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Research Article

Analysis of the performance, variability and nature of pearl millet productive traits in the rainfed environment of Andhra Pradesh

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Abstract
An effort was made to examine one forty pearl millet hybrids in order to assess genetic variance and investigate the relationship between nine yield contributing traits. The study of variance showed that the crosses had significant genetic variability. An attempt was made to choose the best hybrids for grain yield and adaptation to low rainfall regions in arid Alfisols of Andhra Pradesh. Among the tested cross combinations, ABH-61, ABH-50 and ABH-77 were found to be promising for higher yield potential, emerging as an ideal candidate for rainfed conditions. Grain weight and grain yield showed the highest GCV and PCV estimates, as well as high heritability and genetic advance as a per cent of then mean, implying that these traits were due to high additive gene effects and simple directional selection may improve them. The size of the panicle and the height of the plant had a significant and positive relationship with grain yield. As a result, selecting genotypes with longer panicles and taller plants can aid in increasing pearl millet grain yield.

Key words: Pearl millet, variability, heritability, character association, grain yield

INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is an annual C_4 plant that is diploid (2n=14) and highly cross pollinated. It belongs to the poaceae family. It is native to central tropical Africa, but it has successfully adapted to arid and semi-arid regions of Africa and Asia. Pearl millet is also known as bajra, cumbu, cat-tail millet, dark millet, spiked millet or candle millet in different parts of the world and sajja in Andhra Pradesh. It has protogyny and anemophily mechanisms, which allow it to meet biological requirements and easily commercialize hybrid vigour on a large scale. After rice, wheat and maize, pearl millet is India's fourth most widely cultivated cereal crop. It covers an area of 7.41 million ha, produces 10.3 million tonnes and has a productivity of 1391 kg/ha (Anonymous, 2021). The arid tracts are planted with low-yielding landraces/ OPVs (open pollinated varieties). The low production of pearl millet in India necessitates the development of more adaptable, stable, high-yielding varieties and hybrids. The cytoplasmic male-sterility (CMS) system has significantly increased pearl millet yield by allowing commercial hybrid seed production (Kelley *et al.,* 1996).

The degree of genetic diversity determines the ability of any crop plant to be improved. Furthermore, heritability assesses the degree of resemblance between parents and offspring, whereas genetic advancement aids in imposing the necessary selection pressure. Precise predictions of genetic variability, heritability and genetic advance will be required for identifying selection-responsive characters. The basic prerequisite for any selection programme is an understanding of the relationship between various component characters and grain yield. As a result, the goal of this study was to evaluate the efficacy of various experimental hybrids, as well as to investigate genetic variability and character association, in order to identify the best suitable hybrids and to develop efficient selection criteria for increasing pearl millet grain yield.

