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Heterosis and Combining Ability in Okra (*Abelmoschus esculentus* (L.) Moench)

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ABSTRACT. Heterosis and combining ability studies in okra were carried out by using line x tester mating design. The 51 hybrids generated by crossing 17 female lines with 3 male testers were grown along with their parents in a randomized block design with three replications. The variance due to treatments, parents, crosses and parents vs crosses were highly significant, except 100 seed weight for variance of treatment and germinated percentage for variance of parents. The highest heterosis over standard check for seed yield was observed in the cross Raj-12 x Parbhani Kranti. Parbhani Kranti had high GCA effects for all the characters and Raj-12 exhibited high GCA effects for seed yield. Estimates of SCA effects showed that best cross combination for seed yield was Raj-12 x Parbhani Kranti followed by Baunia x Parbhani Kranti.

INTRODUCTION

With the ease in fruit set and the good number of seeds per fruit, okra (*Abelmoschus esculentus* (L.) Moench), a commercially grown vegetable crop, can be exploited for hybrid seed production. Knowledge of GCA of parents is useful in the selection of desirable parents, for their use in further breeding programme and that of SCA of crosses for their direct use as a hybrid variety. A few earlier workers (Raman, 1965; Partap *et. al.*, 1981; Vijay and Manohar, 1986; Shukla *et. al.*, 1989) who studied heterosis and combining ability, primarily for fruit yield and its components in okra, also considered the number of seeds per fruit in their studies. Hence, literature pertinent to seed yield and its components is scanty with regard to this crop. Therefore, the present investigation was initiated to study both heterosis and combining ability for seed yield and its components by using 17 females with 3 male testers in a line x tester mating design.

MATERIALS AND METHODS

Seventeen lines of okra (*Abelmoschus esculentus* (L.) Moench) were crossed with three testers namely Parbhani Kranti, Pusa Sawani and P-7. The varieties, Parbhani Kranti and P-7, are resistant to yellow vein mosaic virus, and Pusa Sawani is a susceptible, but commercially grown variety during disease free season (Spring-Summer). For crossing, fully developed buds were hand emasculated in the evening, a day before anthesis and were pollinated in the next morning (between 8:00-10:00 a.m.). Butter paper bags of 2x5" size were used for enclosing emasculated and pollinated buds/flowers. The 51 hybrids along with 20 parents were sown in the field in July, 1991, in a randomized block design with three replications at the Vegetable Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The spacing between rows and plants was 60 cm and 30 cm, respectively. All the recommended agronomical practices were followed for growing the crop. Observations were recorded on five randomly selected plants for characters, such as, number of seeds per fruit, 100-seed weight, seed yield per plant, germination percentage and seed vigour index. Seed vigour index was calculated as follows:

$$\textit{Vigour index} = \textit{Germination percentage (Shoot length + Root length)}$$

Combining ability effects were worked out according to the method suggested by Kempthrone (1957).

RESULTS AND DISCUSSION

Highly significant differences among the parents showed a wide range of variability. The variance due to parents, treatments, crosses and parents *vs* crosses were highly significant for all characters, except germination percentage for variance due to parents, and 100-seed weight for variance due to treatments. The variance due to males and males *vs* females were also found highly significant (Table 1). The mean values of hybrids and percent heterosis over standard check have been given in Table 2. Out of 51 hybrids, 12 hybrids showed superiority for number of seeds per fruit over standard check. The standard heterosis for number of seeds varied from 9.12 to 44.33 %. Heterosis for number of seeds per fruit has also been reported by Raman (1965), Anonymous (1965) and Partap *et. al.*, (1981). None of the hybrids showed standard heterosis for 100-seed weight. Nine hybrids yielded (seed yield/plant) the standard check which ranged from

Table 1. ANOVA for line x tester analysis in okra.

