Electronic Journal of Plant Breeding, 9 (3) : 1263 - 1271 (Sep 2018) DOI: 10.5958/0975-928X.2018.00158.8
ISSN 0975-928X

Research Note

Genetic variability and association studies in pearl millet for green fodder yield and quality traits

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(Received: 10 Sep 2018; Revised: 06 Oct 2018; Accepted: 08 Oct 2018)

Abstract

In the present study, a total of 22 pearl millet genotypes were evaluated during *kharif*, 2017. The genotypes were analyzed for genetic variability, correlation and path coefficients. Analysis of variance revealed highly significant differences among the genotypes for all the 12 characters *viz.*, plant height, number of tillers per plant, number of leaves per tiller, leaf length, leaf breadth, leaf-stem ratio, dry matter yield per plant, green fodder yield per plant, crude protein, crude fibre, fat content and ash content studied, indicating the presence of sufficient variability in the experimental materials of pearl millet genotypes. The estimates of genotypic coefficient of variation were lesser than that of phenotypic coefficient of variation for all the traits except ash content per cent, indicating the role of environmental influence over the characters studied. High heritability with high genetic advance as per cent of mean was observed for green fodder yield per plant, dry matter yield per plant, fat content, crude protein content and ash content. This indicated the prevalence of additive gene action in their inheritance; hence selection of these traits would facilitate the improvement of both fodder yield and quality. Correlation and path analysis revealed that the traits *viz.*, plant height, leaf breadth and dry matter yield per plant might be responsible for increasing the green fodder yield per plant in fodder pearl millet.

Key words

Pearl millet, Green fodder, Variability, Correlation coefficient, Dry matter yield, Crude protein

Pearl millet (*Pennisetum glaucum* L.) is the most widely grown type of millet. It is being cultivated in Africa and the Indian subcontinents since prehistoric times. It is an important food crop widely produced in Africa and India. It is a diploid (2n=2x=14) species belongs to the family Poaceae. It is the 5th major food grain crop in the world. On account of its performance in the adverse agricultural conditions pearl millet is considered as a hardy crop. As its vegetative matter is rich in minerals like phosphorous and calcium with high protein content and low hydrocyanic acid content, it is also an excellent fodder crop. Pearl millet has great importance as forage as well as stover crop.

Dry matter yield of pearl millet forage vary greatly depending on environmental conditions (soil fertility, soil moisture, temperature) and varieties. In semi-arid environments, dry matter yield can be as low as 0.25 to 3.0 t/ha, while under ideal conditions it can reach 27 t/ha and even more than 40 t/ha. However, dry matter yields are often about 20 t/ha in the tropics, and 8 to10 t/ha in the subtropics (Cook *et al.*, 2005). For any crop improvement programme, the basic knowledge about nature and magnitude of genetic variability for different traits present in germplasm collections is important. Correlation study provides better understanding of yield components, which helps the breeder during selection. The path coefficient analysis measures the direct and indirect contribution of various independent characters on a dependent character in general yield. Keeping the above points in view, the present investigation was made to identify all important yield variables related with the green fodder yield in pearl millet and to estimate the magnitude of variability, heritability, expected genetic advance and nature of association present in the diverse pearl millet germplasms for the different characters.

The experiment was conducted during the year of 2017-2018 at new area farm of Department of Forage Crops, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. The experimental material included 22 pearl millet genotypes which were evaluated in a randomized block design with a spacing of 30 × 15 cm. in two replications. All the recommended agronomic package of practices were followed to raise a good crop. Observations on different traits were recorded on five randomly selected plants at 50% flowering.

The traits leaf stem ratio, green fodder yield per plant and dry matter yield per plant were recorded at the stage of harvest. The quantitative traits recorded were plant height, number of tillers per plant, number of leaves per tiller, leaf length, leaf breadth, leaf - stem ratio, dry matter yield per plant (g), green fodder yield per plant (g) along with the four quality traits *viz.,* protein content, crude fibre content, ash content and fat content. The method suggested by Burton and De Vane (1953) was followed for computation of the GCV and PCV. Heritability in the broad sense was calculated according to the formula given by Allard (1960) and the genetic advance was estimated by the following formula given by Burton (1952). Correlation coefficients were calculated at genotypic and phenotypic level using the formulae suggested by Falconer (1964). Path coefficient analysis suggested by Wright (1921) and elaborated by Dewey and Lu (1959) was used to calculate the direct and indirect contribution of various traits to yield. List of 22 fodder pearl millet genotypes are given in Table 1. These genotypes are single cut fodder pearl millet of 55 days duration.

