Received : 15 Mar 2020 | Revised : 29 Mar 2020 | Accepted : 30 Mar 2020

Electronic Journal of Plant Breeding

Research Article

Genetic variability and association analysis in barnyard millet mutants

S.Vikram[1], R. Sudhagar*[2], P.Masilamani[3] and C.Vanniarajan[1]

[1]Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai.
[2]Sugarcane Research Station, Tamil Nadu Agricultural University, Melalathur, Vellore.
[3]Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirappalli.
***E-Mail**: sudhagar.r@tnau.ac.in

Abstract
The present study was carried out using 40 mutants along with two check varieties CO(Kv)2 and MDU1 during *Kharif* 2019. Sixteen characters were studied and out of which only 11 traits showed significant variation. Correlation and path analysis were done for 11 traits *viz*., number of basal tillers, days to fifty percent flowering, flag leaf length, panicle length, plant height, number of raceme, number of productive tillers, number of leaves in main tiller, average leaves in side tiller, single ear head weight and single plant yield. Among the eleven biometrical traits, high heritability was recorded by traits such as number of basal tillers, days to fifty percent flowering, flag leaf length, plant height, number of racemes, number of productive tillers, number of leaves in main tiller, single ear head weight and single plant yield. Correlation studies showed that number of productive tillers, single ear head weight and plant height possess significant positive correlation with yield at both genotypic and phenotypic level. Path analysis showed that traits like number of basal tillers, single ear head weight and panicle length had high direct effect on yield. Thus, selection of these traits would be rewarding for yield improvement in barnyard millet.

Keywords
Barnyard millet, variability, genetic parameters, correlation, path analysis.

INTRODUCTION

In general, small millets' productivity is lower than other cereal crops but they possess wider adaptability to various biotic and abiotic stresses. It made them as an climate resilient crop (Gupta *et al.,* 2011). Among small millets, barnyard millet is grown as substitute for rice in harsh climatic regions which are unsuitable for rice cultivation (Yabuno, 1987). Millets contain high nutritive value hence popularly known to be Nutri-cereal making them a potential food and fodder (Prakash and Vanniarajan, 2015). Barnyard millet contains high protein (11.1%-13.9%) (Monteiro *et al.,* 1988), high carbohydrate (65%) (Sood *et al.,* 2015) high calcium (23.16 mg/100g) and high Fe content (6.91 mg/100g) (Verma *et al.,* 2015).

Diversity in barnyard millet is eroding fast due to change in social, cultural and economic status of farming community. Creation of variation by conventional breeding in small millets is difficult due to their small floret size (Muduli and Misra, 2007). Mutation breeding is the best alternative approach to small floret sized crops to create variation and improve specific defect of elite cultivar without much alteration in original nature of parent (Mehra, 1963).The present study was carried out using different barnyard millet mutants to estimate correlation, direct and indirect effect of various traits by means of path analysis.

MATERIALS AND METHODS

The present study was carried out to assess correlation and path analysis in barnyard millet in M_4 generation mutants. The study was carried out during *Kharif* 2019 at Sugarcane Research Station, Tamil Nadu Agricultural University, Melalathur, Vellore. The seeds obtained from Agricultural College and Research Institute, Madurai comprising of 40 mutants of the variety CO(Kv)2 (**Table 1**) generated by different doses of Gamma, ethyl methyl sulphonate (EMS) and their combinations *viz.,* Gamma-900Gy(9Nos); 800Gy(4Nos); 700Gy(2Nos); EMS-60mM(6Nos); 70mM(6Nos); 80mM(7Nos); EMS+Gamma-70mM+700Gy(1No); 70mM+800Gy(3Nos); 70mM+900Gy(2Nos) with two check varieties CO(Kv)2 and MDU 1. These genotypes were raised as M_5 generation in RBD with two replications. Each mutant was sown in three rows with 45 x 15 cm spacing. All the recommended package of cultivation practice was adopted.

The observation was recorded for 16 biometrical traits *viz.,* number of basal tillers, days to fifty percent flowering, flag leaf length (cm), flag leaf width (cm), peduncle length (cm), panicle length (cm), length lower raceme (cm), plant height (cm), number of raceme, stem girth (cm), number of productive tillers, number of leaves in main tiller, average leaves in side tiller, single ear head weight (g), 1000 grain weight (g) and single plant yield (g). For every mutant, five plants were selected randomly per replication and used to record the biometrical data except days to fifty percent flowering which was recorded on a plot basis.