Source	d.f.	Number of seeds per fruit	100- Seed weight	Seed yield per plant	Germination percentage	Seed vigour Index
Replication	2	6.61	0.04	6.67	2.03	12489.69**
Treatments	70	289.28**	1.47	572.86**	53.36**	145046.16**
Parents (P)	19	131.14**	1.11*	127.48**	14.35	43717.00*
Hybrids (H)	50	313.27**	1.40**	687.06**	25.40**	106009.00*
Parents x hybrids	1	2094.62**	11.77**	3325.27**	2192.65**	-
Lines (Female)	16	264.89	0.54	442.96	23.55	67628.97
Testers (Males)	2	2674.82**	21.67**	8253.57**	148.18**	547689.75**
Lines x Testers	32	189.86**	0.56**	330.45**	18.65*	97595.75**
Error	140	11.06	0.18	2.40	10.37	23424.73

* - significant at P=0.05 level.
** - significant at P=0.01 level.

Table 2. Mean values of hybrids and per cent heterosis over standard check (five best crosses).

Characters	Crosses	F_1	Standard check
Number of seeds per fruit (44.21)[x]	B-10 x Pb-57	63.81	44.33
	Baunia x Pb-57	63.22	42.99
	L.Sel-1 x Pb-57	61.15	38.31
	Vaishali Vadhu x Pb-57	60.89	37.71
	Dwarf Green Smoth PS	60.48	36.78
Seed Yield per plant (26.5 gm)[x]	Raj-12 x Pb-57	83.65	214.59
	IC 23609 x Pb-57	56.58	113.16
	Baunia x Pb-57	54.14	103.61
	HB-60 x Pb-57	48.20	81.27
	L.Sel-1 x Pb-57	31.91	46.33
Germination percentage (80.67)[x]	B-10 x Pb-57	92.00	14.05
	Dwarf Green Smooth x Pb-57	92.00	14.05
	Vaishali Vadhu x Pb-57	90.67	12.40
	Selection-2-2 x Pb-57	90.67	12.40
	Vaishali Vadhu x PS	90.00	11.57
Seed vigour index (2268.8)[x]	Lam Sel-1 x P-7	2208.47	19.38
	B-10 x Pb-57	2694.93	18.78
	Pusa Makhmali x Pb-57	2693.00	18.70
	Dwarf Green Smooth x PS	2675.73	17.93
	Line 6(1) x P-7	2633.47	126.07

( )[x] = Mean values of standard check, PS = Pusa Sawani, Pb-57 = Parbhani Kranti

21.25% in 214.59%. The highest heterosis was exhibited by the cross Raj-12 x Parbhani Kranti, followed by IC 23609 x Parbhani Kranti and Baunia x Parbhani Kranti. Similar results have also been reported by Swami and Giri Raj (1974) in okra. Heterosis for seed yield in pea was also reported by Singh and Santhoshi (1989). The highest germination percentage (14.05%) was observed in the cross B-10 x Parbhani Kranti over standard check. The highest heterosis for seed vigour index was observed in the cross combination Lam Selection-1 x P-7 (19.38%) over standard check. Most of the crosses showed different trends of heterosis effects for seed yield and its characters, which could be due to differences in the combining ability of the parents. Male parent Parbhani Kranti showed the highest GCA effects for all the characters, whereas the other two male parents (Pusa Sawani, P-7) and all female parents except Raj-12 for seed yield per plant were found to be poor combiners for seed characters (Table 3). Pusa Sawani has been reported a poor combiner for seed quality characters by Pandian and Selvaraj (1991). In chillie high GCA the effects for number of seeds per fruit 100-seed weight were reported by Mishra *et. al.*, (1991).

From 51 cross combinations, the following showed the highest SCA effects, namely Dwarf Green Smooth x Pusa Sawani for number of seeds per fruit; HB-60 x Pusa Sawani for 100-seed weight, Raj-12 x Parbhani Kranti for seed yield per plant; Selection-2 x P-7 for germination percentage and line 6(1) x P-7 for seed vigour index (Table 4). Estimates of SCA effects showed that better cross combinations for all characters were Baunia x Parbhani Kranti, Raj-12 x Parbhani Kranti and B-10 x Parbhani Kranti. These hybrids manifested high heterosis for seed yield mainly due to the dominant nature of genes. Therefore, these crosses may be used to exploit heterosis for seed yield in okra.

