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ISSN: 0974-4908
Res. Environ. Life Sci.
9(4) 515-517 (2016)

Studies on heterosis for grain yield and grain mold parameters in *kharif* sorghum (*Sorghum Bicolor* (L.) Moench)

D. R. Patil[1], S. P. Mehtre[1], R. R. Dhutmal*[2] and D. H. Sarang[1]
[1]Dept of Agril. Botany, [2]Sorghum Research Station, VNMKV, Parbhani- 431 401, India
***e-mail:** rr_dhutmal@rediffmail.com

(Received: August 26, 2015; Revised received: February 17, 2016; Accepted: February 19, 2016)

Abstract: The present investigation was undertaken in Sorghum (*Sorghum bicolor* (L.) Moench) at Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra) during *kharif* 2008-09. Eight hybrids along with six parents and four checks (PVK 400, PVK 801, GMRP 9, and CSH 16) were evaluated in randomized block design with three replications. In general, higher heterotic effects were observed in the crosses involving PMS 28A and 6938B as the female parent and KR 192 and C 43 as the male parents. A total of 7, 8, 3, 8 and 7 hybrids exhibited positive and significant heterosis for grain yield over better parent and standard check *viz*., PVK 400, PVK 801, GMRP 9 and CSH 16, respectively. High and significant heterosis was observed in the crosses 6938A x C 43, MS 28A x C43 and PMS 28A x KR 192 for grain yield as well as earhead length, earhead girth, earhead weight, test weight, grain hardness and germination percentage. The crosses PMS 28A x C 43 and PMS 28A x KR 192 showed significantly desirable heterosis for all the four grain mold attributes *viz*., field grade score, grain hardness and germination percentage

Key Words: Sorghum, Heterosis, Grain yield, Grain mold

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is a major cereal crop in the semi-arid regions of the world as it is an important food and feed crop. It can also be used as raw material for industry and can be processed into malted foods, beverages and beer (Uptmoor *et al*., 2006; Palmer, 1992). In recent years, several national research programs in the semi-arid regions have shown an increased interest in hybrids (Axtell *et al.,* 1999). It is a C4 plant with higher photosynthetic efficiency and higher abiotic stress tolerance (Nagy *et al*., 1995; Reddy *et al*., 2009). In India, sorghum is mainly grown in the states of Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu Madhya Pradesh, Gujrat and Rajasthan. Maharashtra is one of the major sorghumgrowing state in the country. Grain mold is complex disease causing enormous loss in rainy season sorghum in the years of prolonged rainfall at the time of crop maturity. This results in loss in quality of grain leading to poor market value. This is one of the major reason for the replacement of *kharif* sorghum with other crops. Information on genetics of grain mold resistance and mechanism is required to facilitate breeding of resistance cultivars. Heterosis in the sorghum has been reported by several workers including Sankarpandian *et al.* (1994), Prakash *et al*. (2010) and Mahdy *et al*. (2011). The hybrids CSH 19 and CSH 16 can withstand grain deterioration to certain extent, while tolerant variety PVK 801 (Parbhani Shweta) have been developed recently. Therefore, it is necessary to identify new high yielding hybrids, which combines grain and fodder yield potential with better grain quality and ease in seed production. Therefore the present investigation was planned with an objective to study the heterosis for grain yield and grain mold resistance.

Materials and Methods

The present investigation was undertaken in Sorghum (*Sorghum bicolor* (L.) Moench) at Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra) during *kharif* 2008-09. Two male sterile lines and four male parents were crossed in line x tester mating design. Eight hybrids along with six parents and four checks (PVK 400, PVK 801, GMRP 9, and CSH 16) were planted in randomized block design with three replications. Total thirteen observations were recorded for days to 50% flowering, days to maturity, plant height, panicle length, panicle girth, panicle weight, grain yield per plant, test weight, field grade score, grain hardness, seed density and germination percentage. The heterosis was calculated as per procedure suggested by Fonesca and Patterson (1968).

