Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-6: 1992-1998

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7692 **Special Issue-6 pp. 1992-1998**
Journal homepage: http://www.ijcmas.com

Original Research Article

Assessment of Newly Developed Diverse Parental Lines in Sorghum through Combining Ability

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Keywords

Sorghum, Combining ability, Line x tester analysis

A B S T R A C T

A study was conducted to estimate heterosis in hybrids of sorghum [Sorghum bicolor (L.) Moench] with respect to grain yield and its components using fifty-six hybrids. The hybrids and their parents were evaluated to assess the combining ability by using a line x tester analysis involving 4 lines and 14 tester. The line AKMS 30 A was the best general combiner for grain yield per plant along with other component characters and the hybrid AKMS 90 A x AKR 337 exhibited higher significant sca effect for grain yield per plant along with the components traits like panicle weight, 100 seed weight and fodder yield. Among the testers, AKR 337 was found to be suitable for development of high yielding and early maturing hybrids along with minimum shoot fly damaged hybrids in *kharif* sorghum due to its positive significant gca effects for grain yield coupled with negative significant gca effects for days to maturity and shoot fly damage percentage.

Introduction

Sorghum [Sorghum bicolor (L.) Moench] is an often self-pollinating, diploid (2n = 2x = 20) crop with a genome, about 25% the size of maize or sugarcane. It is a C4 plant with higher photosynthetic efficiency and higher abiotic stress tolerance (Nagy *et al.*, 1995; Reddy *et al.*, 2009). It is grown on 40 m ha in 105 countries of Africa, Asia, Oceania and the Americas. Africa and India account for the largest share (> 70%) of global sorghum area while USA, India, Mexico, Nigeria, Sudan and Ethiopia are the major sorghum producers (Kumar *et al.*, 2011). It is the third most important grain crop in India, next only to rice (*Oryza sativa*) and wheat (*Triticum aestivum*). Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Rajasthan and Gujarat are the major sorghum growing states of India. Besides being an important food, feed and forage crop, sorghum also provides raw material for the production of starch, fiber, dextrose syrup, biofuels, alcohol, and other products.

For improvement in such an important crop, the most important prerequisite is the selection of suitable parents, which could combine well and produce desirable hybrids and segregants.

In the present study, an attempt has been made to estimate the heterosis in F1 hybrids with respect to yield and the combining ability in sorghum, using line x tester mating designs.

Materials and Methods

Eighteen genotypes of sorghum were studied in this experiment. Eighteen genotypes consisted of four lines namely, AKMS 14 A, AKMS 90 A, AKMS 30 A and ICS 733 A and fourteen testers namely, AKR 337, AKR 525, AKR 526, AKR 534, AKR 492-1, AKR 535, AKR 536, AKR 537, AKR 538, AKR 539, AKR 527, AKR 540, AKR 541 and AKR 528. These parents were crossed in a line x tester mating design and resultant fifty-six hybrids along with their parents were raised in RBD with three replication during *kharif* 2016-17 in the research farm of Sorghum Research Unit, Dr. P. D. K. V, Akola. Fifty-six hybrids and eighteen parents were evaluated to study the combining ability for following characters viz., days to 50 per cent flowering, Days to maturity Plant height (cm), Chlorophyll content index, Number of primaries per panicle, Number of secondaries per panicle, Panicle length (cm), Panicle breadth (cm), Panicle weight (g), Grain yield per plant (g), 100 seed weight (g), Fodder yield, Grain hardness (Kg/cm2) (g) and Shoofly dead heart percentage (At 28 days). The combining ability analysis was carried out as per the method suggested by Kempthorne (1957). Line x tester analysis is a precise method for obtaining such information when a large number of parents to be tested. Keeping this in view, present study was undertaken for line x tester analysis in Kharif sorghum to develop suitable hybrid parents.