The data was subjected to analysis of variance (ANOVA) as per Panse and Sukhatme (1967). Out of sixteen traits studied only 11 traits showed significant variation which are subjected for further statistical analyses. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were calculated using formula of Sivasubramanian and Madhavamenon (1973). Heritability in broad sense and genetic advance as percent of mean were calculated using the method of Johnson *et al.* (1955). Path analysis was carried out using GENRES version 3.11 software.

Table 1. List of 40 mutants derived from CO(Kv)2

Mutant lines	Treatment details	Mutagen
M1	Gamma ray - 900 Gy	Gamma ray
M2	EMS - 70mM + Gamma ray 700 Gy	EMS + Gamma ray
M3	EMS - 60 mM	EMS
M4	EMS - 70mM + Gamma ray 800 Gy	EMS + Gamma ray
M5	EMS - 70mM + Gamma ray 800 Gy	EMS + Gamma ray
M6	EMS - 70mM + Gamma ray 800 Gy	EMS + Gamma ray
M7	EMS - 70 mM	EMS
M8	EMS - 70 mM	EMS
M9	EMS - 80 mM	EMS
M10	Gamma ray - 900 Gy	Gamma ray
M11	Gamma ray - 900 Gy	Gamma ray
M12	Gamma ray - 800 Gy	Gamma ray
M13	Gamma ray - 800 Gy	Gamma ray
M14	Gamma ray - 800 Gy	Gamma ray
M15	Gamma ray - 800 Gy	Gamma ray
M16	EMS - 80 mM	EMS
M17	EMS - 70 mM	EMS
M18	EMS - 70 mM	EMS
M19	EMS - 70 mM	EMS
M20	Gamma ray - 900 Gy	Gamma ray
M21	Gamma ray - 700 Gy	Gamma ray
M22	EMS - 80 mM	EMS
M23	EMS - 80 mM	EMS
M24	Gamma ray - 700 Gy	Gamma ray
M25	EMS - 70 mM	EMS
M26	Gamma ray - 900 Gy	Gamma ray
M27	Gamma ray - 900 Gy	Gamma ray
M28	Gamma ray - 900 Gy	Gamma ray
M29	Gamma ray - 900 Gy	Gamma ray
M30	Gamma ray - 900 Gy	Gamma ray
M31	EMS - 60 mM	EMS
M32	EMS - 60 mM	EMS
M33	EMS - 60 mM	EMS
M34	EMS - 80 mM	EMS
M35	EMS - 80 mM	EMS
M36	EMS - 70mM + Gamma ray 900 Gy	EMS + Gamma ray
M37	EMS - 70mM + Gamma ray 900 Gy	EMS + Gamma ray
M38	EMS - 60 mM	EMS
M39	EMS - 60 mM	EMS
M40	EMS - 80 mM	EMS

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) showed significant difference for 11 traits out of 16 biometrical traits observed (**Table 2**). The 11 traits showing significant differences are number of basal tillers, days to fifty percent flowering, flag leaf length, panicle length, plant height, number of raceme, number of productive tillers, number of leaves in main tiller, average leaves in side tiller, single ear head weight and single plant yield. Similar results for traits such as days to fifty percent, flag leaf length, panicle length, plant height, number of raceme, number of productive tillers and single plant yield were reported by (Arunachalam and Vanniarajan, 2012; Kumari *et al.,* 2019). Since the mutants derived from a single parent CO(Kv)2 and the study was carried at M_4 generation there was non-significance observed for five traits *viz*., flag leaf width, peduncle length, length of lower raceme, stem girth and 1000 grain weight (**Table 2**).Wide range of variability was recorded for traits such as flag leaf length (20.42-33.67), number of basal tillers (7.50-15.50), days to fifty percent flowering (64.00-76.25), panicle length (15.53-21.95), plant height (103.00-157.83), number of raceme (33.06-52.00), number of productive tiller (2.83-8.00), number of leaves in main tiller (9.50-20.67), average leaves in side tiller (4.94-11.73) single ear head weight (5.54-13.59) and single plant yield (25.43-67.95) (**Table 3**). Similar results for traits like plant height, panicle length, days to fifty percent flowering, single plant yield were reported by Trivedi *et al.* (2017). While reports for traits like flag leaf length, number productive tillers, number of leaves in main tiller was similar to Joshi, 2013.

