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COMBINING ABILITY STUDIES IN DIVERSE CYTOSTERILE BASED *RABI* SORGHUM (*SORGHUM BICOLOR* L. MONECH) HYBRIDS FOR YIELD AND ASSOCIATED TRAITS

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ABSTRACT

Combining ability was studied using line x tester analysis involving 6 male sterile lines of three diverse cytoplasmic backgrounds (A_1, A_2 and A_4) and 4 testers. Analysis of variance revealed the presence of significant differences due to lines, testers and line x tester, indicating the presence of variability. For grain yield/ plant A_2 cytosterile 20A and tester AKR492 were good general combiners. A_2 cytosterile 20A and A_4 cytosterile M-31-2A along with tester 2043 were good general combiners for fodder yield/plant. As regard to specific combining ability, cross combinations 9A x 4109, 25625A x 2043 and 104A x 10515 and 1409A x AKR492 exhibited significant SCA effects in desirable direction for grain yield/ plant. As regard to fertility restoration parameters, all the hybrids based on 1409A (A_1 cytosterile) except 1409A x 4109; *maldandi* cytosterile based hybrids 9A x 2043, M-31-2A x 2043 and A_2 cytosterile based hybrids 20A x 10515, 20A x AKR492, 25625A x 4109 and 25625A x 10515 showed significant SCA effects for pollen fertility (%) and seed setting % under selfing. In present study the pattern of cytoplasmic effect on GCA and SCA was not uniform in autoplasmic lines.

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INTRODUCTION

Sorghum (*Sorghum bicolor* L. Monech) is an important staple food for poor in arid and semiarid tropics, especially in marginal areas with least fertile and low water holding capacity soils. It is also an important source of food, feed, fodder and fuel in different parts of world and has achieved a special significance after wheat, rice and maize among cereals. Sorghum covers 5.8 million hectare area in India producing 5.4 million tonnes of sorghum grains with productivity of 1898 kg/ha. Sorghum is mainly grown as a *kharif* crop and also as *rabi* crop. The *kharif* sorghum gives better yield but quality of *rabi* sorghum is superior due to which its market price is also high. The progress in *rabi* sorghum is limited and there is need for critical studies on heterosis and combining ability involving diverse germplasm. Developing high yielding post rainy season adapted varieties/hybrids is the main objective in almost all the crop improvement programmes. (Kalpande *et al.,* 2015). Selection of parents on the basis of phenotypic performance alone is not a sound phenotypically superior line may yield poor recombination. It is therefore, essential that parents should be chosen on the basis of their genetic value (Krupkar *et al.,* 2013).

To initiate hybrid breeding programme for improvement of any character, it is important to know combining ability of male sterile lines and restorers for that particular character. The estimates of combining ability are useful to predict the relative performance of different lines in hybrid combinations. Combining ability also provides necessary information on nature and magnitude of gene action which is important in understanding genetic potential of population. The line x tester mating design help in assessing the combining ability of parents there by selection of superior parents as well as cross combinations (Sprague and Tatum, 1942). Sakhare *et al.* (1992) and Pillai *et al.* (1995) had reported combining ability and line x tester analysis involving only *milo* sterility system in sorghum. But in present study, combining ability results have been discussed with special emphasis to yield and yield parameters in relation to diverse cytoplasm.

MATERIALS AND METHODS

The experimental material for study consisted of six diverse cytoplasm based male sterile lines *viz*., 104A, 1409A (A_1 cytosterile), M-31-2A, 9A (A_4 cytosterile) and 20A, 25625A (A_2 cytosterile) and four restorers *viz*., 2043, 10515, AKR492 and 4109. Which were crossed in line x tester fashion (Kempthorne, 1957) to obtain 24 hybrids during post rainy season 2013-14. These 24 hybrids along with 10 parents and 2 checks CSH-18 and M-35-1 were grown in randomized block design (Panse and Sukhatme, 1967) with two replications in post rainy season 2014-15 at Sorghum Research Station, VNMKV, Parbhani (MS). Each replication was divided in to two tiers to reduce soil heterogeneity. Each genotype planted in two rows with row length 4m and spacing 45cm x 15cm between and within rows. Observations were recorded for days to 50% flowering, days to maturity, panicle length, panicle width, number of primaries/panicle, number of grains/primary branch, 100 seed weight, pollen fertility (%), seed setting % under selfing, grain yield/plant and fodder

yield/plant.

RESULTS AND DISCUSSION

The analysis of variance for combining ability indicated that highly significant variation due to line was for panicle length, number of primaries/panicle, number of grains/primary branch, grain yield/plant, fodder yield/plant and 100 seed weight. As regard to testers, significant differences observed for all characters except pollen fertility (%) and seed setting % under selfing. The variance due to line x tester were also highly significant for all the traits studied except pollen fertility (%) and seed setting % under selfing indicating interaction of different lines with different testers.

