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STUDY OF VARIABILITY, CORRELATION AND PATH ANALYSIS IN FORAGE SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH]

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ABSTRACT
Genetic variability, correlation and path analysis was studied for yield and its attributing characters in forty diverse genotypes of in forage sorghum [*Sorghum bicolor* (L.) Moench.A wide range of phenotypic variability was recorded for green fodder yield per plant and its component traits. In the present study magnitude of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as percentage of mean were recorded high for various characters like leaf: stem ratio, number of leaves per plant, green fodder yield per plant, stem girth and dry matter yield per plant. The results of Correlation analysis suggested that the magnitude of genotypic correlation were higher as compared to their corresponding phenotypic correlations indicating the inherent relationship among the characters studied. Green forage yield per plant was highly significant and positively correlated with stem girth, leaf length, leaf width and dry matter yield per plant at both genotypic and phenotypic level. These characters may be considered as important yield component in sorghum. Path coefficient analysis revealed high positive direct effect of dry matter yield per plant, stem girth and days to fifty per cent flowering. These traits had high magnitude of genotypic correlation with green forage yield per plant.

INTRODUCTION

Sorghum is one of the important crops of dry land agriculture. In a systematic breeding programme, collection and evaluation of germplasm is the first step. Variability is the prerequisite for the effective selection. The success of any crop improvement programme not only depends on the amount of genetic variability present in the population but also on the extent to which it is heritable, which sets the limit of progress that can be achieved through selection(Narasimharao *et al.,* 1964).Knowledge of heritability influences the choice of selection procedures used by the plant breeder to decide which selection methods would be most useful to improve the character, to predict gain from selection and to determine the relative importance of genetic effects. Characters with high heritability can easily be fixed with simple selection resulting in quick progress. (Mallinath *et al.,* 2004).Genetic advance shows the degree of gain obtained in a character under a particular selection pressure. High genetic advance coupled with high heritability estimates offers the most suitable condition for selection Kalpande *et al.,* (2015). The correlation study among quantitative traits is important for assessing the feasibility of joint selection of two or more traits and hence for evaluating the effect of selection for secondary traits on genetic gain for the primary trait under consideration.Kalpande *et al.,* (2015) A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously Dapke *etal.,* (2014). Path coefficient analysis was performed to qualify the direct and indirect contributors of yield. Therefore the present investigation was undertaken to study the genetic variability, relationships among quantitative traits and Path coefficient analysis in selected genotypes of sorghum.

Green fodder is the cheapest source of feed for milch, beef and draft animals. Therefore, development of fodder resources of the country becomes a high priority national programme. This could be achieved through bringing more area under fodder cultivation and improving productivity of fodder crop. As there is little scope of increasing area under cultivation of fodder crops due to urbanization, industrialization and traditional inclination among farmers. Only 4.4% of the total cropped area of the country is under fodder crops cultivation. Hence, only optional strategy to meet fodder requirement is to exploit crop productivity through better yielding varieties and efficient agronomic management.Therefore the present study was undertaken with the objective to study the variability among the genotypes and finding out the correlation among them with direct and indirect effect on the green fodder yield in sorghum.

MATERIALS AND METHODS

The 40 turmeric accessions were received from different parts of Gujarat and those were evaluated at Main Forage Research Station, A.A.U., Anand., during *kharif*season of the year 2011-2012. The experiment was laied out in randomized block design having three replication with the each two rows of three meter length with 30 cm and 10 cm inter and intra row spacing, respectively. The recommended agronomic practices and plant protection measures were followed timely for the successful raising of the crop. Five competitive plants were

randomly selected and tagged after leaving the one plant in each border row in every plot of all the replications to record the observations ofmorphological traits. The mean value of these plants was computed and used for statistical analysis. Analysis of variance to test the significance difference among accessions for each character was carried out as per methodology advocated by (Panse and Sukhatme, 1967). PCV and GCV were calculated by the formula given by (Panse and Sukhatme, 1967), heritability in broad sense (h^2) was worked out by using formula suggested by (Burtan and Devane, 1953) and genetic advance *i.e.* the expected genetic advance were calculated by using the procedure given by (Johnson, 1955). The genotypic and phenotypic correlation were calculated following the method of Singh and Chaudhary (1985) whereas the path coefficient analysis as per method given by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Variability, Heritability and Genetic Advance

