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COMBINING ABILITY AND HETEROSIS IN MAIZE (*Zea mays* L.)

M. S. Uddin, M. Amiruzzaman, S. A. Bagum[1], M. A. Hakim[2] and M. R. Ali

Plant Breeding Division
Bangladesh Agricultural Research Institute
Gazipur-1701, Bangladesh

ABSTRACT

A line × tester analysis was conducted in maize involving 12 lines and 3 testers for grain yield and its components to determine the heterosis as well as general combining ability (GCA) and specific combining ability (SCA) effects. Highly significant genotypic differences were observed indicated wide range of variability present among the genotypes. GCA and SCA variance for yield per plant number of kernels per row and 100-kernels weight were observed significant, which indicated importance of additive as type of gene action for these characters. The ratio of SCA and GCA variances were high for the all character studied that revealed the preponderance of non additive type of gene action. Standard heterosis ranged from -28.29 to 28.41%; -12.29 to 24.38%; -1.11 to 24.44%; -14.75 to 6.67%; -17.24 to 11.26% and -10.94 to 20.83% for grain yield per plant, number of grains per row, number of rows per ear, ear length, ear diameter and 100-kernel weight, respectively. The lines IPB 911-16, IPB 911-12, IPB 911-2, IPB 911-18 and IPB 911-47 showed significant positive GCA effect and simultaneously possessed high mean value indicating that the *per se* performance of the parents could prove as an useful index for combining ability. The crosses exhibited significant SCA effects involved high x high, high x low, low x high, average x low and low x low general combining parents. The cross combinations with significant positive SCA effect having high mean values might be used for obtaining high yielding hybrids. The information on the nature of gene action with respective variety and characters might be used depending on the breeding objectives.

Key word: Maize, line, tester, heterosis, combining ability, GCA, SCA

INTRODUCTION

Maize plays a significant role in human and livestock nutrition worldwide (Bantte and Prasanna, 2004). In Bangladesh, area, production and yield of maize decreased by 2.9%, 3.59% and 0.69% respectively from the year 1967-68 to 1986-87 due to utilization of traditional variety (Mohiuddin, 2003). Introduction of hybrid varieties and appropriate management practices increased area, production and yield increased by 19.83%, 34.40% and 14.56% respectively from the year 1987-88 to 2003-04 (Moniruzzaman *et al.*, 2007). Now maize has become an important cereal in terms of yield (Maize: 5.36; wheat: 2.21; and rice: 2.15 ton ha^{-1}., Anonymous, 2003) but in terms of area and production, it could be good source of nutrients for under nourished and mal-nourished populations in Bangladesh. It is

[1] **Seed Technology Division, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh; Wheat Research Center, Bangladesh Agricultural Research Institute, Dinajpur, Bangladesh**

now widely used in the poultry farms, fisheries and animals feeding, as well as the people consume roasted and fried maize in Bangladesh. Exploitation of hybrid vigour and selection of parents based on combining ability has been used as an important breeding approach in crop improvement. Breeder's objectives are to select hybrids on the basis of expected level of heterosis as well as specific combining ability. Heterosis and combining ability is prerequisite for developing a good hybrid maize variety. Combining ability is one of the powerful tools in identifying the best combiner that may be used in crosses either to exploit heterosis or accumulate fixable genes. The present study involving a line × tester analysis aimed to determine the general combining ability (GCA) and specific combining ability (SCA) of crosses for different traits and to explore heterotic hybrid combinations.

MATERIALS AND METHODS

Twelve locally developed advanced stage inbred lines (as female parents) and 3 testers (as male parents) of maize were selected and crossed in line × tester fashion to generate 36 cross combinations in rabi 2003 at Bangladesh Agricultural Research Institute, Joydebpur. Seeds of all the parents, their F_1 hybrids and one check variety BARI Hybrid maize 3 (BHM 3) were sown in the same farm following RCBD with 3 replications in rabi 2004. The unit plot size was 5.0 × 0.75m. Spacing adopted was 75 × 20 cm between rows and hills, respectively. One healthy seedling per hill was kept after proper thinning. Fertilizers were applied @ 250, 120, 120, 40 and 5 kg/ha of N, P_20_5, K_20, S and Zn, respectively. Standard agronomic practices were followed (Quayyum, 1993) and plant protection measures were taken as required. Two border rows were used at each end of the replication for minimize the border effect. Ten randomly selected plants were used for recording observations on yield contributing traits viz. number of grains per row (GR), number of rows per ear (NR), ear length (CL), ear diameter (CD) 100-kernel weight (HSW) and grain yield (g). The combining ability analysis was carried out as per the method suggested by Kempthorne (1957). Heterosis were calculated over standard chick varieties (CV) estimate as standard heterosis= $[(F_1\text{-CV})/\text{CV}] \times 100$. To determine the significant of heterosis, t-test was utilized.

