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Genetic parameters and character associations for yield and yield contributing traits in dual sorghum (*Sorghum bicolor* L. Moench)

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ABSTRACT

Thirty two advanced dual sorghum genotypes were evaluated at Sorghum Research Station, S. D. Agricultural Univeristy, Deesa during *Kharif* 2015 to study the genetic variability and genetic association for grain yield, fodder yield and their component characters. Both genotypic and phenotypic variances were highly significant in all the traits with little higher phenotypic variations as usual. Similarly, the low differences between the phenotypic and genotypic coefficients of variations indicated low environmental influences on the expression of these characters. High heritability coupled with high genetic advance in % of mean was obtained with panicle length, leaf length, leaf width, plant height, grain yield and fodder yield. Genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients in most of the traits. Plant height, number of leaves/plant, leaf length, leaf width and days to maturity were the most important characters which possessed positive association with fodder yield. While panicle length was positively and significantly associated with grain yield. Path coefficient analysis revealed that among the different yield contributing characters fodder yield, panicle length and leaf length influenced grain yield directly while leaf width, number of leaves/plant, plant height, days to maturity and grain yield influenced fodder yield directly. The direct effects of these characters on grain yield and fodder yield were positive and considerably high. Thus the plant selection based on these traits will be most effective in the development of dual sorghum varieties.

Key words : Genetic variability, GCV, PCV, character associations, path analysis, genetic advance

Sorghum (*Sorghum bicolor* (L.). Moench) is the fifth most important food crop in world after wheat, rice, maize, and barley and fourth most important in the India after wheat, rice and maize. India contributes about 16% of the world's sorghum production. It is the fifth largest sorghum producer after United States of America, Mexico, Nigeria and Sudan with 5.82 million hectares of area with a total production of 5.39 million tons (FAOSTAT, 2015). Sorghum is tolerant to drought and heat and genetically suited to hot and dry agro-ecologies where it is difficult to grow other food grains. It is important nutrition cereals constituting staple diet of the major population in arid and semi arid region of India. It is also used for feed, fodder and the production of alcoholic beverages. Grain and fodder yield are the principal characters of dual cereal crops. These are complex quantitative characters having positive and negative effects of number of yield contributing traits. They are affected by genetic and environmental factors and thus an interaction between them makes it difficult to select the plant with increased yield. So, the selection for desirable types should not only be based on yield, the other yield components should also be considered. Direct selection for yield is often misleading in sorghum because sorghum grain and fodder yield are controlled by polygenes. For effective utilization of the genetic stock in crop improvement, information of mutual association between yield and yield components is necessary. It is, therefore, necessary to know the correlation of various component characters with yield and among themselves. The correlation coefficients between yield and yield components usually show a complex chain of interacting relationship. Path coefficient analysis partitions the components of correlation coefficient

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into direct and indirect effects and illuminates the relationship in a more meaningful way. The success of a breeding program depends largely upon the amount of genetic variability present in the population and the extent to which the desired traits are heritable. Therefore, an attempt was undertaken to estimate genetic variability, association among desired traits and their direct and indirect effects towards grain and fodder yield of dual sorghum.

MATERIALS AND METHODS

The experiment was conducted at the experimental Farm of the Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa (BK), Gujarat ((latitude of 24.5° N. longitude of 72° E and elevation of 136 M above the Mean Sea Level)) during *Kharif, 2015*. The experiment consisted of 32 dual sorghum genotypes developed at the centre. The details of study materials are shown in Table 1. The soil of the field was sandy in texture with pH value of 7.5 to 8.00 having good physical and chemical properties (Organic Carbon= 0.23 % , EC = 0.232 dSm^{-1}, K_2O= 259.9 kg/ha and P_2O_5= 46.2 kg/ha). The experimental unit was four-row plot of 5.0 m length with row to row and plant to plant distance maintained at 0.45 and 0.15 meters, respectively. NPK 80:40:00 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. The all other recommended agronomical practices were followed to raise a good crop during the season. Data were taken on days to 50 % flowering, plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm), panicle length (cm), grain yield (q/ha) and dry fodder yield (q/ha). Analysis of variance was performed by computer using MSTAT-C software. The test of significance was done by F-test. Genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were estimated according to Burton and De Vane (1953); heritability in broad sense (h2b), genetic advance (GA) and genetic advance as % of mean (GAPM) were calculated following Hanson *et.al.*, (1956); correlation coefficients were estimated according to Al-Jibouri *et.al.*, (1958) and path coefficient analysis was done following Dewy and Lu (1959).

