

Original Research Article

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Heterosis Studies for Fruit Yield and its Components in Tomato (*Solanum lycopersicum* L.)

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ABSTRACT

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The experiment was carried out at Vegetable Research Station, Junagadh Agricultural University, Junagadh, Gujarat during rabi season of 2017-19 to study performance of nine lines and four testers into thirty-six tomato hybrids for fruit yield and its component traits by Line x Tester analysis. The analysis of variance for seventeen characters showed significant differences for all the genotypes indicating that experimental material had sufficient genetic variability for all the characters studied. Among 36 hybrids, 9 and 12 hybrids manifested significant desirable heterobeltiosis and standard heterosis for fruit yield per plant. The heterobeltiosis for fruit yield ranged from -70.26 to 206.04 % while standard heterosis ranged from -66.32 to 189.32 %. The cross JTL-15-02 × Punjab Chhuhara exhibited the highest desirable heterosis over better parent followed by JTL-15-05 × DVRT-2. These hybrids exhibited desirable heterosis for important yield attributes suggesting that the heterosis for marketable yield was associated with heterosis for component characters.

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important world's largest vegetable crop ranks third after potato and onion. It is originated in Peru of South America region (Soni and Soni, 2010). Tomato is mainly grown as rabi crop in the plains of India including tropical, sub-tropical and temperate regions. However, in the hilly region it can also be grown as a summer and rainy season crop. It is a typical day neutral plant and self-pollinated crop but up to 5% cross pollination also occurs through insects such as bees

(Singh *et al.*, 2004). It is a warm season crop reasonably resistant to heat, drought and grows under wide range of soil and climatic conditions. Optimum temperature for tomato cultivation is 20-24°C. The annual worldwide production of tomatoes has been estimated at 177.8 million tonnes from total production area of about 4.7 Mha with a productivity of 37.01 tonnes/ha (FAO, 2016). India ranks 2nd in the world with the total area of 0.80 Mha with production and productivity of 19759.92 tonnes and 25 tonnes/ha, respectively (Indian Horticulture Database, 2018).

In tomato, great amount of heterosis including standard heterosis has been reported by many research workers. Hedrick and Booth (1908) were the first research workers to realize the phenomenon of hybrid vigour in tomato. Heterosis manifestation in tomato is in the form of the greater vigour, faster growth and development, earliness in maturity, increased productivity (Yordanov, 1983). So a speedy improvement can be brought about by exploiting heterosis for fruit yield and its component traits.

Materials and Methods

The present investigation was conducted at Vegetable Research Station, Junagadh Agricultural University, Junagadh, during late *khariif* 2017-18 for development of crosses and late *khariif* 2018-19 for evaluation of crosses and parents. Geographically, Junagadh is situated at 21.5°N latitude and 70.5°E longitude with an altitude of 60 meters above the mean sea level. Experimental material contains nine lines (females) namely, JTL-15-05, JTL-12-07, JTL-16-03, JTL-16-07, JTL-15-02, JTL-12-02, JTL-16-05, JTL-16-08, JTL-17-06 and four testers (males) *i.e.* JT-3, AT-3, DVRT-2, Punjab Chhuharaof tomato (*Solanum lycopersicum* L.) were selected on the basis of their phenotypic variability resulted into thirty-six crosses along with their thirteen parents including one standard check variety (JT-3) was evaluated. The experiment was laid out in a Randomized Block design (RBD) with three replications. Five competitive plants were randomly selected for recording the observations on different characters such as days to 50% flowering, plant height (cm), number of branches per plant, number of clusters per plant, number of fruits per cluster, total number of fruits per plant days to first harvest, fruit yield per plant (kg), average fruit weight (g), numbers of locules per fruit, pericarp thickness (mm), total numbers of

pickings, fruit polar diameter (cm), fruit equatorial diameter (cm), days to last harvest, total soluble solid (°Brix) and acidity (%). Analysis of variance were done as suggested by Panse and Sukhatme (1967).

