) is mild and eco-friendly and it is used as a probiotic in food generally recognized as safe(GRAS) by the FDA(Food and drug administration of USA). Millets are a traditional staple food of the dry land regions of the world. In India, millets are grown on about 17 million ha with an annual production of 18 million tonnes and contribute 10 percent to the country’s food grain basket. These are nutri-cereals that are highly nutritious and are known to have high nutrient content which includes protein, essential fatty acids, dietary fiber, B-Vitamins, and minerals such as calcium, iron, zinc, potassium and magnesium. They help in rendering health benefits like reduction in blood sugar level (diabetes), blood pressure regulation, thyroid, cardiovascular and celiac diseases. However, the direct consumption millet as food has significantly declined over the past three decades. Recently, United Nations General Assembly announced the “International Year of Millets” because of their importance in human health and their thriving in adverse conditions. This study focus on the isolation and characterization of probiotic bacteria from fermented millet grains.

Materials and Methods

The probiotic bacteria were isolated from seeds of farm produce such as finger millet, kodo millet, little millet, and maize which was obtained from local market, Coimbatore. The samples are collected in aseptic zip lock covers.Probiotics were isolated from fermented millet using an enrichment technique (Poornachandra Rao *et.al.,* 2015). Morphologically discrete colonies 40 isolates are purified sub-cultured and preserve in glycerol stock at -20 ºC for further analysis. Preliminary identification of the LAB isolates was done based on their phenotypic and biochemical characteristics that include catalase test, MR-VP test, and osmotic stress with some modification resistance. The growth of the isolates at different temperatures and pH levels was tested at 600nm and simultaneously cell viability was seen by plate count.

Results and Discussion

Totally 40 probiotic bacteria based on morphological characterization were purified from different millets. Among the 40 isolates, 15 isolates showed negative for catalase test. Further these isolates were tested for their biochemical characterization and results showed that 5 isolates were positive for VP test and 10 isolates showed positive for MR test. The result of Osmotic tolerance test showed that 8 isolates tolerated salt, while seven isolates were tolerating only 6.5 % salt concentration. Huligere *et al.* (2022) studied the probiotic potential of *Lactobacillus* spp. isolated from three traditionally fermented foods at biochemical, physiological, and molecular levels and seven isolates demonstrated a high probiotics potential. The isolates incubated under different temperature (low, room and high temperature) and under different pH (4.5, 6.5, 8.5) showed that all the isolates were grown well under room temperature and neutral pH. However three isolates (FM1, BM6 and LM4) showed tolerance under low pH and low Temperature.Reuben *et al.* (2020) investigated that the viability rate was >93% at various temperatures, salt tolerance, and acid bile tolerance.In our study three isolates were tolerance to high temperature, pH and acidic condition. Further molecular characterization and their application in food industry will be studied to explore the potential of probiotic bacteria.

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Fig. 1. Isolation of probiotics from different fermented millets

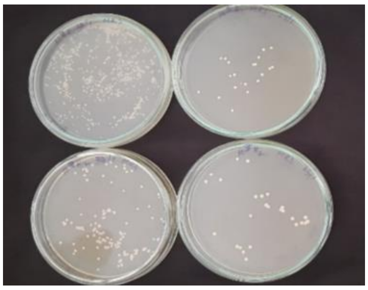
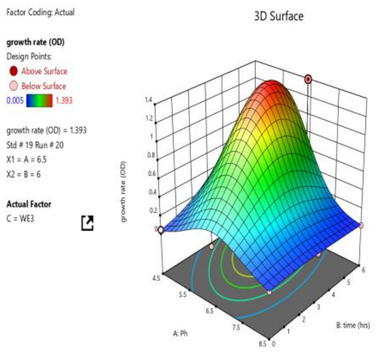
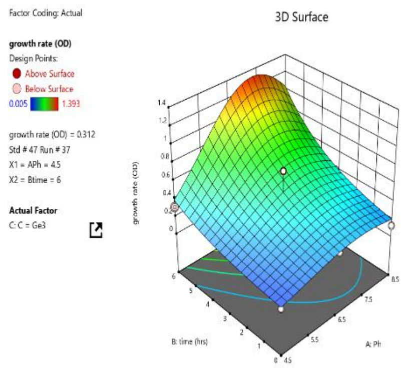


Fig. 2. Response surface analysis of pH tolerance in probiotic bacteria



a.FM1 at pH 4.5



b.LM4 at 4.5 , 8.5

T4-13
Hypoglycemic effect of kodo millet puffed snack

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Abstract

Rapid urbanization and industrialization have produced advancement on the social and economic front in developing countries such as India which have resulted in dramatic lifestyle changes leading to lifestyle related diseases. The transition from a traditional to modern lifestyle, consumption of diets rich in fat and calories combined with a high level of mental stress has compounded the problem further. According to Diabetes Atlas published by the International Diabetes Federation (IDF), there were an estimated 40 million persons with diabetes in India in 2007 and this number is predicted to rise to almost 70 million people by 2025. The countries with the largest number of diabetic people will be India, China and USA by 2030. In this condition, fibre rich, whole grain millet based foods have reported to have overlapping physiological effects, including favorable gastrointestinal function, improved lipid and glycemic profiles, and reduced oxidative stress. With this background the present investigation was taken up. This study was conducted with an aim to standardize wheat based multigrain puffed snack food along with kodo millet, bengal gram and horse gram. The proportions used in preparing multigrain puffed snack food were T_0-100 per cent wheat flouras control, T_1-40:30:30 (wheat flour: kodo millet flour: bengal gram flour), T_2-40:30:30 (wheat flour: kodo millet flour: horse gram flour), T_3 I- 40:22.5:22.5:15 (wheat flour: kodo millet flour: bengal gram flour : inulin), T_4I- 40:22.5:22.5:15 (wheat flour: kodo millet flour:horse gram flour : inulin). The hypoglycemic effect was assessed in Wistar rats (Group I (control), group II (diabetic control) and III to IV were treatment groups) by feeding experimental diets for 28 days. The initial blood glucose level of the control (G1) and positive control (G2) rats was 71.5±5.67 and 148.66±5.48 mg/dL blood respectively. The maximum reduction in blood glucose was found in G6 rats, fed with T_4I multigrain snack containing wheat flour, kodo millet flour, horse gram flour and inulin. The initial glucose levels reduced from 204.16±3.57 to 121.16 ± 3.4mg/dL, which is a reduction of 40.65 % at the end of 28 days of feeding trial.

Keywords: kodomillet, puffed snack, hypoglycemic effect

Introduction

Coarse cereals provide viable alternatives to diversify sources of health components in foods. Obviously, the benefits are highest in whole grain cereal consumption. Although millets are nutritionally superior to cereals, their utilization in the country is not widespread. They are mostly used in the preparation of traditional dishes. One possible way of extending their utilization could be by blending them with wheat flour after suitable processing. On addition of millet flour to wheat flour or other flours, physico-chemical, nutritional and functional characteristics of theblended wheat flour were reported to change beneficially to food processors and nutritionists to formulate commercial products based on wheat and millet blends (Dykes and Rooney, 2007).Fibre rich, whole grain foods have reported to have overlapping physiological effects, including favorable gastrointestinal function, improved lipid and glycemic profiles, and reduced oxidative stress (Manson, 2001). In addition to the non starch polysaccharides of plant cell wall, whole grain foods are rich in myriad vitamins, minerals and other compounds that alone or in combination are likely to have significant health benefits (Marquart *et al.,* 2002).Dietary fibre, a nutritionally important non-nutrient roughage, has been recognized for health benefits. The current surge of interest in dietary fibre is attributed to its prophylatic and curative properties against colon cancer, coronary heart disease, obesity, gall stones, constipation, bowel irregularities, hemorrhoids, etc. The food technologists have responded to the desire of today consumers for fibre rich products that can be used to foster their health, vitality and well being (Nayak *et al.*, 2010).

Materials and Methods

Whole wheat (*Triticum aestivum*), kodo millet (*Pasplum scrobiculatum*), bengalgram *(Cicer arietinum)*, horse gram (*Dolichos biflorus)*, were the grains chosen and standardized various multi grain mixes . The combinations tried were wheat flour **+** kodo millet flour + bengal gram flour, wheat flour **+** kodo millet flour + horse gram flour,In general, starchy materials like rice, corn, refined flours, and potato etc., are being used for snack foods. Puffed snack is a cereal based extruded fat free snack. It is made using a twin screw extruder without addition of fat. When puffed snack is prepared from fiber rich foods, it is an ideal product for diabetic patients and obese people of all age groups owing to its nutraceutical benefits. For animal study experiment, a total of 60 rats (54 diabetic rats and six normal rats) were used. Diabetes was induced three days before starting the experiment. The rats were divided into 10 groups (n=10 rats/ group) after inducing diabetes. In the experiment, six rats were used in each group .

Results and Discussion

The effect of MGM product (puffed snack) on the body weight of the control and experimental animals. The initial weight of the various groups of rats ranged from 189.86±4.51 to 211.66±5.72 g. After 28 days of study there was a statistically significant increase in the body weight of the rat in normal (G1) and treatment groups (G3-G10) while the toxic control (G2 which were the rats with diabetes but not given any treatment) showed decrease in weight. The average weight gain in treated group ranged from 19 g (T_1) to 36g (T_2I) after 28 days of study period. The multigrain mixes brought about weight gain to different extent in all the treatment groups.

The effect of four week feeding with various formulations of the puffed snack on the glucose levels (mg/dL blood) in diabetic rats. The initial blood glucose level of the normal (G1) and toxic control (G2) rats was 71.5±5.67 and 148.66±5.48 mg/dL blood respectively. There was a statistically significant reduction in the blood glucose at the end of four weeks feeding trials. The maximum reduction in blood glucose was found in G6 rats, fed with T_6I sample where initial glucose levels reduced from 204.16 ± 3.57 to 121.16 ± 3.4 mg/dL (a reduction of 40.65%). Rumessen *et al.,* (1999) observed a lowering of blood glycemic response and peak insulin levels when 10g of artichoke inulin was added to 50g of wheat-starch meal of healthy human subjects.

Today's consumers hold high standards for the foods they consume. They demand foods that taste great, fat and calorie reduced, and they are interested in foods that provide added health benefits. It is also expected that these foods will be convenient and affordable. The desire of consumers to look good and stay healthy in a fast-paced environment is becoming more difficult to fulfill. Hence, this developed kodomillet puffed snack fulfill the consumers need.

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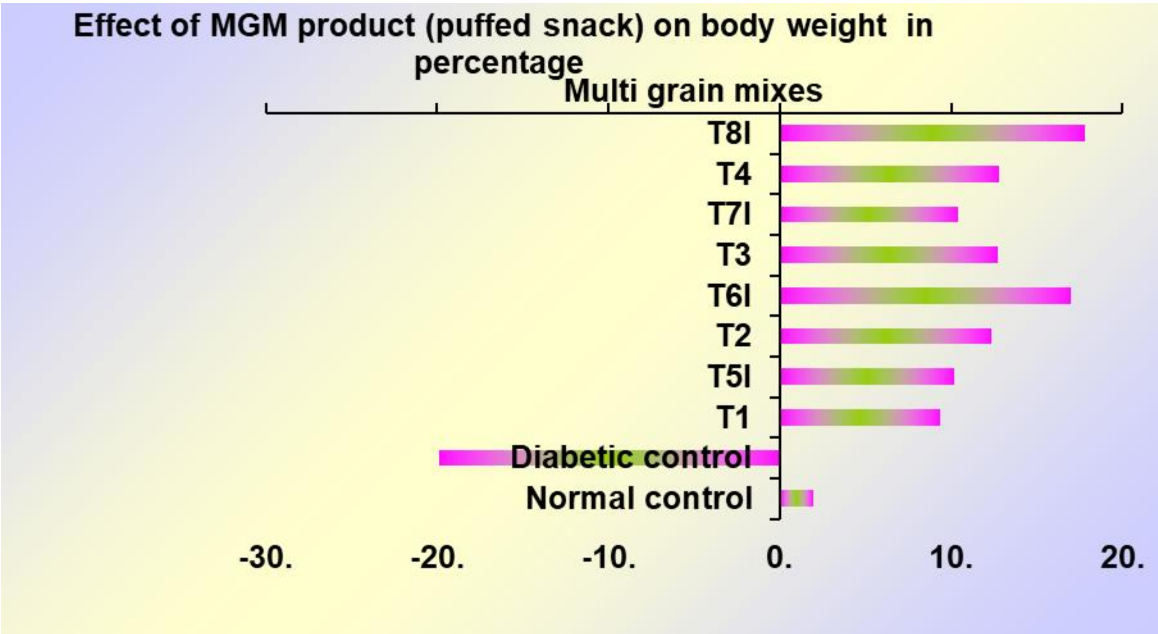

Percentage gain in weight

T4-14

Sensory and nutritional properties of millet based high fiber ready to use (RTU) multigrain mix from regional specified foods

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Introduction

Obesity is an emerging multi factorial non communicable disease (NCD), which is caused due to accumulation of fat cells either by an increase in the size or number of cells. Worldwide, obesity has been proven to be the leading cause for several NCDs like diabetes, hypertension, cancer etc. which is co-related to low fibre diets[Morenga*et al*, 2010]. Obesity levels among men and women in the urban and rural areas of Tamil Nadu state have been on an increase of over 10% over the last decade (NFHS-4). According to the NFHS4, in Tamil Nadu, among the age group of 15-49 years, 30.9 % of women and 28.2 of men are obese. High fibre foods can provide health benefits such as helping to maintain a desirable weight and lowering risk of NCDs like diabetes, cholesterol, heart disease other than its main function of bowel stability and strength(Geetha *et al*, 2019; Singh *et al*.2020). High fiber RTU multigrain mix has been standardized using local available high fibre, low glycemic index plant foods. The product developed from the high fibre mix gives satiety and thereby is ideal for weight management.

Materials and Methods

High fiber RTU multigrain mix

Grains in specified quantity are taken, namely: Whole wheat (40 g), Kodo millet(22.5 g), Whole horse gram (22.5 g), Modified banana starch powder (14 g)and Fenugreek (1 g)are cleaned and roasted at 70^{o}C for 5-6 minutes individually until it turned to light brown colour. The roasted ingredients are cooled and pulverized into flour, and packed in 200 gauge poly bags and stored in ambient condition.

Processing of High fiber RTU multigrain mix

Grains in specified quantity are taken (Whole wheat, Kodo millet, Whole horse gram, Modified banana starch powder and Fenugreek)

↓

Ingredients are roasted at 70^{o}C for 5-6 minutes individually until it turned to light brown colour

↓

Roasted ingredients are pulverized into flour and mixed together

↓

Packed in 200 gauge poly bags and stored in ambient condition.

Modified banana starch powder

Select the matured un-ripe banana, peel and cut into round small pieces. The pieces were soaked in 1 per cent KMS solution for 10 to 15 minutes. Spread the pieces as athin layer on a trays and dry in a cabinet dryer at 60^{o}C for 4- 5 hrs. After it gets dried pulverize it with mixer and sieve through BS 60 sieve (Sift flour). Mix the sift flour well with water in the ratio of 1: 4 and autoclave for 30 minutes to facilitate banana starch gelatinization. Then place autoclaved banana flour into freezer for 24 hours to bring about retrogradation of the gelatinized banana starch. After that the retrogradated banana starch flour is dried for 5-6 hours and cooled. Finally grind the modified banana starch to flour and sieve through BS 60 sieve and pack in polythene bags / airtight container until use.

Results and Discussion

Proximate composition: The moisture content of the high fiber RTU multigrain mix was 6.83±0.01 and had complex carbohydrate, as this mix contained grains which are good sources of carbohydrate of 57.76 ±0.49 g (Table 1). The protein content of the high fibre RTU multigrain mix was 10.38 ±0.21g and 2.13±0.32g of fat. The high fiber RTU multigrain mix had intermediate energy valueof 291.73±0.18 kcal and 1.40±0.28 g of ash which may due to the presence of seed coat in the grains, as majority of the grains were used along with seed coat.The minerals like iron, zinc and calcium were found to be 7.33±0.46,2.17±0.01 and 91.38±0.76 mg per 100 g respectively. The developed mix contains good protein (10%), low fat, energy and high dietary fiber (20%) and minerals. The developed high fibre mix had good antioxidant profiles like ascorbic acid 7.15±0.58 mg, total carotenoids 249.38 ±0.28 µg and DPPH Scavenging activity 86.75±0.10 (% inhibition). Composite flour mixdeveloped from millets and legumes by Chethana, 2008. also had lower protein (10.8 to 11.15 g/100 g) and fat content (0.67 to 1.44 g/100g) compared to the mix developed under the study. The use of soya bean and green gram in addition to millets are the contributing factors for higher protein content. Incorporation of vegetables in addition to whole grains increased the dietary fiber content.

Transition in lifestyle and increasing urbanization tended to more consumption of high energy foods (Junk foods) and reduced intake ofdietary fibre from fruits and vegetables coupled with sedentary life style are the main causes for overweight and obesity. This is because most of the junk foods are rich in fat salt, preservatives, simple sugars and less in complex carbohydrates. The intake of fiber in such foods is far behind the recommendation. However inclusions of high fibre RTU multigrain mixin the daily diet to promote healthy lifestyle to reduce the burden of obesity along with weight management.

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Table 1. Mean nutrient content of High fibre RTU multigrain mix

Nutrient contents	High fibre RTU multigrain mix	Nutrient contents	High fibre RTU multigrain mix
Moisture (%)	6.83 ±0.01	Total Dietary fiber (g)	21.5 ±0.01
Protein (g)	10.38 ±0.32	Iron (mg)	7.35 ±0.46
Fat (g)	2.13 ±0.52	Zinc (mg)	2.17± 0.01
Carbohydrate (g)	57.76 ±0.49	Calcium (mg)	91.38 ± 0.76
Energy (K.cal)	291.73 ± 0.18	Ascorbic acid (mg)	7.15 ± 0.58
Ash (g)	1.40 ±0.28	Total carotenoids (µg)	249.38 ±0.28
Crude fiber (g)	8.20 ±0.63	DPPH Scavenging activity (% inhibition)	86.75± 0.10

T4-15
Development of Kodo Millet based functional beverage

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Abstract
Millets are now gaining popularity among consumers and use of millet grains as a replacement in complementary food and food blends seems to be encouraging for the preparation of nutritional, healthy and safe and high quality food products. In this study, Kodo millet based functional milk beverage was standardized.100g of kodo millet was cleaned to remove foreign substances and were steeped in excess water for 12 hours and allowed to sprout for 48 hours. To the sprouted grains water was added in the ratio of 1:7 and milk was extracted. Sugar 10%, cardamom 0.1 % as a flavouring substance and preservative were added. The Total Soluble Solids were increased to 15° brix. Similarly, milk was extracted from the millet without malting. The millet milk was assessed for their physical characteristics, nutritional characteristics and organoleptic characteristics. The kodo millet-based milk beverage has TSS (15º brix), acidity (0.86), starch (5.73 g%), total sugar (3.26 g%), reducing sugar (1.79 g%) and protein (1.75 g%) contents / 100 g. The product cost is Rs. 25/ 200 ml. The shelf life of the kodo millet milk has shelf life of 3 months at refrigerated temperature. In sensory characteristics, it scored highest values in all aspects like appearance, colour, flavour, consistency, taste and overall acceptability. There was no detectable pesticide residue. In the microbial load, the colony forming unit was1.45± 0.17 (log10 $^{-2}$).

Keywords: Kodo millet**,** sprouting , milk beverage , storage studies , shelf life.

Introduction
Recently, demands by consumers for vegetable milk have experienced a noticeable increase due to noticeable problems of milk protein allergenicity and healthy life (Donkor et al., 2007). Considerable attention has been given to soy and almond milk due to their good nutritional value and functionality (Watkins, 2005). There is no millet milk based functional beverage is available in the market. Kodo millet is a nutritious grain and a good substitute to rice or wheat. millet is an excellent source of fiber (9%), as opposed to rice (0.2%), and wheat (1.2%). Kodo millet contains 66.6g of carbohydrates, 1.4% fat, 2.6% minerals and 353 kcal per 100g of grain, comparable to other millets. Based on these the study was conducted.

Materials and Methods
The materials like kodo millet, sugar, cardamom and muslin cloth were purchased from the local departmental store, Coimbatore. The kodo millets (100g) were cleaned to remove foreign substances and were steeped in excess water for 12 hours to achieve uniform moisture content. At the end of the steeping period, the grains were washed and the excess water was removed. The kodo millet was placed separately in muslin cloth, tied and allowed to sprout for 36-48 respectively with intermittent moistening to prevent dehydration. Malting was carried out at room temperature. To the sprouted grains water was added in the ratio of 1:7 and milk was

extracted. Sugar (10%), cardamom (0.1%) as a flavoring substance and preservative were added. The Total Soluble Solids were increased to 15° brix. Then homogenized, heated and stored in PET bottles (T1). Then kept for storage at refrigerated(R2) conditions. Similarly, milk was extracted from the millet without malting (T2). These samples kept for storage. During storage the physico chemical, sensory characteristics, microbial load, pesticide residue analysis was done.

Results and Discussion

The control sample and sample kept at ambient temperature had a shelf life of one day. The refrigerated samples had a shelf life of three months with preservative. Hence, the parameters were analysed in the refrigerated samples.

Physico – Chemical Characteristics of the millet milk:During storage there was no significant difference during the storage days. In the case of protein, there was slight increase in protein content of sprouted millet milk beverage (1.75%). This is because of sprouting. Malting also had significant effect ($p < 0.05$) on the carbohydrate and fats content of the samples and this is in accordance with Sade,(2009). Ocheme and Chinma (2008) reported that malting decrease fat contents of cereals. pH of the raw millet milk sample is 0.74 while the pH of the sprouted millet milk sample is 0.86. The results were on par with the studies conducted by Ashiru et al., 2003. The acidity of the beverage has been noted to be a result of lactic acid production by some bacteria during fermentation, which is not affecting the sensory qualities of the beverage. The sensory evaluation showed that sprouted kodo millet milk beverage was good in all characteristics (7.87) even though the colour was slightly dull, appreciated like chocolate drink. Modha and Pal (2014) results were on par with the present study. The table 4 showed that the microbial load of the raw millet drink had lesser (1.27 cfu/g) than the and sprouted millet milk beverage (1.45 cfu/g). This may be due to the fermentation total plate count is increased. In this study also no yeast and mould were present in the millet milk. Pesticide residue analysis showed that there was no detectable pesticide residues in the sample.

The sprouted millet milk beverages contained 1.25% protein, 5.73 % starch, 1.79% reducing sugar, 3.26 % Total sugar, 1.21 % fat, 1.63 % calcium, 15° brix TSS and 0.86 acidity. The average overall acceptability of the beverage was 7.86. The present study revealed the feasibility of the sprouted millet milk beverage based on the nutrient analysis and sensory evaluation. The method of processing is very simple and this can be taken up for industrial production

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Table 1. Physico – chemical parameters of Kodo Millet milk beverage

S. No.	Nutrients	Refrigerated Kodo Millet milk(raw) beverage (R2 T1)	Refrigerated Kodo Millet milk (sprouted) Beverage (R2 T2)
1.	Protein (g%)	1.71[a] ±0.144	1.75[a] ±0.149
2.	Starch(g%)	6.01[a] ±0.15	5.73[a] ±0.13
3.	Reducing sugar(g%)	1.36[a] ±0.07	1.79[a] ±0.12
4.	Total Sugar(g%)	3.82[a] ±0.16	3.26[a] ±0.17
5.	Fat(g%)	1.22[a] ±0.078	1.21[a] ±0.074
6.	Calcium(mg%)	1.05[a] ±0.05	1.63[a] ±0.26
7.	T.S.S °brix	15[a] ±0.10	15[a] ±0.10
8.	Acidity	0.74[a] ±0.07	0.86[a] ±0.09

All means are based on triplicate value. Means with different letters in each column differ highly significantly $P < 0.05$*: wet weight basis.

