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Combining Ability Studies in Forage Sorghum [*Sorghum bicolour* (L.) Moench] for Yield and Quality Parameters

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A B S T R A C T

Twenty eight hybrids derived using diallel mating design, eight parents and standard check (GFS 5) were evaluated for general combining ability (gca) and specific combining ability (sca) effects. The mean square due to general and specific combining ability was found significant for all the characters under study. However the ratio of σ^2gca/ σ^2sca advocated that the preponderance of non-additive gene action is express in all the characters under study. The estimates of general combining ability suggested that parents DSF 127, DSF 136 and CSV 21F were good general combiners for green fodder yield per plant and its attributing characters. Out of 28 hybrids, DSF 127 x CSV 15, CSV 21 F x MP Chari, DSF 117 x DSF 123, CSV 15 x GFS 4, DSF 123 x GFS 4 and CSV 21 F x GFS 4 were most promising hybrids for green fodder yield per plant. These hybrids were also found superior for yield contributing characters.

Introduction

Sorghum [*Sorghum bicolor* (L.)Moench] is an often cross-pollinating crop with a genome, about 25 per cent the size of maize or sugarcane and having diploid (2n = 2x = 20) chromosomes. It is a C_4plant with higher photosynthetic efficiency and higher tolerance to abiotic stress (1) and (2). It is the third most important food grain crop in India, next to rice and wheat. Sorghum stands first among the cereal fodder because of its faster growing habit, high yield potential, suitability to cultivate throughout the year, palatable and nutritious fodder quality, higher digestibility and various forms of its utilization like green chop, stover, silage, hay, etc. Diallel mating design has been extensively used in cross-pollinated crops to understand the nature of gene action involved in the inheritance of quantitative traits.

It also provides estimates of components of variance and gca and scavariances and their effects. Thus it helps in the selection of parents suitable for hybridization programme and to frame out an efficient breeding plan leading to rapid improvement of crop.

Materials and Methods

The eight genetically dissimilar lines of sorghum were crossed in diallel matting design (excluding reciprocal cross) to produce 28 hybrids during *kharif*2016. The 28 F_1s, eight parents and check variety GFS 5 were grown at the Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa, Gujarat during *kharif*2017. Deesa is situated at semi-arid region of North Gujarat. Geographically, it is located at 24°-5' North latitude and 72° East longitude with an altitude of 136 meters above mean sea level. The soil of experimental field was sandy to sandy loam. The weather during the growing season was normal and favourable for crop growth. Each genotype was planted in a single row consisted of 20 plants. The distance between plants and between row were 10 cm and 30 cm, respectively. The standard agronomical and entomological practices were followed to raise the healthy experimental crop. The observations were recorded on five randomly selected plants of each genotypes in each replication for twelve characters *viz.*, plant height (cm), number of leaves per plant, leaf length (cm), leaf width (cm), leaf: stem ratio, leaf area (cm^2), stem girth (cm), green fodder yield per plant (g), brix content (%), dry fodder yield per plant (g) and crude protein content (%)while days to flowering was recorded on plot basis. The mean values of observations were subjected to diallel analysis to estimate general combining ability (gca) and specific combining ability (sca) effects as per procedure given by Griffing Method 2, Model 1 (3). Analysis of variance was performed to test the significance of differences among the genotypes including crosses and parents as per standard procedure given by (4).

Results and Discussion

The analysis of variance revealed that (Table 1), mean square due to genotypes were significant for all the characters indicating an existence of sufficient amount of variability in the experimental material for the characters under study. Significance of analysis of variance revealed that, variability was present among the parents and hybrids for majority of characters under study. The analysis of variance for combining ability indicated that the mean squares due to general combining ability and specific combining ability were significant for all the characters except dry fodder yield per plant and protein content. The ratio of σ^2gcaand σ^2sca was less than unity indicated the dominance of non-additive gene effects for the inheritance of characters under study. The preponderance of non-additive gene action resulted in enormous heterotic response in green fodder yield and its attributing traits indicate enough chance for the crop improvement through heterosis breeding in forage sorghum.

General combining ability

Based on estimates of general combining ability effects for various characters (Table 2), the parents were classified as good, average and poor combiners. Earliness being a desirable for days to flowering, hence parents with significant and negative gca effects were preferred for imparting earliness in their hybrids and were considered as good general combiners. The gca estimates revealed that parents GFS 4 (-10.12) and DSF 127 (-2.758) were found good general combiners for days to flowering.

The estimates of general combining ability suggested that the parents DSF 127, DSF 136 and CSV 21 F were found good general combiners for green fodder yield per plant and its attributing traits. The results are in agreement with (5) and (6).In general, good combiners for green fodder yield per plant also had good or average combining ability for one or more of the yield components.

Table.1 Analysis of combining ability and variance component

Source of variation	d.f.	Days to flowering	Plant height	Number of leaves per plant	Leaf width	Leaf length	Leaf area	Stem girth	Leaf : Stem ratio	Brix content	Green fodder yield per plant	Dry fodder yield per plant	protein content
GCA	8	207.06**	4163.65**	1.51**	6.83**	50.64**	342026.80**	1.16**	0.00**	6.83**	5105.63**	495.76	2.08
SCA	28	63.26**	1458.15**	1.16**	2.24**	42.21**	218000.20**	0.91**	0.00**	2.24**	7420.72**	850.31	1.21
Error	70	0.74	90.83	0.19	0.22	8.57	21330.68	0.01	0.00	0.22	147.34	132.75	0.11
σ^2gca		20.63	407.28	0.13	0.66	4.20	32069.61	0.11	0.11	0.00	0.66	495.82	45.15
σ^2sca		62.52	1367.32	0.96	2.02	33.64	196669.52	0.90	0.90	0.00	2.02	7273.38	806.06
σ^2 gca/σ^2sca		0.32	0.29	0.13	0.32	0.12	0.16	0.12	0.12	0.39	0.32	0.06	0.05

