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Research Note

Heterosis for yield and yield components in Tomato (*Lycopersicon esculentum Mill*)

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Abstract
A trial comprising 15 hybrids and 8 parental lines was in conducted a randomized block design with three replications during winter 2010-11 at Vegetable Research Farm, Banaras Hindu University, Varanasi, India. Heterosis was estimated in fifteen single experimental cross hybrids, obtained by five parental lines namely H-24, DT-2, CO-3, Punjab Upma, Pant T-3 and three testers of tomato viz. Floradade, Kashi Sharad, Azad T-5 for yield and yield related traits; plant height, days to 50% flowering, number of fruits per plant, average fruit weight, fruit diameter, number of fruits per cluster and total yield per plant. Significant differences among genotypes were observed for all the traits. Positive and highly significant heterosis was found for number of fruits per plant 25.27%, 25.13% and 21.13% over better parent and 29.95%, 25.27% and 24.46% over standard parent and for total yield per plant 32.06%, 18.34%, 13.36% and 11.27% over better parent and 31.83%, 31.14%, 30.10% and 25.26% over standard check 'Azad T-5'. The hybrid also showed significantly high percentage of positive heterosis over better and standard parent for number of fruits per cluster, average fruit weight and the hybrids showed negative heterosis for plant height and day to 50% flowering which are desirable characters.

Keywords
Tomato, Heterosis, yield, component, significant.

Tomato (*Lycopersicon esculentum*) is one of the most widely grown vegetable across the globe. Efforts are being made to increase its productivity by developing superior varieties. India is the fourth largest tomato producer in the world after China, USA and Turkey, accounting for about 9% of the world tomato production and during 2009-10, the area and production of tomato in India was about 0.63 million hectare and 12.43 million tonnes respectively with average productivity of 19.6 tonnes per hecatre (Indian Horticulture Database, 2010). However, yield is a complex character and its direct improvement is difficult. Heterosis breeding provides an efficient means to break the yield barrier in most of crops including tomato. Knowledge of the extent of heterosis for yield and its various component characters is a pre- requisite to bring improvement through heterosis breeding. Heterosis in tomato was first observed by Hedrick and Booth (1968) for higher yield and more number of fruits. Since then, heterosis for yield, its components and quality traits were extensively studied. Choudhary *et al.* (1965) emphasized the extensive utilization of heterosis to step up tomato production. Heterosis\hybrid vigour is manifested as an improved performance of F_1 hybrids generated through crossing of two genetically diverse parents. The improvement in different quantitative and qualitative traits in tomato through heterosis breeding was observed by Tiwari and Lal, (2004), and reported significant heterosis ranging from 23.8% to71.71% for total yield. The present study was undertaken with a clear cut objective to estimate best heterotic combinations, obtained from eight diverse-tomato parental lines, crossed in line X tester pattern (Kempthorne,1957).

The present investigation was conducted at the vegetable research farm, Institute of Agricultural Sciences, Banaras Hindu University Varanasi, during winter season 2010-11. The experimental material consisted of five tomato lines (H-24, DT-2, CO-3, Punjab Upma, Pant T-3) and three testers (Floradade, Kashi Sharad, Azad T-5) which were crossed in a line X tester fashion during rainy season 2010. Twenty three genotypes of tomato comprising 15 crosses, 5 lines and 3 testers were grown during winter season 2011 and a standard check was included with parents (Azad T-5). The seedlings were transplanted in a randomized block

design with three replications at a spacing of 60 cm between rows and 45 cm between plants. Recommended cultural practices and plant protection measures were followed. The observations were recorded for seven traits viz., plant height, day to 50% flowering, number of fruits per plant, average fruit weight, fruit diameter, number of fruits per cluster and total yield per plant. The data were compiled for analysis of variance of different traits using method suggested by Panse and Sukhatme (1967). Heterosis was estimated over the better parent and over check by using the formulae (Kempthorne, 1957).

$$\text{Heterobeltiosis (\%)} = \frac{F_1 - BP}{BP} \times 100$$

$$\text{Standard Heterosis (\%)} = \frac{F_1 - C}{C} \times 100$$

F_1 = mean value of F_1, BP = mean value of better parent, C = mean value of check variety.