Results and Discussion

The analysis of variance for all the yield and yield component traits studied are presented in Table 2. Variance due to parents was highly significant for all the traits studied except grain yield per plant, indicating good amount of genetic differences among the parents. Variance due to hybrids was also highly significant for all the fourteen traits studied. Variance due to lines was highly significant for, Days to maturity, Chlorophyll content index, Number of primaries per panicle, Number of secondaries per panicle, Panicle length, Panicle breadth, Panicle weight and Shoofly dead heart percentage. Variance due to testers was highly significant for all the traits studied, except grain yield per plant.

The variance due to lines x testers recorded very high levels of significance for all the traits except plant height (Table 3). The lines, (females) recorded significant variation for characters like days to 50 per cent flowering, days to maturity, plant height, panicle length, number of secondaries per panicle, and grain hardness. The testers (males) showed significant variation for only the character plant height.

Harer and Bapat (1982) stated that the per se performance of the parents with the nature of combining ability provide the criteria for the choice of parents for hybridization. On this basis, those parents which performed well for both per se performance and gca effects can be considered as good parents.

Among the lines, AKMS 14 A and ICS 733 A recorded low mean value and negative gca effects for days to 50 per cent flowering, which might be useful in breeding programme for earliness. Among the 14 testers, six tester showed negative significant gca effects for days to 50 per cent flowering and the testers are AKR 527, AKR 526, AKR 537, AKR 492-1, AKR 337 and AKR 536. Among the testers, AKR 337 was found to be suitable for development of high yielding and early maturing hybrids along with minimum shoofly affected hybrids in *kharif* sorghum due to its positive significant gca effects for grain yield coupled with negative significant gca effects for days to maturity and shoot fly dead heart percentage. The line AKMS 30 A was found to be suitable for developing high grain yielding and fodder yielding hybrid in kharif sorghum due to its positive significant gca effects for grain yield along with fodder yield.

The hybrid ICS 733 A x AKR 492-1 exhibited higher significant sca effects for grain yield per plant along with other yield contributing characters like panicle weight, panicle length, panicle breadth and 100 seed weight. The Cross AKMS 30 A x AKR 535 also exhibited higher significant sca effects for grain yield per plant along with two component characters like panicle weight, shoofly deadheart. Ghorade *et al.,* (2016) reported ten promising cross combination based on positive significant sca effects for grain yield per plant. These hybrid were one of the top five ranking hybrids. It was a derivative of high x high parental combinations in terms of gca and these hybrids might produce desirable segregants. Hence, these hybrids might be desirable for biparental selection or intermating.

The hybrids AKMS 90 A x AKR 337 for Days to 50 percent flowering, Days to maturity, Chlorophyll content index, number of primaries per panicle and panicle weight, AKMS 14 A x AKR 525 for shoot fly dead heart percentage and panicle weight, AKMS 30 A x AKR 337 for plant height panicle length, plant height and fodder yield recorded high sea effects.

Table.1 Mean yield performance, standard heterosis, SCA effects and GCA effects of some promising hybrids

Sr. No.	Crosses	Mean for Grain yield / plant (g)	Standard Heterosis (%) over (CSH -35)	SCA effects for grain yield	Significant SCA effects for other characters	GCA effect with type of parents for grain yield	Significant GCA effects for other characters
1	AKMS 90 A x AKR 337	57.00	23.91**	11.57**	9,11,13	-2.15** X 5.59** L H	P_1: 13 P_2:1,2,4,5,9,11,14
2	ICS 733 A x AKR 492-1	53.83	17.03*	8.48**	7,8, 9,11	-2.02** X 5.39** L H	P_1 :1,11,12,14 P_2:1,9,12
3	AKMS 30 A x AKR 535	54.43	18.33*	6.31**	9,14	3.35** X 2.78* H H	P_1 :3,7,9,12,13 P_2:4,12,13
4	AKMS 14 A x AKR 525	54.67	18.84*	5.27*	9	0.83 X 6.59** L H	P_1:1,2,4,6,9,14 P_2:9,11
5	AKMS 30 A x AKR 337	56.00	21.74**	5.06*	7, 9,12	3.35** X 5.59** H H	P_1:3,7,9,12,13 P_2:1,2,4,5,9,11,14

