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Original Research Article

Combining Ability Studies for Different Agronomic Traits and Yield Components in Sorghum

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A B S T R A C T

The present investigation entitled as "GENETICS OF SHOOTFLY RESISTANCE, HETEROSIS AND COMBINING ABILITY IN SORGHUM (*Sorghum bicolor* (L.) Moench)" was conducted in *kharif* 2015 at sorghum research station Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhanito estimate the general and specific combining ability for selection of potential parents and crosses. In the present study, a set of 15 Parents, (7 lines and 8 testers) 56 Hybrids and 3 checks were evaluated to study the inheritance of yield traits. The parents AKR456, ICSA101, KR125, PMS71A, PMS74A and PMS42A exhibited highly significant positive gca effects. The crosses ICSA101 × KR125, PMS71A × AKR456, PMS74A × AKR456 and PMS232A × C43 exhibited highly significant positive sca effects for most of the traits under study. The magnitude of sca was higher than gca. Crosses ICSA101 × KR125 (47.97 gm) and PMS71A × AKR456 (47.79 gm) exhibited significant highest grain yield. Similar trend was recorded in yield contributing characters.

Keywords

Poaceae, Tribe Andropogenae, Cereal crop, Productivity

Introduction

Sorghum (*Sorghum bicolor* (L.) Moench) is an important cereal crop in India. Sorghum belongs to natural order Poaceae, tribe Andropogenae, with ten pairs of chromosomes (2n=20) and considered to be of Ethiopian origin (Vavilov, 1935).

Recent FAO statistics indicates a world production of 60 million tonnes of grain sorghum from 44 million hectare of land with productivity of 1238 kg/ ha (FAO stat 2016).

Area under sorghum in India is 9.1 million hectare with 6.7 million tonnes of production and 783 kg productivity per hectare. Maharashtra which contributes about 49.14 per cent of area and 42.07 per cent production with an area of 28.58 lakh hectares, production of 25.07 lakh tonnes and productivity of 1971 kg/ha (Anonymous 2015).

In India, hybrid sorghum project was started in 1962 and breakthrough has been achieved in yield potential however the yield level become static hence to increase yield through selection of potential parents and crosses was carried out in the present experiment.

Line × tester analysis studies furnish useful information regarding the selection of suitable parents for effective hybridization programme (Sprague and Tatum, 1942). This approach has practical utility in breeding programme aimed at genetic improvement in yield. In this analysis, total genetic variation is partitioned into GCA and SCA effects to verify the parents in terms of combining ability to combine in hybrid combination. The present investigation was carried out to obtain information on the following objectives:-

To study the general and specific combining ability of the genotypes

To identify potential crosses for future crop improvement programme

Materials and Methods

In *Rabi*, 2015 seven lines i.e. PMS28A, PMS74A, PMS71A, PMS98A, ICSA101A, PMS42A, PMS232A, were crossed with the eight testers i.e. I26, AKR456, KR191, KR196, KR125, C43, 9825REC and ICSR196. In *kharif* 2016, 15 parents, 56 hybrids along with three checks i.e. CSH 25, SPH 1641 and CSH 16 were raised with 2 rows per treatment in randomized block design with 3 replications and a spacing 45 × 15 at sorghum research station Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani. Parbhani is located in the South-west part of Maharashtra, India, Parbhani comes under agro-climatic zone-VII in the state. The site of experiment is located at 19^{o} 16' N latitude, 67^{o} 47' E longitude and 409 meter above the sea level. This region has Sub-tropical climate with extreme of summer and medium winter. The temperature falls down to as low as $12\text{-}14^{0}$C during winter season especially in the month of December and January. The mercury rises up to $46\text{-}48^{0}$C during summer. The average rainfall in this area is around 950 mm annually

Observation recorded were Days to 50 per cent flowering, Plant Height (cm), Flag leaf area (cm^2),Days to maturity, Grain yield per plant (gm), Fodder yield per plant (gm), Test weight (gm) and Harvest index (%).The data recorded on the material generated was subjected to analysis of variance as per the Line x Tester model given by Kempthorne (1957).

Results and Discussion

Analysis of variance and variance components

General and specific combing ability effects were marked for each character. The result of general combing ability (gca) effects and specific combing ability (sca) effects for yield characters are presented in the Table 1. It can be concluded that among all the female parentsPMS74A was best general combiner followed by PMS71A and PMS232A for yield and yield contributing characters. These parents are identified as good general combiners. All good combing parents for yield per plant were also good combiner for important yield components traits. Among the male parents KR125 and AKR456 was best general combiner for yield and yield contributing components. Thus depending upon the character to be improved male parent can thus be chosen.