Estimates of mean squares for all the characters studied were highly significant indicating wide genetic differences among the genotypes. The heterotic effect in F_1 generation over standard, and better parents are presented in Tables 1 and 2.The plant height is an important trait by which growth and vigour of plants are measured. The hybrid CO-3 X Kashi Sharad exhibited the highest mean (78.60cm) for plant height at 60 days after transplantation. Heterosis for plant height at 60 days after transplantation varied from -45.78% to 5.36 % over better parents and -34.79% to -16.49% over standard check. Among the crosses, only the hybrid CO-3 X Kashi Sharad was significantly positive to better parent (5.36%). All crosses showed negative heterosis for plant height but only five crosses were showed negative heterosis for fruits per plant over standard check and ten crosses showed high number of fruits per cluster than their parents and check which are desirable traits for high yield. Because of spreading of plants more number of primary and secondary branches per plant, fruit cluster per plant and number of fruits per plant are useful to yield.

The longest days to 50% flowering (35 days after transplanting) were observed in Pant T-3 X Floradade. Significant and useful negative heterosis was observed for all 15 combinations over better parent and standard variety. Negative heterosis for days to first flowering was also reported by Premalakshme *et al* (2005).The number of fruits per plant is a major yield contributing character. The hybrid Pant T-3 X Kashi Sharad exhibited the highest mean number of fruits per plant(46.80). Heterosis varied from -16.48% to 29.95% over standard parent and -26.45% to 34.13% over better parent. Highly significant positive useful heterosis was observed in CO-3 X Kashi Sharad (34.13%). Seven crosses [CO-3 X Kashi Sharad (34.13%), H-24 X Azad T-5 (25.27%), Pant T-3 X Kashi Sharad (25.13%), Pant T-3 X Azad T-5 (21.13%), CO-3 X Floradade (13.67%), Punjab Upma x Azad T-5 (9.60%) and H-24 X Floradade (9.57%)] gave significantly positive heterosis over better parent and seven crosses [CO-3 X Kashi Sharad(29.95%), H-24 X Azad T-5 (25.27%), Pant T-3 X Kashi Sharad (28.57%), Punjab Upma x Azad T-5 (24.46%), Pant T-3 X Azad T-5 (24.46%), CO-3 X Floradade (20.33%) and H-24 X Floradade (15.99%)] gave significantly positive heterosis over standard check. Significant result has been found for number of fruits per plant by Saleem *et al*., (2009). High average fruit weight is of prime importance in breeding high yielding cultivars. The hybrid H-24 X Kashi Sharad exhibited the highest Average (98g) fruit weight. Heterosis varied from -5.46% to 23.53% over standard parent and -26.57% to 13.08% over better parent. Highly significant positive useful heterosis was observed in H-24 X Kashi Sharad (13.08%) and Co-3 X Azad T-5 (10.84%) over better parent. H-24 X Kashi Sharad showed highly significant heterosis over standard check (23.53%). Eight crosses [H-24 X Kashi Sharad (23.53%), DT-2 X Kashi Sharad (14.71%), DT-2 X Azad T-5 (14.20%), Punjab Upma X Kashi Sharad (12.18%), CO-3 X Azad T-5 (11.31%), CO-3 X Floradade (9.66%), DT-2 X Floradade (7.14%) and Pant T-3 X Azad T-5 (7.14%).] gave significantly positive heterosis over standard parent. Positive heterosis over better parent for average fruit weight was also reported by Singh *et al* (2005). Four hybrids possessed significantly useful heterobeltiosis for fruit weight by Rahmani Gul *et al*. (2010).The hybrid DT-2 X Azad T-5 exhibited the highest fruit diameter ((6.16 mm). The estimate of heterosis varied from -25.49% to 16.96% over better parent and -27.85% to 16.96% over standard parent, only in one cross highly significant positive useful heterosis was observed (DT-2 X Azad T-5) (16.96%) over standard parent.

The number of fruits per cluster is a major yield contributing character and maximum number of fruits per cluster was observed in Co-3X Azad T-5 (5.22).The estimate of heterosis varied from -25.97% to 16.95% over better parent and -22.73% to 18.18% over standard parent. H-24 X Azad T-5 (14.71%) and Co-3 X Azad T-5 (9.86%) hybrid showed highly significant positive heterosis over better parent. Hannan, *et al.* (2007) also found that six crosses gave significantly positive mid parent heterosis and four of them exhibited significant positive heterobeltiosis. High fruit yield per plant is the ultimate goal of any breeding programme and so requires higher consideration. The hybrid Co-3 X Kashi Sharad had the highest total yield (3.79Kg) per plant. Heterosis varied from -8.54% to 31.83% over standard parent and - 26.57% to 32.06% over better parent. Significant positive heterosis over standard parent was observed in Co-3 X Floradade (31.83%) followed by Co-3 X Kashi Sharad (31.14%).

