Research Article

Performance, Genetic Variability and Association Analysis of Pearl Millet Yield Attributing Traits in Andhra Pradesh's Arid Region

R Narasimhulu[1]*, B Sahadeva Reddy[1], C Tara Satyavathi[2] and B.C Ajay[3]

[1]Agricultural Research Station (Acharya N.G. Ranga Agricultural University), Ananthapuramu, Andhra Pradesh
[2]All India Coordinated Research Project on Pearl Millet, Mandor, Rajasthan
[3]Regional Research Station, ICAR-Directorate of Groundnut Research, Ananthapuramu, Andhra Pradesh

Abstract

The current study was carried out to estimate the genetic parameters of 95 pearl millet hybrids and to investigate the relationship between nine yield attributing traits during *Kharif*, 2020. The research found a wide range of variation in quantitative traits. ATPH-16, ATPH-81, ATPH-56, ATPH-40, and ATPH-12 were found to be promising for higher yield and suitable for dryland conditions based on the mean performance of new experimental hybrids. GCV and PCV were highest for the number of productive tillers per plant, plant population per plot, and grain yield. For number of productive tillers per plant and grain yield, high heritability was observed, along with high genetic advance as a percentage of mean, implying that these traits were probably due to their high additive gene effects, and that simple directional selection may be effective to improve these traits. Plant population per plot and 1000-grain weight had a significant and positive relationship with seed yield. As a result, maintaining an optimal plant population under dryland conditions and selecting for genotypes with large seed sizes could help improve seed yield in pearl millet.

Keywords: Pearl Millet, Genetic Parameters, Association Analysis, *per se* performance and Grain Yield

***Correspondence**
Author: Narasimhulu R
Email: narsi46@gmail.com

Introduction

Pearl millet (*Pennisetum glaucum* L.R.Br.) is staple food crop for people living in dry regions of arid and semi-arid tropics. It is well-adapted to nutrient-depleted soil and low rainfall conditions, yet it is capable of grow quickly and vigorously in the right conditions [1]. After rice, wheat, and maize, pearl millet is the fourth most widely cultivated food crop in India and it occupies an area of 7.5 m ha with a production of 9.8 million tons and productivity of 1243 kg/ha [2]. Nutritionally pearl millet is rich source of proteins (6-15%), fat (5-6%), fiber (1-1.8%), minerals like iron, calcium, zinc and essential amino acids when compared to other cereals [3]. Pearl millet cultivation is the heart of dry land agriculture in the current changing climate situation; as a C_4 plant, it can efficiently utilize sunlight and water, addressing both food and nutritional security in the arid region. The arid tracts are grown with the landraces/OPVs (open pollinated varieties) that are poor yielders. The low production of pearl millet in India necessitates the development of stable, high-yielding varieties and hybrids that are more adaptable. The cytoplasmic male-sterility (CMS) system has increased pearl millet yield significantly by allowing commercial hybrid seed production [4-5]. The progress of any crop improvement is determined by the degree of variability and relationships among quantitative traits of that crop. The aim of this research was to assess the effectiveness of different experimental hybrids, as well as to determine variation among the grain yield and related traits and assess the relationship between traits and grain yield. Furthermore, to identify the best suitable hybrids and to develop efficient selection criteria for increasing pearl millet grain yield.