T4-16
Development of millet milk beverage from millets by microwave and steaming technique

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Abstract

Millets are more nutritious and are cultivated in areas of drought tolerance. It is a poor man's crop, it serves many purposes of nutrition, nutraceutical and therapeutic uses. Milk is very important in our diet and grain milk is becoming popular and is a substitute to cow's milk for lactose intolerant people. Millet milk is extracted by grinding and is tested for its nutritionalcontent. The carbohydrate values of steamed millets in millet milk, ranged between 72.89- 82.94%±3.56, protein ranged between 7.00-13.47%±2.11, fat ranged between 1.4-7.25%± 2.03, ash ranged between 1.29-4.40%±1.13. total dietary fibre ranged between 8.84% to 11.88% ± 0.39.Total dietary fibre is more in foxtail millet, 11.88%±0.39 followed by sorghum, 11.4% ± 0.39, proso millet,10.72%±0.39,ragi millet, 10.02% ±0.39, bajra, 9.48%±0.39, little, 9.4%±0.39, barnyard millet,9.11%±0.39 and kodo millet, 8.84%±0.39. The moisture content of the microwaved millets beverage ranged between 3.42 to 6.78%wb±6.49, protein ranged between 7.97 to 14.33 % ±0.9, fat ranged between 0.97 to 4.91%±0.46, ash ranged between 0.86 to 2.63% ±0.20, total dietary fibre ranged between 4.84 to 11.29%±0.70 and carbohydrate ranged between 67.55 to 73.29% ± 0.74. The range of phytic acid was found to be 0.025 to 0.89±0.09. The range of anti nutrient tannin was found to be 0.05, kodo steamed and 1.92 in little millet. From the study it is evident that the steaming and microwaved pretreatment causes increase in its nutrition content of carbohydrate, protein, fat, ash, crude fibre and decrease in phytic acid content and can be recommended for making millet milk beverage.

Keywords: millets, processing, microwave, steaming, nutrition, antinutrients

Introduction

Millets are third in staple food crop next to rice and wheat. The millets crop is more suitable for diabetic people and people with cardiovascular diseases, obesity, hypertension, blood pressure and sugar. There is a permanent remedy for people with obesity to regain the physical fitness and an active life with brisk actions. Value added products include thepreparation of products from millets that add value and serve as a cost boosting income oriented technique to the end usage of farmers and entrepreneurs involved in millet processing

Methods and materials

The millets include major and minor millets, major millets being sorghum, bajra and ragi and minor millets include little, kodo, proso, barnyard,little and foxtail millets. Millet milk was extracted from both major and minor millets by grinding method. Then a portion of it is subjected to soaking in a beaker and then subjected to steaming or microwaved for 30minutes. Then it is dried in a tray drier and then powdered in a pulverizor and stored in ziplock covers. Then a weighed quantity is taken for proximate analysis of moisture content, %wb, carbohydrate, protein, fat, ash, phytic acid tannin and total dietary fibre using standard procedure. The experimental values were tested for its significance at 5% level of significance using statistical software, SPSS 16.0.

Results and Discussion

Moisture content of the steamed millet sample powder varied between 4.10-8.50% wb± 1.51. Steamed pretreatment helps in softening the outer skin of the millets and helps in absorption of moisture during soaking and increases in volume almost double. The corresponding weight also gets increased. The values of the nutrients were more than the normal untreated millet milk with steaming technique especially in fat and fibre content.as compared with the findings of Puniyamoorthy Sheela et.al., 2018. (Fig.2) The moisture content of the microwaved sample ranged between 3.42 to 6.78% wb± 6.49, protein ranged between 7.97 to 14.33 % ±0.9, fat ranged between 0.97 to 4.91% ±0.46, ash ranged between 0.86 to 2.63% ± 0.20, total dietary fibre ranged between 4.84 to 11.29% ± 0.70 and carbohydrate ranged between 67.55 to 73.29%±0.74. (Fig.1) The range of phytic acid was found to be 0.025 to 0.89±0.09. The range of anti nutrient tannin was found to be 0.05, kodo steamed and 1.92,little millet, steamed. The kodo steamed, 0.50 followed by sorghum, steamed, 0.58, bajra steamed, 0.66,ragi steamed, 0.86, foxtail steamed, 0.89, barnyard steamed, 1.03 and proso steamed, 1.32, little steamed, 1.91±0.57. (Table.1) Milling grains and removing the bran decreases phytic acid. Phytic acid is reduced due to steaming technique and this coincided with the earlier findings of Agte et.al.,1999) and is favourable for the absorption of minerals, iron and zinc.

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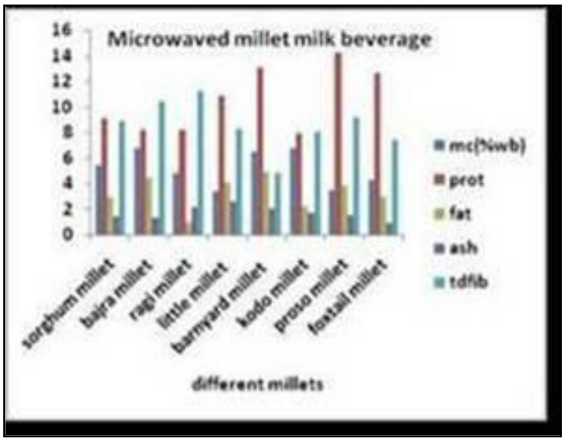
Table.1 Free, total phosphorous and phytic acid of different millets

S.N	Sample	free phosp	tot phosp	phytic acid
1	oat ctrl	0.113	0.837	1.674
2	sorghum steamed	0.027	0.278	0.580
3	bajra steamed	0.073	0.363	0.668
4	ragi steamed	0.052	0.429	0.868
5	little millet steamed	0.068	0.899	1.917
6	kodo steamed	0.003	0.025	0.050
7	proso steamed	0.040	0.615	1.325
8	barnyard steamed	0.066	0.513	1.033
9	foxtail steamed	0.026	0.414	0.895
	average	0.05	0.49	1.00
	maximum	0.00	0.90	1.92
	minimum	0.11	0.02	0.05
	sem	0.01	0.09	0.19
	sd	0.03	0.27	0.57
	cv	62.32	55.92	57.17



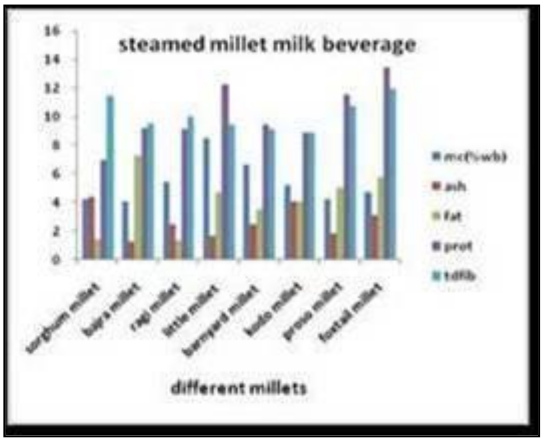


Fig.1 Microwaved millet milk beverage **Fig. 2 Steamed millet milk beverage**

T4-17
Formulation of functional beverage from *Quinoa*

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Abstract

Quinoa (Chenopodium quinoa Wild.) a starchy, dicotyledonous indigenous plant of the Andean region is a pseudo cereal widely cultivated in South America.The aim of the present study was to analyze the physico-chemical, functional and anti-nutritional property of *quinoa* seed and *quinoa* milk. The standardization of functional beverage was done and evaluated its proximate composition, sensory and shelf life evaluation during the period of 15 days of storage.For germination, *quinoa* seed was washed three times with deionized water and soaked for 16 hours. After draining the excess water the seed was tied in wet muslin cloth. It was kept at 15-25°C for 72 hours. The germination percentage was about 65.5 per cent. The raw and germinated *quinoa* seed was ground with water at 1:8 ratio and it was filtered by muslin cloth to separate the *quinoa* milk extract. Then the functional beverage using raw andgerminated *quinoa* milk was formulated as 20% *quinoa* milk with 10% carrot extract, beetroot extract and papaya pulp (natural flavor) and with 0.1% vanilla essence ,mango essence and chocolate essence (synthetic flavor) along with sugar and water added. The extracted raw and germinated *quinoa* milk was pasteurized separately at 60° C for 5 min. The beverage was bottled by PET bottle and glass bottle and stored in refrigerator at 4°C. During storage the proximate composition such as pH, viscosity, starch, total sugar, protein, fiber, insoluble fiber, soluble fiber, fat, vitamin E, antioxidant activity and β-carotene level of beverage get reduced rapidly in PET bottle when compared to glass bottle. The acidity and reducing sugar level was increased. There were no changes in calcium and mineral content. The nutrient content retention was highly occurred in glass bottle. Among the functional beverage the minimum microbial load was absorbed in glass bottle. The nutrient and calorie rich functional beverage is acceptable for all age groups and preferred as diet for lactose intolerance, celiac disease and degenerative disease person due to its high nutritious and gluten free promotes the awareness among the consumers about the health benefit of *quinoa* seed.

Keywords: *quinoa*, functional beverage,germination, pseudo cereal

Introduction

In India, the *quinoa* is cultivated in Andhra Pradesh, semi-arid Rajasthan and Uttarakhand, in between October and March (rain fed crop). It exhibit anti-oxidative, anti-hypertensive, anti-diabetic properties and it is considered to be an excellent functional food. The germination of *quinoa* seeds has been reported to improve the protein digestibility, mineral bioavailability, vitamin, antioxidant activity, flavonoids, phytosterols, and polyphenols. The present study was to analyze the physico-chemical, functional and anti-nutritional property of quinoa seed and *quinoa* milk.

Materials and Methods

The raw and germinated *quinoa* grains were utilized to prepare functional beverages with different flavoring ingredients in order to increase the consumption of *quinoa* grain. Select the white variety *quinoa* grain, fresh fruit and vegetables. Functional beverage from raw *quinoa* grain was prepared from 100 g of *quinoa* grain which was cleaned, washed and soaked for 16 hours, for germination at 15-20°C for 72 hours. Both raw and germinated *quinoa* seed was ground separately with water in the ratio 1:8. The extracted raw and germinated *quinoa* milk was pasteurized separately at 60° C for 5 min. The vegetables carrot, beetroot and papaya fruit were washed thoroughly in clean water and the skin was peeled off. Carrot and beetroot were cut into pieces and the juice was extracted by grinding. Similarly papaya pulp was prepared. Spices like dry ginger, cardamom and pepper were powdered and sieved separately for flavoring.

Results and Discussion

The functional beverage control (T_0) was standardized by raw and germinated *quinoa* milk with water which was cooked separately at 80 °C, packed in sterilized polyethylene terephthalate (PET) bottles and glass bottles and stored in refrigerator at 4°C. The raw and germinated *quinoa* grains were utilized to prepare functional beverages with different flavoring ingredients in order to increase the consumption of *quinoa* grain. The extracted raw (T_1) and germinated *quinoa* milk (T_2) was pasteurized separately at 60° C for 5 min. Then the functional beverage T_1 (using raw quinoa milk) and T_2 (using germinated *quinoa* milk) was formulated as T_1V_1 and T_2V_1 (20% *quinoa* milk with 10% carrot extract), T_1V_2 and T_2V_2 (20% *quinoa* milk with 10% beetroot extract), $T_1V_3$and T_2V_3(20% *quinoa* milk with 10% papaya pulp) T_1V_4 and T_2V_4 (20% quinoa milk with 0.1% vanilla essence), T_1V_5 and T_2V_5 (20% *quinoa* milk with 0.1 % mango essence) , $T_1V_6$and T_2V_6 (20% *quinoa* milk with 0.1 % chocolate essence) along with sugar and water added to standardize the beverage. The beverage was bottled by PET bottle and glass bottle and stored in refrigerator at 4°C for nutritional, sensory and shelf life evaluation.The shelf life of beverage was upto 15 days without deterioration. Initially, based on sensory evaluation the taste wise acceptability was higher in ($T_1V_1$and T_2V_1), ($T_1V_3$and T_2V_3) and (T_1V_5 and T_2V_5) when compared toT_0. The overall acceptability was given for ($T_1V_1$and T_2V_1), (T_1V_2 and T_2V_2) and ($T_1V_3$and T_2V_3) followed by (T_1V_4 and T_2V_4), (T_1V_5 and T_2V_5) and ($T_1V_6$and T_2V_6).

During storage the proximate composition such as pH, viscosity, starch, total sugar, protein, fiber, insoluble fiber, soluble fiber, fat, vitamin E, antioxidant activity and β-carotene level of beverage T_0, $T_1$and T_2 get reduced rapidly in PET bottle (P_1) when compared to glass bottle (P_2). The acidity and reducing sugar level was increased. There was no variation occur in calcium and mineral content. The nutrient content retention was highly occurred in P_2.Among the functional beverage T_0, $T_1$and T_2 the minimum microbial load absorbed glass bottle (P_2). Which might be due to the gas defecation higher in $P_1$when compared to P_2 leads to air circulation occur inside the PET bottle (P_1) and rapid contamination occur in the beverage. Due to germination, there might be rapid nutrient loss, increased microbial load and reduced sensory attributes occur in T_2 when compared to T_0andT_1.Finally, we concluded that for preventing nutritional loss, sensory and storage stability of the beverage, glass bottles (P_2) were acceptable. The nutrient and calorie rich functional beverage is acceptable for all age groups and promotes the awareness among the consumers about the health benefit of quinoa seed.

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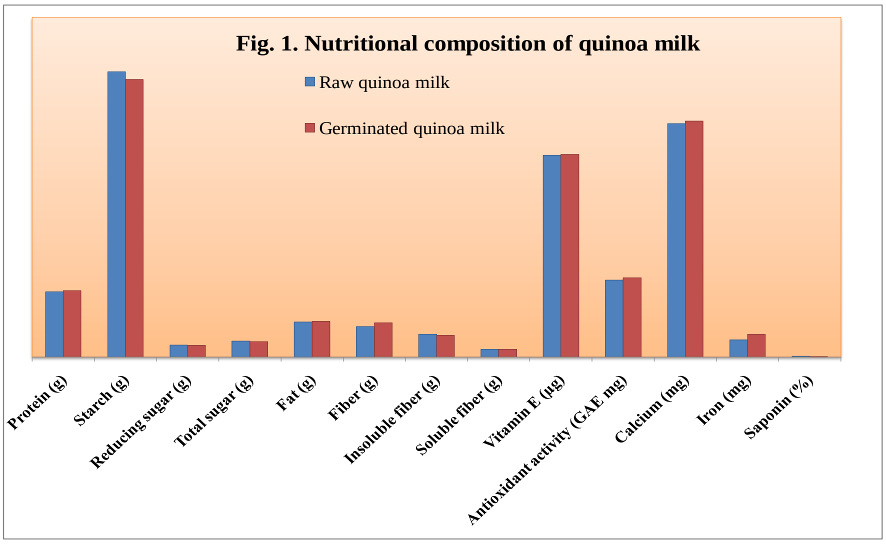

T4-18

Biochemical and rheological characterization of composite millet flours for developing value added extruded products

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Abstract

Extrusion processing is a viable technique for incorporating majority of legumes, milletby-products, etc for developing ready-to eat products. Present study provided an alternate way to utilize a by-product of rice mill and green gram grits by incorporating them into millet to obtain an extruded product. Rheological characterization of the various flours from the broken rice, barnyard millet and green gram flour were investigated for flow behaviour. The flour combinations include (broken rice, barnyard millet and green gram flour): Mix 1- 80:10:10; Mix 2- 60:20:20; Mix 3- 40:30:30; Mix 4- 50:30:20 and Mix 5- 50:20:30.The optimised process variables were: 110˚C barrel temperature , 260 rpm screw speed and 12. 5% feed moisture content and the final product had hardness - 540 g, bulk density, 0.23 g/cm^3, Water absorption index,5.10g/g and expansion ratio,1.98.The results showed that the by-products could be successfully used for nutritional supplemented expanded snacks.

Keywords: Extrusion cooking, By-product utilization, biochemical and functional properties

Introduction

Minor millets are nutritionally superior to rice and wheat and the presence of all the required nutrients in millets makes them suitable for industrial scale utilisation in the manufacture of food stuffs (e.g. baby foods, snack foods and dietary food). During processing such flours undergo the process of gelatinization. Barnyard millet comes under the category of Minor millets they are popularly known as coarse cereals and included in the broad category of cereals. In the food industry, starch based products like cereal flours are cooked during extrusion processes. Green gram being rich in quality protein, minerals and vitamins, they are inseparable ingredients in the diets of a vast majority of Indian population. When supplemented with cereals, they provide a perfect mix of essential amino acid with high biological value (Qin et al., 2011). Extrusion processing is a viable technique for incorporating majority of legumes, millet, by-products, etc for developing ready-to eats products. Present study provided an alternate way to utilize a by-product of rice mill and green gram grits by incorporating them into millet to obtain an extruded product. Rheological and biochemical characterization of the various flours from the broken rice, barnyard millet and green gram flour were investigated for flow behavior and their suitability for value addition.

Materials and Methods

Broken rice, Barnyard millet and green gram were cleaned to remove dirt and discoloured grains, washed with water and sun dried by placing on clean cloth. The sample was made into flour using a burr mill in a local flourmill to a 100-micron particle size that passed through ISS 40 metal sieve and cooled to room temperature to avoid clump formation and stored in airtight containers for further experiments. Calculated amount of flour and distilled water were taken to obtain the fresh paste. The slurry was prepared in the ratio of 5g of flour and 25ml of distilled water (Musa et al., 2010). The flour combinations include (broken rice, barnyard millet and green gram flour): Mix 1- 80:10:10; Mix 2- 60:20:20; Mix 3- 40:30:30; Mix 4- 50:30:20 and Mix 5- 50:20:30. The pasting properties and viscoelastic study were conducted for five composite flours at three temperatures (90, 100, 110˚C). The extrusion of selected composite flour was carried out at barrel temperature of 90-110˚C, screw speed of 230- 290 rpm with feed moisture of 10-14% to evaluate effect of extrusion on physical, functional and textural properties of the products like swelling power and water solubility index. Numerical optimization was done to find the best process parameters based on the quality parameters. The extrudate obtained at optimized process conditions from flour mix 3 was used for storage studies. The quality parameters like colour change, water activity, protein content, fat content, and carbohydrate were analysed at month's interval.

Results and Discussion

The swelling power (SP) and solubility index (SOL) of Broken rice, Barnyard millet and green gram flour are shown in Figs. 1 and 2, The ability of broken rice flour to swell in the presence of excess water was different from millet and green gram flours. The mix 1 (80:10:10) showed the highest swelling power and solubility index was maximum for mix 5 (50:20:30) compared to other combinations. Swelling was regulated by the degree of crystallinity of the starch granules and the swelling power was determined by the ability of starch granules to swell in the presence of excess water when heated. Swelling power of starches reflects the interactions between water molecules and starch chains in amorphous and crystalline domains, respectively (Kim et al., 2012). The process of pasting can be expressed as the state that is largely associated with gelatinization of starch and retro gradation to a minor extent. The apparent viscosity of starch dispersions in water is strongly influenced by the extent of swelling of starch granules. Starch granules swell radially in the beginning of heat induced pasting, and when the temperature is increased, the amylopectin-rich granules swell tangentially (Shinoj et al., 2006).As a consequence, the granules get deformed and lose their original shape. The presence of amylose in the continuous phase surrounding the swollen granules results in the formation of a gel on cooling. This result demonstrated that broken rice flour inhibited starch swelling and prevented amylose leach out than millet flour and green gram flour seemed to have no effect on these properties. Nutrient composition of composite flour especially of mix3 found to contain maximum quantity as well as it has been identified as suitable for preparing various extruded products comparing with other combinations(Tables 1 &2).

The study showed flour formulations were significantly influenced on viscosity of the samples. Higher amount of millet and green gram led to higher consistency index values.On increased broken rice content the swelling power increased whereas solubility decreased and the composite millet flours are suitable for preparing various extruded products. Present study provided an alternate way to utilize a by-product of rice mill and green gram grits by incorporating them into millet to obtain an extruded product.

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Table 1. Nutrient composition of the individual grain flour (per 100g)

Nutrient composition	Protein (%)	Fat (%)	Carbohydrate (%)
Rice	6.90	1.02	64.3
Green gram	20.50	1.01	55.0
Barnyard millet	11 .00	3.90	45.0

Table 2. Nutrient composition of the composite flour(per100g)

Nutrient composition	Protein (%)	Fat (%)	Crabohydrate(%)
MIX 1	8.3	1.2	68.9
MIX 2	8.9	1.0	69.8
MIX 3	8.4	1.3	67.9
MIX 4	8.2	1.9	64.9
MIX 5	8.1	1.9	65.3

Fig 1. Swelling power of broken rice, barnyard millet and green gram

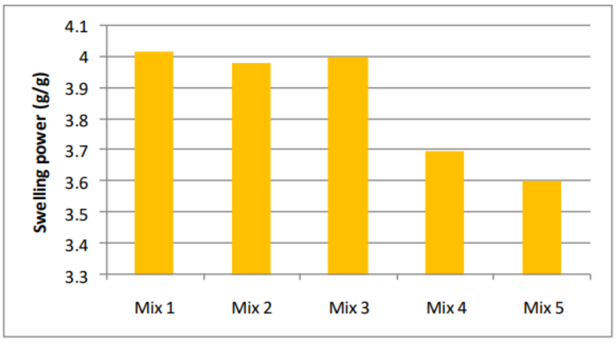
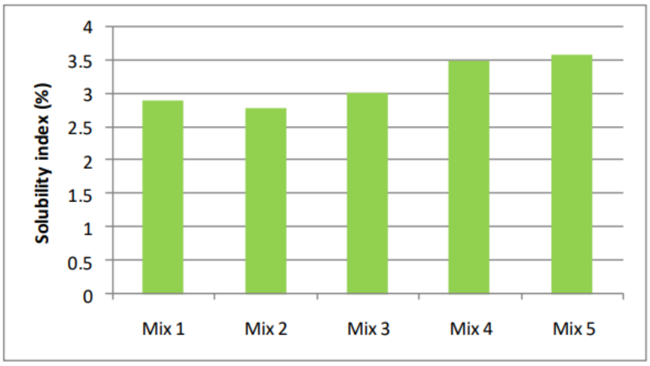


Fig. 2. Solubility index of broken rice, barnyard millet and green gram



Theme 4

Post-harvest management, value addition and therapeutic foods in millets

Abstract

T4-19

Analysing the cooking quality of little millet landraces for popularization and the development of value-added products

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Abstract

Little millet is one of the underutilized crops among small millets that has a resonance for climate resilience and nutrition. This is highly nutritious and gluten free with flavonoids, PUFA, magnesium, selenium, iron, anthocyanins and protein (Arunachalam et al.2005). Although there are innovative breeding strategies adopted in the mainstream crops like rice, this crop with immense cultural heritage and nutritional value still remains to be untapped for its improvement and production. This embraces the preference of consumers for cooking and value-addition. Compared to rice and wheat, post-harvest processing including cooking needs a higher time and process as these have nearly 7-8 layers of hull (Pramitha et al.2023). This further reduces the choice of opting them as a food in regular diets. In a view of this, a set of seventeen little millet landraces collected from Malyali tribes of Kolli Hills were subjected to be analysed for their cooking quality parameters. Among all little millet landraces, Kolunthana samai and Chittan samai recorded the lowest duration for cooking as compared to the ATL 1 and CO 4 (samai). The cooked weight of the landraces was lowest in Siru samai and highest in Chittan samai. However, the highest cooked volume was found in Kothu samai and lowest was in Siru samai. Among all landraces, Kolunthana samai, Chittan samai, Vellai Samai and Perungolai samai were desirable for their cooking quality and taste compared to released varieties. Further, Chittan samai and Perungolai samai were also found to be better performers of yield (Sneha et al.2023). Hence, these landraces could be forwarded for frontline popularization for cultivation among people. Also, this investigation also involved in producing two value added products namely samai kothu and samai vadai. On popularising these landraces, it was found that based on taste preference, samai kothu was much preferred by analysis among the people of siruvani foothills.

Keywords: Little Millet landraces, cooking quality, value added products: samai kothu and samai vadai.

