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ESTIMATION OF GENETIC VARIABILITY, HERITABILITY AND ASSOCIATION OF GREEN FODDER YIELD WITH CONTRIBUTING TRAITS IN FODDER PEARL MILLET [*Pennisetum glaucum* (L.)]

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ABSTRACT
An evaluation of 54 accessions of pearl millet for genetic variability, heritability, genetic advance along with the association of green fodder yield with component traits was performed. The ANOVA showed highly significant differences among the genotypes for all the characters studied, indicating the presence of sufficient variability in the experimental material. The PCV were slightly higher than GCV indicating little influence of environment on the expression of characters. High PCV and GCV were recorded for all the characters except dry matter per cent, crude protein and crude fibre content. High heritability with high genetic advance as per cent of mean for plant height, number of nodes in main culm, number of tillers per plant, number of leaves per tiller, leaf width, leaf weight, stem weight, leaf stem ratio, dry matter per cent, crude protein and crude fat suggested the prevalence of additive gene action in their inheritance indicating the selection based on these traits to be quite effective. The traits, plant height, number of tillers per plant, number of leaves per tiller and leaf stem ratio showed positive association with green fodder yield for which indirect selection can be made in future breeding programme to enhance green fodder yield.

KEY WORDS: *Pennisetum glaucum*, Genetic variability, Correlation, Path analysis, Crude protein.

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.], 2n = 14, an outstanding dual purpose crop generally grown as a cereal or as fodder is endued with enormous variability for agronomically important traits adapted to diverse agro-ecological conditions. Due to its potential to with stand drought and adverse agro climatic conditions, it is generally grown under marginal lands having low rainfall during *Kharif* season (Vidyadhar *et al*., 2007) and (Bhoite *et al.*, 2008). The production potential of green fodder of pearl millet at present is very low (Shashikala *et al.,* 2013). To improve productivity of the animal population, high fodder yielding multicut pearl millet varieties need to be developed (Harinarayana *et al.,* 2005). Genetic improvement for quantitative traits in fodder pearl millet depends on the degree of variability for the desired traits in the base material *vis-à-vis* extent to which the desirable traits are heritable and thus, play a vital role in successful selection for evolving superior cultivars. Green fodder yield is a complex character and is the final product of actions and interactions of various characters; hence understanding association between yield and its components is of paramount importance. An understanding the pattern of the variability, inheritance of target characters and the nature of character association are useful for effective breeding strategies and successful selection for evolving superior cultivars. Therefore, the present research work was attempted to understand variability, inheritance pattern of different fodder yield and character association among its contributing traits in 54 pearl millet accessions.

MATERIALS & METHODS

The experimental material included 54 pearl millet accessions of which, 24 inbreds were collected from Department of Forage Crops, TNAU, Coimbatore while 11 inbreds and 19 CMS lines (A & B) were obtained from ICRISAT, Hyderabad. The pearl millet accessions consisting of 35 inbreds and 19 ‘A’ & ‘B’ lines were raised in the ‘F’ block of the New Area farm of Department of Forage Crops, CPBG, TNAU during *kharif*, 2015 for characterization of quantitative traits based on the pearl millet descriptor list published by Bioversity international. The experiments were laid out in Randomized Block Design (RBD) with two replications. Each accessions of pearl millet was grown in two rows of four meter length with a spacing of 45 cm x 15cm and plant to plant distance of 15 cm was maintained by thinning/transplanting at 3 leaf stage. All the recommended agronomic package of practices was followed to raise a good crop. Five competitive plants were randomly selected from each genotype in each replication avoiding border plants. Plants to be selected were tagged before initiation of ear emergence for recording the observations at the time of days to 50 per cent flowering on 14 quantitative traits *viz.*, plant height, number of nodes in main stem, number of tillers per plant, number of leaves per tiller, leaf length, leaf width, leaf weight, stem weight, leaf/stem ratio, green fodder yield per plant, dry matter, crude protein, crude fat and crude fibre contents. Crude protein, crude fat and crude fibre estimation was made using Australian Fodder Industry Association (AFIS) laboratory methods manual (http://www.afia.org.au). Plant samples were collected at the time of panicle initiation and were chopped, air dried and finally oven dried at $60^{o}C$ for two days. The oven dried samples were ground and sieved using different sieve sizes. Sieve size of 0.5 mm was used for estimation of crude fibre and 0.1 mm sieve size was used for crude protein and crude fat estimation. Crude protein was estimated by Kjeldahl's method and crude fat by soxhlet method using petroleum ether while crude fibre estimation was made through digestion with sulphuric acid and sodium hydroxide solution as mentioned in AFIS laboratory methods manual. Mean values were used to compute the genetic parameters and statistical analysis of data was carried out for each character as described by Panse and Sukhatme (1967). Genotypic and phenotypic coefficient of variation was estimated as suggested by Burton (1952) while correlation coefficients and path coefficient analysis were calculated using the formulae suggested by Falconer (1964) and Dewey & Lu (1959) respectively.

