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Genetic Analysis of Leaf and Physiological Traits in Forage Sorghum Across Environments

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ABSTRACT

Genetics of 4 leaf and 3 physiological traits was studied in forage sorghum (*Sorghum bicolor* (L.) Moench) through the combining ability analysis of a, 6 x 18, line x tester set in 4 environments and also on pooled basis. Variances due to gca and sca, and σ gca/σ sca indicated the importance of both additive and non additive gene action with higher megnitude of non-additive gene action for majority of the traits across environments. It was found that 2077A, 36A and M-31-2 A among females; and C 10-2, Vidisha, Rio, PC6, IS 685, IS 3287 and IS 4776 among males showed high gca effects, whereas CK 60A x PC 6, 2219 A x IS 612, 36 A x IS 3301, 36 A x IS 662 and M-31-2A x IS 612 among F_1 S exhibited the significant sca effects on pooled basis for majority of the leaf and physiological traits. The study revealed the stability of gca for dry leaves, leaf weight, leaf : stem ratio and leaf area ratio where as sca was unstable for all characters.

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INTRODUCTION

Leafiness has been found to be positively correlated with portein (1, 2), digestibility (3), stability of drymatter production (4), and green fodder and drymatter yield (5, 6). It has also been reported to be the most useful criterion for voluntary intake (7,8). Accordingly, leafiness should form a major criterion of selection at the phenotypic level in a forage breeding programme aiming at genetic improvement both for yield and quality. It is with this view that the genetics of leaf and certain physiological traits was studied through a line x tester analysis in forage sorghum.

MATERIALS AND METHODS

The experimental materials consisted of 6 CMS lines viz., CK 60A, 2077A, 36A, 3660 A, 2219A, and M-31-2A and 18 diverse pollinators selected from the huge germplasm of forage sorghum maintained at Forage Research Farm, Gujarat Agricultural University, Anand. The females and males were crossed in a line X tester fashion. The resulting 108 hybrids alongwith parents were studied in a randomized block design with three replications in four environmental conditions created by planting at two dates and two locations viz., Anand (21 July and 20 August) and Sardar Krishinagar (30 July and 25 August) during kharif (rainy season), 1981. The parents were grown in a separate contiguous block. Each parent and F_1 had single row of 3 m length, following 30 cm interrow and 10 cm intra row spacings. The recommended agronomic practices were adopted to raise the crop and a complete plant stand was obtained in each environment. Five competitive plants were used for recording

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observations, in each genotype in each replication and in all environments, on nine quantitative traits. Leaf area was calculated as leaf length x leaf breadth x number of leaves X 0.798 (a constant calculated for the diverse parental materials used under the present investigation). Leaf area per plant was divided by the ground area covered to get the leaf area index, whereas the leaf area ratio was calculated by dividing the leaf area per plant by its drymatter yield. The mean values for all characters were used for statistical analysis. The combining ability analysis was done according to (9). All characters were analysed separately for each environment as well as for the pooled data.

RESULTS AND DISCUSSION

The results obtained under the present investigation are presented in Tables 1 to 3. The analysis of variance revealed significant differences due to females, males and female x males for all/majority of the traits revealing great deal of varibility among parents, and pronounced but varying degrees of combining ability for these traits under study. The results on variance components revealed that the females showed greater variability than males with respect to number of leaves, leaf weight, leaf area per plant and leaf area index whereas males recorded greater variability than females for dry leaves, leaf : stem ratio and leaf area ratio on pooled basis.

The results on combining ability analysis revealed that variance due to both gca and sca were significant for number of leaves, dry leaves per plant, leaf weight, leaf area per plant and leaf area index and sca for leaf area ratio on pooled basis (Table 1). The data further revealed that neither σ gca nor σ sca was observed significant for the leaf : stem ratio on pooled basis. This indicated that both ad as well as nonadditive gene actions acco for the inheritance of leaf and physiol traits in forage sorghum. The ratio σ gca/ however, indicated relatively higher magn of sca for these traits except leaf weigh leaf area ratio indicating preponderance of additive gene actions for the former, and a tive gene action for the latter traits, respec on pooled basis. Our results are in conform earlier reports (9, 10-15) showing higher m nitude of sca in the inheritance of various characters in forage sorghum. Howe predominance of additive gene action various leaf characters in sorghum has been reported from other studies (10, 16-1

It was found that σ gca x environment nonsignificant for dry leaves, leaf weight, l stem ratio and leaf area ratio, which indic the stability of gca for these traits over envi ments. Highly significant σ sca x environm for all the traits, on the contrary, revealed th stability of sca for these traits. The ratio of σ x environment/σ sca x environment revealed that gca was more stable than sca all leaf and physiological traits in the presen vestigation.