MATERIALS AND METHODS

A total of 140 pearl millet hybrids were included for the study, comprising 136 experimental crosses and four popular hybrids serving as checks. The experiment was carried out at the Agricultural Research Station, ANGRAU, Ananthapuramu (14° 41' N, longitude: 77 ° 40' E and 373 m above mean sea level) in Andhra Pradesh, India, in the scarce rainfall zone. This district has an annual rainfall average of about 553 mm and is characterized by low and erratic rainfall in terms of area, time and distribution during the season. During *Kharif,* 2020, 140 hybrids were planted in an Alpha lattice design with two replications (in 10 blocks with 14 hybrids in each block). Each hybrid representing one row of 4 m length spaced 50 cm apart with 15 cm between hills. The field was uniformly fertilized with a basal dose of 30 kg Nitrogen, 20 kg P_2O_5 and 20 kg K_2O per hectare just before seeding and adose of 30 kg Nitrogen per hectare 35 days after seeding. Standard cultural and agronomic practices were used to achieve good crop growth. Data were collected on the days to 50% flowering, days to maturity, plant height (cm), the number of productive tillers per plant, panicle length (cm), panicle diameter (cm), test weight (g) and grain yield (kg/ha). Except for days to 50% flowering, maturity and grain yield, which are recorded plot by plot, five random competitive plants were chosen for data collection in each plot. The analysis of variance (ANOVA) method, as described by Singh and Chowdary (1985) was used. Burton's approach (1952) was applied to calculate the variability parameters, genotypic and phenotypic coefficients of variation (GCV and PCV). The method proposed by Lush (1940) was used to compute broad sense heritability estimates, while Johnson *et al.*(1955) offered a technique for estimating expected genetic progress. R-software was used to compute Pearson's correlation coefficients for the nine individual traits (RDevelopment Core team 2020).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences in all traits between hybrids in the current study (**Table 1**), indicating that there is sufficient variability and opportunities for further selection to breed superior genotypes. The performance of the top ten high yielding hybrids across a range of yield attributes was summarized in **Table 2**. Under dryland conditions, the new hybrids yielded 3.41 (ABH-101) to 19.97 per cent (ABH-61) more grain than the best commercial check Kaveri Super Boss (KSB) (2563.78 kg/ha). Among the new hybrids, ABH-61 produced the highest grain yield (3076.21 kg/ha) and excelled in the majority of yield traits, followed by ABH-50 (3054.86 kg/ha) and ABH-77 (2965.67 kg/ha). The hybrid ABH-61 was chosen as the best single cross hybrid with a medium maturity period (78.50 days) due to its superior performance on the majority of traits as well as grain yield (more than 19.97 per cent yield superiority than the best check KSB). When other agronomic characteristics were compared *via* crosses, the new top hybrids were three days earlier and had greater grain sizes ranging from 0.2 to 6.4 g/1000 grain weight. In comparison to the best commercial check KSB, the new hybrid combinations expressed few differences in plant height, the number of productive tillers per plant, panicle length and panicle diameter (**Table 2**). In practice, these experimental hybrids can be commercialized following multilocation trials.

The mean, range and various genetic variability parameters for yield related traits (**Table 3**) revealed that the mean values for the majority of the traits varied significantly. The grain yield ranged from 942.43 to 3076.21 kg/ha, the days to 50% flowering ranged from 38.00 to 47.50, the days to maturity ranged from 65.50 to 82.50, the plant height ranged from 159.34 to 255.00 cm, the number of productive tillers per plant ranged from 0.67 to 2.84, the panicle length ranged from 16.95 to 29.54 cm, the panicle diameter ranged from 2.15 to 3.90 cm and 1000 grain weight from 7.40 to 19.70 g. with a four-to-five-fold difference for the majority of the traits, suggesting the potential for genetic enhancement of the material through selection.

Table 1. Analysis of variance (ANOVA) for yield contributing traits in 140 pearl millet hybrids

Source	DF	Mean sum of squares								
		Days to 50 % flowering	Days to maturity	Population (number/net plot)	Plant height	Productive tillers (number/ plant)	Panicle length	Panicle diameter	1000 grain weight	Grain yield
Replication	1	3.43	1.43	30.23	27.80	0.64	3.33	1.71*	0.17	242078.00
Genotype	139	10.11**	23.25**	31.24*	385.30*	0.35	8.19*	0.22*	12.29**	442108.00**
Rep: Block	9	4.54	16.20	38.03	381.00	2.07*	17.05*	2.31*	2.65	68958.00
Residuals	130	3.09	10.35	21.09	152.20	0.28	3.91	0.15	1.59	67770.00

*, ** significant at 5% and 1% levels, respectively

Table 2. Mean performance of top ten pearl millet hybrids for nine yield contributing traits and per cent superiority over the best check

