Indian J. Genet., **66**(2): 123-126 (2006)

Heterosis and combining ability for grain yield and its components in sorghum [*Sorghum bicolor* (L.) Moench]

N. Premalatha, N. Kumaravadivel and P. Veerabadhiran

Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore 641 003

(Received: May 2005; Revised: May 2006; Accepted: May 2006)

Abstract

A study was conducted to estimate heterosis in F_1 hybrids of sorghum [*Sorghum bicolor* (L.) Moench] with respect to grain yield and its components using thirty-six hybrids. The hybrids and their parents were evaluated to assess the combining ability and gene action governing the quantitative traits. Among the hybrids, CSV 15 × SPV 1521 recorded maximum grain yield with 90, 86.89 and 33.45 per cent heterosis over the mid parent, better parent and standard check respectively. This cross found to be superior in terms of days to 50 percent flowering, plant height, number of grains per panicle and grain yield per plant. It was followed by CSV 15 × SPV 1531, CO 26 × SPV 1531 and CO(S) 28 × SPV 1531. The estimates of general combining ability and specific combining ability revealed the presence of non-additive gene action for all the traits under study.

Key words: Sorghum, heterobeltiosis, relative heterosis, combining ability, gene action, line × tester analysis

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] plays a very important role in providing nutrition to human race along with wheat, rice and maize. The traits like yield and its components are governed by polygenes with complex gene action and hence understanding the nature and magnitude of gene action help the breeder in selection of an appropriate breeding method. 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 F_1 hybrids with respect to yield, the combining ability and gene action governing the quantitative traits in sorghum, using line × tester mating designs.

Materials and methods

Thirteen genotypes of sorghum were studied in this experiment. Thirteen genotypes consisted of four lines namely, APK 1, CO 26, CSV 15 and CO(S) 28 and nine testers namely, SPV 1481, SPV 1531, SPV 1532, SPV 1536, SPV 1472, SPV 1333, SPV 1521, TNS 356 and TNS 357. These parents were crossed in a line × tester mating design and resultant thirty-six hybrids along with their parents were raised in RBD with two replication during *kharif* 2002. Heterosis was assesed over the better parent (Heterobeltiosis), mid parental value (relative heterosis) and standard variety (standard heterosis). Estimations of these three types of heterosis were done for following characters *viz.*, days to 50 per cent flowering, plant height, number of leaves per plant, leaf area index, brix, panicle length, number of grains per panicle, 100 grain weight and grain yield per plant. Thirty-six hybrids and thirteen parents were also evaluated to study the combining ability and gene action for nine quantitative characters. The combining ability analysis was carried out as per the method suggested by Kempthorne [1].

Results and discussion

The analysis of variance for all the yield and yield component traits studied are presented in Table 1. Variance due to parents was highly significant for all the traits studied, indicating good amount of genetic differences among the parents. Variance due to hybrids was also highly significant for all the nine traits studied. Variance due to lines was highly significant for days to 50 per cent flowering, plant height, panicle length, leaf area index, number of grains per panicle and grain yield per plant, but non-significant for number of leaves per plant, brix and 100 grain weight. Variance due to testers were highly significant for all the traits studied, days to 50 per cent flowering, plant height, number of leaves per plant, leaf area index, brix, panicle length, number of grains per panicle, 100 grain weight and grain yield per plant. The variance due to lines × testers recorded very high levels of significance for all the traits (Table 2). The relative estimation of variance due to general combining ability indicated that the specific combining ability variances were predominant for all

Table 1. Analysis of variance for parents and hybrids for yield and yield component traits in sorghum

Source	df	Mean squares								
		Days to 50 per cent flowering	Plant height (cm)	Number of leaves per plant	Leaf area index	Brix (%)	Panicle length (cm)	Number of grains per panicle	100 grain weight (g)	Grain yield per plant (g)
Parents	12	30.79**	645.90**	1.20*	2.95**	7.90**	8.02**	541026.23**	0.53**	196.57**
Lines	3	12.66**	372.99**	1.33	1.71**	4.50	5.19**	0.45**	11337.50	192.81**
Testers	8	30.97**	812.55**	1.30*	3.65**	9.51**	6.48**	0.57**	803629.30**	220.44**
L *vs* T	1	83.76**	131.35**	0.02	1.05**	5.23**	28.75**	0.42**	29267.90	16.95
Crosses	35	170.35**	1001.37**	4.10**	3.08**	14.82**	6.80**	1187723.30**	0.33**	1073.11**
Parents *vs* crosses	1	27.79**	18928.95**	0.19	3.45	22.68**	27.43**	23372.86**	0.61	0.34
Error	48	0.72	12.27	0.60	0.07	1.91	0.485	9310.10	0.02	4.71

**,*Significant at 1 and 5% level respectively

Table 2. Analysis of variance for combining ability for yield and yield component traits in sorghum

