

Combining Ability Analysis in Sorghum*

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ABSTRACT

Thirty-six hybrids of sorghum (*Sorghum bicolor* (L.) Moench) were grown alongwith 3 female parents (fertile counterparts of male steriles), 12 male parents and GJ 108 and CSH 5 as checks. Additive genetic variance predominantly governed the expression of yield and components in present set of material.

Line 2077 A was a superior female for number of grains and grain yield, whereas SPV 228 and SPV 230 were good combiners for these characters. Specific combination 2219A x SPV 226 appeared most desirable for grain yield.

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INTRODUCTION

The object of hybridization is to combine in a single genotype desirable genes contained in two or more genotypes. However, the choice of the parents and the choice of cross are the two basic things about which the breeder must have some information. Among several experimental designs, line X tester design enables the geneticist to evaluate large number of genotypes for their suitability as parents for hybridization. Present study reports on this aspect of sorghum.

MATERIALS AND METHODS

The experimental material comprised of 36 F₁ hybrids, derived by crossing 12 diverse varieties to 3 diverse male sterile lines alongwith 15 parents (12 males and 3 fertile counterparts of male sterile lines). The fifty-three genotypes were grown in 1979 *kharif* season at N. M. College of Agriculture, Navsari in a

randomized block design with three replications. GJ 108, an improved local variety and CSH 5 a released hybrid were used as check. Plot size comprised of 3 rows 3m long spaced 45 cm apart.

Observations were recorded on 5 competitive plants in each replication on days to 50% bloom, plant height (cm), length of the panicle (cm), panicle circumference (cm), panicle weight (g), number of whorls/panicle, number of primaries/panicle, length of primary branch, number of primaries/whorl, number of secondary branches/primary branch, number of grains/primary branch, number of grains/panicle, 1000-grain weight (g) and grain yield/plant (g). Data were analysed following Kempthorne (1957) and Rao *et al.* (1968).

RESULTS AND DISCUSSION

Analysis of the data revealed that there were significant differences among the genotypes for all the attributes in-

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TABLE 1

Analysis of variance for combining ability for various characters studied in line x tester crosses in sorghum.

Source of variation	df	Mean sum of square						
		Days to 50% bloom- ing	Plant height	Panicle length	Panicle circum- ference	Panicle weight	No. of whorls per panicle	Number of primaries per panicle
Replications	2	2.69*	35.03	35.22**	2.52	420.08	11.16**	65.11
Hybrids	35	49.76**	2179.42**	56.81**	12.64**	1404.76**	1.78**	270.52**
Males	11	27.98**	5358.97**	22.00	12.17**	1506.62**	1.74*	407.45**
Females	2	696.33**	4686.03**	798.67**	106.32**	13102.96**	13.51**	1690.42**
M x F	22	1.87**	361.77**	6.77**	4.35**	299.45**	0.74	91.15*
Error	70	0.73	93.92	3.83	1.72	174.05	0.89	24.21
$\hat{\sigma}^2$ gca:		16.01	207.14	17.94	2.44	311.35	0.31	42.57
$\hat{\sigma}^2$ sca:		0.38	89.29	0.96	0.87	41.79	-0.05	22.31
$\hat{\sigma}^2$ gca/ $\hat{\sigma}^2$ sca:		42.14:1	2.32:1	18.68:1	2.80:1	7.45:1	6.38:1	1.19:1

TABLE 1 (Contd.)

Source of variation	df	Mean sum of squares							
		Number of primaries/ whorl	Length of primary branch	Number of second arises/ primary	Number of grains per primary	Number of grains/ panicle	1000-grain weight	Grain yield/ panicle	
	1	2	3	4	5	6	7	8	
Replications	2	0.64*	0.01	6.83**	47.34	261634.77	0.20	232.42	
Hybrids	35	1.25**	5.21	0.79**	120.14**	695483.01**	52.88**	718.45**	
Males	11	2.57**	0.57	0.75	261.93**	1228991.19**	32.63**	801.25**	
Females	2	2.25**	78.72**	3.08**	297.60**	3759379.75**	621.36**	5951.64**	
M x F	22	0.5**	0.69	0.60	33.10	150192.85	11.33**	201.31	
Error	70	0.19	0.45	0.42	22.55	132376.88	0.41	139.12	
$\hat{\sigma}^2$ gca:		0.08	1.73	0.06	10.96	104177.44	14.03	141.12	
$\hat{\sigma}^2$ sca:		0.11	0.09	0.06	3.53	5938.82	3.69	13.82	
$\hat{\sigma}^2$ gca/ $\hat{\sigma}^2$ sca :		0.78:1	19.22:1	1.00:1	3.10:1	17.54:1	3.80:1	10.21:1	