Highly significant mean squares due to genotypes for all the characters revealed the presence of enough genetic variability in the material under study (Table 1). The genotypic coefficient of variation provides a measure to compare of genetic variability present fifteen parameters (Table 2). The highest genotypic coefficient of variation was recorded for leaf: stem ratio (83.08), dry matter yield per plant (g) (51.65), green fodder yield per plant (g) (43.08), number of leaves per plant (30.60), stem girth (29.11) and number of tillers per plant (23.45), crude fiber content (22.89%) and dry matter content (%) (22.34) show high GCV and low estimates of genotypic coefficient of variation value were observed NDF content (6.72%) Similar finding were reported by (Sharma and Sharma, 2006). Phenotypic coefficient of variation which measures the total relative variation was high dry matter yield per plant (52.13) and green fodder yield per plant (43.39) whereas, low estimate of phenotypic coefficient of variance were observed for crude protein content (10.07), days to fifty per cent flowering (11.84), leaf length (12.62) and plant height (14.23) (Table 3). These findings are in agreement with the findings of (Sharma and Sharma, 2006).

The heritability estimates help the breeders in selection based on the phenotypic performance. In the present study the estimation of heritability ranged from NDF content (37.8) to days to fifty percent flowering (99.2). The characterdays to fifty percent flowering showed highest heritability in traits like days

Table 1: Analysis of variance (ANOVA) showing mean sum of squares of fifteen characters in sorghum

Sr. No.	Source d.f.	Replications 2	Genotypes 39	Error 78
1.	Days to 50 per cent flowering	5.29**	157.03**	0.44
2.	Plant height (cm) at 50 per cent flowering	1327.5**	2663.3**	150.3
3.	Number of tillers per plant	0.098	0.94**	0.055
4.	Leaf: Stem ratio	0.011**	0.40**	0.0012
5.	Number of leaves per plant	2.63*	41.6**	0.78
6.	Leaf length (cm)	64.09*	228.83**	13.31
7.	Leaf width (cm)	1.08	2.91**	0.39
8.	Stem girth	0.0040	0.15**	0.0070
9.	Green fodder yield per plant (g)	43.75	8858.25**	43.07
10.	Dry matter content (%)	4.37	130**	5.57
11.	Dry matter yield per plant (g)	2.23	1081.51**	6.76
12.	Crude protein content (%)	0.13	1.78**	0.089
13.	HCN content (ppm)	90.25	958.53**	112.48
14.	NDF content (%)	85.56	121.35**	43.00
15	Crude fibre content (%)	10.67*	110.63**	2.34

*, ** Significant at 0.05 and 0.01 level of probability, respectively.

Table 2: Range of variation, Mean ± S.E., C.D. and components of variance of different characters in sorghum

Sr. No.	Character	Range	Mean ± S.E.	C.D.	Phenotypic	Genotypic
1.	Days to 50 per cent flowering	48.33-71.67	61.29± 0.54	1.08	52.63	52.2
2.	Plant height (cm) at 50 per cent flowering	157.23-276.80	220.84± 10.01	19.53	987.98	837.69
3.	Number of tillers per plant	1.2-3.4	2.31± 0.19	0.37	0.35	0.295
4.	Leaf:Stem ratio	0.04-1.2	0.44± 0.03	0.031	0.13	0.13
5.	Number of leaves per plant	6.67-22.8	12.05± 0.72	1.41	14.38	13.6
6.	Leaf length (cm)	56.0-93.83	73.15± 2.98	5.82	85.16	71.84
7.	Leaf width (cm)	2.77-6.53	4.90± 0.51	1	1.23	0.84
8.	Stem girth	0.45-1.55	0.76± 0.07	0.076	0.054	0.047
9.	Green fodder yield per plant (g)	45.17-306.67	125.84± 5.21	6.04	2981.46	2938.39
10.	Dry matter content (%)	18.27-43.48	28.83± 2	2.17	47.05	41.48
11	Dry matter yield per plant (g)	11.83-85.83	36.64± 2.12	2.4	365.01	358.25
12	Crude protein content (%)	7.03-9.49	8.00± 0.24	0.080	0.649	0.56
13	HCN content (ppm)	34.30-123.40	84.12± 8.66	9.77	394.49	282.01
14	NDF content (%)	65.20-84.93	76.00± 5.35	6.03	69.12	26.12
15	Crude fibre content (%)	18.40-44.50	26.25± 1.25	1.41	38.43	36.09

Table 3: The estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), Heritability (%), expected genetic advance and expected genetic advance as percentage of mean for various characters in sorghum.