Materials and Methods

The experimental material included 90 test crosses and five popular hybrids used as controls in the observational hybrid trial. The experiment was carried out at the Agricultural Research Station, ANGRAU, Ananthapuramu (latitude: 14° 41' N, longitude: 77° 40' E, and elevation: 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, 95 hybrids of pearl millet were planted in an Alpha lattice design in 8 blocks with 12 hybrids in each block and 2 replications. Each hybrid represents one row of 4 m length spaced 50 cm apart with 15 cm between hills. To ensure a single plant per hill, thinning was performed after 20 days of germination when the plant height was 10- 15 cm. 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 30 kg Nitrogen per hectare 35 days after seeding. To achieve good crop growth, standard cultural and agronomic practices were used. Data on the following nine yield parameters were collected for all hybrids in the experiment: Days to 50% flowering, Days to maturity, Plant Height (cm), Number of productive tillers per plant, Panicle length (cm), Panicle diameter (cm), Test weight (g), Grain yield (kg/ha). Except for days to 50% flowering, maturity, and grain yield, which are recorded on a plot-by-plot basis, five random competitive plants, excluding border plants, were chosen for data collection in each plot. The analysis of variance (ANOVA) method was used, as described [6]. The variability parameters, genotypic and phenotypic coefficients of variation (GCV and PCV), were calculated using [7]. To calculate estimates of broad sense heritability, the method proposed [8] was used. The expected genetic advance was calculated using the method proposed [9]. PCV and GCV [10] and GA and GAM [9] were divided into three categories: low (0-10%), moderate (10.1-20%), and high (>20%). Heritability was divided into three categories: low (0-30%), moderate (30.1-60%), and high (>60%) [10]. Pearson's correlation coefficients for the nine individual traits were calculated using R-software [11].

Results and Discussion

In the present study the analysis of variance revealed highly significant differences among hybrids for all the traits (**Table 1**), which indicates presence of sufficient variability and scope for further selection and breeding superior and desirable genotypes. Mean performance of top ten high yielding hybrids for different yield attributes were presented in **Table 2**. The new experimental hybrids ATPH-16 (4781.50 kg/ ha), ATPH-81 (4102.50 kg/ ha), ATPH-56 (3762.50 kg/ ha), ATPH-40 (3367.00 kg/ ha), and ATPH-12 (3042.50 kg/ ha) performed admirably for the majority of yield traits and had the best *per se* performance, when compared to that of best commercial check KSB (2974.50 kg/ ha). As a result, after multilocation trials, these potential hybrids can be commercially exploited.

Table 1 Analysis of variance (ANOVA) for yield attributing traits in 95 pearl millet hybrids

Source	DF	Mean sum of squares								
		Days to 50 % flowering	Days to maturity	Population (no./ net plot)	Plant Height (cm)	Productive tillers (no./ plant)	Panicle Length (cm)	Panicle Diameter (cm)	1000 - grain weight (g)	Grain Yield (kg/ ha)
Replication	1	23.63	2.55	1.35	318.50	1.69**	22.58*	2.43*	1.56	86201.00
Genotype	94	9.53*	7.36*	54.68**	1000.00 *	0.85**	16.4*	0.62**	7.92**	1421626.00 **
Rep: Block	7	3.14	0.98	50.15	358.90	0.07	23.61*	0.22	1.36	129858.00
Residuals	87	6.34	5.55	28.75	617.60	0.14	10.00	0.37	2.25	91703.00

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

The mean, range of variation and the estimate of genetic parameters such as heritability in broad sense, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV) and genetic advance as *per cent* of mean are illustrated in **Table 3**. In the present study, large differences in mean values for all the traits were observed. The trait grain yield ranged from 112.50 to 4781.50 kg/ha, days to 50% flowering from 39.50 to 53.00, days to maturity from 71.50 to 82.00, plant height from 118 to 227 cm, number of productive tillers per plant from 0.50 to 3.15, panicle length from 17.40 to 36.90 cm, panicle diameter from 2.10 to 4.30 cm and 1000 - grain weight from 8.25 to 19.10 g. The experimental material had wide range of variability and favorable mean performance for most of the traits studied and these possible combinations could be exploited as potential hybrids aimed for simultaneous improvement of grain yield and other yield attributing traits. The PCV was higher magnitude than GCV for all the traits, indicating the presence of influence of environment in the expression of these traits. However, differences between them were not of high magnitude. High estimates of GCV and PCV were observed for grain yield (46.38, 49.48), number of productive tillers per plant (32.01, 37.86) and plant population (20.07, 35.99). This meant that genotypes had a great deal of intrinsic variability, making them more useful for selection. Likewise, high estimates of variability were also reported [12 -13] for number of productive tillers per plant and for grain yield which corroborates with the findings of the present study.