The *per se* performance of the parent is reflected to some extent in their gca effect for yield AKR456 and KR125 had highest mean value and also the high gca effect. Similarly, the first four parents in order of merit for mean values for yield included PMS74A, PMS71A, C43 and PMS232A which also have significant desirable gca effects. Thus, *per se* performance can give some idea about general combining ability.

Specific combining ability effects are indication of heterosis, dominance and epistatic gene action. Five top ranking cross combinations on the basis of yield per plant along with their sca effects for yield per plant and gca effects of the parents of cross combinations were ICSA101 × KR125, PMS71A × AKR456, PMS74A × AKR456, PMS232A × C43 and PMS74A × KR125 which exhibiting better per se performance for yield per plant and also exhibited significant positive sca effects for yield per plant. A linear relationship between per se performance and sca effects is not observed (Table 2 and 3).

Days to 50% flowering

The parents KR125 (-2.85), and AKR456 (-1.66) showed significant negative gca effect. Out of fifty six crosses, only five crosses exhibited desired (significantly negative) sca effect.

The highest significant negative sca effect were recorded by cross PMS42A × KR191 (-5.55) followed by PMS71A × AKR456 (-5.45) these results are in accordance with the finding of Premalatha *et al.,* (2006)

Days to maturity

Earliness is one of the considerable objectives of selection in breeding programme. Therefore, significant and negative gca effects of higher magnitude are considered beneficial

The parent KR125 (-2.32), showed significant negative gca effect, the parent appeared to be best general combiner for this trait. Out of fifty six crosses, two crosses exhibited desired significant negative sca effect. The top crosses for sca effects were cross PMS232A × C43 (5.05) followed by PMS98A × ICSR196 (-4.02). Chaudhary and Narkhede (2004) also reported similar type of results.

Plant height (cm)

The parents KR125 (11.22), KR196 (9.71), PMS232A (5.50), ICSA101 (5.33) and PMS74A (5.32) exhibited highly significant positive gca effects. The sca effects were observed to be significant in most of the crosses for the plant height. The top crosses with significant sca recorded in cross PMS71A × AKR456 (27.75) followed by PMS28A × KR196 (20.22).these results were in accordance with Premalatha *et al.,* (2006)

Flag leaf area (cm^2)

The parents AKR456 (50.66), KR125 (41.97), and PMS42A (18.02) exhibited highly significant positive gca effects. The sca effects were observed to be significant in most of the crosses for this trait. The top crosses for sca effects were cross ICSA101 × KR125 (97.02) followed by PMS98A × 9825REC (85.62). Chaudhary and Narkhede (2004) also reported similar type of results.

Grain yield per plant (gm)

The parents KR125 (6.25), AKR456 (4.97), and I26 (3.88) exhibited highly significant and positive gca effects. The sca effects were observed to be significant in most of the crosses for grain yield (gm).

The top crosses with positive sca effects was PMS232A × C43 (14.00) followed by PMS 42A × KR191 (10.73) for grain yield per plant. Premalatha *et al.,* (2006), Chaudhary and Narkhede (2004) have also reported similar results.

Table.1 Analysis of variance for combining ability for different characters in Line × Tester Analysis of Sorghum genotypes

S. No.	Characters	Replication (2)	Mean sum of squares			
			Lines (6)	Testers (7)	L vs. T (42)	Error (110)
1	Days to 50% Flowering	4.10	10.34	65.42 *	27.43 **	11.20
2	Days to Maturity	8.09	33.67	22.91	20.46**	7.78
3	Plant Height (cm)	147.88	791.00	729.58	614.89**	123.33
4	Flag Leaf Area (cm²)	50.15	5364.33	19703.07**	6305.51**	176.36
5	Grain Yield (gm)	1.30	115.69	537.35*	187.37**	4.82
6	Fodder Yield Per Plant(gm)	124.46	1758.73	2807.77	1258.85**	70.20
7	Test Weight (gm)	0.04	0.20	0.29*	0.11**	0.02
8	Harvest Index (%)	6.72	47.98**	43.46**	12.76**	2.71

Table.2 Estimation of General combining ability (gca) effect of crosses in sorghum