Source	df	Mean squares								
		Days to 50 per cent flowering	Plant height (cm)	Number of leaves per plant	Leaf area index	Brix (%)	Panicle length (cm)	Number of grains per panicle	100 grain weight (g)	Grain yield per plant (g)
Lines	3	172.86*	2287.98*	4.83	2.53	66.55**	6.10	0.21	876198.01	1152.38
Testers	8	540.38**	1643.89*	9.07**	4.61	11.21	9.52	0.29	3290973.30**	2957.06**
L × T	24	46.69**	626.39**	2.35**	2.63**	9.56**	5.99**	0.36**	525580.63**	435.21**
Error	35	0.85	11.23	0.65	0.07	1.97	0.39	0.02	9339.66	3.61
gca		3.33	10.11	0.04	0.01	0.14	0.02	-	17854.38	17.20
sca		22.92	307.58	0.84	1.28	3.79	2.79	0.16	258120.48	215.80
gca/sca		0.14	0.03	0.04	0.007	0.03	0.007	-	0.06	0.07

Negative valves of *gca* variances are not indicated in Table, **,*Significant at 1 and 5% level respectively.

the traits studied. The ratio of variances due to general and specific combining ability ranged from 0.007 for leaf area index to 0.14 for days to 50 per cent flowering (Table 2). Various workers have reported predominance of non-additive gene action for days to 50 per cent flowering and 100 grain weight [2] and [3] for plant height [3], for leaf area index [4], for brix [1], for panicle length [5], for number of leaves per plant and number of grains per panicle [6] and for grain yield per plant [7].

Harer and Bapat [8] 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, CO(S) 28 recorded low mean values and negative *gca* effects for days to 50 per cent flowering, which might be useful in breeding programme for earliness. Among the testers, TNS 356 had low mean values and negative *gca* effects for days to 50 per cent flowering. Among the testers, SPV 1531, SPV 1333, SPV 1536 and SPV 1472 were found to be good general combiners with good *per se* performance for most of the yield traits. However, CO(S) 28 and TNS 356 for days to 50 per cent flowering, CSV 15 and SPV1536 for plant height, APK 1 and SPV 1532 for number of leaves per plant, APK 1 and SPV 1472 for leaf area index, CO 26 for brix, CSV 15 and SPV 1333 for panicle length, CSV 15 and SPV 1536 for 100 grain weight, CSV 15 and SPV 1531 for number of grains per panicle and CO 26 and SPV 1531 for grain yield per plant might be utilized as potential parents since they possessed high *per se* performance with significant *gca* effects for the respective traits.

The hybrids CSV 15 × SPV 1521 recorded the maximum *sca* effects for two of the traits out of nine traits studied namely, number of grains per panicle and grain yield per plant. The hybrids, APK 1 × SPV 1481 recorded significant *sca* effects for number of leaves per plant. This hybrid was one of the top five ranking hybrids. It was a derivative of high × 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. These hybrids appeared in the top ranking hybrids with high *sca* effects. The hybrids, CO 26 × SPV 1536 for leaf area index, APK 1 × SPV 1521 for brix, APK 1 × TNS 357 for 100-grain weight were derived from low x low parental combinations and might be suitable for selection in later generations.

The hybrids, APK 1 × SPV 1472 for days to 50 per cent flowering, CO(S) 28 × SPV 1521 for plant height, APK 1 × SPV 1531 for number of leaves per plant, CSV 15 × SPV 1521 for grain yield per plant were the derivatives of low × high or high × low parental combinations in terms of *gca* and these hybrids also recorded high *sca* effects.

In the estimation of heterosis, Sharma [9] 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 vigour. Close association between *per se* performance of hybrids and heterosis was observed for all the traits except for number of leaves per plant, suggesting that selection of the crosses based on *per se* performance would be more realistic in sorghum.

The hybrid CSV 15 × SPV 1521 recorded superior heterotic expression for either of the three or all the heterosis, namely relative heterosis, heterobeltiosis and standard heterosis for number of grains per panicle and grain yield per plant. It also showed high *per se* performance for number of grains per panicle and grain yield per plant. The hybrids *viz.*, CSV 15 × SPV 1472, CO(S) 28 × SPV 1531 and APK 1 × TNS 357 recorded significant standard heterosis for days to 50 per cent flowering, combined with significant *sca* and *per se* performance. The hybrid CO(S) 28 × SPV 1521 recorded significant standard heterosis for plant height. Hence, this hybrid could be utilized to develop the hybrids with good plant height.