Table 3. Values for general combining ability effects of parents.

Parents	Number of seeds per fruit	100-seed weight	Seed yield per plant	Germination percentage	Seed vigour index
Lines					
B-10 P^1	3.00**	-0.47**	-6.72**	1.19	-3.18
Pusa Makhmali P_2	-2.42	0.13	-2.93*	0.08	147.88**
Selection-2 P_3	3.74**	0.38	0.54	-1.25	-117.62**
Selection-1 P_4	6.14**	-1.14	-7.18**	-0.81	-108.60*
Selection-2-2 P_5	4.82**	-0.02	-3.86**	0.74	-4.79
IC 23609 P_6	-2.83*	0.15	4.65**	0.74	50.64
Hb-55 P_7	-6.65	0.22	-3.74**	-1.03	-70.42
Line 6(1) P_8	1.48	0.36**	0.47	0.08	-3.69
Vaishali Vadhu P_9	5.41**	-0.15	-2.53**	3.63**	96.60
HB-30-4 P_{10}	-10.63**	0.06	2.23**	-0.81	-58.84
IC 23592 P_{11}	-5.77*	0.03	-3.83**	-1.03	-3.04
Baunia P_{12}	-2.08	-0.28	2.36**	0.30	79.93
Lam Selection-1 P_{13}	4.39**	-0.16	3.32**	-0.59	39.29**
Dwarf Green Smooth P_{14}	7.08**	0.02	7.26**	2.52*	80.73
Raj-12 P_{15}	0.74	-0.17	19.59**	1.19	-29.49
HB-60 P_{16}	8.33*	0.32*	5.70**	-3.03**	-90.22
Punjab Padmini P_{17}	-2.60*	-0.31	-10.86**	-1.92	-105.07*
Testers					
P-7 P_{18}	-4.48**	-0.05	-5.75**	-0.29	-17.62
Pusa Sawani P_{19}	-3.88**	-0.63**	-8.91**	-1.54*	-93.69**
Parbhani Kranti P_{20}	8.36**	0.68**	14.66**	1.83**	11.31**
SE (gi)	1.11	0.14	0.52	1.07	51.02
SE (gj)	0.47	0.06	0.22	0.45	21.43
CD for lines at 5%	2.17	0.27	1.02	2.10	100.00
CD at 1%	2.85	0.36	1.34	2.75	132.12
CD for testers at 5%	0.92	0.12	0.45	0.88	42.00
CD at 1%	1.21	0.15	0.56	1.16	55.07

* - Significant at P=0.05 level
** - Significant at P=0.01 level

P = Parent(s)

Table 4. Values for SCA of 5 best cross combinations.

Number of seeds per fruit		100 seed weight		Seed yield per plant		Germination percentage		Seed vigour Index	
$P_{14}xP_{20}$	15.96	$P_{16}xP_{19}$	0.63	$P_{15}xP_{20}$	28.57	P_3xP_{18}	3.84	P_8xP_{18}	288.51
$P_{12}xP_{20}$	15.63	$P_{17}xP_{19}$	0.60	P_6xP_{20}	16.54	$P_{15}xP_{19}$	3.29	P_3xP_{29}	277.84
P_1xP_{20}	11.04	$P_{15}xP_{20}$	0.57	$P_{12}xP_{20}$	16.29	P_1xP_{20}	3.32	P_1xP_{20}	220.53
P_9xP_{18}	8.87	$P_{12}xP_{20}$	0.53	$P_{17}xP_{19}$	10.49	P_8xP_{18}	3.28	$P_{13}xP_{18}$	220.53
$P_{15}xP_{18}$	7.71	P_7xP_{19}	0.52	P_7xP_{19}	9.98	P_4xP_{20}	2.61	$P_{12}xP_{19}$	170.62
SE (sij)	11.92		0.25		0.90		1.86		88.36
CD at 5%	3.76		0.49		11.76		3.65		173.18
CD at 1%	4.93		0.64		2.31		4.78		227.08

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