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Assessment of Variability and Character Association in Pearl Millet [*Pennisetum glaucum* (L.) R.Br.]

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A B S T R A C T

The present investigation was carried out to study the genetic variability parameters and character association in fifty pearl millet genotypes for thirteen different biometrical traits. A wide range was observed for all parameters of genetic variability for all the traits. The traits like grain yield, seed weight per spike, number of productive tillers, flag leaf area, number of nodes per plant showed greatest variability and considered highly variable compared to other 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.

Introduction

Pearl millet [*Pennisetum glaucum* (L) R.Br], 2n = 14, is an annual C_4 coarse grained crop, ranked as the sixth most important global cereal crop widely cultivated by the resource poor farmers in arid and semi-arid regions of Africa and the Indian subcontinent (Srivastava *et al.,* 2019). It can thrive under adverse conditions like drought, salinity low rainfall and fertility (Kumawat *et al.,* 2019). It has higher potential for biomass production, multiple forage crop characteristics such as rapid regeneration efficiency, high tillering capacity, more leaf area, and greater green fodder yield and pest and disease tolerant.

Pearl millet remains as the major source of nutritious food for poorest people in semi-arid regions of tropical and sub-tropical countries. It is the staple food grain with a 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). In India, it is grown in an area of 7.4 million hectares with 9.13 million tonnes of production and a productivity of 1237 kg/ha (Directorate of millets Development). Pearl millet grains are rich in calories, proteins (6-15%), fat (5-6%), carbohydrates(60-72%), fibre (1-1.8%), vitamins, minerals and less amount of anti-nutritional factors like HCN, Phytic acid which makes it highly nutritive and palatable crop in comparison with other crops (Sharma *et al.,* 2018). Grain yield variability can be correlated with number of filled grains per spike and grain weight per spike are determined by genotype , environmental factors like temperature, soil and nutritional factors and availability of water (Ullah *et al.,* 2018). Improved grain yield of pearl millet depends upon contribution of the biometrical traits. The system for crop enhancement needs knowledge on genetic variability, interaction between yield and yield contributing traits. The main aim of plant breeding programmes is improvement of productivity which is measured in terms of yield per unit area. The complex nature of yield is associated with yield contributing traits which are interrelated among them. 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. Path analysis gives impact of each contributing characters to yield directly as well as indirectly and also helps the breeders to rate the genetic traits according their contribution. The objective of the present study was to assess genetic variability for yield and related traits 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 details of the genotypes are given in Table 1.

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. Each genotype represented by six rows of each six m length with 45cm between rows and 15 cm between plants. Appropriate agronomic practices were followed to raise a good crop. The Observations were recorded at various growth stage of pearl millet 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

Variability

The analysis of mean, range, various genetic variability parameters like genotypic coefficient of variance, phenotypic coefficient of variance, heritability, genetic advance and

genetic advance mean for different traits (Table 2) revealed that, the large differences in mean values for most of the traits were observed. Plant height ranged from 118.18 to 383.3 cm, grain yield 38.76 to 478.46 g, number of nodes per plant 20.60 to 292.8, flag leaf area 12.09 to 130.49 cm^2, days to fifty percent flowering 37 to 74 d, spike length 9.87 to 58.7 cm, peduncle length 3.34 to 46.82 cm , flag leaf length 9.34 to 40.98 cm , seed weight per spike 6.69 to 40.09 g, 1000 grain weight 1.88 to 20.79g , number of tillers per plant 3 to 18.8, number of productive tillers per plant 3 to 18.8 and flag leaf width 1.32 to 4.90 cm.

According to Deshmukh *et al.,* (1986) genotypic coefficient of variation (GCV %) and phenotypic coefficient of variance (PCV%) values greater than 20% are considered as high, whereas values less than 10% are regarded as low, and values between 10 and 20 considered to be medium. The estimated GCV % ranged from 12.03 for days to 50% flowering to 57.71 for grain yield and the corresponding values for PCV% were respectively 14.08 to 57.91. In the present analysis, high values of PCV and GCV were obtained for the traits like 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 and plant height. These results were similar to the earlier studies reported in Pearl millet by several workers Kumar, Ravindra, *et al.,* (2020), Priyanka *et al.,* (2019) for 1000 grain weight, Dapke *et al.,* (2014) for flag leaf area and seed weight per spike, Vinodhana *et al.,* (2013) for number of tillers per plant, Lakshmana *et al.,* (2009) for spike length, plant height and number of productive tillers. Days to 50% flowering had moderately high PCV and GCV values. Contrast result also reported by Sharma *et al.,* (2018) as days to 50% flowering had moderately high PCV and GCV.