T4-20
Development of low cost protein rich supplementary snacks for pre-school children

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Abstract

Millets are staple food grains for majority of the population around the world. These are rich sources of carbohydrates and supply calories and other nutrients to the consumers. Apart from value addition by processing the traditional products from these grains, development of newer products offers variety, convenience, quality and cost efficiency. There are many traditional foods in India which include confectionary products. Traditional foods give us good and unique taste which is also healthy for human beings. Among those nutrient bar plays an important role in ready to eat traditional sweet products which is preferred by all age groups of population. Ragi nutrient bar and chickpea protein bar were prepared with addition of barnyard millet flour and nuts. The grains of finger millet being nutritionally superior to rice and wheat, provide cheap proteins, minerals and vitamins to the poor where the need for such ingredient is maximum. Barnyard millet is a good source of protein, which is highly digestible and is an excellent source of dietary fibre with good amount of soluble and insoluble factions. The carbohydrate content of barnyard millet is low and slowly digestible, which makes the barnyard millet a nature's gift for the people. Ragi nutrient bar was prepared with four different proportions of barnyard millet flour as 12 %, 25 %, 35 % and 50 % and the proportion containing 12 % of barnyard millet flour was organoleptically accepted. The product was appealed to have good taste, keeping quality and better nutritional value. The Chickpea protein has high digestibility. Presence of isoflavones may also have hypocholesterolemic effect. Chickpea protein bar was prepared with addition of25 % barnyard millet flour and spices and it was baked to cook. The addition of barnyard millet increased the protein content in both ragi nutrient bar and chickpea protein bar as 3.74 g and 3.0 g respectively. The fat content of both of these products prepared with addition of barnyard millet flour was found to be low when compared to the control samples. The calcium content of these products were increased content in both ragi nutrient bar and chickpea protein bar as 280 mg and 30 mg respectively after the addition of barnyard millet flour. Hence it was concluded that inclusion of barnyard millet flour into snacks improved the nutritional quality of these products.

T4-21

Effect of processing techniques on enhancing the nutritional factors in Pearl Millet

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Abstract

Pearl millet (*Pennisetum glaucum*) is a versatile cereal cultivated for food, feed andforages particularly in Asian countries. More than 95 per cent pearl millet production comes fromdeveloping countries, and India as the largest producer covers anarea of 9.8 million hectares out of total world production. Processing is commonly done to enhance the quality of the grains by converting them intoedible form. This experimental study was conducted in the Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore to study the effect of processing techniques on enhancing the nutritional aspects of pearlmillet. Four different types of processing techniques viz., soaking, sprouting, raw fermentation, cooked and fermentation of flour were applied. Among which the cooked and fermented sample was found effective in the improvement of nutritional qualities factors. During fermentation of cooked pearl millet flour there was reduction in the carbohydrate (24.33 per cent) and starch (66.35 per cent) content at 72 h. The reduction may be due to the microbial utilization of the reduced carbohydrate as carbon source and also due to increased amylolytic enzyme activity, inherent in such products. The amylolytic enzymes hydrolyzed carbohydrate to simpler sugars and much more utilizable source of energy for the microorganism and also reported that, the synergistic effect of cooking and fermentation is of great importance in nutritional quality of plant foods. Similarly there was decrease in the starch content, which may be due to the enzyme that hydrolyzes complex starch to simpler ones as sources of energy for the fermenting microflora. Starch is degraded to more absorbable sugars for quick energy supply when it is cooked and fermented.The level of reducing sugar increased in cooked and fermented sample to 4.56 g $100g^{-1}$ at 36 h of fermentation, the increase could be attributed to the increased amylolytic enzyme activity and also due to low levels of tannin and starch as a result of fermentation. The protein content also increased during fermentation of the cooked pearl millet flour at 72 h, when compared to the other techniques. The cooking process denatured and fermentation hydrolyzed proteins into free amino acids, the increase in free amino acids released due to increased activity of proteolytic enzymes, which were used in the synthesis of new protein.In case of lipid content, considerable reduction was observed during all the process, among which maximum reduction of 42.13 per cent was recorded at cooking and fermentation process. The reduction is due to high lipolytic enzyme activity, which acts by cleaving triglycerides to simpler free fatty acids, sterol esters and polar lipids. These free fatty acids served as a source of flavour to the product. These changes impart aroma, improve nutritive value and provide energy for the fermentative microflora. It was also found there was direct relationship between protein and lipid levels, as the protein level increases the lipid level decreases.

T4-22

Studies on the isolation of probiotic microorganism from fermented Pearl Millet porridge

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Abstact

Fermented foods are gaining importance in the current world because of nutritive safety, preservative effects, enriching the diet with flavour, texture and aroma of the fermented products. The production of fermented foods is also important in adding value to agricultural raw materials and their marketability, which is crucial for agriculture. This experimental study in the isolation of probiotic microbes from fermented pearl millet porridge was conducted in the Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore. Naturally fermented indigenous pearl millet porridge is consumed in southern parts of India. The pearl millet porridge sample was collected from different places *viz*., Salem, Atturin and around Coimbatore region. The samples were used for isolation of lactic acid bacteria including *Lactobacillus*, *Leuconostoc*, *Pediococcus* and yeast. The fermentative microorganisms involved in food fermentation are *Lactobacillus*, *Leuconostoc*, *Pediococcus* and yeast and they were isolated in MRS (De Man Rogosa Sharpe, 1960) medium for *Lactobacillus*, *Leuconostoc* medium for *Leuconostoc*, APT medium for *Pediococcus* and yeast extract malt extract agar medium for yeast. A total of 25 isolates were isolated based on the variation in the colony morphological character. Amoung 25 isolates 13 belong to lactobacilli, 3 *Leuconostoc*, 3 *Pediococcus* and 6 yeast isolates. The colonies were small irregular and cream coloured in LA2 isolate.In case of LE1 the colonies were cream coloured entire, raised and circular. The colony of yeast isolates of Y1 was cream coloured smooth raised and glossy in appearance.The selection of efficient isolates as starter culture for preparation of pearl millet porridge was done, based on their efficiency to improve nutritional qualities, reduction in antinutritional factors, preservative properties and probiotic characteristics of this isolates they were further used as starter culture consortium.

T4-23

Post harvesting methods for Finger millets – Value addition

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Abstract

Finger millet (*Eleusine coracana* L.) is commonly known as ragi is extensively cultivated in various regions of India and in the entire world. India is the major producer of finger millet contributing nearly 60% of the global production. Finger millet based diets have shown lower glycemic response due to high fiber content and also alpha amylase inhibition properties which are known to reduce starch digestibility and absorption. Germination of finger millet is the most familiar method in India and nutrition profile of germinated finger millet is measured better than other millets. Germination protects the grains from fungal infection and has dominant effect on number of biochemical changes which enhances the nutritional value of malted products. It leads to expansion of α and β-amylase throughout germination process, which develops desirable aroma during roasting/kilning and makes it a supreme grain for malt foods.

The finger millet can offer various health advantages including antidiabetic, hypocholesterolaemic, Prevention from diet associated chronic diseases, antioxidant and antimicrobial effects. Processing technologies can be applied to improve micronutrients bioavailability and also for enhancing the diets quality of finger millet. Nutritional configuration of finger millet contributes to reduced risk of diabetes mellitus, high blood pressure and gastro-intestinal tract disorder when absorbed in the body.

Finger millet grain has a carbohydrate content of 81.5%, protein 9.8%, crude fiber 4.3%, and mineral 2.7% which is comparable to other cereals like rice, wheat, maize and millets. Its protein profile is relatively well balanced; as it contains more lysine, threonine, and valine than other millets. Finger millet varieties contain calcium (220–450) and iron (3–20%) respectively10. The finger millet contains important amino acids viz., isoleucine (4.4 g), leucine (9.5 g), methionine (3.1 g) and phenyl alanine (5.2 g) which are deficient in other starchy meals.

The dietary fiber and polyphenols in finger millet are known to offer several health benefits such as antidiabetic, antioxidant, hypocholesterolaemic, antimicrobial effects and protection from diet related chronic diseases to its regular consumers. The millet polyphenols is a complex mixture of benzoic acid and cinnamic acid derivatives and exhibit enzyme inhibitory and anti-cataractogenic activities also. The non starchy polysaccharides of the millet form bulk of its dietary fiber constituents and offer several health benefits including delayed nutrient absorption, increased faecal bulk and lowering of blood lipids. Regular consumption of finger millet as a food or even as snacks helps in managing diabetes and its complications by regulation of glucose homeostasis and prevention of dyslipideamia.

Consumption of finger millet in our diet can be promoted through its proper processing and value addition from rural to urban area. Finger millet may be applicable formulations of different value-added food products possibly attributed to its well-balanced protein profile and gluten free nature.

T4-24
Effect of TNAU Parboiling Tank on the Milling and Nutritional Qualities of Barnyard and Kodo Millet

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Abstract

Millets are remarkable in their nutritional content and are consumed as food by the man kind from time immemorial. Although they are nutritionally superior to cereals like rice and wheat these consumption of these nutri-cereals has received less attention compared to the major cereals Awareness about the nutritional and functional qualities of millets are gaining importance in recent days due to its gluten free nature and hypoglycemic effect. Due to the difficulty in primary processing operations and lesser milling recovery the consumption of millets declined among the farmers cultivating millets. In the present study the Parboiling tank designed byTamil Nadu Agricultural University was popularized through the Front Line Demonstration on their milling recovery and nutritional qualities. Millets such as barnyard millet and kodo millet were parboiled and their quality parameters were assessed. Barnyard millet parboiled using TNAU parboiling tank shown the head rice recovery of 58.25 ±1.19 percent and the broken rice yield was 9.75 ± 0.96 % and the milling percentage was 68 ±1.58. The total starch content was found to be 74.38 ±0.63 percent, soluble fibre content was 2.39 ± 0.01 per cent and insoluble 5.28 ± 0.17 per cent. In the kodo millet the head rice recovery was 5.73 ±0.5 %, broken rice yield was 9.5 ± 1.7, milling percentage was 67.5 ± 0.6, total starch content was 82.3 ± 1.1 per cent, soluble fibre content 0.4 ± 0.01 per cent and in soluble fibre 2.4 ± 0.01 per cent.

T4-25
Phytochemicals in Cereal Foods

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Abstract

Millet is one of the most important cereals and also main staple food grain in developing countries in Africa and Asia as well as in some other economically developed countries of the world. Millets are small grained, annual crop, belong to Poaceae family. Millets are the oldest ancient cultivated crops. Millets are rich source of carbohydrates, dietary fiber, proteins, vitamins, aminoacids, anti-oxidant, low-glycemic index and regarded as functional foods.Plant metabolism contain two types *viz*., Primary and secondary metabolisms.

Different types of stresses such as abiotic and biotic ones, cause these secondary metabolites to be produced. The plants are abundant in polyphenolic compounds that lower the risk of obesity, liver disease, cancer, gastrointestinal tract illness, and neurological disease. One class of phenolic chemicals is the flavonoids. Vitamin C, E, and carotenoids are phenolic substances with significant antioxidant potential. It is thought that antioxidants help to lower oxidative stress, which is linked to heart disease, cancer, and early ageing. A class of substances known as alkaloids includes aromatic nitrogen. It has anti-tumor, antipyretic, anti-pain, nervous system stimulation, and microbial infection fighting properties. The cereal foods include maize, sorghum, pearl millet, and minor/small millets. These crops are having various therapeutic properties as well as their resistant to harsh environmental conditions. The current study elucidates the various phytochemicals present in the cereal food crops.

Keywords: *Secondary Metabolites, antioxidant,Maize,Millets.*

T4-26
Health benefits and Nutritional Composition of Barnyard millet

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Abstract

Globally, malnutrition is an emerging challenge in the context of rising uncertainty about emerging populations and food supplies. To feed the world's growing population and meet their need for nutritional food security is a challenge. Millets are a rich source of nutrition; hence, they are called “nutri-cereals”. Collectively, eight millets were practised in cultivation all over the world for gaining health benefits in human populations. Barnyard millet (*Echinochloafrumentaceae*) is one of them, mainly cultivated in rainfed areas and utilised for food and fodder by humans and animals, respectively. In the world, in India, China, Japan, Pakistan, and Africait is widely cultivated. In India, it is mainly confined to Orissa, Madhya Pradesh, Bihar, Tamil Nadu, Andhra Pradesh, Karnataka, and Uttarakhand. It is a short-duration crop and is able to withstand adverse climatic conditions, *viz*., biotic and abiotic stresses. It has wider adaptability and is hence suitable for climate-resilient agriculture. Regarding therapeutic properties, barnyard millet contributes a major source of protein, carbohydrates, fibre, and micronutrients such as iron, zinc, and phosphorous compared to other millets for various health problems like diabetes, celiac disease, high blood pressure, and cardiovascular disease. Therefore, it provides nutrition for many malnourished people in developing and developed countries across the world. It also contains numerous bioactive compounds like gallic acid, vannilic acid, caffeic acid, linoleic acid, palmitic acid, and ferulic acid, which have anticarcinogenic, anti-inflammatory, antiviral, and neuroprotective activities. Based on the aforementioned information, the current study could elucidate the various health-promoting benefits and nutritious composition of barnyard millet.

Keywords: *Barnyard millet, antioxidant, micronutrients, health benefits.*

T4-27
Sorghum as a potential candidate for circular economy

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Abstract

Given the prevailing circumstances of limited resources, the escalating effects of global climate change, the degradation of our environment, and the growing need for food, the concept of the circular economy (CE) emerges as a highly encouraging approach to foster sustainable agriculture that is restorative and regenerative in nature.It involves optimizing resource use through techniques such as recycling, reusing, and waste reduction. By embracing closed-loop systems and circular inputs, agricultural waste can be transformed into valuable resources, such as organic fertilizers and renewable energy. The circular economy also emphasizes efficient waste management, including composting and recycling, to minimize environmental impact.It promotes the effective handling of agricultural waste by utilizing methods like composting, anaerobic digestion for bioenergy generation, and recycling of packaging materials.In contrast to the linear economy, which follows a "take-make-use-dispose" model, the circular economy adopts a "grow-make-use-restore" approach.Sorghum is an ideal crop for the circular economy due to its versatility, resource efficiency, and multiple value streams. With applications ranging from food and feed to bioenergy and industrial uses, sorghum minimizes waste and maximizes resource utilization. Sorghum residues, such as stalks and leaves, present a range of possibilities for repurposing. They can serve as feed for livestock, be utilized in the production of biochar or bioplastics, and even contribute to the production of biogas through anaerobic digestion.sorghum husk can also be used as a sustainable alternative to natural aggregate in the production of lightweight concrete. Repurposing these sorghum residues in such diverse ways aligns with the principles of the circular economy, promoting resource optimization and waste reduction in agriculture. Incorporating sorghum into crop rotation systems enhances soil health and reduces reliance on synthetic inputs. Thus, sorghum exemplifies the circular economy principles, making it a promising crop for sustainable agriculture.

Keywords: Circular economy, bioenergy, bioplastic, biochar, renewable energy.

T4-28
Millets in India: A Comprehensive Review of Cultivation Patterns, Production and Productivity

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Abstract

Millets, comprising jowar, bajra, ragi and minor millets have garnered increasing attention for their nutritional value, climate resilience and potential for sustainable agriculture. This review article explores the cultivation patterns, area, production and productivity of these millets in India. Statistical data and insights reveal the decline in millet cultivation, the challenges faced and the opportunities for revival. The importance of millet in addressing food security, nutrition and climate change adaptation is highlighted. Additionally, the Agency-wise Average Annual Growth Rate of production is examined, emphasizing the role of government interventions in promoting sustainable agriculture. Understanding the significance of millets and their potential for a healthier and more sustainable future is crucial for fostering their cultivation and ensuring food security in India.

Keywords: Area, Productivity, Annual Growth Rate, Crop distribution

Theme 5

Millet value chain management, Policies
Extended summaries

T5-01

A study on consumer buying behavior of Nutri cereals in Western Tamil Nadu

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Abstract

Due to awareness of environmental degradation and the emerging health problems, the consumer behavior is changing towards purchase of nutritional and functional foods. Nowadays, Nutri cereals consumption among the people has been steadily growing. This study was formulated with the objective to analyze the trends in consumption pattern, preference and expectations for Nutri cereals. To fulfill the objectives of the study, Coimbatore, Tiruppur and Salem districts had been selected in western Tami Nadu. The total sample households consisted of 300 samples 150 from urban and 150 from rural in selected districts of Western Tamil Nadu. Results revealed that majority of the urban and rural respondents consuming Nutri cereals for the past five years and they mostly preferred finger and pearl millets only. Consumers were purchasing Nutri cereals because of its high nutritional content 38 per cent (Urban) and 32 per cent (Rural) respectively.

Keywords: Millets, Consumption pattern, consumer preference, Expectations.

Introduction

Millets *(Poaceae or Gramineae)* are the group of small grained cereal crops or grains for fodder and human consumption that can be grown in dry land with low water and able to endure drought and other extreme climate conditions and are grown with low inorganic inputs such as fertilizers and pesticides. Since millets grown in dry lands as rain fed crops with less water compared to wheat and rice, it resumes greater importance for sustained agriculture and food security. Millets helps to conquer some of the biggest nutritional and health issues (iron, zinc, folic acid, calcium, diabetes and more (Bhat.et al.,2018). Many studies highlighted the emerging food consumption pattern in India and it is observed that there is a clear shift in grain to other cereal consumption in recent decades along with more of vegetables and red meat. There is a large section of the population living below the poverty line in India alongside the growing middle class that is driving up the demand for quality food.

Materials and Methods

Coimbatore, Tiruppur and Salem districts have been selected in western Tami Nadu based on Tier II cities catecogy. From each of the selected districts, 50 households were selected by simple random sampling method. Thus the total sample households consisted of 300 samples 150 from urban and 150 from rural in selected districts of Western Tamil Nadu. Percentage analysis, Regression and Kruskal Wallis test were the tools used for analyzing the data.

Results and Discussion

Majority of the respondents in both urban and rural areas were female. High nutrition content is the major reason for purchasing Nutri cereals in both rural and urban areas. Respondents obtained the information from their own family members, friends and relatives mainly through word of mouth. The expenditure towards food decreased as income increased but the expenditure on Nutri cereals increased as income increased both in rural and urban areas. (Kostakis, 2020). Majority of the urban and rural respondents consuming Nutri cereals for the past five years and they mostly preferred finger and pearl millets only (Kumar,2020). Monthly income, age, family size, proportion of children in the family was found positive and significantly influenced the consumption of Nutri cereals while analyzing through regression. Still most of the rural and urban respondents purchased Nutri cereals on monthly basis with preferred size of 500 -1 kg and average quantity consumed 1kg/month. Respondents willing to pay extra up to 15 per cent for cleaned and processed Nutri cereals, food safety and quality certification, grading, packing and labeling and for organic certification (Amarapurkar and Banakar,2017).Kruskal Wallis Test result(Fig.1)revealed that expectations of the rural and urban consumers were similar and the rural and urban respondents.

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Table 1. Factors determining the Nutri cereal consumption

S.No	Variables	Co-efficients	t-value
1	Constant	-1028.47	-10.0***
2	Monthly income	0.0017	3.17***
3	Literacy rate of the respondents	0.8417	0.10NS
4	Age	30.6088	8.82***
5	Family size	64.3801	3.13***
6	Proximity of the store	5.6813	0.10 NS
7	Proportion of children in the family	28.4189	2.05**
	Dummy	168.6882	2.92***
	R2	0.70	

***1 % significant, **5 % Significant, NS- Non significant

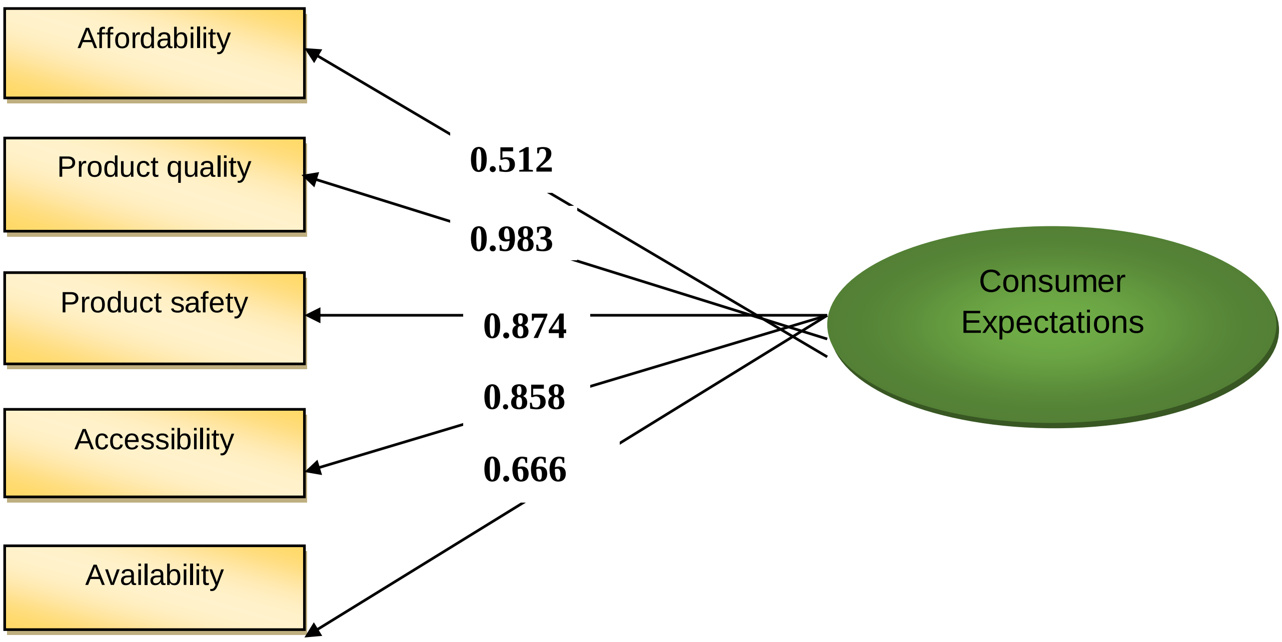

Fig. 1. Consumer expectations towards Nutri cereals

T5-02
Constraints faced by the small millet growers and millet processing units in Madurai region

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Abstract

Tamil Nadu has four per cent of the land area and three per cent of the water resources at National level. About 92 per cent of total land holdings in Tamil Nadu belong to small and marginal farmers. Millets is one of the oldest foods known to mankind. Millets hold enormous hope for food and nutritional security. It is essential to know the constraints faced by millet growers in the millet cultivation and utilizing millet processing units. In view of the International Year of Millets, this study will help the policy developers to take the necessary measures. An Ex-post facto research design was used for the study. A sample size of 120 millet farmers and 10 millet processing units were selected for the study. To find out the most significant factor which influences the respondent, Garrett's ranking technique was used. Among the constraints faced by the millet farmers animal menace was found to be first rank followed by lack of knowledge on improved varieties as second rank, uncertainty of rainfall as third and unable fetch remunerative price as fourth rank. Among the constraints faced by the processing units lack of millet polish machine ranked as first followed by lack of cooperation among members of processing unit ranked as second and lack of flexibility to operation on various phase of electricity as third rank.

Keywords: Millet growers, Processing units, Constraints and Garrett ranking.

Introduction

Agriculture is the major livelihood provider to about forty per cent of the population of Tamil Nadu. Nearly ninety per cent of underground water potential has been exploited. In these circumstances millets can be cultivated to safeguard the food requirement. Millets is one of the oldest foods known to mankind. Millets hold enormous scope for food and nutritional security. They are predominantly grown in areas with low rainfall and contribute to food and fodder requirements. Millets need very little inputs for their sustenance and require only 25 per cent of the water consumed by irrigated crops. Millets are pest free crops and are highly suitable for organic farming. It is essential to know the constraints involved in the millet cultivation and utilization of millet processing units. In view of the International Year of Millets this study will help the policy developers to take the necessary measures.

Materials and Methods

An Ex-post facto research design was adopted for the study. The ex-post facto research design is a systematic empirical enquiry in which the researcher does not have any direct control of independent variables and are not manipulable. Madurai district was purposively selected for this study. Kallikudi, Thirumangallam and Sedapatti blocks were purposively selected based on the highest area under small millets. A sample size of 120 millet farmers and all government supported and NGO operated millet processing units were selected for the study.

To find out the most significant constraints faced by the millet growers, Garrett's ranking technique was used. It can be employed to learn what bothers more and what does not bother the respondent from the list of items given.

Results and Discussion

Among all the constraints faced by farmers animal menace in millet cultivation got first rank followed by lack of knowledge on improved varieties as second rank, uncertainty of rainfall as third and unable fetch remunerative price as fourth rank as per Garrett's score. Marketing through local agents, weeds problems, lack of skills on value addition of small millet produces, lack of access to millet processing unit and non-availability of improved seeds obtained as fifth,sixth, seventh, eighth and ninth rank respectively. It could be found that the majority of the millet grower experiencing weed problems, hence it is suggested that awareness about the summer ploughing need to be created among the millet growers.

Among all the constraints faced by processing units millet polish machine needs to be included got first rank followed by lack of cooperation among members of processing unit got second rank and lack of flexibility to operation on various phase of electricity got third rank. Majority of the millet consumers preferred polished millets than semi polished millets even though it is nutritious one Lack of storage facilities and drying yard, lack of safety measures and store dehuller unable to process small quantity less than 50 kg of store dehuller got fourth, fifth and sixth rank respectively.

