Correlation and Path Coefficient Analysis for Agronomical Traits in Forage Sorghum [*Sorghum bicolor* (L.) Moench]

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Forage sorghum germplasm field experiment was conducted at Sorghum Research Station, Deesa (Gujarat) during *kharif* 2008 by using 144 genotypes to study the variability parameters and genotypic and phenotypic correlations and path analysis among agronomic traits. Significant variation among all the genotypes was recorded for all the characters. Most of the characters had higher genotypic and phenotypic coefficient of variation which is indicative that character expression in this sorghum population was genetic and can be exploited in breeding programs. The genotypes also exhibited varying degrees of heritability and genetic advance. Characters such as plant height, stem girth and dry and green fodder yield responded positively to selection because of high broad sense heritability and high genetic advance. Plant height, stem girth and leaf length were positively and significantly associated with green fodder and dry fodder yield per plant. Leaf breath was positively and significantly associated with plant height, number of leaves per plant and leaf length. The path coefficient analysis indicated positive and significant correlation as well as high direct effect of dry fodder yield per plant, plant height, number of leaves per plant and stem girth on green fodder yield per plant.

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) crop is genetically suited to hot and dry agro-ecologies with frequent drought, where it is difficult to grow other crops. In north Gujarat areas sorghum is mainly grown for dual and forage purposes. Therefore, it can play a vital role for the uplift of socio-economic status of the farmers of north Gujarat areas through development of high yielding varieties along with reasonable amount of green and dry fodder for the livestock.

The study of relationships 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. A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. The path coefficient analysis allows partitioning of correlation coefficient into direct and indirect contributions (effects) of various traits towards dependent variable and thus helps in assessing the cause-effect relationship as well as effective selection. Hence, this study is aimed to analyze and determine the traits having greater interrelationship with yield utilizing the correlation and path analysis for different traits in forage sorghum.

Materials and Methods

One-hundred forty-four forage sorghum genotypes collected from Directorate of Sorghum Research (DSR), Hyderabad and local landraces of Gujarat were used for the present study. The trial was grown in augmented block design at Sorghum Research Station, Sardar Krushinagar Dantiwada Agricultural University, Deesa (Gujarat) during 2008 *kharif* season. Deesa is situated at latitude of 24.5° N and longitude 72° E and at an elevation of 136 m above the msl. The soil of the field was sandy in texture with pH value of 7.5 to 8.0 having good physical and chemical properties (Organic Carbon= 0.23, EC dsm^{-} = 0.232, K_2O= 259.9 kg/ha and P_2O_5= 46.2 kg/ha). The experimental unit was a single-row plot of 6.75 m long, spaced 0.45 m apart. NPK 120:40:00 fertilizers was applied as half basal dose of nitrogen and full dose of phosphorus at the time of sowing and half nitrogen applied after one month of sowing. Plots were thinned down after two weeks of crop emergence and plant-to-plant distance of 0.10 m was maintained. The total rainfall during the crop season was 495.4 mm. The other recommended agronomic practices were followed to raise a good crop. Data was taken on time to 50% flowering (days), plant height (cm), number of leaves per plant, leaf length (cm), leaf breath (cm), stem girth (cm), leaf stem ratio, green fodder yield per plant(g) and dry fodder yield per plant (g). Analysis of variance was done by method suggested by Panse

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and Sukhatme (1978). Genotypic and phenotypic coefficient of variability, heritability and genetic gain, genotypic and phenotypic correlation coefficient and path coefficient using standard method suggested by Burton (1952), Johnson, *et al.* (1955), Al-Jibouri, *et al.* (1958) and Dewey and Lu (1959), respectively.

Results and Discussion

Analysis of variance indicated significant differences among genotypes for all the traits studied, indicating thereby the presence of wide range of variability (Table 1). The genetic constants for the characters revealed that the magnitude of phenotypic coefficient of variation (PCV) was higher than the corresponding genotypic coefficient of variation (GCV) for all the traits denoting environmental factors influencing their expression to some degree or other. Wide differences between PCV and GCV implied their susceptibility to environmental fluctuation, where as narrow differences between PCV and GCV suggested their relative resistance to environmental alteration. In the present study, the PCV and GCV were higher for plant height (cm), number of leaves per plant, leaf breath (cm), stem girth (cm), leaf stem ratio, green fodder yield per plant (g) and dry fodder yield per plant (g) (Table 2). High amount of GCV and PCV suggested greater scope for selection of superior genotypes for these traits while the lower degree of GCV and PCV for leaf length and days to 50% flowering indicated that improvement for such traits may be achieved only up to some extent. Similar findings were also obtained from earlier reports (Warkad *et al.*, 2008).