Hight to moderate co-efficient of variation was observed for panicle diameter (11.27, 22.71), test weight (13.72, 18.37), whereas moderate to low co-efficient of variation was observed for plant height (7.48, 15.39) and panicle length (6.88, 13.98). which is in agreement with the findings [14] for panicle diameter; [15] for both plant height and panicle diameter and [16] for plant height. Low GCV and PCV was noticed for days to 50% flowering (2.78, 6.20) and days to maturity (1.22, 3.26) indicating a limited range of variability for these traits, limiting the possibilities for easy selection. Similar kind of findings were also reported [17-18] for days to flowering and days to maturity.

Table 2 Mean performance of top ten pearl millet hybrids along with checks for nine yield attributing traits

Hybrids	Days to 50 % flowering	Days to maturity	Population (no./net plot)	Plant Height (cm)	Productive tillers (no./ plant)	Panicle Length (cm)	Panicle Diameter (cm)	1000 - grain weight (g)	Grain Yield (kg/ ha)
ATPH-16	51.50	82.00	21.50	202.00	1.65	26.35	3.60	16.15	4781.50
ATPH-81	45.00	79.00	34.00	198.50	2.30	28.15	2.60	10.80	4102.50
ATPH-56	46.00	79.50	20.50	192.50	2.15	23.65	2.60	13.70	3762.50
ATPH-40	46.50	77.00	23.50	203.00	0.85	27.60	3.80	11.15	3367.00
ATPH-12	46.00	79.00	19.00	188.00	1.80	27.20	3.90	12.00	3042.50
ATPH-66	47.00	80.50	17.50	210.50	1.35	25.65	3.25	12.30	2969.50
ATPH-01	42.50	76.50	15.00	129.00	2.00	22.10	2.35	13.70	2842.50
ATPH-15	46.50	79.00	15.50	195.50	1.85	27.90	3.50	13.45	2816.00
ATPH-05	42.00	75.50	28.00	186.50	2.50	24.95	3.75	10.80	2783.50
ATPH-33	47.00	79.50	20.50	200.50	1.15	27.05	3.95	12.00	2781.50
KSB#©	45.00	77.00	20.50	186.50	1.85	26.05	3.20	11.80	2974.50
HHB299©	42.50	75.50	17.50	176.50	1.50	23.85	3.55	11.00	2058.50
86 M 64©	45.50	78.50	13.50	196.00	1.85	26.95	3.30	10.00	2038.00
Pratap©	41.00	71.50	18.00	180.00	1.80	22.70	2.70	13.40	1815.00
PHB 3©	46.00	78.00	14.50	185.00	1.35	22.50	3.50	14.55	838.50
C.V. (%)	**5.38**	**2.90**	**30.00**	**13.05**	**19.78**	**12.66**	**19.46**	**11.88**	**17.39**
SE.m±	**1.73**	**1.60**	**3.89**	**17.03**	**0.26**	**2.33**	**0.43**	**1.03**	**215.95**
C.D at 5%	**4.85**	**4.48**	**10.91**	**47.82**	**0.72**	**6.55**	**1.20**	**2.90**	**606.22**

© checks, #© Best performing check (Kaveri Super Boss)

Table 3 Mean, range, coefficients of variation, heritability (broad sense) and genetic advance as *per cent* of mean for yield attributing traits in 95 pearl millet hybrids

S. No.	Traits	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	45.44	39.50	53.00	1.60	7.93	2.78	6.20	20.12	2.57
2	Days to maturity	77.85	71.50	82.00	0.91	6.45	1.22	3.26	14.02	0.94
3	Population (no/net plot)	17.95	7.00	34.00	12.97	41.71	20.07	35.99	31.09	23.05
4	Plant Height (cm)	184.80	118.00	227.00	191.20	808.76	7.48	15.39	23.64	7.49
5	Productive tillers (no./ plant)	1.86	0.50	3.15	0.35	0.50	32.01	37.86	71.52	55.77
6	Panicle Length (cm)	25.99	17.40	36.90	3.20	13.20	6.88	13.98	24.22	6.98
7	Panicle Diameter (cm)	3.09	2.10	4.30	0.12	0.49	11.27	22.71	24.64	11.53
8	1000 - grain weight (g)	12.27	8.25	19.10	2.83	5.08	13.72	18.37	55.76	21.10
9	Grain Yield (kg/ ha)	1758.16	112.50	4781.5	664961.39	756664.28	46.38	49.48	87.88	89.57