Genetic variability studies provide basic information regarding the genetic properties of the population, based on which, breeding methods are formulated for further improvement of the crop. The extent of variability and heritability of the characters among the genotypes is the basic source for the exploitation of superior potentiality of genotypes. The variation occurred due to genotypes was significant for all the characters studied (Table 2).

Based on the mean performance, 22 pearl millet genotypes differed highly for all the 12 characters studied. The traits like plant height (164.8 cm. to 257.4 cm.), number of tillers per plant (3.0 – 5.0), number of leaves per tiller (7 – 10.5), leaf length (59 cm. – 77.4 cm.), leaf breadth (3.4 to 4.9 cm.), green fodder yield per plant (375.0 g. – 790.6 g.), dry matter yield per plant (54.4 g. – 152.6 g.) and quality traits *viz.*, crude fibre content (28% to 34.25%), crude fat (1.70% - 4.78 %), crude protein (6.24% to 11.63%) and ash content (8.5% - 14.5%) had wide range of mean values.

In the present investigation, the estimates of genotypic coefficient of variation were lesser than that of phenotypic coefficient of variation for all the traits except for ash content indicating the role of environmental influence over the characters studied (Table 3). This variation indicated the scope for selection of these traits for further improvement. High phenotypic variability which encompasses genotypic variability was evident from the range of values for different characters. In the present study the trait fat content and dry matter yield per plant exhibited higher PCV and GCV. These findings were in accordance with Santosh *et al.* (2017). With regard to dry matter yield per plant similar findings were reported by Bhagirath *et al.* (2007) in pearl millet and Satapute *et al.* (2014) in Bajra Napier hybrids. Moderate values for GCV and PCV were noticed for the trait plant height, number of tillers per plant, L: S ratio and crude protein content. A similar finding with regard to plant height was reported by Bhasker *et al.* (2017) in pearl millet. For number of tillers per plant and crude protein content, similar results were reported by Satapute *et al.* (2014) in BN hybrids. The traits leaf length, leaf breadth and crude fibre content showed low values for GCV and PCV. Similar results were reported by Satapute *et al.* (2014) in BN hybrids for leaf length and leaf breadth and Santosh *et al*. (2017) for the trait crude fibre content.

For green fodder yield, high PCV (21.22) and moderate GCV (17.49) were obtained. Similar results were reported by Bhagirath *et al.* (2007). Low PCV and moderate GCV were noticed for the trait ash content. Govindaraj *et al.* (2017) reported low values for GCV and PCV for this trait.

In conclusion, based on variability analysis**,** the traits, fat content and dry matter yield per plant exhibited higher PCV and GCV, indicating the availability of high variation for these traits among the genotypes. The co-efficient of variation indicates only the extent of variability existing for various characters, but does not give any information regarding heritable proportion of it. Hence, the amount of heritability permits greater effectiveness of selection by separating out the environmental influence from the total variability and to indicate accuracy with which a genotype can be identified phenotypically. In the present study, the broad sense heritability which includes both additive and non-additive gene effects was estimated.

Heritability estimates are useful in selection of genotypes based on phenotypic performance and genetic advance as per cent of mean provides information on expected genetic gain resulting from selection of superior individuals. So considering heritability values along with genetic advance would be more reliable and helpful in predicting the gain under selection than heritability estimate alone. In the present investigation among the quantitative traits studied, green fodder yield per plant and dry matter yield per plant exhibited high values for heritability

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and genetic advance as per cent of mean. Similar results were reported by Satapute *et al.* (2014) in BN hybrids for green fodder yield per plant and Kapoor (2017) in Napier grass for dry matter yield per plant. The traits leaf breadth and leaf-stem ratio exhibited high heritability and moderate genetic advance as per cent of mean. While the traits, number of tillers per plant and number of leaves per tiller showed moderate values for heritability and genetic advance as percent of mean. High heritability coupled with high genetic advance as per cent of mean recorded by the traits, GFY/plant and DMY/plant indicating the preponderance of additive gene action and hence phenotypic selection would be more effective for these traits.