Table 2. ANOVA for 16 biometrical traits in barnyard millet mutants

Source of variation	df	Mean Squares															
		NBT	DFF	FLL	FLW	PEL	PAL	LLR	PH	NR	SG	NPT	NLM	ALS	SE Wgt	1000GW	SPY
Replication	1	1.182	2.506	21.139	0.270	0.844	30.897	0.009	2.191	56.545	0.201	1.348	0.541	2.279	4.703	0.010	12.825
Treatment	41	6.354**	26.677**	17.881**	0.358^{NS}	0.987^{NS}	4.522**	0.263^{NS}	282.717**	38.567**	0.304^{NS}	3.058**	8.544**	2.245**	6.556**	0.272^{NS}	230.920**
Error	41	1.059	0.881	2.530	0.145	0.634	1.770	0.120	19.148	0.494	0.094	0.494	0.821	0.607	0.982	0.054	2.810

NS-non significance

*, ** significance at 5% and 1% respectively

NBT - number of basal tillers; DFF - days to fifty percent flowering; FLL - flag leaf length (cm); FLW - flag leaf width (cm); PEL - peduncle length (cm); PAL - panicle length (cm); LLR - length of lower raceme (cm); PH - plant height (cm); NR - number of racemes; SG - stem girth(cm); NPT - number of productive tillers; NLM - number of leaves in main tiller; ALS - average number of leaves in side tiller; SE wgt - single ear head weight (g);1000 GW - thousand grain weight (g); SPY - single plant yield (g).

The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all 11 traits. The range of heritability for different traits under study was ranged between 43.73% and 97.60%. High heritability (H^2) were recorded for nine traits *viz.,* number of basal tillers (71.42), days to fifty percent flowering (93.61), flag leaf length (75.21), plant height (87.31), number of raceme (97.47), number of productive tillers (72.16), number of leaves in main tiller (82.46), single ear head weight (73.96) and single plant yield (97.60). These results were in accordance with findings of (Dhanalakshmi *et al.,* 2019) for flag leaf length, plant height and single plant yield. While moderate heritability was recorded for two traits *viz.,* panicle length and average leaves in side tiller. Among the various traits studied, number of productive tillers and single plant yield possesses high GCV together with high H^2 while average leaves in side tiller possess moderate GCV and moderate H^2 (**Table 3**) indicated the effectiveness of phenotypic selection.

The genetic advance as percent mean (GAM) for 11 traits ranged from 9.06% to 49.74% showed the effectiveness of phenotypic selection alone. While heritability along with GAM gives clear-cut idea about level of genetic enhancement attained through phenotypic selection. High GAM was recorded for seven traits namely number of basal tillers, number of racemes, number of productive tillers, number of leaves in main tiller, average number of leaves in side tiller, single ear head weight and single plant yield. Similar results were reported for single plant yield and number of productive tillers by (Arunachalam and Vanniarajan, 2012, Sood *et al.,* 2015). Moderate GAM was recorded for three traits namely days to fifty percent flowering, flag leaf length, plant height. While low GAM was recorded for panicle length. High H^2 and high GAM were recorded for traits *viz*., number of basal tillers, number of racemes, number productive tillers, number of leaves in main tiller, single ear head weight and single plant yield indicating additive gene effect and selection for these traits are highly effective. While moderate H^2 and low GAM were recorded for panicle length indicating non-additive gene action and selection for such trait may not be rewarding (**Table 3**).

Yield is a polygenic trait so by selecting traits that are highly correlated with yield is the indirect way to improve the yield. The traits such as number of productive tillers

Table 3. Estimation of genetic parameters for 11 biometric traits in barnyard millet mutants

S. No	Character	Range	GCV	PCV	Heritability (%)	Genetic advance as percent of mean
1	NBT	7.50-15.50	15.32	18.13	71.42	26.67
2	DFF	64.00-76.25	5.02	5.19	93.61	10.00
3	FLL	20.42-33.67	10.73	12.38	75.21	19.17
4	PAL	15.53-21.95	6.65	10.06	43.73	9.06
5	PH	103.00-157.83	9.15	9.79	87.31	17.61
6	NR	33.06-52-00	10.03	10.16	97.47	20.40
7	NPT	2.83-8.00	23.00	27.07	72.16	40.25
8	NLM	9.50-20.67	16.18	17.81	82.46	30.26
9	ALS	4.94-11.73	13.33	17.58	57.44	20.81
10	SE Wgt	5.54-13.59	17.28	20.10	73.96	30.62
11	SPY	25.43-67.95	24.44	24.74	97.60	49.74