Results and Discussion

In the estimation of heterosis, Sharma (1994) opined that heterosis over the best check or the local variety could be considered as the better criteria for evaluation of hybrids. The present study revealed the distribution of heterosis in both positive and negative directions for all the traits. The potentiality of hybrid might be judged by comparing the *per se* performance and heterotic vigor . Close association between *per se* Performance of hybrids and heterosis was observed for all the traits, suggesting that selection of the crosses based on per *se* performance would be more realistic in sorghum (Kenga *et al*., 2005; Mahdy *et al*., 2005). Heterosis is calculated as percentage increase or decrease exhibited by hybrids over better parents or check. In the present study, heterosis over better parent (heterobeltiosis) and standard checks (PVK 400, PVK 801, GMRP 9 and CSH 16) was estimated. In general, higher heterotic effects were observed in the crosses involving PMS 28A and 6938B as the female parent and KR 192 and C 43 as the male parents. A total of 7, 8, 3, 8 and 7 hybrids exhibited positive and significant heterosis for grain yield over better parent and standard check *viz*., PVK 400, PVK 801, GMRP 9 and CSH 16, respectively. These results are in agreement with Thawari (2000) Khapre *et al.* (2000), Nimbalkar (2001), Prabhakar (2001) and Madhusudana (2002).

High and significant heterosis was observed in the crosses 6938A x C 43, MS 28A x C43 and PMS 28A x KR 192 for grain yield as well as earhead length, earhead girth, earhead weight, test weight, grain hardness and germination percentage. Hariprasanna *et al*. (2012) also observed similar results for most of the characters under study, Sankarapandian *et al*. (1994) for test weight Prakash *et al*. (2010) and Mahdy *et al*. (2011) for grain yield. The crosses PMS 28A x C 43 and PMS 28A x KR 192 showed significantly desirable heterosis for all the four grain mold attributes *viz*., field grade score, grain hardness and germination. Significant heterosis for grain yield and its components was associated with high mean in most of the crosses. Cultivar selection with grain mold resistance and high grain yield is an important component of disease management for increased production. In the present study best heterotic crosses for different attributes involved parental contribution of high x high and high x low yielders. The present study further suggests that heterosis for grain yield should be through component trait heterosis. In general, the heterosis for grain yield was reflected through heterosis in yield components specially earhead length, earhead girth and earhead weight. These results are in confirmation with Hariprasanna *et al*. (2012) Veerabadhiran *et al*. (1994). The present study revealed that hybrids that exhibited heterosis for grain yield were not heterotic for all the traits. Among the lines, PMS 28A performed well for most of the characters studied. The performance of testers *viz*., C 43 and KR 192 with the above lines was considerably good and exhibited significant levels of heterosis for most of the characters that contributes to yield. The results indicated that exploitation of the heterosis or hybrid vigor might be one of the promising methods to effect crop improvement in sorghum for grain purpose. The result also indicated that the heterosis for grain yield can be exploited commercially.

The cross combinations like PMS 28A x C 43, PMS 28A x KR 192 and 6938 Ax C43 having high heterosis for grain yield and related yield components and to some extent for grain mold attributes should be evaluated in multilocation testing and identification of new hybrid combination for commercial exploitation on cultivators field. The hybrids identified in this study with higher grain yield and superior grain mold resistance fit well for rainy season adaptation.

Table-1: Details of breeding material

Parental lines	Pedigree	Specific characters
Lines (females)		
PMS 28A	Tall selection from 296A	Agronomically elite *kharif* base parent, good combiner for grain yield
6938A	Sel. From (ICSVGMRLP 88014)	Agronomically elite *kharif* based newly developed seed parent, good combining ability for grain yield
Testers (Males)		
KR 191	Selection from (ICSV 91006)	Medium seed size, more number of seeds per panicle, mold tolerant
KR 192	Selection from (CSV 13 x SPV 462)	Multiple resistance, suitable for *kharif* , *Rabi* and summer. Good combiner for grain yield and grain mold resistance
C 43	Selection from (CS 3541 x IS 23549)	Bold seed, good combiner for grain yield and grain mold resistance.
TC 43	Tall selection from (CS 3541 x IS 23549)	Tall, agronomic base, good combiner for grain yield and grain mold resistance

Table-2: Estimation of heterosis over better parent (BP) and standard checks (PVK 401, PVK 801, GMRP 9 and CSH 16)