Results and Discussion

There were significant differences among the parental lines with respect to different characters studied including yield per plant. The mean performance of eight parental lines along with 36 F₁ hybrids is given in table 1 and 2. Heterobeltiosis for days to 50 % flowering over better parent ranged from -9.60 per cent (JTL-15-02 × JT-3) to 11.02 per cent (JTL-16-05 × DVRT-2). Heterosis over standard check ranged from -2.70 per cent (JTL-12-02 × AT-3) to 18.02 per cent (JTL-16-05 × DVRT-2). Significant negative heterosis also been reported by Droka *et al.*, (2013), Sureshkumara *et al.*, (2017), Adnan *et al.*, (2018) and Kattagoudar *et al.*, (2018). Heterobeltiosis for plant height over better parent ranged from -41.60 per cent (JTL-12-07 × JT-3) to 42.66 per cent (JTL-12-07 × DVRT-2). The heterosis over standard check ranged from -43.78 per cent (JTL-16-08 × AT-3) to 23.32 per cent (JTL-12-02 × AT-3). These results are in confirmation with the results of Yadav *et al.*, (2013), Ahmad *et al.*, (2015), Marbhal *et al.*, (2016), Adnan *et al.*, (2018), Gautam *et al.*, (2018), Kattagoudar *et al.*, (2018) and Sundharaiya *et al.*, (2018).

Heterosis over better parent for number of branches per plant ranged from -25.64 per cent (JTL-16-08 × AT-3) to 28.77 per cent (JTL-16-03 × JT-3). Heterosis over standard check ranged from -13.43 per cent (JTL-16-08 × AT-3) to 56.72 per cent (JTL-16-07 × Punjab Chhuhara). These results are in confirmation with the results of Droka *et al.*, (2013), Sureshkumara *et al.*, (2017), Kattagoudar *et al.*, (2018), Sundharaiya *et al.*, (2018). Heterosis over better parent for

number of clusters per plant ranged from -38.84 per cent (JTL-16-08 × AT-3) to 57.84 per cent (JTL-16-08 × JT-3). Heterosis over standard check ranged from -27.45 per cent (JTL-16-08 × AT-3) to 82.35 per cent (JTL-15-05 × JT-3). These results are in confirmation with the results of Sekhar *et al.*, (2010), Marbhal *et al.*, (2016). The range of heterosis over better parent for Number of fruits per cluster was recorded from -30.91 per cent (JTL-17-06 × DVRT-2) to 46.51 per cent (JTL-16-05 × Punjab Chhuhara). Heterosis over standard check ranged from -24.00 per cent (JTL-17-06 × DVRT-2) to 26.00 per cent (JTL-16-05 × Punjab Chhuhara). Similar findings were reported by Ahmad *et al.*, (2015), Marbhal *et al.*, (2016), Sureshkumara *et al.*, (2017), Adnan *et al.*, (2018).

The magnitude of heterosis over better parent for total number of fruits per plant ranged from -76.56 per cent (JTL-16-03 × Punjab Chhuhara) to 100.00 per cent (JTL-15-05 × JT-3 and JTL-15-02 × Punjab Chhuhara). Heterosis over standard check ranged from -64.21 per cent (JTL-16-08 × AT-3) to 129.47 per cent (JTL-15-05 × DVRT-2 and JTL-15-05 × JT-3). Similar findings were reported by Yadav *et al.*, (2013), Gautam *et al.*, (2018), Kattagoudar *et al.*, (2018), Sundharaiya *et al.*, (2018). The range of heterosis over better parent for days to first harvest was recorded from -10.75 per cent (JTL-16-05 × Punjab Chhuhara) to 9.71 per cent (JTL-12-07 × AT-3). Heterosis over standard check ranged from -1.32 per cent (JTL-16-05 × Punjab Chhuhara) to 14.85 per cent (JTL-16-05 × AT-3). Significant negative heterosis for this character has been reported by Rana and Vidyasagar (2005), Rattan (2007), Droka *et al.*, (2013). The range of heterosis over better parent for fruit yield per plant (Kg) recorded from -70.26 per cent (JTL-16-08 × DVRT-2) to 206.04 per cent (JTL-15-02 × Punjab Chhuhara). The range of standard heterosis

for this trait varied from -66.32 per cent (JTL-16-08 × AT-3) to 189.32 per cent (JTL-15-05 × DVRT-2). Similar findings were reported by Panchal *et al.*, (2017), Sureshkumara *et al.*, (2017), Tamata and Singh (2017), Triveni *et al.*, (2017), Kattagoudar *et al.*, (2018), Sundharaiya *et al.*, (2018).