Hybrids	Days to 50 % flowering	Days to maturity	Population (number/ net plot)	Plant height (cm)	Productive tillers (number/ plant)	Panicle length (cm)	Panicle diameter (cm)	1000 -grain weight (g)	Grain yield (kg/ha)	Per cent superiority over best check (KSB)
ABH-61	41.50	78.50	24.00	196.83	1.67	26.97	3.17	19.10	3076.21	19.97
ABH-50	41.50	77.00	26.50	223.50	1.33	24.33	2.22	12.60	3054.86	19.15
ABH-77	44.50	77.00	27.50	217.17	1.84	26.02	2.54	18.15	2965.67	15.66
ABH-136	43.00	78.00	26.50	209.00	2.33	26.10	3.15	13.70	2924.59	14.06
ABH-39	43.00	77.50	27.50	205.84	1.34	25.35	2.62	9.35	2904.05	13.26
ABH-81	44.50	78.00	28.00	222.84	1.50	26.42	2.92	11.50	2883.51	12.46
ABH-69	43.50	77.00	28.50	212.50	1.00	25.47	2.47	11.45	2811.62	9.65
ABH-16	44.50	79.50	21.00	193.00	2.50	25.63	2.95	13.40	2712.43	5.79
ABH-7	40.50	73.00	24.50	189.17	1.67	24.77	2.65	12.35	2657.02	3.63
ABH-101	41.50	78.50	23.50	201.17	2.33	24.08	3.30	12.05	2651.08	3.41
Kaveri Super Boss KSB (C)	47.00	82.00	32.50	221.17	2.00	27.75	3.22	12.70	2563.78	
HHB299 (C)	44.00	77.00	20.50	171.17	1.34	23.37	2.97	11.00	2358.92	
Pratap (C)	47.50	79.50	20.00	159.34	1.67	21.79	2.60	11.85	2196.75	
PHB 3 (C)	46.50	75.00	23.50	194.00	2.00	26.65	3.14	10.35	1635.40	
C.V. (%)	4.28	4.38	17.33	6.59	20.83	9.07	14.09	10.95	14.09	
SE.m+	1.28	2.36	3.15	9.35	0.24	1.54	0.29	0.93	184.59	
C.D at 5%	3.57	6.58	8.82	26.14	0.67	4.29	0.80	2.60	516.09	

(C) checks, #(C) Best performing check

Table 3. Mean, range, coefficients of variation, heritability(broad sense) and genetic advance as per cent of mean for yield contributing traits in 140 pearl millet hybrids

S. No.	Characters	Mean	Range		Variance		Coefficient of variation		Heritability (broad sense) (%)	Genetic advance as per cent of mean
			Min.	Max.	Geno-typic	pheno-typic	Geno-typic	pheno-typic		
1	Days to 50 % flowering	42.2	38.00	47.50	3.51	6.6	4.44	6.09	53.24	6.68
2	Days to maturity	76.16	65.50	82.50	6.45	16.79	3.33	5.38	38.41	4.26
3	Population (number/ net plot)	25.83	12.50	37.50	5.07	26.16	8.72	19.8	19.39	7.91
4	Plant height (cm)	200.84	159.34	255.00	116.54	268.79	5.37	8.16	43.36	7.29
5	Productive tillers (number/plant)	1.6	0.67	2.84	0.03	0.31	11.26	34.95	10.38	7.48
6	Panicle length (cm)	23.91	16.95	29.54	2.14	6.05	6.12	10.29	35.36	7.49
7	Panicle diameter (cm)	2.87	2.15	3.90	0.03	0.19	6.36	15.13	17.66	5.5
8	1000 grain weight (g)	12.04	7.40	19.70	5.35	6.94	19.21	21.88	77.05	34.73
9	Grain yield (kg/ha)	1859.52	942.43	3076.21	187169.3	254938.9	23.27	27.15	73.42	41.07

The phenotypic coefficient of variation (PCV) was greater than the genotypic coefficient of variation (GCV) for all of the characters, indicating that the environment has an effect on their expression. GCV values ranged between (3.33%) and (23.27%) for days to maturity and grain yield. Grain yield (23.27, 27.15) and 1000 grain weight (20.21, 21.88) were estimated to have a high GCV and PCV. This indicated that genotypes possessed a high degree of inherent variability, making them ideal for selection. Similar estimates for 1000 grain weight and grain yield were also reported by Priyanka *et al.* (2019), Annamalai *et al.* (2020) and Shankar Lal Yadav *et al.* (2020). The coefficient of variation for productive tillers per plant was found to be high to moderate (11.26, 34.95), whereas the coefficient of variation for panicle diameter (6.36, 15.13) and panicle length was found to be moderate to low (6.12, 10.29). Similar estimates for panicle diameter was also reported by Sowmiya *et al.* (2016), Patil *et al.* (2018)