It is evident from the study that, the estimates of components of variance for GCA were higher in magnitude than SCA variances for days to 50% flowering, days to maturity, panicle length, grain yield and fodder yield per plant indicating preponderance of additive gene action. Prabhakar *et al.* (2013) also reported additive gene action for days to 50% flowering, days to maturity and grain yield/plant. Whereas, SCA variances were higher than GCA variances for panicle width, number of primaries/panicle, number of grains per primary branch, 100 seed weight, pollen fertility (%) and seed setting % under selfing. Similarly, Premlatha *et al.* (2006) also observed non-additive gene action in 100 seed weight, number of grains/panicle, panicle length while, Khandelwal *et al.* (2006) reported non-additive gene action, for number of primaries and leaf length. GCA effects reflect true genotypic value of a line, as these are estimated as mean effect of a line in a series of crosses (Reddy *et al.* 2007). *Per se* performances of the parents with high GCA provide criteria for choice of the parents for hybridization and they are desirable for obtaining useful segregants in early generations (Jain and Patel 2014). Estimation of GCA effects indicated that, out of six lines A_4 cytosterile 9A, A_1 cytosterile 104A & 1409A and A_2 cytosterile 25625A were good general combiners for days to 50% flowering. Whereas, tester 2043 was best general combiner for days to 50% flowering as they exhibited significant negative GCA effect which is desirable for early flowering. As regard to days to maturity, A_4 cytosterile line 9A, A_1 cytosterile 104A and A_2 cytosterile 25625A were good general combiners while, among testers AKR492 and 2043 were good general combiners. Similarly Girma *et al.* (2010), Prabhakar (2013) also reported good general combiners for days to maturity. For panicle length cytoplasmic male sterile lines 1409A (A_1) and 25625A (A_2) were good general comb iners. Khidse *et al.* (1982), Solanki and Patel (2007) also reported similar results. A_4 cytosterile lines 9A and M-31-2. Aamong females and AKR492 among male were good general combiners for panicle width.

None of the male sterile line showed significant GCA effect for number of primaries/panicle and number of grains/primary branch. However, tester 10515 and AKR492 exhibited significant GCA effect for number of primaries/panicle and grains/primary branch respectively. As regard to grain yield per plant, A_2 cytoplasmic male sterile line 20A and tester AKR492 were best general combiners. Murumkar *et al.* (2005), Prabhakar and Raut (2010) and Ghorade *et al.* (2014) also reported promising general combiners for yield and its components from their studies. A_4 cytosterile M-31-2A and A_2 cytosterile 20A whereas, tester 2043 were best general combiners for fodder yield/plant. A4 cytoplasmic male sterile line 9A was best general combiner for pollen fertility (%) and seed setting % under selfing. Jahagirdar *et al.* (2004) also reported good general combining ability for pollen fertility (%) and seed setting % under selfing. A_2 cytosterile line 20A and three testers 4109, 2043 and 10515 were good general combiners for 100 seed weight. However, effect of cytoplasm on GCA has not shown uniformity and more influence on yield and its component traits. It may be due to different genetic back ground of iso-cytosterile lines or interaction of cytoplasm with nuclear genes of A lines and R lines. Reddy *et al.* (2007) also observed that cytoplasm has limited influence on GCA effects for plant height, grain yield and days to 50% flowering

Specific combining ability is indicative of heterosis. High SCA effect mostly from dominance and interaction effects existed between the parents used in hybridization (Bhati *et al.*, 2015). For days to 50% flowering and days to maturity none of the cross exhibited significant SCA effects. A_4 cytoplasm based hybrid, 9A x AKR492 hybrid exhibited significant SCA effect in desirable direction for panicle width. Among 24 hybrids 6 hybrids exhibited significant SCA effect in desirable direction for number of primaries/panicle. Hybrid 20A x AKR492 rank I in significant SCA effects followed by M-31-2A x 2043, 9A x 4109, 25625A x 10515, 104A x 4109, 1409A x 10515 for number of primaries/panicle. 6 hybrids out of 24 exhibited significant SCA effects for number of grains/primary branch. The hybrid 1409A x 2043 exhibited highest SCA effects in desirable direction followed by 25625A x AKR492, 20A x 4109, 104AxAKR492, M-31-2AxAKR492, 9A x 10515 for number of grains/ primary branch. As regard to grain yield/ plant, 4 hybrids out of 24 showed significant SCA effects in desirable direction in which 9A x 4109 rank I followed by 25625A x 2043, 104A x 10515 and 1409A x AKR492. As