RESULTS AND DISCUSSION

The analysis of variance showed significant variations among the genotypes for yield and yield contributing characters that revealed wide range of variability among the genotypes (Table 1). Sofi and Rather (2006) also found similar results of genotypic difference for ear length (cm), ear diameter (cm), kernel rows per ear, 100-seed weight (g) and grain yield per plot (g). Highly significant differences between parents, hybrids and interaction of parent x hybrid due to all traits except 100-kernel weight (g) were observed that also indicated wide range of variability among the parent, hybrid and interaction of parent x hybrid, respectively. Significant differences between the lines were found for all the traits, indicating substantial variability in lines for these traits. Significant differences between testers due to yield per plant (g), number of grains per row and number of rows per ear were observed. Highly significant differences due to interaction of line x tester were observed in all traits except 100-kernel weight (g) indicated the wide range of variability among these traits. Similar results have also been reported by Venkatesh *et al*. 2001, Narro *et al*. 2003 and Sofi and Rather (2006). The analysis of variance for combining ability (Table 1) revealed significant GCA and SCA for yield per plant, number of kernels per row and

100-kernel weight were observed which indicated importance of additive as well as non additive type of gene action. The ratios of SCA and GCA variance were high for the all character studied that revealed the preponderance of non additive gene action. Sanghi *et al*. (1983), Debnath *et al*. (1988), Das and Islam (1994), Roy *et al*. (1998) and Uddin *et al*. (2006) also reported predominance of non additive gene action in maize.

Table 1. ANOVA for line x tester analysis including parents in Maize

Source of variation	d.f.	Mean sum of squares and components of variance					
		Yield per plant (g)	Kernel per row (no.)	Row per ear (no.)	Ear length (cm)	Ear dia. (cm)	100 -kernel weight (g)
Replication	2	130.12	2.14	0.07	1.39	1.50	22.25
Genotypes	50	2102.46**	49.78**	3.26**	3.30**	2.42**	24.32**
Parents (p)	14	2342.64**	73.34**	5.98**	5.30**	2.83**	47.94**
Parent × Hybrid	1	33720.83**	358.46**	21.66**	25.80**	24.92**	66.56**
Hybrid	35	1103.00**	31.54**	1.65**	1.86**	1.61**	13.66
Line	11	1673.14**	68.01*	4.81**	5.35*	3.26*	59.11**
Tester	2	820.81**	125.83**	11.67**	1.14	0.85	6.78
Line x Tester	22	1250.16**	36.88**	1.52**	1.33**	1.58**	6.30
Error	100	44.83	0.65	0.36	0.33	0.51	13.10
σ^2_{GCA}	14	1.87*	2.45*	0.24	0.06	0.15	1.86*
σ^2_{SCA}	35	387.17**	9.92**	0.53	0.51	0.34	7.93**
$\sigma^2_{SCA:}\ \sigma^2_{GCA}$		207.04	4.05	2.21	8.50	2.27	4.26

*P=0.05, **P=0.01

Table 2. Proportional contribution of lines, tester and their interactions total variance in maize

Source	Yield per plant (g)	No. of kernel per row	No. of row per ear	ear length (cm)	Ear diameter	100 -kernel weight (g)
Due to line	19.07	23.87	26.55	47.07	34.87	41.50
Due to tester	9.69	2.64	15.59	7.97	3.60	29.49
Due to line x tester	71.24	73.50	57.86	44.96	61.52	29.01

*P=0.05, **P=0.01

The contribution of lines, testers and interactions to total variance are presented in Table 2. The proportional contribution of lines to the total variances was much higher than tester in all the traits but lower than that of interaction of line x tester except ear length and 100-kernel indicating higher estimates of variances due to specific combining ability. Sarker *et al*. (2002) found similar SCA estimates in rice. The proportional contribution of lines to the total variances was much higher than that of tester and interaction of line x tester for ear length and 100-kernel weight indicating higher estimates of variance due to general combining ability. Rissi *et al*. (1991) and Sarker *et al*. (2002) also found similar GCA estimates in maize and rice, respectively.