RESULTS & DISCUSSION

Genetic Variability

The development of an effective breeding programme depends upon the existence of genetic variability which provide basic information regarding the genetic properties of the population, nature and extent of variability, heritability of the characters and genetic advance based on which, breeding methods are formulated for further improvement of the crop. In this study, the analysis of variance showed highly significant differences among the genotypes for all the characters studied, indicating the presence of sufficient variability in the experimental materials of pearl millet. The PCV were slightly higher than GCV indicating little influence of environment on the expression of characters (Table 1). In pearl millet, high PCV and GCV was recorded for 11 characters *viz.,* plant height, number of nodes in main culm, number of tillers per plant, number of leaves per tiller, leaf length, leaf width, leaf weight, stem weight, leaf stem ratio, green fodder yield per plant and crude fat content. PCV and GCV was higher for all the traits except dry matter content and crude fiber discerning more variability and suggesting the greater scope of improvement for these traits and these traits could be used to make the selection effective. Concomitant results for plant height was obtained by Netaji *et al*. (2000), Galeta *et al*. (2005) and for total number of tillers by Hepziba *et al.* (1993), Suthamathi and Stephen Dorairaj (1995a) and Vidyadhar *et al*. (2007). High GCV and PCV for total number of leaves, leaf weight, stem weight and green fodder yield per plant was also reported by Suthamathi and Stephen Dorairaj (1995a), Vidyadhar *et al*. (2007) and Bhoite *et al*. (2008). Moderate PCV and moderate GCV were observed for dry matter per cent and crude protein content while low PCV and low GCV was found for crude fibre content as discerned by Dhamdhere *et al.* (2011) in finger millet. Similar results for dry matter per cent and crude protein content was reported by Suthamati and Dorairaj (1997) in Napier grass and Govindaraj *et al.*, (2011) in pearl millet respectively. Heritable variation cannot be estimated with the help of GCV alone. Yield and its attributes are highly environmentally influenced and difficult to conclude, whether the observed variability is heritable or not. Therefore, partitioning the observed variability into heritable and non-heritable components is essential. Heritability indicates the accuracy with which a genotype can be identified by its phenotypic performance. Burton (1952) reported that genotypic coefficient of variation along with heritability estimates would be better for efficient selection. Relative comparison of heritability estimates and expected genetic advance as per cent of mean gives an idea about the nature of gene action governing a particular character. High heritability with high genetic advance as per cent of mean was observed for plant height, number of nodes in main culm, number of tillers per plant, number of leaves per tiller, leaf width, leaf weight, stem weight, leaf stem ratio, dry matter per cent, crude protein and crude fat. This indicated the lesser influence of environment in expression of these characters and prevalence of additive gene action in their inheritance, since selection of these traits in breeding programme would facilitate the improvement of both fodder yield and quality. Similarly high heritability for these characters studied reported by Nagy *et al*. (2013), Rakesh Kumar Dhanwani *et al*. (2013). The obtained results were in accordance with the results on number of leaves per plant by Suthamathi and Dorairaj (1997) and Babu *et al*. (2009) in Napier grass, Vedansh *et al*. (2010) in fodder maize and Sharma *et al*. (2003) in pearl millet. High heritability along with high genetic advance for leaf weight, stem weight, leaf stem ratio and crude protein content was reported by Suthamathi and Stephen Dorairaj (1995a) in pearl millet. In pearl millet accessions, crude fibre alone registered high heritability and moderate genetic advance as per cent of mean, similarly reported by Suthamati and Dorairaj (1997) in Napier grass. This inferred that selection would be effective for these characters when favourable environment prevails. For green fodder yield per plant, same results were reported by Sharma *et al*. (2003) and Vidyadhar *et al*. (2007) in pearl millet, Vedansh *et al*. (2010) in fodder maize, Jain and Patel (2012) in fodder sorghum and Vinodhana *et al*. (2013) in pearl millet. High values for desirable variability, heritability, genetic advance were observed in the traits such as, plant height, number of nodes in main stem, number of tillers per plant, number of leaves per plant, leaf length, leaf width, leaf weight, stem weight, leaf stem ratio and crude fat. It represents that selection based on these characters may be quite effective and influenced by additive gene action. Therefore, selection of these traits would offer scope for improvement of green fodder yield and quality in pearl millet.