NBT - number of basal tillers; DFF - days to fifty percent flowering; FLL - flag leaf length (cm); PAL - panicle length (cm); PH - plant height (cm); NR - number of raceme; NPT - number of productive tillers; NLM - number of leaves in main tiller; ALS - average number of leaves in side tiller; SE wgt - single ear head weight (g);SPY - single plant yield (g).

and single ear head weight possess highly significant positive correlation with yield. In finger millet, similar results were reported by Sapkal *et al.,* (2019); Keerthana *et al.,* (2019). While days to fifty percent flowering possess highly significant but negative correlation with yield (**Table 4**). Among the various traits, plant height, number of productive tillers and single ear head weight showed significant and positive correlation with yield at both genotypic and phenotypic level. While the trait days to fifty percent flowering possess significant but negative correlation with yield at both genotypic and phenotypic level (**Table 4 & 5**). Studies on traits association among the yield attributing components showed significant positive correlation between flag leaf length with panicle length and number of productive tillers; panicle length with number of productive tillers; plant height with number of productive tillers; number of leaves in main tiller with average leaves in side tiller at genotypic level (**Table 4**).

Table 4. Genotypic correlation coefficient matrix for 11 biometric traits

S. No	Character	NBT	DFF	FLL	PAL	PH	NR	NPT	NLM	ALS	SE wgt	SPY
1	NBT	1	0.138	-0.043	0.171	0.131	-0.146	0.177	-0.172	-0.383*	-0.377*	0.01
2	DFF		1	-0.498**	-0.768**	-0.046	-0.095	-0.753**	-0.021	0.013	-0.108	-0.487**
3	FLL			1	0.545**	-0.086	-0.107	0.381*	-0.135	0.042	0.045	0.233
4	PAL				1	0.156	0.108	0.588**	-0.144	-0.339*	-0.167	0.365*
5	PH					1	-0.249	0.342*	-0.174	0.069	-0.195	0.345*
6	NR						1	0.128	0.291	0.084	0.44	0.178
7	NPT							1	0.058	-0.009	0.221	0.660**
8	NLM								1	0.691**	0.299	0.145
9	ALS									1	0.241	0.157
10	SE wgt										1	0.624**
11	SPY											1

***, ** indicates significance at 5% and 1% respectively**

NBT - number of basal tillers; DFF - days to fifty percent flowering; FLL - flag leaf length (cm); PAL - panicle length (cm); PH - plant height (cm); NR - number of raceme; NPT - number of productive tillers; NLM - number of leaves in main tiller; ALS - average number of leaves in side tiller; SE wgt - single ear head weight (g);SPY - single plant yield (g).

Table 5. Phenotypic correlation coefficient matrix for 11 biometric traits

S. No	Character	NBT	DFF	FLL	PAL	PH	NR	NPT	NLM	ALS	SE wgt	SPY
1	NBT	1	0.131	-0.044	-0.024	0.187	-0.141	0.173	-0.168	-0.301	-0.255	0.005
2	DFF		1	-0.456**	-0.555**	-0.079	-0.09	-0.614**	0.002	0.053	-0.109	-0.474**
3	FLL			1	0.501**	-0.056	-0.072	0.266	-0.124	-0.023	0.135	0.203
4	PAL				1	0.136	0.07	0.324*	-0.056	-0.218	-0.012	0.251
5	PH					1	-0.23	0.325*	-0.16	0.052	-0.138	0.326*
6	NR						1	0.103	0.265	0.098	0.374*	0.173
7	NPT							1	0.058	0.118	0.158	0.561**
8	NLM								1	0.581**	0.294	0.147
9	ALS									1	0.155	0.116
10	SE wgt										1	0.537**
11	SPY											1

***, ** indicates significance at 5% and 1% respectively**

NBT - number of basal tillers; DFF - days to fifty percent flowering; FLL - flag leaf length (cm); PAL - panicle length (cm); PH - plant height (cm); NR - number of raceme; NPT - number of productive tillers; NLM - number of leaves in main tiller; ALS - average number of leaves in side tiller; SE wgt - single ear head weight (g);SPY - single plant yield (g).

