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Short communication

Heterosis for yield and its contributing traits in tomato

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Tomato (*Lycopersicon esculentum* Mill.), is one of the most remunerative cash crop of mid hills of Himachal Pradesh as off-season vegetable for fresh market supply to plains. The hybrid cultivars have generated interest among the breeders for the possibility of combining a complex of valuable attributes in a genotype. However, in public sector, there is still a dearth of tomato hybrids. Realizing the economic potential of this crop, there is an urgent need to isolate the genotypes with desirable horticultural traits. Hence, the present investigations were undertaken for development of hybrids having better quality, earliness, uniformity and resistance to diseases.

The experimental material consisting of ten lines, *viz.*, EC-15998, AI-9, EC-174023, FT-5, Solan Vajr, UHF-656 (all indeterminate), UHF-553, UHF-659 (semi-determinate), UHF-612, and UHF-663 (determinate), were crossed in half-diallel fashion. The resulting, forty five F_1(s) along with ten parents and a commercial check hybrid Naveen were evaluated in a Randomized Complete Block Design (RCBD) with three replications, at experimental farm of Department of Vegetable Crops, Dr Y.S. Parmar UHF, Nauni, Solan (H.P.). Eighteen plants of each genotype were transplanted at a spacing of 90 cm x 30 cm. Observations were recorded on plant height, days to first picking, number of fruits per cluster, number of fruits per plant, fruit weight, pericarp thickness, fruit yield, total soluble solids and harvest duration. The data was statistically analyzed as suggested by Gomez and Gomez (1).

The analysis of variance for all the traits under study showed significant differences among parents and crosses revealing the presence of considerable variability among the genotypes. The mean performance of parents and crosses is presented in Table 1 and the heterobeltiotic effects are presented in Table 2. The tomato varieties/hybrids with indeterminate plant height are preferred in Himachal Pradesh due to longer harvest duration and lesser disease incidence. In the present studies, twenty seven hybrids showed significant heterobeltiosis for plant height (Table 2). The magnitude of heterosis varied from-34.44 (EC-174023 × UHF-612) to 43.67 per cent (FT-5 × UHF-659). These results are in close conformity with those of Joshi and Thakur (6). Early maturity is a desirable trait as it results in early supply of the produce with least competition and making the crops more profitable to the farmers. Thus, negative heterosis over better parent is desired for days to first flowering. Maximum (-9.01%) significant magnitude of negative heterobeltiosis was observed in FT-5 × Solan Vajr followed by UHF-659 × UHF-663. Heterobeltiosis for number of fruits per cluster was found to be highest in FT-5 × UHF-612 followed by UHF-656 × UHF 659. The hybrids UHF-656 × UHF-612 and EC-174023 × UHF-612 showed maximum heterobeltiotic effects for number of fruits per plant. Similar effects for this trait were also reported by Joshi *et al.* (5), and Pujari and Kale (7).

The heterobeltiotic effect for average fruit weight ranged from -21.60 (FT-5 × UHF-612) to 23.52 per cent (EC-15998 × UHF 612). Three crosses FT-5 × Solan Vajr, AI-9 × Solan Vajr and EC-15998 × Solan Vajr showed significant positive increase over check Naveen. The heterosis over better parent for pericarp thickness ranged from -41.82 (EC 174023 × Solan Vajr to 24.20 per cent (UHF-656 × UHF -612). Only five crosses registered significant positive heterobeltiotic effect for this trait. Similar effects were also obtained by Uppal *et al.* (8). Heterobeltiosis for fruit yield per plant ranged from - 29.04 (EC 15998 × UHF-656) to 40.74 per cent (FT-5 × Solan Vajr). A total of sixteen crosses showed significant positive heterobeltiotic effect with maximum increase of 40.74 per cent, whereas only four crosses produced significantly higher fruit yield per plant than check Naveen. Similar results were also reported by Bora *et al.* (3).

The highest (14.07%) heterosis over better parent for total soluble solids was observed in the cross Solan Vajr × UHF-659 and lowest (-27.14%) in FT-5 × UHF-612. Significant positive heterosis over better parent was observed in eight cross combinations. These results are in close conformity with Ashok Kumar (1), and Attri (2). Prolonged harvest duration is desirable for fresh market tomato production as it ensures continuous supply of vine ripe tomatoes and avoid glut in the market. The heterosis over better parent for the trait ranged from -27.03 (EC-174023 × FT-5) to 31.25 per cent (EC-15998 × AI-9).

EC-15998 × AI-9, FT-5 × Solan Vajr, AI-9 × Solan Vajr and Solan Vajr × UHF 659 were identified as

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Table 1. Mean performance of parents and crosses for yield and other horticultural traits in tomato.

