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Heterosis for earliness, marketable yield and component traits in tomato (*Lycopersicon esculentum* Mill.)

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Abstract

A set of 20 F_1 hybrids of tomato developed as a result of line x tester mating design involving 10 lines and two testers were evaluated in Randomized Block Design in three replications during 2002-2003 for earliness, marketable fruit yield and component traits. The cross combinations showed the manifestation of hybrid vigour over better parent (BP) and standard checks (JK66 and Avtar) for all the characters except polar and equatorial diameter. The standard heterosis in the desirable direction could be recorded in 10 cross combinations *viz.*, BL342-1 x Solan Gola, EC 392697 x Solan Gola, EC 392697 x Roma, Rodade x Solan Gola, BL342-1 x Roma, EC 357838 x Roma, BL-333 x Roma, and EC 357838 x Solan Gola, Rodade x Roma and EC 179908 x Roma in one or other important horticultural traits. The hybrids BL342-1 x Solan Gola and EC 357838 x Solan Gola were the top overall performer and early yielder, respectively and needs to be further evaluated for commercial utilization.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the major vegetable crops grown both for fresh market and processing. In Himachal Pradesh, tomato is grown extensively as a cash crop in Zone II and of late in zone I (Anonymous, 2005).The agro-climatic conditions of Himachal Pradesh are ideally suited for the production of tomato as an off-season crop, since the fruits are available in the market at such a time (June-October) when it does not grow well in the plains on account of unfavourable temperature (high) prevailing over there. Tomato, though, a self-pollinated crop, has tremendous potential for heterosis breeding. Of late, the commercial exploitation of hybrid vigour has received great importance on account of several advantages of hybrids over pure line varieties such as increased marketable fruit yield and resistance to biotic and abiotic stresses, resulting in the development of large number of hybrids in the country. Tiwari and Lal (2004) and Joshi and Thakur (2003) realized improvement in different quantitative and qualitative traits in tomato through heterosis breeding. With the popularity of F_1 hybrids in tomato, it is imperative to obtain such hybrid, which has excellent qualities along with high yields. The best way to achieve this in shortest possible time is by mating large number of selected parents and elimination of poor progenies. Keeping these facts under consideration, the present investigation was therefore, designed to study the nature and extent of heterosis for earliness, marketable fruit yield and component traits in tomato.

Material and Methods

The experimental material for the present study comprised 10 lines used as female viz., BL-333, Hawaii 7998, Rodade, EC 357838, EC29627, EC 392698, EC 179908, EC 179906, EC 392697, BL342-1, two testers used as male *viz.*, Solan Gola and Roma, their 20 F_1 hybrids and two standard checks *viz.*, JK66 (SC_1) and Avtar (SC_2). All the thirty four entries were evaluated in Randomized Block Design with three replications at the Experimental Farm, Hill Agricultural Research and Extension Centre, Bajaura (Kullu). The experimental area represents mid hill of Himachal Pradesh and is situated between 32°8' N latitude and 77°E longitude at an elevation of 1090 m above mean sea level with average rainfall upto 1000 mm. Each experimental plot consisted of two rows of 3.6 m length. The spacing between and within rows was 75 cm and 45 cm, respectively. Out of the two checks, the one hybrid giving higher desirable mean value for the character under consideration was recognized as the best standard check (BSC). The

observations were recorded on 5 competitive plants taken at random in each entry and replication for marketable yield per plant (kg), number of fruits per plant, mean fruit weight (g), fruits per cluster, polar diameter (cm), equatorial diameter (cm), days to 50 per cent flowering, days to first harvest and plant height (cm). Statistical analysis was carried out as per Singh and Chaudhary (1977) and heterosis was calculated as per cent increase or decrease in F_1 hybrids over better parent (BP) and best standard check (BSC).

Results and Discussion

The analysis of variance, for all the characters studied, indicated significant differences among the treatments i.e. lines, testers and hybrids. The range of mean performance and heterosis along with three best cross combinations on the basis of *per se* performance heterosis over better parent (BP) and over best standard check (BSC), are given in Table 1. Heterosis to the extent of 38.99, 47.14, 18.39, 17.07, 2.40, 6.96, -31.53, -9.10 and 36.59 per cent over better parent and 71.31, 41.23, 63.59, 14.58, 6.07, 10.89, -25.29, -15.56, -2.95 over best standard check was recorded for marketable fruit yield, number of fruits per plant, mean fruit weight, fruits per cluster, polar diameter, equatorial diameter, days to 50 per cent flowering, days to first harvest and plant height, respectively.