The range of heterosis over better parent for average fruit weight (g) recorded from -46.12 per cent (JTL-15-05 × JT-3) to 34.71 per cent (JTL-15-02 × Punjab Chhuhara). Heterosis over standard check ranged from -35.37 per cent (JTL-16-08 × Punjab Chhuhara) to 32.87 per cent (JTL-16-05 × JT-3). Significant positive heterosis for this character has been reported by Sureshkumara *et al.*, (2017), Tamata and Singh (2017), Gautam *et al.*, (2018), Kattagoudar *et al.*, (2018). The range of heterosis over better parent for number of locules per fruit was recorded from -33.33 per cent (JTL-17-06 × JT-3) to 44.00 per cent (JTL-15-02 × JT-3). Heterosis over standard check ranged from -10.64 per cent (JTL-17-06 × JT-3) to 53.19 per cent (JTL-15-02 × JT-3). Significant positive heterosis for this character has been reported by Garg *et al.*, (2013), Sureshkumara *et al.*, (2017), Sharma and Singh (2018). The range of heterosis over better parent for pericarp thickness (mm) was recorded from -22.90 per cent (JTL-15-02 × Punjab Chhuhara) to 14.68 per cent (JTL-17-06 × DVRT-2). Heterosis over standard check ranged from -10.85 per cent (JTL-15-02 × Punjab Chhuhara) to 25.33 per cent (JTL-16-05 × Punjab Chhuhara). Significant positive heterosis for this character has been reported by Joshi *et al.*, (2005), Rattan (2007), Garg *et al.*, (2013), Sureshkumara *et al.*, (2017).

Heterobeltiosis for total number of pickings ranged from -45.16 per cent (JTL-16-08 × DVRT-2) to 15.38 per cent (JTL-16-07 × JT-3).

Table.1 Mean value for yield and yield attributing traits of the parents.

Genotype	Days to 50% Flowering	Plant height (cm)	Number of branches per plant	Number of clusters per plant	Number of fruits per cluster	Total number of fruits per plant	Days to first harvest	Fruit yield per plant (Kg)	Average fruit weight (g)
Lines									
JTL-15-05	39.00	116.47	6.40	10.73	3.20	36.33	107.67	3.10	71.25
JTL-12-07	37.67	82.47	6.13	8.87	3.13	51.67	103.00	2.88	56.20
JTL-16-03	37.33	105.67	4.87	9.60	3.27	64.00	103.67	2.69	42.98
JTL-16-07	40.33	107.40	6.07	10.33	3.60	42.33	106.67	1.87	43.63
JTL-15-02	41.67	89.47	5.67	7.53	3.40	22.33	106.67	0.91	39.15
JTL-12-02	39.00	110.53	6.07	7.13	3.13	21.00	112.67	0.62	32.97
JTL-16-05	39.33	107.33	5.20	7.93	2.80	24.33	111.67	1.14	44.25
JTL-16-08	36.33	70.80	5.20	6.33	3.27	24.67	111.67	1.22	36.79
JTL-17-06	39.33	79.73	5.20	5.93	3.67	19.00	103.67	0.91	38.39
Testers									
JT-3 (Standard check)	37.00	116.33	4.47	6.80	3.33	31.67	101.00	1.62	52.48
AT-3	37.00	99.20	5.20	8.07	3.53	37.00	102.33	1.35	37.13
DVRT-2	38.00	89.07	5.20	8.20	3.00	41.00	105.67	2.57	51.59
Punjab Chhuhara	38.00	114.20	3.20	4.93	2.87	34.67	104.33	1.21	34.92