Among the quality traits, fat content, crude protein and ash content exhibited high heritability and high genetic advance as per cent of mean. Similar results were reported by Govindaraj *et al.* (2017) in pearl millet and Santosh *et al.* (2017) in fodder pearl millet for crude protein content. For fat content, it was reported by Govindaraj *et al.* (2017) in fodder pearl millet. The traits green fodder yield per plant, dry matter yield per plant, fat content (%), crude protein content (%) and ash content had high genetic advance, indicating that these characters are governed by additive gene action and may express consistently in succeeding generations, leading to greater efficiency of breeding programme.

Yield is a complex trait and depends upon a number of yield contributing traits. In order to understand the inter character association among the different yield contributing characters, it is necessary to interpret correlation in crop plants. The selection practiced for one character may simultaneously bring change in the other related characters. Thus, the information on the magnitude and direction of association between the component characters is essential for improvement in the desirable direction. The values regarding the correlation studies are given in Table 4.

The traits *viz.,* plant height, leaf breadth and DMY/plant were positively and significantly correlated with green fodder yield/plant. Therefore, selection for these traits may aid in the enhancement of the green fodder yield. Similar findings were also reported by Santosh *et al.* (2017) in fodder pearl millet for plant height and DMY/plant. The traits, number of tillers per plant, number of leaves per tiller, leaf length, leaf stem ratio, crude protein and ash content were positively correlated but not significant. On the other hand, the traits, crude fibre and fat content were negatively correlated with green fodder yield. Reduced crude fibre content in green fodder increases the palatability of fodder and ultimately its intake. Similarly increase in fat content decreases the palatability of the diet and coat the dietary fibre, interfering with its digestibility by rumen microbes (Moran, 2005). The results obtained for crude fibre and fat content coincides with the findings of Santosh *et al.* (2017) in fodder pearl millet.

Plant height inter-correlated positively with number of leaves/tillers, leaf length, leaf breadth and DMY/plant and negatively with leaf- stem ratio. Positive inter- correlation between number of tillers per plant and leaf length, leaf breadth and DMY/plant, and number of leaves/ tiller and leaf breadth, indicated that these traits can be used as selection criteria that helps in increasing the green fodder yield. Negative inter- correlation was recorded for leaf- stem ratio with plant height and leaf length, indicating that selection of these traits will negatively influence each other.

Therefore, selection for component characters, combined with high crude protein and ash content or low fibre content helps in increasing the fodder yield and quality.

In the current investigation, the estimate of residual effect was low (0.341), indicating the adequacy of the traits included for path analysis (Table 5). Among the traits included for path analysis, DMY/plant (0.882) has registered high direct positive effect on green fodder yield, followed by number of tillers per plant (0.162). Therefore, these traits may be indicated to have a true correlation and could be taken as component trait for the improvement of fodder yield. These results were in agreement with the findings of Kumari *et al.* (2018) in BN hybrids. Low positive direct effect was shown by plant height, leaf stem ratio and ash content. Hence, direct selection of these traits does not have any impact on forage yield improvement. On the other hand, the traits *viz.,* leaf length, leaf breadth, crude fibre and fat content showed negative direct effect.

DMY/plant showed very high positive indirect effect through plant height, leaf breadth, leaf length and ash content and negative indirect effects through fat content. Same results were reported for leaf length by Patel *et al.* (2005) in fodder maize. Based on correlation and path analysis studies, the traits namely, DMY/plant, plant height, leaf breadth and leaf length might be responsible for enhancing the green fodder yield/plant.