Parent/Cross	Plant height (cm)	Days to first picking (days)	No. of fruits per cluster	No. of fruits per plant	Av. fruit weight (g)	Pericarp thickness (mm)	Yield/plant (g)	Total soluble solids (°B)	Harvest duration (days)
Parent									
EC-15998	115.36	70.00	3.59	20.67	56.19	5.92	1160.33	4.17	32.00
Al-9	98.49	72.00	3.53	21.67	71.04	6.38	1347.16	3.93	30.67
EC-174023	120.36	76.00	3.08	16.00	60.44	5.24	1013.48	3.97	28.33
FT-5	139.57	74.00	2.98	18.33	76.12	7.23	1279.35	4.79	37.00
Solan Vajr	164.37	75.33	3.77	18.67	69.51	7.46	1215.59	4.12	40.00
UHF-656	137.71	80.00	3.01	16.33	63.29	4.67	1056.96	3.44	39.00
UHF-553	89.14	67.00	3.31	18.67	55.43	3.84	1034.45	3.65	27.00
UHF-659	93.43	71.00	2.86	21.00	52.29	5.63	1172.59	3.33	38.00
UHF-612	72.13	62.00	3.37	16.67	56.31	4.43	963.92	3.22	31.00
UHF-663	84.25	69.00	4.07	19.33	53.30	6.72	922.19	3.98	28.00
Cross									
EC-15998 x Al-9	164.87	69.33	4.44	24.00	72.94	7.64	1743.48	4.32	42.00
EC-15998 x EC-174023	145.74	70.00	3.64	16.67	63.48	4.94	1047.70	3.60	41.00
EC-15998 x FT-5	168.73	69.00	2.35	18.00	59.91	5.64	1080.66	4.44	33.67
EC-15998 x Solan Vajr	175.82	71.00	3.38	14.67	82.41	5.71	1181.91	3.94	38.00
EC-15998 x UHF-656	163.98	73.00	2.82	13.67	71.53	5.41	823.42	4.03	42.00
EC-15998 x UHF-553	86.52	70.00	2.71	18.33	51.32	4.76	861.55	3.77	30.00
EC-15998 x UHF-659	143.67	73.00	3.63	20.00	61.71	5.70	1211.88	3.39	38.00
EC-15998 x UHF-612	98.67	71.00	3.69	21.67	69.55	4.64	1397.03	3.64	29.33
EC-15998 x UHF-663	96.00	70.00	3.28	16.33	68.59	6.64	1112.35	3.68	33.00
Al-9 x EC-174023	149.31	68.00	4.00	20.67	66.26	4.65	1340.60	3.92	35.00
Al-9 x FT-5	169.30	69.00	3.98	23.33	69.89	7.11	1601.67	4.02	36.67
Al-9 x Solan Vajr	168.04	71.00	4.16	22.00	82.59	7.00	1808.23	4.13	39.00
Al-9 x UHF-656	145.82	73.00	3.15	13.67	74.16	5.00	1060.83	3.44	37.00
Al-9 x UHF-553	118.04	68.00	3.02	16.67	68.71	4.40	1543.16	3.97	27.67
Al-9 x UHF-659	95.29	67.33	3.72	25.67	62.15	6.18	1585.25	4.03	29.67
Al-9 x UHF-612	102.69	63.67	3.26	14.00	74.13	5.64	1086.91	4.17	28.00
Al-9 x UHF-663	92.94	71.00	2.95	18.33	63.48	6.57	1165.76	3.94	31.67
EC-174023 x FT-5	151.65	73.00	3.23	20.67	73.37	4.42	1465.24	4.11	27.00
EC-174023 x Solan Vajr	153.66	79.00	3.28	18.67	80.22	4.37	1430.94	3.79	40.00
EC-174023 x UHF-656	162.43	82.33	3.50	16.67	65.48	4.04	1061.12	4.02	42.67
EC-174023 x UHF-553	118.15	75.33	3.59	16.33	57.29	5.06	858.12	3.20	30.67
EC-174023 x UHF-659	167.84	75.00	3.23	21.67	53.42	4.17	1204.07	3.52	40.00
EC-174023 x UHF-612	78.91	73.00	2.52	22.33	50.02	5.23	984.93	3.46	26.00
EC-174023 x UHF-663	133.62	70.00	2.53	15.33	70.02	5.60	764.43	3.87	35.00
FT-5 x Solan Vajr	221.84	67.33	4.35	22.00	83.00	7.25	1800.56	4.46	38.67
FT-5 x UHF-656	193.28	73.00	3.73	16.33	69.99	7.45	1200.06	4.39	38.00
FT-5 x UHF-553	112.50	68.00	3.72	20.00	68.33	5.68	1198.15	3.72	35.00
FT-5 x UHF-659	200.52	66.00	3.35	23.67	63.25	7.02	1620.68	3.79	48.00
FT-5 x UHF-612	99.57	72.00	4.50	20.00	59.68	6.48	1190.74	3.49	38.00
FT-5 x UHF-663	106.52	70.00	3.65	21.67	63.62	6.03	1272.38	3.83	37.00
Solan Vajr x UHF-656	192.53	81.00	3.46	19.33	63.96	4.73	1092.26	4.36	37.00
Solan Vajr x UHF-553	117.32	78.00	3.52	23.67	58.41	6.35	1474.78	4.00	34.00
Solan Vajr x UHF-659	197.40	72.00	3.46	28.33	60.92	6.44	1627.12	4.70	43.67
Solan Vajr x UHF-612	166.72	73.00	3.63	16.67	59.54	5.48	920.67	3.73	35.00
Solan Vajr x UHF-663	133.35	70.00	3.32	18.67	61.58	5.71	1190.00	3.89	34.33
UHF-656 x UHF-553	92.50	66.00	3.32	18.67	68.02	4.77	1270.15	3.83	30.00
UHF-656 x UHF-659	140.65	71.00	3.75	20.00	60.85	5.48	1176.25	3.27	36.00
UHF-656 x UHF-612	115.42	70.00	3.56	22.67	55.08	5.80	1217.10	3.23	37.33
UHF-656 x UHF-663	125.52	69.00	3.65	16.67	60.52	6.91	1089.13	3.80	35.00
UHF-553 x UHF-659	94.63	68.00	3.76	20.00	57.54	6.02	1208.60	3.55	30.67
UHF-553 x UHF-612	97.99	65.67	4.05	22.67	68.37	5.16	1213.92	3.91	37.00
UHF-553 x UHF-663	83.39	66.67	4.20	20.33	60.64	6.18	1231.28	4.00	32.00
UHF-659 x UHF-612	116.20	69.00	4.02	21.00	66.23	4.14	1273.63	3.10	36.00
UHF-659 x UHF-663	82.13	64.00	3.13	18.00	64.58	5.08	1157.63	3.60	33.00
UHF-612 x UHF-663	78.54	69.00	2.90	15.67	59.16	6.37	876.24	3.25	29.67