Genotypes	Days to 5% flowering					Days to maturity					Plant height (cm)				
and Crosses	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMRP 9	CSH 16
PMS 28A x KR 192	6.74**	4.10**	1.13	10.14**	8.57**	3.10	-.92	0.85	4.42**	2.43	-17.17	-29.61**	-7.48	3.91	-2.58
PMS 28A x TC 43	-2.73	-2.73	-5.52**	2.89**	1.42	-0.67	-0.159	0.17	3.71**	1.73	-10.06	-17.87	7.93	12.09	13.65
PMS 28A x KR 191	-2.66**	0.00	-2.86	5.79**	4.28**	0.08	1.04	2.86**	6.5**	4.47**	-3.21	-0.00	5.13	9.19	10.70
PMS 28A x C 43	-0.35	-3.97	-6.71**	1.56	0.14	1.76	3.44**	-1.70	1.76	-0.17	8.68	-28.00**	-5.36	-1.72	-0.36
6938A x KR 191	5.86**	1.36	-1.53	7.24**	5.71**	-0.85	-1.76	0.00	3.53**	1.56	0.60	-16.85	9.28	13.49	15.06
6938A x KR 192	3.00	-1.36	-4.19**	4.34**	2.85	-0.39	-4.28**	-2.56	0.88	-1.4	-12.88	-25.96	-2.68	1.06	2.46
6938A x TC 43	-2.00	-6.16**	-8.94**	-0.72	-2.14	-0.16	-2.47	2.72	2.78**	0.82	18.96	8.63	42.77**	48.27**	50.33
6938A x C 43	0.14	-4.10**	-6.85**	1.44	0.00	-0.57	-5.66**	-3.97**	-0.57	-2.47**	7.88	22.65	1.65	5.57	7.03
SE +	1.41					1.4					16.20				

Genotypes	Panicle length					Panicle girth					Panicle weight (cm)				
and Crosses	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMRP 9	CSH 16
PMS 28A x KR 192	-8.78	53.40**	28.32**	48.35**	16.37**	0.53	50.00**	23.52**	35.97**	17.02**	-4.43**	26.52**	2.82	12.35**	1.57
PMS 28A x TC 43	-5.13	59.45**	33.46**	54.28**	21.03**	-11.43**	32.14**	8.82	19.78**	6.38	-9.19**	20.21**	-2.29	6.75**	-3.49**
PMS 28A x KR 191	-14.32**	44.09**	20.53**	39.34**	9.31	-15.15**	26.58**	4.23	14.74**	-1.23	-14.12**	13.69**	-7.59**	0.96	-8.72**
PMS 28A x C 43	-2.70	63.63**	36.88**	58.24**	24.13**	2.12	52.38**	25.49**	38.12**	18.88**	0.49	33.04**	8.12**	18.14**	6.80**
6938A x KR 191	3.30	49.09**	24.71**	49.09**	13.10**	-9.30	19.84**	1.30	8.63	-6.50	-3.57**	17.39**	-4.59**	4.24**	-5.75**
6938A x KR 192	4.25	5.45**	25.85**	45.49**	14.13**	3.89	37.69**	13.39**	24.82**	7.43	-2.40	23.47**	0.35	9.65**	0.87
6938A x TC 43	-4.25	38.18**	15.85**	33.62**	4.82	-3.90	26.98**	4.7	15.10**	-0.92	-11.96**	7.17**	-12.89**	-4.82**	-13.96**
6938A x C 43	26.36**	82.36**	52.54**	76.35**	38.34**	10.51**	46.3**	20.26**	32.37**	13.93**	17.50**	32.90**	16.25**	27.02**	14.83**
SE +	1.20					0.81					1.28				