Heterosis

Percentage of heterosis over standard check (BHM 3) for grain yield and other related characters are presented in Table 3. The degree of heterosis varied from cross to cross and from character to character. Standard heterosis ranged from -28.29- to 28.41%; -12.29 to 24.38%; -1.11 to 24.44%; -14.75 to 6.67%; -17.24 to 11.26% and -10.94 to 20.83% for grain yield per plant, number of grains per row, number of rows per ear, ear length, ear diameter and 100-kernel weight, respectively. Similar results have also been reported by Uddin *et al*. (2006). The highest significant positive heterosis (28.41%) for grain yield was observed in the cross IPB 911-12 x BM-7.

General combining ability

The GCA effects and *per se* performance of the parents revealed that none of the parents were found to be a good general combiner for all the characters studied (Table 4). The lines IPB 911-16, IPB 911-18, IPB 911-12, IPB 911-2 and IPB 911-47 showed significance positive GCA effect and simultaneously possessed high mean values indicating that the *per se* performance of the parents could prove as an useful index for combining ability. Roy *et al*. (1998) Hussain *et al.* (2003) Uddin *et al*. (2006) also observed the similar phenomenon. So, these four parents could be used extensively in hybrid breeding program with a view to increasing the yield level.

Table 3. Standard heterosis (%) values for different yield contributing characters of 36 F_1s in maize

Hybrids	Yield per plant (g)	Kernel per row (no.)	Row per ear (no.)	Ear length (cm)	Ear diameter (cm)	100 -kernel weight (g)
IRB 911-1 X Barnali	-17.69**	-5.68**	6.11**	-6.67**	2.99**	-3.13**
IPB 911-1 X BM-7	4.26*	-12.29**	20.00**	-0.61	7.59**	4.17**
IPB 911-1 X E -32	-20.51**	13.33**	21.11**	5.05**	8.97**	-2.60*
IPB 911-2 X Barnali	-3.51	2.33	5.83**	5.86**	11.26**	-7.81**
IPB 911-2 X BM -7	-13.12**	-2.19	14.44**	-2.63**	7.13**	-2.60
IPB 911-4 X Barnali	13.03**	-6.04**	5.56**	3.43**	2.53**	2.08**
IPB 911 -4 X BM -7	-13.51**	24.38**	18.33**	6.26**	0.69	4.17**
IPB 911-4 X E-32	21.48**	-2.08	10.56**	6.67**	1.15	8.85**
IPB 911-2 X E-32	-24.23**	20.68**	8.89**	1.41	4.37**	-1.56
IPB 911-12 X Barnali	-4.45	3.13	16.11**	-5.86**	0.23	-10.94**
IPB 911-12 X BM -7	28.41**	13.17**	1.67	-4.65**	2.99**	9.90**
IPB 911 -12 X E-32	-19.18**	-2.19	12.22**	-5.86**	1.84*	-3.65**
IRB 911-16 X Barnali	13.13**	-10.83**	15.00**	2.63**	5.29**	-1.56
IPB 911-1 6X BM-7	-21.45**	17.22**	9.61**	0.20	5.29**	9.90**
IPB 911-1 6X E -32	26.47**	-5.83**	8.89**	-6.67**	-2.99**	-5.21**
IPB 911-18 X Barnali	-16.07**	3.13	2.22	-2.22**	1.84*	-2.60
IPB 911-18X BM-7	25.56**	16.50**	6.11**	-5.45**	-2.53**	-1.04
IPB 91-18X E-32	-4.54	8.33**	13.33**	1.01	2.53**	-10.94**
IPB 911-22 X Barnali	-16.09**	1.59	14.44**	-1.01	1.61	1.04**
IPB 911-22 X BM -7	-14.72**	1.06	14.44**	-7.47**	5.29**	20.83**
IPB 911-22 X E-32	5.73*	13.96**	17.78**	1.01	3.45**	7.81**
IPB 911-31 x Barnali	-27.57**	11.25**	6.11**	2.63**	6.67**	3.65**
IPB 911-31 X BM -7	-17.87**	8.67**	11.67**	-4.04**	5.29**	9.90**
IPB 911-31 X E-32	4.51*	-4.79**	22.50**	5.45**	9.43**	-4.17**
IPB 911-36X Barnali	-10.14	16.88**	7.22**	-14.75**	-17.24**	-8.85**
IPB 911 -36 X BM -7	-5.47	-7.08**	10.56**	-6.26**	0.69**	-5.73**
IPB 911-36 X E-32	-27.53**	-4.38	-1.11	-1.01	6.90**	-4.17**
IPB 911-39 X Barnali	-19.94**	-1.88	5.00**	0.61	6.67**	0.52
IPB 911 -39 X BM -7	2.48	2.10	14.44**	-0.20	3.45**	6.25**
IPB 911-39 X E-32	-28.29**	-2.29	5.56**	-1.82	0.23	-4.69**
IPB 911-47 X Barnali	-4.61	-6.67**	4.44**	1.41	3.91**	0.00
IPB 911 -47 X BM -7	-2.28	-5.63**	15.56**	-7.47**	10.80**	4.17**
IPB 911-47 X E-32	-2.36	-11.20**	24.44**	-3.03**	-2.99**	-3.65**
IPB 911-50 X Barnali	-12.17*	21.25**	6.67**	-1.41	3.91**	0.00
IPB911-50 X BM -7	-0.77	10.42**	14.44**	-0.20	9.43**	3.65**
IPB 911-50 X E-32	-3.98	-1.25	15.56**	4.24**	2.53**	-3.13**
SE (±)	2.60	1.69	1.03	0.80	0.84	1.11
CD (0.05)	5.26	3.43	2.09	1.62	1.71	2.26
CD (0.01)	7.07	4.58	2.79	2.17	2.28	3.01

