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Heterosis and combining ability for yield and its related traits in ash gourd

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ABSTRACT

The heterosis and combining ability studies with 10 parent diallel crosses (without reciprocals) in ash gourd were conducted for yield and its related traits. The mid-parent heterosis was observed as high as 166% for the yield per vine. In the present study, DAG-12 × DAG-11 was the best heterotic combination (in terms of better parent, mid parent and top parent heterosis) for number of female flowers; DAG-5 × DAG-11 for number of fruits per vine and DAG-1 × DAG-5 for individual fruit weight and yield per vine. The parent, DAG 4 was found to be the best combiner for yield per vine, respectively. The specific crosses, $P_3 \times P_8$ (DAG-1 × DAG-5), $P_2 \times P_{10}$ (DAG-4 × DAG-11), $P_5 \times P_{10}$ (DAG-6 × DAG-11), $P_4 \times P_5$ (DAG-9 × DAG-6), and $P_9 \times P_{10}$ (DAG-12 × DAG-11) can be utilized in heterosis breeding programme for the improvement of yield per vine in ash gourd.

Key words: *Benincasa hispida*, heterosis, combining ability.

INTRODUCTION

Benincasa hispida [syn. *Benincasa cerifera* (Thunb.) Cogn.], commonly called wax gourd, gives very high return to the growers due to its high productivity, long storage and great demand in processing industry. In India, its fruits are used as vegetable both in immature and mature stage and fully mature fruits are used in preparing '*petha*' sweet (candy) and *murraba*. In spite of its economic importance and availability of a considerable genetic diversity in plant and fruit characters, the genetic potentialities of ash gourd are practically unexplored and very little attempt has so far been made for its genetic improvement (Verma and Behera, 8; Verma *et al.,* 9). Mandal *et al.* (3) found relatively higher contribution of dominance gene action over the additive gene action and they suggested the heterosis breeding in ash gourd for the improvement of yield traits. Ash gourd, being a monoecious, cross-pollinated crop, provides ample scope for exploitation through hybrid vigour. The analysis of combining ability for different traits including yield in the present study will be helpful in the selection of inbreds for use in hybridization programme.

MATERIALS AND METHODS

The experimental materials consisted of ten parental lines, namely P_1 (DAG-2), P_2 (DAG-4), P_3 (DAG-1), P_4 (DAG-9), P_5 (DAG-6), P_6 (DAG-8), P_7 (DAG-13), P_8 (DAG-5), P_9 (DAG-12) and P_{10} (DAG-11) and 45 F_1 hybrids obtained by crossing them in diallel fashion (without reciprocals). In *kharif* 2005, the performance of the parents and 45 F_1 hybrids was assessed in a randomized block design (RBD) with three replications at the Main Experimental Farm of the Division of Vegetable Science, IARI, New Delhi. Seeds were sown on prepared hills at tip on the slope of both sides of channels keeping a distance of 6.5 m between channels and 1.5 m between hills. The width of the irrigation channels was kept at 90 cm. Standard and uniform agronomic practices recommended under irrigated conditions were followed throughout the growing season to raise a healthy crop. Five plants were selected for taking observations after discarding the border plants at both the ends. Data were recorded on total number of staminate and pistillate flowers, number of fruits per vine, individual fruit weight and yield per vine. The mean values for each trait were used for statistical analysis in the SPAR 1 software developed by Indian Agricultural Statistical Research Institute, New Delhi.

RESULTS AND DISCUSSION

The results of the characters studied for heterosis are presented in Table 1. The range of heterosis for total number of male flowers varied from -36.64 ($P_6 \times P_7$) to 66.67% ($P_4 \times P_5$) for mid percent heterosis, -33.65 ($P_6 \times P_{10}$) to 22.50% ($P_4 \times P_9$) for better parent heterosis and 0.00 ($P_5 \times P_{10}$) to 131.58% ($P_1 \times P_{10}$) for top parent heterosis. Out of 45 crosses, 21 crosses showed significant negative mid parent heterosis, 10 crosses showed significant negative better percent heterosis whereas none of them showed negative top parent heterosis. Out of 5 top crosses expressing significant negative mid parent heterosis ($P_6 \times P_7$, $P_6 \times P_{10}$, $P_3 \times P_6$, $P_7 \times P_{10}$ and $P_1 \times P_9$) and better parent

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Table 1. Estimates of heterosis (%) over better parent (BP), mid parent (MP) and top parent (TP) for earliness in ash gourd (*,**Significant at 5 and 1% levels).