investigated (Table 1). Female parents also followed the same trend. Rao *et al.* (1968) also reported that there were no differences among existing females with regards to grain yield. Mean squares for male parents were also significant for all characters except length of primary and number of secondary/primary branches. This finding is, however, contradictory with the findings of Rao *et al.*, (1968). It is possible that the dry spell which prevailed during the later part of the season when experiment was conducted led to non-significant differences among the parental lines. On the other hand, the hybrids differed significantly for all the characters indicating that heterozygotes are more homeostatic. Mean squares for parents *vs.* hybrids were also significant for all the characters which strongly implied heterosis for these attributes.

Almost all the characters under study (Table 1) revealed preponderance of additive genetic variance. Importance of additive genetic variance for grain yield components was also observed by Whitehead (1962), Kambal (1963), Kambal and Webster (1965), Niehaus and Pickett (1966), Beil and Atkins (1967), Rao *et al.* (1968) and Shankargowda *et al.* (1972). On the other hand, several reports are available where non-additive genetic variance was found to be of greater importance for grain yield (Nagur and Murty, 1970; Rao *et al.*, 1970; Goud, 1971; Goud *et al.*, 1973 and Govil and Murty, 1973). It depends on the material used whether additive genetic variance or the non-additive genetic variance is important because the gene frequencies and degree of dominance influence the magnitude of the components of genotypic variances.

The estimates of combining ability effects for grain yield and number of

grains revealed that 2077A was most desirable female and SPV 228 as well as SPV 230 were most desirable males by virtue of their significant positive gca effects (Tables 2 and 3). On the other hand for 1000-grain weight, 36A appeared to be a good female and SPV 221, SPV 225 and SPV 231 were desirable males.

Since early maturity and medium stature are desirable, parents with negative gca effects would be desirable. It was found that 2219 A was most superior female parent with respect to these traits. However, among male parents, SPV 224 and 221 were found to be desirable for days to flowering, while SPV 230 and 223 were desirable for plant height (Tables 2 and 3).

Two best parents (both female as well as male, best F1s, best general combiners and the best specific cross combinations for different characters were identified (Table 3). The order of best parents selected on the basis of GCA effect and array means was essentially the same. It implies that for practical purpose the selection of the best parents could be made on the basis of array mean and in so doing the use of long and time-consuming statistical computations could be avoided. This finding confirms the earlier reports of Rao *et al.* (1968) and Shankargowda *et al.* (1972).

The best crosses selected on the basis of SCA effects and *per se* performance were not the same for almost all the characters. High SCA need not necessarily mean a high performance by the hybrid. Therefore, the estimation of SCA effects seems rather of limited value. The choice of best cross combinations should be based on *per se* performance. 2077A x SPV 228 and 2077A x SPV 230 were identified as best crosses for yield.

TABLE 2

Estimates of general combining ability effects associated with parents.