The estimate of GCV and PCV alone is not much helpful in determining the heritable portion. The amount of advance to be expected from selection can be achieved by estimating heritability along with coefficient of variability. Burton also suggested that GCV and heritability estimate would give better information about the efficiency of selection (Burton,1952). The heritability ranged from 63.56% for days to 50% flowering to 92.49% for stem girth. The high degree of heritability estimate for most of the traits suggested that the characters are under genotypic control. Similar result was also reported by Warkad *et al.* (2008). The high heritability doesn't necessarily mean high genetic gain and alone is not sufficient to make improvement through selection. The utility of heritability is increased when it is used to estimate genetic advance (Johnson *et al.*, 1955). Thus the genetic advance has an added edge over heritability as a guiding factor to breeders in selection programme. High heritability coupled with high genetic advance and GCV were noticed for green fodder yield/plant, dry fodder yield/plant and plant height indicating control of additive gene action. Simple selection model will be good enough to do needful and no additional gain is achieved by using sophisticated models.

Table 1. Analysis of variation for different traits in forage sorghum

Source	DF	Days to 50% flowering	Plant height (cm)	No. of leaves per plant	Leaf length (cm)	Leaf breadth (cm)	Stem girth (cm)	Leaf stem ratio	Green fodder yield per plant (g)	Dry fodder yield per plant (g)
Replication	6	10.90	917.90*	8.90	54.78	0.23	1.12	0.01	3232.59**	888.27**
Treatments	143	127.18**	1621.45**	10.71**	79.32	1.22**	2.35**	0.2**	4282.68**	891.03**
(a) Checks	3	1294.32**	2262.14**	24.79**	474.99**	1.18**	3.59**	0.1**	6852.63**	1737.00**
(b) Germplasm	140	102.17**	1607.72**	10.41**	70.84**	1.22**	2.32**	0.2**	4227.61**	872.90**
Error	18	16.79	286.59	3.46	71.52	0.23	0.17	0.01	771.47	185.91

Table 2. Variability parameters for different traits in forage sorghum

Characters	CV	SE	PCV	GCV	H2	GA	GG
Days to 50% flowering	6.17	2.19	13.52	12.36	83.56	17.40	23.28
Plant height (cm)	8.12	9.05	29.95	36.90	92.17	67.87	87.16
No. of leaves per plant	19.63	0.99	36.60	29.91	66.79	4.44	50.36
Leaf length (cm)	13.05	4.52	13.88	9.00	90.00	0.17	0.27
Leaf breath (cm)	8.88	0.26	24.06	21.69	81.24	1.85	40.26
Stem girth (cm)	12.51	0.22	49.67	47.77	92.49	2.90	94.64
Leaf stem ratio	30.89	0.04	43.29	35.99	69.09	0.21	61.62
Green fodder yield per plant (g)	23.33	14.85	50.73	45.87	81.75	109.50	85.43
Dry fodder yield per plant (g)	23.69	7.29	54.89	48.69	78.70	47.90	88.99

Genotypic and phenotypic correlation coefficients between the various traits, computed are presented in Table 3. Genotypic correlation coefficient provides measures of genetic association between traits and thus helps to identify the more important as well as less important traits to be considered in breeding programmes. For most of the association in this study, the genotypic correlation coefficients are higher than phenotypic correlation coefficients. Higher genotypic correlations of characters than phenotypic correlation coefficients had earlier been reported (Alhassan *et al*., 2008). Expressions of higher genotypic than phenotypic correlations are indications of strong inherent relationships between these characters (Johnson, 1955). However, when phenotypic correlations are higher than genotypic correlations, environmental effect or non-additive effects are acting on the trait in the same direction. Plant height, number of leaves per plant, stem girth and leaf length were positively and significantly associated with green fodder and dry fodder yield per plant. Leaf breadth was positively and significantly associated with plant height, number of leaves per plant and leaf length. However, number of leaves per plant was negatively and significantly correlated with leaf length. All other traits indicated no significant correlation among themselves. Green and dry fodder yield per plant had a strong association with leaf length, number of leaves per plant and plant height and stem girth. This indicated that when the number of leaves are many, there will be a greater surface area for photosynthesis; greater photosynthesis can translate into more photosynthates, ultimately resulting in increased fodder yield (Alhassan *et al.*, 2008). In maize also a positive association between photo synthetically active leaf number and grain and fodder yield had been indicated (Mohammed *et al*., 2003). Path analysis provides an effective means of partitioning direct and indirect causes

