Biological Forum – An International Journal **14(1): 416-421(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Genetic Parameters and Association Studies for Yield and Yield Contributing Traits in Pearl Millet Cultivars

D. Shashibhushan**, C.V. Sameer Kumar and Ravi Kiran Reddy Kondi
Department of Genetics and Plant Breeding, PJTSAU, Hyderabad, Telangana, India.

(Corresponding author: D. Shashibhushan)*
(Received 12 October 2021, Accepted 17 December, 2021)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The genetic characteristics for eight quantitative traits were studied using a set of 40 pearl millets genotypes. Peral millet is the only crop which is enriched with nutrients and can give robust yield under harsh conditions. Therefore, exploring the variability, heritability and other parameters can make it as potential crop for future. Analysis of variance revealed significant differences for all studied parameters in the experimental materials. All characters have a high broad sense heritability. Except for days to maturity, all traits had the highest heritability when combined with GAM. GCV values were highest for productive tillers/plant and fodder yield/plot. Plant height, productive tillers per plant, yield per plant, and fodder yield per plot all had the highest PCV. At both the genotypic and phenotypic levels, grain yield per plant demonstrated a strong significant positive association with attributes such as fodder yield per plot, productive tillers per plant, panicle length, and panicle diameter. Characters like days to 50% flowering, productive tillers per plant, panicle length, fodder yield per plot, and panicle diameter showed positive direct effects, with fodder yield per plot, productive tillers per plant, panicle length, and panicle diameter showing true relationships with grain yield per plant, according to genotypic path coefficient analysis.

Keywords: Pearl millets, RBD, Genetic parameters, GCV, PCV, Association analysis.

INTRODUCTION

Millions of people in the tropics of dry and semi-arid regions used to eat pearl millet [*Pennisetum glacum*. (L).R.Br], a warm-season cereal crop. It's a robust, quickly growing type with good yield potential and strong tillering capability with temperature range for germination is 23 to 32°C (Kakarla *et al.*, 2021). Many cereal crops, such as maize and sorghum, unable to provide economic yields under tough agro-climatic circumstances, however the pearl millet crop endures. Pearl millet has an ideal rainfall requirement of 500-800 mm, however it can thrive in places with less than 500 mm of annual rainfall. Because it provides a good source of energy, carbohydrate, protein, fat, ash, dietary fibre, iron, and zinc, pearl millet is rightly referred to be a "nutri grain" (Kakarla *et al.*, 2021). It's a drought-resistant crop that's grown in over 30 countries across five continents, including Asia, Africa, North America, South America, and Australia. It is mostly grown as a food grain in India and Africa (Pawase *et al*., 2021). It is the 8th most important cereal crop in the world, after wheat, rice, maize, and sorghum, and the fifth most significant crop in India. India is a major grower of pearl millet, both in terms of geography and production (Rasitha *et al.*, 2019). India is the largest pearl millet grower, with 43.3 percent of the planet's area and 42 percent of the world's production. In India, it is annually grown on 7.5 million ha area producing nearly 9.73 million tones of grains with productivity of 1305 kg/ha during 2016-17 (Directorate of Millet Development, 2018). It is mostly grown in states like Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Uttar Pradesh, and Tamil Nadu (Rana *et al*., 2012). For breeding projects attempting to generate improved landrace-based cultivars for tough growing environments, landrace genetic variation is crucial (Yadav *et al*., 2001). Climatic change can have an impact on a genotype's performance, and if the traits' heritability is stronger, the selection procedure will be simpler and the responsiveness to selection will be higher (Larik *et al*., 2000; Soomro *et al.*, 2008). Grain yield is a quantitative trait that is also quantitatively regulated (Sowmiya *et* *al*., 2016). Selection only on the basis of grain yield character is rarely practical or efficient. In the generation of improved varieties/hybrids, the amount of variability and heritability should be present in an experimental material. This variability can be used for breeding the future crop which can give potential yield with quality. The extent of variation is determined by using GCV and PCV, that provide knowledge on variance on the traits under studied. In discovering the most effective experimental material for crop development, heritability, along with genetic advance, has played a vital role. In order to assess variability, heritability, and genetic advance for yield and yield contributing traits in a group of 40 pearl millet cultivars, the current study was performed.