Genotypes and Crosses	Field grade scores					Threshed grade scores					Grain hardness (kg/cm^2)				
	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMRP 9	CSH 16
PMS 28A x KR 192	12.50	-10.00	-18.18**	-10.00	-35.71**	-11.11	-11.11	-33.33**	-11.11	-33.33**	32.00**	13.79**	31.25**	6.45	17.85**
PMS 28A x TC 43	0.0	20.00**	9.09	20.00**	-14.28	-8.33	22.22**	-8.33	22.22**	-8.33	-30.30**	-20.68**	-28.12**	-25.80**	-17.85**
PMS 28A x KR 191	-9.09	0.00	-9.09	0.00	-28.57**	12.50	0.00	25.00**	0.00	-25.00**	-6.25	3.44	-6.25	12.48	7.14
PMS 28A x C 43	0.00	18.00**	0.00	-18.00**	-21.42**	0.0	11.11	-16.66**	21.11**	-16.66**	0.00	-17.24**	25.00**	-22.58**	-14.28**
6938A x KR 191	27.27**	40.00**	27.27**	40.00**	0.00	50.00	33.33**	0.00	33.33**	0.00	-21.87**	-13.79**	-21.87**	-19.35	-10.71
6938A x KR 192	25.00	0.00	-9.09	0.00	-28.57**	44.44**	44.44**	8.33	44.44**	8.33	0.00	-3.44	-12.50	-9.67	0.00
6938A x x TC 43	16.66**	40.00**	27.27**	40.00**	0.00	22.22**	22.22**	-8.33	22.22**	-8.33	-3.03	10.34	0.00	3.22	2.04
6938A x C 43	9.09	20.00**	9.9	20.00**	-14.28**	55.55**	55.55**	16.66	55.55**	16.66**	3.57	0.00	19.37**	16.45**	3.57
SE +	0.29					0.21									

Genotypes and Crosses	Grain yield/ plant					Test weight				
	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMR 9	CSH 16
PMS 28A x KR 192	19.51**	47.86**	8.31**	54.45**	31.68**	13.59**	21.27**	3.74	17.30**	2.86
PMS 28A x TC 43	14.48**	41.63**	3.75	47.95**	26.13**	-7.14**	3.37	-11.56**	0.00	-17.19**
PMS 28A x KR 191	11.37**	37.79**	0.93	43.93**	22.72**	-5.22**	8.15**	-7.48	4.61	-13.37**
PMS 28A x C 43	25.65**	55.46**	13.87**	62.38**	38.44**	-4.82	17.69**	0.68	13.84**	-5.73
6938A x KR 191	11.77**	27.98**	-6.25	33.68**	13.98**	-16.72**	-4.97	-18.7**	-8.07**	-23.88**
6938A x KR 192	19.40**	37.11**	0.43	43.22**	22.11**	6.14**	13.32**	-3.06	9.61**	-9.23
6938A x TC 43	2.75	17.66**	-13.81**	22.90**	4.78	-18.75**	-9.54**	-22.61**	-12.50**	-27.54**
6938A x C 43	38.30**	58.36**	16.00**	65.41**	41.03**	-12.86**	7.75**	-7.82**	4.23	-13.69**
SE +	1.01					0.90				

Genotypes and Crosses	Seed density					Germination percentage				
	BP	PVK 401	PVK 801	GMR 9	CSH 16	BP	PVK 401	PVK 801	GMR 9	CSH 16
PMS 28A x KR 192	-3.47	-1.76	-4.31	-3.47	-2.63	33.69**	23.75**	28.23**	25.60**	-27.38**
PMS 28A x TC 43	9.56**	11.50**	8.62**	9.56**	10.52**	-3.48	3.75	-2.35	1.21	-1.19
PMS 28A x KR 191	0.90	-0.88	-3.44	-2.60	-1.75	12.67**	0.00	-5.88	-2.43	-4.76
PMS 28A x C 43	-0.86	0.88	-1.72	0.86	0.00	14.60**	5.00	10.58**	7.31**	-9.52**
6938A x KR 191	1.80	0.00	2.58	-1.73	-0.87	21.42**	6.25**	0.00	13.65	1.19
6938A x KR 192	0.00	1.76	-0.86	0.00	0.87	-8.69	5.00	-1.17	2.43	0.00
6938A x TC 43	14.41**	12.38**	9.48**	10.43**	11.40**	0.00	7.50**	1.17	4.87	14.41**
6938A x C 43	0.00	0.88	-1.72	-0.86	0.00	16.85**	7.50**	12.94**	9.75**	0.00
SE +	0.068					1.24				

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