Genotype	Number of locules per fruit	Pericarp thickness (mm)	Total numbers of picking	Fruit polar diameter (cm)	Fruit equatorial diameter (cm)	Days to last harvest	Total Soluble Solids (°Brix)	Acidity %
Lines								
JTL-15-05	3.40	4.44	9.33	4.10	4.58	174.33	5.51	0.67
JTL-12-07	3.80	4.80	9.67	4.08	4.28	181.33	5.31	0.70
JTL-16-03	3.80	4.75	9.33	3.70	3.74	179.00	4.91	0.60
JTL-16-07	4.00	4.76	8.00	3.73	3.95	176.67	5.84	0.82
JTL-15-02	3.33	4.19	6.33	3.87	4.24	163.67	5.29	0.56
JTL-12-02	3.60	4.90	6.00	3.97	4.35	160.33	4.83	0.63
JTL-16-05	3.33	4.34	6.33	4.39	4.42	163.67	4.97	0.51
JTL-16-08	3.00	4.92	7.00	4.36	4.64	167.33	4.36	0.73
JTL-17-06	4.20	4.61	4.00	4.33	4.60	159.00	5.13	0.69
Testers								
JT-3 (Standard check)	3.13	4.33	8.67	4.12	4.64	167.33	5.00	0.69
AT-3	3.00	4.96	9.00	4.54	4.61	172.00	5.00	1.04
DVRT-2	3.27	4.56	10.33	3.97	4.03	181.33	4.57	0.68
Punjab Chhuhara	2.47	5.01	9.00	6.22	3.45	167.33	5.79	0.80