MATERIALS AND METHODS

A total of 40 pearl millet genotypes were used in the study. In 2017, a field trial was undertaken at the Regional Agricultural Research Station in Palem, PJTSAU. Table 1 lists the genotypes in more detail. The experiment was repeated three times using Randomized Block Design. Seeds of 40 pearl millet genotypes were immediately sowed in the field at a 45 × 15 cm spacing. 6 rows of each genotype, each 6 meters long, were used to represent each genotype. To raise a good crop, proper agronomic procedures were used. Observations were made for economically important biometrical traits such as days to 50% flowering, days to maturity, plant height, productive tillers per plant, panicle diameter, panicle length, yield per plant, and fodder yield per plot on 10 randomly selected pearl millet plants at various growth stages. Panse and Sukhatme's (1985) method, were used to construct the analysis of variance. Burton's (1952) formulae for genotypic and phenotypic coefficients of variation, and Johnson *et al.* (1955) method for heritability and genetic advance. The correlation coefficient was determined according to Al-Jibouri *et al.* (1958). The path coefficient study was carried out according to the procedures provided by Wright (1921); Dewey and Lutetium (1959). R-studio was used to perform statistical analysis.

Table 1: Pearl millet lines tested in the study.

Sr. No.	Millet lines	Sr. No.	Millet lines	Sr. No.	Millet lines	Sr. No.	Millet lines
1.	Fe-101-1	11.	Fe-111-30	21.	Fe-121-34	31.	Fe-131-29
2.	Fe-102-37	12.	Fe-112-9	22.	Fe-122-20	32.	Fe-132-2
3.	Fe-103-28	13.	Fe-113-16	23.	Fe-123-11	33.	Fe-133-4
4.	Fe-104-24	14.	Fe-114-6	24.	Fe-124-35	34.	Fe-134-36
5.	Fe-105-17	15.	Fe-115-18	25.	Fe-125-39	35.	Fe-135-31
6.	Fe-106-15	16.	Fe-116-10	26.	Fe-126-26	36.	Fe-136-19
7.	Fe-107-27	17.	Fe-117-25	27.	Fe-127-12	37.	Fe-137-38
8.	Fe-108-3	18.	Fe-118-32	28.	Fe-128-8	38.	Fe-138-13
9.	Fe-109-23	19.	Fe-119-33	29.	Fe-129-14	39.	Fe-139-22
10.	Fe-110-5	20.	Fe-120-40	30.	Fe-130-7	40.	Fe-140-21

RESULTS AND DISCUSSIONS

To partition the variances into their components, analyses of variance was performed. The findings of the analysis revealed that all of the traits have extremely significant differences (Table 2). Days to 50% flowering (43-69), days to maturity (79-106), plant height (71-188 cm), productive tillers per plant (2-5), panicle width (1.9-3.8 cm), panicle length (12-28cm), fodder yield per plot (0.48-1.73), and grain yield per plot (20-50) were all reported as genetic possible ranges for distinct parameters. Days to 50% flowering (94.37), productive tillers per plant (94.35), fodder yield per plot (92.49), panicle width (91.89), panicle length (90.92), plant height (88.88), yield per plant (88.38), and days to maturity (86.96) all showed strong heritability in the broad sense. Bajaj and Phul (1982), Chand *et al.* (2008); Govindaraj *et al.* (2010) all came to similar conclusions. With the exception of days to maturity, all of the characters showed high GAM, productive tillers per plant (62.78), fodder yield per plot (49.15), plant height (38.70), yield per plant (37.76), panicle diameter (36.59), panicle length (31.49), days to 50% flowering (20.30). All variables exhibited the highest heritability and GAM, with the exception of days to maturity (11.72), indicating that additive gene action and selection will be efficient for such variables. Jyothsna *et al.* (2016); Subbulakshmi *et al.* (2018); Sumathi *et al*. (2010) reported similar results. The phenotypic coefficient of variance (PCV) was slightly higher than the genotypic coefficient of variance (GCV) for all of the variables studied, indicating that genotype and environment interacted (Table 3). The tight match between the related PCV and GCV estimates in virtually all of the traits indicated that environmental factors played a minor role in their development. Similar findings were reported by Subbulakshmi *et al*. (2018). GCV was greatest for productive tillers per plant and fodder yield per plot, and intermediate for variables such as days to 50% blooming, plant height, panicle diameter, panicle length, and yield per plant. Days to maturity had the lowest GCV. Plant height, productive tiller per plant, yield per plant, and fodder yield per plot all had the highest PCV.