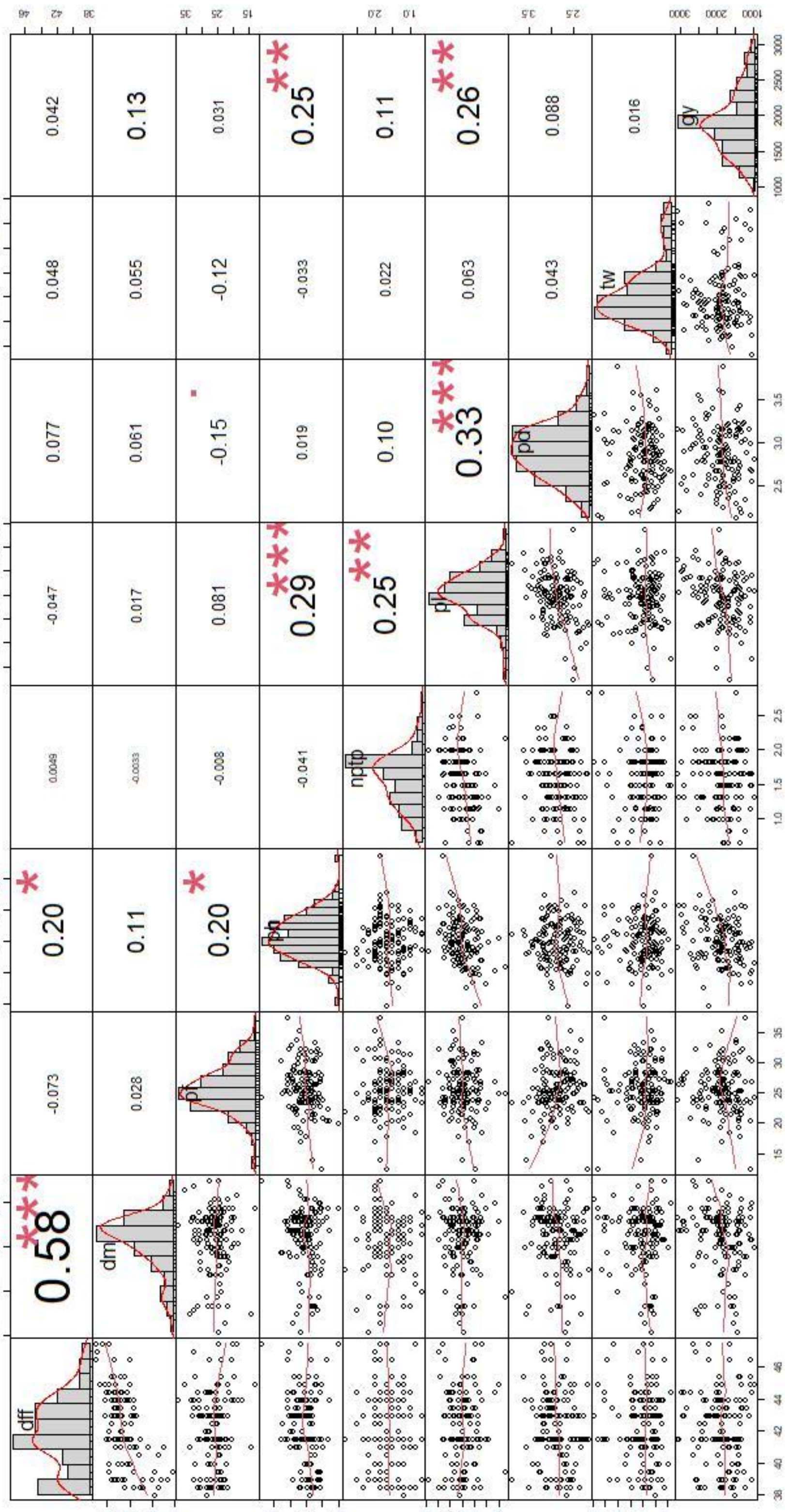

Fig. 1. Genotypic correlation for yield and yield contributing traits in Pearl millet

dff: Days to 50 % flowering, dm: Days to maturity, pp: Population (number./net plot), ph: Plant height , nptp: Productive tillers (number/plant), pl: Panicle length pd: Panicle diameter , tw: 1000 - grain weight , gy: Grain Yield and Priyanka *et al.* (2019); however, low GCV and PCV values were observed for days to 50% flowering (4.44, 6.09), days to maturity (3.33, 5.38) and plant height (5.37, 8.16), indicating a limited range of variability for these traits and thus limiting the possibility for easy selection. Patel *et al.* (2019) and Narasimhulu *et al.* (2021) also reported similar findings for days to flowering and days to maturity.