Higher yield is the basic objective of all crop improvement programmes and unless a new hybrid has a potential equal to or exceeding that of commercial cultivar or hybrid, it will fetch no success even if it has excellent quality. For marketable yield per plant (Kg) the magnitude of heterosis ranged from -43.59 (EC 29627 x Roma) to 38.99 per cent (BL342-1 x Solan Gola) and -65.89 (EC 29627 x Roma) to 71.31 per cent (BL342-1 x Solan Gola) over BP and BSC, respectively. The hybrid BL342-1 X Solan Gola (38.99 %) showed the maximum hybrid vigour followed by Hawaii 7998 x Solan Gola (31.52 %), EC 392697 x Solan Gola (29.35 %) and EC 179906 x Solan Gola (29.35 %) for marketable yield per plant (Table 2). Hybrid vigour for marketable yield in tomato has also been reported by Sharma *et al.* (2001) and Katoch (2002). As many as seven hybrids over BP and one over BSC displayed significant positive heterosis.

Number of fruits per plant and mean fruit weight are the traits, which directly contribute towards higher yield in tomato. Five of the crosses over better parent and three over BSC exhibited hybrid vigour for number of fruits per plant. The cross Rodade x Solan Gola (47.14 %) was having highest positive heterosis over better parent and EC 392697 x Solan Gola (41.23 %) over best standard check (JK66). The other crosses *viz.*, EC 179908 x Solan Gola (29.76 %) and EC179906 x Solan Gola (26.43 %) were also found promising. The crosses BL342-1 x Solan Gola (63.59 %) and BL342-1 x Roma (8.79 %) exhibited the significant desirable standard heterosis for mean fruit weight. Mageswari and Natarajan (1999) have also observed hybrid vigour in variable number of hybrids for these traits.

Number of fruits per cluster has direct influence on fruit number per plant. Only two crosses *viz.*, Rodade x Roma (17.07%) and Rodade x Solan Gola (14.79%) expressed significant and desirable heterobeltiosis while only one i.e. EC 357838 x Roma (14.58%) had shown standard heterosis for this trait. Hybrid vigour for fruits per cluster was also reported by Sharma (1988). None of the cross combinations exhibited significant desirable heterosis for polar and equatorial diameter in the present investigation, which were in line with the findings of Raijadhav and Kale (1985).

Earliness is a highly desirable attribute in vegetables in the sense that the prevailing prices in the market are invariably higher early in the season. Days to 50 per cent flowering and days to first harvest are the two important traits used as a measure of earliness. EC357838 x Solan Gola and BL-333 x Roma are the only two crosses found promising for these two traits with significant negative heterobeltiosis of -31.53 and -27.04 per cent for days to 50 per cent flowering and -9.10 and -7.28 per cent for days to first harvest, respectively. Vidyasagar *et al* .(1998) also reported the similar findings. Increased plant height is a desirable trait to realize higher marketable yield provided the environmental conditions are the otherwise conducive for fruiting and growth over a longer period. Seven hybrids exhibited significant heterobeltiosis for increased plant height and none exhibited standard heterosis. However, for decreased plant height the cross EC179906 x Roma (-39.39 per cent) can be successfully exploited. Kaul (1967) recorded increase as well as decrease in plant height in the F_1 hybrids of tomato.

Table 1. Range of mean performance, heterosis, best standard check and top three hybrids for earliness, marketable yield and component traits in tomato