Table.2 Mean value for yield and yield attributing traits of the F₁ hybrids

Genotype	Days to 50% Flowering			Plant height (cm)			Number of branches per plant			Number of clusters per plant			Number of fruits per cluster		
	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)
JTL-15-05 × JT-3	37.33	-4.27	0.90	80.67	-30.74 *	-30.66 *	6.13	-4.17	37.31*	12.40	15.53	82.35 **	3.47	4.00	4.00
JTL-15-05 × AT-3	37.67	-3.42	1.80	101.80	-12.59	-12.49	5.60	-12.50	25.37	11.20	4.35	64.71 **	3.33	-5.66	0.00
JTL-15-05 × DVRT-2	38.67	-0.85	4.50	104.60	-10.19	-10.09	5.80	-9.38	29.85	11.73	9.32	72.55 **	3.83	19.79	15.00
JTL-15-05 × Punjab Chhuhara	37.67	-3.42	1.80	69.00	-40.76 **	-40.69 **	6.27	-2.08	40.30 *	12.13	13.04	78.43 **	3.80	18.75	14.00
JTL-12-07 × JT-3	38.67	2.65	4.50	67.93	-41.60 **	-41.60 **	5.27	-14.13	17.91	11.60	30.83	70.59 **	3.27	-2.00	-2.00
JTL-12-07 × AT-3	40.00	6.19	8.11	119.70	20.67	2.89	6.80	10.87	52.24 **	10.80	21.80	58.82 **	3.53	0.00	6.00
JTL-12-07 × DVRT-2	37.33	-1.75	0.90	127.07	42.66 *	9.23	6.87	11.96	53.73 **	11.33	27.82	66.67 **	3.13	0.00	-6.00
JTL-12-07 × Punjab Chhuhara	38.33	0.88	3.60	114.40	0.18	-1.66	6.33	3.26	41.79 *	6.00	-32.33 *	-11.76	4.00	27.66 *	20.00
JTL-16-03 × JT-3	39.33	5.36	6.31	122.73	5.50	5.50	6.27	28.77	40.30 *	11.47	19.44	68.63 **	3.13	-6.00	-6.00
JTL-16-03 × AT-3	41.00	9.82*	10.81	113.67	7.57	-2.29	6.00	15.38	34.33 *	6.47	-32.64 *	-4.90	3.33	-5.66	0.00
JTL-16-03 × DVRT-2	37.67	-0.88	1.80	120.40	13.94	3.50	5.80	11.54	29.85	8.93	-6.94	31.37	3.17	-3.06	-5.00
JTL-16-03 × Punjab Chhuhara	41.00	7.89	10.81	133.20	16.64	14.50	5.67	16.44	26.87	6.93	-27.78	1.96	2.67	-18.37	-20.00
JTL-16-07 × JT-3	39.33	-2.48	6.31	114.47	-1.60	-1.60	6.80	12.09	52.24 **	7.87	-23.87	15.69	3.53	-1.85	6.00
JTL-16-07 × AT-3	39.33	-2.48	6.31	110.00	2.42	-5.44	5.93	-2.20	32.84 *	10.13	-1.94	49.02 *	3.10	-13.89	-7.00
JTL-16-07 × DVRT-2	40.67	0.83	9.91	123.60	15.08	6.25	5.93	-2.20	32.84 *	9.80	-5.16	44.12 *	3.53	-1.85	6.00
JTL-16-07 × Punjab Chhuhara	37.33	-7.44	0.90	122.73	7.47	5.50	7.00	15.38	56.72 **	9.73	-5.81	43.14 *	3.40	-5.56	2.00
JTL-15-02 × JT-3	37.67	-9.60*	1.80	95.20	-18.17	-18.17	6.40	12.94	43.28 *	7.60	0.88	11.76	3.13	-7.84	-6.00
JTL-15-02 × AT-3	39.00	-6.40	5.41	89.20	-10.08	-23.32	5.53	-2.35	23.88	9.53	18.18	40.20	3.40	-3.77	2.00
JTL-15-02 × DVRT-2	38.67	-7.20	4.50	95.13	6.33	-18.22	5.60	-1.18	25.37	10.80	31.71	58.82 **	3.47	1.96	4.00
JTL-15-02 × Punjab Chhuhara	40.33	-3.20	9.01	94.87	-16.93	-18.45	5.13	-9.41	14.93	11.87	57.52 **	74.51 **	3.83	12.75	15.00
JTL-12-02 × JT-3	40.67	4.27	9.91	115.47	-0.74	-0.74	5.67	-6.59	26.87	9.67	35.51	42.16 *	3.13	-6.00	-6.00
JTL-12-02 × AT-3	36.00	-7.69	-2.70	143.47	29.79 *	23.32	6.13	1.10	37.31 *	7.27	-9.92	6.86	3.90	10.38	17.00
JTL-12-02 × DVRT-2	39.00	0.00	5.41	118.27	7.00	1.66	5.87	-3.30	31.34	10.40	26.83	52.94 *	3.00	-4.26	-10.00
JTL-12-02 × Punjab Chhuhara	37.67	-3.42	1.80	139.33	22.01	19.77	6.20	2.20	38.81 *	7.27	1.87	6.86	3.40	8.51	2.00
JTL-16-08 × JT-3	40.33	2.54	9.01	126.20	8.48	8.48	5.60	7.69	25.37	10.87	36.97 *	59.80 **	3.27	-2.00	-2.00
JTL-16-05 × AT-3	41.00	4.24	10.81	129.13	20.31	11.00	6.67	28.21 *	49.25 **	11.13	38.02 *	63.73 **	3.27	-7.55	-2.00
JTL-16-05 × DVRT-2	43.67	11.02**	18.02	117.73	9.69	1.20	6.27	20.51	40.30 *	8.47	3.25	24.51	3.30	10.00	-1.00
JTL-16-05 × Punjab Chhuhara	36.67	-6.78	-0.90	102.53	-10.22	-11.86	6.60	26.92	47.76 **	9.87	24.37	45.10 *	4.20	46.51 **	26.00 *
JTL-16-08 × JT-3	37.33	0.90	0.90	74.73	-35.76 **	-35.76 **	5.67	8.97	26.87	10.73	57.84 **	57.84 **	3.53	6.00	6.00
JTL-16-08 × AT-3	39.67	7.21	7.21	65.40	-34.07 *	-43.78 **	3.87	-25.64	-13.43	4.93	-38.84 *	-27.45	3.53	0.00	6.00
JTL-16-08 × DVRT-2	41.67	9.65*	12.61	92.33	3.67	-20.63	4.93	-5.13	10.45	9.07	10.57	33.33	3.00	-8.16	-10.00
JTL-16-08 × Punjab Chhuhara	37.00	-2.63	0.00	83.80	-26.62	-27.97 *	5.13	-1.28	14.93	9.27	46.32 *	36.27	3.07	-6.12	-8.00
JTL-17-06 × JT-3	38.00	-3.39	2.70	119.20	2.46	2.46	5.00	-3.85	11.94	9.07	33.33	33.33	3.80	3.64	14.00
JTL-17-06 × AT-3	37.33	-5.08	0.90	124.40	25.40	6.93	5.73	10.26	28.36	9.67	19.83	42.16 *	3.13	-14.55	-6.00
JTL-17-06 × DVRT-2	41.00	4.24	10.81	117.13	31.51	0.69	4.80	-7.69	7.46	10.07	22.76	48.04 *	2.53	-30.91 **	-24.00 *
JTL-17-06 × Punjab Chhuhara	38.33	-2.54	3.60	108.27	-5.20	-6.93	5.50	5.77	23.13	8.13	37.08	19.61	3.27	-10.91	-2.00
Mean	38.82			105.84			5.70			9.11			3.33		
C.D (5%)	3.15			30.69			1.45			2.77			0.68		
C.V %	5.01			17.87			15.71			18.76			12.7		