Unless and until the heritability of phenotypic traits is understood, the genotypic coefficient of variation does not provide a precise indication of the level of genetic advantage to be expected (Burton, 1952). The estimates of heritability in a broad sense for the nine traits examined ranged from 10.38 per cent for productive tillers per plant to 77.05 per cent for 1000 grain weight (**Table 2**). The 1000 grain weight (77.05 %) had the highest heritability, followed by the grain yield (73.42%). Grain yield had a high GCV and heritability, indicating that it is less affected by environmental factors and offers considerable scope for improvement through simple selection.

Genetic gain from the selection can be estimated using heritability, but genetic advance expressed as per cent of mean (GAM) is more precise and reliable. Grain yield (73.42, 41.07) had high heritability and a high genetic advance as per cent of mean, followed by 1000 grain weight (77.05, 34.73), indicating that additive gene action prevails and selection is effective for these traits. Sangwan *et al.* (2019) and Narasimhulu *et al.* (2021) provided similar confirmatory results for grain yield and 1000 grain weight. For panicle diameter, a low heritability (17.66 %) was observed in conjunction with a low GAM (5.5), indicating that the environment has a significant influence on this character and that direct selection may be ineffective. To summarize genetic parameters, high GCV, heritability and genetic advance as a per cent of mean were observed for 1000-grain weight and grain yield, implying that additive gene activity is the primary cause of the genetic variance.

It is difficult to improve grain yields that are quantitatively inherited through simple selection. As a result, other highly heritable and easily selectable characteristics can be used to improve grain yields. Correlation between multiple traits enables the selection of superior genotypes *via* a phenotypic selection of easily heritable characters. Each variable's distribution is exhibited on the diagonal (**Fig.1**). The vicariate schematic model plots with a line of best fit are seen on the lower side. The values of the association are labelled with critical values as stars above the diagonal. The correlation matrix is used to look at the interdependence of several variables simultaneously. The grain yield increase was significantly associated with panicle length (0.26**) and plant height (0.25**) increases. Similarly, Anuradha *et al.* (2020) and Annamalai *et al.* (2020) previously reported a positive correlation between grain yield and plant height and panicle length. Grain yield, on the other hand, demonstrated a non-significant positive correlation with all other traits, including days to maturity (0.13), the number of productive tillers per plant (0.11), panicle diameter (0.088), days to 50 % flowering (0.042), plant population (0.031) and 1000 grain weight (0.016). A similar kind of non-significant association was revealed earlier by Annamalai *et al.* (2020) for days to 50 % flowering and panicle diameter. Narasimhulu *et al.* (2021) also found a similar kind of grain yield association with days to 50 % flowering, day to maturity, the number of productive tillers per plant and panicle diameter.

Inter-correlation analysis revealed a strong and positive relationship between panicle length and panicle diameter (0.33**), plant height (0.29**) and productive tiller number per plant (0.25**). Nehra *et al.* (2017) reported similar results for the number of productive tillers per plant and Sundar Lal Dadarwal *et al.* (2020) reported similar results for panicle diameter, plant height and the number of productive tillers per plant. Increased plant height was associated with a large population (0.20*), delayed flowering (0.20*) and proportionate increase in panicle length (0.29**). Additionally, the days to 50 % flowering had a stronger relationship (0.58**) with the days to maturity. Kumawat Kana Ram *et al.* (2019) and Narasimhulu *et al.* (2021) reported similar results for days to 50 % flowering; Annamalai *et al.* (2020) reported similar results for panicle length and Sundar Lal Dadarwal *et al.* (2020) reported similar results for panicle length and days to 50 % flowering. The present study established a link between grain yield and yield component characteristics such as 1000 grain weight, panicle length, panicle diameter and plant height. As a result, selection for these traits may prove beneficial for pearl millet yield improvement.

In a nutshell, when selecting for high yielding genotypes, the 1000 grain weight, panicle length, panicle diameter, plant height and the number of productive tillers per plant were given high priority. ABH-61 had the highest grain yield and excelled in the majority of yield related traits among the 140 pearl millet experimental hybrids evaluated, followed by ABH-50 and ABH-77, which were considered promising for high grain yield under dryland conditions.

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