It is evident from results that animal menace in millets cultivation reported as a major constraint which is ranked as first. It is suggested that village panchayat has to take concrete step to solve this problem by co-operative effects. In rural areas shifting of electric phases, two phase and three phase is one among the problem. Hence, machines should be supplied in such a way flexible in operation on various phases. Further small dehuller need to be supplied to them to do service for minimum quantity of grains.

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Table 1. Constraints faced by the millet growers (n=120)

S. No.	Constraints faced by the millet growers	Per cent position	Garrett Score	Rank
1.	Animal menace	5.56	8253	I
2.	Lack of knowledge on improved varieties	16.67	7483	II
3.	Uncertainty of rainfall	27.78	7302	III
4.	Unable fetch remunerative price	38.89	6158	IV
5.	Middleman involvement	50.00	5701	V
6.	Weeds problems (Kongra vali, peacock grass, Malla)	61.11	5321	VI
7.	Lack of skills on value addition of small millet produces	72.22	5097	VII
8.	Lack of access to millet processing unit	83.33	5077	VIII
9.	Non availability of improved seeds	94.44	4448	IX

Table 2 Constraints faced by the millet processing units (no. of units=10)

S. No.	Constraints faced by the millet processing units	Per cent position	Garrett Score	Rank
1.	Millet polish machine needs to be included	8.33	696	I
2.	Lack of cooperation among members of processing unit	25.00	533	II
3.	Lack of flexibility to operation on various phase of electricity	41.67	499	III
4.	Lack of storage facilities and drying yard	58.33	488	IV
5.	Lack of safety measures	75.00	400	V
6.	Store dehuller unable to process small quantity less than 50 kg of store dehuller	91.67	364	VI

T5-03
Demand and supply projections of Ragi in India

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Abstract

Millets are sustainable options to achieve food and nutritional security as it has a superior nutritional profile among the cereals groups. The present study examines the supply of millets would be sufficient to meet the demand (direct and Indirect demand) in the near future. In projection of direct demand (household demand) of ragi, the behavioristic approach was used, which is based on the growth of population, and change in consumption behavior on account of change in per capita income in a growing economy, measured in terms of consumption expenditure elasticities. In addition, indirect demand for seed, feed, wastages, and industrial use also were considered. The future supply of millets was projected based on the compound annual growth rates (CAGR). The direct demand for ragi in 2036 for rural areas will be more than in urban areas. The total supply will be 13.98 lakh tonnes under scenario 1, 11.78 lakh tonnes under scenario 2 and 25.69 lakh tonnes in scenario 3. The gap between projected demand and projected supply decreases over the years and becomes deficit in the near future. The present study will help the Government of India has to take necessary action in reverting the consumption of millets and to increase its awareness among the consumers to lead a healthy life. In addition, there is a scope for augmenting the production in the short run by improving the productivity without increasing the area through popularizing new varieties, expanding certified seed distribution, and improving crop management practices.

Keywords: Demand, Supply, Ragi, Consumption

Introduction

Millets cultivated and consumed traditionally in India such as Pearl Millet, Sorghum (Great Indian Millet), Ragi (Finger Millet), Foxtail millet, Kodo, Barnyard, Proso, Little Millet and Pseudo Millets like Buckwheat and Amaranthus. Pearl millet (Bajra), Sorghum (Jowar) and Finger Millet (Ragi) constitutes the largest share in India's total production of millets. In India, millets are mostly cultivated in Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Odisha, Madhya Pradesh, Rajasthan and Uttarakhand. Finger Millet commonly known as ragi, is one of the most important millet crops grown in India. It is grown for food, feed and fodder purposes. It ranks sixth in production after wheat, rice, maize, sorghum and bajra in India. During 2021-22, India produced 17.55 lakh tonnes of ragi from 10.04 lakh ha with a productivity of 1747.27 kg per ha. In the year 2000-01 Ragi has grown in an area of 17.59 lakh ha and produced 27.32 lakh tonnes with a yield of 1553 kg per hectare (Indiastat.com)

Materials and Methods

For projecting the household demand, national level estimates of demand elasticities based on food characteristics Demand System (Bouis, Howarth and Haddad, 1992) calculated by Kumar et. al. (2009). Scenario 1 is the actual demand projection obtained by considering baseline demand for various millets during the year 2011. It is presumed that nowadays demand for millets for household consumption is on increase due to rising awareness about the health benefits of millets and the availability of ready-to-eat value-added products. Hence, two more scenarios were considered by assuming a 5 percent (Scenario 2) and a 10 percent (scenario 3) increase in demand over projection using baseline demand (Sreekala et. al, 2023). In addition, indirect demand for seed, feed, wastages, and industrial use also were considered by using an estimate of the share of indirect demand of coarse grains in total supply as 32.45 percent. The future supply of millets was projected based on the compound annual growth rates (CAGR). Besides, three scenarios have been considered for projection to get a range of future supply. It was assumed that production continues to grow according to growth rates during the past 15, 10, and 5 years under Scenario 1, Scenario 2, and Scenario 3, respectively.

Results and Discussion

From the analysis, the direct demand for ragi in 2036, is likely to be 6.95 lakh tonnes in rural areas and 3.37 lakh tonnes in urban areas indicating the demand for rural area will be more than in urban area. In 2036, the total demand will be 14.86 lakh tonnes by considering the baseline demand and 14.66 lakh tonnes under 5% increase and 19.69 lakh tonnes under 10 per cent increase in total demand. The total supply will be 13.98 lakh tonnes under scenario 1, 11.78 lakh tonnes under scenario 2 and 25.69 lakh tonnes in scenario 3. From the projected total demand and total supply, the net deficit and net surplus for ragi was calculated. . In 2036, the demand and supply gap is -0.88 lakh tonnes in scenario 1, -2.88 lakh tonnes under and 6 lakh tonnes under 10 per cent increase. The gap between projected demand and projected supply decreases over the years and becomes deficit under scenario 1 and 2. The supply of ragi in the near future is not in equilibrium with the projected demand which is a matter of concern. In order to increase the consumption of millets, Karnataka and Odisha government started their action towards millets to revive them. In Tamil Nadu under pilot basis, ragi is supplied through the Public Distribution System in the Nilgiris and Dharmapuri districts as 2 kg per cardholders per month. By introducing ragi under the Public Distribution System, 11.06 lakh tonnes of ragi per annum is required to be provided in the major consuming states of the country.

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T5-04

Farmers Producer Organization (FPO) driven millet value chain model in Tamil Nadu, India

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Abstract

Co-operatives and Farmer Producer Organizations (FPO's) are the farmers collectives emerged through collective action as substitute for increasing market participation and decreasing transaction cost. (Markelova *et al.* (2009)). Farmer Producer Companies (FPC's) were a hybrid between private companies and co-operatives(Trebbin, 2014). The Farmer Producer Organization provides the platform to the small and the marginal farmers for effective marketing and the production through which they could reduce the transaction cost of input access and also the regular flow of market information with which they could act accordingly so as to achieve the maximum profits and tap the high value markets. Producer Organizations can be a potential solution to lack of value addition in agricultural commodities coupled with farmers in India disposing their produce in unprocessed form(Murray, 2008). By considering the above points the present study was taken up to map the Farmer Producer Organization (FPO) driven millet value chain and also to assess the profitability of the millet value chain. With the help of the Farmer Producer Organization, the value addition of the millet produce can be done as the machineries for the processing of the produce can be availed by the farmer producer organization at the subsidized rate through the policy initiatives accomplished by the government of India. Present study intends to examine the FPO driven millet value chain through map the FPO driven millet value chain and to suggest measures to improve management of millet value chain in Tamil Nadu.

Keywords: Producer Organization, Value Chain, Millets, Farmers Collectives, Value Addition

Introduction

Millets were prehistoric super grains which serve as the store house of the nutrition for an improved health Government of India has recognized the importance of millets in the food chain through National Food Security Mission (NFSM) in the 12th five year plan. It had targeted an additional 25 million tonnes of food production with which, the share allocated for millets was two million tonnes. Further, the government of India had taken several steps to increase the cultivation of millets and also the awareness on the millet products. This was evident through the activities of the government in which the FAO has agreed to celebrate 'International Year of Millets' in 2023 based on India's proposal.

Value Chain Model look at the value chain activities performed by each actors in order to assess the effectiveness and economics. Value chain was developed in various agri-food, livestock products and fisheries produces. In order to bring more efficiency and effectiveness in the agricultural sector the value chain framework has been considered as one of the approaches along with the association of agriculture. The value-chain network may be demarcated as an array of activities that are obligatory to bring a product from its conception, through its designing, raw materials sourcing and intermediate inputs, marketing and distribution, to the final consumer. However, there are reluctances about the competence of smallholders because of numerous operational constraints they face in production and marketing to regulate to the evolving environment. The present study aimed to analyze the value chain of millets in Dharmapuri district in terms of cost and returns, value addition, profitability of the value chain, the impact of FPO on the member farmers and the perception of farmers on the FPO

Materials and Methods

Dharmapuri district have the millet based farmer producer organization and it ranks second in area under millets (Season & Crop Report, TN). Hence, Dharmapuri district of Tamil Nadu was purposively selected for the study by using Multi-stage purposive and random sampling methods. Data was collected from the sample respondents during the months of January to March, 2019. The tabular analysis was done to analyze the cost and returns of millets. The profitability can be determined with the help of Benefit cost ratio. A benefit-cost ratio (BCR) is an indicator used in cost-benefit analysis to show the relationship between the relative costs and benefits, expressed in monetary or qualitative terms. Value addition is defined as the activities involved to add value to the products through grading, cleaning, processing and grading to distribution.

The net value added for the value added products of millets (finger millet, little millet and foxtail millet) namely cookies, flour and rice can be estimated by using the formula given below.

Value added = Value of Output (O) –Value of all Intermediate Inputs (I)

Where,

Value of Output	=	Value of final product
Value of all Intermediate inputs	=	Value of purchase price of all products from other actor plus the processing cost
Processing cost	=	Wastage cost, Labour cost, Repairs & maintenance cost, Grading, cost Electricity cost, Ingredients cost*, Labeling and Packaging cost, Transportation cost.

** The flour and rice products of the millets do not incur ingredient cost.*

Results and Discussion

The average cost of cultivation of the millets was Rs.23318.19 per ha, in which finger millet incurred 16.37 per cent increased cost because of human labour and inputs. The cost of cultivation of foxtail millet was lower than the average by 37.77 per cent because the farmers were not using manures and followed reduced tillage. Among the selected three millet crops, the cost of cultivation (Cost C_3) of the finger millet was found to be high (Rs.27136.82) when compared to that of the other two millet crops. The cost of cultivation (Cost C_3) of finger millet was found to be higher than the little millet (23.05 per cent) and foxtail millet (46.52 per cent).The average yield of finger millet, little millet and foxtail millet were found to be 1640 Kg/ha, 1230 Kg/ha and 756 Kg/ha respectively. The average price of the selected millets in the study area were Rs.32, Rs.24 and Rs.23.The net income of finger millet was 2.39 times higher than that of little millet and 7.80 times higher than that of the foxtail millet.

The value chain actors involved in the FPO based millet value chain were Farmers, FPO cum Processors and Retailers. The farmers were involved in the production function with inputs from the FPO at subsidized rates. The farmers sold their produce to the FPO cum Processor as grains. The millet grains were then converted into the value added products like cookies, flour, sprouted flour and rice by the FPO cum Processor. The value added products were then sold to the retailers through which it reaches the ultimate end user.

The BC Ratio of the farmers remained same for all the value added products as 1:1.93 for Finger millet, 1:1.33 for little millet and 1:1.19 for foxtail millet. For FPO cum processor, BC Ratio was higher for the little millet flour (1:2.01) and foxtail millet flour (1:2.08) as due to the demand factor of the product, high price was fixed for the flour. Thus, the FPO cum processor could get maximum benefit when they dealt with flour products of little millet and foxtail millet. For retailer, the BC ratio of the value added products of millets ranges from 1:1.15 to 1:1.33.

Most of the farmers are with basic primary education qualification and they are being involved in agriculture and its allied activities. The respondents are of small and marginal farmers with fragmented lands. The actors involved in the value chain of millets were farmers, Farmer Producer Organization and the retailers. The basic actor viz., farmers were involved only in the production function while the FPO activities include input supply to the farmers, technical guidance, procurement of the produce and wholesaling the value-added products

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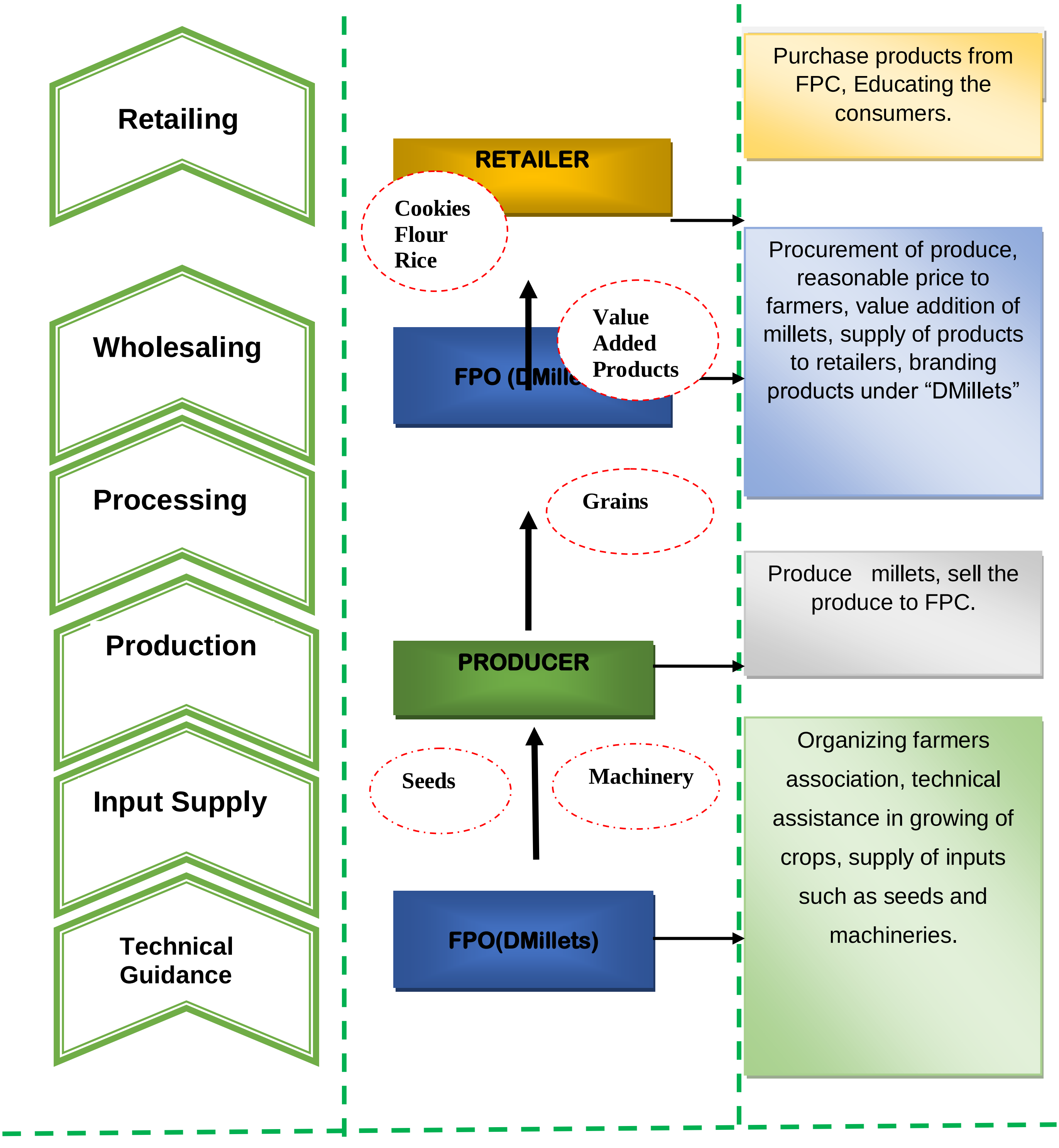
Table 1 Generic Worksheet Crossing Functions to Identify the Actors in FPO based Millet Value Chain

Value Chain Actor	Functions					
	Technical guidance	Input supply	Production	Processing	Wholesaling	Retailing
FPO						

Farmers						
Retailers						

Source: Adapted from (Patil and Reddy, 2015)

Fig 1. Value Chain Model of Millets in Tamil Nadu (Gokul et.al.,2019)



T5-05

Structural change in Millet production, consumption pattern and implication in achieving nutritional security

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Abstract

India has become self-reliant in cereal production and is a leading producer of many high value agricultural commodities. India produced 281.8 mt of food grains, 307.7 mt of horticulture crops, 176.5 mt of milk, 96 billion eggs and 7.7 mt of meat during TE 2018–19. Indian agriculture plays a vital role with 58% of rural households depending on it even though India is no longer an agrarian economy. In spite of status of fast growing double digit trillion economy, India has one quarter of the hungry population of the world with 195.9 million undernourished people lacking sufficient food to meet their daily nutritional requirements; 58.4% of children under the age of five suffer from anemia, while in the age group of 15–49, 53% of women and 22.7% of men are anaemic; 23% of women and 20% of men are underweight, and 21% of women and 19% of men are obese (FAO, 2018, IIPS 2017).

Considering the complexity in production, consumption and nutrition intake in the present study explore the food production and consumption pattern and its implication on healthy diet and level of nutritional security. This study mainly used secondary source of information on area, production and productivity of rice, wheat, maize, bajra, sorghum, pulses and other coarse cereals for 1950-51-2020-21 for the country and the major cereals producing states. Besides that six rounds of NSSO Household Consumer Expenditure survey (38, 50, 55, 61, 66 and 68th rounds) data and five National Family Health Survey (NFHS) reports for the country and the states were used to analyse the consumption and healthy diet and nutritional implications. Simple percentage analysis and annual compound growth estimation tools were employed. The results of the growth performance analysis clearly indicated that the rice, wheat and pulses had an increasing growth trend in before WTO and after National Food Security Mission (NFSM) programmes, while stagnant growth were reported after WTO period. The NSSO consumer expenditure surveys results clearly indicated the 40 to 80% decline in coarse cereals consumption and marginal increase in pulses in all income group consumers. However, the high value nutrient rich food such as milk, meat, fish and eggs consumption reported significant increase in all the income group consumers. However, the observed structural changes in production and consumption brings marginal improvement in reduction of malnutrition problem particularly in children and pregnant women. The problem of obesity were increased to one fifth of children age <5 years. This is mainly due to decline trend in millet consumption which are rich in protein, vitamins, and minerals. Thus, specific policy action could involve legislation and capacity building; fiscal policy instruments such as tariffs, taxes and subsidies to modify food prices and influence consumer choice; food-based dietary guidelines; co-investment and

institutional procurement; and behavioural nudging are to addressed to achieving the equity in nutritional security.

Keyword: food security, food diversity, consumption pattern, nutritional security, income group

Introduction

India's dominated by smallholders which constitute 86.1% of total farm holdings. The all India average landholding size is 1.08 hectares (ha) (DoAC&FW, Agricultural Census, 2016). Despite being a smallholder economy, India has become self-reliant in cereal production and is a leading producer of many high value agricultural commodities. India produced 281.8 mt of food grains, 307.7 mt of horticulture crops, 176.5 mt of milk, 96 billion eggs and 7.7 mt of meat during TE 2018–19. Millets are rich in protein, vitamins, and minerals. Singh et al. report proteins in millets as a good source of essential amino acids, including histidine, isoleucineleucine, methionine, phenylalanine, tryptophan, and valine, lacking lysine and threonine. They are also rich inmethionine and cysteine that contains sulfur. Furthermore, millets are also a very good source of dietary minerals such as phosphorus, calcium, iron, and zinc, especially finger millet which contains nine- to ten fold higher calcium than others. India account one fifth of global millet area and production in 2019, producing 17.3 mt of millets from 13.8 mha with slightly higher than the global millet productivity of 1239 kga/ha. African countries accounts more than two third of millet area and about half of the millet production. The diversified production including increased milk and meat is not accompanied by commensurate increase in farmers' income due to lack of robust market linkages. In response to changing consumption patterns, agricultural production has diversified from food grain to high-value commodities including horticulture, livestock and fisheries. Demand for value-added and nutrient-rich foods is fast replacing calorie rich grain-based diets. India is the leading producer of milk and a significant producer of poultry meat, eggs, fruits and vegetables and pulses supported diversifying food basket. The global per-capita calorie intake has increased by more than 17 per cent over four decades and expected to increase to 3040 and 3130 kcal in 2030 and 2050, respectively. India also reported similar increasing calorie intake. With the present production and consumption pattern, this study attended to identify structural changes in production and consumption pattern with a special emphasis to millets and other major food grains like rice, wheat and maize. It also assessed the consumption pattern changes across different income group so as to derive achieving nutritional security more specifically for the targeted consumer.

Materials and Methods

This study mainly used secondary information on area production productivity of rice, wheat, maize, bajra, sorghum, pulses and other cereals for 1950-51-2020-21 for the country and the major cereals producing states such as Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, UP and West Bengal which account 76 percent of the total countries coarse cereals production. The structural changes in consumption pattern were analysed using NSSO Household Consumer Expenditure survey rounds 38, 50, 55, 61,66 and 68th rounds data. Using lastsix rounds (two decades) consumption pattern of various commodities, consumption pattern were projected for 2020-21 due to non-availability of latest consumer expenditure survey. Simple percentage analysis, growth rate estimation were used to compare the structural changes in production and consumption pattern. National Family Health Survey (NFHS) reports 1-to 5 (2019-21) were used to assess the impact of changes in nutrient intake, intensity of malnutrition's for the country and for Tamil Nadu and Kerala state comparison.

Results and Discussion

India holds the second-largest agricultural land in the world, with 20 agro-climatic regions and 157.35 million hectares of land under cultivation (DES, 2014). Thus, agriculture plays a vital role with 58% of rural households depending on it even though India is no longer an agrarian economy. In spite of the fast growing double digit trillion economy, India has one quarter of the hungry population of the world with 195.9 million undernourished people lacking sufficient food to meet their daily nutritional requirements; 58.4% of children under the age of five suffer from anemia, while in the age group of 15–49, 53% of women and 22.7% of men are anaemic; 23% of women and 20% of men are thin, and 21% of women and 19% of men are obese (FAO, 2018, IIPS 2017).The major crops cultivated in the era preceding the Green Revolution were rice, millets, sorghum, wheat, maize, and barley (Hall HF, 1964, USDA, 1964). But the production of millets has gone down, and the crops that were once consumed in every household became a fodder crop in just a few decades after the Green Revolution. The decomposed growth analysis for three periods before WTO (P1: 1970-1992), after WTO (P2:1993-2006) and after National Food Security Mission (NFSM) (P3:2007-2021). The estimated annual compound growth rate for rice and wheat was 2.98 and 4.51 per cent in P1: before WTO, but after WTO, the growth rate of rice and wheat were stagnated growth at 0.87 and 1.06 per cent. However, introduction of NFSM in 2007 and central and state support has enhanced the production of rice and wheat with the significant annual growth of 1.94 and 2.4. However, coarse cereals production reported marginal increasing growth after NFSM by sorghum reported highest negative growth (-4.59) production and for Bajra with stagnation in production (0.88%). This growth analysis clearly indicated the unbalanced production pattern ignoring the major and minor millet production in the country. The NFSM scheme fund utilization was only 52% for the last four year after declare 2018 as Millet year for country. The NFSM central share under millets was Rs 717 crores from 2018 to 2021 of which Rs 374 crores were utilised under various components which indicated slow millet expansions.

Similar negative growth has been also been reported in major millet producing states during the second and third period. Jowar production is mainly contributed from Maharashtra, Karnataka, Madhya Pradesh, and Rajasthan which account more than 70% of the millet production reported significant decline after WTO (Fig 2). Rajasthan is major contributor of Bajra production found declining growth in area while marginally increasing growth in production due productivity improvement by the hybrid and composite verities develop by both public and private research institutions. The various rounds of NSSO consumers' expenditure survey results (Fig 3) clearly indicated a declining trend in per capital consumption of rice both in rural and urban consumer, while that wheat consumption has stagnated over last two decades. However, the pulses and milk consumption has increased significantly both in rural and urban area. Similar increasing trend in consumption of eggs and banana were reported from the NSSO data.This indicated a shift in the dietary pattern from traditional fibre-rich, grain-based food to fat-rich, processed, packaged and animal-based food items across states. A declining trend in food grain demand and increasing trend in the consumption of high value food substances, which are rich in fat and protein, but not towards the healthy dietary pattern. Between 1983-84 and 2011-12, coarse cereals consumption has decreased substantially and pulses consumption has decreased as well by 16 percent. Fruits, vegetables and livestock products has increased significantly over the years. Fruits 268% in Rural, 241% in urban; Edible oil 107 and 45%; livestock products such as milk and meats has been increasing.