Path coefficient analysis Dewey and Lu (1959) was done to know direct and indirect contribution of various independent characters on a dependent character. Traits such as number of basal tillers, panicle length, plant height, number of productive tillers, average leaves in side tiller and single ear head weight possess positive direct effect on single plant yield. Similar results for single ear head weight was reported by (Mohan and Maloo, 2006; Nirmalakumari and Vetriventhan, 2010; Prakash and vanniarajan, 2015; Renganathan *et al.*, 2017). While traits such as days to fifty percent flowering, flag leaf length, number of racemes, number of leaves in main tiller possess negative direct effect on single plant yield. Among the various traits experimented, high positive direct effect was contributed by single ear head weight (0.949), while low positive direct effect was contributed by number of productive tillers (0.049). Based on the scales suggested by Lenka and Misra (1973), the calculated coefficient was categorized into negligible (0.00-0.009), low (0.10-0.19), moderate (0.20-0.29), high (0.30-1.00) and very high (>1.00). Among the different biometrical studied, the direct effect by number of productive tillers was negligible. This was in accordance with the findings of (Arunachalam and Vanniarajan, 2012) while the direct effect of traits such as flag leaf length, plant height, number of raceme and number of leaves in main tillers are moderate; traits such as number of basal tillers, panicle length, average leaves in side tiller and single ear head weight possess high direct effect respectively (Table 6).

Table 6. Path analysis for 11 biometric traits in barnyard millet mutants

S. No	Character	NBT	DFF	FLL	PAL	PH	NR	NPT	NLM	ALS	SE wgt	SPY
1	NBT	**0.310**	-0.003	0.010	0.114	0.029	0.031	0.009	0.041	-0.173	-0.358	0.010
2	DFF	0.043	**-0.023**	0.121	-0.509	-0.010	0.020	-0.037	0.005	0.006	-0.103	-0.487**
3	FLL	-0.013	0.012	**-0.243**	0.361	-0.019	0.023	0.019	0.032	0.019	0.043	0.233
4	PAL	0.053	0.018	-0.132	**0.663**	0.035	-0.023	0.029	0.034	-0.153	-0.158	0.365*
5	PH	0.041	0.001	0.021	0.104	**0.221**	0.053	0.017	0.041	0.031	-0.185	0.345*
6	NR	-0.045	0.002	0.026	0.072	-0.055	**-0.214**	0.006	-0.069	0.038	0.418	0.178
7	NPT	0.055	0.017	-0.092	0.390	0.076	-0.027	**0.049**	-0.014	-0.004	0.210	0.660**
8	NLM	-0.053	0.000	0.033	-0.096	-0.038	-0.062	0.003	**-0.237**	0.311	0.284	0.145
9	ALS	-0.119	0.000	-0.010	-0.225	0.015	-0.018	0.000	-0.164	**0.450**	0.229	0.157
10	SE wgt	-0.117	0.003	-0.011	-0.110	-0.043	-0.094	0.011	-0.071	0.109	**0.949**	0.624**

RESIDUAL EFFECT=0.3169807

***, ** indicates significance at 5% and 1% respectively**

NBT - number of basal tillers; DFF - days to fifty percent flowering; FLL - flag leaf length (cm); PAL - panicle length (cm); PH - plant height (cm); NR - number of raceme; NPT - number of productive tillers; NLM - number of leaves in main tiller; ALS - average number of leaves in side tiller; SE wgt - single ear head weight (g);SPY - single plant yield (g).

The correlation studies showed that traits such as number of productive tillers, single ear head weight, panicle length and plant height are significant and positively associated with single plant yield. Path analysis revealed that the traits *viz.*, number of productive tillers, single ear head weight, panicle length and plant height possess positive direct effect. The number of productive tillers had negligible direct effect on yield. Based on association studies among 11 traits, it is noticed that selection by single ear head weight, panicle length and plant height could help in improvement of the single plant yield.

REFERENCES

Arunachalam, P, and C Vanniarajan. 2012. Genetic parameters and quantitative traits association in barnyard millet(Echinochloa frumentacea). *Plant Archives* **12** (2):691-694.

Dewey, Douglas R, and KH Lu. 1959. A Correlation and Path-Coefficient Analysis of Components of Crested Wheatgrass Seed Production 1. *Agronomy journal* **51** (9):515-518. [Cross Ref]

Dhanalakshmi, R, A Subramanian, T Thirumurugan, M Elangovan, and T Kalaimagal. 2019. Genetic variability and association studies in barnyard millet (*Echinochloa frumentacea* (Roxb.) Link) germplasm under sodic soil condition. *Electronic Journal of Plant Breeding* **10** (2):430-439. [Cross Ref]

Gupta, Arun, Salej Sood, Pawan Kumar Agrawal, and Jagdish Chandra Bhatt. 2011. Floral biology and pollination system in small millets. *Eur J Plant Sci Biotechnol* **6**:81-86.