According to Singh (1985), heritability values greater than 80% are very high, values from 40 to 59 are medium and values less than 40% are low. The very high heritability (broad Sense) values were observed for grain yield, seed weight per spike, plant height, number of nodes per plant, 1000 grain weight, number of productive tillers per plant, flag leaf width, flag leaf length, spike length, flag leaf area, number of tillers per plant. Days to 50% flowering and peduncle length had moderately high heritability. These results were confirmed by previous findings of Dapke *et al.,* (2014) for flag leaf area and seed weight per spike, Sankar *et al.,* (2013) for grain yield, number of nodes per plant, number of productive tillers and 1000 grain weight. Vetriventhan and Nirmalakumari (2007) for number of tillers per plant, spike length, plant height and days to 50% flowering. Heritability was conjunction with genetic advance would give a more reliable selection index value. The traits that have high heritability coupled with high genetic advance estimates were grain yield, plant height, number of nodes per plant, flag leaf area. High variability and heritability coupled with greater genetic advance indicated greater role of additive gene action in genetic control of the given traits. High heritability coupled with high genetic advance of these traits were similar to earlier results of Singh *et al.,* (2014), Irshad-ul-Haq *et al.,* (2015) and Basavaraj *et al.,* (2017).

Johnson *et al.,* (1955) classified genetic advance mean values from 0 to 10% as low, 10 to 20% as moderately high and 20 and above as high. The expected genetic advance mean was high for grain yield, plant height, days to 50% flowering, peduncle length, number of nodes per plant, flag leaf length, flag leaf width, flag leaf area, number of

tillers per plant, number of productive tillers, spike length, seed weight per spike and test grain weight. This results were in concordance with genetic advance mean value reports of Dhedhi *et al.,* (2016) for days to 50% flowering, plant height, grain yield, Singh, Yadav, *et al.,* (2015) for number of nodes per plant, Sathya *et al.,* (2014) for number of productive tillers, 1000 grain weight, seed weight per spike and Vidyadhar *et al.,* (2007) for number of tillers per plant. The traits like grain yield, seed weight per spike, number of productive tillers, flag leaf area, number of nodes per plant revealed greatest variability parameters, and considered highly variable in Pearl millet.

Correlation

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 Table 3 and Fig. 1.

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 traits were important yield determinant characters due to their positive and highly significant correlations 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, Singh *et al.,* (2018) and Bhasker *et al.,* (2017) for 1000 grain weight, Singh, Sharma, *et al.,* (2015) for spike length and Izge *et al.,* (2006) for number of tillers per plant. However, grain yield revealed non-significant positive correlation with other characters like plant height (0.23), number of nodes per plant (0.21), flag leaf length (0.16), days to 50% flowering (0.10), and flag leaf area (0.07). But flag leaf width (-0.02) exhibited non-significant negative correlation with grain yield. Grain yield also showed non-significant correlation with these traits similar to findings of Shobha *et al.,* (2019) for days to 50% flowering, Dapke *et al.,* (2014) for flag tleaf area, Kumari *et al.,* (2013) for plant height Sankar *et al.,* (2013) for number of nodes per plant.

From the inter-correlation studies, it was observed that number of productive tillers had positive significant correlation with number of tillers per plant (0.90), number of nodes per plant (0.62), grain yield (0.53). These results were similar to findings of Nehra *et al.,* (2017) for number of nodes per plant, Yahaya (2015) for number of tillers per plant and Arulselvi *et al.,* (2008) for grain yield.

Seed weight per spike exhibited positive significant correlation with spike length (0.70), grain yield (0.70) and test grain weight (0.73). These results were accordance with findings of Subbulakshmi *et al.,* (2018) for grain yield and 1000 grain weight, Talawar *et al.,* (2017) for spike length. Correlation of number of productive tillers with number of tillers per plant (0.90) was positive and highly significant when compared to other biometrical traits indicating that it is possible to achieve a significant improvement in both the traits depending upon the intensity of linkage between the two traits. Contrast result was reported by Bikash *et al.,* (2013).Thus, selection for lengthier spike with increased seed weight per spike will be significant for the improvement of grain yield in pearl millet in the material under study.