In both rural and urban areas, poor people bear a triple burden of malnutrition – undernourishment, micronutrient deficiencies and overweight prevalence – because current food system transitions have not made nutritious diets sufficiently available, accessible or affordable to them. Economic, demographic and policy trends are reinforcing this triple burden disproportionately on poor people. The present diversified food production and per capita availability, food subsidy programms made significant implication in reducing the malnutrition indicators (Underweight: weight-for-age; Stunted: height-for-age and Wasted: weight-for-height) particularly in children age below 5 years (Table 2). National Family Health Survey (NFHS) reports 1-to 5 (2019-21) results revealed that per cent of underweight children had declined from 53.4% in 1992-93 to 32.1 in 2019-20. Similar improvements in percentage of stunted children's were reduced from 52% to 35.3%. But it is caution to note that the wasted children percentage has marginally increased from 17.5% to 19.3% indicating the obesity issues due to unbalanced nutritional food consumption pattern. According to NFHS reports 4 and 5 revealed that anaemic children share has increased from 50% to 57% in four years.

Consumption pattern different income group between 1983-84 and 2011-12 indicated (Table 3) indicated 18% increase in rice consumption for low income group while it was -8.98 and 6.69 for middle and higher income group consumers respectively. In spite of increasing growth reported in both coarse cereals and pulses production in the country, the low income consumers reported a significant decline of 85.88% in coarse cereals, 10.65% in pulses indicating lack of market linkage and purchasing power to poor. Similar declining consumption per cent changes were also found in middle income consumers at -78.97 and -24.67 in the above period. However, high value food items such as milk, meat, fish and eggs consumption were found increasing in all income group consumers (Table 3). Similar, increasing trend was reported in edible oils, vegetables and fruitsin both in low and middle income groups. For a basic plate of food (staple and legume stew), people would have to spend 9-50 per cent of their income on food in Asia, and 25-158 per cent in non-conflict-affected countries in Africa (WFP, 2017).

The present study conclude that increasing food production does not increase the per capita availability considerably and particularly low and middle income consumers reported a declining trend in consumption of millets and pulses. This indicate for the targeted poor people, healthy diets are out of reach due to inadequacy in availability and affordability. A basic principle of healthy diets is diversity and proportionality among food groups. FAO reported that the healthy diets are unaffordable for more than 3 billion people, most of them in Africa and Asia (FAO et al., 2020). To reduce critical nutrition gaps, a food system need to be transformed in four dimensions: driving consumer choices towards more diversified diets inclusive of millets, empowering women and other disadvantaged groups, strengthening rural-urban linkages and improving physical access to varied types of food. Empowering poor people, including women in food systems, to earn better incomes and taking control over consumption can yield significant benefits in health and nutrition outcomes.

Because food systems respond to consumer demand, demand-led incentives must be the main leverage for food system transformation. This could be achieved by targeting social safety nets and cash transfers programme to the poor people; supporting women's empowerment and gender equality to level access to resources and widen choices; promotion of better food preparation practices; and behavioural change communication. Increase the millet access to targeted population by expanding millet in PDS distribution.

Expands millet based breakfast to preschool and school going children will also increase the consumption of healthy diet to reduce triple burden of Malnutrition. Specific actions can involve legislation and capacity building; besides formulating fiscal policy instruments such as tariffs, taxes and subsidies to modify food prices and influence consumer choice; food-based dietary guidelines; co-investment and institutional procurement; and behavioural nudging are to addressed to achieving the equity in nutritional security in India. It is also important to have a proper planning and intensive collaborative research work should be initiated by the stake holders for the conservation of the traditional varieties and the inclusion of these varieties and practices into the food and nutrition security plans for the nation.

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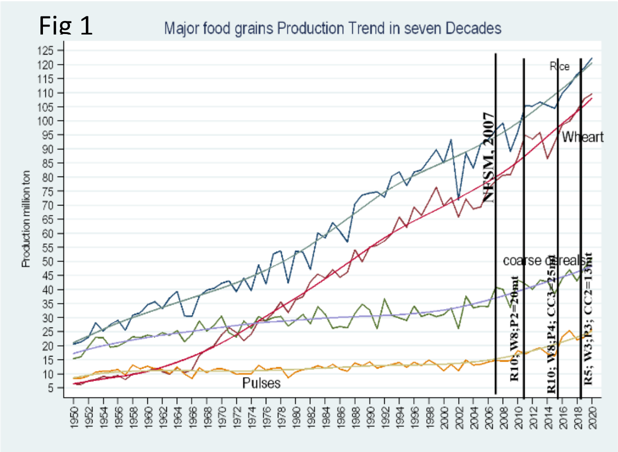
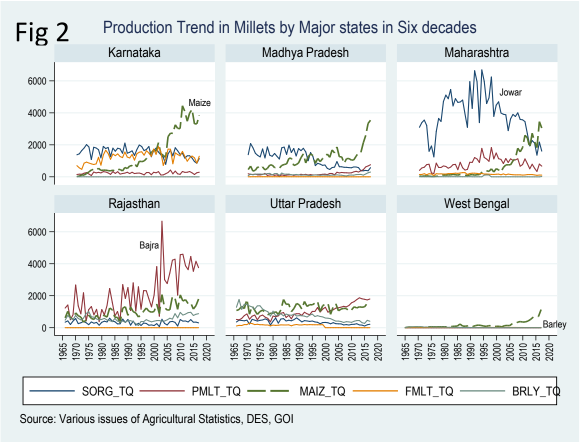
Table 1. Growth (%) performance of major foods crop production in five decades

Crops	**1970-71 to 1992-93**	**1993-94 to 2006-07**	**2007-08 to 2020-21**
Rice	2.98	0.87	1.94
Wheat	4.51	1.06	2.40
Coarse cereals	0.71	0.90	1.72
Pulses	0.95	0.00	4.33
Sorghum	1.29	-3.05	-4.59
Bajra	0.58	2.77	0.88
Maize	1.90	4.04	4.07
9 Oilseed	3.81	0.70	1.30
Sugarcane	3.08	0.74	1.68

Table 2. Malnutrition indicator changes in five decades

Survey	Underweight (Weight-for-age)	Stunted (Height-for-age)	Wasted (Weight-for-height)
NFHS-1 (1992-93)	53.4	52	17.5
NFHS-2 (1998-99)	47	45.5	15.5
NFHS-3 (2005-06)	42.5	48	19.8
NFHS-4 (2015-16)	35.8	38.4	21
NFHS-5 (2019-21)	32.1	35.5	19.3





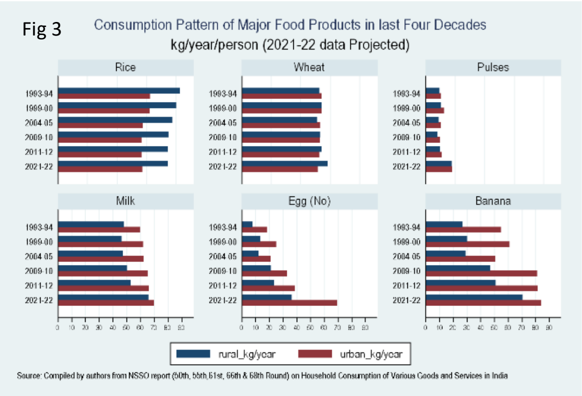


Table 3. Income group-wise changes in monthly per-capita quantity consumption of food commodities in India

Food items	Low income			Middle income			Higher income		
	1983-84	2011-12	% Δ	1983-84	2011-12	% Δ	1983-84	2011-12	% Δ
Rice	5.40	6.39	18.41	7.50	6.82	-8.98	7.84	6.69	-14.66
Wheat	3.77	3.46	-8.2	4.46	3.77	-15.31	5.92	4.30	-27.47
Corse cereals	2.95	0.42	-85.88	2.52	0.53	-78.97	2.35	0.44	-81.4
Total cereals	12.12	10.27	-15.26	14.48	11.13	-23.14	16.11	11.42	-29.11
Pulses	0.66	0.59	-10.65	0.96	0.72	-24.67	1.48	0.99	-33.03
Edible oils	0.23	0.45	100	0.36	0.59	63.81	0.61	0.81	33.01
Vegetables	2.98	3.52	17.89	3.99	4.22	5.57	5.42	5.41	-0.17
Fruits	0.13	0.34	161.29	0.23	0.61	171.96	0.54	1.47	174.07
Milk	1.39	1.89	35.99	3.36	3.73	11.01	7.47	7.74	3.64
Sugar	0.56	0.52	-6.42	0.89	0.72	-19.59	1.56	1.02	-34.59
Meat, fish & eggs	0.26	0.29	11.04	0.41	0.48	16.16	0.74	0.84	12.71

T5-06

Rediscovering India's Millets Heritage: A historical reading

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The observance of National Year of Millets 2018 and the International Year of Millets 2023 has brought a renewed focus on these yester year staples of India. However, the public memory of millet as a staple cereal has lost in most parts of the country where it is not consumed today. This marginalization of millets is generally traced to the Green Revolution of the 1960s (Bhat et.al 2018). A historical reading of agricultural science and research in India suggests that millets marginalization has its origin in the approach towards these grains, beginning from as early as the 19th century. This paper looks at the transformation of agriculture with the advent of western science and technology, having its origins in the British agriculture revolution and the subsequent experiments of the 17th and 18th centuries (Randhawa 1983: 49-54).

Experiments implies parameters are to be measured and metrics on which the parameters can be reported and compared, and where needed, improve them towards certain set standards or a desirable 'potential'. The unifying nature of standards and measurements is a precondition for something to become a mass commodity (Scott 1998:31). This means being part of a market that overlooks diversity for the convenience of uniformity. This aspect has implications for the production, processing and consumption of something as diverse as millets. Here we look at what these implications are, how they came into being and why it is important for the re-valorisation of millets.

Agricultural research in India during the 19th century is identified as an understudied domain despite its role in shaping many institutions and institutional structures that continues to stand even now (Jayaraman 2016: 42). It has been observed that most studies on this topic "excludes discussions of why and how certain types of knowledge are generated, or some forms of knowledge ignored or given relatively low priority" (Raina 2011: 100). Even as scholars looked into the creation of institutions, structures and norms of agriculture sciences, the focus has been on the crops that were subjected to experimentations and how it was put to use. And millets lie in the neglected side of this story.

This study draws on archival records and reports on agricultural research, infrastructure and trade in 19th and mid-20th centuries. It begins from referring to the documents from the Agricultural and Horticultural Society of India (AHSI) – a pioneering institute established in Calcutta in 1820 for conducting research on its eponymous subjects (AHSI n.d.). We argues how the stated purpose of the AHSI, in line with the "*imperial pretensions* of agronomic science", has impacted research on millets through its conspicuous absence (Scott, 1998: 264). Textual Analysis of the publications of AHSI describing experiments by its members testifies this.

Following this, we look into the policy motive of establishment of canal and railway infrastructure and its impact on millets (see Table 1).

Adapted from: Attwood 1987; Attwood 2005; Stone 1984; Whitcombe 1994; *Wheat was used for subsistence during drought when Sorghum and Millets fail (Attwood 1987: 360)

The neglect of millets continued even as its health benefits over rice was evident. For instance, Dr. Cornish, the Madras Sanitary Commissioner during in 1877 expresses his disappointment in serving rice in jails instead of "*ragi, cholum and cumboo"* due to its non-availability in markets. He notes that "…millets contain more albuminates…are better digested, and tend to keep up the vitality of the people better than rice" (Moore 1879: 218). Further at the turn of the 20th century millets cultivation can be seen dwindling in the British governed India whereas it continued to hold ground in the self-ruled native states. We conclude by showing the repercussions on millets when the programmes and processes of colonial origin has been taken over by the independent India without much amends, partly because of historical contingencies. We hope the historical learnings from this study could lead to a wider appreciation of millets as a daily cereal instead of it becoming a premium product accessible to few.

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Table 1. State of Millets in the Major Canal Areas of the 19th century

Region	Canal Type	Major Subsistence Crops	Major Cash Crops	Impact on Millets
Bombay Deccan	Productive turned protective[1]	Sorghum, Pearl Millet, Pulses	Sugarcane, Cotton	• Millet productivity increased • Millet acreage decreased • Use of sorghum as a staple increased
Punjab	Productive	Sorghum, Millets	Sugarcane, Wheat	• Shift from millets to wheat in the canal colonies of eastern Punjab
North Western Provinces (NWP)	Productive	Sorghum, Bajra, Pulses	Wheat*****, Indigo, Cotton, Sugarcane	• Increase in rabi millets area, part of which is attributed to a switch from kharif. • Increase in total fodder sorghum acreage. • Shift from fodder sorghum to maize during Kharif • Increase in production of cash crops

[1] The Tungabhadra canal, opened in 1865, was originally built to encourage wet-crops like sugarcane. But recurrent droughts and famine led to its reclassification as protective

T5-07
Public procurement and private trading of Ragi: The Odisha experience

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Public procurement of cereals in India at the Minimum Support Price (MSP) has almost exclusively been limited to Rice and Wheat since the inception of this mechanism in 1965-66. This policy has made India foodgrain secure, which is important, as evident from the free distribution of grains during the pandemic drawing from the foodgrain reserves. However, public procurement is primarily focused on Rice and Wheat, which account for around 96% of the total foodgrains procured (See Fig. 1).

Only about 0.5% of the procured foodgrains are coarse grains, i.e. Jowar, Bajra, Ragi and Maize. The three important millets are grossly underrepresented, while non-ragi small millets are nowhere in the process. This starkly contrasts with the situation in India during the 1950s when Jowar was the 2nd most produced cereal and millets were the preferred staple of the masses (NAAS 2022). The Public Procurement and Public Distribution System (PDS) network now supplies rice and wheat to more than 800 million people, but whose duopoly has led to a steep decline in small millet production and consumption (Jena and Mishra 2021).

The realisation that the hitherto neglected public policy aspect of rainfed agriculture, including small millets, can be a solution to issues like malnutrition of humans and soil, climate crisis, the rising cost of cultivation etc., led to a renewed focus on millets by the governments during the 2010s. In this context, the Govt. of Odisha introduced the Special Programme for the Promotion of Millets in Tribal Areas or the Odisha Millets Mission (OMM) in 2017 with the support of academia and civil society organisations (Equator Initiative n.d.). OMM incentivises farmers to follow improved millet cultivation practices and was acknowledged as a model worth emulating elsewhere (Millets Mission 2018). In 2018 Odisha started public procurement of ragi at MSP, which increased from 1900 to 2897 per quintal between 2017 and 2018.

This quasi-experimental study conducted in 10 Grama Panchayaths in 5 blocks of Rayagada, Malkangiri and Koraput Districts of Southern Odisha investigates *How the market and farmers responded to the public procurement of finger millet by the Govt. of Odisha?* (See Fig.2 for study locations).

The overarching research question has the following subcomponents:

- Is it and in what ways is procurement influencing the prices of Ragi in the local markets?
- How are the traders responding to the public procurement at MSP in terms of price and volume of trading?
- How are the marketing practices influenced by the Fair Average Quality introduced through Ragi Procurement?
- Does the improved methods of cultivation influence farmers' participation in public procurement?

Between November 2021 and March 2023, we conducted household surveys of 1157 farmers, focus group discussions in 9 villages, interviews based on the cost of cultivation with 58 farmers and trading practices with 9 ragi traders. Some of the salient results we observed include:

- Open market price of ragi increased from 15-18 ₹/kg between January 2014 and September 2017 to ₹20-₹23 (on-season) and ₹21-₹25 (off-season) after initiation of OMM and public procurement of ragi by Govt. of Odisha
- The odds ratio of ragi procurement participation based on improved methods of Line Sowing (LS), Line Transplantation (LT) and System of Millets Intensification (SMI) are respectively 4.4, 4.7 and 8.4 times compared with broadcasting
- Cost of cultivation has a higher coefficient of variation for LS and Broadcasting (1.07 and 1.04) than LT and SMI (0.73 and 0.74) indicative of standard practices reducing cost uncertainties in LT and SMI, the most popular methods adopted by farmers under OMM.

The study shows the public procurement to small millets could be beneficial to farmers, even those who are not part of the procurement system through a general increase in the market price. Learnings from this study, as a part of the University of Cambridge lead Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies (TIGR^{2}ESS) project, would be helpful in policy interventions for diversifying the PDS, and in turn India's agriculture and food systems.

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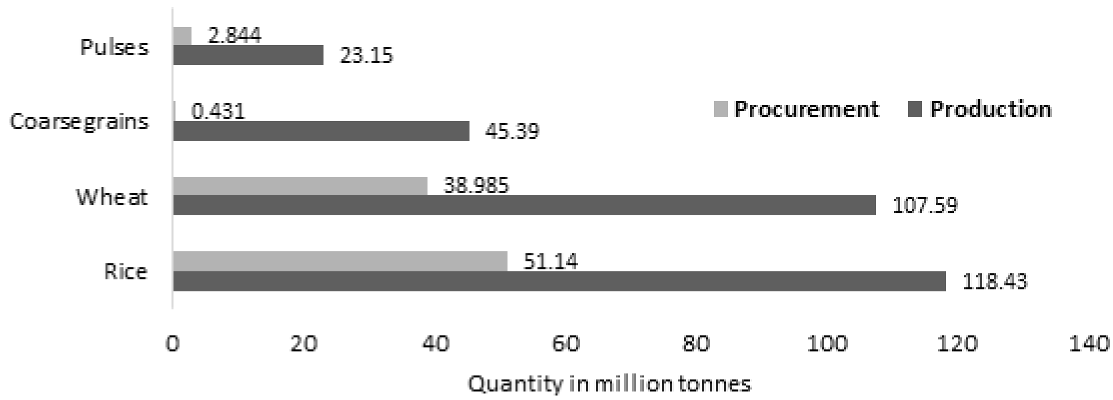
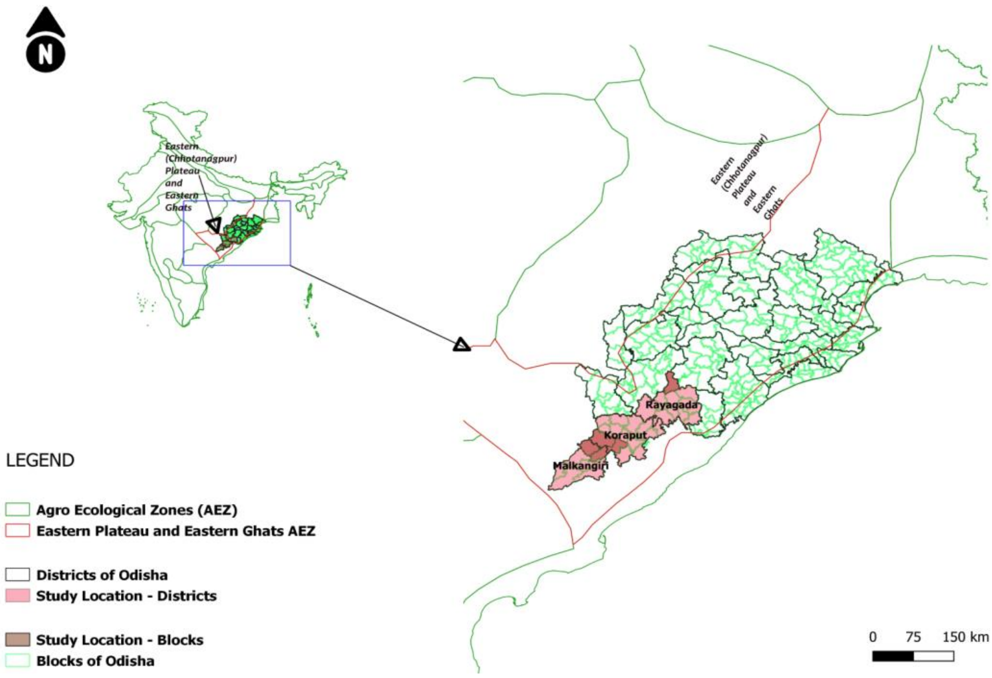
Fig. 1. All India Foodgrains production and MSP procurement during 2019-20.



Source: Lok Sabha unstarred question #331, 15 September 2020 (DoFPD 2020)

Fig. 2. Study locations in Odisha



Source: Authors

T5-08

Understanding the Small Millets capes in Andhra Pradesh and Odisha : Baseline survey results from an action research

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Small millets except finger millet are far more marginalised in India than the larger grain Sorghum and Pearl Millet. The post-harvest processing of husked millets, unlike the naked grain millets of finger millet, sorghum and pearl millet, involves the removal of its hard cellulosic husk through dehulling (see Fig.1). Manual removal of the husk involves drudgery and is a task culturally delegated to women (Balasubramanian 2013). This drudgery has played a major role in husked small millets becoming less popular.

Little millet, the most produced husked millet in India, can tolerate drought and grows in the tropical and subtropical conditions, even at altitudes of 7000 feet above mean sea level. Its grains can be preserved for over a decade without much loss of quality (Selvi et.al 2014 in Ganapathy 2017). But addressing the bottlenecks in post-harvest processing at a household level consumption scale is essential. The short shelf life of dehulled millets - about 2 to 3 months - means that the shorter the supply chain and volume of grain processed, immediate it can be consumed as desirable.

Keeping these constraints in mind, an action research was devised to understand whether the provision of a desktop small millet dehuller to local micro-enterpreneurs could influence the production and consumption of little millet and foxtail millet. The project has been implemented in the Sri Satya Sai (SSS) and Alluri Sitarama Raju (ASR) districts of Andhra Pradesh and Malkangiri district of Odisha. Each district of Andhra Pradesh has 10 entrepreneurs and Malkangiri have 5 entrepreneurs. All the entrepreneurs belongs to Adivasi communities of respective region. These locations and entrepreneurs were identified based on necessity of processing located during previous research studies and projects like the TIGR^{2}ESS and the Andhra Pradesh Community managed Natural Farming (Swaran et.al 2022).

A baseline survey was conducted on randomly selected 15 households in each of the 25 entrepreneurs' villages. The random selection was based on the list of households made available through prior government programmes in the respective states.

The objective of the baseline survey was to understand:

- Existing crop mix;
- Changes in cropping pattern during the past 15 years,
- End uses of the most widely cultivated agriculture produce;
- Unit price of cereals
- Willingness to pay for local dehulling facility, if available

The household surveys provides valuable insights into the potential acceptance of the dehuller in the community. The crop mix in three districts is as diverse as it could get, especially in the case of small millets. For instance, more than 75% of households from ASR district cultivates little millet and ragi compared with 50% cultivating rice (Fig. 2). In the case of SSS district, 98% surveyed households cultivate groundnut while less than 10% of households grow small millets. About 70% of households from SSS reported they have stopped cultivating little millets in the past 15 years. In comparison only about 20% of ASR households discontinued jowar and foxtail millets. In Malkangiri all the surveyed households cultivate paddy, with ragi and little millets cultivated in 98% and 53% households.

An important learning from the survey is drudgery for dehulling was not mentioned as a reason to discontinue little millet and foxtail millet cultivation in either ASR or SSS districts. In ASR, low yield of jowar and foxtail was the major cause for stopping their cultivation and increased animal/bird attack since the 2010s is another reason. Farmers in ASR have responded by switching to pulses cultivation (black gram and redgram). However, small millets remains to be a part of their diet with almost 50% of them reporting to have consumed little millet in the past 7 days. Almost 70% of the respondents mill the little millet for household consumption and most of them do it manually.

This baseline survey is a glimpse to the changing dynamics of millets cultivation, consumption and processing in its traditional belts. Inasmuch as it shows the importance of dehulling equipment of household level, it also suggests that communities even overlook the drudgery of manual processing to consume the small millets and often reason extraneous to processing is causing decline of their cultivation. This study was undertaken as a part of the , as a part of the University of Cambridge lead Transforming India's Green Revolution by Research and Empowerment for Sustainable food Supplies (TIGR2ESS) project.