Parents	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Leaf Area (cm²)	Grain Yield (gm)	Fodder Yield Per Plant (gm)	Test Weight (gm)	Harvest Index (%)
PMS28A	1.04	0.04	-6.21 **	-4.66	0.75	-8.82**	-0.03	-1.50**
PMS74A	-0.58	-0.50	5.32*	-19.50 **	0.93	8.19**	0.14 **	2.21**
PMS71A	-0.59	-1.21	-6.45**	16.29 **	3.02**	8.14**	0.06	0.59
PMS98A	-0.09	0.21	1.75	-11.06 **	-4.02**	-12.46**	-0.13 **	-2.07**
ICSA101	0.35	0.21	5.33*	-10.18 **	0.89	-4.45**	0.02	0.42
PMS42A	0.52	-1.08	-5.24*	18.02 **	-1.05*	2.55	-0.09 **	0.19
PMS232A	-0.65	2.33 **	5.50*	11.09 **	-0.53	6.85**	0.04	0.15
I26	0.85	1.01	-0.93	-18.56 **	3.88**	-2.99	0.02	-0.44
AKR456	-1.66*	0.01	1.49	50.66 **	4.97**	10.07**	0.15 **	1.34**
KR191	2.48 **	0.92	-3.98	-8.23 **	-0.53	4.06*	0.01	1.85**
KR196	1.30	0.06	9.71**	-22.11 **	-2.30**	-3.15	-0.09 **	-1.37**
KR125	-2.85 **	-2.32 **	11.22**	41.97 **	6.25**	20.56**	0.16 **	1.07**
C43	-1.12	-0.37	1.79	5.93 *	0.38	-1.50	0.02	0.07
9825REC	1.05	0.30	-0.58	-30.80 **	-3.64**	-11.50**	-0.11 **	-2.46**
ICSR196	-0.05	0.39	0.70	-18.85 **	-9.02**	-15.55**	-0.16 **	-0.07
CD 95% GCA(Line)	1.40	1.38	4.22	5.38	0.97	3.34	0.06	0.69
CD 95% GCA(Tester)	1.50	1.47	4.51	5.75	1.04	3.57	0.06	0.74
sl² Line HS	-0.07	0.92	28.43	216.16	4.58	70.44	0.01	1.88
sl² Tester HS	2.54	0.54	29.57	929.83	25.31	130.46	0.01	1.93
sl² GCA (Average) HS.	1.15	0.74	28.96	549.20	14.26	98.45	0.01	1.90
sl² L * T (SCA)	5.13	2.97	168.77	2042.97	60.53	396.90	0.03	3.27
sl² e	4.01	3.85	36.19	58.86	1.92	22.72	0.01	0.98

Table.3 Estimation of Specific combining ability (sca) effect of crosses in sorghum