Table.1 The experimental material consisted of 50 pearl millet genotypes collected from ICRISAT, Hyderabad

S.No	Genotypes	S.No	Genotypes
1	IP3080	26	IP15320
2	IP3476	27	IP15321
3	IP3604	28	IP15322
4	IP3613	29	IP15341
5	IP3616	30	IP15342
6	IP3625	31	IP15343
7	IP3627	32	IP15344
8	IP3628	33	IP15348
9	IP3636	34	IP15351
10	IP3645	35	IP15369
11	IP3663	36	IP15710
12	IP3665	37	IP17428
13	IP5836	38	IP20273
14	IP8327	39	IP20339
15	IP10437	40	IP20346
16	IP11839	41	IP20347
17	IP11840	42	IP20348
18	IP15257	43	IP20350
19	IP15285	44	IP20379
20	IP15288	45	IP20539
21	IP15290	46	IP20540
22	IP15301	47	IP20585
23	IP15302	48	IP21226
24	IP15306	49	PT4806
25	IP15307	50	PT4181

Table.2 Mean, range and other important variability parameters for different characters in Pearl millet

Traits	Mean	Range	Range	PCV	GCV	H (%)	GA	GAM (%)
		Min	Max					
DFF	57.19	37.00	74.00	14.08	12.03	72.96	12.11	21.17
PH	208.11	118.18	383.30	28.64	28.48	98.86	121.40	58.34
PL	17.26	3.34	46.82	54.03	42.37	61.49	11.82	68.44
NNPP	87.42	20.60	292.80	50.89	50.29	97.66	89.50	102.37
FLL	24.21	9.34	40.98	31.32	30.19	92.94	14.51	59.96
FLW	2.78	1.32	4.90	30.31	29.22	92.96	1.61	58.04
FLA	48.20	12.09	130.49	52.04	50.03	92.44	47.76	99.09
NTPP	9.54	3.00	18.80	42.51	39.35	85.70	7.16	75.05
NPT	9.01	3.00	18.80	41.44	40.13	93.76	7.21	80.05
SL	22.25	9.87	58.70	33.56	32.33	92.83	14.28	64.17
SWS	14.04	6.69	40.09	41.78	40.88	95.75	11.57	82.40
TGW	9.68	1.88	20.79	31.71	31.10	96.18	6.08	62.83
GY	122.15	38.76	478.46	57.91	57.71	99.32	144.73	118.48

Table.3 Genotypic correlation for yield and yield contributing traits in Pearl millet

Traits	DFF	PH	PL	NNPP	FLL	FLW	FLA	NTPP	NPT	SL	SWS	TGW	GY
DFF	**	0.135	-0.044	0.007	0.345*	0.125	0.270	0.045	-0.108	0.222	0.208	0.356*	0.106
PH		**	0.506**	0.255	-0.061	0.072	0.047	0.170	0.179	0.156	0.107	0.061	0.238
PL			**	-0.001	-0.054	0.010	0.019	0.123	0.229	0.241	0.263	0.192	0.423**
NNPP				**	-0.052	-0.195	-0.143	0.692**	0.628**	0.089	-0.246	-0.145	0.210
FLL					**	0.643**	0.887**	0.036	-0.097	0.269	0.240	0.309*	0.165
FLW						**	0.903**	-0.065	-0.212	0.165	0.111	0.267	-0.029
FLA							**	-0.019	-0.159	0.208	0.177	0.320*	0.074
NTPP								**	0.907**	0.174	-0.134	0.055	0.493**
NPT									**	0.101	-0.174	-0.066	0.534**
SL										**	0.702**	0.536**	0.697**
SWS											**	0.735**	0.706**
TGW												**	0.563**
GY													**