Character	Range		Heterosis (%) over		Best standard check	Best hybrids based on		
	Parents (Lines and testers)	Hybrids	Better parent	Best standard check		*Per se* performance	Heterosis over BP	Heterosis over BSC
Marketable yield / plant (kg)	0.33-1.59	0.44-2.21	-43.59 to 38.99	-65.89 to 71.31	JK66	BL342-1 Solan Gola, Hawaii7998 x Solan Gola, EC179906 x Solan Gola, EC29627 x Solan Gola	BL342-1x Solan Gola, Hawaii7998 x Solan Gola, EC392697 x Solan Gola, EC179906 x Solan Gola	BL342-1 x Solan Gola
Number of fruits / plant	24.23-72.07	25.33-52.07	-51.53 to 47.14	-31.29 to 41.23	JK66	EC392697 x Solan Gola, EC392697 x Roma, Rodade x Solan Gola	Rodade x Solan Gola, EC179908 x Solan Gola, EC179906 x Solan Gola	EC392697 x Solan Gola, EC392697 x Roma, Rodade x Solan Gola
Mean fruit weight (g)	19.81-66.66	27.01-78.92	-48.16 to 18.39	-44.01 to 63.59	JK66	BL342-1 Solan Gola, BL342-1 Roma, EC392697 x Solan Gola	BL342-1 x Solan Gola	BL342-1x SolanGola, BL342-1 x Roma
Fruits / cluster	4.00-5.97	4.10-5.50	-30.53 to 17.07	-20.83 to 14.58	JK66	EC357838 x Roma, Rodade x Solan Gola , Hawaii7998 x Roma	Rodade x Roma, Rodade x Solan Gola	EC357838 x Roma
Polar diameter (cm)	2.57-6.06	2.96-5.24	-51.16 to 2.40	-40.08 to 6.07	JK66	EC392697 x Roma, BL342-1 x Solan Gola	-	-
Equatorial diameter (cm)	3.25-5.52	3.09-5.60	-33.51 to 6.96	-38.81 to 10.89	JK66	BL342-1 x Solan Gola	-	-
Days to 50 per cent flowering	28.33-33.00	20.67-30.67	-31.53 to 7.06	-25.29 to 10.84	Avtar	BL-333 x Roma, EC357838 x Solan Gola, Rodade x Roma	EC357838 x Solan Gola, Rodade x Roma, BL333 x Roma	BL-333 x Roma, EC357838 x Solan Gola, Rodade x Roma
Days to first harvest	67.33-73.67	63.33-73.33	-9.10 to 4.96	-15.56 to -2.23	JK66	EC357838 x Solan Gola, BL-333 x Roma, EC179908x Roma	EC357838 x Solan Gola, BL-333 x Roma , EC179908x Roma	EC357838 x Solan Gola, BL-333 x Roma , EC179908 x Roma
Plant height	62.26-129.49	67.86-133.93	-45.60 to 36.59	-50.81 to -2.95	JK66	EC179906 x Solan Gola, EC357838 x Roma, EC357838 x Solan Gola	EC392697 x Roma , BL342-1 x Roma, EC179906 x Solan Gola	-

Table 2. Heterosis (%) over better parent (BP) and best standard check (BSC) for earliness, marketable yield and component traits in tomato