S. No.	Crosses	Days to 50% Flowering	Days to Maturity	Plant Height (cm)	Leaf Area (cm²)	Grain Yield (gm)	Fodder Yield/ Plant (gm)	Test Weight (gm)	Harvest Index (%)
1.	PMS28A × I26	0.89	1.53	-0.47	14.09	0.95	-15.09 ***	0.15	0.13
2.	PMS28A × AKR456	1.90	3.20	-13.96*	-26.78**	0.87	-12.66 **	-0.10	-0.65
3.	PMS28A × KR191	0.01	1.63	5.36	-11.86	2.27	-2.63	0.08	-0.74
4.	PMS28A × KR196	-0.86	-2.18	20.22**	55.46**	1.19	19.17 **	0.04	0.36
5.	PMS28A × KR125	-0.65	-0.47	-18.14**	21.86**	0.94	16.86 **	-0.13	-1.77
6.	PMS28A × C43	0.89	0.58	-2.77	-53.07**	3.03 *	1.52	-0.12	-1.03
7.	PMS28A × 9825REC	-1.79	-2.42	11.33	-15.55*	-11.10 **	5.16	-0.14	1.39
8.	PMS28A × ICSR196	-0.37	-1.85	-1.58	15.87*	1.86	-12.33 *	0.22 **	2.31 *
9.	PMS74A × I26	2.50	-1.60	-17.99**	-0.14	1.69	-12.96 **	-0.08	0.26
10.	PMS74A × AKR456	-4.81 *	0.07	18.71**	75.93**	8.18 **	29.02 **	0.26 **	0.70
11.	PMS74A × KR191	1.28	1.83	-15.09*	-45.56**	5.11 **	-10.43 *	0.06	-2.30 *
12.	PMS74A × KR196	-0.12	2.36	-3.09	-12.92	-8.04 **	-20.74 **	-0.01	1.01
13.	PMS74A × KR125	-2.07	-0.60	0.21	66.01**	5.25 **	16.01 **	0.18 *	-0.45
14.	PMS74A × C43	1.38	-2.21	12.74*	-33.24**	-3.77 **	19.29 **	-0.18 *	1.53
15.	PMS74A × 9825REC	3.41	-0.88	-4.73	-67.19**	-1.64	-8.61	-0.05	-0.73
16.	PMS74A × ICSR196	-1.58	1.02	9.24	17.12*	-6.77 **	-11.59 *	-0.17 *	-0.03
17.	PMS71A × I26	-2.98	-2.55	2.17	-5.23	5.39 **	31.25 **	0.26 **	3.75 **
18.	PMS71A × AKR456	-5.45 **	-2.89	27.75**	48.78**	6.52 **	29.76 **	0.37 **	-0.20
19.	PMS71A × KR191	1.29	-1.46	2.84	-25.15**	-8.54 **	-6.03	-0.18 *	3.15 * *
20.	PMS71A × KR196	-1.95	1.40	-18.35**	26.58**	4.18 **	22.91 **	-0.12	-0.25
21.	PMS71A × KR125	5.25 **	3.11	-8.46	-34.73**	-10.64 **	-42.31 **	-0.20 *	-0.87
22.	PMS71A × C43	2.70	0.83	19.85**	10.76	-7.40 **	-31.16 **	-0.05	-1.44
23.	PMS71A × 9825REC	0.70	2.49	-4.87	-7.40	7.32 **	-8.86	-0.02	-2.22 *
24.	PMS71A × ICSR196	0.44	-0.93	-20.93**	-13.62	3.19 *	4.44	-0.05	-1.93
25.	PMS98A × I26	-2.32	-0.30	8.41	51.01**	-10.35 **	-10.69 *	-0.06	-1.87
26.	PMS98A × AKR456	1.97	1.03	-21.11**	-55.86**	4.11 **	-11.71 *	-0.06	2.80 **
27.	PMS98A × KR191	1.60	4.13 *	12.45*	10.59	10.27 **	4.58	0.08	1.64
28.	PMS98A × KR196	-1.43	-1.02	-5.80	-7.21	-8.94 **	1.21	0.09	-1.53
29.	PMS98A × KR125	0.93	0.03	0.73	-71.54**	-9.30 **	-22.56 **	-0.26 **	-0.90
30.	PMS98A × C43	1.99	3.41	-20.20**	7.72	8.93 **	4.42	0.11	-2.12 *
31.	PMS98A × 9825REC	-0.67	-3.26	16.19**	85.62**	6.01 **	16.27 **	0.03	-1.88
32.	PMS98A × ICSR196	-2.07	-4.02 *	9.32	-20.34**	-0.75	18.48 **	0.06	3.85 **
33.	ICSA101 × I26	0.98	0.03	9.40	-27.34**	1.25	4.07	-0.33 **	-1.81
34.	ICSA101 × AKR456	1.08	0.03	-11.55	8.28	-1.88	-11.67 *	-0.21 **	-0.84
35.	ICSA101 × KR191	-0.07	-3.21	-6.52	-3.39	-6.12 **	-14.21 **	-0.05	0.55
36.	ICSA101 × KR196	6.27 **	-0.35	6.54	-1.36	8.49 **	1.59	0.14	-2.47 *
37.	ICSA101 × KR125	-5.20 *	-1.97	14.64*	97.02**	7.54 **	33.23 ***	0.45 **	4.15 **
38.	ICSA101 × C43	-1.12	1.08	-17.92**	-52.92**	-6.66 **	-16.97 **	-0.18 *	0.68
39.	ICSA101 × 9825REC	-3.12	5.74 **	6.95	-15.05	-2.96 *	5.22	0.16 *	1.03
40.	ICSA101 × ICSR196	1.17	-1.35	-1.54	-5.24	0.34	-1.25	0.03	-1.29
41.	PMS42A × I26	2.85	-0.01	-6.05	-33.08**	-1.64	-1.63	0.10	-0.74
42.	PMS42A × AKR456	5.36 **	-1.01	-8.84	-41.04**	-20.19 **	-27.88 **	-0.20 *	0.31
43.	PMS42A × KR191	-5.55 **	-2.92	9.49	54.38**	10.73 **	29.21 **	0.23 **	1.38