** Significant at 1 percent level; * Significant at 5 percent level

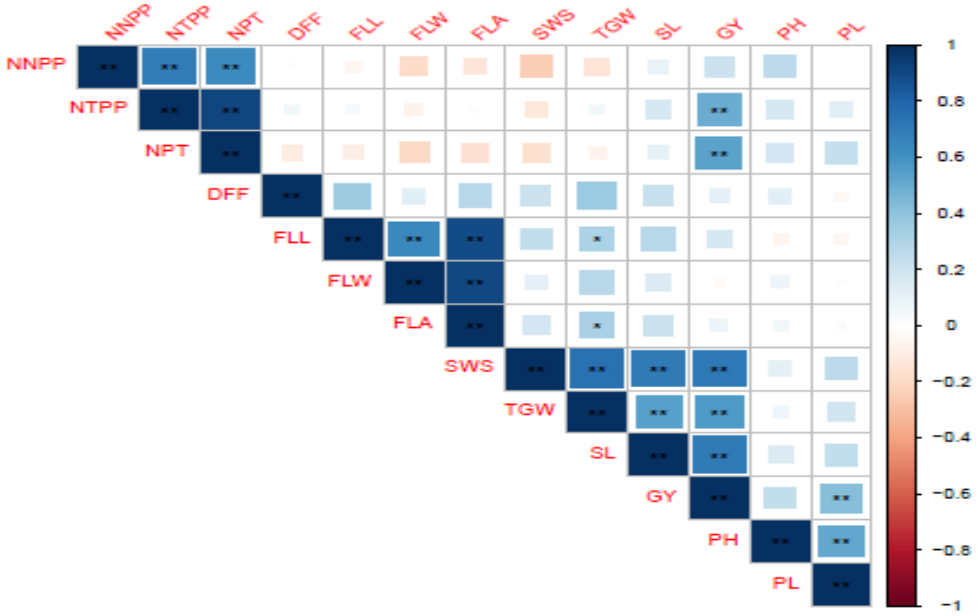
DFF= Days to 50% flowering, PH=Plant height, PL=Peduncle length, NNPP=Number of nodes per plant, FLL=Flag leaf length, FLW=Flag leaf width, FLA=Flag leaf area, NTPP=Number of tillers per plant, NPT=Number of productive tillers per plant, SL=Spike length, SWS=Seed weight per spike, TGW=Test grain weight, GY=Grain yield

Table.4 Path co-efficient analysis for yield and yield contributing traits in Pearl millet

Traits	DFF	PH	PL	NNPP	FLL	FLW	FLA	NTPP	NPT	SL	SWS	TGW	GY
DFF	**-0.0135**	0.0017	-0.0001	-0.0001	-0.0199	-0.0182	0.0569	-0.0027	-0.0761	0.0299	0.1455	0.0043	0.1056
PH	-0.0018	**0.0132**	0.02	-0.0079	0.0035	-0.0104	0.0098	-0.01	0.1256	0.0208	0.0742	0.0007	0.2376
PL	0.0005	0.0067	**0.0399**	0.0004	0.003	-0.0014	0.004	-0.0076	0.1605	0.0324	0.1823	0.0023	0.423**
NNPP	-0.0008	0.0033	-0.0005	**-0.0313**	0.003	0.0282	-0.0301	-0.0431	0.4402	0.0119	-0.1702	-0.0017	0.2100
FLL	-0.0046	-0.0008	-0.0021	0.0016	**-0.0577**	-0.0932	0.1865	-0.0022	-0.0683	0.0361	0.1662	0.0037	0.1653
FLW	-0.0017	0.0009	0.0004	0.0061	-0.0371	**-0.145**	0.1901	0.004	-0.1489	0.0221	0.0767	0.0032	-0.0291
FLA	-0.0036	0.0006	0.0007	0.0044	-0.0511	-0.131	**0.2104**	0.0012	-0.1114	0.0278	0.1224	0.0039	0.0745
NTPP	-0.0006	0.0022	0.0049	-0.0216	-0.0021	0.0094	-0.004	**-0.0623**	0.6356	0.0234	-0.0929	0.0006	0.493**
NPT	0.0014	0.0023	0.0091	-0.0196	0.0056	0.0308	-0.0334	-0.0565	**0.7012**	0.0135	-0.1202	-0.0008	0.534**
SL	-0.03	0.0002	0.0096	-0.0027	-0.0155	-0.0239	0.0436	-0.0108	0.0707	**0.1342**	0.4863	0.0065	0.697**
SWS	-0.0028	0.0014	0.0105	0.0077	-0.0138	-0.016	0.0372	0.0083	-0.1217	0.0943	**0.6923**	0.0089	0.706**
TGW	-0.0048	0.0008	0.0076	0.0045	-0.0178	-0.0386	0.0673	-0.0034	-0.0462	0.0719	0.509	**0.012**	0.563**

