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RESEARCH PAPER

Combininig ability analysis for drought tolerance and grain yield in *Rabi* sorghum

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Abstract : Combining ability analysis to study drought tolerance in *Rabi* sorghum using the line x tester design was conducted using five lines and 12 testers to generate total 60 hybrids. The estimates of gca effects revealed that among the five line, the line MS 104A showed positive and significant gca effect for grain yield per plant along with eight drought tolerance traits. Among the testers, M 35-1 was the best tester with significant gca effects for grain yield along with seven drought tolerance traits. Other promising testers sowing significant gca effects for grain yield and some of the other drought tolerance parameters were SPV-504, CSV-216 R, Ringni, Parbhani Moti and AKSV-13 R. Among the hybrids, the crosses showing high mean performance for grain yield per plant and desirable significant sca effects for grain yield per plant along with some of the drought tolerance traits may be considered for further breeding programme.

Key Words : Combining ability analysis, GCA, Line x tester, SCA, Sorghum

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INTRODUCTION

Sorghum is one of the most important cereal grain in the world. *Rabi* sorghum is normally grown under scared and receding soil moisture condition with increasing temperature particularly after flowering. The erratic and uneven distribution of rainfall destabilizes the yield. Development of drought tolerant hybrid and variety of *Rabi* sorghum is the major objective of the sorghum breeder. The choice of parents for hybridization depends not only on the diversity of parents but also on their combining ability as well. The parents which combine well with other parents in cross combining are the most desirable ones and the consideration of gca and sca may help in isolating this desirable genotypes. Certain parents combine well, whereas others which appeared equally good may produce poor progenies in cross combination suggesting there by that the physical appearance, yielding potential and drought tolerance of a parent are not necessarily indication of good combining ability. The present study was therefore undertaken to identify potential donor parents for various physiological traits associated with drought tolerance though combining ability analysis.

MATERIAL AND METHODS

Five lines *viz*., MS 104 A, AKMS 69 A, AKMS 47 A, AKMS 45 A and AKMS 65 A were crossed with each of the 12 testers *viz*., CSV 216R, AKR 354, AKR 365, AKR 371, AKR 373, Ringni, SPV 504, AKSV 13R, M35-1, P. Moti, AKR 372 and AKR 370 by using line x tester mating design to generate total 60 hybrids during *Rabi* 2005-2006. These 60 hybrids along with five lines and 12 testers were grown in Randomized Block Design with three replications at Sorghum Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during *Rabi* 2006-2007. All the recommended package of practices were followed during the crop growth to raise a good crop. The observations were recorded on five randomly selected plants from each treatment and each replication. Observations were recorded

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on leaf area at 75 DAS, dry matter at harvest, chlorophyll content at 75 DAS, proline content, chlorophyll stability index, stomatal index, specific leaf weight, harvest index and gain yield per plant. The line x tester analysis was done as per the method suggested by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among all the characters under study indicating considerable genetic diversity among the parents selected. The analysis of variance for combing ability showed that mean sum of squares due to females, was significant for all the characters studied except for leaf area at 75 DAS and proline content. Mean sum of squares due to males was significant for all the characters except stomatal index. The mean sum of squares due to female vs. male was highly significant for all the characters except dry matter at harvest. This indicated the presence of sufficient amount of wide genetic diversity among the parents used in the hybridization (Table 1).

The estimates of general combining ability effects (Table 2) indicated that out of five lines, the line MS 104A was good general combiner for grain yield per plant (0.93*) along with five drought tolerance traits *viz*., leaf area ratio at

Table 1 : Analysis of variance for combining ability

Sr. No.	Characters	Females	Males	Female x Males	Error
1.	Leaf area at 75 DAS	15.59	15.92*	15.98**	10.79
2.	Dry matter at harvest	573.39**	595.19**	630.16	42.89
3.	Chlorophyll content at 75 DAS	1.04**	0.70**	0.30**	0.11
4.	Proline content	14.99	37.24*	45.24**	17.36
5.	Chlorophyll stability index	4.02	8.98*	6.99*	4.21
6.	Stomatal index	5.94*	1.42	5.22**	1.66
7.	Specific leaf weight	0.327*	0.226	0.336*	7.081
8.	Harvest index	52.63**	136.64**	40.42**	12.56
9.	Grain yield per plant	35.03**	97.39**	32.57**	11.17

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 2 : Estimation of general combining ability effects of parents