Cross	Number of staminate flowers			Number of pistillate flowers			Number of fruits per vine		
	Heterosis over BP	Heterosis over MP	Heterosis over TP	Heterosis over BP	Heterosis over MP	Heterosis over TP	Heterosis over BP	Heterosis over MP	Heterosis over TP
$P_1 \times P_2$	-1.34	-18.56**	28.95	-55.56	-38.46	-55.50	-50.00	-36.84	-50.00
$P_1 \times P_3$	8.72	3.18	42.11	27.27**	47.37**	-22.17	0.00	6.67**	-33.25
$P_1 \times P_4$	25.83	12.27	32.45	25**	25**	-44.50	-14.29	-14.29	-50.00
$P_1 \times P_5$	44.74	25.48	44.74	100**	86.67**	-22.17	0.00	7.69**	-41.75
$P_1 \times P_6$	-4.7	-20.45**	24.55	-38.46	-23.81	-55.50	0.00	-6.67**	-41.75
$P_1 \times P_7$	-16.78**	-18.42**	8.76	-56.25	-41.67	-61.17	-14.29	-14.29	-50.00
$P_1 \times P_8$	-17.45**	-21.66**	7.89	-41.67	-30.00	-61.17	-25.00	-20.00	-50.00
$P_1 \times P_9$	-10.74**	-23.34**	16.66	-18.18	-5.26**	-50.00	-14.29	-30.00	-50.00
$P_1 \times P_{10}$	77.18	47.90	131.58	60.00**	77.78**	-11.17	12.5**	20.00*	-25.00
$P_2 \times P_3$	20.00	5.04	73.68	-50.00	-37.93	-50.00	-41.67	-30.00	-41.75
$P_2 \times P_4$	21.67	-12.05**	28.08	-50.00	-30.77	-50.00	-50.00	-36.84	-50.00
$P_2 \times P_5$	78.07	24.54	78.08	11.11**	60.00**	11.16**	8.25**	44.44**	8.25**
$P_2 \times P_6$	-11.06**	-11.9**	62.29	-33.33	-22.58	-33.33	-41.67	-30.00	-41.75
$P_2 \times P_7$	3.87	-12.26**	41.24	-27.78	-23.53	-27.83	-41.67	-26.32	-41.75
$P_2 \times P_8$	-2.42	-14.59**	41.24	-61.11	-53.33	-61.17	-50.00	-40.00	-50.00
$P_2 \times P_9$	12.12	8.29	94.74	-16.67	3.45**	-16.67	-16.67	5.26**	-16.75
$P_2 \times P_{10}$	25.00	23.81	128.08	5.56**	35.71**	5.5**	62.50**	30**	8.25**
$P_3 \times P_4$	40.83	18.60	48.24	-27.27	-15.79	-55.50	-12.50	-6.67	-41.75
$P_3 \times P_5$	31.58	7.53	31.58	-9.09	11.11**	-44.50	-25.00	-14.29	-50.00
$P_3 \times P_6$	-20.00**	-29.22**	15.79	-46.15	-41.67	-61.17	-25.00	-25.00	-50.00
$P_3 \times P_7$	34.19	30.00	82.45	-12.50	3.70**	-22.17	12.50**	20.00**	-25.00