RESULTS AND DISCUSSION

Evaluation of 32 advanced genotypes of dual sorghum showed significant differences for the traits viz., days to 50 % flowering, plant height, number of leaves per plant, leaf length, leaf width, panicle length, grain yield and dry fodder yield suggesting the presence of significant variation among the genotypes under study (Table 2). The extent of variability for any character is very important for the improvement of a crop through breeding. The variability of the characters was also measured by Mean, range, GCV, PCV, broad sense heritability (h2b), genetic advance (GA) and genetic advance *per cent* of mean (GAPM) for all traits are given in Table 3.

Table 1 List of 32 sorghum genotypes with their pedigree used in this study

S.N.	Entry	Pedigree	S.N.	Entry	Pedigree
1	DS 0130	IS 22557 x I 12	17	DS 0146	NSSB 15 x NSSB 1005
2	DS 0131	Selection from GJ 39	18	DS 0147	AKR 150 x CS 3541
3	DS 0132	Selection from GJ 39	19	DS 0148	SB 7001 x IS 7528
4	DS 0133	C 43 x ICSR 16	20	DS 0149	IS 22557 x I 12
5	DS 0134	AKR 354 x RS 29	21	DS 0150	CSV 15 x S 35
6	DS 0135	AKR 150 x CS 3541	22	DS 0151	Selection from GJ 39
7	DS 0136	NSSB 15 x NSSB 1005	23	DS 0152	SPV 772 x SPV 1754
8	DS 0137	AKR 150 x CS 3541	24	DS 0153	AKR 150 x CS 3541
9	DS 0138	AKR 150 x CS 3541	25	DS 0154	ICSR 16 x CSV 17
10	DS 0139	SB 7001 x IS 7528	26	DS 0155	SPV 772 x SPV 1754
11	DS 0140	AKR 150 x CS 3541	27	DS 0156	AKR 354 x RS 29
12	DS 0141	IS 22557 x I 12	28	DS 0157	ICSR 16 x CSV 17
13	DS 0142	AKR 354 x SPV 1616	29	DS 0158	SB 7001 x IS 7528
14	DS 0143	IS 22557 x I 12	30	DS 0159	SPV 1616 x(IS 73210xSPV 1428) x I12
15	DS 0144	Selection from SRF 2805	31	GJ 39	M 49 x M 51
16	DSF 0145	SPV 772 x SPV 1754	32	CSV 20	SPV 946 x Kh. 89-246

Table 2 Analysis of variance (mean square) for yield and yield contributing characters in 32 genotypes of sorghum

Characters	Sources of variation		
	Replication (df 2.00)	Treatment (df 31.00)	Error (df 62.00)
Days to 50% flowering	0.85	74.70**	4.92
Days to maturity	6.76	89.97**	4.73
Plant height	343.05	4100.63**	192.44
No of leaves/plant	1.32	2.92**	0.71
Leaf length	18.24	151.48**	4.34
Leaf width	0.19	3.42**	0.63
Panicle length	3.78	96.25**	6.14
Grain yield	90.63*	41.89**	4.70
Fodder yield	1806.26*	2992.66**	492.14

* = significant (at 5% level); ** = highly significant (at1% level), d.f. = degree of freedoms