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Fig. 1. Grain structure of husked grains.
Courtesy: Dwiji Guru/The Millet Foundation

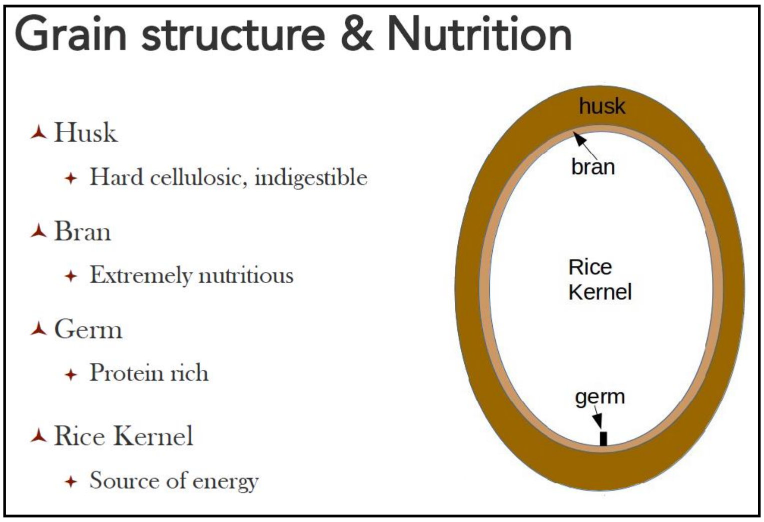


Fig. 1. Study locations in Andhra Pradesh and Odisha

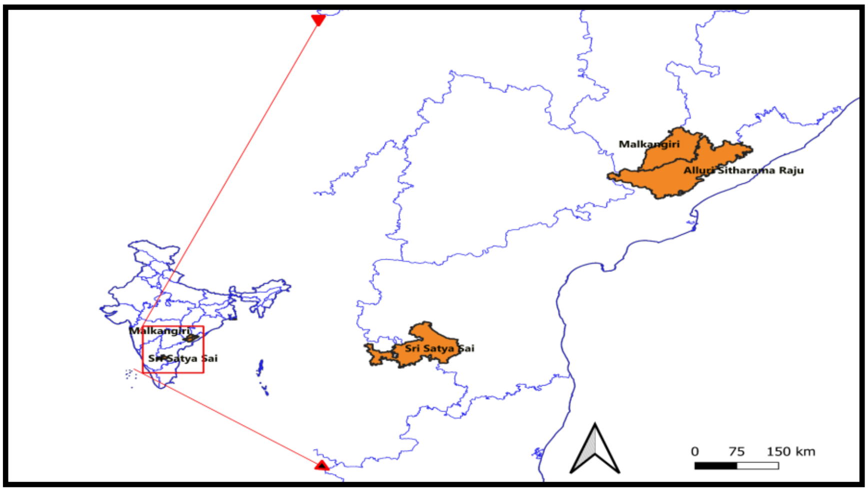
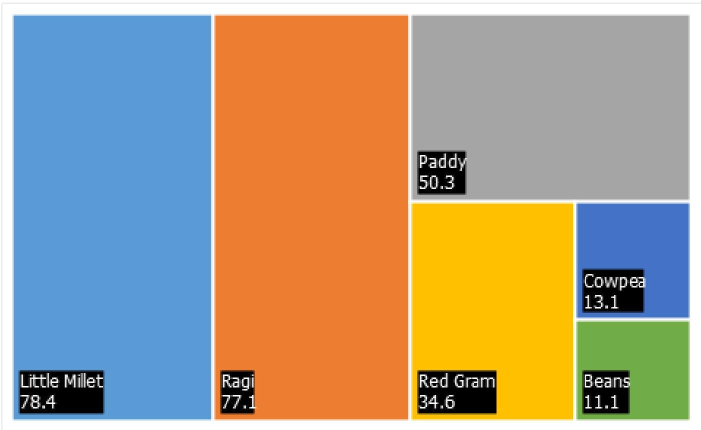


Fig. 2. Crops cultivated by >10% of households surveyed in ASR district during 2021-22



T5-09

Value chain analysis of organic Minor Millets in Dharmapuri District

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Abstract

The present study aimed to examine the cost and returns of organic minor millets and to analyze the value chain and its efficiency. Based on the results of the study, it is concluded that the share of family labour was found to be high on the total cost of cultivation in organic finger millet .Net income per ha was Rs.86015. The price spread was higher in finger millet cookies and lower in flour. The farmer's share in consumer price was higher in finger millet flour and lower in cookies. Marketing efficiency was relatively higher in finger millet flour in both the approaches. The net value addition was higher in case of cookies and sprouted flour. Hence, the study suggested that the farmers should be educated on latest improved varieties for getting higher yield. Minor millet processing units may be supplied to the Organic Farmers Association at free of cost for value addition at group level so as to increase the farmer's share in consumer price and also to provide additional employment. Self Help Group and Joint Liability Group's may be organized among the Organic Farmers Association members so as to start up new enterprises relating to value addition and opening retail outlets on their own to get sustainable income.

Keywords: Organic farming, minor millets, economics, marketing efficiency, Value chain

Introduction

The present study was conducted to analyse the value chain of organic minor millets in Dharmapuri district, Tamil Nadu with the specific objectivesto examine the cost of cultivation and returns in organic minor millets, to map the value chain of organic minor millets and to analyse the net value gain in the value chain.An organic farmers' association who got Group organic certification from Tamil Nadu Organic Certification Department (TNOCD), Coimbatore, Tamil Nadu was chosen. The total sample was 100 farmers, one farmer producer company cum processor, three retailers and 60 consumers.

Economics of Organic Finger Millet: Cost of cultivation analysis using CACP approach (Table 1) indicated the total cost of cultivation of finger millet was Rs.27137 per ha. Direct expenses incurred on crop production (Cost A1) was 52 per cent. The imputed value of family labour alone accounted for 26.91 per centindicated that the role of family labour is high in case of organic cultivation. Overall, human labour including hired labour accounted for the major share of 50 per centand found labour intensive.Net income per ha was Rs.73215. Family labour income was Rs.82986 per ha which indicates organic minor millets cultivation generates income in the form of contribution of family labour. Cost of production was Rs.9 per kg which was lower than average price realized by the farmer, may be due to higher price offered by the FPC cum processor over the market price.

Value Chain of Organic Finger Millet: The members of FPC sell their produce only to the Farmer Producer Company established by an NGO namely Sitilingi Organic Farmers

Association 'SOFA' during 2008 in Harur block. There are more than 500 organic farmers in SOFA. The value chain for organic finger milletidentified is as follows

Organic Farmers ⟶ FPC cum processor ⟶ Retailer ⟶ Consumer

Price spread of Organic Finger Millet

Table 2 revealed that the net price received by the farmerwas 20.36 per cent, 58.81 per cent and 37.36 per cent for cookies, flour and sprouted flour, respectively. Price spread for millet cookies, flour and sprouted flour was 79.64 per cent, 41.18 per cent and 62.63 per cent, respectively. It is concluded that price spread was higher in case of cookies followed by sprouted flour.

Value Addition of Organic Finger Millet

The net value addition finger millet cookies was Rs.5707/qtl. In case of finger millet flour, net value addition flour was Rs.1567/qtl and in sprouted finger millet flour, it was Rs.4687/qtl. Overall, the net value addition was found high in case of cookies and sprouted flour (Table.3).

The study suggested that the farmers should be educated on latest improved varieties for getting higher yield.Minor millet processing units may be supplied to the Organic Farmers Association at free of cost for value addition at group level so as to increase the farmer's share in consumer price and also to provide additional employment.Self Help Group and Joint Liability Group's may be organized among the Organic Farmers Association members so as to start up new enterprises relating to value addition and opening retail outlets on their own to get sustainable income.

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Table 1.Economics of Organic Finger Millet

Cost Particulars	Amount (Rs./ha)	% to Total cost
Cost A1	14104.09	51.97
Cost A2	14104.09	51.97
Cost B1	14532.72	53.55
Cost B2	17366.05	63.99
Cost C1	21836.51	80.47
Imputed value of family labour	7303.78	26.91
Cost C2	24669.84	90.91
Cost C3 (Total Cost)	27136.82	100.00
Average yield (kg/ha)	3136	
Average price (Rs./kg)	32.00	

Gross Income (GI)	100352	
Cost of Production (Rs./kg)	8.65	
Net Income	73215	
Farm Business Income (GI -Cost A1)	86248	
Family labour income	82986	

Source: Primary Survey, 2018

Table 2. Price Spread of Finger Millet Products

(Rs. Per quintal)

S.No.	Particulars	Finger millet					
		Cookies		Flour		Sprouted flour	
		Value (Rs.)	% to CP	Value (Rs.)	% to CP	Value (Rs.)	% to CP
1	Farmer						
	Sale price	3200	20.51	3200	59.26	3200	37.65
	Marketing Cost	24	0.15	24	0.44	24	0.28
	Net Price received	3176	20.36	3176	58.81	3176	37.36
2	Farmer Producer Company Cum Processor						
	Purchase price	3200	20.51	3200	59.26	3200	37.65
	Marketing Cost	58	0.37	58	1.07	58	0.68
	Value Addition	6575	42.15	495	9.17	475	5.59
	Total marketing cost	6633	42.52	553	10.24	533	6.27
	Marketing margin	3687	23.64	747	13.83	3517	41.38
3	Retailer						
	Purchase price	13520	86.67	4500	83.33	7250	85.29
	Marketing cost	60	0.38	80	1.48	80	0.94
	Marketing margin	2020	12.95	820	15.19	1170	13.76
4	Consumer Price	15600	100.00	5400	100.00	8500	100.00
	Price spread	12400	79.64	2200	41.18	5300	62.63

CP: Consumer Price

Table 3. Value addition of Organic finger millet

(per quintal of grain)

Stake holder	Source	Purchase price (Rs./qtl)	Processing cost	Value added product			Gross return	Total cost	Value added	%
				Qty (kg/qtl)	Price (Rs./kg)	Value (Rs.)				
Cookies										
Farmer									3200	35.9
FPC	Farmer	3200	6633	52	260	13520	13520	9833	3687	41.4
Retailer	FPC	13520	60	52	300	15600	15600	13580	2020	22.7
Consumer	Retailer	15600								
Total (Rs./qtl)									8907	100
Net Value addition (Rs./qtl)									5707	
Flour										
Farmer									3200	67.1
FPC	Farmer	3200	553	60	75	4500	4500	3753	747	17.8
Retailer	FPC	4500	80	60	90	5400	5400	4580	820	19.5
Consumer	Retailer	5400								
Total (Rs./qtl)									4767	100
Net Value addition (Rs./qtl)									1567	
Sprouted flour										
Farmer									3200	40.6
FPC	Farmer	3200	553	50	145	7250	7250	3733	3517	44.6
Retailer	FPC	7250	80	50	170	8500	8500	7330	1170	14.8
Consumer	Retailer	8500								
Total (Rs./qtl)									7887	100
Net Value addition (Rs./qtl)									4687	

Note: Conversion ratio was 52 kg of cookies, 60 kg of flour and 50 kg of sprouted millet flour from 1 Qtl of millet grain

T5-10

Marketing Linkage and Agripreneurship Development among the Stakeholders of Farmer Producer Organizations is the Key success of FPOs

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Introduction

Agriculture has always been a lifeline of the Indian economy, 54.6 per cent of the total workforce is engaged in agricultural and allied sector activates and accounts for 17.8 per cent of the country's Gross Value Added (GVA). However high production costs, low access to credit, as well as poor market linkages hinder the sector's growth.Aggregation is an effective method to mitigate risk in agriculture and strengthen livelihoods of farmers particularly small and marginal which comprises around 86.08 % of the sector. The aggregation in the form of FPOs will help effectively to link producers and off-takers to achieve economies of scale along with value chain. The FPOs proved to be the pathway to increase investments in agricultural production, improve their bargaining powers, improve efficiency of value chains, access to and adoption of frontier technologies, expand markers for their produce, enable farmers to exploit both domestic and export market opportunities. In the present context there is gap and issues that needs to be rectified in farmer's aggregations which needs interventions.

Materials and Methods

The study was conducted in the five northern districts of Tamil Nadu Viz., Tiruvannamalai, Tirupattur, Vellore, Ranipet and Kanchipuram with a sample size of 40 FPOs. Structured questionnaire was prepared and pre tested for collecting the details for assessment of the reason for success and failure for the FPOs. The stakeholders of the FPOs Viz., the Directors, CEOs and lead members were identified and interviewed for collecting the required details for the study.

Results and Discussion

The key factor identified for the non-performance of the FPO/FPC to an expected level was found to be the lack of cooperation among Directors and members of FPOs followed by other factors as in the Table 1.The factors identified for the successful performance of the FPO/FPC to an expected level was found to be the presence of Entrepreneurial character among few Directors with in the FPOs that made the FPO as a success full one followed by other aspects as in the Table 2.

Major Gaps Identified: Farmers do not possess the ability to organize into groups of 1000 members in the form of a corporate entity. Several FIGs and Farmers Clubs and FPOs have been formed in Tamil Nadu, but they have not moved further in a strategic way for positioning their organization in the long term considering the competitive globalized market environment. Value chain management (VCM) approach is not in practice to a greater extent in Indian agriculture. It has tremendous benefits and farmers groups have to be guided in establishing Farmer group centric VCM approach that would benefit farmers. Enhancement of managerial capability of farmers to operate a corporate entity, especially in the area of marketing which is lacking at present.FPOs face problem in networking and negotiation with various stakeholders for implementing their business plan and hence unable to realize benefits of economies of scale. The participation of farmers is observed to be restricted by limitations like poor vertical and horizontal linkages and limited access to market, training and to finance. FPOs often experience difficulties in establishing necessary infrastructure facilities to complement their business activities due to limited access to equity or institutional funds at initial stage. They also face challenges in availing related support from various schemes and departments of the Government.

The success of any FPO is vests with the mindset of the Directors in the FPOs, The FPOS with the Directors who have the entrepreneurial character lead the FPO to success. Thus, there is a need for strong leadership to coordinate the members and promoting organized marketing. This will enable the FPO member farmers to get remunerative prices for their produce and ensure adequate and timely availability of raw materials to the manufacturers.There is need for Strengthening Market Linkage as the development ofmarketing linkage is available only for the corporate setup but the farming community is deprived out of the chain due to dis economies of scale and lake of value addition. There is need for strengthening market linkage among the FPOs for strengthening the business model of FPOs through group marketing. It is important to intervene in formation of groups, governance, agribusiness strategy, implementation of business plan, resource mobilization, profitability, distribution of benefits and sustainability.

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Table.1. Key factors for Non-performance of FPOs

S.No	Constraints	Rank
1.	Lack of Cooperation among Directors and Members	I
2.	Lack of Marketing Linkages	II
3.	Lack of clarity in the role of Directors, CEOs and Members	III
4.	Lack of distinctiveness in Products	IV
5.	Non adoption of proper Business Plan	V
6.	Lack of clarity regarding the organisation's objectives	VI
7.	Skill set of Board of Director &Chief Executive Officer	VII
8.	Insufficient technical support	VIII
9.	Poor governance and management	IX
10	Lack of farmer participation in FPO activities	X
11	Intra-organisational conflict	XI

Table 2. Key factors for successful performance of FPOs

S.No	Constraints	Rank
1.	Entrepreneurial character among few Directors	I
2.	Risk taking ability of the Directors	II
3.	Dedicated Directors	III
4.	Adoption of proper Business Plan	IV
5.	Diversification of the business	V
6.	Contact with the Institutions	VI
7.	Farmer participation in FPO activities	VII
8.	Managerial capabilities of the Director and CEOs	VIII

T5-11
An Economic Analysis of Production and Marketing of Little Millet (*Panicum sumatrense*)

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Introduction

The minor millet demand gains momentum due to the health benefits and the United Nations also declaredthe year 2023 as International Year of the Millet due to its importance. The millets are called as miracle or wonder crop that supports livelihood of millions of marginal and small farmers throughout the world. India ranks first in area under minor millet cultivation and production in the world during 2019-20 with 4.58 lakh hectares and production of 3.7 lakh tonnes. The average yield of minor millets in India was 809 kg/ha during 2019-20. In India, the little millet crop is cultivated in 2.6 lakh hectares with production of 1.2 lakh tonnes during 2018 (ICRISAT, 2023). Of the total minor millets area in Tamil Nadu, little millet contribute13987 hectares and production of 18638 tonnes and it had the productivity of 1333 kg/ha during 2020-21(Season and Crop Report of Tamil Nadu, 2021). TheDharmapuriand Tiruvannamalai districts, were the major producers of little millet but the area under cultivation of little millet has been declined drastically from 1991-92 to 2020-21.

Materials and Methods

Among the 32 districts of Tamil Nadu, Dharmapuri and Tiruvannamalaidistricts had71.01 per cent ofthe total little millet area in the state during 2020-21. These two districts were selected for studying the marketing aspects of little millet. A two stage random sampling procedure has been followed to select a sample of 120 farmersand 120 consumers and surveyed was conducted 2021. In addition to track the price spread 20numbers of commission agents, wholesalers, little millet processors, distributors and retailers was surveyed. The secondary data on area, production and productivity of little millet in Tamil Nadu was collected for 30 years from 1990-91 to 2020-21 from the published sources.The collected data were subjected to statistical and econometric analysis like percentage, average, Garrett's Ranking, Compound Growth Rate, Coefficient of Variation and Market efficiency measures like Shepherd's Formula and Acharya's Approach.

Decadal Growth in Area, Production and Productivity of Little Millet in Tamil Nadu: The demand for the millet products has been increasing due to its health benefits, which has to be fulfilled through the supply by increasing area and productivity. The decadal compound growth rate is worked out for assessing the growth performance of little millet area, production and productivity for three decades since 1991-92 to 2020-21 in Tamil Nadu. However, the growth in area and production is found to be negative but still in gives an idea on the period in which the area and production had drastically declined.

The decline in growth rates of area was found to be more during 2001-02 to 2010-11 which was -10.67 per cent compared to other study periods. The decline in the area of little millet during overall growth period 1991-92 to 2020-21 is found to be -5.93 per cent. In a similar study the area of sorghum, pearl millet, finger millet and total millets in India registered positive growth during 1950-51 to 1980-81 and registered a negative growth subsequently (Malathiet.al., 2016). The production in the overall study period was found to be negative (-3.86) but, it was comparatively low during recent decade, which was -2.03 per cent. Since the productivity growth during 1991-92 to 2001-02 recorded an in significant growth of 0.02 percent per annum, the declining growth in total production was higher than the period 2001-02 to 2011-12. The overall growth in the total little millet production was -3.86 per cent per annum for the study period. In all the study periods, it was observed that little millet productivity had registered positive growth.

Channel wise marketing efficiency: Channel wise marketing efficiency is presented in (Table 1). Among the four different channels identified, farmer's share in consumer's rupee was relatively higher in channel IV, which was 44.17 per cent for little millet rice, followed by channel III with 41.67 per cent for little millet rice. In channel I and II , it was 36.07 per cent for little millet rice. Even though the farmer's share in consumer's rupee was more in channel IV than the other channels, most of the farmers in the study area preferred channel I and III for disposing their produce. Marketing efficiency was relatively higher in channel IV in Acharya's approachi.e., 0.80 per cent for little millet rice. Marketing efficiency was relatively higher in channel IV in Shepherd's approach also i.e., 1.79 for branded rice.

Constraints faced by the sample farmers in little millet marketing: Production of the crops will have the constrains mostly pertaining to natural vagaries which cannot be controlled at a larger level but, the marketing constraints that the farmers face can be controlled to a possible extent through proper approach.From the table 3, it could be observed that the price fluctuation is expressed as the most important marketing problem. Followed by late payment from the traders, high transportation cost, lack of market intelligence facility, not possible for value addition and un aware on the quality standards.

It could be concluded that the declining area and production can be stabilized and also can be enhanced through price incentives.The productivity can be further raised by the consistent efforts in improving the little millet varieties, spread of recent and potential technologies along with incentives for the package of practices in little millet production. At present the intermediaries were exploiting the farmers and tuck a considerable share of the consumer rupee, this can be reduced by procurement of the littlemillet directly farmers and also organizing marketing infrastructure specifically to the millets as it could not compete with other cereals/crops.

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Table 1.Channel wise marketing efficiency (Per cent)

S.No.	Particulars	Channel I	Channel II	Channel III	Channel IV
1.	Farmers' share (%)	36.07	36.07	41.67	44.17
2.	Marketing efficiency (Acharya's approach)	0.56	0.56	0.71	0.80
3.	Marketing efficiency (Shepherd's approach)	1.56	1.56	1.71	1.79

T5-12

Millets: A path to sustainable development goals and global food security

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Abstract

Millets with their unique characteristics and benefits have emerged as key contributors to achieving multiple Sustainable Development Goals (SDGs). The abstract highlights the significant role of millets in addressing global challenges and promoting sustainable development. Millets possess exceptional nutritional value, being rich in protein, fiber, vitamins and minerals. Their inclusion in diets helps combat malnutrition and achieve Zero Hunger (SDG 2). These climate-resilient crops require fewer resources including water and contribute to Clean Water and Sanitation (SDG 6). Millets are also gluten-free, low glycemic index alternatives that promote Good Health and Well-being (SDG 3). By integrating millets into urban diets, we can foster Sustainable Cities and Communities (SDG 11) and reduce the ecological footprint of food consumption. Furthermore, millets contribute to Climate Action (SDG 13) by mitigating greenhouse gas emissions and conserving water resources. Cultivating millets supports Biodiversity Conservation (SDG 15) through their diverse genetic pool and preservation of indigenous seed systems. Additionally, promoting millet necessitates Partnerships for the Goals (SDG 17). Collaborative efforts between governments, agricultural organizations, researchers and communities are essential to strengthening millet value chains and achieving shared objectives. Embracing millets offers an opportunity to transform food systems, enhance resilience and ensure food and nutrition security for present and future generations. It requires concerted action and the establishment of cross-sectoral partnerships to scale up millet cultivation, consumption and market development. This abstract emphasizes the importance of recognizing millets as sustainable, nutritious and climate-smart crops. It highlights the potential of millets in achieving SDGs related to hunger eradication, health promotion, water conservation, climate change mitigation, biodiversity preservation and sustainable partnerships. By prioritizing millets, we can forge a path toward a more sustainable and inclusive future.

Keywords: Millets, Sustainable Development Goals (SDGs), Nutrition security, Climate resilience, Food security

Theme 6

Entrepreneurship/start-up and success of FPOs
Extended summaries

T6-01
Empowering SHGs of Ballari district through value addition in newly released millet genotypes

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Abstract

Millets in Kannada are referred to as 'Siridhanya' which translates to 'rich grains' because of their nutritional abundance. The Ballari district of Karnataka is a prominent millet growing district with an area of 5764 hectares. The Agricultural Research Station in Hagari, Ballari, has released five types of millet genotypes having high nutritional value namely foxtail millet (HN46), proso millet (HB-1), brown top millet (HBr-2), little millet (HS-1) and finger millet (HR-13). The nutritional superiority of the novel genotypes was determined by comparing them with local checks. Macro and micro nutrients, physico-chemical properties cooking quality parameters and organoleptic evaluation of millet products were carried out. The varieties when popularized through Large Scale Demonstrations were highly accepted by the farmers. Farmers and SHGs were offered several Capacity Building Programmes linked to millet value addition through the Entrepreneurship Development Programme of ICAR-Krishi Vigyan Kendra, Ballari. Two of the trained Self Help Groups (SHG) started millet based enterprises in the name of 'Neela Naturals' and 'SampurnaAhara'. Neela Naturals is involved in dehusking and packing of millet rice and also makes Ready To Cook (RTC) millet dosa, idli mixes, and malt mix. SampurnaAhara is a brand that produces multigrain mixes. These two product lines have been tested in the NABL approved Pesticide Residue and Food Quality Analysis Laboratory of UAS, Raichur, and have received FSSAI certification. The products are available in local markets as well as in various organic outlets throughout the state competing with other millet brands in the market. SHG women who earn their livelihood through this activity get a B:C ratio of 2:1.