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ISSN 0975-928X

Table 1. List of 22 pearl millet genotypes

1.	PT 5382
2.	IP 20350
3.	GP 16021
4	IP 20840
5.	PT 5752
6.	PT 5749
7.	IP 20379
8.	DRS B4
9.	CO 7
10	CO 8
11.	RFBJ 2
12.	RFBJ 3
13.	RFBJ 10
14.	RFBJ 16
15.	RFBJ 116
16.	IP 6202
17.	IP 6140
18.	IP 13150
19.	IP 9445
20.	IP 18308
21.	PT 5140
22.	IP 15564

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Table 2. Analysis of variance for different characters in pearl millet genotypes

S. No.	Sources of variation	df	Plant height (cm.)	No. of tillers/p lant	No. of leaves /tiller	Leaf length (cm.)	Leaf breadth (cm.)	L:S ratio	GFY /plant (g)	DMY/ plant (g)	Crude fibre (%)	Fat content (%)	Crude protein (%)	Ash content (%)
1.	Treatment	21	879.96**	0.61*	1.44*	41.74*	0.28**	0.002**	24801.9**	945.78**	5.38**	1.57**	5.23**	4.76**
2.	Error	21	75.04	0.23	0.51	16.78	0.03	0.0004	4725.2	150.94	0.36	0.01	0.06	0.40

** Significant at 1% level * Significant at 5% level;*DMY- Dry matter yield, GFY- Green fodder yield

Table 3. Genetic analysis in pearl millet genotypes

Characters	Mean	Range	Variance			PCV (%)	GCV (%)	Heritability (h^2)	Genetic Advance	Genetic advance as per cent of mean
			σ^2 P	σ^2 G	σ^2 E					
Plant height (cm.)	198.3	164.8- 257.4	477.50	402.46	75.04	11.02	10.11	84.28	37.94	19.13
No. of tillers/plant	3.78	3.0- 5.0	0.420	0.19	0.23	17.18	11.44	44.33	0.59	15.68
No. of leaves/tiller	9.36	7.0 - 10.5	0.970	0.46	0.51	10.54	7.27	47.56	0.97	10.32
Leaf length (cm.)	64.4	59- 77.4	29.26	12.48	16.78	8.39	5.48	42.66	4.75	7.38
Leaf breadth (cm.)	4.24	3.4- 4.9	0.156	0.123	0.033	9.31	8.27	78.91	0.64	15.13
L:S ratio	0.26	0.20- 0.33	0.0013	0.0009	0.0004	13.99	11.43	66.80	0.05	19.25
GFY/plant (g.)	572.5	375.0- 790.6	14763.6	10038.4	4725.17	21.22	17.49	67.99	170.19	29.72
DMY/ plant (g.)	96.9	54.4- 152.6	548.36	397.42	150.94	24.17	20.57	72.47	34.96	36.08
Crude fibre (%)	31.1	28- 34.25	2.87	2.51	0.36	5.44	5.09	87.33	3.05	9.79
Fat content (%)	3.23	1.70- 4.78	0.79	0.78	0.012	27.59	27.38	98.42	1.80	55.95
Crude protein (%)	8.39	6.24 – 11.63	2.65	2.58	0.06	19.39	19.16	97.58	3.27	38.99
Ash content (%)	11.4	8.50 – 14.5	2.58	2.18	0.4	5.58	12.96	84.36	2.79	24.52

GCV- Genotypic coefficient of variation, PCV- Phenotypic coefficient of variation, σ^2 P – Phenotypic variance, σ^2 G – Genotypic variance, σ^2 E – Environmental variance

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Table 4. Genotypic and phenotypic correlation coefficient among twelve characters in pearl millet genotypes