Table 3 Estimates of genetic parameters for nine characters in sorghum

Parameters	Days to 50%	Days to maturity flowering	Plant height	No of leaves/ plant	Leaf length	Leaf width	Panicle length	Grain yield	Fodder yield
Mean	70.56	102.41	308.66	13.67	88.25	8.25	27.26	19.96	146.80
Range	60.00-79.00	95.00-114.00	234.00-388.00	11.60-16.00	76.20-101.40	6.06-10.60	18.10-38.30	10.70-28.00	83.20-194.20
Heritability (h2b)	82.53	85.72	87.13	50.85	91.87	59.83	83.03	72.53	62.88
GCV	6.84	5.21	11.69	6.27	7.94	11.70	20.10	17.64	19.67
PCV	7.52	5.62	12.53	8.80	8.28	15.13	22.06	20.71	24.80
Genetic advance	9.03	10.17	69.40	1.26	13.83	1.54	10.29	6.18	47.16
GA in % Mean	12.79	9.93	22.49	9.21	15.67	18.64	37.74	30.95	32.13

Among the characters; leaf width, panicle length, grain yield and dry fodder yield displayed more than 15% variation at phenotypic level, which could be considered as high enough. At genotypic level, panicle length, grain yield and dry fodder yield had more than 15% variation and others had less than 15% variation. PCV were slightly higher than GCV indicating presence of environmental influence on the expression of these characters. The high GCV and PCV were recorded for panicle length, grain yield and dry fodder yield but it was moderate for plant height, leaf length, and leaf width. Days to 50% flowering, days to maturity and number of leaves per plant exhibited low genotypic as well as phenotypic coefficient of variation in the present study, which may be due to presence of both positive and negative alleles in the population. The findings were also supported by Amare *et.al.*, (2015) and Chittapur and Birather (2015) who observed high GCV and PCV for grain yield and panicle length. 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 (1952) also suggested that heritability estimate would give better information about the efficiency of selection. The study of heritability indicates that the characters leaf length, plant height, days to maturity, panicle length, and days to 50% flowering were highly heritable. Whereas grain yield, fodder yield, leaf width and number of leaves per plant were moderately heritable indicating that the character was more influenced by environment. Although high heritability estimate have been found to be effective in the selection of superior genotypes on the basis of phenotypic performance, Johnson *et.al.*, (1955)

suggested that heritability estimates along with genetic advance will be more useful in predicting the effect for selecting the best individual. The analysis of genetic advance in percentage of mean showed that the characters; plant height, panicle length, grain yield and fodder yield indicated good response to selection. These characters had more than 20% expected genetic advance under selection. Jain and Patel (2014) and Khandelwal *et.al.,* (2015) also reported high genetic advance associated with high heritability for these characters. Days to maturity, days to 50% flowering, number of leaves/plant, leaf length and leaf width had moderate to minimum genetic advance in percentage of mean. These characters had also moderate to low phenotypic and genotypic coefficients of variation indicating that they were less important to selection. Number of leaves/ plant also had low genetic advance associated with medium heritability. Low heritability with low genetic advance for this character was also reported by Khandelwal *et.al.*, (2015). The poor estimates of heritability and genetic advance were due to the influence of environment on this trait. The high heritability estimates along with low genetic advance indicates that non additive type of gene action and genotype-environment interaction plays a significant role in the expression of the traits as observed in days to 50% flowering, Days to maturity and leaf length in the present study. Panicle length, grain yield, dry fodder yield and plant height had high heritability with high genetic advance in percentage of mean making these four characters most important in the selection of dual sorghum. High GCV, PCV, heritability and GA% of mean for panicle length, grain yield and fodder yield suggested that these two characters could be transmitted to the hybrid progeny and phenotypic selection based on these would be effected.