Sr. No.	Parents	Leaf area at 75 DAS	Dry matter at harvest	Chlorophyll content at 75 DAS	Proline content	Chlorophyll stability index	Stomatal index	Specific leaf weight	Harvest index	Grain yield per plant
Lines										
1.	MS 104A	0.57*	2.69**	0.21**	0.50	-0.02	-0.08	0.07**	1.17*	0.93*
2.	AKKMS 69	0.35	0.51	0.15**	-0.04	-0.04	-0.16	0.08**	-0.06	0.75
3.	AKMS 47	0.64**	-2.82**	0.12**	-0.76	-0.03	-0.12	0.04	-0.70	0.39
4.	AKRMS 45	1.06**	-2.64**	0.02	0.39	0.05*	0.47**	0.04	-1.15*	-1.04*
5.	AKRMS 66	-2.02**	-1.30	-0.08	-0.83	0.04	0.65**	-0.13**	-1.49**	-1.13**
	SE	0.25	0.86	0.05	0.55	0.03	0.17	0.03	0.47	0.44
Testers										
1.	CSV 216R	0.82*	2.24	0.17*	0.08	-0.10**	0.06	0.06	3.14**	2.61**
2.	AKR 354	1.34**	3.31*	0.14	-2.56**	-0.05	0.60*	-0.05	1.06	1.39
3.	AKR 365	-1.21**	-3.78**	-0.17*	-0.60	0.02	0.33	-0.12*	-2.18**	-3.13**
4.	AKR 371	1.80**	2.38	-0.19*	-0.99	0.13**	0.56*	0.04	-1.75*	-2.21**
5.	AKR 373	0.61	2.24	-0.20**	-0.02	-0.04	0.07	0.05	-2.85**	-3.87**
6.	Ringni	0.74	3.29*	0.21**	0.33	-0.06	-0.47	0.11*	1.66*	3.39**
7.	SPV 504	1.05*	3.40*	0.17*	1.85*	-0.13**	-0.58*	0.06	1.16	2.07**
8.	AKSV 13R	-0.27	2.57	0.27**	3.29**	-0.06	-0.24	0.02	2.83**	2.22**
9.	M35-1	0.84*	3.62**	0.34**	2.95**	-0.07*	-0.35	0.14*	3.74**	3.61**
10.	P. Moti	0.64	1.98	0.21**	1.31	-0.07*	-0.04	0.11*	2.55**	1.62*
11.	AKR 372	-0.43	2.47	-0.06	0.70	0.01	0.37	0.04	-0.21	0.42
12.	AKR 370	0.87*	4.48**	-0.35**	-1.39	0.04	0.32	0.27**	-2.12**	0.65
	SE	0.42	1.43	0.08	0.91	0.04	0.28	0.06	0.77	0.73

* and ** indicate significance of values at P=0.05 and 0.01, respectively

75 DAS (0.57*), dry matter at harvest (2.69**), chlorophyll content at 75 DAS (0.21**), specific leaf weight (0.07**) and harvest index (1.17*). Similar results were obtained by Khatod *et al.* (2002) who reported that MS 104 A line performed best in yield attributes and also was good combiner. Salunke *et al.* (1996) found MS 104A as a good combiner for yield and also good for physiological components like leaf area index, total dry matter per plant, and harvest index. Among the testers, M 35-1 showed desirable gca for grain yield per plant (3.61**) along with seven physiological parameters associated with drought tolerance *viz*., leaf area ratio at 75 DAS (0.84**), dry matter at harvest (3.62**), chlorophyll content at 75 DAS (0.34**), proline content (2.95**), chlorophyll stability index (-0.07*), specific leaf weight (0.14**) and harvest index (3.74**). Narkhede *et al.* (2004) found that M 35-1 gave better performance for characters such as total dry matter per plant and grain yield per plant under drought stress condition. Another tester SPV 504 had also transmitted desirable genes for grain yield per plant (2.07**) along with six physiological parameters like leaf area ratio at 75 DAS (1.05*), dry matter at harvest (3.40*), chlorophyll content at 75 DAS (0.17**), proline content (1.85*), chlorophyll stability index (-0.13**) and stomatal index (-0.58*). Rao *et al.* (1994) recorded that SPV 504 was good genotype under water stress. Besides these two testers some of the other promising testers with significant gca effects for grain yield per plant along with some of the physiological traits associated with drought tolerance were CSV-216 R, Ringni, Parbhani Moti and AKSV-13 R. All these six testers and one line *i.e.* MS-104 A need to be exploited for future breeding programme to develop high yielding drought tolerant hybrids in *Rabi* sorghum. But consideration of *per se* performance in combination with combining ability estimates was reported to provide a better criteria for the choice of superior parents in hybridization programme (Rao,1972). Results of the present study also revealed the close relationship between *per se* performance and GCA effects for grain yield per plant.