$P_3 \times P_8$	14.55	14.55	65.79	41.67**	47.83**	-5.50	50.00**	50.00**	0.00
$P_3 \times P_9$	5.45	-4.13*	52.63	18.18**	18.18**	-27.83	0.00	6.67**	-33.25
$P_3 \times P_{10}$	30.30	15.28	88.61	63.64**	71.43**	0.00	37.50**	37.5**	-8.25
$P_4 \times P_5$	71.05	66.67	71.05	87.5**	100**	-16.67	14.29**	23.08**	-33.25
$P_4 \times P_6$	24.17	-9.15**	30.71	-46.15	-33.33	-61.17	-25.00	-20.00	-50.00
$P_4 \times P_7$	45.83	27.27	53.50	-56.25	-41.67	-61.17	-14.29	-14.29	-50.00
$P_4 \times P_8$	19.17	0.35	25.45	-16.67	0.00	-44.50	-12.50	-6.67**	-41.75
$P_4 \times P_9$	82.50	37.74	92.11	45.45**	68.42**	-11.17	42.86**	42.86**	-16.75
$P_4 \times P_{10}$	18.33	-13.41**	24.55	-30.00	-22.22	-61.17	-25.00	-20.00	-50.00
$P_5 \times P_6$	13.16	-19.88**	13.16	-38.46	-20.00	-55.50	-12.50	0.00	-41.75
$P_5 \times P_7$	18.42	0.37	18.42	-56.25	-39.13	-61.17	0.00	7.69**	-41.75
$P_5 \times P_8$	1.75	-16.85**	1.76	-25.00	-5.26	-50.00	-25.00	-14.29	-50.00
$P_5 \times P_9$	43.86	5.13	43.87	-18.18	0.00	-50.00	0.00	7.69**	-41.75
$P_5 \times P_{10}$	0.00	-29.19**	0.00	10.00**	29.41**	-38.83	12.50**	28.57**	-25.00
$P_6 \times P_7$	-25.81**	-36.64**	0.87	-56.25	-51.72	-61.17	-25.00	-20.00	-50.00
$P_6 \times P_8$	25.45	10.99	81.58	15.38**	20**	-16.67	62.50**	62.5**	8.25**
$P_6 \times P_9$	-1.52	-3.94	71.05	7.69**	16.67**	-22.17	12.50**	20.00**	-25.00
$P_6 \times P_{10}$	-33.65**	-33.65**	21.05	-23.08	-13.04	-44.50	-12.50	-12.50	-41.75
$P_7 \times P_8$	-14.84**	-17.5**	15.79	-43.75	-35.71	-50.00	-25.00	-20.00	-50.00
$P_7 \times P_9$	51.61	33.14	106.13	12.50**	33.33**	0.00	42.86**	42.86**	-16.75
$P_7 \times P_{10}$	-13.55**	-26.17**	17.55	-56.25	-46.15	-61.17	-25.00	-20.00	-50.00
$P_8 \times P_9$	12.12	1.93	62.29	41.67**	47.83**	-5.50	25**	33.33**	-16.75
$P_8 \times P_{10}$	36.36	20.64	97.37	66.67**	81.82**	11.16**	87.5**	87.5**	25**
$P_9 \times P_{10}$	-11.62**	-13.79**	53.50	90.91**	100**	16.66**	37.5**	46.67**	-8.25
CD at 5%	5.25	4.06	5.11	1.31	1.13	1.13	0.86	0.74	0.74