Among the fifteen crosses, nine crosses showed significantly positive heterosis over standard parent and five of them over better parent. The increased yield in these two hybrids may be due to the high yielding parents selected for hybridization as suggested by Courtney and Peirce (1979). Positive high significant heterosis was found for yield over the better parent by Bhatt e*t al*. (2001) and significant high positive heterosis over mid-parent and better parent along with better performance in term of yield per plant by Sekhar *et al*.(2010).

It can be concluded from the result that tomato hybrid H-24 X Azad T-5 produced the highest number of fruits/plant while CO-3 X Kashi Sharad produced highest total yield/ plant.

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Table 1. Mean performance of Parents and F_1 hybrids and extent of heterosis in tomato for Plant height, Day to 50% flowering and No. of fruits/plant.

Parents &Crosses	Plant height (cm)			Day to 50% flowering			No. of fruits/plant		
	Mean	Heterobeltiosis	Standard heterosis	Mean	Heterobeltiosis	Standard heterosis	Mean	Heterobeltiosis	Standard heterosis
H-24	94.00	_	_	30	_	_	35.40	_	_
DT-2	90.17	_	_	30	_	_	36.13	_	_
CO-3	64.93	_	_	35	_	_	35.27	_	_
PUNJABUPMA	119.33	_	_	28	_	_	41.33	_	_
PANT T-3	98.70	_	_	26	_	_	37.40	_	_
FLORADADE	81.60	_	_	36	_	_	38.53	_	_
KASHI SHARAD	74.60	_	_	39	_	_	33.13	_	_
AZAD T-5 (check)	101.67	_	_	36	_	_	36.40	_	_
Crosses									
H-24 X FLORADADE	84.90	-9.68**	-16.49**	28	-23.64**	-23.64**	42.22	9.57**	15.99**
H-24 X KASHI SHARAD	75.95	-19.20**	-25.30**	32	-18.64**	-12.73**	33.21	-6.19	-8.76*
H-24 X AZAD T-5	77.14	-24.12**	-24.12**	30	-18.18**	-18.18**	45.60	25.27**	25.27**
DT-2 X FLORADADE	66.30	-26.47**	-34.79**	26	-29.09**	-29.09**	33.80	-12.28**	-7.14
DT-2 X KASHI SHARAD	69.74	-22.65**	-31.40**	28	-28.81**	-23.64**	31.70	-12.26**	-12.90**
DT-2 X AZAD T-5	67.73	-33.38**	-33.38**	32	-12.73**	-12.73**	30.40	-16.48**	-16.48**
CO-3 X FLORADADE	68.61	-15.92**	-32.51**	24	-34.55**	-34.55**	43.80	13.67**	20.33**
CO-3 X KASHI SHARAD	78.60	5.36*	-22.69**	32	-18.64**	-12.73**	47.30	34.13**	29.95**
CO-3 X AZAD T-5	77.03	-24.23**	-24.23**	28	-23.64**	-23.64**	35.30	-3.01	-3.01
PUNJAB UPMA X FLORADADE	70.97	-40.53**	-30.19**	28	-23.64**	-23.64**	30.40	-26.45**	-16.48**
PUNJAB UPMA X KASHI SHARAD	68.19	-42.86**	-32.93**	30	-23.73**	-18.18**	38.20	-7.58*	4.95
PUNJAB UPMA X AZAD T-5	64.70	-45.78**	-36.36**	26	-29.09**	-29.09**	45.30	9.60**	24.46**
PANT T-3 X FLORADADE	78.63	-20.33**	-22.66**	35	-4.55*	-4.55*	39.50	2.52	8.53*
PANT T-3 X KASHI SHARAD	78.34	-20.63**	-22.95**	26	-33.90**	-29.09**	46.80	25.13**	28.57**
PANT T-3 X AZAD T-5	75.97	-25.28**	-25.28**	24	-34.55**	-34.55**	45.30	21.13**	24.46**
SE		1.51	1.51		0.74	0.74		1.27	1.27
CD (0.05)		3.09	3.09		1.53	1.53		2.60	2.60

*,** = Significant at 0.05 and 0.01 level of probability respectively.

Table 2. Mean performance of Parents and F1 hybrids and extent of heterosis in tomato for days to average fruit weight, Fruit diameter, fruits/cluster and fruit yield / plant.