PCV was moderate in the days to 50% blooming and panicle length, and the lowest in the days to maturity. Govindaraj *et al.* (2010) observed similar findings. At the genotypic level, grain yield per plant showed a high positive association with characters like fodder yield per plot (0.8873**), productive tillers per plant (0.7355**), panicle length (0.6062**), and significantly positively correlated with panicle diameter (0.4014 *), but not with characters like days to 50% flowering, days to maturity, and plant height.

Table 2: Analysis of variance of replication, treatments and error for 21 characters in 41 rice genotypes.

Sr. No.	Source of variation	Mean sum of square		
		Replication (df=2)	Treatment (df=39)	Error (df=78)
1.	Days to 50% flowering	3.908	99.550***	1.943
2.	Days to Maturity	11.725	99.282***	4.725
3.	Plant height (cm)	32.53	2146.100***	85.91
4.	Productive tillers /plant	0.100	2.490***	0.048
5.	Panicle Diameter (cm)	0.020	0.681***	0.019
6.	Panicle Length (cm)	0.743	26.542***	0.855
7.	Yield / plant (gm)	4.508	162.205***	6.807
8.	Fodder Yield / plot (Kg)	0.002	0.223***	0.005

**, ***Significant at 1% and 0.1% level

Table 3: Values of Range, Mean, Heritability broad sense [h^2], Genetic advance (GA), Genetic advance as percentage of mean (GAM), Genetic coefficient of variation (GCV), Phenotypic coefficient of variation (PCV) in present study.

Sr. No.	Characters	Minimum	Maximum	Mean	h^2 [b](%)	GA	GAM	GCV	PCV
1.	Days to 50% flowering	43	69	56.20	94.37	11.414	20.307	10.148	10.446
2.	Days to Maturity	79	106	92	86.96	10.785	11.722	6.102	6.543
3.	Plant height (cm)	71	188	131.48	88.88	50.893	38.707	19.930	21.140
4.	Productive tillers /plant	2	5	2.87	94.35	1.805	62.789	31.379	32.304
5.	Panicle Diameter (cm)	1.9	3.8	2.53	91.89	0.927	36.591	18.530	19.331
6.	Panicle Length (cm)	12	28	18.24	90.92	5.747	31.496	16.034	16.816
7.	Yield / plant (gm)	20	50	36.90	88.38	13.9385	37.765	19.500	20.741
8.	Fodder Yield / plot (Kg)	0.48	1.73	1.08	92.49	0.534	49.155	24.810	25.797

Days to 50% flowering were found to have a strong positive correlation with days to maturity. At the genotypic level, productive tillers per plant is extremely inversely connected with plant height and very positively correlated with fodder yield per plot. At the phenotypic level, characters like fodder yield per plot (0.8292 **), productive tillers per plant (0.664 **), panicle length (0.5802 **), and panicle diameter (0.3516 **) were shown to be significant but when compared to characters like days to 50% flowering, days to maturity, and plant height non-significant. Days to 50% flowering were found to have a strong positive correlation with days to maturity. At the phenotypic level, plant height is strongly linked with days to 50% flowering and days to maturity. At the phenotypic level, productive tillers per plant is extremely inversely connected with plant height and very positively correlated with fodder yield per plot. The results of the grain yield per plot matched those of Govindaraj and Selvi (2012); Kumar *et al.* (2014); Singh *et al.* (2016); Talawar *et al*. (2017). In the study, the genotypic and phenotypic link was demonstrated (Table 4). General correlation was presented in (Fig. 1).

