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Manifestation of heterosis breeding for fruit yield and its attributing traits in brinjal (*Solanum melongena*)

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ABSTRACT

A field experiment was conducted during *rabi* 2011 and *kharif* of 2012 to estimate the magnitude of heterosis and heterobeltiosis for fruit yield and its attributing traits in brinjal. Ten indigenous parental lines of brinjal were selected and crossed in a half diallel-fashion and the resultant 45 F1 hybrids (excluding reciprocals) along with their parents were evaluated for yield and its component traits in a randomized block design (RBD) with three replications. The observations were recorded on five randomly selected plants per replication for each genotype on eight important characters, viz. days to first flowering, days to 75% flowering, days to first fruit harvest, number of fruit clusters/ plant, fruit width (cm), number of fruits/plant, average fruit weight (g) and average fruit yield/plant (kg). Relative heterosis and heterobeltiosis provides an idea about the nature of gene actions involved in the genetic control of the concerned trait. Relative heterosis besides epistatic effects also indicate the presence of dominance effects (intra allelic interaction), while heterosis is indicative of over dominance. Analysis of variance and result reveals highly significant difference for almost all the characters. The heterosis and heterobeltiosis ranged from 23.33 to 197. 80% and from 21.06 to 166.03 %, respectively. The results of present investigation also revealed that the crosses P7 × P8 (PPC × Udaipur local) and P8 × P10 (Udaipur local and Pusa Bhairav) exhibited high degree of heterosis and heterobeltiosis for fruit yield and other yield attributing traits, viz. fruit weight, fruit width and number of fruits/cluster indicating the additive or synergistic effect of the component characters on fruit yield.

Key words: Attributing traits, Brinjal, Diallel cross, Heterobeltiosis, Hybridization, Manifestation

Recent exploitation of hybrid vigour in vegetable crops is considered to be one of the outstanding achievements in vegetable breeding. Being primary centre of origin, India has accumulated wide range of variability in brinjal as reported by several workers. Inspite of large number of varieties available in this crop, only a few are promising. This fact draws the attention of plant breeders for its improvement. The estimation of heterosis and heterobeltiosis provides information regarding the yield potential of that particular genotype. To know the potentiality of hybrids in a particular crop, the magnitude and direction of heterosis is of paramount importance. Heterosis response largely depends upon the genetic divergence among parents involved in a particular study. Very meagre work were done especially in southern Rajasthan on brinjal which is one of the major vegetable crops of this state. In the present study, an attempt has been made to gather information on the extent of heterosis in a diallel cross to produce promising hybrids/pure lines in brinjal.

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MATERIALS AND METHODS

An experiment was conducted during *rabi* 2011 and *kharif* 2012 at Department of Horticulture, MPUAT, Udaipur (Rajasthan). The experimental materials comprised 10 diverse brinjal lines, viz. Pusa Ankur (P-1), Arka Nidhi (P-2), Arka Keshav (P-3), IC-112358 (P-4), IC-90984 (P-5), Pusa Uttam (P-6), Pusa Purple Cluster (P-7), Udaipur local (P-8), Pusa Upkar (P-9) and Pusa Bhairav (P-10). The complete set of 45 F1's and 10 parents were grown in randomized block design (RBD) with three replications. The spacing 75 × 60 cm was adopted in rows of 7.20 m length. All the recommended agronomic package of practices was followed to grow a healthy crop. The observations were recorded on five randomly selected plants per replication for each genotype on eight important characters, viz. days to first flowering, days to 75% flowering, days to first fruit harvest, number of fruit clusters/plant, fruit width (cm), number of fruits/plant, average fruit weight (g) and average fruit yield/plant (kg). Heterosis was calculated over mid, better and best (top) parents, respectively. In the study, the economic heterosis for fruit yield as well as other yield

attributing traits were calculated over the standard parent, i.e. Udaipur local (P-8), a local and commonly grown variety in southern Rajasthan having spines on the fruit calyx. The data obtained for each character in F1 generation and parents were analysed as per the method suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