H : High GCA L : Low GCA
P_1 & P_2 : Female parent and male parent of the concerned cross, respectively
* : Significant at 5 % level of significance
** : Significant at 1 % level of significance

Note: 1: Days to 50 % flowering 2: Days to maturity 3: Plant height (cm)
4: Chlorophyll content index 5: Number of primaries / panicle 6: Number of secondaries/panicle 7: Panicle length (cm)
8: Panicle breadth (cm) 9: Panicle Weight (g)
10: Grain Yield/ Plant (g) 11: 100 Seed Weight (g) 12: Fodder Yield/ Plant (g)
13: Grain Hardness 14: Shoot fly dead heart percentage (at 28 days)

Table.2 Analysis of variance of Parents and Hybrids for various characters under Line x Tester analysis

Source of Variation	d.f.	Days to 50% Flowering	Days to Maturity	Plant Hei	Chlorophyll content index	Number of Primaries/ Panicle	Number of Secondaries/ Panicle	Panicle Length	Panicle Breadth	Panicle Weight	Grain Yield/ Plant	100 Seed Weight	Fodder Yield /Plant	Grain Hardness	Shoot Fly Dead Heart
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Replications	2	3.49	1.96	359.45	0.89	40.73	169.22	1.93	0.50	3.18	7.44	0.22	129.04	0.11	1.18
Genotypes	73	42.88**	7.70**	2538.83**	16.64**	196.49**	10664.32**	8.96**	0.39**	190.97**	109.13**	1.04**	1121.62**	2.05**	34.81**
Parents	17	12.87**	5.01**	2070.06**	29.92**	369.26**	14103.72**	8.81**	0.47**	80.32**	27.24	0.68**	280.35**	1.54**	39.95**
Females	3	2.08	11.42**	1210.76	45.32**	456.97**	13845.19*	14.50**	0.72*	93.20**	26.90	0.38	75.63	0.23	5.73**
Males	13	12.63**	3.89**	2426.56**	13.77**	373.63**	15083.39**	7.90**	0.41*	83.44**	29.15	0.73**	342.98**	1.77**	40.23**
Females vs Males	1	48.25**	0.38	13.52	193.64**	49.27	2143.55	3.48	0.49	1.12	3.38	1.03*	80.28	2.43**	138.83**
Hybrids	55	42.45**	8.62**	2648.76**	10.11**	144.08**	9793.85**	9.17**	0.36**	221.27**	125.78**	1.04**	559.68**	1.78**	29.56**
Parents vs Hybrids	1	576.69**	2.86	4461.72**	150.46	142.55	70.85	0.06	0.13	405.01**	585.68**	6.80**	46329.63**	25.71**	236.45**
Error	146	1.43	1.18	601.45	2.09	59.11	3581.20	3.03	0.19	13.03	17.09	0.17	65.99	0.11	0.69

Note: * - Significant at 5 % level of significance

** - Significant at 1 % level of significance

Table.3 Analysis of variance for combining ability for various characters under Line x Tester analysis