Days to 50 percent flowering (0.52453), productive tillers/plant (0.5194), panicle length (0.35046), fodder yield/plot (0.30391), and panicle diameter (0.24834) all showed a positive direct effect, with grain yield per plant of which fodder yield per plot (0.8873 **), productive tillers per plant (0.7355 **), panicle length (0.6062 **), and panicle diameter (0.4014 *) showing a true relationship with grain yield per plant at the genotypic level, traits like days to maturity (-0.61515) and plant height (-0.01605) had a negative direct effect on grain yield per plant. Characters such as productive tillers per plant (0.4687), fodder yield per plot (0.35778), panicle length (0.32153), days to 50% flowering (0.16538), panicle diameter (0.15957), and plant height (0.01902) showed positive direct effects, of which productive tillers per plant (0.7355 **), fodder yield per plot (0.8873 **), panicle length (0.6062 **), and panicle diameter (0.4014 *) showing true relationship with grain yield per plot a t the phenotypic level, features like days to maturity (-0.23311) had a negative direct effect on grain yield per plant. As a result, selecting characters that have a direct effect on the genuine relationship increases grain production. These findings were found to be consistent with those of Govindaraj and Selvi (2012); Dapke *et al.* (2014); Kumar *et al*. (2014). The examination of genotypic and phenotypic path coefficients can be found in (Table 5).

Table 4: Genotypic and Phenotypic correlation for all the characters under study.

Characters	Correlation	DF	DM	PH	PT	PD	PL	FY	Y
DF	G	1 **	0.993 **	0.1923 NS	-0.1445 NS	0.3048 NS	0.0434 NS	-0.0196 NS	-0.0796 NS
	P	1 **	0.9738 **	0.207 *	-0.1452 NS	0.3 **	0.0661 NS	0.0142 NS	-0.0513 NS
DM	G		1 **	0.1858 NS	-0.1832 NS	0.3263 *	0.0439 NS	-0.0175 NS	-0.1013 NS
	P		1 **	0.2167 *	-0.1725 NS	0.3193 **	0.0765 NS	0.0312 NS	-0.062 NS
PH	G			1 **	-0.4305 **	0.2838 NS	0.2435 NS	-0.1269 NS	-0.1358 NS
	P			1 **	-0.3992 **	0.2603 **	0.232 *	-0.0829 NS	-0.0976 NS
PT	G				1 **	-0.0415 NS	0.0421 NS	0.5522 **	0.7355 **
	P				1 **	-0.0389 NS	0.0347 NS	0.5116 **	0.664 **
PD	G					1 **	0.2878 NS	0.3922 *	0.4014 *
	P					1 **	0.2978 **	0.3752 **	0.3516 **
PL	G						1 **	0.5611 **	0.6062 **
	P						1 **	0.5536 **	0.5802 **
FY	G							1 **	0.8873 **
	P							1 **	0.8292 **
Y	G								1 **
	P								1 **

Days to 50% flowering = DF, Days to Maturity = DM, Plant height (cm) = PH, Productive tillers /plant = PT, Panicle Diameter = PD, Panicle Length (cm) = PL, Yield / plant (gm) = Y, Fodder Yield / plot (Kg) = FY, G = genotypic and P = phenotypic correlation.

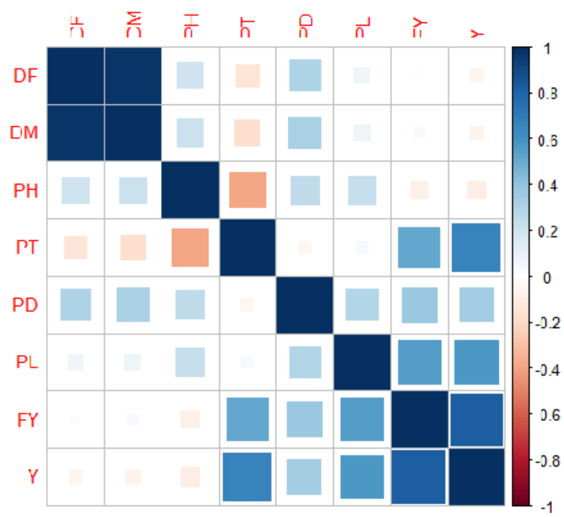

Fig. 1. Correlation heat map showing general correlation of the characters under study.