Table 1: Analysis of variance

Sr. No.	Source	d.f.	Grain yield/ plant (gm)	Fodder yield/ plant (gm)	Days to 50% flowering	Days to maturity	Panicle length (cm)	Panicle width (cm)	No.of primaries /panicle	No. of grains/ primary branch	100 seed weight (gm)	Pollen fertility (%)	Seed setting % undue selfing
1	Replications	1	2.39	8.61	9.19	5.31	0.85	0.02	0.53	8.33	0.02	1041.08**	3045.86**
2	Genotypes	33	482.52**	2023.04**	37.34*	36.26**	27.73**	2.80**	175.03**	157.39**	0.72**	46.93	0.00
3	Line	5	667.04**	986.25**	15.00	15.00	31.18**	1.23	168.91**	64.08**	0.70**	72.70	0.00
4	Tester	3	219.39**	547.76**	70.12*	65.33**	38.71**	1.72*	60.45**	42.94**	0.51*	16.30	0.00
5	Line x Tester	1	157.67*	198.66**	1.88	1.20	1.57	2.30	189.33**	88.96**	0.65*	9.97	0.00
6	Error		25.84	20.53	16.95	13.67	3.48	0.59	9.38	9.11	0.14	37.21	49.82

Table 2: General combining ability effects (GCA) for yield and yield parameters.

Sr. no.	Genotypes	Grain yield/ plant (gm)	Fodder yield/ plant (gm)	Days to 50% flowering	Days to maturity	Panicle length (cm)	Panicle width (cm)	No.of primaries /panicle	No. of grains/ primary branch	100 seed weight (gm)	Pollen fertility (%)	Seed setting % undue selfing
	Lines											
1	104A	1.76	-20.20**	-2.96**	-3.02**	1.78	-0.28**	1.46	3.20	-0.05**	12.91	15.21
2	1409A	6.50	-4.97**	-0.08**	0.48	2.99*	-0.42**	1.33	1.85	-0.41**	5.72	14.58
3	9A	-1.66**	3.80	-3.08**	-3.27**	-3.00**	1.19**	0.04	0.83	-0.14**	21.34*	41.49*
4	M-31-2A	-9.36**	31.53**	4.04	4.35	-3.16**	0.54*	-3.14**	-7.36**	0.01	-33.71**	-46.04**
5	20A	15.13*	21.30**	2.92	2.73	-1.03**	-0.80**	4.99	3.13	0.55**	1.55	3.33
6	25625A	-12.37**	-31.47**	-0.83**	-1.27**	3.01*	-0.23**	-4.68**	-1.64**	0.04	-7.81**	-28.54**
	SE +	1.80	1.60	1.46	1.31	0.66	0.27	1.08	1.07	0.13	2.16	2.50
	Tester											
1	4109	-7.05**	-1.34**	1.63	1.65	-1.43**	0.08	-0.75**	-2.69**	0.22**	-4.32**	-6.88**
2	2043	-10.26**	31.01**	-1.88**	-1.85**	-1.46**	-0.33**	-5.33**	-5.36**	0.10**	-11.14**	-13.96**
3	10515	4.26	-13.45**	3.29	2.98	-0.89**	-0.76**	4.39*	-2.24**	0.09*	8.16	15.63
4	AKR 492	13.05*	-16.22**	-3.04	-2.77**	3.77**	1.01**	1.69	10.30**	-0.40**	7.27	5.21
	SE +	1.47	1.31	1.19	1.07	0.54	0.22	0.88	0.87	0.11	1.76	2.04