Characters		Plant height	No. of tillers/ plant	No. of leaves/ tiller	Leaf length	Leaf breadth	L:S ratio	DMY/ plant	Crude fibre	Fat content	Crude protein	Ash content	GFY/ plant
Plant height (cm)	rG	**1.000**	-0.013	0.673**	0.599**	0.497**	-0.376*	0.526**	0.293	-0.290	-0.289	0.053	0.435*
	rp	**1.000**	0.051	0.376*	0.404*	0.468*	-0.319	0.494**	0.297	-0.247	-0.252	0.044	0.370*
No. of tiller/plant	rG		**1.000**	-0.471*	0.544*	-0.443*	0.040	0.248	0.085	-0.374*	-0.048	-0.227	0.339
	rp		**1.000**	-0.368*	0.061	-0.341	0.144	0.134	0.169	-0.240	-0.065	-0.210	0.176
No. of leaves/ tiller	rG			**1.0000**	0.176	0.402*	- 0.025	0.184	0.455*	0.155	-0.310	-0.401*	0.121
	rP			**1.0000**	0.241	0.226	-0.007	0.146	0.302	0.099	-0.209	-0.187	0.094
Leaf length (cm)	rG				**1.0000**	0.139	-0.543**	0.343	0.176	-0.145	-0.275	-0.025	0.055
	rp				**1.0000**	0.158	-0.306	0.238	0.009	-0.101	-0.145	-0.004	0.182
Leaf breadth (cm)	rG					**1.000**	-0.002	0.499**	0.459*	0.084	0.135	0.351	0.374*
	rP					**1.000**	-0.092	0.429*	0.360	0.089	0.105	0.315	0.300
L:S ratio	rG						**1.000**	0.019	-0.005	-0.262	0.538**	-0.198	0.186
	rp						**1.000**	0.046	0.014	-0.233	0.401*	-0.237	0.125
DMY /plant (g)	rG							**1.000**	0.189	-0.121	0.064	0.317	0.867**
	rP							**1.000**	0.188	-0.112	0.069	0.304	0.904**
Crude fibre (%)	rG								**1.000**	0.079	-0.313	-0.092	-0.011
	rP								**1.000**	0.067	-0.304	-0.082	0.0009
Fat content (%)	rG									**1.0000**	0.022	-0.013	-0.193
	rp									**1.0000**	0.023	-0.004	0.141
Crude protein (%)	rG										**1.000**	0.069	0.256
	rP										**1.000**	0.076	0.245
Ash content (%)	rG											**1.000**	0.287
	rp											**1.000**	0.289
GFY /plant (g)	rG												**1.000**
	rP												**1.000**

** Significant at 5% level, * Significant at 1% level, rG – Genotypic correlation coefficient, rP – Phenotypic correlation coefficient

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Table 5. Path coefficient analysis for different characters with green fodder yield in pearl millet genotypes

Traits	Plant height (cm)	No. of tillers/plant	No. of leaves/tiller	Leaf length (cm)	Leaf breadth (cm)	L:S ratio	DMY/ plant (g)	Crude fibre (%)	Fat content (%)	Crude protein (%)	Ash content (%)	GFY/ plant (g)
Plant height (cm)	**0.011**	0.001	0.004	0.004	0.005	-0.004	0.005	0.003	-0.003	-0.003	0.0005	0.370*
No. of tillers/ plant	0.008	**0.162**	-0.059	0.009	-0.055	0.023	0.022	0.028	-0.039	-0.011	-0.034	0.176
No. of leaves/ tiller	0.058	-0.057	**0.154**	0.037	0.035	-0.001	0.020	0.047	0.015	-0.032	-0.0287	0.095
Leaf length (cm)	-0.036	-0.005	-0.021	**-0.089**	-0.014	0.027	-0.024	-0.001	0.009	0.013	0.0004	0.182
Leaf breadth (cm)	-0.003	0.002	-0.001	-0.001	**-0.006**	0.0005	-0.002	-0.002	-0.001	-0.001	-0.002	0.300
L:S ratio	-0.0002	0.0001	0.000	-0.0002	-0.0001	**0.001**	0.000	0.000	-0.000	0.0002	-0.0001	0.125
DMY/ plant (g)	0.413	0.118	0.118	0.241	0.368	0.026	**0.882**	0.154	-0.087	0.069	0.272	0.904 **
Crude fibre (%)	-0.052	-0.029	-0.053	-0.002	-0.063	-0.002	-0.031	**-0.175**	-0.012	0.053	0.014	0.001
Fat content (%)	0.007	0.006	-0.003	0.003	-0.002	0.006	0.003	-0.002	**-0.027**	-0.001	0.0001	-0.141
Crude protein (%)	-0.039	-0.010	-0.032	-0.022	0.016	0.061	0.012	-0.046	0.003	**0.153**	0.012	0.245
Ash content (%)	0.002	-0.012	-0.010	-0.0002	0.017	-0.013	0.017	-0.004	-0.0002	0.004	**0.055**	0.289