44.	PMS42A × KR196	-1.04	-1.06	1.40	-27.31**	4.28 **	-1.92	-0.05	0.72
45.	PMS42A × KR125	-3.04	1.99	13.72*	7.70	6.56 **	21.91 **	0.05	0.16
46.	PMS42A × C43	-0.61	1.37	-4.89	44.93**	-8.12 **	-18.65 **	-0.01	-0.80
47.	PMS42A × 9825REC	0.60	-2.96	-24.16**	13.97	3.50 *	3.99	0.07	-0.35
48.	PMS42A × ICSR196	1.44	4.61 *	19.33**	-19.55*	4.88 **	-5.03	-0.19 *	-0.68
49.	PMS232A × I26	-1.91	2.90	4.53	0.69	2.72	5.06	-0.03	0.28
50.	PMS232A × AKR456	-0.04	-0.43	9.00	-9.31	2.39	5.13	-0.05	-2.12*
51.	PMS232A × KR191	1.44		-8.54	21.00**	-13.72 **	-0.48	-0.23 **	-3.69 **
52.	PMS232A × KR196	-0.87	0.86	-0.91	-33.25**	-1.16	-22.23 **	-0.08	2.15*
53.	PMS232A × KR125	4.77 *	-2.10	-2.71	-86.31**	-0.35	-23.15 **	-0.09	-0.32
54.	PMS232A × C43	-5.23 *	-5.05 *	13.19*	75.83**	14.00 **	41.55 **	0.44 **	3.17**
55.	PMS232A × 9825REC	0.87	1.29	-0.71	5.59	-1.12	-13.17 **	-0.06	2.75**
56.	PMS232A × ICSR196	0.98	2.52	-13.85*	25.77**	-2.76 *	7.28	0.10	-2.22*
	CD 95% SCA	3.97	3.89	11.92	15.20	2.75	9.45	0.16	1.96

*and ** significant level at 5% and 1 % respectively

Fodder yield per plant (gm)

Parents KR125 (20.56), AKR456 (10.07), and PMS71A (8.19) exhibited highly significant positive gca effects. The sca effects were observed to be significant in most of the crosses for fodder yield per plant (gm). The top crosses for sca effects were cross PMS232A × C43 (41.55) followed by ICSA101 × KR125 (33.23). Chaudhary and Narkhede (2004) also reported similar type of results.

Test weight (gm)

The parents KR125 (0.16), PMS74A (0.15) and AKR456 (0.15) exhibited highly significant positive gca effects. The sca effect were observed to be positive significant in most of the crosses for test weight (gm). The top crosses for sca effects were cross PMS232A × C43 (0.44) followed by PMS71A × AKR456 (0.37) these results were in accordance with Premalatha *et al.*, (2006).

Harvest index (%)

The parents PMS74A (2.21), and KR191 (1.85) exhibited highly significant positive gca effects. The sca effects were observed to be positive and significant in most of the crosses for harvest Index (%). The top crosses for sca effects were recorded in cross ICSA101 × KR125 (4.15) followed by PMS98A × ICSR196 (3.85) these results were in accordance with Chaudhary and Narkhede (2004) and Prakash *et al.*, (2010).

In general, crosses (hybrids) were early in maturity and high yielding compared to the parents, which is desirable and may be exploited for development of high yielding hybrids.

The parent ICSA101, KR125, PMS71A, AKR456, PMS74A, PMS232A and C43 recorded early flowering and early maturity along with significantly higher Plant height (cm), Flag leaf area (cm²), Grain yield (gm), Fodder yield per plant (gm) and harvest index.

Amongst the hybrids ICSA101 × KR125, PMS71A × AKR456, PMS74A × AKR456 and PMS232A × C43 exhibited significant earliest flowering and early maturity along with significantly higher Plant height (cm), Flag leaf area (cm²), Grain yield (gm), Fodder yield per plant (gm) and harvest index.

The parents AKR456, ICSA101, KR125, PMS71A, PMS74A and PMS42A exhibited highly significant positive gca effects. The crosses ICSA101 × KR125, PMS71A × AKR456, PMS74A × AKR456 and PMS232A × C43 exhibited highly significant positive sca effects for most of the traits under study. The magnitude of sca was higher than gca. Out of fifty six crosses, ICSA101 × KR125 (47.97 gm) and PMS71A × AKR456 (47.79 gm) exhibited significant highest grain yield followed by cross PMS74A × AKR456 (47.36 gm) and PMS232A × C43 (46.13 gm). Similar is the trend in yield contributing characters. The parents AKR456, ICSA101, KR125, PMS71A, PMS74A and PMS42A were found as best general combiner for yield, yield contributing characters. The crosses ICSA101 × KR125, PMS71A × AKR456, PMS74A × AKR456 and PMS232A × C43 were found as best specific combiner for yield per plant and other yield contributing characters and exhibited highest positive significant heterosis over better parents and standard checks.

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