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Table 1. Estimates of heterosis (%) over better parent (BP), mid parent (MP) and top parent (TP) for earliness in ash gourd (*,**Significant at 5 and 1% levels).

Cross	Individual fruit weight			Yield per vine		
	Heterosis over BP	Heterosis over MP	Heterosis over TP	Heterosis over BP	Heterosis over MP	Heterosis over TP
$P_1 \times P_2$	-55.29	-39.78	-55.23	-77.25	-72.46	-77.25
$P_1 \times P_3$	-56.38	-39.35	-51.69	-60.07	-55.24	-66.76
$P_1 \times P_4$	31.82**	36.15**	-45.90	-52.29	-34.18	-68.85
$P_1 \times P_5$	-22.33	-19.19	-62.29	-65.14	-53.94	-77.25
$P_1 \times P_6$	-53.12	-42.97	-64.69	-74.31	-70.83	-83.22
$P_1 \times P_7$	-36.11	-18.73	-45.90	-66.06	-63.90	-77.83
$P_1 \times P_8$	-46.51	-27.67	-45.90	-68.85	-67.10	-77.25
$P_1 \times P_9$	-32.14	-21.81	-55.23	-70.64	-62.57	-80.85
$P_1 \times P_{10}$	72.33**	74.88**	-16.38	8.72**	44.51**	-29.03
$P_2 \times P_3$	-27.66	-24.02	-19.92	-53.29	-49.02	-53.29
$P_2 \times P_4$	-12.94	14.73**	-12.85	-65.87	47.22	-65.86
$P_2 \times P_5$	-8.24	26.83**	-8.19	-16.17	25.56**	-16.17
$P_2 \times P_6$	-5.88	7.38**	-5.79	-43.71	-24.80	-43.69
$P_2 \times P_7$	-8.24	-0.64	-8.19	-46.11	-31.56	-46.10
$P_2 \times P_8$	-11.76	-12.28	-11.72	-55.09	-48.10	-55.08
$P_2 \times P_9$	-57.65	-48.94	-57.63	-64.07	-47.60	-64.07
$P_2 \times P_{10}$	10.59**	50.4**	10.59**	13.77**	71.17**	13.80
$P_3 \times P_4$	-21.28	7.25**	-12.85	-37.41	-7.45	-47.90
$P_3 \times P_5$	-8.51	30.3**	1.27**	-48.92	-27.18	-57.49
$P_3 \times P_6$	-40.43	-29.11	-34.04	-66.19	-57.66	-71.86
$P_3 \times P_7$	-58.51	-53.01	-54.10	-57.19	-49.36	-64.36
$P_3 \times P_8$	8.09**	12.89**	19.63**	48.20**	57.85**	23.36
$P_3 \times P_9$	-17.02	4.00**	-8.19	-23.02	6.47**	-35.93
$P_3 \times P_{10}$	-27.66	1.49**	-19.92	-10.79	27.84**	-25.73
$P_4 \times P_5$	81.82**	95.12**	-5.79	94.64**	107.62**	-34.71
$P_4 \times P_6$	-46.88	-37.04	-60.03	-57.83	-46.97	-79.05
$P_4 \times P_7$	-52.78	-41.38	-60.03	-69.79	-60.00	-82.43
$P_4 \times P_8$	-37.21	-16.92	-36.44	-48.36	-26.32	-62.27
$P_4 \times P_9$	16.07**	30.00**	-23.45	75.00**	95.50**	-35.03
$P_4 \times P_{10}$	-2.50	-7.14	-54.10	-29.09	-25.00	-76.64
$P_5 \times P_6$	-17.12	4**	-37.57	-22.89	-7.91	-61.66
$P_5 \times P_7$	-22.22	1.82**	-34.04	-22.92	-2.63	-55.70
$P_5 \times P_8$	-25.58	3.23**	-24.72	-39.34	-16.85	-55.70
$P_5 \times P_9$	0.00	19.15**	-34.04	61.29**	69.49**	-40.10
$P_5 \times P_{10}$	115.00**	120.51**	1.27**	134.29**	166.67**	-11.35
$P_6 \times P_7$	-11.11	-5.88	-24.72	-33.33	-28.49	-61.66
$P_6 \times P_8$	-46.51	-38.67	-45.90	-18.85	-3.41	-40.71
$P_6 \times P_9$	-21.88	-16.67	-39.97	4.82*	20.00**	-47.90
$P_6 \times P_{10}$	-3.12	19.23**	-26.98	-13.25	4.35*	-56.88
$P_7 \times P_8$	-34.88	-29.11	-34.04	-54.10	-48.62	-66.48
$P_7 \times P_9$	-19.44	-9.38	-31.78	1.04	22.78**	-41.90
$P_7 \times P_{10}$	-27.78	-7.14	-38.84	-45.83	-31.13	-68.85
$P_8 \times P_9$	-48.84	-38.03	-48.16	-28.28	-4.89	-47.61
$P_8 \times P_{10}$	-37.21	-14.29	-36.44	9.84**	51.41**	-19.76
$P_9 \times P_{10}$	34**	56.33**	-11.72	128.23**	141.88**	-15.27
CD at 5%	0.76	0.64	0.66	3.86	3.58	3.54

heterosis ($P_6 \times P_{10}$, $P_6 \times P_2$, $P_3 \times P_6$, $P_1 \times P_6$, $P_1 \times P_7$), most of them had P_6 as one of the parents. The F_1 hybrid $P_6 \times P_7$ noted highest negative better parent heterosis (-36.64%) and P_6 x P_{10} showed highest negative better parent heterosis (-33.65%) for this trait. Like total number of male flowers, total number of female flowers also had wide range of heterosis (Table 1). The range varied from -53.33 ($P_2 \times P_8$) to 100.00% ($P_9 \times P_{10}$ and $P_4 \times P_5$), -56.25% ($P_1 \times P_7$) to 100 ($P_1 \times P_5$) and -61.17 ($P_1 \times P_7$) to 16.67% ($P_9 \times P_{10}$) for mid parent, better parent and top parent heterosis, respectively. Significant positive mid parent heterosis was observed in 21 crosses, better parent heterosis in 18 crosses and top parent heterosis in 4 crosses. The F_1 cross, $P_1 \times P_5$ displayed the highest better parent heterosis (100%) and $P_9 \times P_{10}$ exhibited highest top parent heterosis (16.67%) for this trait.