Mutual relationship between grain yield, fodder yield and their contributing characters revealed that in most of the causes the genotypic correlation coefficient was higher than the corresponding phenotypic correlation coefficient indicating strong inherent relation between the traits but suppressing effect of the environment, which modified the phenotypic expression of these characters by reducing phenotypic coefficient values. Such environmental influence in reducing correlation coefficients in sorghum was also reported by Khandelwal *et.al.,* (2015) and Amare *et.al.*, (2015). From the study, grain yield was positively and significantly correlated with panicle length both at genotypic and phenotypic levels. It suggests that grain yield would increase with increase of panicle length. The leaf length and leaf width were also positively correlated with grain yield but the values were non-significant. Among the grain yield contributing characters panicle length had positive and significant interaction with plant height, number of leaves/plant, leaf length and leaf width. Among the studied characters panicle length is the primary yield components and leaf length leaf width, plant height and number of leaves per plant are the most important physiological traits. The fodder yield was positively and significantly correlated with, plant height, number of leaves/plant, leaf length, leaf width and days to maturity. Among the fodder yield contributing traits plant height and number of leaves per plant had positive and significant interaction with leaf length, leaf width and panicle length. The leaf length and leaf width had positive correlation with, days to 50% flowering, days to maturity, number of leaves per plant, plant height and panicle length. This indicated that there is greater relationship between number of leaves with the greater surface area, results in greater photosynthesis that can improve source to sink relationship which lead to improve the fodder yield. Positive relationship between fodder yield and various fodder yield contributing characters were also reported by Alhassan *et.al.,* (2008), Jain *et.al.*, (2011) and Khandelwal *et.al.*, (2015). The study of correlation among seed yield, fodder yield and yield contributing traits suggests that panicle length, plant height, number of leaves/plant, leaf length, leaf width and days to maturity were the most important characters which possessed positive association with grain yield as well as fodder yield. Therefore, these characters could be utilized in breeding program to improve dual purpose sorghum varieties.

Relationship between seed yield, fodder yield and their contributing characters were studied in details through path coefficient analysis. Path coefficient analysis performed to disclose the causes and effects of chain relationships of different yield contributing characters with grain as well as fodder yield. Estimates of direct and indirect effects of yield contributing characters on grain yield using genotypic correlation are presented in Table 5. It was revealed that considerably highest positive direct effect on gain yield was exhibited by fodder yield, panicle length and leaf length. whilst leaf width, plant height, number of leaves per plant, days to 50% flowering and days to maturity had a

Table 4 Estimates of genotypic (r_g) and phenotypic (r_p) correlation coefficients between yield and its contributing characters in sorghum

Parameters		Days to 50% flowering	Days to maturity	Plant height	No of leaves/ plant	Leaf length	Leaf width	Panicle length	Grain yield
Days to maturity	r_g	0.919**							
	r_p	0.749**							
Plant height	r_g	-0.094^{NS}	-0.168^{NS}						
	r_p	-0.034^{NS}	-0.160^{NS}						
No of leaves/plant	r_g	0.089^{NS}	0.194^{NS}	0.249*					
	r_p	0.097^{NS}	0.042^{NS}	0.195^{NS}					
Leaf length	r_g	0.434**	0.402**	0.462**	0.279**				
	r_p	0.381**	0.342**	0.401**	0.219*				
Leaf width	r_g	0.330**	0.457**	0.204*	0.194^{NS}	0.579**			
	r_p	0.265**	0.309**	0.147^{NS}	0.152^{NS}	0.419**			
Panicle length	r_g	-0.086^{NS}	-0.009^{NS}	0.419**	0.219*	0.498**	0.423**		
	r_p	-0.033^{NS}	0.004^{NS}	0.369**	0.112^{NS}	0.454**	0.357**		
Grain yield	r_g	-0.482**	-0.388**	0.011^{NS}	-0.182^{NS}	0.089^{NS}	0.166^{NS}	0.391**	
	r_p	-0.401**	-0.324**	-0.038^{NS}	-0.147^{NS}	0.071^{NS}	0.084^{NS}	0.373**	
Fodder yield	r_g	-0.004^{NS}	0.151^{NS}	0.350**	0.565**	0.275**	0.560**	0.056^{NS}	0.122^{NS}
	r_p	0.094^{NS}	0.120^{NS}	0.220*	0.457**	0.230*	0.388**	0.037^{NS}	0.011^{NS}

* = significant (at 5% level); ** = highly significant (at1% level), NS= no significant.