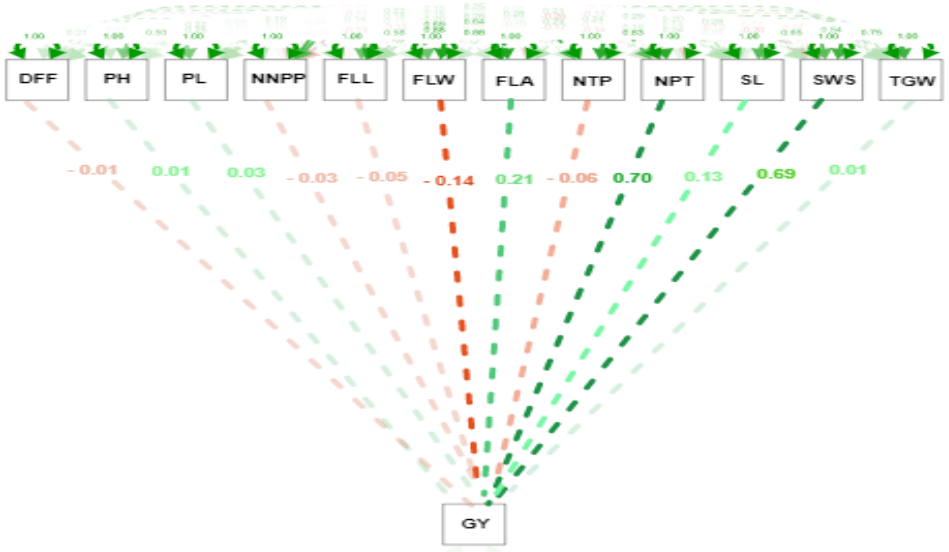
(Residual effect = 0.39) DFF= Days to 50% flowering, PH=Plant height, PL=Peduncle length, NNPP=Number of nodes per plant, FLL=Flag leaf length, FLW=Flag leaf width, FLA=Flag leaf area, NTPP=Number of tillers per plant, NPT=Number of productive tillers per plant, SL=Spike length, SWS=Seed weight per spike, TGW=Test grain weight, GY=Grain yield

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



** Significant at 1 percent level; * Significant at 5 percent level

Figure.2 Path co-efficient analysis for yield and yield contributing traits in Pearl millet



DFF= Days to 50% flowering, PH=Plant height, PL=Peduncle length, NNPP=Number of nodes per plant, FLL=Flag leaf length, FLW=Flag leaf width, FLA=Flag leaf area, NTPP=Number of tillers per plant, NPT=Number of productive tillers per plant, SL=Spike length, SWS=Seed weight per spike, TGW=Test grain weight, GY=Grain yield.

Path analysis

Path analysis is a statistical methodology used to separate overall effect into direct and indirect effect. The values regarding the path analysis are given in Table 4 and Fig 2. The grain yield had positive high direct effect with number of productive tillers per plant and seed weight per spike. This result was similar to findings of Abuali *et al.,* (2012). Flag leaf area on grain yield had positive moderate direct effect. These results revealed true relationship of these characters with the grain yield. Hence, direct selection of these traits could be rewarding for the improvement of grain yield in pearl millet. Plant height, peduncle length, spike length, 1000 grain weight had very low positive direct effect with grain yield. These results were similar to findings of Kumar, Sanadya, *et al.,* (2020) for 1000 grain weight, Kumar *et al.,* (2014) for spike length and Chaudhry *et al.,* (2003) for plant height. Hence, direct selection of these traits do not have any impact on grain yield improvement. Grain yield had negative direct effect with traits like days to 50% flowering, number of nodes per plant, flag leaf length, flag leaf width, number of tillers per plant. These results were similar to findings of Kumar *et al.,* (2014) for days to 50% flowering and number of nodes per plant. The high direct effect of number of productive tillers, seed weight per spike appeared to be the main factors for their strong association with grain yield per plant. Hence, this investigation suggested that number of productive tillers, seed weight per spike should be given maximum consideration as the appropriate selection indices in breeding for dual purpose Pearl millet hybrids.

Number of nodes per plant, number of tillers per plant showed highly positive indirect effect on grain yield through number of productive tillers. Spike length, plant height, peduncle length had low positive indirect effect with grain yield through number of productive tillers. Grain yield had negative indirect effect with traits like days to 50% flowering, flag leaf length, flag leaf width, flag leaf area, seed weight per spike and test grain weight. These indirect effect results were similar to findings of (Subbulakshmi *et al.,* 2018) and Govindaraj and Selvi (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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