The results on gca effects (Table revealed that 2077A, 36A and M-31-2A ar females; and Vidisha, PC 6, C-10-2, Ric 685, IS 3287 and IS 4776 among m showed significant and desirable gca effec all/majority of the traits under the present in tigation on pooled basis. The female, 2077A for leaf : stem ratio, however, reco undesirable gca effects on pooled basis dry leaves, 2219 A, CK 60A and 3660A sh negatively significant gca effects indic lower number of dry leaves at flowering in genotypes. It was found that 2077A, 36A M- 31-2A among females and C-10-2, Vid

TABLE 1

Analysis of variance and variance estimates for combining ability for leaf and physiological traits in forage sorghum pooled over 4 environments.

Source	*d.f.*	*Mean squares*						
		Number of leaves	*Dried leaves/ plant*	*Leaf weight*	*Leaf : Stem ratio*	*Leaf area/ plant*	*Leaf area index*	*Leaf area ratio*
Environments (Env.)	3	371.05**	69.67**	33182.6**	0.0628**	283343000**	3152.7**	4996.3**
Rep./environment	8	1.21**	6.36**	569.4**	0.0025**	4354250.0**	48.3**	641.5**
Females (F.)	5	88.04**	19.06**	3265.2**	0.0217**	53214200.0**	592.8**	3836.6**
Males (M.)	17	28.03**	8.01**	696.8**	0.0102**	16364235**	182.4**	1864.8**
F x M	85	5.53**	1.68**	231.2**	0.0022	3459364**	38.4**	441.1*
F x Env.	15	2.77**	1.39*	212.8*	0.0035*	1875666**	20.8**	522.8
M x Env.	51	2.49**	0.86	152.2	0.0021	1430039**	15.8**	447.3
F x M X Env.	255	1.05**	0.71**	112.3**	0.0020**	663055**	7.4**	330.8**
Pooled Error	856	0.35	0.62	41.9	0.0006	298975	3.3	70.8
σ^2 gca		0.35**	0.079**	11.66**	0.00009	210694.8**	2.35**	15.7
σ^2 sca		0.37**	0.081**	9.91**	0.00012	233025.8**	2.59**	9.2*
σ^2 gca x Env.		0.04**	0.012	1.95	0.000020	27494.4**	0.30**	4.3
σ^2 sca x Env.		0.23**	0.061**	23.44**	0.000479**	121359.8**	1.44**	86.7**

*, ** Significant at 5% and 1% levels, respectively.

TABLE 2

Estimates of gca effects of lines (females) and tester (males) for leaf and certain physiological traits in sorghum pooled over 4 environments.

Parents	No. of leaves	Dry leaves/ plant	leaf weight	Leaf: stem ratio	Leaf area/ plant	Leaf area index	Leaf area ratio
Lines							
CK 60A	-0.65**	-4.0**	-0.29**	-0.010**	-537**	-1.8**	-6.1**
2077 A	0.72**	4.4**	0.45**	- 0.002**	454**	1.5**	3.4**
36 A	0.33**	3.0**	0.13**	0.012**	438**	1.5**	3.4**
3660 A	-0.07*	-1.3**	-0.04	-0.005**	-202**	-0.7**	-2.1**
2219 A	-0.84**	-4.8**	-0.36**	-0.009**	-576**	-1.9**	-2.7**
M-31-2A	0.52**	2.7**	0.11	0.013**	419**	1.4**	4.1**
S.E. (gi)	0.03	0.4	0.04	0.001	31	0.1	0.5
S.E. (gi.gj)	0.06	0.6	0.07	0.002	53	0.2	0.8
Testers							
C 10-2	0.78**	0.2	0.52**	0.13**	477**	1.6**	3.0**
S 1049	-0.24**	-2.9**	-0.04	0.002	1.3	-0.01	0.5
Vidisha	1.19**	7.8**	0.45**	-0.014**	852**	2.8**	9.4**
Rio	0.03	1.9**	0.09	-0.0003	395**	1.3**	8.1**
PC-6	0.40**	1.5*	0.24**	0.008**	436**	1.5**	2.3**
IS-606	-0.73**	-1.3	-0.51**	0.015**	372**	-1.2**	1.5
IS-612	-0.05	2.3**	-0.17*	0.019**	103	-0.3	-0.5
IS-632	-0.31**	-2.9**	-0.18*	-0.003	-405**	-1.4**	-1.1
IS-643	-0.55**	-3.7**	-0.02	-0.002	-385**	-1.3**	-4.6**
IS-644	0.15**	1.3	0.27**	-0.026**	95	0.3	-3.5**
IS-662	-0.97**	-5.0**	-0.34**	-0.017**	-671**	-2.2**	-5.9**
IS-685	0.37**	1.6*	0.12	0.006*	309**	1.1**	9.1**
IS-3301	-1.12**	-3.4**	-0.61**	-0.005*	-995**	-3.3**	-8.5**
IS-3223	-0.17**	-.6	-0.16*	-0.014**	-83	-0.3	-4.7**
IS-3353	-0.28**	0.4	-0.37**	-0.002	-390**	-1.3**	-3.0**
IS-3245	0.08	-1.4**	-0.06	-0.006*	-42	-0.2	-3.5**
IS-3287	0.70**	2.0**	0.36**	0.002	372**	1.2**	1.5
IS-4776	0.70**	3.6**	0.41**	-0.010**	509**	1.7**	-0.1
S.E. (gi)	0.06	0.7	0.08	0.0025	57	0.2	0.9
S.E. (gi-gj)	0-10	1.08	0.12	0.004	91.1	0.3	1.4

*, ** Significant at 5% and 1% levels, respectively.