The range of heterosis varied from -36.84 ($P_1 \times P_2$) to 87.50% ($P_8 \times P_{10}$), -50.00 ($P_1 \times P_2$), 87.50 ($P_8 \times P_{10}$) and -50.00% ($P_1 \times P_2$) to 25.00% ($P_8 \times P_{10}$) over the mid parent, better parent and top parent, respectively for number of fruits per vine. Among the 45 F_1crosses, 4 crosses exhibited significant positive heterosis over the top parent (P_2). Among the top 5 crosses showing maximum positive heterosis (in descending order of merit) over mid parent ($P_8 \times P_{10}$, $P_6 \times P_8$, $P_3 \times P_8$, $P_9 \times P_{10}$ and better parent ($P_2 \times P_5$, $P_8 \times P_{10}$, $P_6 \times P_8$, $P_3 \times P_8$ and $P_7 \times P_9$), three had P_8 as one of the parents. The F_1 cross, $P_8 \times P_{10}$ displayed maximum mid parent and better parent heterosis (87.5%) and top parent heterosis (25.00%).

Like number of fruits per vine, wide range of heterosis was also noticed for individual fruit weight and it ranged from -48.94 ($P_2 \times P_9$) to 120.51% ($P_5 \times P_{10}$) for mid parent heterosis, -58.51 ($P_3 \times P_7$) to 115.00% ($P_5 \times P_{10}$) for better parent heterosis and 64.69 ($P_1 \times P_6$) to 19.63% ($P_3 \times P_8$) for top parent heterosis. Significant positive heterosis over mid parent, better parent and top parent were observed in 20 crosses, 8 crosses and 4 crosses, respectively. The heterosis for yield per vine ranged from -72.46 ($P_1 \times P_2$) to 166.67 % ($P_5 \times P_{10}$) over mid parent, -77.25 ($P_1 \times P_2$) to 164.29% ($P_5 \times P_{10}$) over better parent and -83.43 ($P_1 \times P_6$) to 23.36% ($P_3 \times P_8$) over top parent. It showed the highest positive heterosis (166.49%) among all other traits. The hybrid $P_5 \times P_{10}$ (DAG-6 × DAG-11) exhibited the maximum mid parent heterosis (166.67%) and better parent heterosis (166.49%) followed by $P_9 \times P_{10}$ (141.88 and 128.23%) and $P_4 \times P_5$ (107.62 and 94.64%), respectively for yield per vine. Highest positive significant heterosis over the top parent (DAG- 4) was detected in the hybrid $P_3 \times P_8$ (23.35%) followed by the cross $P_2 \times P_{10}$ (13.79%) for this trait.

Among the 5 traits, the highest (more than 100%) level of heterosis was detected for yield per vine followed by individual fruit weight and intermediate range of heterosis (50 to 100%) was observed for number of fruits per vine. In the present study, $P_8 \times P_{10}$ (DAG-5 × DAG-11) was the best heterotic combination (in terms of better parent, mid parent and top parent heterosis) for number of fruits per vine; $P_5 \times P_{10}$ for individual fruit weight and fruit yield per vine. Sureja *et al.* (7) observed high better parent and mid parent, heterosis fruit yield per vine, fruit number per vine, fruit weight and TSS content. Mohanty and Mishra (5) observed high heterosis over mid parent and better parent for fruits per vine (156.3 and 145.6%), individual fruit weight (92.3 and 82.0%) and yield per plant (191.4 and 188.2%), respectively, in pumpkin.

Table 2. Estimates of gca effect of parents in ash gourd.

Parent	Total number of male flowers	Total number of female flowers	Number of fruits/ vine	Fruit weight (kg)	Yield per vine
P_1	-4.19**	-0.54**	-0.36**	-1.22**	-3.66**
P_2	6.86**	0.54**	0.31**	0.93**	3.29**
P_3	1.86**	0.10**	0.06**	0.99**	2.70**
P_4	-3.64**	-0.65**	-0.33**	-0.40**	-3.35**
P_5	-7.25**	-0.32**	-0.16**	0.07**	0.16
P_6	-1.44**	-0.40**	-0.11**	-0.38**	-2.26**
P_7	-3.64**	-0.21**	-0.30**	-0.21**	-2.34**
P_8	-1.36**	0.18**	0.26**	0.38**	2.19**
P_9	6.61**	0.71**	0.20**	-0.32**	0.36*
P_{10}	6.19**	0.57**	0.42**	0.16**	2.92**
SE (gi)	0.30	0.016	0.007	0.005	0.18
SE (gi-gj)	0.67	0.037	0.016	0.06	0.41

*, ** Significant at 5 and 1% level of significance.