Table 4. GCA effect and mean performance (in parenthesis) of parent for different yield contributing traits in maize

Parents	Yield per plant (g)	Kernel per row (no.)	No. of row per ear	Ear length (cm)	Ear diameter (cm)	100-kernel weight (g)
Line						
IPB 9 11-1	-6.84** (48.22)	-1.54** (23.8)	0.54** (11.8)	0.07 (12.6)	0.46** (13.0)	-0.25 (34.5)
IPB 911-2	5.60** (85.12)	1.18** (35.6)	-0.19** (13.7)	0.45** (16.4)	0.61** (15.7)	-1.36 (33.5)
IPB 911-4	0.41 (87.61)	0.69* (24.1)	0.03 (12.5)	1.09** (13.8)	-0.28 (13.1)	1.53 (30.0)
IPB 911-12	9.03** (82.74)	0.46 (33.8)	-0.15* (13.7)	-0.71** (17.3)	-0.24 (15.3)	-0.58 (27.3)
IPB 911-16	14.51** (121.09)	-0.98** (35.5)	-0.01 (12.9)	-0.02 (15.3)	-0.12 (13.7)	0.25 (24.5)
IPB 911-18	9.10** (73.88)	1.94** (30.6)	-0.49** (11.7)	-0.18 (16.7)	-0.40* (14.7)	-1.63 (29.5)
IPB 911-22	-3.21* (41.93)	0.73* (23.4)	0.51** (10.4)	-0.22 (15.3)	0.01 (13.0)	3.09 (40.3)
IPB 911-31	-9.71** (101.05)	0.57* (23.9)	0.26** (9.90)	0.41** (13.9)	0.55** (12.7)	0.92 (29.2)
IPB 911-36	-10.61** (45.46)	-0.46 (33.0)	-0.69** (12.3)	-1.02** (15.3)	-0.95** (15.0)	-2.08 (32.3)
IPB 911-39	-11.69** (74.69)	-1.26** (31.40	-0.35** (12.3)	0.11 (15.8)	0.01 (13.3)	0.14 (32.0)
IPB 911-47	3.28* (79.76)	-3.55** (30.30	0.43** (14.1)	-0.31 (15.1)	0.08 (14.8)	-0.02 (26.2)
IPB 911-50	0.14 (57.61)	2.20** (26.3)	0.11 (12.4)	0.33* (14.3)	0.28 (13.7)	-0.02 (34.5)
SE (gi)	2.14	0.26	0.08	0.18	0.23	1.15
SE (gi-gj)	4.73	0.57	0.43	0.41	0.50	2.56
Tester						
Barnali	-6.52** (98.13)	-0.28 (38.6)	-0.41** (11.1)	-0.02 (17.2)	-0.13* (14.5)	-0.81 (30.0)
BARI Maize-7	7.74** (123.99)	0.73* (28.60	0.16 (14.5)	-0.26* (16.1)	0.19* (15.1)	1.62** (33.00
E-32	-1.22* (128.92)	-0.45 (26.5)	0.24 (14.5)	0.28* (16.1)	-0.06 (14.0)	-0.80 (31.3)
SE (gj)	0.91	0.37	0.20	0.16	0.10	0.81
SE (gi-gj)	9.47	1.14	0.85	0.81	1.10	5.12
r (GCA, Mean)	0.52*	0.09	0.29	0.24	0.24	0.26