Sr. No.	Character/parents	Days to 50% blooming	Plant height	Panicle length	Panicle circumference	Panicle weight	Number of whorls/panicle	Number of primaries/panicle
1	2	3	4	5	6	7	8	9
1	2077 A	2.11**	12.89**	4.68**	0.16	8.66**	0.34*	3.76**
2	2219 A	-5.05**	-8.81**	0.07	-1.79**	-21.87**	-0.71**	-7.91**
3	36 A	2.94**	-4.08**	-4.75**	1.63**	13.33**	0.37*	4.15**
	S.E. (i)	± 0.14	± 1.62	± 0.33	± 0.22	± 2.20	± 0.16	± 0.82
1	SPV 220	-1.92**	-9.81**	-1.61*	-0.64	-6.79	-0.60	-2.43
2	SPV 221	-2.36**	7.64**	0.35	-0.16	-11.66*	-0.07	1.05
3	SPV 223	-1.25**	-20.25**	0.15	-2.27**	-28.10**	0.71*	-3.79*
4	SPV 224	-2.25**	-4.36	1.95**	-0.52	-0.48	0.62	7.21**
5	SPV 225	-0.58*	-1.69	-0.91	-0.41	1.17	-0.29	2.36
6	SPV 226	1.86**	26.42**	-1.35*	0.72	-5.30	-0.20	0.98
7	SPV 227	1.64**	-12.25**	-1.80**	-0.08	-3.34	-0.60	-5.81**
8	SPV 228	1.53**	2.31	-0.20	1.77**	20.10**	0.06	1.14
9	SPV 229	-0.47	-7.92*	1.45*	-1.10*	3.52	-0.12	-16.30**
10	SPV 230	0.19	-32.03**	3.33**	-0.02	14.03**	0.60	1.45
11	SPV 231	2.97**	62.52**	-0.32	1.88**	13.50**	-0.14	4.34*
12	SPV 232	0.64*	-10.58**	-1.04	0.67	3.35	0.03	9.80**
	S.E. (j)	± 0.28	± 3.23	± 0.65	± 0.44	± 4.40	± 0.32	± 1.64

TABLE 2 (Contd.)

Sr. No.	Parents	Number of primaries/whorl	Length of primary branch	Number of secondary condaries/primary	Number of grains/primary	Number of grains/panicle	1000-grain weight	Grain yield/panicle
1	2077 A	0.12	1.49**	0.21	2.97**	367.25**	-1.46**	8.07**
2	2219 A	-0.29**	-0.03	-0.33**	-0.20	-240.83**	-3.23**	-14.83**
3	36 A	0.17*	-1.46**	0.11	-2.76*	-126.42*	4.69**	6.76**
	S.E. (i)	±0.07	±0.11	±0.11	±0.79	±60.64	0.11	±1.97
1	SPV 220	0.11	-0.11	-0.22	-1.73	-177.66	0.99**	-3.11
2	SPV 221	0.24	-0.03	-0.30	-6.79**	-485.66**	4.00**	-7.76
3	SPV 223	-0.67**	0.02	0.11	-7.57**	-663.88**	-0.17	-21.42**
4	SPV 224	0.24	0.03	0.35	-3.14	-31.56	0.90**	1.53
5	SPV 225	0.32*	-0.12	-0.02	-0.86	17.44	1.33**	4.36
6	SPV 226	0.17	-0.17	0.05	-1.47	-100.11	-1.01**	-6.80
7	SPV 227	-0.17	-0.23	-0.08	2.23	8.11	-2.01**	-3.71
8	SPV 228	0.04	0.04	0.11	5.51**	502.00*	-1.03**	13.58**
9	SPV 229	-1.28**	0.29	0.56*	11.54**	262.22**	-2.59**	1.75
10	SPV 230	-0.17	0.62**	0.14	4.88**	486.44**	-2.35**	9.62*
11	SPV 231	0.41**	0.00	-0.20	0.03	156.33	1.12**	8.95*
12	SPV 232	0.76**	-0.34	-0.50*	-3.03	26.33	0.82**	3.00
	S.E. (j)	±0.15	±0.23	+0.22	±1.58	+121.28	±0.21	±3.93

*Significant at 5% level, **Significant at 1% level.

TABLE 3

Two best parents, best general combiners, best F_{16} and best specific combinations for each character.