The estimates of gca effects (g_i) of 10 parents for 5 traits are presented in Table 2. The parent, P_5 (DAG-6) showed maximum negative gca effects for total number of male flowers where as the parent, P_9 (DAG-12) showed maximum positive estimate of gca for female flowers. P_{10} (DAG11) had the highest positive gca effect for number of fruits per vine and P_3 (DAG-1) was significantly different exhibiting highest positive gca effects for individual fruit weight, which was statistically on par with P_2 (DAG-4). Hence, it was revealed from this study that parent P_5 (DAG-6) was the best general combiner (in negative direction) for total number of male flowers whereas parents P_4 and P_9 for total number of female flowers. The parent, P_{10} (DAG-11) exhibited best combiner for number of fruits per vine and P_3 (DAG-1) for individual fruit weight. In contrast to the present experiment, Pandey *et al.* (6) did not find the better general combiners in ash gourd for all these traits.

The *per se* (mean) performance of the parent along with the gca effect offers reliability/authenticity of gca effect as a guide to selection of parent. Many studies using Griffing's analysis have shown that the *per se* performance of the parents are often associated with their combining abilities, *i.e.* promising parental performers tend to perpetuate desirable progeny (Gill *et al*., 1; Kumar and Agarwal, 2; Mather and Poysa, 4). In the present study, besides obtaining maximum gca effects in the desirable direction, the parents P_3 (DAG-1) and P_{10} (DAG-11) also recorded highest mean values for yield per vine.

Out of 45 F_1 hybrids, significant sca effects in favourable direction were exhibited by 16 for number of fruits per vine, 16 for individual fruit weight, and 8 for yield per vine (Table 3). Two F_1 crosses showing the highest significant desirable sca effects for various traits in order of merit were $P_9 \times P_{10}$ (DAG-12 × DAG-11) and $P_2 \times P_5$ (DAG-4 × DAG-6) for number of female flowers, $P_8 \times P_{10}$ (DAG-5 × DAG-11) and $P_2 \times P_5$ (DAG-4 × DAG-6) for number of fruits per vine, $P_3 \times P_8$ (DAG-1 × DAG-5) and $P_4 \times P_5$ (DAG-9 × DAG-6) for individual fruit weight. The cross, $P_3 \times P_8$ (DAG-1 × DAG-5) exhibited higher significant and positive sca effects for yield per vine followed by the crosses, $P_2 \times P_{10}$, $P_5 \times P_{10}$, $P_4 \times P_5$, and $P_9 \times P_{10}$. It is interesting to note that crosses showing more sca effects in terms of individual fruit weight contributed maximum yield rather than the crosses having more number of fruits per vine. The promising hybrids with respect to yield per vine were $P_3 \times P_8$ (DAG-1 × DAG-5), $P_2 \times P_{10}$ (DAG-4 × DAG-11), $P_5 \times P_{10}$ (DAG-6 × DAG-11), $P_4 \times P_5$ (DAG-9 × DAG-6), and $P_9 \times P_{10}$ (DAG-12 × DAG-11), few of these are under the evaluation in mulitilocation trials under All India Coordinated Research Project (AICRP)-Vegetable Crops.

Table 3. Estimates of sca effect of 45 F_1 hybrids in ash gourd.