TABLE 1: Genetic analysis in pearl millet

S. No.	Characters	Mean	Range	Variance		PCV (%)	GCV (%)	Heritability (h^2)	Genetic advance	GA as per cent of mean
				σ^2p	σ^2g					
1.	Plant height (cm)	176.56	61.00 - 270.63	2597.42	2425.54	28.87	27.89	93.00	98.04	55.53
2.	Number of nodes in main culm	5.97	1.63 - 9.50	3.73	2.92	32.36	28.61	78.00	3.11	52.10
3.	Number of tillers/plant	3.92	1.70 - 7.50	2.17	1.49	37.54	31.12	69.00	2.08	53.14
4.	Number of leaves/tiller	7.94	3.63 - 13.25	3.61	2.64	23.92	20.45	73.00	2.86	36.0
5.	Leaf length (cm)	57.48	32.17 - 78.34	158.21	155.91	21.88	21.72	98.50	25.54	44.42
6.	Leaf width (cm)	3.70	1.94 - 5.59	0.81	0.68	24.42	22.26	83.00	1.54	41.79
7.	Leaf weight (g)	334.61	139.01 - 1021.06	25237.11	23807.42	47.48	46.11	94.00	308.72	92.26
8.	Stem weight (g)	861.50	367.83 - 1569.83	87768.73	82573.35	34.39	33.36	94.00	574.17	66.65
9.	L/S ratio	0.39	0.24 - 0.66	0.0090	0.0081	24.67	23.40	90.00	0.18	45.71
10.	Dry matter (%)	23.35	16.21 - 32.01	13.59	11.82	15.78	14.73	87.00	6.61	28.30
11.	Green fodder yield/plant (g)	1196.36	511.64 - 2590.89	189596.47	179921.39	36.40	35.46	95.00	851.20	71.15
12.	Crude protein (%)	11.63	8.23 - 14.65	2.14	2.11	12.58	12.48	98.00	2.97	25.50
13.	Crude fat (%)	4.42	1.87 - 8.19	2.77	2.62	37.63	36.59	94.50	3.24	73.29
14.	Crude fibre (%)	27.00	22.79 - 32.19	5.24	4.13	8.48	7.53	79.00	3.72	13.77

TABLE 2. Genotypic (rG) and phenotypic (rP) correlation coefficients among eleven characters in pearl millet