** Significant at 1% level * Significant at 5% level
DMY – Dry matter yield, GFY – Green fodder yield, Residual effect = 0.341

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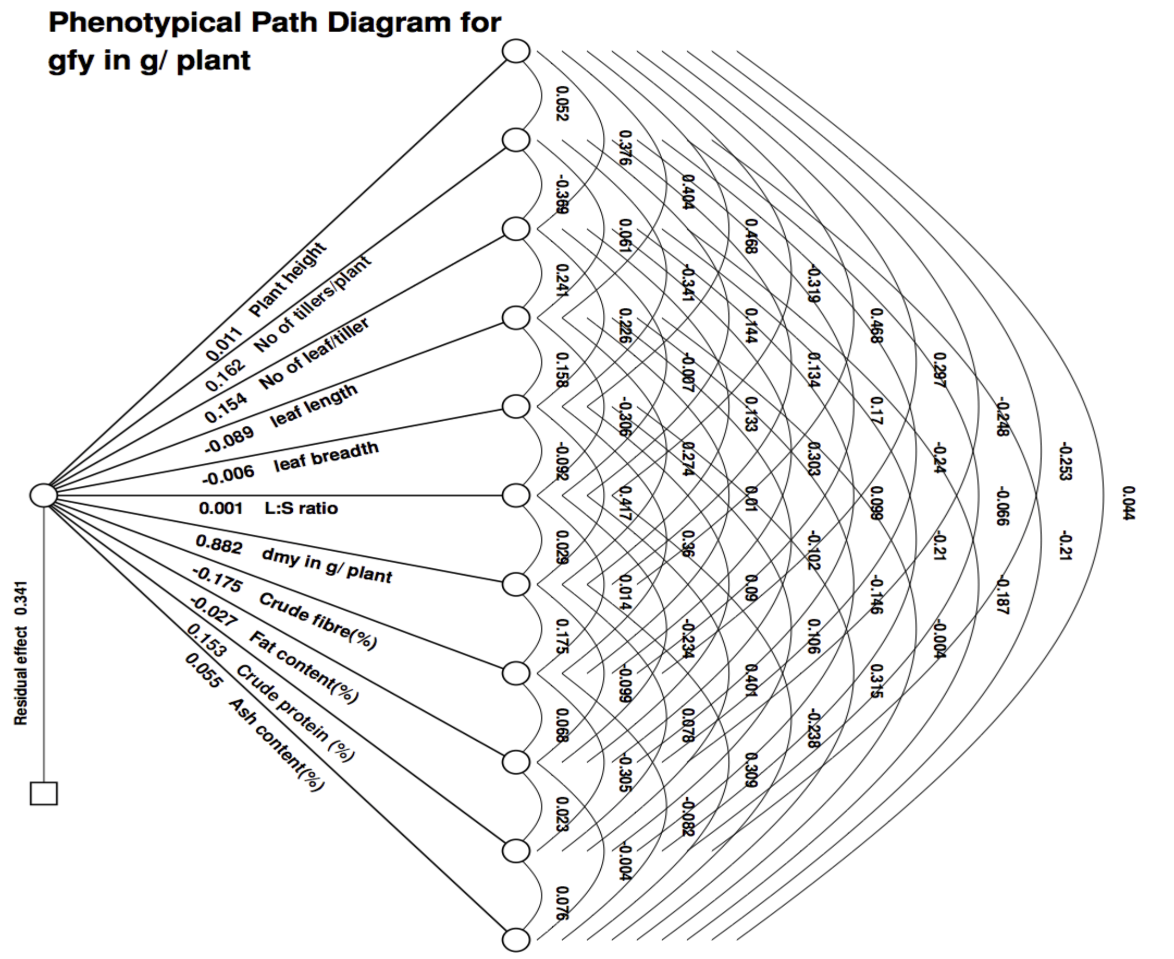

Fig.1. Direct, indirect and residual effects of different traits on fodder yield in Pearl millet