*P=0.05, **P=0.01

In case of number of kernels per row, IPB 911-50 was the best general combiner followed by IPB 911-18, IPB 911-2, IPB 911-22, IPB 911-4 and IPB 911-31. For number of rows per ear, IPB 911-1, IPB 911-22, IPB 911-31 and IPB 911-47 were good general combiner. For ear length, IPB 911-4, IPB 911-2, IPB 911-31 and IPB 911-50 were good general combiners and for ear diameter, IPB 9 11-1, IPB 911-2 and IPB 911-31were good general combiners in order of merit posing significant positive SCA effects. Among the testers, BARI Maize-7 was good general combiner for yield per plant; number of kernel per row, Ear diameter and 100-kernel weight and E-32 was good combiner for ear length only.

None of the parents except BM-7 exhibited significant GCA effect for 100-kernel weight. Sofi and Rather (2006) observed similar good general combiner testers for grain yield.

Table 5. SCA effects of F_1 hybrids for different yield and yield contributing traits in maize

Hybrids	Yield per plant (g)	No. of kernel per row	No. of row per ear	Ear length (cm)	Ear diameter (cm)	100 -kernel weight (g)
IRB 911-1 X Barnali	-1.32	-1.04**	-0.75**	-0.96**	-0.38**	-0.02
IPB 911-1 X BM-7	11.41**	-4.17**	0.35**	0.28**	-0.03	-0.12
IPB 911-1 X E -32	-10.10**	5.21**	0.40**	0.68**	0.42**	0.13
IPB 911-2 X Barnali	3.68	-1.19**	-0.06	0.73**	0.66**	-0.41**
IPB 911-2 X BM -7	-22.40**	-3.65**	0.41**	-0.43**	-0.26**	-1.17**
IPB 911-2 X E-32	18.72**	4.84**	-0.34**	-0.30**	-0.41**	1.58**
IPB 911-4 X Barnali	-3.43	-3.38**	-0.31**	-0.31**	0.29**	-0.13
IPB 911 -4 X BM -7	25.35**	5.34**	0.66**	0.39**	-0.30**	-1.89**
IPB 911-4 X E-32	-21.92**	-1.95**	-0.36**	-0.08	0.02	2.02**
IPB 911-12 X Barnali	-0.91	-0.22	1.14**	-0.05	-0.08	-2.19**
IPB 911-12 X Bm -7	25.24**	1.98**	-1.16**	0.39**	0.00	2.05**
IPB 911 -12 X E-32	-24.33**	-1.76**	0.02	-0.35**	0.08	0.13
IRB 911-16 X Barnali	15.23**	-3.24**	0.87**	0.67**	0.53**	-0.02
IPB 911-1 6X BM-7	-41.56**	4.72**	-0.35**	0.50**	0.21**	1.22**
IPB 911-1 6X E -32	26.33**	-1.48**	-0.52**	-1.17**	-0.74**	-1.20**
IPB 911-18 X Barnali	-15.27**	-1.70**	-0.19*	0.02	0.31**	1.54**
IPB 911-18X BM-7	21.67**	1.57**	-0.29**	-0.28**	-0.65**	-0.39**
IPB 91-18X E-32	-6.40**	0.13	0.49**	0.25**	0.34**	-1.14**
IPB 911-22 X Barnali	-2.98	-0.98**	0.27**	0.27**	-0.14	-2.02**
IPB 911-22 X Bm -7	-15.57**	-2.16**	-0.29**	-0.56**	0.08	1.88**
PB 911-22 X E-32	18.55**	3.14**	0.02	0.30**	0.06	0.13
IPB 911-31 x Barnali	-10.61**	2.27**	-0.47**	0.23*	0.06	0.98**
IPB 911-31 X BM -7	-12.94**	0.43	-0.37**	-0.63**	-0.46**	0.55**
IPB 911-31 X E-32	23.55**	-2.70**	0.84**	0.40**	0.39**	-1.53**
IPB 911-36X Barnali	11.74**	5.10**	0.61**	-1.20**	-1.90**	-0.02
IPB 911 -36 X BM -7	3.22	-3.57**	0.44**	0.44**	0.38**	-1.45**
IPB 911-36 X E-32	-14.96**	-1.53**	-1.04**	0.77**	1.53**	1.47**
IPB 911-39 X Barnali	0.75	-0.10	0.01	0.20*	0.60**	0.76**
IPB 911 -39 X BM -7	14.07**	0.17	0.57**	0.30**	-0.19*	0.16
IPB 911-39 X E-32	-14.82**	-0.07	-0.58**	-0.50**	-0.41**	-0.92**
IPB 911-47 X Barnali	4.64*	0.65**	-0.84**	0.75**	0.13	0.76**
IPB 911 -47 X BM -7	-6.75	-0.02	-0.07	-0.48**	0.81**	-0.34*
IPB 911-47 X E-32	2.11	-0.63**	0.91**	-0.28**	-0.94**	-0.42**
IPB 911-50 X Barnali	-1.52	3.84**	-0.26*	-0.36**	-0.07	0.76**
IPB 911-50 X BM -7	-1.74	-0.64**	0.11	0.08	0.41**	-0.50**
IPB 911-50 X E-32	3.26	-3.20**	0.16	0.28**	-0.34**	-0.25
SE (S_{ij})	3.03	0.46	0.09	0.09	0.10	0.19
SE (S_{ij}-S_{kl})	5.47	0.66	0.49	0.47	0.58	2.95