Characters		**Plant height (cm)**	**Number of nodes in main culm**	**Number of tillers/ plant**	**Number of leaves/ tiller**	**Leaf length (cm)**	**Leaf width (cm)**	**Dry matter (%)**	**L/S ratio**	**Crude protein (%)**	**Crude fat (%)**	**Crude fibre (%)**	**Green fodder yield/ plant (g)**
Plant height (cm)	rG	**1.000**	0.888**	0.517**	0.946**	0.732**	0.745**	-0.228	0.271*	-0.196	-0.313*	0.014	0.915**
	rP	**1.000**	0.768**	0.413**	0.782**	0.700**	0.658**	-0.206	0.250*	-0.186	-0.296*	-0.004	0.856**
Number of nodes in main culm	rG		**1.000**	0.540**	0.921**	0.591**	0.612**	-0.035	0.295*	-0.175	-0.361**	-0.028	0.784**
	rP		**1.000**	0.299*	0.713**	0.513**	0.483**	-0.063	0.232*	-0.151	-0.313*	-0.001	0.674**
Number of tillers/plant	rG			**1.000**	0.438**	0.277*	0.391**	-0.425**	0.351**	-0.377**	-0.099	0.050	0.675**
	rP			**1.000**	0.352**	0.233*	0.319*	-0.280*	0.249*	-0.320*	-0.104	0.037	0.556**
Number of leaves/ tiller	rG				**1.000**	0.573**	0.680**	-0.160	0.231*	-0.219	-0.300*	-0.056	0.814**
	rP				**1.000**	0.483**	0.547**	-0.155	0.196	-0.191	-0.253*	-0.056	0.699**
Leaf length (cm)	rG					**1.000**	0.619**	-0.205	0.126	-0.075	-0.059	-0.102	0.678**
	rP					**1.000**	0.548**	-0.178	0.117	-0.073	-0.053	-0.087	0.655**
Leaf width (cm)	rG						**1.000**	-0.234*	0.234*	-0.135	-0.086	-0.203	0.745**
	rP						**1.000**	-0.190	0.211	-0.127	-0.087	-0.162	0.673**
Dry matter (%)	rG							**1.000**	0.020	0.072	-0.121	0.085	-0.325**
	rP							**1.000**	0.001	0.071	-0.091	0.061	-0.291*
L/S ratio	rG								**1.000**	-0.025	0.142	-0.117	0.332**
	rP								**1.000**	-0.029	0.138	-0.088	0.312*
Crude protein (%)	rG									**1.000**	-0.085	-0.079	-0.246*
	rP									**1.000**	-0.083	-0.075	-0.240*
Crude fat (%)	rG										**1.000**	-0.201	-0.277*
	rP										**1.000**	-0.156	-0.249*
Crude fibre (%)	rG											**1.000**	-0.112
	rP											**1.000**	-0.089
Green fodder yield/plant (g)	rG												**1.000**
	rP												**1.000**

*, ** Significant at 5 and 1 per cent level, respectively

TABLE 3. Path coefficient analysis of different characters with green fodder yield per plant in pearl millet

S. No.	Characters	Plant height (cm)	Number of nodes in main culm	Number of tillers/ plant	Number of leaves/ tiller	Leaf length (cm)	Leaf width (cm)	Dry matter (%)	L/S ratio	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Green fodder yield/plant (g)
1.	Plant height (cm)	**1.516**	1.347	0.783	1.435	1.110	1.129	-0.345	0.411	-0.298	-0.474	0.021	0.915**
2.	Number of nodes in main culm	-0.078	**-0.088**	-0.048	-0.081	-0.052	-0.054	0.003	-0.026	0.015	0.032	0.003	0.784**
3.	Number of tillers/plant	0.119	0.125	**0.231**	0.101	0.064	0.090	-0.098	0.081	-0.087	-0.023	0.012	0.675**
4.	Number of leaves/tiller	-0.586	-0.57	-0.271	**-0.619**	-0.355	-0.421	0.099	-0.143	0.135	0.186	0.035	0.814**
5.	Leaf length (cm)	-0.099	-0.080	-0.038	-0.078	**-0.136**	-0.084	0.028	-0.017	0.010	0.008	0.014	0.678**
6.	Leaf width (cm)	0.028	0.023	0.015	0.026	0.024	**0.038**	-0.009	0.009	-0.005	-0.003	-0.008	0.745**
7.	Dry matter (%)	-0.003	-0.0004	-0.005	-0.002	-0.002	-0.003	**0.011**	0.0002	0.001	-0.001	0.001	-0.325**
8.	L/S ratio	-0.001	-0.001	-0.001	-0.001	-0.0003	-0.001	0.000	**-0.002**	0.0001	-0.0003	0.0002	0.332**
9.	Crude protein (%)	0.007	0.007	0.014	0.008	0.003	0.005	-0.003	0.001	**-0.037**	0.003	0.003	-0.246*
10.	Crude fat (%)	0.014	0.016	0.004	0.013	0.003	0.004	0.005	-0.006	0.004	**-0.044**	0.009	-0.277*
11.	Crude fibre (%)	-0.003	0.006	-0.010	0.011	0.020	0.041	-0.017	0.023	0.016	0.040	**-0.201**	-0.112