Table 3: Specific combining ability

Sr. no.	Genotypes	Grain yield/ plant (gm)	Fodder yield/ plant (gm)	Days to 50% flowering	Days to maturity	Panicle length (cm)	Panicle width (cm)	No. of primaries /panicle	No. of grains/ primary branch	100 seed weight (gm)	Pollen fertility (%)	Seed setting(%) under selfing
1	104A x 4109	5.93	-16.14**	2.63	2.85	-0.91	-0.21	8.92**	-6.82**	-0.41	4.27	13.13*
2	104A x 2043	-14.43**	-2.99	0.13	0.35	0.13	-0.16	-6.27**	-4.74*	0.01	4.86	-19.79**
3	104A x 10515	12.65**	15.88**	-2.54	-2.48	0.06	1.00	-2.26	2.80	0.47	-6.22	-6.88
4	104Ax AKR 492	-4.15	3.25	-0.21	-0.73	0.72	-0.62	-0.39	8.76**	-0.07	-2.91	13.54*
5	1409A x 4109	-14.75**	17.14**	0.75	1.85	-1.06	-0.49	-6.99**	-0.72	0.45	-34.04**	-51.25**
6	1409A x 2043	2.34	-6.41	-1.75	-2.15	0.81	1.10	-1.20	13.76**	-0.03	14.84**	18.33**
7	1409A x 10515	1.05	-1.85	1.08	0.02	-1.17	0.75	8.26**	-0.15	-0.58*	9.16*	11.25*
8	1409A x AKR492	11.36**	-8.88*	-0.08	0.27	1.41	-1..36*	-0.07	-12.90**	0.15	10.04*	21.67**
9	9A x 4109	15.17**	-20.14**	-0.25	-0.40	2.07	-0.04	11.47**	1.41	-0.29	4.34	6.88
10	9A x 2043	2.95	-2.39	1.25	1.10	-0.29	-0.30	1.48	2.59	-0.12	9.20*	13.96*
11	9A x 10515	-11.81**	1.18	0.58	0.77	-0.85	-2.00**	-8.87**	5.74*	0.06	-7.20	-15.63**
12	9A x AKR492	-6.31	21.35**	-1.58	-1.48	-0.93	2.34**	-4.08	-9.74**	0.35	-6.26	-5.21
13	M-31-2A x4109	-3.87	12.44**	0.63	-0.02	0.50	-0.17	-7.06**	3.91	-0.04	-10.74*	-5.63
14	M-31-2A x 2043	-5.33	-1.31	3.13	2.98	-0.37	-0.67	14.33**	-4.26	-0.17	28.20**	51.46**
15	M-31-2A x 10515	4.18	-3.25	0.46	1.15	0.28	0.82	-1.49	-6.31**	0.51	-14.08**	-28.13**
16	M-31-2A x AKR492	5.01	-7.88*	-4.21	-4.10	-0.35	0.02	-5.79*	6.66**	-0.30	-3.09	-17.71**
17	20A x 4109	-3.21	4.36	-0.75	-0.90	1.06	1.10	-7.27**	9.18**	-0.19	16.41**	10.00
18	20A x 2043	1.35	-5.59	-3.25	-2.90	-0.17	0.22	-3.33	-6.71**	0.08	-30.77**	-47.92**
19	20A x 10515	-1.19	-3.62	-0.42	-0.73	2.35	-0.45	-6.05*	0.94	0.13	4.50	15.00**
20	20A x AKR492	3.05	4.85	4.42	4.52	-3.24*	-0.86	16.65**	-3.40	-0.02	9.86*	22.92**
21	25625A x 4109	0.72	2.34	-3.00	-3.40	-1.66	-0.20	0.92	-6.96**	0.47	19.77**	26.88**
22	25625A x 2043	13.12**	18.69**	0.50	0.60	-0.11	-0.18	-5.02*	-0.64	0.23	-26.33**	-16.04**
23	25625A x 10515	-4.88	-8.35*	0.83	1.27	-0.61	-0.10	10.42**	-3.01	-0.59*	13.91**	24.38**
24	25625A x AKR492	-8.96*	-12.68**	1.67	1.52	2.39	0.48	-6.32*	10.61**	-0.11	-7.35	-35.21**
	SE +	3.59	3.20	2.91	2.61	1.32	0.54	2.17	2.13	0.27	4.31	4.99

regard to fodder yield per plant, 5 crosses showed significant positive SCA effects. The cross 9A x AKR492 exhibited highest significant SCA effects in desirable direction followed by cross combinations 25625A x 2043, 1409A x 4109, 104A x 10515 and M-31A x 4109. For pollen fertility (%) and seed setting % under selfing, all hybrids based on A_1 cytosterile 1409A showed significant SCA effects except 1409A x 4109 and only two hybrids based on 104A exhibited SCA effect in desirable direction for seed setting % only. Two hybrids based on *maldandi* cytoplasm *viz.*, 9A x 2043 and M-31-2A x 2043 showed significant SCA effect. While, A_2 cytosterile based hybrids 20A x AKR492, 25625A x 4109 and 25625A x 10515 exhibited significant SCA for both fertility restoration parameters.

5 hybrids each based on A_1 & A_2 cytoplasm and 3 hybrids based on A_4 cytoplasm showed positive SCA effect for fertility restoration. Senthil *et al.* (1998) also reported that more number of fertile hybrids were obtained in A_1 (*milo*) cytoplasm followed by A_2, A_4 and least in A_3 cytoplasm. Fertility in A_2 and *maldandi* cytoplasm based hybrids was due to restoration of fertility by testers. (Bhavsar and Borikar 2002). The hybrids with higher SCA effects for the grain yield and its contributing traits are the derivatives of low x high and low x low parental contribution in term of GCA.

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