The proportion of variability transferred from parent to offspring's could be studied by calculating heritability parameters. The perusal of the Table 3 revealed the estimates of heritability in broad sense for nine traits studied, which ranged from 14.02 to 87.88 *per cent*. The highest heritability was registered for grain yield (87.88) followed by number of productive tillers per plant (71.52). Both grain yield and the number of productive tillers per plant have high GCV and heritability, indicating that these traits are less affected by the environment and offer great scope for improvement through simple selection procedures. Heritability estimates coupled with expected genetic advance as *per cent* of mean indicates the mode of gene action and assist in choosing an appropriate breeding methodology. High heritability coupled with high genetic advance as *per cent* of mean was recorded for grain yield followed by number of productive tillers per plant, indicating the presence of additive gene action and scope for genetic improvement through simple selection for these traits. Such confirmatory results were also given [19] for grain yield per plant.

Furthermore, understanding the relationships between plant traits will aid in the development of effective breeding strategies by allowing for the formulation of effective selection indices that will result in the development of productive genotypes. It was observed that the traits *viz.*, plant population (0.37) and test weight (0.18) were found to be significantly associated with higher grain yield (**Figure 1**). Similarly, positive association of grain yield with1000-grain weight was reported earlier [20-21]. However, grain yield revealed non-significant positive correlation with other traits like panicle diameter (0.15), plant height (0.15), days to maturity (0.10), number of productive tillers per plant (0.083) and days to 50% flowering (0.027). But panicle length (-0.047) exhibited non-significant negative correlation with grain yield. These findings were supported [21].