TABLE 3

Estimates of sca effects for 10 best hybrids for leaf and certain physiological traits in forage sorghum pooled over environments.

Leaves/plant (No.)		*Leaf length*		*Leaf breadth*		*Dry leaves/plant*		*Leaf weight*		*Leaf : stem ratio*		*Leaf area/plant*		*Leaf area index*		*Leaf area ratio*	
Hybrid	*Sca effect*	*Hybrid*	*Sca effect*	*Hybrid*	*Sca effect*	*Hybrid*	*Sca effect*	*Hybrid*	*Sca effect*	*Hybrid*	*Sca effect*	*Hybrid*	*Sca effect*	*Hybrid*	*Sca effect*	*Hybrid*	*Sca effect*
1 x 4	1.7**	6x7	6.2**	5 x 7	0.8**	5 x 5	-0.8**	2x3	11**	5x7	0.04**	1x5	1139**	1x5	3.8**	6x7	16**
5 x 7	1.4**	3x10	4.3**	5x17	0.8**	6x14	-0.7**	4x7	8**	2x14	0.03**	5x7	1068**	5x7	3.6**	2x15	13**
3 x 13	1.2**	5x12	4.3**	1x5	0.7**	3x7	-0.6**	1x18	7**	5x1	0.02**	6x7	955**	6x7	3.2**	3x11	12**
2 x 15	1.1**	2x11	4.3**	3x11	0.7**	4x3	-0.6**	5x7	7**	1x18	0.02**	6x15	880**	6x15	2.9**	4x8	11**
6 x 7	1.1**	4x7	4.2**	2x3	0.6**	6x13	-0.6**	6x4	7**	3x11	0.02**	2x3	866**	2x3	2.9**	5x7	9**
5 x 14	0.9**	5x14	4.1**	2x11	0.6**	1x16	-0.6**	3x13	6**	4x9	0.02**	5x17	792**	5x17	2.7**	5x1	9**
2 x 5	0.9**	4x14	4.0**	6x7	0.6**	1x18	-0.6**	6x15	6**	4x12	0.02**	3x11	770**	3x11	2.6**	2x4	9**
4 x 12	0.8**	1x18	3.9**	6x8	0.6**	3x17	-0.5**	5x18	5**	4x10	0.02**	3x13	700**	3x13	2.3**	5x3	8**
3 x 6	0.7**	5x18	3.8**	6x15	0.6**	4x6	-0.5**	3x5	5**	1x6	0.02**	4x7	683**	4x7	2.3**	5x2	8**
4 x 7	0.7**	5x7	3.7**	5x18	0.5**	2x13	-0.5**	5x17	5**	2x4	0.02**	2x11	647**	2x11	2.2**	5x12	7**

Hybrid combination shows the number of male and female parents involved, as shown in Table 2.
**Significant at 1% level.

PC 6, Rio, IS 685, IS 3287 and IS 4776 among males for leaf and physiological characters except dry leaves; and CK 60 A and 2219A among females and IS 662, IS 643 and IS 3301, among males, for dry leaves exhibited superior gca effects in individual environments too and thus appeared to be the best parents contributing larger number of favourable genes for these traits.

It was found that the hybrids *viz.*, 2219A x IS 612, 36A x IS 3301, 2219A x IS 685, and 36A x IS 662 showed highly significant and desirable sca effects for all the leaf and physiological traits except dry leaves per plant. CK 60A x PC 6, M-31-2A x IS 612, 2077A x IS 3353, 2219A x IS 3287, M-31-2A x IS 3353 and 2077A x Vidisha also showed highly significant sca effect for majority of the characters. Further hybrids, viz., 2219A x PC 6, M-31-2-A x IS 3223, 36 A x IS 612, 3660A x Vidisha and M-31-2A X IS 3301 showed significant and negative sca effect for dry-leaves per plant at flowering.

Since additive and non-addi... gene effects controlled the inheritance of ... and physiological traits, these can be impro... following recurrent selection. For this purp... Vidisha, PC 6, C-10-2, Rio, IS 685, IS 3287 ... IS 4776, 2077 B, 36 B and M-31-2B show... high gca effects for these traits could be in... mated to develop a base population with ... recombinants using genetic male sterility (... The base population could then be improved ... following an appropriate method of recur... selections. Elite population, thus, develo... may serve as a source material for develop... superior hybrid combination/experime... varieties/ or may be recombined for sec... cycle of selection to develop a still supe... population with respect to these traits.

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