Table 2. Per cent heterobeltiosis effects of the crosses for yield and other horticultural traits in tomato.

Cross	Plant height (cm)	Days to first picking (days)	No. of fruits per cluster	No. of fruits per plant	Fruit weight (g)	Pericarp thickness (mm)	Yield	Total soluble solids (°B)	Harvest duration (days)
EC-15998 x AI-9	42.92*	-0.95	23.88*	10.77	2.67	19.75*	29.42*	3.59*	31.25*
EC-15998 x EC-174023	21.09*	0.00	1.49	-19.35*	5.02	16.60*	-9.71*	-13.66*	28.12*
EC-15998 x FT-5	20.90*	-1.43	-34.39*	-12.90	-21.30*	-22.04*	-15.53*	-7.38*	-9.00*
EC-15998 x Solan Vajr	6.96	1.43	-10.34*	-29.03*	18.55*	-24.04*	-2.77	-5.44*	-5.00
EC-15998 x UHF-656	19.08*	4.29	-21.47*	-33.87*	13.01*	-8.61*	-29.04*	-3.28*	7.69
EC-15998 x UHF-553	-25.00*	4.48	-24.44*	-11.29	8.66*	-19.64*	-25.75*	-9.59*	-6.25
EC-15998 x UHF-659	24.54*	4.29	1.12	-7.69	9.83*	-3.71	3.35	-18.78*	0.00
EC-15998 x UHF-612	-14.46*	14.52*	2.88	4.84	23.52*	-21.72*	20.39*	-12.70*	-8.34
EC-15998 x UHF-663	-16.78*	1.45	-19.49*	-20.97*	22.08*	-1.19	-4.14	-11.83*	3.12
AI-9 x EC-174023	24.05*	-5.56*	13.31*	-4.62	-6.72*	-27.10*	-0.48	-1.26*	14.13*
AI-9 x FT-5	21.30*	-4.16	12.74*	7.69	-8.18*	-1.71	18.89*	-16.14*	-0.89
AI-9 x Solan Vajr	2.23	-1.39	10.34*	1.52	16.25*	-6.17*	34.22*	0.24	-2.50
AI-9 x UHF-656	5.89	1.39	-10.94*	-36.92*	4.39	-21.72*	-21.25*	-12.31*	-5.13
AI-9 x UHF-553	19.84*	1.49	-14.62*	-23.08*	-3.27	-31.02*	14.54*	1.19	-9.78
AI-9 x UHF-659	-3.25	-5.16	5.28	18.46*	-12.51*	-3.13	17.67*	2.55*	-21.93*
AI-9 x UHF-612	4.26	2.69	-8.11	-35.39*	3.09	-11.59*	-19.32*	6.20*	-9.68
AI-9 x UHF-663	-5.63	2.90	-27.52*	-15.58	-10.65*	-2.23	-13.47*	-1.01	3.26
EC-174023 x FT-5	8.66	-1.35	4.88	12.73	-3.61	-38.82*	14.53*	-14.20*	-27.03*
EC-174023 x Solan Vajr	-6.51	4.87*	-12.91*	0.00	15.40*	-41.82*	17.72*	-8.01*	0.00
EC-174023 x UHF-656	17.95*	8.33*	13.76*	2.04	3.46	-22.95*	0.39	1.25*	9.41*
EC-174023 x UHF-553	-1.84	12.44*	8.56	-12.50	-5.21	-3.56	-17.05*	-19.39*	8.25
EC-174023 x UHF-659	39.45*	5.63*	5.09	0.00	-11.63*	-25.95*	2.68	-11.33*	5.26
EC-174023 x UHF-612	-34.44*	17.75*	-25.30*	34.00*	-17.24*	-0.19	-2.82	-12.48*	-16.12*