Table 5: Genotypic and Phenotypic Path analysis for the characters under study (Direct relation= diagonal highlighted one).

Characters		DF	DM	PH	PT	PD	PL	FY	Cor~Y
DF	G	**0.52453**	-0.61087	-0.00309	-0.07505	0.07569	0.0152	-0.00597	-0.0796 NS
	P	**0.16538**	-0.227	0.00394	-0.06802	0.04796	0.02125	0.0052	-0.0513 NS
DM	G	0.52089	**-0.61515**	-0.00298	-0.09516	0.08104	0.01537	-0.00531	-0.1013 NS
	P	0.16104	**-0.23311**	0.00412	-0.08086	0.05099	0.02463	0.01118	-0.062 NS
PH	G	0.10088	-0.11431	**-0.01605**	-0.2236	0.07048	0.08534	-0.03858	-0.1358 NS
	P	0.03423	-0.05051	**0.01902**	-0.18701	0.04158	0.0746	-0.02951	-0.0976 NS
PT	G	-0.07579	0.11271	0.00691	**0.5194**	-0.0103	0.01477	0.16782	0.7355 **
	P	-0.02401	0.04023	-0.00759	**0.4687**	-0.00631	0.01116	0.18183	0.664 **
PD	G	0.15988	-0.20074	-0.00456	-0.02154	**0.24834**	0.10085	0.1192	0.4014 *
	P	0.04965	-0.07441	0.00495	-0.0185	**0.15957**	0.09575	0.1347	0.3516 **
PL	G	0.02274	-0.02699	-0.00391	0.02189	0.07146	**0.35046**	0.17052	0.6062 **
	P	0.01093	-0.01786	0.00441	0.01626	0.04758	**0.32153**	0.19735	0.5802 **
FY	G	-0.0103	0.01074	0.00204	0.28681	0.0974	0.19664	**0.30391**	0.8873 **
	P	0.00241	-0.00732	-0.00158	0.23929	0.06045	0.17826	**0.35778**	0.8292 **

Days to 50% flowering = DF, Days to Maturity = DM, Plant height (cm) = PH, Productive tillers /plant = PT, Panicle Diameter = PD, Panicle Length (cm) = PL, Yield / plant (gm) = Y, Fodder Yield / plot (Kg) = FY.
Genotypic path Residual and phenotypic path Residual values are 0.0134 and 0.147

CONCLUSION

Variability most important for breeding potent varieties, by ANOVA we came to know there is significant amount variation present with the population for all studied parameters. All characters have a high broad sense heritability. Except for days to maturity, all traits had the highest heritability when combined with GAM this means selection of these characters is worthy in improving the yield ability of genotypes. PCV observed little bit high than GCV values showing environmental influence on the characters. Plant height, productive tillers per plant, yield per plant, and fodder yield per plot all had the highest PCV showing genotype and environmental interaction on character expression. At both the genotypic and phenotypic levels, grain yield per plant demonstrated a strong significant positive association with attributes such as fodder yield per plot, productive tillers per plant, panicle length, and panicle diameter showing true relationships with grain yield per plant, according to genotypic path coefficient analysis.

FUTURE SCOPE

Pearl millet is a potent crop for upcoming generations which is rich in mineral contents and energy source, which can used mostly used for diabetic patients and it also improves health conditions. It is the only crop which can grow under adverse conditions with little amount of water requirements. But yield is a potential barrier to meet the demands of the future generations, so by looking into the yield and yield contributing characters one can breed improved cultivar and looking into the diversity one break yield barrier along with good quality traits. So this study will provide enough data for future work.

Acknowledgement. Necessary facilities provided by Regional Agricultural Research Station in Palem, PJTSAU are acknowledged.

Conflict of Interest. None.

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How to cite this article: D. Shashibhushan, C.V. Sameer Kumar and Ravi Kiran Reddy Kondi (2022). Genetic Parameters and Association Studies for Yield and Yield Contributing Traits in Pearl Millet Cultivars. *Biological Forum – An International Journal*, *14*(1): 416-421.