Keywords: hydration index, hydration capacity, Entrepreneurship development

Introduction

Millets have never been new to Indians, but in recent decades, a variety of other cereals have snatched the market share that millets once had. Millets are regarded as one of the most essential cereal grains due to their high concentration of phytochemicals and micronutrients. Millets are not just environment friendly but also resume greater importance for sustained agriculture and food security. In Karnataka, the total area under production of millets is 26,236 hectares, with a total yield of 20,400 tonnes. The Ballari district of Karnataka is the state's second largest millet producing district, encompassing 5764 hectares and generating 3326 tonnes of millets. Agricultural Research Station, Hagari of Ballari district has developed 5 types of high yielding and nutrient dense millet varieties for the benefit of the farmers and consumers namely foxtail millet (HN46), proso millet (HB-1), brown top millet (HBr-2), little millet (HS-1) and finger millet (HR-13). An attempt has been undertaken to popularise the newly released varieties among farmers' fields in order to bring them to consumer plates, and these varieties are subsequently used to develop value added food products. Further Entrepreneurship opportunities were created among SHGs through value addition activities.

Materials and Methods

Standard methods have been used to study the physical-chemical, cooking-characteristics, and nutritional value of different millet cultivars (AOAC 1980, 1990). Physical characteristics including 1000 kernel weight, volume, and density (William et al., 1983) were studied using standard procedures. Hydration capacity, the Hydration Index, and cooking quality variables like cooking time, cooked weight, and volume were also evaluated as functional qualities. SHGs have been identified and trained in standardizing the RTE and RTC millet based products. Developed products were tested for quality and microbial safety. SHGs received advice on how to obtain an FSSAI licence, attractive packaging, branding, and marketing.

Results and Discussion

The released millet varieties are not just high yielding but also proved to be nutritionally superior to the locally grown millet varieties. Nutritional and physico-chemical properties are very important factors in food product development, in this regard a study was carried out to know the nutritional and physico-chemical characteristics of 5 millet genotypes developed in the station. Results of macro and micro nutrient analysis of these millets conducted at PRFQAL showed the better nutrient profile than the check varieties (Table. 1). The results of physical properties showed superior quality over the check varieties (Fig 1).The varieties when popularized through Large Scale Demonstrations were highly accepted by the farmers. SHGs were offered several Capacity Building Programmes linked to millet value addition and processing through the EDP programme of ICAR-Krishi Vigyan Kendra, Ballari. One among the trained SHG runs 'Neela Naturals' operates a small-scale millet processing unit that is involved in the dehusking and packing of different types of millet rice, as well as the production of Ready To Cook (RTC) millet dosa and idli mixes and malt mix. SampurnaAhara is a brand that makes multigrain mixes, which may be used to manufacture a range of items from a single mix. ICAR-KVK, Ballari has offered consistent guidance to SHGs for product standardisation, quality testing, licencing, branding, and marketing. A successful millet entrepreneur from Raichur with the brand 'Farm Bandi' is also producing a variety of millet value-added products under the guidance of KVK, Ballari. As a result now the products are accessible in local markets as well as many organic outlets throughout the state, where they compete with other organic products. SHG women who earn their livelihood through this activity get a B:C ratio of 2:1.According to the findings of this study, millet cultivars developed at ARS, Hagari are nutritionally dense, have good physicochemical features, and have good cooking qualities. The addition of value to such nutrient-dense millet cultivars has proven to improve the livelihood security of SHG women.

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Table1. Nutritional composition of millet genotypes developed at ARS, Hagari (per 100 gm dry weight basis)

Millets	Foxtail millet		Proso Millet		Browntop millet		Little millet		Finger millet	
Varieties	**HN-46**	**DHftmv 333(C)**	**HB-1**	**Dhpm-2769 (C)**	**HBr-2**	**Br Koluru (C)**	**HS-1**	**Dhlm 36-3 (C)**	**HR-13**	**GPU-67 (C)**
Moisture (g)	9.65	9.39	14.12	11.28	9.59	9.60	10.6	11.78	12.22	10.23
Protein (g)	11.50	12.98	10.82	11.77	13.94	12.64	8.38	9.18	6.40	6.59
Fat (g)	3.35	2.98	3.50	3.76	3.67	3.11	4.30	4.57	1.07	1.29
Crude fiber (g)	2.06	2.23	11.81	10.97	12.90	13.63	9.56	9.33	4.71	4.82
Carbohydrate (g)	72.40	73.45	67.99	67.55	62.37	62.93	71.55	68.37	77.38	78.90
Total minerals (g)	1.28	1.20	3.50	5.64	10.43	12.64	5.37	6.10	2.93	2.99
Iron (mg)	2.90	2.60	4.0	4.50	2.35	4.58	6.30	6.10	4.87	4.44
Zinc (mg)	2.50	2.30	3.50	3.50	3.3	3.9	2.00	2.20	2.61	2.22
Calcium (mg)	37.0	28.0	14.5	12.80	17.05	37.60	17.05	15.50	34.10	33.90

C denotes Check/control

Analysed values at PRFQALab UAS, Raichur and IIMR,Hyderab ad

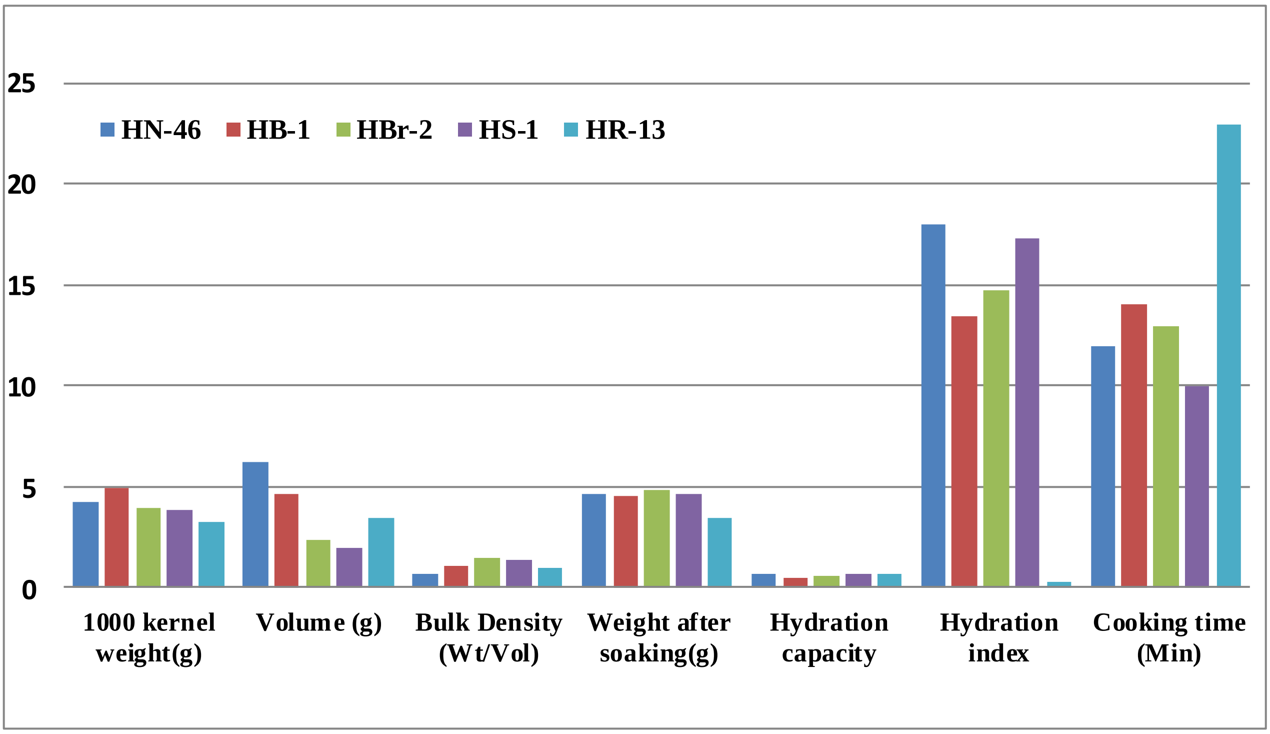

Fig. 1. Physical and cooking quality parameters of millet genotypes developed at ARS, Hagari

T6-02
Demonstration of value addition in millets as a successful venture in Salem District

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Krishi Vigyan Kendra, Salem was established in the year 1994 for disseminating location specific technological modules at district level through technology assessment, refinement and demonstration and training the farmers, farm women and rural youth on agricultural production technologies and post harvest technologies. KVK acts as a knowledge resource centre for agricultural technology by supporting initiatives of public, private and voluntary sector for improving the agricultural economy of the district.

Millets are traditional grains grown and consumed in the Indian Sub Continent from the past more that 5000 years. Millets are highly tolerant to drought and other extreme weather conditions. They are popularly known as Nutricereals as they provide most of the nutrients required for normal functioning of human beings.

Salem District is well known for its millet production in an area of 4,07,692 ha and sorghum in an area of50349 ha. The other millet crops grown in Salem are finger millet (1933 ha), ragi (8141 ha), maize (33447 ha),samai(780 ha) and other minor millets (1233 ha) with total production of about 4,07,692 metric tonnes per year.

Now a days, renewed interest among farmers and consumers on millets increased the are under millet cultivation. Millets are highly nutritious with high calcium, iron, potassium, magnesium, and zinc contents, besides other essential molecules such as vitamins, amino acids, and fatty acids. Government of India has declared 10 crops as ‘NutriCereals’ for production and consumption which include three major millets i.e., pearlmillet, sorghum and finger millet; five minor millets i.e. foxtail millet, prosomillet, kodo millet, barnyard millet, little millet; and two pseudo millets i.e. kuttu (buckwheat)and amaranthus.

Since millets have in-built tolerance to water stress and environmental stresses due to their morpho-physiological, molecular and biochemical characteristics, they are considered climate smart crops. Moreover, as millets are largely produced with low external inputs especially chemicals, they are considered as nature friendly. Several traits such as short stature, small leaf area, thickened cell walls, and dense root system also contribute to circumventing the stresses. Thirdly, being C4 crops, millets have greater potential to utilize atmospheric CO2 in the accumulation of biomass per unit of water used and thus are recognized as crops with low carbon- and water-footprints. The short life cycle of millets (10–12 weeks) as compared to other major crops (20–24 weeks)also helps in stress mitigation. Because of these attributes millets are

Millets play a vital role in the livelihood of the poor and malnourished population, provide food and nutritional security, and help in achieving the first three sustainable development goals of the United Nations i.e. reducing poverty, zero hunger and good health and well-being. However, despite such positive attributes and qualities of millets for the present and future agriculture, their cultivation in India has been on decline over the last few decades, which has attracted the attention of policy makers and India celebrated 2018 as the ‘National Year of Millets’ to create greater awareness about unparalleled attributes of millets.

The farmers growing millets in Salem district are only small and marginal farmers and are getting only marginal income because of the involvement of middleman in the supply chain of millets. Hence, the millet growers are motivated by KVK by conducting frequent trainings and demonstrations, entrepreneurship development programmes on value addition to make aware of farmers to increase their income.

Several hands on trainings on production of millet cookies without including wheat or maida were conducted. Since 2019, the demonstrations and trainings on value addition of millets were regularly conducted at KVK for the benefit of farmers, farm women, rural youth and Farmer Producer Organizations.

Millet cookies are prepared with 100 percent ragi, pearl millet and tenai flour without addition of any preservatives. Multi grain cookies and millet cookies blended with flour of tapioca and banana preparation were also demonstrated to the stakeholders.

The post harvest processing and value addition facilities available with KVK for post harvest processing and value addition of millets was shared to farmers on minimal cost basis. Tribal groups of Shervaroy hills were got benefitted and they utilized processing machineries and baking units at KVK.

More over, KVKis regularly conducting the awareness programmes in collaboration with Integrated Child Development Scheme, Salem during every September months for creating awareness to famers, school and college students, anganwadi workers etc., by organising Mela and Exhibitions to showcase the importance of millets in balanced diet of the children, women especially pregnant women as a part of Poshan Abhiyan and Poshan Maah Programmes.

Since 2018, the millet cookies produced by KVK, Salem is given as refreshment to the participants during all the training programmes and farmer melas and sold through sales counter to create awareness among different stakeholders about the nutritional aspects of the Nutri cereals.

Awareness creation as well as sale of millet cookies has been done in collaboration with Forest Department too by selling KVK prepared millet cookies at Kurumbapatti Park of Salem which is one of the important tourist places in Salem District functioning under the Department of Forests. By this way Salem KVK is not only creating awareness but also demonstrated the successful venture of value addition of millets through preparation of millet cookies to not only to farmers of Salem District but also to farmers of other districts too.

T6-03

Success story of Annai Kaveri Farmer Producer Organization in organic cultivation, value addition and marketing of millets from Salem District of Tamil Nadu

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Annai Kaveri Collective Farmers Producer Company Ltd., located at Kolathur, Mettur, Salem was registered as a Producer Company on 17/11/2020th with 1000 members covering about 10 revenue villages promoted by TNSFAC under National Mission for Sustainable agriculture scheme (NMSA).In this connection, the Department of Agricultural Marketing and Agri Business, Salem and the Erode Precision Farm Producer Company Ltd, the Resource Institution have conducted preliminary levels of meetings with farmers and had started enrolling farmers who would become potential shareholders. Most of the farmers are small and marginal cultivating predominantly cultivating paddy, groundnut, sesame, millets, banana and chillies in rainfed conditions.

Around 85% of the land holdings are small and Marginal Farmers, being unorganized and divided into small fragments these farmers are not able to get remunerative prices for their produce at the right time. A prosperous and sustainable Agriculture is needed that enables farmers to enhance productivity through efficient, cost-effective cost productive resource use and realize higher returns. In search of avenues for getting higher net profit, the CEO and BODs of Annai Kaveri FPO were imparted knowledge with organic farming practices, waste management technologies, value addition technologies etc., from KVK, Salem through different On Farm Trials, Front Line Demonstrations, trainings, method demonstrations and entrepreneurship development programmes etc., They were imparted their knowledge and skill from the Directorate of Agri Business Development (DABD), TNAU, National Institute of Food Technology Entrepreneurship and Management (NIFTEM), Tanjore and Indian Institute of Millet Research, Hyderabad too regarding different techniques of millets value addition, packing, branding etc.,

Mrs. Rani Murugesan, one of the BODs of Annai Kaveri FPO applied for getting organic certification for her 3.5 acre land as per the suggestions of KVK and now it is organically certified. She is also encouraging other too in getting organic certification for better remuneration. Being a women board of directors, with assistance of four of the women members of FPO, she started producing the traditional value added products like murukku, mixture etc., from minor millet produces received from her organically certified land.

The Women Director Mrs. Rani Murugesan from Anna Kaveri FPO, won first prize in the “COOKATHAN” event conducted by Indian Institute of Technology – Madras, RESEARCH PARK, Tharamani with a cash prize of twenty-five thousand.

Few women farmers of Anna Kaveri FPO were converted into traditional entrepreneurs for making confectionery and sweets using minor millets and traditional rice under the brand name of “UZHAVAR MAGAL.”

The list of traditional snack food from millets from Anna Kaveri FPO is as follows.

- Murkku from Little Millet, Pearl Millet, Barnyard Millet, Finger Millet, Kodu millet, Foxtail Millet

- Ribbon murukku from Little Millet, Pearl Millet, Barnyard Millet, Finger Millet, Kodu millet, Foxtail Millet
- Mixture from Foxtail Millet, Finger Millet
- Sweet boondhi from Foxtail Millet
- Finger millet sweet ball (kolukattai)
- Uzhavarmagal millet health mix
- Karupukavooni and Foxtail Millet Athirasam.

- All these snacks were already launched by our honourable Tamil Nadu Agricultural Minister Thiru M.R.K. Panneerselvam at Dharamapuri.
- In Kolathur bus stand, this FPO started a stall for selling their snack food items from traditional millet and rice varieties.
- So traditional snack foods from traditional millets that too from organically grown millets in the brand name of Uzhavar Magal will be available not only across the country but also across the world in near future.

Inputs Distribution by Salem KVK for FLD on Cumbu

Off campus training by Salem KVK on minor millets cultivation techniques

Value addition training by Salem KVK

Entrepreneurship Development Programmeby Salem KVK

Packing of snack food items prepared from millets by Annai Kaveri FPO

Branded pack of snack food from minor millets by Annai Kaveri FPO

Participation of Annai Kaveri FPO in Cookathan Competition at IITM, Chennai

Receiving first prize in Cookathan Competition at IITM, Chennai

Inauguration of products of Annai Kaveri in brand name of Uzhavar Magal by the Honourable Tamil Nadu Agricultural Minister Thiru M.R.K. Panneerselvam

Exhibition of products of Annai Kaveri in the exhibition jointly conducte by Periyar University and KVK Salem at Periyar University

T6-04

Value addition and marketing of millets and millet products - A success story of an entrepreneur in Salem District

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KrishiVigyan Kendra, Salem District established in the year 1994 disseminates agricultural technology by supporting initiatives of public, private and voluntary sector for improving the agricultural economy of the district.

KVK, Salem conducted hands on trainings on millets processing and value addition for the benefit of farmers, farm women and rural youth, students and anganwadi workers and other extension officials too.

Mrs.Dhivya, a young software engineer of Salem got instigation and inspiration after attending millets processing and value addition training, started a venture in procuring few chemical free farm produces and supplying the same to the needy consumers in small through online. She became incubatee of Entrepreneurship Development and Innovation Institute (***EDII***), , Horticultural College and Research Institute, Periyakulam, TNAU and got several ideas on product development and marketing. Technological backstopping was given to her regularly by KVK, Salem.

To supply chemical free natural quality farm produces to the consumers continuously that too directly from the farmers, she started Ana Foods in 2020. Initially she started marketing of jaggery and ghee only and now she markets millets as whole grains, millet flour, value added products of millet, ready to cook products, ready to eat products and health drinks *etc.*, through the marketing platform of her brand “Ana Foods”.

Unpolished millets as such like ragi, cumbu, tenai, varagu, panivaragu, Kuthiraivali, red and white sorghum, flours of ragi, cumbu, tenai, varagu, panivaragu, Kuthiraivali etc., millet instant health mixes along with carrot and beetroot for improving nutritional status as well as adding natural colour to the products, instant sprouted health mix, heath mix for weight loss, noodles, semiya, vermicelli, pasta from millets are also available in the basket of Ana Foods Start Up Company.

By this way, she encouraged the farmers to go for producing the millets in natural way and supporting them by procuring their products directly from them for her business venture. There are more than 25 food products in her basket to spread over the earth through online marketing. She has registered her brand “Ana Foods: in FSSAI and MSME too. She used face book, what sap, instagram etc., to market the food products of Ana Foods. Now she created a web site too to do online marketing of products in a better manner. She planned to do marketing in collaboration with online marketing platforms like Amazon, Flipkart, Mesoetc.,Within a short period of time, she was encouraged with many awards too as an encouragement from the society.

Grow Local, Eat Local and Support Local Farmers is the motto of Ana Foods.

Motto of Ana Foods will be changed in future asGrow Local, Get Local and Spread through out the World.

Ana Food Start Up Launching Programme

Ana Foods Product Launching Programme

Rava prepared from millets by Ana Foods

Sprouted health mix prepared from millets by Ana Foods

Noodles made from different millets by Ana Foods

Exhibition of different products made by Ana Foods

T6-05
Export potential of Indian Millets – An analysis

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Abstract

India produces all nine commonly known millets and is the largest producer and fifth-largest exporter of millets in the world. India ranked number two in terms of export of millets (139 countries) across the globe and as a key player in the global supply chain of millet and its value added products. Secondary data pertaining to export of millets from India for the year 2017 to 2021 were collected and analysed through trade map website. The HSN product code selected was 100829 Millet (excluding grain sorghum and seed for sowing). Major millet importing countries across the globe for the period from 2017 to 2021 were collected. Indonesia (17.5%) ranked number one position in terms of imports of millets from different countries followed by Germany (7.3%), Belgium (5.9%), Canada (5.9 %), South Korea (4.8%) and Netherlands (3.5%). However, share of imports to above countries from Indian millets were very minimum. From the figure 1, it is estimated that markets with potential for India's exports of millets (excluding grain sorghum) was higher in Indonesia, Nepal, United Arab Emirates, United States of America, Pakistan, Saudi Arabia, Germany, South Africa, South Korea, Turkey, Oman, Sri Lanka and United Kingdom. Above analysis showed that positive and stable export potential exists for Indian millets in south east Asia, middle east and western countries.

Keywords: Millets (HSN 100829), export growth rate and export potential

Introduction

Asia and Africa are the major production and leading consumption centres of millets and its value added products. Within Asia, India produces all nine commonly known millets and is the largest producer and fifth-largest exporter of millets in the world. India ranked number two in terms of export of millets (139 countries) across the globe and as a key player in the global supply chain of millet and its value added products. India recorded 27 per cent growth in millet production during 2021-22 when compared 15.92 MMT in the year 2020-21. In India, pearl millet was cultivated maximum (60%) among all millets followed by Sorghum (27%), Finger millet (11%) and Small millets (2%). The major millets producing states in India are Rajasthan, Uttar Pradesh, Haryana, Gujarat, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh and Telangana. Under National Food Security Mission (NFMS) programme, the NFSM-Nutri Cereals is being implemented in 212 districts of 14 states. Millet products are highly nutritious, gluten free and have rich dietary fibre supports the human health. India is enriched with unique varieties of value added products of millets ranging from millet pizza base, millet ice creams, ice cream cones and cups, millet cakes & brownies, breakfast cereals, traditional Indian dosa, poha, upma, pasta, noodles millet milk, tea, consumable millet tea cups, Idli, Dosa, Idiyappam, Roti, Puttu, Upma, Porridge, Chapati, Pancakes, Vermicelli upma, Pasta, Noodles, Macaroni, Semolina/ Suji, Muesli, Instant mixes, Mudde as Breakfast items, Halwa, Adhirasam, Kesari, Nutritious ball, Payasam/ Kheer as Sweets, Vada, Pakoda, Murukku, Bhelpuri, Boli, Pappads, Ready to eat mixes, Flakes, Puffs, Millet Laddus, Millet rusks as Snacks and some bakery products like Bread, Cake, Cookies, Soup sticks, Edible biscuit cups, Health bars, Spreads, Muffins, etc. Beverages like Beer, Soups, Malted millet-based beverage, Germinated Ragi drink mix, Multigrain drink mix, Ready to drink beverages

As per DGCIS data, India registered a growth of 8.02% in the export of millets in the financial year 2021-22 as the export of millets was 159,332.16 metric tonne against 147,501.08 metric tonnes in the year 2020-21. India has more than 500 start-ups working in the millet value-added chain. India exported millet products worth of USD 34.32 million during 2021-22. However, the value realised, and the quantity exported to other countries are minimum when compared to other agricultural commodities. The major millet importing countries in the world are Indonesia, Belgium, Japan, Germany, Mexico, Italy, U.S.A, United Kingdom, Brazil and Netherlands.

Materials and Methods

In order to carry out the research on export potential of millets, secondary data pertaining to export of millets at international level for the year 2017 to 2021 from United Nations Commodity Trade (UN COMTRADE) Statistics were collected and analysed through trade map website. The quantity and value represents from the month of January to December. The HSN product code selected was 100829 Millet (excluding grain sorghum and seed for sowing). Major millet importing countries across the globe for the period from 2017 to 2021 were collected. Trade indicators *viz.,*trade balance, quantity unit, annual growth in value over the last five years, share in world imports/ exports and market concentration were calculated. Percentage and compound growth rate analysis techniques were adopted for this study. Similar type of compound growth rate analysis technique was adopted by Kumareswaran et al., (2019) in his study and reported that coffee had a stable and positive fluctuation trend in the export

Results and Discussion

From the table 1, It could be inferred that during the year 2020-21, India exported huge volume of millet products to United Arab Emirates (19,512 M.Tonnes) followed by Saudi Arabia (11,104 M.Tonnes), Yemen (4,075 M.Tonnes), Oman (3,363 M.Tonnes), Libya (2,782 M.Tonnes), Tunisia (2,197 M.Tonnes), Qatar (1,891 M.Tonnes), Morocco (1,628 M.Tonnes), Iran (1,392 M.Tonnes), Bahrain (1,287 M.Tonnes), Nepal (1,158 M.Tonnes), Kuwait (739 M.Tonnes), Algeria (648 M.Tonnes), Taipei (502 M.Tonnes), Belgium (356 M.Tonnes), South Korea (270 M.Tonnes), Canada (264 M.Tonnes), Sri Lanka (51 M.Tonnes) *etc.,* However, the percentage growth from the year 2017 to 2021 in terms of quantity and value of the millet products exported were higher in case of United States of America, Belgium, Qatar, Oman and South Korea. It could be inferred from the analysis that export growth rate of Indian millets from the year 2017 to 2021 is higher in case of USA followed by Belgium, Qatar and Oman. Similar studies were conducted by Arghyadeep das et al., (2019) and revealed that Indian coffee were exported to Russian federation, Germany, Spain, Belgium and Poland.