Crosses	Marketable yield plant (Kg)		Number of fruits plant		Fruits / cluster		Mean fruit weight (g)		Polar diameter (cm)		Equatorial diameter (cm)		Days to 50 per cent flowering		Days to first harvest		Plant height (cm)	
	BP	BSc	BP	BSc	BP	BSc	BP	BSc	BP	BSc	BP	BSc	BP	BSc	BP	BSc	BP	BSc
BL-333 x Solan Gola	-10.87	-36.43*	-39.84*	-11.04	-11.25*	3.54	-16.78*	-0.062	-7.58	-6.28	-14.67*	-6.73	-5.86	-3.61	0.96	-7.56*	-20.84*	-37.06*
BL-333 x Roma	11.54	-32.56*	-23.88*	12.56	-14.82*	-0.63	-2.03	-19.11*	-24.09*	-6.88	-2.08	-16.04*	-27.04*	-25.29*	-7.28*	-15.10*	31.58*	-30.08*
Hawaii7998 x Solan Gola	31.52*	-6.20	-43.43*	10.58	-4.51	1.46	-32.73*	-19.22*	-26.35*	-25.30*	-20.65*	-13.27*	1.12	10.84*	0.94	-4.44	12.63*	-10.44*
Hawaii7998 x Roma	-11.54	-46.51*	-51.53*	-5.26	1.37	7.71	-1.86	-18.97*	-44.39*	-31.78*	-1.16	-32.48*	1.12	10.84*	3.28	-2.23	7.89	-26.88*
Rodade x Solan Gola	6.52	-24.03*	47.14*	30.38*	14.79*	8.33	-28.66*	-14.32*	-28.94*	-27.94*	-33.51*	-27.33*	-12.37*	2.39	0.92	-3.56	-0.72	-13.33*
Rodade x Roma	15.38*	-30.23*	23.45*	9.38	17.07*	0.00	-13.09*	-27.59*	-27.56*	-11.13	-1.04	-24.95*	-29.88*	-18.07*	-5.12*	-9.33*	0.71	-12.07*
EC357838 x Solan Gola	-32.61*	-51.94*	-14.10	-11.77	-12.25*	0.00	-37.91*	-25.44*	-29.94*	-28.95*	-22.46*	-15.25*	-31.53*	-24.10*	-9.10*	-15.56*	2.39	-3.92
EC357838 x Roma	0.00	-39.53*	-7.76	-5.26	0.55	14.58*	-29.32*	-41.65*	-51.16*	-40.08*	6.96	-26.93*	-9.78*	0.00	2.87	-9.77*	2.80	-3.54
EC29627 x Solan Gola	-21.74*	-44.19*	-6.78	-9.06	10.07	4.79	-48.16*	-37.75*	-29.94*	-28.95*	-33.33*	-27.13*	3.41	9.61*	0.48	-7.56*	-9.82	-28.29*
EC29627 x Roma	-43.59*	-65.89*	-29.58*	-31.29*	0.00	-4.79	-32.19*	-44.01*	-50.33*	-39.07*	-10.43	-38.81*	-4.53	1.19	1.93	-6.22*	34.06*	-27.12*
EC392698 x Solan Gola	7.61	-23.26*	1.27	1.44	-30.53*	-20.83*	-19.60*	-3.44	-22.75*	-21.66*	-18.48*	-10.89	-7.68*	1.19	-5.58*	-9.77*	-1.28	-19.78*
EC392698 x Roma	8.97	-34.11*	-4.49	-4.34	-10.97*	1.46	-7.91	-23.96*	-20.13*	-2.02	1.45	-30.69*	-16.48*	-8.46*	-2.32	-6.22*	3.75	-15.68*
EC179908 x Solan Gola	-18.48*	-41.86*	29.76*	15.19	-3.53	-8.96	-44.93*	-33.87*	-15.97*	-14.78*	-24.82*	-17.82*	-13.19*	-4.84	3.85	-4.00	3.65	-6.27
EC179908 x Roma	2.56	-37.98*	19.37*	5.97	0.00	-14.58*	-4.52	-21.17*	-24.59*	-7.49	-16.33*	-26.93*	-23.08*	-15.68*	-5.77*	-12.89*	-45.60*	-50.81*
EC179906 x Solan Gola	29.35*	-7.75	26.43*	2.87	-7.28	-12.50*	-24.51*	-9.35*	-15.17*	-13.97*	-19.20*	-11.68*	0.00	3.61	3.97	-6.67*	22.05*	-2.95
EC179906 x Roma	20.51	-27.13*	14.59	-5.42	9.30	-2.08	-16.12*	-20.41*	-16.17*	2.83	-14.57*	-23.37*	-4.67	-1.23	4.96	-5.77*	7.05	-39.39*
EC392697 x Solan Gola	29.35*	-7.75	3.93	41.23*	-24.62*	-6.25	-16.26*	0.56	-13.37*	-12.15	-12.86*	-4.75	0.00	2.39	-2.36	-8.44*	8.27	-13.90*
EC392697 x Roma	15.38*	-30.23*	0.34	36.34*	-12.40*	8.96	-19.81*	-33.79*	-13.53*	6.07	2.89	-22.57*	0.00	2.39	-1.42	-7.56*	36.59*	-6.76
BL342-1 x Solan Gola	38.99*	71.31*	3.51	14.46	-8.11	-5.63	18.39*	63.59*	2.40	3.63	1.45	10.89	7.06	9.61*	1.86	-2.67	14.90*	-8.64*
BL342-1 x Roma	-27.04	-10.07*	-17.10*	-8.33	-12.17*	-9.79	-21.27*	8.79*	-27.23*	-10.73	-11.94*	-10.89	-9.39*	7.23	-5.10*	-8.89*	24.52*	-33.83*

* Significant at 5 per cent level of significance

In literature most of the research work pertaining to heterosis refers to average heterosis and hetrobeltiosis only. However, it is the standard heterosis, which is practically useful to the breeder. In the present studies, the cross combinations viz., BL342-1 x Solan Gola, EC 392697 x Solan Gola, EC 393697 x Roma, Rodade x Solan Gola, BL342-1 x Roma, EC 357838 x Roma, and EC 357838 x Solan Gola, BL-333 x Roma, Rodade x Roma and EC 179908 x Roma exhibited standard heterosis in one or more important horticultural traits. In some of the cross combinations lack of heterosis may be attributed to the internal cancellation of positive and negative effects and the dominance not being of unidirectional nature (Mather and Jinks, 1971).

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