The commercial exploitation of heterosis is an outstanding example of application of the principles of genetics in the field of plant breeding. For commercial exploitation of heterosis, a hybrid must have sufficient level of superiority over standard/best variety. Relative heterosis and heterobeltiosis provides an idea about the nature of gene actions involved in the genetic control of the concerned trait. Relative heterosis besides epistatic effects also indicates the presence of dominance effects (intra-allelic interaction), while heterobeltiosis is indicative of over dominance. The analysis of variance revealed that mean square due to the parents and hybrids were highly significant for all the characters, indicating sufficient variation among these genotypes. The estimates of heterosis over mid, better and standard parent for different characters are presented in Table 1. Significance of mean square due to parents vs crosses for all the characters, suggested the presence of heterosis for these characters. F1 crosses varied in magnitude and direction of heterosis for most of the characters. The main cause of heterosis was dominance effect. The range of parents and F1's average performance of heterosis over all crosses and over heterotic crosses, number of heterotic crosses, range of heterosis over better parents, best heterotic F1's, best performing F1 and the top parent value are presented in Table 2. Out of the 45 F1 hybrids, as many as 10 and 39 crosses were better than their better parent and standard parent, respectively, in respect to days to first flowering, 22 in days to first fruit harvest, 6 for number of fruit clusters/plant, 36 for number of fruits/plant,12 in average fruit weight and all the 45 F1 hybrids in fruit yield/plant. Early flowering gives an idea of early fruiting. Wide variation was recorded among parents and hybrids in respects of days to flowering and days to first fruit harvest. Earliest flowering parents were taken as a base for heterosis estimates. In general, heterosis for days to first flowering, days to 75% flowering and days to first fruit harvest were required in negative direction hence,10 cross combinations showed negative and significant heterosis over better parent, while 21 and 20 cross combinations exhibited negative and significant over their respective mid parental value for these two characters. For days to first flowering trait heterobeltiosis in desirable direction was noted in only 10 cross combinations out of 45 studied. The cross P1× P4 depicted the highest heterobeltiosis (-18.01%) followed by P1× P10 (-6.20 %), P6 × P8 (-5.50%), P2 × P3 (-4.67%) and P5 × P8 (-4.08%) and lowest heterobeltiosis was exhibited by cross P7 × P8 (-2.45%). In case of days to 75% flowering the heterobeltiosis varied from -2.47% (P2 × P7) to -11.61% (P1 × P4). Ten crosses revealed the significant and negative heterobeltiosis for days to 75% flowering. High heterobeltiosis was noted in the cross combinatiob P7 × P8(-4.15%), P1 × P10 (-3057 %), P4 × P8 (-3.32%) and P5 × P8 (-3.32%). Where as the significant negative heterobeltiosis for days to first harvest was depicted by 22 cross combinations that ranged from -2.48% (P4 × P5) to 13.01% (P1 × P4). The best five crosses for this trait were P1 × P4, P2 × P3, P2 × P7, P3 × P5 and P3 × P9. However, the significant negative heterobeltiosis for days to first flowering and days to first fruit harvest were recorded in crosses P1 × P4, P1× P10, P6 × P8, P2 × P3 and P5 × P8. The heterosis for earliness in brinjal has also been reported by many workers, Chowdhury *et al.* (2010), Nagai and Kida (1926), Singh and Gautam (1991) and Singh and Maurya (2005).