Residual effect = 0.2327 *, ** Significant at 5 and 1 percent level respectively Diagonal values (bold) are direct effects

Correlation

In a forage crop, the green fodder yield, which is ultimately harvested, is influenced by number of vegetative plant characters. The knowledge of association between yield and other biometrical characters and the association among the component traits themselves would greatly help in indirect effective selection for high fodder yield. In the present investigation, the traits, plant height, number of tillers per plant, number of nodes, number of leaves per tiller, leaf length, leaf width and leaf stem ratio were positively correlated while dry matter per cent, crude protein and crude fat were negatively correlated with green fodder yield (Table 2). The obtained result coincided with the findings for number of tillers with green fodder yield by Mangat and Satija (1991) in fodder pearl millet, Logasundari (1995) in pearl millet and Khan *et al*. (2002) in Napier grass. Shinde *et al*. (2010) in Bajra Napier hybrid grass found positive correlation of dry matter content with green fodder yield. Vijendra Das and Ratnam Nadar (1991) remarked positive association of green fodder yield with plant height, number of tillers and leaf length. Plant height inter-correlated positively with number of nodes in main stem, number of tillers per plant, number of leaves per tiller, leaf length and width and leaf stem ratio and negatively with crude fat. Positive inter-correlation between number of tillers per plant and number of leaves per tiller and leaf stem ratio indicated that indirect selection for these traits can be helpful in increasing the green fodder yield along with more amounts of leaves leading to better palatability and intake. Similar result was reported by Ramakrishnan *et al*. (2013) in guinea grass. Hence, selection for component characters along with high protein content or low fibre content may indirectly help in increasing the fodder yield and fodder quality.

Path analysis

Path analysis is a statistical technique that helps in partitioning the total effect into direct and indirect effects (Wright, 1921). Since, the component traits themselves are inter-dependent; they often affect their direct relationship with yield and consequently restrict the reliability of the selection indices based purely on correlation coefficient alone. In view of this, correlation among the characters was subjected for analyzing the direct and indirect effects. The number of tillers per plant on green fodder yield had high positive direct effect (Table 3) and this result was in accordance with the results of Boe *et al*. (2008) in switch grass and Iyanar *et al*. (2010) in fodder sorghum. Number of leaves per plant had direct effect on green fodder yield were reported by Patel *et al*. (2005) in fodder maize, Bahadur and Lodhi (2009) in fodder oats and Jain and Patel (2012) in fodder sorghum. Plant height had very high positive indirect effect through number of nodes in main stem, number of leaves per tiller, leaf length and leaf weight. High positive indirect effect through number of tillers per plant and high negative indirect effect through dry matter per cent and crude fat on green fodder yield was observed. Same results were reported by Paramathma *et al*. (1994) and Patel *et al*. (2005) in fodder maize, Bahadur and Lodhi (2009) in fodder oats and Iyanar *et al*. (2010) in fodder sorghum. Number of tillers per plant had moderate positive indirect effect for dry matter per cent. Selection can be induced for high tillering genotypes for increasing the dry matter content. Inter-correlation for remaining traits was low and negligible on green fodder yield. Based on correlation and path analysis studies, the traits namely, plant height, number of nodes in main stem, number of tillers per plant, number of leaves per tiller, leaf length and leaf stem ratio might be responsible for increasing the green fodder yield per plant and thus could be used as selection criteria in future breeding programme for improving the fodder yield and quality. The estimates of correlation and direct and indirect effects are population dependent.

CONCLUSION

The traits plant height, number of nodes in main culm, number of tillers per plant, number of leaves per tiller, leaf width, leaf weight, stem weight, leaf stem ratio, dry matter per cent, crude protein and crude fat showed high heritability with high genetic advance as per cent of mean indicating the prevalence of additive gene action in their inheritance denoting the selection based on these traits to be quite effective. In association study, the traits, plant height, number of tillers per plant, number of nodes, number of leaves per tiller, leaf length, leaf width and leaf stem ratio being positively correlated with green fodder yield could be used as traits of interest for indirect selection to improve green fodder yield in further breeding programme.

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