Among different countries in the world, Indonesia (17.5%) ranked number one position in terms of imports of millets from different countries followed by Germany (7.3%), Belgium (5.9%), Canada (5.9 %), South Korea (4.8%) and Netherlands (3.5%). However, share of imports to above countries from Indian millets were very minimum. From the figure 1, it is estimated that markets with potential for India’s exports of millets (excluding grain sorghum) was higher in Indonesia, Nepal, United Arab Emirates, United States of America, Pakistan, Saudi Arabia, Germany, South Africa, South Korea, Turkey, Oman, Sri Lanka and United Kingdom. Above analysis showed that positive and stable export potential exists for Indian millets in south east Asia, middle east and western countries.

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Fig. 1. Markets with potential for India’s exports of millet (excluding grain sorghum)

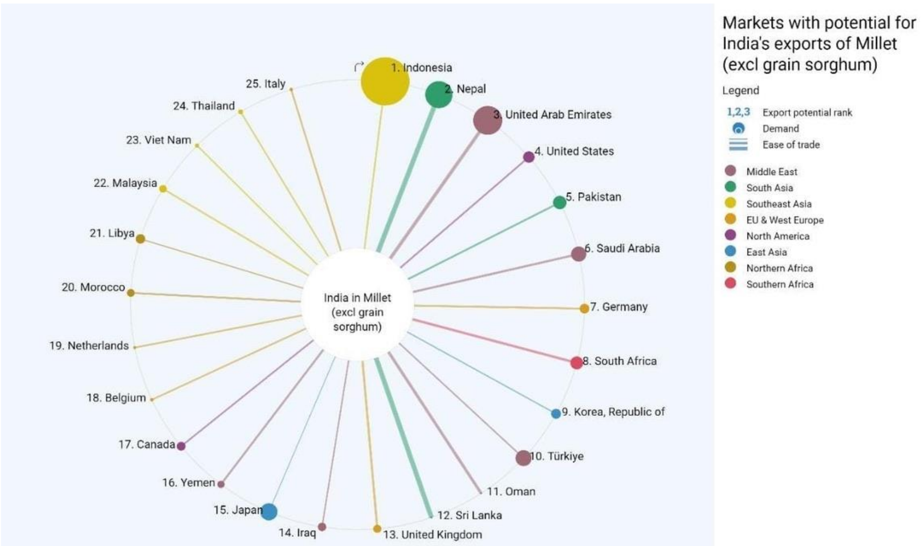

Table 1. Millet products exported from India to different countries from the year 2017 to 2021

Importers	Quantity exported in 2021 (Metric Tonnes)	Value exported in 2021 (USD thousand)	Share in India's export (%)	Growth in exported value between 2017-2021 (%, p.a.)	Growth in exported quantity between 2017-2021 (%, p.a.)	Ranking of partner countries in world imports	Share of partner countries in world imports (%)	Total imports growth between 2017-2021 (%, p.a.)	Concentration of all supplying countries of partner countries
United Arab Emirates	19,512	4,919	29.6	13	13	9	2.9	5	0.83
Saudi Arabia	11,104	2,863	17.2	13	12	33	0.6	-27	0.34
Yemen	4,075	1,036	6.2	-18	-18	36	0.5	-18	0.94
Libya	2,782	942	5.7	23	17	32	0.7	29	0.44

Oman	3,363	858	5.2	37	40	22	1.4	84	0.49
Tunisia	2,197	619	3.7	18	17	112	0		0.61
United Kingdom	1,535	660	4	18	18	20	1.6	5	0.24
Qatar	1,891	516	3.1	39	39	51	0.2	65	0.56
Morocco	1,628	465	2.8	0	-3	21	1.6	32	0.44
Japan	781	370	2.2	9	-2	12	2.7	13	0.24
Egypt	1,257	366	2.2	12	7	71	0.06		0.55
Bahrain	1,287	349	2.1	14	13	63	0.1	-11	0.44
Iran	1,392	328	2			27	0.8	-37	0.97
Nepal	1,158	326	2	-9	-13	10	2.8	23	1
Taipei, Chinese	502	233	1.4	5	-6	42	0.3	8	0.33
Kuwait	739	229	1.4	0	1	65	0.09	52	0.30
Algeria	648	178	1.1	-15	-14	35	0.5	17	0.21
United States of America	139	165	1	55	37	8	3.1	57	0.25
Belgium	356	158	1	42	29	3	5.9	13	0.16
Canada	264	146	0.9	26	22	4	5.9	30	0.31
South Korea	270	137	0.8	27	13	5	4.8	11	0.53
Israel	225	104	0.6	15	5	38	0.4	14	0.34
Portugal	158	81	0.5	183	83	26	0.8	17	0.32
Thailand	141	62	0.4	26	13	16	1.9	19	0.38
South Africa	146	53	0.3	-16	-19	37	0.5	57	0.63
Spain	170	52	0.3	14	8	15	2.1	17	0.24
Maldives	86	49	0.3	22	14	111	0.01	23	0.75
Malaysia	84	44	0.3	-5	-6	24	1	9	0.31
Ghana	61	24	0.1	114	179	83	0.04	-50	0.60
Sri Lanka	51	21	0.1	-14	-13	73	0.06	-48	0.51
Kenya	71	20	0.1	11	7	6	3.5	-21	0.93
Singapore	21	18	0.1	90	68	62	0.1	9	0.37
Australia	23	17	0.1	-2	-10	48	0.2	35	0.41
Turkey	54	16	0.1			11	2.7	72	0.81
Italy	23	12	0.1	-22	-29	13	2.6	16	0.15
Pakistan	50	12	0.1	-76	-61	66	0.09	-58	0.68
Germany	10	9	0.1	-27	-11	2	7.3	8	0.14
Ukraine	24	8	0			68	0.07	-5	0.50
Indonesia						1	17.5	31	0.31
Poland						14	2.1	29	0.76
Iraq						18	1.8	320	0.76
Bulgaria						29	0.7	37	0.77
World	**58,661**	**16,610**	**100**	**7**	**5**		**100**	**12**	

Source: ITC calculations based on UN COMTRADE statistics

Product: 100829 Millet (excluding grain sorghum and seed for sowing)

T6-06
Scope of millet processing for startups in India

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Abstract

Millets, formerly considered to be a staple of the poor, are now a key component of the rich's diet. Millets have recently experienced an increase in demand, mostly because of their capacity to defend against diseases associated with modern lifestyles. The use of millets as a smart food is unavoidable in order to address these significant ongoing problems. India is the largest global producer, with a 43.0% global market share in 2021 with Sorghum (jowar), Pearl Millet (bajra), Finger millet (ragi), and other minor millets are grown in the country. Due to increased knowledge of its nutritional benefits, traditional millet is starting to be seen as a super grain. The demand for millets-based products is increasing in the urban areas and thus creating ample opportunities for new market entrant's entrepreneurs. The worldwide millet-based packaged food market is anticipated to develop at a compound annual growth rate (CAGR) of 5.5% from 2021 to 2026. Production (FPO groups), primary processing, millet value addition, seed entrepreneurs, packaging for markets and industry, food entrepreneurs, millet-based hotels, the millet export sector, etc. are significant factors for millet entrepreneur or startups. There are numerous opportunities for new market entrants entrepreneurs as millets-based product demand rises in urban areas. It's important to seize the chance when it arises.

Keywords: millets, production, value addition, food market, new market

Introduction

Millets are the next generation "smart foods" due to their high nutritional and energy content. Millets, formerly considered to be a staple of the poor, are now a key component of the rich's diet. Millets have recently experienced an increase in demand, mostly because of their capacity to defend against diseases associated with modern lifestyles. In addition, people are becoming more and more aware of the advantages of eating millets in terms of nutrition and health. Millets are excellent sources of carbohydrates, minerals, and phytochemicals with nutraceutical characteristics and are similar to main cereals in terms of nutrition. It is necessary to link dryland farmers with actors throughout the value chain and bring all the stakeholders from the production to consumption system value chain to a unified platform in order to resurrect the demand for millets in India.

Production of millets in India

India's average millet yield (2021–2022) is 1208 kg per hectare. Despite the fact that millet planting has been declining steadily in India during 1971–1972 the production of millets has grown by 7% (1966–2022). India is the largest global producer, with a 43.0% global market share in 2021 with Sorghum (jowar), Pearl Millet (bajra), Finger millet (ragi), and other minor millets are grown in the country. According to the Ministry of Agriculture and Farmers Welfare, millet production in India has increased from 14.52 million tonnes in 2015-16 to 17.96 million metric tons in 2020-21. In India, 86% of all farmers are small or marginal farmers that are struggling financially.

Malnutrition and hidden hunger are issues that Indian mothers and children deal with. Global agriculture production may decline in the future decades as a result of climate change. The use of millets as a smart food is unavoidable in order to address these significant ongoing problems. By implementing numerous programmes and policies including ICRP, INSIMP, and NFSM, as well as by making important millets like bajra, sorghum and ragi eligible for MSPs, the Indian government is also attempting to increase the level of millet production and consumption in India.

Status of millet Processing and Value addition

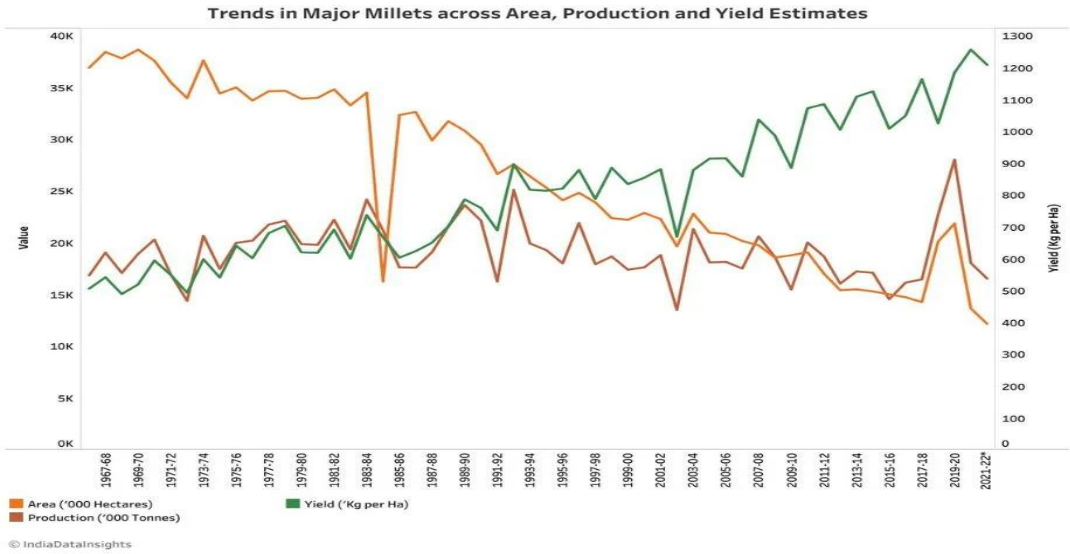
Due to increased knowledge of its nutritional benefits, traditional millet is starting to be seen as a super grain. Since the beginning of the COVID-19 epidemic, consumption of millet-based goods has been steadily increasing. The increase in health awareness among the populace can be attributed to the growth in millets intake during the epidemic. According to Mordor Intelligence, the worldwide millet-based packaged food market is anticipated to develop at a compound annual growth rate (CAGR) of 5.5% from 2021 to 2026 and reach a market size of 2.5 million by the end of 2026. Three categories—product type, distribution channel, and geography are used to categorise the market. The millet-based snacks, morning cereals, bakery goods, drinks, and other things are included in the product type section. Due to the growing need for quick and healthful snacking choices, the snacks category is predicted to hold a market share of more than 35% in 2030.The millet market is segmented according to application into fodder, bread products, alcoholic and non-alcoholic drinks, breakfast foods, and baby food. Porridge and other millets-based infant foods are ideal for growing the infant market and lowering the prevalence of malnutrition in newborns. Bakery products, notably packaged cookies, are steadily growing in popularity due to their extensive availability in supermarkets, hypermarkets, and online shopping sites, particularly in Asia Pacific countries.

Production (FPO groups), primary processing, millet value addition, seed entrepreneurs, packaging for markets and industry, food entrepreneurs, millet-based hotels, the millet export sector, etc. are significant factors for a millet entrepreneur. Millets are being used more often in baby food and nutrition products, and many manufacturers are growing their businesses by purchasing smaller businesses. Beverages like beer have also used it. Products made from millets, such as flour, flakes, biscuits, etc., are more prevalent than ever on the consumer market. Ready to eat products, ready to cook products, ready to serve products were more of value addition aspects of millets.

The usage of millets in infant food and nutrition products is increasing and many manufacturers are expanding their business operations by acquiring smaller firms. It has also found usage in beverages like beer. Gluten-free beers are specially produced for individuals focused on reducing their gluten intake or diagnosed with celiac disease or a gluten intolerance. Breweries have started to add gluten-free beer option to increase their consumer base.

The market for millets is growing quickly and has enormous potential. There are numerous opportunities for new market entrants entrepreneurs as millets-based product demand rises in urban areas. It's important to seize the chance when it arises.

Trends of millets across area, Production, and yield estimates



T6-07

Performance of Farmer ProducerOrganizations: A Study in Prakasam District of Andhra Pradesh, India

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Abstract

Farmers are organized into FPOs for tackling marketing problems, productivity issues, collective farming and challenges arising from small farm sizes. In view of reality the study was carried out to assess the performance of FPOs and was conducted in the Prakasam district of Andhra Pradesh. The findings of the study revealed that there was a provision of input services like quality seeds, custom hiring centers, fertilizers and micronutrients to members of FPO. Timely information on crop production and protection was easily accessible to members. The findings also revealed that FPO members got reliable market information, through collective procurement of produce got more remunerative prices and transparent payments. These aspects built trust among the members towards FPO. Like-wise in networking facilities improved knowledge and skill of farmers through contact with SAUs and KVKs were observed. The financial services offered to FPO farmers enhanced their access to government schemes and subsidies. Hence, improvements were observed in revenue generation, profit attainment, social recognition and self-confidence. FPO needs further improvements to compete with corporate enterprises and international markets. So the concept of collectivization should be promoted, nurtured and supported by the government to improve the farmer's share in rural enterprise. Through consistent efforts by the government for FPOs will be reached in near future for the concept of a farmer to Agri entrepreneur.

Key words: Farmer Producer Organization, performance, technical service, financial service, network service, marketing service

Introduction

Many Central, State Government institutions and non-governmental organizations were promoting Farmer Producer Organizations. During the 2020-21 budget, GOI announced "Formation and Promotion of 10,000 new FPOs" in the next five years with a budgetary allocation of Rs 6,865 crore [1]. Formation and promotion of FPOs was the first step to convert "Krishi to Atma nirbhar krishi" which is the transformation of agriculture into a sustainable enterprise. The study assessed the performance of FPOs and also the services offered by the FPO to its members.

Methodology

Ex-post-facto research design was used and purposive sampling done for selection of state, district and blocks. APDMP- promoted FPO was selected from each block. The selected FPOs were Rhythu Bandhu Farmer Producer Macs Ltd (RBFPL) and the Prudulapuri Farmer Producer Macs Ltd (PFPML). Totally 1003 members were in the selected FPOs in the selected seven villages. By adopting the proportionate random sampling, fifteen percent of the total population was selected for the study constituted 150 numbers. The required data for the study was obtained by using a pre-tested structured interview schedule.

Results and Discussion

Input services

The quality inputs provided at a lower price (2.67) ranked first among the input services followed by timely supply of farm implements and machinery from FPO owned custom hiring center (2.5), supply of quality livestock breeds like goat, hen, sheep (2.43). Supply of quality seeds with a mean score of 2.39 was observed.

Technical services

Timely information on crop production and protection practices ranked first with a mean score of (2.66) followed by information disseminated on technological innovations among FPO members (2.53). Demonstrations related to crop and livestock ranked third (2.4), succeeded by crop diversification and alternative farming methods (2.29). FPO members exposure visits, Kisan melas, and field trips ranked fifth with a mean score of (2.08).

Marketing services

The members were given timely and trustworthy market information (2.65) which was ranked first, followed by a promise of better price for produce (2.52) has got high mean scores. The outcomes were consistent with Saha [2]. Quick and fair payments for produce were given to members (2.45), followed by collective procuring and marketing of produce from FPO members (2.39). The elimination of middlemen (2.28), followed by the identification of a suitable market (2.13) has recorded medium scores.

Networking services

Better access for availing Government schemes (2.64) ranked first followed by improved association with other organizations like felicitating agencies and NGOs (2.38). Establishment of linkages with the state department of agriculture (2.35) followed by linkages with SAUs and KVKs institutions (2.22) were observed. The results were in accordance with Khandave et al*.,* [3].

Financial services

Government schemes and subsidies relating to farming were frequently disseminated among members of the organization (2.65) and credit availability for acquiring farm implements (2.49) to the members by FPO was extremely observed. Raising funds via improving business activity (2.35), followed by crop insurance (2.12). The results were in accordance with Sharma et al*.,* [4].

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Table 1. Distribution of respondents based on the services (n=150)

S.No	Category	Mean score	Rank
	Input services		
1.	Supply of quality seeds	2.39	IV
2.	Supply of chemical fertilizers	1.86	VI
3.	Supply of plant protection chemicals and micronutrients	1.99	V
4.	Supply of quality livestock breeds	2.43	III
5.	Timely supply of farm implements and machines from theFPO owned custom hiring centre	2.5	II
6.	Supply of quality inputs at lower rate	2.67	I
	Technical services		
1.	Provision of timely information on crop production andprotection	2.66	I
2.	Provision of information on new technological innovations	2.53	II
3.	Demonstrations on new technologies to enhance theknowledge	2.4	III
4.	Provision of trainings on post- harvest management and value addition of products to enhance the skill	1.89	VII
5.	Crop diversification and alternate farming system had advisedand promoted.	2.29	IV
6.	Exposure visits, kisan melas, Field trips	2.08	V
7.	Provision of Agro advisory services in the form of publications.	1.98	VI
	Marketing services		
1.	Provision of timely and reliable market information	2.65	I
2.	Collective procurement and marketing of the agriculturalproduce from the FPO members	2.39	IV
3.	Provision of storage facilities	1.99	VII
4.	Arrangement of transport facilities to market the produce	1.89	VIII
5.	Identification of suitable market for sale of produce	2.13	VI
6.	Quick & fair payments to the produce procured by FPO fromits members	2.45	III
7.	Elimination of middleman	2.28	V
8.	Assurance of better price for the produce	2.52	II
	Networking services		
1.	Membership in FPO facilitated linkages with financialinstitutions	2.10	V
2.	Direct contact with consumers/ customers	1.94	VI
3.	Establishment of linkages with state department of Agriculture	2.35	III
4.	Facilitated linkages with SAUs, KVKs, ICAR institutes	2.22	IV
5.	Improved and better access to avail government subsidies	2.64	I
6.	Membership in FPO facilitated to connect with otherorganizations	2.38	II
	Financial services		
1.	Credit facilities for the purchase of inputs and farm equipment	2.49	II
2.	Information dissemination of Government schemes andsubsidies related to farming among the FPO members	2.65	I
3.	Information on crop insurance are done	2.12	IV
4.	Information on life insurance	1.89	V
5.	Information on obtaining grants from various sources andways of raising funds	2.35	III

TAMIL NADU AGRICULTURAL UNIVERSITY

Office of the Director,
Centre for Plant Breeding and Genetics,
Coimbatore - 641 003.

No. CPBG/ Millets / International Conference/ICMFFE 2023 dated. 08.05.2023

PROCEEDINGS

Sub: Millets - International Millet Conference and Futuristic Food Expo' 2023 - IYoM 2023 - Centenary Celebration of Millets 2023 - Committees for event - Communication - regarding.

Ref: Note file approved by the Vice Chancellor, TNAU on 08.05.2023

It has been planned to conduct an International Millet Conference and Futuristic Food Expo' 2023 (ICMFFE 2023) and 100 years of Millets research at CPBG, Tamil Nadu Agricultural University and Coimbatore during 24 – 26, May, 2023 at TNAU, Coimbatore jointly with Indian Society of Plant Breeders. In this connection, the following committees have been formulated for the successful conduct of the conference ICMFFE 2023.

Overall coordination - Dr. R. Ravikesavan, Director (CPBG)

I. Registration and Reception Committee

1. Dr. S. Manonmani, Professor and Head, Department of Rice - **Chairman**
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7. Dr. V. Vasuki, Associate Professor (Agronomy), Department of Millets
8. Th. R. Balachander, Agrl. Supervisor, Department of Pulses
9. Tmt. S. Mythili, AAO, Department of Millets
10. Th. S. Rajendran, AAO, Department of Rice
11. Th. C. Thirunavukarasu, AAO, Department of Rice
12. Tmt. Jacklin Shanthi, Lab Tech., Department of Pulses
13. Tmt. K. Divya, Lab Assistant, Department of Millets

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4. Dr. P.T. Sharavanan, Associate Professor (Plant Pathology), CEM, Athiyandal
5. Dr. P. Shanthi, Associate Professor(PBG), Dept. of GPB
6. Dr. M. Umadevi, Assistant Professor (PBG), Department of Oil Seeds
7. Dr. D. Kavithamani, Assistant Professor (PBG), Department of Millets
8. Th. R. Jaishankar, AO, Department of Millets
9. Th. S. Thangavel, JAO, Department of Oil Seeds
10. Th. K. Girishkumar, JAO, Department of Millets
11. Th. K. Ganesan, Lab Tech., Department of Pulses
12. Th. K. Balasubramaniam, Lab Tech., Department of Pulses
13. Th. A. Thirugnanam, Lab Asst. Department of Millets

III. Refreshments and Food Committee

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3. Dr. G. Karthikeyan, P&H (Plant Pathology) & His team
4. Dr. S. Karthikeyan, Professor& Head, Dept. of PHTC
5. Public Relation Officer, TNAU **(VIP food arrangements at South House)**
6. Dr. K. Iyanar, Professor (PBG), Department of Millets
7. Dr. I. Johnson, Associate Professor (Plant Pathology), Department of Millets
8. Dr. T. Srinivasan, Associate Professor (Ag. Ento.) ,Department of Millets
9. Dr. R. Suresh, Associate Professor (PBG), Department of Rice
10. Dr. R. Sasikala, Assistant Professor (PBG), Department of Oil Seeds
11. Dr. D. Nagarajan, TA, Dept. of GPB
12. Dr. R. Premkumar, TA, Dept. of GPB
13. Th. R. Palanisamy, Lab Asst., Department of Millets
14. Th. P. Maduraiveeran, SAO, Department of Pulses
15. Th. G. Ganesan, JAO, Department of Millets
16. Th. R. Uthiramoorthi, JAO, Department of Oilseeds
17. Th. D. Krishnamurthy, JAO, Department of Oilseeds
18. Tmt. V. P. Mowli, Agrl. Supervisor, Department of Millets
19. Tmt. S. Jaipunisha, Agrl. Supervisor, Department of Cotton
20. Th. S. Rajesh, AAO, Agrl. Supervisor, Department of Cotton

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A. Session 1

1. Director, CPBG & team
2. Director, CPMB & team

B. Session 2

1. Director, Crop Management & Team
2. Director, NRM & Team

C. Session 3

1. Director, CPPS & team
2. Prof & Head, Millets & Team
3. Prof & Head, Crop Physiology & Team

D. Session 4

1. Dean, Agrl Engg & team
2. Dean, HSC&RI & Team
3. Prof & Head, CPHT & Team

E. Session 5 & 6

1. Director, CARDS & team
2. Director, ABD & Team

X. Expo arrangements committee

1. Director, CPBG & Team
2. Director, CARDS & Team
3. DEE & Team
4. Director, ABD & Team

<u>Committee for Hon. Governor visit on 26.05.2023</u>

Expo arrangements

1. Director, CPBG
2. Director, Extension Education
3. Director, CARDS
4. Director, ABD

Signing of MoU with FPO's

1. Director, CARDS

Interaction meeting with FPO's and Entrepreneurs

1. Director, CARDS
2. Director, ABD

Interaction meeting with students

1. Dean (Agri), AC&RI, Coimbatore
2. Dean, School of Post graduate studies

Cooking competition and Food Expo

1. Dean, Students Welfare
2. Professor and Head, Post Harvest Technology

Food arrangements for VIP's

1. Public Relations Officer & Team

I request all the committee members for their cooperation in the successful conduct of ICMFFE 2023.

Director
CPBG

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