For number of leaves per plant, hybrids namely, APK 1 × SPV 1481 and APK 1 × SPV 1531 recorded significant standard heterosis combined with good *sca* and mean performance. Shinde and Borikar [10] obtained similar results. For leaf area index, the hybrids CO(S) 28 × SPV 1481 and CO 26 × SPV 1532 recorded significant maximum standard heterosis combined with *sca* effects and good *per se* performance. For brix, the hybrids, CSV 15 × SPV 1532 and CSV 15 × TNS 356 recorded significant heterosis coupled with good mean performance and high *sca* effects.

For panicle length, the hybrids namely, CO(S) 28 × TNS 356, APK 1 × SPV 1536 and CO 26 × TNS 357 recorded significant *sca* effects coupled with good *per se* performance but failed to express heterosis. However, significant heterosis for panicle length was reported by Salunke and Deore [11]. For number of grains per panicle, the hybrids CSV 15 × SPV 1521 and CO(S) 28 × SPV 1333 recorded significant heterosis coupled with good mean performance and also high *sca* effects. Hence, these hybrids might be useful for further breeding programme. For 100 grain weight, CO 26 × SPV 1536 recorded significant heterosis over check coupled with good *per se* performance and high *sca* effects.

The hybrids, *viz.*, CSV 15 × SPV 1531 and CSV 15 × SPV 1521 recorded significant heterosis for grain yield per plant coupled with good mean performance and high *sca* effects. The hybrid, CSV 15 × SPV 1521 recorded 90 per cent, 86.89 per cent and 33.45 per cent heterosis for this trait over mid parent, better parent and standard check respectively. Significant heterosis for this trait was reported by [12, 13 and 14].

The present study revealed that hybrids that exhibited heterosis for grain yield were not heterotic for all the traits. Among the lines, CSV 15 performed well for most of the characters studied. The performance of testers SPV 1521 and SPV 1531 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 vigour might be one of the promising method to effect crop improvement in sorghum for grain purpose. The result also indicated that the heterosis for grain yield can be exploited commercially.

For grain yield per plant and number of grains per panicle, some of the hybrids were found to involve high × low and low × high combinations in terms of *gca* indicating the role of the dominance gene action. Thus, it can be concluded that both inter and intra allelic interactions were involved in the expression of these traits.

References

1. **Kempthorne O.** 1957. An Introduction to Genetic Statistics. John Wiley and Sons. Inc., New York.
2. **Badhe P. L. and Patil H. S.** 1997. Line × testers analysis in sorghum. Ann. Agric. Res., **18**: 281-284.
3. **Ramakrishnan.** 2000. Development of heterotic hybrids in sorghum resistance to downy mildew. M.Sc. Thesis, Tamil Nadu Agricultural University, Coimbatore 3, India.
4. **Sanghi A. K. and Monpara B. A.** 1981. Diallel analysis of forage yield and its components in sorghum. Madras Agric. J., **68**: 296-300.
5. **Pillai M. A., Rangaswamy P., Nadarajan N., Vanniarajan C. and Ramalingam J.** 1995. Combining ability analysis for panicle characters in sorghum. Indian J. Agric. Res., **29**: 98-102.
6. **Manickam S. and Das L. D. V.** 1995a. Combining ability analysis for forage characters in sorghum [*Sorghum bicolor* (L.) Moench]. Ann Agric. Res., **16**: 49-52.

7. **Subbarao G. and Aruna C.** 1997. Line (mutants) × Tester studies in sorghum [*Sorghum bicolor* (L.) Moench]. J. Res. ANGRAU, **25**: 15-18.

8. **Harer P. N. and Bapat D. R.** 1982. Line × tester analysis of combining ability in grain sorghum. J. Maharashtra Agric. Univ., **7**: 230-232.

9. **Sharma S. M.** 1994. Present status of hybrid sesame with special reference to its commercial utilization. Hybrid sesame Proc. of group discussion, 14 June 1994. DOR, Hyderabad, pp. 8-15.

10. **Shinde S. S. and Borikar S. T.** 1991. Heterosis studies involving maldandi cytoplasm in sorghum. J. Maharashtra Agri. Univ., **16**: 121-122.

11. **Salunke C. B. and Deore G. N.** 1998. Heterosis and Heterobeltiosis studies for grain yield and its components in *rabi* sorghum. Ann. Plant Physiol., **12**: 6-10.

12. **Manickam S. and Das L. D. V.** 1995b. Heterosis for forage yield quality in sorghum [*Sorghum bicolor* (L.) Moench]. Ann. Agric. Res., **16**: 111-113.

13. **Senthil N., Ramasamy P. and Khan A. K. F.** 1998. Fertility restoration and heterosis involving different cytoplasms in sorghum [*Sorghum bicolor* (L.) Moench] hybrids. J. Gen. Breed., **5**: 339-342.

14. **Hovny M. R. A., El-Nagouly O. O. and Hassaballa E. A.** 2000. Combining ability and heterosis in grain sorghum. Aust. J. Agric. Sci., **31**: 1-16.