Table 3. Correlation matrix for different traits in forage sorghum

Character	r	Plant height (cm)	No. of leaves per plant	Leaf length (cm)	Leaf breath (cm)	Stem girth (cm)	Leaf stem ratio	Green fodder yield per plant (g)	Dry fodder yield per plant (g)
Days to 50% flowering	g	0.111	0.213	–0.100	0.243	0.140	0.150	0.236	0.395*
	p	0.079	0.081	0.183	0.156	0.103	0.076	0.166	0.333*
Plant height (cm)	g		0.685**	–0.220	0.769**	–0.067	–0.448*	0.796**	0.538*
	p		0.550**	0.330	0.517**	–0.022	–0.284	0.766**	0.416*
No. of leaves per plant	g			–0.491*	0.635**	–0.086	–0.138	0.833**	0.276
	p			–0.451*	0.529**	–0.031	–0.142	0.710**	0.399*
Leaf length (cm)	g				0.600**	0.200	–0.100	0.723**	0.390*
	p				0.500*	0.195	–0.246	0.610**	–0.020
Leaf breath (cm)	g					–0.131	–0.222	0.207	–0.021
	p					–0.111	–0.256	0.233	0.040
Stem girth (cm)	g						–0.102	0.630**	0.499*
	p						–0.106	0.639**	0.433*
Leaf stem ratio	g							0.064	0.191
	p							0.026	0.083
Green fodder yield per plant (g)	g								0.873**
	p								0.891**

Table 4. Path analysis for green fodder yield per plant (g) in forage sorghum

Character	Days to 50% flowering	Plant height (cm)	No. of leaves per plant	Leaf length (cm)	Leaf breath (cm)	Stem girth (cm)	Leaf stem ratio	Dry fodder yield per plant (g)	r
Days to 50% flowering	–0.2623	–0.0828	–0.0571	–0.0245	0.2306	0.0183	–0.0273	0.5385	0.3334
Plant height (cm)	0.0292	0.5441	0.0841	0.012	0.0221	–0.0087	0.0819	0.0321	0.0796
No. of leaves per plant	–0.3857	–0.5098	0.868	–0.1322	0.6027	–0.0112	0.0252	0.3767	0.8337
Leaf length (cm)	0.3605	0.421	0.4188	–0.1222	–0.5456	–0.1744	0.6432	–0.2775	0.7238
Leaf breath (cm)	–0.0637	–0.5719	–0.1706	–0.3451	0.9495	–0.0170	0.0406	–0.0293	–0.2075
Stem girth (cm)	–0.0368	0.0496	0.0231	–0.111	–0.1241	0.1305	0.0187	0.6804	0.6304
Leaf stem ratio	–0.0392	0.3337	0.0372	–0.1212	–0.2112	–0.0134	–0.1826	0.2612	0.0645
Dry fodder yield per plant (g)	–0.1035	–0.1772	–0.0742	–0.1452	–0.0204	0.0651	–0.0350	1.3640	0.8738

Res. Effect: 0.0774

of association while permitting a critical examination of the specific forces to produce a given correlation and measure the relative importance of each causal factor. The path coefficient analysis indicated positive and significant correlation as well as high direct effect of dry fodder yield per plant, plant height, number of leaves per plant and stem girth on green fodder yield per plant. A similar finding was also reported by Sankarapandian (2000). Results from the present study indicated that selection for plant height, leaf length, number of leaves per plant, stem girth will be the best indirect selection indices for increasing green and dry fodder yield.

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