Wide range of heterosis over better parent was recorded, ranged from -2.45 to -18.01 and -2.47 to -11.61 for these two characters, respectively. The hybrid P1 × P4 showed maximum heterosis for both the traits. This hybrid is also the best performer in respect of these two characters. Presence of heterosis for early flowering and fruiting in brinjal has also reported by Dash and Mishra (1995), Ingale and Patil (1997), Prakash *et al.* (2008) and Suneetha and Kathiria (2006). In case of fruit clusters per plant, the cross combination P7 × P8 recorded the highest positive heterosis (219.0%), whereas six crosses showed significant positive heterobeltiosis for this trait. The almost all hybrids except only one exhibited significant and positive heterosis for number of fruits per plant. The highest magnitude of heterosis was depicted by the cross P7 × P8 (129.89%). Significant and positive heterobeltiosis was recorded in 36 crosses. The cross combination P6 × P9 was found to be best performing hybrid for fruit width and fruit weight. In case of fruit weight, the parent P9 has recorded the maximum mean fruit weight (170.67), whereas the best performing F1 hybrid P6 × P9 has recorded fruit weight (193.00g). In brinjal fruit width and fruit weight are directly related to the fruit yield. Significant positive economic heterosis for fruit width was observed in crosses P6 × P9, P1 × P8, P1 × P9, P6 × P8 and P1 × P6. All these crosses exhibited sufficient heterosis for average fruit weight also. Significant positive heterobeltiosis for fruit width was exhibited in crosses P5 × P7, P1 × P8 and P8 × P10. Out of these three crosses, two crosses, i.e. P1 × P8 and P8 × P10 exhibited significant heterobeltiosis for average fruit weight also. Similar, results have also been obtained by the Khapte *et al.* (2012) and Mankar *et al.* (1995), Nalini *et al.* (2011), Sawant *et al.* (1992) and Shafeeq *et al.* (2007).

Number of fruit clusters/plant is an important yield attributing trait in brinjal because it is closely associated with more number of fruits/plant and ultimately increased fruit yield/plant. Significant and positive economic heterosis for fruit clusters/plant was recorded only in one cross, i.e. P3 × P7. This cross also exhibited significant economic heterosis for number of fruits/plant and average fruit yield/plant. Significant and positive heterobeltiosis for fruit

Table 1 Extent of heterobeltiosis for fruit yield and its attributing traits in brinjal