Table 5 Path coefficient analysis of yield contributing characters on grain yield of sorghum

Parameters	Days to 50% flowering	Days to maturity	Plant height	No of leaves/ plant	Leaf length	Leaf width	Panicle length	Folder yield
Days to 50% flowering	-0.380	-0.147	0.046	-0.045	0.164	-0.071	-0.047	-0.002
Days to maturity	-0.350	-0.160	0.082	-0.099	0.152	-0.098	-0.005	0.089
Plant height	0.036	0.027	-0.489	-0.127	0.175	-0.044	0.227	0.207
No of leaves /plant	-0.034	-0.031	-0.122	-0.512	0.105	-0.042	0.119	0.334
Leaf length	-0.165	-0.064	-0.226	-0.143	0.378	-0.125	0.270	0.162
Leaf width	-0.125	-0.073	-0.100	-0.100	0.219	-0.215	0.230	0.330
Panicle length	0.033	0.001	-0.205	-0.112	0.188	-0.091	0.543	0.033
Fodder yield	0.002	-0.024	-0.171	-0.289	0.104	-0.120	0.031	0.591

Residual are 0.384

Table 6 Path coefficient analysis of yield contributing characters on fodder yield of sorghum

Parameters	Days to 50% flowering	Days to maturity	Plant height	No of leaves/ plant	Leaf length	Leaf width	Panicle length	Grain yield
Days to 50% flowering	-0.435	0.378	-0.040	0.046	-0.055	0.196	0.049	-0.144
Days to maturity	-0.399	0.411	-0.071	0.100	-0.051	0.272	0.005	-0.115
Plant height	0.041	-0.069	0.423	0.129	-0.058	0.121	-0.240	0.003
No of leaves /plant	-0.039	0.080	0.105	0.518	-0.035	0.115	-0.126	-0.054
Leaf length	-0.189	0.165	0.195	0.144	-0.126	0.344	-0.285	0.026
Leaf width	-0.143	0.188	0.086	0.101	-0.073	0.594	-0.243	0.049
Panicle length	0.037	-0.004	0.177	0.114	-0.063	0.251	-0.573	0.116
Grain yield	0.210	-0.160	0.005	-0.094	-0.011	0.099	-0.224	0.298

Residual are 0.194

negative direct effect on grain yield. Khandelwal *et.al.*, (2015) obtained panicle length and dry fodder yield had positive direct effects on grain yield and negative direct effect of plant height, number of leaves per plant, days to 50% flowering and days to maturity. Among the above traits panicle length was highly correlated with grain yield at genotypic level and the direct effects of this character on grain yield could be considered as causes of such high correlation. Fodder yield and leaf length although exhibited high and positive direct effects on grain yield but their correlations with grain yield were minimum. High negative indirect effect of fodder yield and leaf length through plant height and number of leaves per plant reduced the correlation of the character with grain yield to be negligible. The character days to 50% flowering and days to maturity had negative direct effect on grain yield, which suggests that the selection for early maturing lines with high yield is possible.

Estimates of direct and indirect effects of yield contributing characters on fodder yield using genotypic correlation are presented in Table 6. It was revealed that considerably highest positive direct effect on fodder yield was exhibited by leaf width, number of leaves per plant, plant height, and days to maturity and grain yield. Whilst panicle length, days to 50% flowering, and leaf length had a negative direct effect on dry fodder yield of dual sorghum. Among them plant height, number of leaves/plant, leaf length, leaf width and days to maturity were highly correlated characters with dry fodder yield at genotypic level. The direct effects of these characters on dry fodder yield could be considered as causes of such high correlation. These results are in line with Jain *et.al.*, (2009) and Jain *et.al.*, (2010). The residual effect of the present study were 0.384, for grain yield and 0.194 for fodder yield indicating that the characters studied in the present study contributed 62% of the grain yield and 79% for fodder yield. It is suggested that maximum emphasis should be given on the above characters in selecting the dual sorghum varieties. It is also suggested that further study should be made with more characters to find out other traits which contribute rest of the percentage of the grain as well as fodder yield. The characters also showed moderate to high heritability and genetic advance in percentage of mean. Thus, the results suggest that high plant height with higher number of leaves per plant with broaden leaves and long panicle are the important yield contributing traits in dual sorghum and thus plant selection based on these traits will be most effective.

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