It is apparent that none of the cross combinations was found to have consistently significant sca effects in desired direction for all the characters. Among the sixty cross combinations total 23 hybrids exhibited positive and significant sca effect for grain yield per plant. The best cross combination was observed to be MS 104 A x M35-1 with highest sca along with highest mean performance of grain yield per plant (Table 3). This cross also recorded desirable and significant sca effects of six traits associated with drought tolerance traits *viz.*, dry matter at harvest, chlorophyll content at 75 DAS, proline content, chlorophyll stability index, specific leaf weight and harvest index. Other promising cross combinations showing high mean performance for grain yield per plant and significant sca effects grain yield per plant along with some of the traits associated with drought tolerance in *Rabi* sorghum were MS 104 A x SPV 504, MS 104 A x Parbhani Moti, AKMS 47 A x M 35-1, AKMS 69 A x Ringni, MS 104A x Ringni, AKMS 47 A x SPV 504, AKMS 45 A x CSV 216 R, AKMS 69 A x AKSV 13 R, AKMS 47 A x CSV 216 R (Table 3). All these ten promising cross combinations need to be tested on large scale in multilocation trials for their evaluation. Rafiq *et al.* (2002), Badhe and Patil (1997) observed that hybrids exhibiting desirable sca effects for important traits related to drought tolerance are of great importance in selecting drought tolerant genotypes. Reddy *et al.* (2012) reported that chlorophyll stability index is associated with desiccation tolerance under terminal water deficit condition and can be used as one of the reliable selection criteria in rapid screening for post rainy adapted genotypes for drought tolerance.

Some of the hybrids with significant and desirable sca effects for grain yield recorded high x high gca combination

Table 3: SCA effects of promising hybrids for grain yield per plant and drought tolerance traits

Sr. No.	Hybrid	Grain yield/ plant(g)	SCA effects for grain yield/ plant	GCA status of parents involved	Desirable SCA effects for drought tolerance traits
1.	MS 104 A x M 35-1	24.91	5.34**	H x H	DM,CC,PC,CSI,SLW,HI
2.	MS 104 A x SPV 504	22.98	4.36**	H x H	LA,CC,PC,CSI,SI SLW,HI
3.	MS 104 A x Parbhani Moti	22.70	2.23**	H x H	DM,CC,PC,CSI,HI
4.	AKMS 47 A x M 35-1	22.54	3.09**	L x H	CC,PC,HI
5.	AKMS 69 A x Ringni	22.28	3.22**	L x H	CC,CSI,SLW,HI
6.	AKMS 104 A x Ringni	22.04	2.10**	H x H	DM,CC,CSI
7.	AKMS 47 A x SPV 504	21.33	2.83**	L x H	SI,HI
8.	AKMS 45 A x CSV 216 R	21.29	3.81**	L x H	DM
9.	AKMS 69 A x AKSV 13 R	21.23	2.33**	L x H	LA,CC,CSI,PC,HI
10.	AKMS 47 A x CSV 216 R	20.60	1.55**	L x H	DM,SI,SLW

* and ** indicate significance of values at P=0.05 and 0.01, respectively
LA-Leaf area at 75 DAS, DM-Dry matter at harvest, CC-Chlorophyll content at 75 DAS, PC-Proline content, CSI-Chlorophyll stability index, SI-Stomatal index, SLW-Specific leaf weight and HI- Harvest index

while some recorded high x low gca parental lines. Thus in the development of high yielding and drought tolerant hybrids, at least one parent should be having high gca effects for grain yield. Similar suggestion was also given by Ravindrababu et.al. (2001). However, Hariprasanna *et al.* (2012) reported that some of the crosses with positive significant SCA for grain yield involved even low x low combinations of parents.

Thus it is concluded from the present study that the line MS 104 A and the testers M 35-1, SPV 504, CSV 216 R, Ringni, Parbhani Moti and AKSV 13 R showed significant and desirable sca effects for grain yield and some of the drought tolerance parameters. In view of their high gca effects and better *per se* performance for the drought tolerance, their further utilization in the hybridization programme may result in getting superior segregants with better drought tolerance. Further the cross combinations showing high mean performance for grain yield per plant and significant sca effects for grain yield per plant along with some of the drought tolerance were MS 104 A x M35-1,MS 104 A x SPV 504, MS 104 A x Parbhani Moti, AKMS 47 A x M 35-1, AKMS 69 A x Ringni, MS 104A x Ringni, AKMS 47 A x SPV 504, AKMS 45 A x CSV 216 R, AKMS 69 A x AKSV 13 R, AKMS 47 A x CSV 216 R and these need to be exploited further. The seed production and the testing of these crosses on large scale in field trials for possibility of their exploitation in drought tolerance is essential.

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