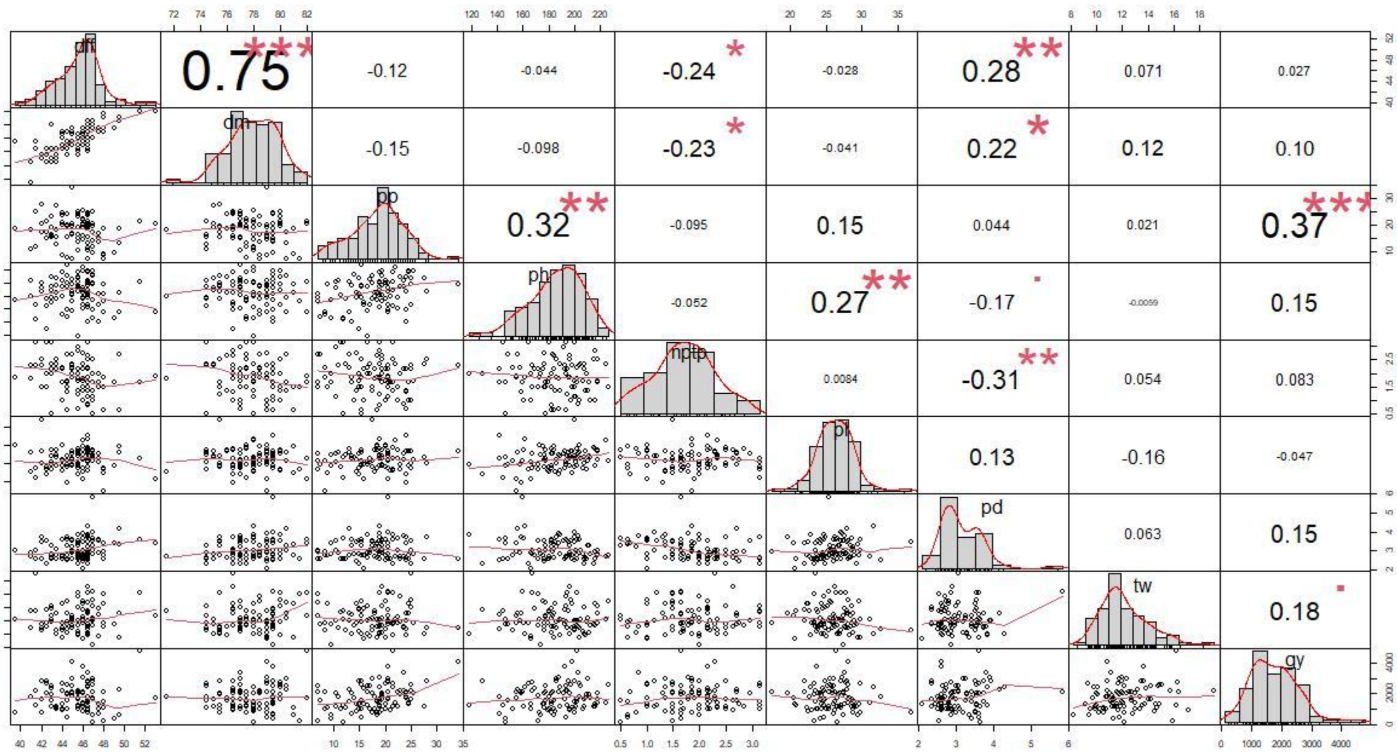

Figure 1 Genotypic correlation for yield and yield attributing traits in Pearl millet
dff: Days to 50 % flowering, dm: Days to maturity, pp: Population (no./ net plot), ph: Plant Height (cm), nptp: Productive tillers (no./ plant), pl: Panicle Length (cm) , pd: Panicle Diameter (cm), tw: 1000 - grain weight (g), gy: Grain Yield (kg/ ha)

From the inter-correlation studies, it was observed that days to 50% flowering exhibited significant and positive association with days to maturity (0.75) which was also confirmed [22]. Early flowering/maturation hybrids with less productive tillers per plant (-0.24) and had larger panicle diameters (0.28). Similar results were reported [23-25] for number of productive tillers per plant. However, the length of a panicle is proportional to the plant's height and population. These results are in consonance with [13].

Conclusion

Analysis of variance revealed substantial differences among hybrids for all the traits with sufficient variability and scope for selecting suitable genotypes. In the current study it is clear that maintaining optimal plant populations with genotypes having bold seed size, ideal plant height, and panicle diameter could improve grain yield in dryland regions. ATPH-16, ATPH-81, ATPH-56, ATPH-40, and ATPH-12 were discovered to have potential for most of the traits and to be promising for high grain yield under dryland conditions.

References

[1] Maiti R K and Bidinger F R. 1981. Growth and development of pearl millet plant. ICRISAT Research Bulletin. 6.
[2] Anonymous, 2019-20. Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers

Welfare (MoA&FW), India
[3] Fleck H.1981 Introduction to nutrition. Macmillan Publishing Co., Indi. 49(9).
[4] Bidinger F R, Weltzien E, Mahalakshmi R V, Singh S D, and Rao K P. 1994. Evaluation of landrace topcross hybrids of pearl millet for arid zone environments. Euphytica. 76(3): 215-226.
[5] Kelley T G, Rao P P, Purohit M L and others. 1996. Adoption of improved cultivars of pearl millet in an arid environment: straw yield and quality considerations in western Rajasthan. Experimental Agril. 32(02): 161-171.
[6] Singh R K and Chowdary B D. 1985. Biometrical methods in Quantitative Genetic Analysis. Kalyani Pub., N. Delhi, India:38-54.
[7] Burton G W. 1952. Quantitative inheritance in grasses. Proceedings of 6th International Grassland Congress. 1: 277-283.
[8] Lush J L. 1940. Intra-sire correlation and regression of offspring of dams as a method of estimating heritability of characters. Proceedings of American Society of Animal Production. 33: 293-301.
[9] Johnson H W, Robinson J F and Comstock R E. 1955. Estimates of genetic and environmental variability in soybean. Agronomy Journal. 47: 314-318.
[10] Robinson H F, Comstock R E and Harney P H. 1949. Estimates of heritability and degree in corn. Agronomy Journal. 41: 353-359.
[11] R Development Core Team. 2020. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.
[12] Nehra M, Kumar M, Kaushik J, Vart D, Sharma R K and Punia M S. 2017. Genetic divergence, character association and path coefficient analysis for yield attributing traits in pearl millet [Pennisetum glaucum (L.) R. Br] inbreds. Chemical Science Review and Letters. 6(21): 538-543.
[13] Anuradha N, Tara S C, Bharadwaj C, Sankar M and Lakshmi Pathy T. 2018. Association of agronomic traits and micronutrients in pearl millet. International Journal of Chemical Studies. 6(1): 181- 184.
[14] Patil S K, Gupta S K, Dangi K S, Sashibhushan D, Balram M and Ramesh T. 2018. Panicle traits and plant height are important selection indices to enhance productivity in pearl millet [Pennisetum glaucum (L.) R. Br.] Populations. International Journal of Current Microbiology and Applied Sciences. 7(12): 306-312.
[15] Sowmiya P, Sumathi P and Revathi S. 2016. Estimates of genetic parameters and quantification of beta-carotene in pearl millet [Pennisetum glaucum L.] segregating population. Electronic Journal of Plant Breeding. 7(3): 640-648.
[16] Shankar Lal Yadav, Vikas Khandelwal, Rajpurohit B S, Tara Satyavathi C and Manisha Kumari. 2020. Genetic Variability for Grain Iron, Zinc and Yield Contributing Traits in Pearl Millet [Pennisetum glaucum (L.) R. Br.]. International Journal of Current Microbiology and Applied Sciences. 9(10): 1927-1932.
[17] Sharma B, Chugh L K, Sheoran R K, Singh V K and Sood M. 2018. Study on genetic variability, heritability and correlation in pearl millets germplasm. Journal of Pharmacology and Phyto chemistry. 7(6): 1983-1987.
[18] Patel J M, Patel M S, Soni N V, Patel H N and Prajapati N N. 2019. Genetic architecture of morpho-physiological traits over environments in pearl millet [Pennisetum glaucum (L.) R. Br.]. Electronic Journal of Plant Breeding. 10(1): 127-136.
[19] Sangwan S, Yashweer S, Kumar R, Hemender, Sharma S and Redhu N. 2019. Multivariate analysis reveals substantial diversity in pearl millet (Pennisetum glaucum (L.) R. Br.) inbred lines. Journal of Experimental Biology and Agricultural Sciences. 7(4): 358-375.
[20] Subbulakshmi K, Sumathi P, and Babu C. 2018. Association Study of Grain Yield and Nutritional Quality Traits in Pearl Millet [Pennisetum glaucum (L.) R. Br.] Hybrids. International Journal of Current Microbiology and Applied Sciences. 7(10): 2035-2039.
[21] Annamalai R N, Aananthi M, Arumugam Pillai and Leninraja D. 2020. Assessment of Variability and Character Association in Pearl Millet [Pennisetum glaucum (L.) R.Br.]. International Journal of Current Microbiology and Applied Sciences. 9(06): 3247-3259.
[22] Shobha Rani T, Kumar S C V, Maheswaramma S, Parimal M, Kumar A G and Sravanthi K. 2019. Selection criteria for grain yield in pearl millet (Pennisetum glaucam L.) in association with yield contributing traits. International Journal of Pure & Applied Bioscience 7(3): 257-262.
[23] Bhasker K, Shashibhushan D, Murali Krishna K, and Bhave M H V. 2017. Correlation and path analysis for grain yield and it components in Pearl Millet [Pennisetum glaucum (L). R. Br.]. Bulletin of Environment, Pharmacology and Life Sciences 6 (1):104-106.
[24] Kumawat, Kana Ram N K, Sharma and Nemichand Sharma. 2019. Genetic variability and character association analysis in pearl millet single cross hybrids under dry conditions of Rajasthan. Electronic Journal of Plant Breeding 10(3):1067-1070.

[25] Rasitha R, Iyanar K, Ravikesavan R and Senthil N. 2019. Studies on genetic parameters, correlation and path analysis for yield attributes in maintainer and restorer lines of pearl millet [Pennisetum glaucum (L.) R. Br.]. Electronic Journal of Plant Breeding. 10(2): 382-388.

Publication History

Received	30.04.2021
Revised	22.05.2021
Accepted	22.05.2021
Online	25.05.2021