*P=0.05, **P=0.01

Significant positive correlation between *per se* performance and GCA effect was found for grain yield per plant only. For number of kernels per row, number of rows per ear, ear length , ear diameter and 100-kernel weight the correlation between *per se* performance and GCA were positive but not significant. Das and Islam (1994) also observed similar result. The high significant positive GCA effects observed for different desired characters could be helpful in identifying outstanding parents with favorable alleles for yield and other desirable components.

Specific combining ability effects (SCA)

Among the 36 crosses twelve crosses exhibited significant positive SCA effects for grain yield. These crosses involved high x high, high x low, low x high, average x low and low x low general combining parents. The crosses with high SCA effect for grain yield, IPB 911-2 x E-32, IRB 911-16 x Barnali, IPB 911-16 x E -32, and IPB 911 -39 x BM -7 and IPB 911-47 x Barnali evolved from high x low general combiner parents were reveled additive x dominance type of gene action.. For same trait, IPB 911-1 x BM-7 and IPB 911-4 x BM -7 involved low x high combiners depicting dominance x additive types of gene action. Roy *et al.* (1998) and Uddin *et al.* (2006) also found significant positive SCA effects in high x low and low x high general combiners. The hybrids IPB 911-22 x E-32, IPB 911-31 x E-32, IPB 911-36 x Barnali evolved from low x low general combiner parents revealed dominance x dominance type of gene action. These results agreed with the result of Uddin *et al.* (2006) in maize, Sarker *et al*. (2002) in rice. The hybrid 91 -12 x BM-7 and IPB 911-18 x BM-7 involved high x high general combiners parent depicting additive x additive types of gene action. Paul and Duara (1991) reported that the parents with high GCA always produce hybrids with high estimates of SCA.

Significant positive SCA effect was observed in eleven crosses for number of kernels per row. These crosses mostly involved high x low, low x high, high x average, average x low and low x low general combining parents. Thirteen cross combinations exhibited significantly positive SCA for number of rows per ear. Eighteen and thirteen cross showed significant positive SCA for ear length and ear diameter. For 100-kernel weight, twelve hybrids showed significant SCA effect. Significant positive SCA represents dominance and epistatic component of variation.

From the study, Five lines (IPB 911-2, IPB 911-12, IPB 911-16, IPB 911-18 and IPB 911-47) and one tester (BM-7) exhibited significant positive SCA and possessed comparatively well *per se* performance. Though, these parents could use for developing high yielding hybrids. The crosses posses high yield with significant SCA effects could be used for better hybrid selection. The information on the nature of gene action with respective variety and characters might be used depending on the breeding objectives.

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