Sr.No.	Source	GCV	PCV	Heritability(%)	GA	GA(%)
1.	Days to 50 per cent flowering	11.79	11.84	99.2	14.82	24.18
2.	Plant height (cm) at 50 per cent flowering	13.11	14.23	84.8	54.90	24.86
3.	Number of tillers per plant	23.45	25.57	84.1	1.03	44.59
4.	Leaf:Stem ratio	83.08	83.45	99.1	0.75	170.45
5.	Number of leaves per plant	30.60	31.47	94.5	7.39	61.33
6.	Leaf length (cm)	11.59	12.62	84.4	16.04	21.93
7.	Leaf width (cm)	18.72	22.69	68.0	1.56	31.84
8.	Stem girth	29.11	31.11	87.6	0.43	56.58
9.	Green fodder yield per plant (g)	43.08	43.39	98.6	110.86	88.12
10.	Dry matter content (%)	22.34	23.79	88.2	12.46	43.22
11	Dry matter yield per plant (g)	51.65	52.13	98.1	38.63	105.43
12	Crude protein content (%)	9.35	10.07	86.3	1.42	17.75
13	HCN content (ppm)	19.96	23.61	71.5	29.25	34.77
14	NDF content (%)	6.72	10.94	37.8	6.47	8.51
15	Crude fibre content (%)	22.89	23.62	93.9	11.99	45.68

Table 4: Genotypic and phenotypic correlation coefficient for fifteen characters of sorghum

Characters		DTF	PLH	NTP	LSR	NLP	LL	LW	SG	GFYPP	DMC	DMYPP	CP	HCN	NDF	CF
DTF	Rg		0.080	-0.143	-0.137	-0.119	0.109	0.190	0.088	0.103	-0.033	-0.015	-0.087	0.266	0.308	-0.028
	Rp		0.077	-0.134	-0.136	-0.115	0.100	0.153	0.082	0.103	-0.026	-0.015	-0.078	0.222	0.191	-0.028
PLH	Rg			-0.495**	-0.794**	-0.561**	-0.242	0.326*	0.258	0.253	0.723**	0.525**	-0.307	-0.068	0.174	-0.136
	Rp			-0.432**	-0.732**	-0.494**	-0.203	0.248*	0.222	0.220	0.639**	0.476**	-0.256*	-0.070	0.113	-0.111
NTP	Rg				0.432**	0.355*	0.192	-0.232	-0.311	-0.247	-0.251	-0.231	0.261	0.229	0.004	-0.164
	Rp				0.397**	0.332**	0.147	-0.150	-0.267*	-0.224	-0.224	-0.211	0.209	0.142	-0.005	-0.142
LSR	Rg					0.845**	0.401*	-0.153	-0.071	-0.068	-0.620**	-0.357*	0.468**	-0.166	-0.442	0.296
	Rp					0.816**	0.369**	-0.124	-0.069	-0.065	-0.585**	-0.353**	0.436**	-0.136	-0.273*	0.283*
NLP	Rg						0.403*	-0.076	0.155	0.117	-0.309	-0.075	0.253	-0.346*	-0.441**	0.407*
	Rp						0.398**	-0.052	0.132	0.106	-0.285*	-0.078	0.220	-0.285*	-0.285*	0.384**
LL	Rg							0.436**	0.414**	0.612**	-0.167	0.367*	0.157	0.128	-0.135	-0.028
	Rp							0.388**	0.349**	0.552**	-0.150	0.319**	0.127	0.095	-0.099	-0.041
LW	Rg								0.565**	0.750**	0.262	0.751**	-0.174	0.127	0.275	-0.218
	Rp								0.464**	0.616**	0.167	0.609**	-0.157	0.114	0.129	-0.195
SG	Rg									0.858**	0.220	0.706**	-0.268	-0.232	-0.165	0.260
	Rp									0.797**	0.194	0.652**	-0.232*	-0.196	-0.142	0.255*
GFYPP	Rg										0.177	0.828**	-0.200	0.007	-0.062	0.053
	Rp										0.164	0.816**	-0.187	0.010	-0.046	0.045
DMC	Rg											0.646**	-0.458**	-0.263	0.042	-0.091
	Rp											0.605**	-0.376**	-0.216	0.034	-0.081
DMYPP	Rg												-0.351*	-0.059	0.131	-0.142
	Rp												-0.319**	-0.053	0.072	-0.126
CP	Rg													0.256	-0.010	-0.278
	Rp													0.228*	0.017	-0.248*
HCN	Rg														0.526**	-0.684**
	Rp														0.290*	-0.566**
NDF	Rg															-0.795**
	Rp															-0.489**
CF	Rg															
	Rp															