Cross	Total number of male flowers	Total number of female flowers	Number of fruits/ vine	Fruit weight (kg)	Yield per vine
$P_1 \times P_2$	-10.03**	-1.23**	-0.62**	-1.53**	-7.72**
$P_1 \times P_3$	-0.03	1.21**	0.30**	-1.33**	-3.70*
$P_1 \times P_4$	1.80	0.63**	0.22**	1.47**	1.76
$P_1 \times P_5$	10.08**	1.63**	0.19**	-1.16**	-4.00*
$P_1 \times P_6$	-3.39	-0.29	0.13*	-0.89**	-3.33*
$P_1 \times P_7$	7.20**	-0.81**	-0.01	0.28**	-1.75
$P_1 \times P_8$	-0.81	-1.20**	-0.56**	-0.31**	-.6.11**
$P_1 \times P_9$	-14.45**	-1.06**	-0.51**	-0.28**	-5.28**
$P_1 \times P_{10}$	29.64**	1.41**	0.27**	1.99**	6.57**
$P_2 \times P_3$	0.91	-1.54**	-0.70**	-1.23**	-6.91**
$P_2 \times P_4$	-10.92**	-0.79**	-0.64**	0.66**	-4.36*
$P_2 \times P_5$	11.69**	2.55**	1.52**	0.53**	5.96**
$P_2 \times P_6$	-0.11	-0.04	-0.53**	1.14**	0.71
$P_2 \times P_7$	-5.92	0.10	-0.34**	0.80**	0.12
$P_2 \times P_8$	-8.20**	-2.29**	-1.23**	-0.04	-6.91**
$P_2 \times P_9$	4.16	-0.15	0.16	-2.59**	-7.57**
$P_2 \times P_{10}$	17.25**	1.33**	0.94**	1.76**	11.53**
$P_3 \times P_4$	1.75	-0.67**	-0.06	0.60**	1.23

Contd...

Contd...

Cross	Total number of male flowers	Total number of female flowers	Number of fruits per vine	Fruit weight (kg)	Yield per vine
$P_3 \times P_5$	-0.97	-0.34	0.56**	1.13**	-4.94**
$P_3 \times P_6$	-12.78**	-1.26**	-0.62**	-0.92**	-6.5**
$P_3 \times P_7$	14.75**	0.88**	0.58**	-2.51**	-4.36**
$P_3 \times P_8$	6.14*	1.49**	1.02**	2.12**	15.52**
$P_3 \times P_9$	-6.84*	-0.37	-0.26**	0.85**	0.86
$P_3 \times P_{10}$	7.25**	1.44**	-0.52**	-0.46**	1.13
$P_4 \times P_5$	19.53**	2.08**	-0.49**	2.02**	7.44**
$P_4 \times P_6$	-1.61	-0.51**	-0.23**	-1.37**	-2.48
$P_4 \times P_7$	9.25**	-0.70**	-0.03	-1.54**	-3.40**
$P_4 \times P_8$	-3.70	-0.09	-0.26**	-0.46**	-2.26
$P_4 \times P_9$	13.66**	1.30**	0.80**	1.15**	7.16**
$P_4 \times P_{10}$	-11.59**	-1.48**	-0.76**	-1.49**	-6.99**
$P_5 \times P_6$	-4.67	-0.51**	-0.06	-0.25**	-1.15
$P_5 \times P_7$	-0.47	-1.04**	0.13	-0.17**	0.59
$P_5 \times P_8$	-9.09**	-0.76**	-0.76**	-0.10**	-3.93*
$P_5 \times P_9$	-1.06	-1.29**	-0.37**	-0.06	2.23
$P_5 \times P_{10}$	-17.31**	-0.48**	0.08	1.96**	7.67**
$P_6 \times P_7$	-12.95**	-0.95**	-0.26**	0.94**	1.34
$P_6 \times P_8$	15.44**	1.33**	1.52**	-1.15**	2.65
$P_6 \times P_9$	3.47	0.46*	0.24**	-0.12**	2.48
$P_6 \times P_{10}$	-15.11**	-0.73**	-0.64**	0.40**	-2.58
$P_7 \times P_8$	-7.36**	-0.87**	-0.62**	-0.48**	-4.44**
$P_7 \times P_9$	19.00**	1.60**	0.77**	0.38**	-4.23**
$P_7 \times P_{10}$	-14.25**	-1.92**	-0.78**	-0.60**	-5.84**
$P_8 \times P_9$	0.05	0.88**	0.22**	-1.38**	-1.89
$P_8 \times P_{10}$	13.80**	2.02**	1.66**	-1.03**	3.30
$P_9 \times P_{10}$	-10.84**	14.83**	0.38**	1.42	6.39**
S.E. (Sic)	2.75	0.15	0.06	0.05	1.69
S.E. (Sic-Sji)	5.38	0.37	0.13	0.09	3.31
S.E. (Sij)	3.43	0.19	0.08	0.06	2.10
S.E. (Sij-Sik)	7.40	0.41	0.18	0.13	4.50
S.E. (Sij-Skl)	6.47	0.38	0.16	0.12	4.10

*, ** Significant at 5 and 1% levels of significance.

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