EC-174023 x UHF-663	11.02	1.45	-17.77*	-20.69*	15.84*	-16.63*	-3.66	-2.76*	23.53*
FT-5 x Solan Vajr	34.96*	-9.01*	15.38*	17.86*	12.97*	-2.81	40.74*	-6.88*	-3.32
FT-5 x UHF-656	38.48*	-1.35*	23.67*	-10.91	-8.05*	3.04*	-6.19*	-8.35*	-2.56
FT-5 x UHF-553	-19.39*	1.49	12.29*	7.14	-10.23*	-21.44*	-6.34*	-22.41*	-5.41*
FT-5 x UHF-659	43.67*	-7.04*	12.53*	12.71	-16.90*	-2.90	26.67*	-20.88*	26.32*
FT-5 x UHF-612	-28.65*	16.13*	33.30*	9.09	-21.60*	-10.42*	-6.93*	-27.14*	2.70
FT-5 x UHF-663	-23.67*	1.45	-10.24*	12.07	-16.42*	-16.64*	-0.54	-20.11*	0.00
Solan Vajr x UHF-656	17.13*	7.52*	-8.22	3.57	-7.99*	-37.07*	-10.15*	5.91*	-7.50
Solan Vajr x UHF-553	-28.62*	16.42*	-6.72	26.78*	-15.97*	-15.57*	21.32*	-2.91*	-15.00*
Solan Vajr x UHF-659	20.09*	1.41	-8.49	30.77*	-12.36*	-14.32*	33.85*	14.07*	9.17*
Solan Vajr x UHF-612	1.43	17.74*	-3.80	-10.71	-14.35*	-27.05*	-24.26*	-9.39*	-12.50*
Solan Vajr x UHF-663	-18.87*	1.45	-18.43*	-3.45	-11.40*	-23.99*	-2.10	-5.59*	-14.17*
UHF-656 x UHF-553	-32.83*	-1.49	0.32	0.00	7.46*	2.21	20.17*	4.93*	-23.08*
UHF-656 x UHF-659	2.13	0.00	24.56*	-7.69	-3.87	-2.66	0.31	-4.94*	-7.69
UHF-656 x UHF-612	-16.19*	12.90*	5.43	36.00*	-12.97*	24.20*	15.15*	-6.10*	-4.27
UHF-656 x UHF-663	-8.85	0.00	-10.24*	-8.62	-4.38	2.82	3.04	-4.52*	-10.26*
UHF-553 x UHF-659	1.28	1.49	13.49*	-7.69	3.81	6.93*	3.07	-2.83*	-19.30*
UHF-553 x UHF-612	9.93	5.91	20.17*	21.43*	21.42*	16.55*	17.34*	6.93*	19.35*
UHF-553 x UHF-663	-6.45	-0.50	3.28	5.17	9.41*	-8.03*	19.03*	0.59	14.29*
UHF-659 x UHF-612	24.37*	11.25	19.07*	-3.08	17.63*	-26.36*	8.62*	-6.90*	-5.26
UHF-659 x UHF-663	-12.09	-7.25*	-23.18*	-16.92*	21.16*	-24.37*	-1.28	-9.46*	-13.16*
UHF-612 x UHF-663	-6.78	10.44*	-28.75*	-18.97*	5.06	-5.11*	-9.10*	-18.34*	-4.29
$CD_{0.05}$	13.60	3.96	0.32	3.23	3.16	0.23	60.67	0.06	3.32

*Significant at 5% level.

superior crosses on *per se* performance basis. These crosses may be exploited for the development of superior hybrids of tomato. Significant heterobeltiosis was observed in desirable direction for all the traits under study except for days to first picking and total soluble solids.

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