** Significant at P = 0.05 and 0.01 levels respectively.DTF: Days to 50% flowering, PLH: Plant height at 50% flowering, NTP: Number of tillers per plant, LSR: Leaf: stem ratio, NLP: Number of leaves per plant, LL: Leaf length (cm) , LW: Leaf width (cm), SG: Stem girth (cm), DMC: Dry matter content (%), DMYPP: Dry matter yield per plant (g), CP:Crude protein content (CP %), HCN:Hydrocyanic acid content (ppm), NDF: Neutral detergent fibre content (%), CF:Crude fibre content (CF %)

to fifty per cent flowering (99.2%), leaf: stem ratio (99.1%), green fodder yield per plant (98.6%), dry matter yield per plant (98.1%) and number of leaves per plant (94.5). Similar results have been reported for days to fifty per cent flowering by Agrawal (2004). Whereas Anjana (2006) noticed similar results for days to fifty per cent flowering and green fodder yield per plant in sorghum and low heritability observed in NDF content (37.8), Leaf width (68.0) and HCN (71.5) (Table 3). Similar findings were observed by (Sharma and Sharma., 2006). On examining the estimate of genetic advance expressed in per cent of mean of different character (Table 3), it was high forleaf: stem ratio (170.45), dry matter yield per plant (105.43), green fodder yield per plant (88.12), number of leaves per plant (61.33), stem girth (56.58), number of tiller per plant (44.59) and dry matter content (43.22). It was low for days to 50 % flowering (24.18), leaf length (21.93), leaf width (31.84), plant height (24.86) and NDF content (8.51) (Table 3).High heritability coupled with genetic advance was observed for Leaf: stem ratio, green fodder yield per plant and in dry matter yield per plant. The similar results byBangarawa (1989)and Sood and Ahluwalia (1989)

Correlation

Correlation analysis suggested that the magnitude of genotypic correlation were higher as compared to their corresponding

Table 5: Path coefficient analysis showing direct and indirect effects of fifteen causal variables on Green fodder yield per plant in sorghum