Table.2 Estimation of general combining ability (GCA) effects associated with each parent for various characters

Parents	Days to flowering	Plant height	Number of leaves per plant	Leaf width	Leaf length	Leaf area	Stem girth	Leaf : Stem ratio	Brix content	Green fodder yield per plant	Dry fodder yield per plant	Crude protein content
DSF 117	0.808**	-11.344**	-0.380**	-0.541**	-2.881**	191.538**	-0.214**	-0.017**	-0.541**	6.739	-0.841	-0.117*
DSF 127	-2.758**	15.062**	0.207	0.231	3.161**	120.589**	-0.180**	-0.005	0.231	30.757**	-0.811	0.687**
DSF 123	2.775**	17.680**	0.560**	0.506**	2.311**	128.389**	0.301**	0.046**	0.506**	2.701	2.277	0.180**
DSF 136	3.375**	20.758**	0.027	0.231	0.022	74.624	0.118**	0.004	0.231	14.575**	1.438	0.488**
CSV 15	0.575*	-24.925**	0.440**	1.014**	-1.016	50.383	0.534**	-0.004	1.014**	-8.889*	10.730**	0.114*
CSV 21 F	3.142**	5.609	-0.051	0.719**	1.938*	-99.792*	0.209**	-0.014**	0.719**	17.181**	5.921**	-0.534**
GFS 4	-10.125**	-32.656**	-0.536**	-0.726**	-2.394**	-383.179**	-0.439**	0.004	-0.726**	-31.262**	-11.918**	-0.602**
MP Chari	2.208**	9.815**	-0.268 *	-1.435**	-1.141	-82.552	-0.328**	-0.015**	-1.435**	-31.801**	-6.796**	-0.215**
S.E.$_{(gi)}$ ±	0.255	2.819	0.130	0.139	0.866	43.202	0.033	0.004	0.139	3.590	1.967	0.056
S. E. $_{(gi-gj)}$ ±	0.385	4.262	0.197	0.210	1.309	65.315	0.050	0.006	0.210	5.428	2.974	0.085

*, ** Significant at 5 and 1 per cent levels, respectively.

Table.3 Estimates of specific combining ability effects of best three crosses based on per se performance

Characters	DSF 127 x CSV 15		CSV 15 x GFS 4		DSF 117 x DSF 123		SE	CD (at 5 % level)
	Per se	sca	*Per se*	sca	*Per se*	sca		
Days to flowering	47.00	-22.47**	71.00	8.89**	71.33	-3.90**	0.88	2.48
Plant height	270.64	-4.36	244.00	16.71	321.30	30.09**	9.52	26.83
Number of leaves per plant	10.86	-0.92*	12.93	1.88**	11.10	-0.22	0.44	1.23
Leaf width	7.66	-0.50	9.47	-0.21	8.30	2.17**	0.25	0.72
Leaf length	83.86	2.42	89.92	14.04**	75.36	-3.35	2.89	8.15
Leaf area	1779.00	-246.71	1169.46	352.48*	2022.68	-151.99	144.49	407.34
Stem girth	3.58	0.60**	2.74	0.03	2.81	0.10	0.11	0.32
Leaf : Stem ratio	0.24	0.00	0.22	-0.01	0.23	-0.04**	0.02	0.04
Brix content	9.43	-0.50	8.76	-0.21	10.83	2.17**	0.47	1.32
Green fodder yield per plant	625.61	273.27**	395.86	105.54**	478.38	138.46**	12.05	33.98
Dry fodder yield per plant	199.84	84.08**	130.06	25.40**	130.48	23.21**	6.57	18.53
Crude protein content	6.38	-1.80**	7.76	0.85**	6.29	-1.16**	0.19	0.53

Specific combining ability

The estimates of sca effects (Table 3) revealed that none of the hybrids were consistently and significantly superior for all the traits. Out of 28 hybrids evaluated, 6 hybrids were registered significant positive sca effects for green fodder yield per plant. On the basis of *per se* performance and specific combining ability effects for green fodder yield per plant crosses, DSF 127 x CSV 15, CSV 15 x GFS 4, DSF 117 x DSF 123, CSV 21 F x MP Chari and DSF 117 x MP Chari were good specific combiners for green fodder yield. These crosses also exhibit positive and significant specific combining ability effects for one or more of its contributing traits *i.e.* plant height, leaf width, number of leaves per plant, leaf length, and dry fodder yield per plant. These findings are in agreement with the results of (7) and (8).

Based on the overall studies, it can be concluded that, looking to the parents for their characterization of their ability to transmit desirable genes to their progenies, three parents *viz.*, DSF 127, DSF 136 and CSV 21 F were found good general combiners for green fodder yield and its contributing characters. Therefore, these parents were noted as good source of favourable genes for increasing green fodder yield through various yield contributing characters. Estimates of sca effects did not reveal any specific trend among the crosses. The crosses exhibited high sca effects did not always involve both parents as good general combiners with high gca effects, thereby suggesting importance of intra as well as inter-allelic interactions. From the present findings the preponderance of non-additive gene effects for the expression of green fodder yield per plant and its attributes, indicate that heterosis breeding would be rewarding for the improvement of green fodder yield per plant and its components in forage sorghum.

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