Johnson, Herbert W, HF Robinson, and RE Comstock. 1955. Estimates of genetic and environmental variability in soybeans 1. *Agronomy journal* **47** (7):314-318. [Cross Ref]

Joshi, Vijeta. , 2013. Assessment of Genetic Variability and identification of genotypes for different traits in Barnyard millet (*Echinochola* spp.). *International Journal of Agricultural and Food Science* **4**:65-67.

Keerthana, K, S Chitra, A Subramanian, and M Elangovan. 2019. Character association and path coefficient analysis in finger millet (*Eleusine coracana* (L.) Gaertn) genotypes under sodic condition. *The Pharma Innovation Journal*. [Cross Ref]

Kumari, Nikita, Rajesh Kumar, and Avinash Kumar. 2019. Genetic variability and association of traits in mutant lines of rice (*Oryza sativa* L.) for submergence tolerance. *Current Journal of Applied Science and Technology*:1-7. [Cross Ref]

Lenka, D, and PK Misra. 1973. Response of groundnut (*Arachis hypogaea* L.) to irrigation. *Indian Journal of Agronomy*.

Mehra, KL. ,1963. Differentiation of cultivated and wild Eleusine species. *Phyton* **20**:189-198.

Mohan, L, and SR Maloo. 2006. Path coefficient anlaysis for seed yield in barnyard millet millet [*Echnichloa frumentacea* (roxb.) Link]. *Agric. Sci. Digest* **26** (2):151-152.

Monteiro, P Vincent, L Sudharshana, and Geeta Ramachandra. 1988. Japanese barnyard millet (*Echinochloa frumentacea*): protein content, quality and SDS–PAGE of protein fractions. *Journal of the Science of Food and Agriculture* **43** (1):17-25. [Cross Ref]

Muduli, KC, and RC Misra. 2007. Efficacy of mutagenic treatments in producing useful mutants in finger millet (*Eleusine coracana* Gaertn.). *Indian Journal of Genetics and Plant Breeding* **67** (3):232-237.

Nirmalakumari, A, and M Vetriventhan. 2010. Characterization of foxtail millet germplasm collections for yield contributing traits. *Electronic Journal of Plant Breeding* **1** (2):140-147.

Panse, VG, and PV Sukhatme. 1967. Statistical methods for agricultural workers ICAR Publication. *New Delhi* 259.

Prakash, R, and C Vanniarajan. 2015. Path analysis for grain yield in barnyard millet (*Echinochloa frumentacea* (Roxb.) link). *Bangladesh Journal of Botany* **44** (1):147-150. [Cross Ref]

Renganathan, VG, C Vanniarajan, A Nirmalakumari, M Raveendran, S Thiyageshwari, and P Arunachalam. 2017. Association analysis in germplasm and F2 segregating population of Barnyard Millet (*Echinochloa frumentacea* Roxb. Link) for biometrical and nutritional traits. *International Journal of Current Microbiology and Applied Sciences* **6** (8):3394-3400. [Cross Ref]

Sapkal, Sneha R, VV Bhavsar, KK Barhate, and NK Sarika. 2019. Correlation and Path Analysis for Different Characteristics in Germplasm of Finger Millet (*Eleusine coracana* (L.) Gaertn.). *International Journal of Current Microbiology and Applied Sciences* **8** (1):2319-7706. [Cross Ref]

Sivasubramanian, S, and P Madhavamenon. 1973. Genotypic and phenotypic variability in rice. *Madras Agric. J* **60** (9-13):1093-1096.

Sood, Salej, Rajesh K Khulbe, Arun K Gupta, Pawan K Agrawal, Hari D Upadhyaya, and Jagdish C Bhatt. 2015. Barnyard millet–a potential food and feed crop of future. *Plant Breeding* **134** (2):135-147. [Cross Ref]

Trivedi, AK, L Arya, SK Verma, RK Tyagi, and A Hemantaranjan. 2017. Evaluation of barnyard millet diversity in central Himalayan region for environmental stress tolerance. *The Journal of Agricultural Science 155 (10):1497-1507.* [Cross Ref]

Verma, Suman, Sarita Srivastava, and Neha Tiwari. 2015. Comparative study on nutritional and sensory quality of barnyard and foxtail millet food products with traditional rice products. *Journal of food science and technology* **52** (8):5147-5155. [Cross Ref]

Yabuno, Tomosaburo. 1987. Japanese barnyard millet (*Echinochloa utilis*, Poaceae) in Japan. *Economic Botany* **41** (4):484-493. [Cross Ref]