Sr. No.	Characters	DTF	PLH	NTP	LSR	NLP	LL	LW	SG	DMC	DMYPP	CP	HCN	NDF	CF	GCGFYPP
1.	DTF	0.164	-0.012	-0.002	0.083	-0.015	0.001	-0.013	0.014	0.030	-0.017	0.070	-0.057	-0.153	0.010	0.103
2.	PLH	0.013	-0.149	-0.006	0.482	-0.072	-0.002	-0.022	0.040	-0.655	0.611	0.034	0.015	-0.087	0.050	0.253
3.	NTP	-0.023	0.074	0.011	-0.262	0.046	0.002	0.015	-0.049	0.228	-0.269	-0.029	-0.049	-0.002	0.061	-0.247
4.	LSR	-0.022	0.118	0.005	-0.607	0.109	0.004	0.010	-0.011	0.562	-0.415	0.034	0.036	0.220	-0.110	-0.068
5.	NLP	-0.020	0.083	0.004	-0.513	0.129	0.004	0.005	0.024	0.280	-0.087	0.064	0.075	0.219	-0.151	0.117
6.	LL	0.018	0.036	0.002	-0.244	0.052	0.010	-0.029	0.065	0.152	0.427	0.073	-0.028	0.067	0.010	0.612**
7.	LW	0.031	-0.049	-0.003	0.093	-0.010	0.004	-0.067	0.089	-0.237	0.874	0.108	-0.028	-0.137	0.081	0.750**
8.	SG	0.014	-0.038	-0.004	0.043	0.020	0.004	-0.038	0 .157	-0.200	0.821	0.042	0.050	0.082	-0.097	0.858**
9.	DMC	-0.005	-0.107	-0.003	0.377	-0.040	-0.002	-0.017	0.035	-0.906	0.751	0.026	0.057	-0.021	0.034	0.177
10.	DMYPP	-0.002	-0.078	-0.003	0.217	-0.010	0.004	-0.050	0.111	-0.585	1.163	0.062	0.013	-0.065	0.053	0.828**
11.	CP	-0.045	0.077	0.013	-0.714	0.186	-0.026	-0.044	0.031	0.716	-0.485	-0.127	-0.154	0.015	0.356	-0.200
12.	HCN	0.044	0.010	0.003	0.101	-0.045	0.001	-0.008	-0.036	0.238	-0.068	-0.009	-0.216	-0.262	0.254	0.007
13.	NDF	0.050	-0.026	0.000	0.269	-0.057	-0.001	-0.018	-0.026	-0.038	0.152	-0.051	-0.114	-0.498	0.295	-0.062
14	CF	-0.005	0.020	-0.002	-0.180	0.053	0.000	0.015	0.041	0.083	-0.165	0.021	0.148	0.396	-0.372	0.053

Residual effect = 0.5009 *, ** Significant at P = 0.005 and 0.001 levels respectively; DTF: Days to 50% flowering, PLH: Plant height at 50% flowering, NTP: Number of tillers per plant, LSR: Leaf: stem ratio, NLP: Number of leaves per plant, LL: Leaf length (cm) , LW: Leaf width (cm), SG: Stem girth (cm), DMC: Dry matter content (%), DMYPP: Dry matter yield per plant (g), CP:Crude protein content (CP %), HCN:Hydrocyanic acid content (ppm), NDF: Neutral detergent fibre content (%), CF:Crude fibre content (CF %), GCGFYPP: Genotypic correlation with Green fodder yield

phenotypic correlations indicating the inherent relationship among the characters studied (Table 4). Green forage yield per plant was highly significant and positively correlated with stem girth, leaf length, leaf width and dry matter yield per plant at both genotypic and phenotypic level. These characters may be considered as important yield component in sorghum.

whereas green fodder yield per plant was positively and non-significantly correlated with dry matter content, HCN content, CF content, days to 50 per cent flowering, plant height and number of leaves per plant at both the levels. Crude protein content, NDF content, number of tillers per plant and leaf: stem ratio were showing negative and non-significant correlation. The present findings were in close conformity with green fodder yield per plant by Sood and Ahluwalia (1989), Yadav *et al*. (2003).

Path coefficient analysis

In sorghum green fodder yield per plant is the result of direct and indirect effects of several yield contributing characters. To know the contribution of various characters towards green fodder yield per plant, the significant genotypic correlation of different traits with green fodder yield per plant have been partitioned into their direct and indirect effects. This will provide more precise information for the selection of important traits, which may contribute more towards green fodder yield per plant. Direct and indirect effects of fifteen casual variables on green fodder yield per plant are presented in Table 5.

Fifteen characters were considered as casual variables of green fodder yield, the high positive direct effect on green fodder yield per plant was that of leaf length; stem girth, dry matter yield per plant. These three characters had positive and significant correlation with green fodder yield per plant. These findings are in accordance with the results obtained in sorghum by Rohewal (1964), Phul *et al*. (1972), Sood (1975), Gopalan and Balasubramanian (1978) and Grewal (1983), Bangarawa (1989) and Sood and Ahluwalia (1989). In such situation indirect causal factors can be used for selection.

Based on above conclusions, the characters dry matter yield per plant, green fodder yield per plant, number of leaves per plant, stem girth, leaf legth and leaf width had maximum genetic advance under selection and significant positive genotypic correlation along with high direct or indirect effect on green fodder yield per plant. These characters should be used for selection of desirable genotype after hybridization between the accessions for creating wide spectrum of favorable genetic variability for improvement of green fodder yield in sorghum.

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