Cross	Days to Ist flowering	Days to 75% flowering	Days to first fruit harvest	Fruit clusters/ plant	Fruit width (cm)	Number of fruits/plant	Average fruit weight(g)	Average fruit yield/plant(kg)
	Heterobeltiosis	Heterobeltiosis	Heterobeltiosis	Heterobeltiosis	Heterobeltiosis	Heterobeltiosis	Heterobeltiosis	Heterobeltiosis
P1×P2	-3.84**	-0.45				59.65**		56.59**
P1×P3			80..44**	5.68	87.53**			
P1×P4	-18.01**	11.61**	-13.01**		45.40**	21.99**	53.32**	
P1×P5		23.07**	27.80**	57.60**				
P1×P6	-0.10		26.57**		80.71**			
P1×P7		24.07**	52.80**					
P1×P8	-3.54**		16.54**	86.51**	15.95**	125.13**		
P1×P9		59.65**		26.78**				
P1×P10	-6.20**	-3.57**		83.43**		91.77**		
P2×P3	-4.67**	-2.47*	-6.97**		9.84	60.44**		44.18**
P2×P4		-0.83	-1.86	16.99**		68.99**	11.54**	122.99**
P2×P5	-1.73	-2.04	-4.18**		50.20**	26.58**	92.35**	
P2×P6	-2.52*	0.42		14.56**		58.25**		58.26**
P2×P7		-2.47*	-5.27**		63.19**	6.59	50.09**	
P2×P8		-0.41	-1.29	29.13**		58.54**		25.46**
P2×P9	-0.95	-1.24	-4.27**		37.03**		41.19**	
P2×P10	-0.67		10.68**		80.54**		102.20**	
P3×P4		-0.47		78.43**	8.71	108.17**		
P3×P5	-1.74	-1.23	-5.77**		59.16**	14.02**	94.11**	
P3×P6	-0.75		50.36**		50.38**			
P3×P7		-0.41	-2.67**		57.22**		56.64**	
P3×P8	-1.11			97.07**		92.83**		
P3×P9	-1.90		-5.52**		104.75**	26.12**		
P3×P10		116.45**		109.82**				
P4×P5	-1.13	-2.49**	-2.48**		10.72**	13.50*	28.28**	
P4×P6	-0.75	-0.42	-3.26**		36.06**		93.36**	
P4×P7	-0.28	-1.66	-3.80**	6.37		1.71	21.06**	
P4×P8	-1.89	-3.32**	-2.72**		74.90**	18.23**	144.97**	
P4×P9	-1.05	-2.07	-4.27**	65.52.**		40.90**		
P4×P10	-0.58			88.12**	13.75**	134.93**		
P5×P6	-3.54**	-1.67			39.62**		113.49**	
P5×P7		-0.41	-3.41**		27.65**	12.64**		46.76**
P5×P8	-4.08**	-3.32**	-3.41**		34.46**		96.79**	
P5×P9		-1.24	-3.17**		20.08**		73.14**	
P5×P10				8.28		71.67**		
P6×P7		-4.42**		2.73		49.60**		
P6×P8	-5.50**	-2.93*	-2.87**		24.96		170.06**	
P6×P9	-0.57		-3.25**		13.09**	36.99**		
P6×P10			-0.24		12.99	1.74	120.06**	
P7×P8	-2.45	-4.15**	-5.22**	59.55**		62.65**		157.87**
P7×P9		-2.48*	-4.60**	1.87		0.77		23.11**
P7×P10			14.23**			53.35**		
P8×P9	-029	-2.07	-2.80**		107.05**	65.40**		
P8×P10		-0.43			11.24**	62.57**	9.40*	166.03**
P9×P10	-					106.04**		79.22**
SED	0.77	0.91	0.89	0.68	0.15	3.21	4.27	0.31
CD 5%	1.52	1.81	1.76	1.34	0.29	6.37	8.47	0.061
CD 1%	2.01	2.39	2.33	1.77	0.39	8.43	11.20	0.81

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

Table 2 Range and mean values of parents and F1 hybrids and heterosis

Range, mean and heterosis	Days to first flowering	Days to 75% flowering	Days to first harvest	Fruit clusters/ plant	Fruit width (cm)	Number of fruits/plant	Av. fruit weight (g)	Av. fruit yield/ plants (kg)
Parents range	67.73-74.07	74.67-82.00	79.40-92.73	13.73-17.80	2.66-7.57	28.67-78.07	47.67-170.67	2.61-5.11
Hybrid	55.53-72.87	66.00-81.33	69.07-88.60	12.73-28.40	2.53-7.49	33.33-127.40	52.00-193.00	4.68-13.13
Parents mean	71.20	79.80	87.64	15.53	4.99	41.13	96.23	3.84
Hybrids	69.39	78.21	84.36	17.79	4.87	69.27	102.86	7.53
Grand mean	69.72	78.50	85.01	5.38	4.89	64.16	101.66	6.86
CV	1.35	1.42	4.28	15.38	3.70	6.13	5.15	5.53
Top parent	(P1)67.73	(P1)74.67	(P1)79.40	(P7)17.80	(P6)7.57	(P7)78.07	(P9)170.67	(P9)5.11
Best performing	(P1×P4)	(P1×P4)	(P1×P4)	(P7×P8)	(P6×P9)	(P2×P7)	(P6×P9)	(P7×P8)
F1	55.53	66.00	69.07	28.40	7.49	127.40	193.00	13.13
Av. heterosis (%)	-19.75	-14.84	-16.45	219.00	0.79	111.98	26.56	197.81
Number heterotic crosses	21,10,3,9	20,10,39	37,22,4,4	13,6,1	8,3,11	44,36,45	26,12,14	45,45,45
Range of heterotic (%) over BP	-2.45-(-)-18.01	-2.47(-)-11.61	-2.48-(-)13.01	10.68-59.55	11.24-27.65	12.64-116.45	9.40-27.80	21.06-157.87
Best heterotic	(P1×P4)	(P1×P4)	(P1×P4)	(P7×P8)	(P1×P8)	(P3×P10)	(P4×P8)	(P7×P8)
F1(%) over BP	-18.01	-11.61	-13.01	59.55	16.54	116.45	18.23	157.87