Parents &Crosses	Average fruit weight(g)			Fruit diameter(cm)			fruits/cluster			Total Yield/ plant (kg)		
	Mean	Hetero beltiosis	Standard heterosis	Mean	Hetero beltiosis	Standard heterosis	Mean	Hetero beltiosis	Standard heterosis	Mean	Hetero beltiosis	Standard heterosis
H-24	80	_	_	4.44	_	_	4.53	_	_	2.85	_	_
DT-2	87	_	_	5.00	_	_	4.87	_	_	3.00	_	_
CO-3	79	_	_	4.64	_	_	4.73	_	_	2.76	_	_
PUNJAB UPMA	87	_	_	5.24	_	_	5.13	_	_	3.60	_	_
PANT T-3	87	_	_	4.44	_	_	3.93	_	_	3.25	_	_
FLORADADE	89	_	_	5.26	_	_	3.80	_	_	3.45	_	_
KASHI SHARAD	86	_	_	5.08	_	_	3.87	_	_	2.87	_	_
AZAD T-5 (check)	79	_	_	5.25	_	_	4.40	_	_	2.89	_	_
						Crosses						
H-24 X FLORADADE	81	-9.67**	2.10	4.48	-14.94**	-14.94**	4.80	5.88	9.09*	3.42	-0.97	18.34**
H-24 X KASHI SHARAD	98	13.08**	23.53**	5.12	0.30	-2.78	4.60	1.47	4.55	3.25	13.36**	12.57**
H-24 X AZAD T-5	75	-7.02**	-5.46*	4.42	-16.08**	-16.08**	5.20	14.71**	18.18**	3.42	18.34**	18.34**
DT-2 X FLORADADE	85	-5.20*	7.14**	5.42	2.91	2.91	5.20	6.85	18.18**	2.87	-16.80**	-0.58
DT-2 X KASHI SHARAD	91	3.90	14.71**	4.30	-15.69**	-18.35**	3.80	-21.92**	-13.64**	2.88	-3.67	-0.23
DT-2 X AZAD T-5	90	3.46	14.20**	6.16	16.96**	16.96**	4.40	-9.59**	0.00	2.75	-8.02*	-4.73

Table 2. contd..

Parents &Crosses	Average fruit weight(g)			Fruit diameter(cm)			fruits/cluster			Total Yield/ plant (kg)		
	Mean	Hetero beltiosis	Standard heterosis	Mean	Hetero beltiosis	Standard heterosis	Mean	Hetero beltiosis	Standard heterosis	Mean	Hetero beltiosis	Standard heterosis
CO-3 X FLORADADE	87	-2.97	9.66**	4.44	-15.70**	-15.70**	4.80	1.41	9.09*	3.81	10.33**	31.83**
CO-3 X KASHI SHARAD	80	-7.46**	1.09	5.24	2.75	-0.51	3.40	-28.17**	-22.73**	3.79	32.06**	31.14**
CO-3 X AZAD T-5	88	10.84**	11.31**	4.26	-19.11**	-19.11**	5.20	9.86**	18.18**	3.12	7.84	7.84
PUNJAB UPMA X FLORADADE	87	-2.97	9.66	5.00	-5.06*	-5.06*	3.80	-25.97**	-13.64**	2.64	-26.57**	-8.54*
PUNJAB UPMA X KASHI SHARAD	89	2.30	12.18**	5.28	0.89	0.25	4.00	-22.08**	-9.09*	3.40	-5.56	17.65**
PUNJAB UPMA X AZAD T-5	83	-4.60	4.62	5.20	-1.27	-1.27	3.80	-25.97**	-13.64**	3.76	4.44	30.10**
PANT T-3 X FLORADADE	81	-9.67**	2.10	5.30	0.63	0.63	4.60	16.95**	4.55	3.20	-7.34*	10.73*
PANT T-3 X KASHI SHARAD	75	-13.79**	-5.46*	3.80	-25.49**	-27.85**	4.00	1.69	-9.09	3.51	7.89*	21.45**
PANT T-3 X AZAD T-5	85	-2.30	7.14**	4.30	-18.35**	-18.35**	3.50	-20.45**	-20.45**	3.62	11.27**	25.26**
SE		2.02	2.02		0.11	0.11		0.16	0.16		0.11	0.11
CD (0.05)		4.14	4.14		0.23	0.23		0.33	0.33		0.23	0.23

*,** = Significant at 0.05 and 0.01 level of probability respectively.