Source of Variation	d.f.	Days to 50% Flowering	Days to Maturity	Plant Height	Chlorophyll content index	Number of Primaries/ Panicle	Number of Secondaries/ Panicle	Panicle Length	Panicle Breadth	Panicle Weight	Grain Yield/ Plant	100 Seed Weight	Fodder Yield /Plant	Grain Hardness	Shoot Fly Dead Heart
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Replications	2	4.29	1.09	206.45	1.588	24.12	194.66	6.41	0.32	0.89	4.96	0.54*	40.25	0.08	1.51
Crosses	55	42.46**	8.63**	2648.76**	10.11**	144.08**	9793.85**	9.17**	0.37**	221.27**	125.78**	1.05**	559.69 **	1.78**	29.57**
Lines	3	339.47**	30.79*	4221.66**	13.61	95.86	45270.58**	48.94**	0.25	467.52	289.10	2.21	1039.51	10.72**	17.11
Testers	13	40.16	4.44	7564.49**	8.34	199.04	6872.29	7.38	0.27	158.74	160.49	1.16	243.94	0.59	25.55
Line x Testers	39	20.37**	8.32**	889.19	10.44**	129.47**	8038.73**	6.79**	0.41**	223.17 **	101.6**	0.92**	628.03 **	1.51**	31.86**
Error	110	1.44	1.02	668.70	1.57	52.65	3275.64	3.39	0.20	10.48	17.41	0.17	72.96	0.13	0.68

Note: * - Significant at 5 % level of significance
** - Significant at 1 % level of significance

Table.4 Mean performance and sca effects of top ranking four crosses with gca effects of their parents for days to flowering

Sr. no.	crosses	Mean performance for physiological maturity	sca effects	gca effects of parents	
				P1	P2
1	AKMS 30A x AKR 337	104	-0.01	-0.19	-1.19
2	AKMS 14A x AKR 525	105	-0.98	-1.09	-0.27
3	AKMS 30A x AKR 525	104	-1.56	-0.19	-0.27

The mean performance and specific combining ability effects of top promising 6 crosses with gca effects of their parents for grain yield per plant with other yield contributing characters are presented in Table 1. The crosses which showed significant sca effect along with higher heterosis and per se performance were AKMS 90A X AKR 337, ICS 733 X AKR 492-1, AKMS 30A X AKR 535, AKMS 14A x AKR 525 and AKMS 30A x AKR 337. High heterotic crosses showed significant sca effects with higher per se performance. It was noticed that the crosses AKMS 90A X AKR 3377 and ICS 733 X AKR 492-1 which showed the highest sca effects, had one parent with negative and other parent with positive gca effects. Under such situation if additive genetic system is present in good combiner and complementary one in acting in the same direction to maximize the expression of desirable attributes, then such crosses are expected to show transgressive segregants in future generation. The findings suggested that it is very important to consider the heterosis, gca of the parents involved and per se performance of the crosses while selecting the best cross combinations. Thus, the combinations of poor x high or high x high combiners could result into the hybrids with high performance depending on the per se performance of the parents concerned, Boratkar *et al.,* (2014). It is observed that the line AKMS 30A and tester AKR 337 which was the best general combiners for grain yield per plant were involved in the crosses having higher sca effects. These crosses can be directly used in the breeding programme for improvement of grain yield.

The mean performance, sca effects and gca effects of parents for top ranking 3 crosses for days to flowering are given in Table 4. The crosses selected for earliness based on significant sca effects and heterosis in the desirable direction along with per se performance were AKMS 30A X AKR 337, AKMS 14A X AKR 525 and AKMS 30A X AKR 525. The crosses showed high heterosis in the desirable direction with significant sca effects and higher per se performance. Here also, the crosses which showed earliness had gca effects of one parent in the desirable direction. The line AKMS 14A and tester AKR 337 which was the best combiners for earliness were involved in the selected crosses. It is necessary to select crosses based on heterosis and per se performance in addition to significant sca effects. These crosses can be directly used in breeding for earliness in Kharif sorghum.

The present investigation clearly indicated the importance of gca effects of parents and per se performance during choice of parents and consideration of heterosis and per se performance in addition to sca effects of crosses while selecting the best hybrid combinations. The parents AKMS 90A, AKMS 30A, AKR 337, AKR535 and AKR 525 can be directly used for breeding for high yield and the parents AKMS 14A and AKR 525 for breeding for early varieties and hybrids in kharif sorghum.

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