clusters/plant was exhibited by the cross P7 × P8, P2 × P8, P2 × P4, P2 × P6, and P7 × P10. Most of these crosses, except P7 × P10 showed also significant heterobeltiosis for number of fruits/plant and average fruit yield/plant. In case of number of fruits/plant the significant and positive heterobeltiosis was recorded in 36 crosses. The highest magnitude of heterobeltiosis was exhibited by the cross P3 × P10 (116.45%) followed by P8 × P9 (107.05%), P9 × P10 (106.04%), P3 × P9 (104.75%), P3 × P8 (97.07%), P4 × P10 (88.12%) and P1 × P8 (86.51%). However, the rest of the crosses exhibited less than 85% heterobeltiosis. Manifestation of hybrid vigour for number of fruit clusters/ plant in brinjal was reported by Singh and Kalda (1989), Singh and Rai (1990) and Singh and Krishna Prasad (1995). While in case of fruit weight, the significant heterobeltiosis in positive direction was estimated in three cross combinations over the better parental value.The highest magnitude of heterobeltiosis was depicted by the cross P5 × P7 (27.65 %) followed by P1 × P8 (16.54 %) and P8 × P10 (11.24%).

Yield/plant ranged from 2.61 kg (P4) to 5.11 kg (P9) in case of parents and from 4.68 kg (P2 × P8) to 13.13 kg (P7 × P8) for hybrids. The highest magnitude of heterosis for yield/plant over mid (197.81%), better (157.87%) parent indicating the great possibility of heterosis breeding in brinjal. All the 45 cross combinations exhibited significant and positive heterobeltiosis. The highest magnitude of heterobeltiosis was depicted by the cross P8 × P10 (166.03%) followed by P7 × P8 (157.87%), P4 × P8 (144.97), P4 × P10 (134.93%) and P1 × P8 (125.13%). In rest of the crosses its magnitude was less than 125%. If hybrid vigour were mainly due to additive gene action, it would be associated with high genetic gain and if it is due to non-additive gene action, genetic gain would be low (Makani *et al*. (2013) and Suneetha and Kathiria (2005)). The range of heterosis was from 21.06 to 157.87% over the better parents and from 23.33 to 197.81% when compared to the corresponding mid parents. The cross P7 × P8 showed highest magnitude of heterosis for fruit yield and other economic characters. Makani *et al*. (2013), Nalini *et al.* (2011), Prakash *et al.* (2008) and Singh and Maurya (2005) noted that the increased yield over their respective better parents in heterotic hybrids ranging from 6.50 to 142.19%. From the foregoing discussion, it can be concluded that heterosis for fruit yield/plant, the number of fruits and fruit clusters, fruit width and days to harvest, to a large extent decide about the magnitude of heterosis for fruit width and days harvest ,a large extent decide about the magnitude of heterosis for fruit yield potentially. Further, it also indicates the heterosis for fruit yield might be through individual yield components or alternatively due to multiplicative effects of partial dominance of component characters. P7 × P8 stood out as the most divergent parents among the parental lines as one of them is involved in most of the crosses for highest heterotic effects. The cross combination P7 × P8 can be considered as to be the superior cross among the 45 crosses evaluated in the study and can be used for development of hybrids.

It is concluded that the crosses P7 × P8 (PPC × Udaipur local) and P8 × P10 (Udaipur local and Pusa Bhairav) showed high degree of heterosis and heterobeltiosis for fruit yield and most other desirable traits and can be utilized for further commercial exploitation and determining the strategies for future brinjal hybridization programme.

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