Character	Best parent		Best general combiner		Best F_1	Best specific combination
	Female	Male	Female	Male		
Days to 50% blooming	2219B	SPV.221	2219A	SPV.221	2219A x SPV.220	36A x SPV.223
	2077B	SPV.223	2077A	SPV.224	2219A x SPV.221	36A x SPV.231
Plant height	2219B	SPV.232	2219A	SPV.230	36A x SPV.223	2077A x SPV.226
	36B	SPV.230	36A	SPV.223	2219A x SPV.230	2219A x SPV.225
Panicle length	2077B	SPV.229	2077A	SPV.230	2077A x SPV.229	2219 x SPV.226
	2219B	SPV.224	2219A	SPV.224	2077A x SPV.224	2219A x SPV.225
Panicle circumference	2077B	SPV.232	36A	SPV.231	36A x SPV.231	2077A x SPV.221
	36B	SPV.228	2077A	SPV.228	36A x SPV.228	36A x SPV.225
Panicle weight	2077B	SPV.229	36A	SPV.228	2077A x SPV.228	2077A x SPV.230
	36B	SPV.232	2077A	SPV.230	2077A x SPV.230	2077A x SPV.228
No. of whorls/panicle	2077B	SPV.230	36A	SPV.223	36A x SPV.224	2077A x SPV.227
	36B	SPV.223	2077A	SPV.224	2077A x SPV.223	2219A x SPV.221
No. of primaries/panicle	2077B	SPV.221	36A	SPV.230	36A x SPV.232	2077A x SPV.235
	36B	SPV.224	2077A	SPV.224	36A x SPV.225	2077A x SPV.220
No. of primaries/whorl	2219B	SPV.232	36A	SPV.232	36A x SPV.225	2219A x SPV.229
	2077B	SPV.226	2077A	SPV.231	36A x SPV.232	2219A x SPV.230
Length of primary branch	2077B	SPV.220	2077A	SPV.230	2077A x SPV.229	2219A x SPV.225
	2219B	SPV.223	2219A	SPV.229	2077A x SPV.231	36A x SPV.225
No. of secondaries/primary	2077B	SPV.229	2077A	SPV.229	2077A x SPV.229	2077A x SPV.231
	36B	SPV.223	36A	SPV.224	36A x SPV.223	36A x SPV.223
No. of grains/primary	2077B	SPV.229	2077A	SPV.229	2077A x SPV.229	2219A x SPV.225
	2219B	SPV.220	2219A	SPV.228	2077A x SPV.228	2219A x SPV.232
No. of grains/panicle	2077B	SPV.225	2077A	SPV.228	2077A x SPV.230	2077A x SPV.230
	2219B	SPV.229	36A	SPV.230	2077A x SPV.228	2077A x SPV.228
1000-grain weight	36B	SPV.221	36A	SPV.221	36A x SPV.221	2077A x SPV.221
	2219B	SPV.224	2077A	SPV.225	36A x SPV.225	2077A x SPV.232
Grain yield/panicle	2077B	SPV.229	2077A	SPV.228	2077A x SPV.228	2219A x SPV.226
	36B	SPV.225	36A	SPV.230	2077A x SPV.230	2077A x SPV.230

For grain yield, 22 A x SPV 226 appeared to be the most superior combination whereas for number of grains, an important component of yield, 2077A x SPV 230 was most superior combination. Bolder grains are desirable. Several specific combinations like 2077A x SPV 221; 2077A x SPV 232, 36A x SPV 224, 2219 x SPV 220, and 2219A x SPV 229 were identified as best specific crosses. For days to 50 % blooming, 36A x SPV 223 and 36A x SPV 231 were superior cross combinations since they had highly significant negative sca effects. Significant sca effects in negative direction were also found for 2077A x SPV 226 and 2219A x SPV 225 crosses for plant height.

Unless yield improves, we may not be interested in other panicle characters and therefore sca effects for other characters are not discussed.

Since variance for grain yield was predominantly additive in nature, desirable segregants for yield could be expected to be used as varieties from crosses among 2077B, SPV 228 and SPV 230. Superior transgressive segregants could also be fixed. This would exploit highly significant heterosis observed for grain yield when 2077A is crossed with SPV 228 and SPV 230. The use of good general combiners in hybridization programme and selecting desirable segregants from the segregating generations by adopting progeny selection technique for exploiting additive genetic variance would lead to rapid improvement.

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