Table.2 (Contd.) Mean value for yield and yield attributing traits of the F₁ hybrids

Genotype	Total no. of fruits per plant			Days to first harvest			Fruit yield per plant (Kg)			Average fruit weight (g)			Number of locules per fruit			Pericarp thickness (mm)		
	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)
JTL-15-05 × JT-3	72.67	100.00**	129.47**	107.33	-0.31	6.27	2.87	-7.43	76.59 **	38.39	-46.12**	-26.85*	3.07	-9.80	-2.13	4.94	11.41	14.24
JTL-15-05 × AT-3	71.00	91.89 **	124.21 **	107.00	-0.62	5.94	2.93	-5.38	80.49 **	46.38	-34.90 **	-11.62	3.33	-1.96	6.38	4.75	-4.10	9.78
JTL-15-05 × DVRT-2	72.67	77.24 **	129.47 **	106.33	-1.24	5.28	4.70	51.67 **	189.32 **	64.77	-9.09	23.43	3.20	-5.88	2.13	4.86	6.73	12.32
JTL-15-05 × Punjab Chhuhara	18.00	-50.46 **	-43.16 *	110.00	2.17	8.91 *	1.42	-54.14 **	-12.53	57.75	-18.94 *	10.06	3.60	5.88	14.89	4.59	-8.32	6.00
JTL-12-07 × JT-3	50.67	-1.94	50.00 **	108.67	5.50	7.59 *	3.09	7.28	90.55 **	57.72	2.70	9.99	3.20	-15.79	2.13	4.80	0.14	10.85
JTL-12-07 × AT-3	52.33	1.29	55.26 **	113.00	9.71 **	11.88 **	2.34	-18.96	43.94 *	51.61	-8.17	-1.65	3.60	-5.26	14.89	4.49	-9.48	3.62
JTL-12-07 × DVRT-2	42.33	-18.06	33.68	109.00	3.15	7.92 *	2.32	-19.77	42.51 *	53.39	-5.00	1.74	3.40	-10.53	8.51	5.20	8.48	20.09 *
JTL-12-07 × Punjab Chhuhara	14.00	-72.90 **	-55.79 **	107.33	2.88	6.27	1.03	-64.28 **	-36.55	60.26	7.22	14.83	3.53	-7.02	12.77	4.73	-5.59	9.16
JTL-16-03 × JT-3	33.33	-47.92 **	5.26	105.67	1.93	4.62	2.17	-19.23	33.68	47.99	-8.56	-8.56	3.47	-8.77	10.64	4.85	2.18	12.01
JTL-16-03 × AT-3	26.33	-58.85 **	-16.84	110.00	6.11	8.91 *	1.42	-47.27 **	-12.73	47.43	10.36	-9.61	3.53	-7.02	12.77	4.24	-14.39	-2.00
JTL-16-03 × DVRT-2	33.00	-48.44 **	4.21	107.33	1.58	6.27	2.30	-14.39	41.68 *	55.07	6.75	4.94	3.07	-19.30	-2.13	4.41	-7.02	1.92
JTL-16-03 × Punjab Chhuhara	15.00	-76.56 **	-52.63 **	111.33	6.71	10.23 **	0.93	-65.38 **	-42.71 *	42.27	-1.66	-19.46	2.87	-24.56 *	-8.51	4.71	-5.99	8.70
JTL-16-07 × JT-3	42.00	-0.79	32.63	103.00	-3.44	1.98	1.73	-7.3	6.98	38.87	-25.94 *	-25.94 *	3.27	-18.33	4.26	4.44	-6.86	2.39
JTL-16-07 × AT-3	67.67	59.84 **	113.68 **	104.00	-2.50	2.97	3.12	66.73 **	92.40 **	44.34	1.63	-15.50	3.47	-13.33	10.64	4.77	-3.70	10.24
JTL-16-07 × DVRT-2	33.00	-22.05	4.21	105.00	-1.56	3.96	1.93	-24.68 *	19.10	50.49	-2.13	-3.79	4.00	0.00	27.66 *	4.27	-10.36	-1.46
JTL-16-07 × Punjab Chhuhara	24.67	-41.73**	-22.11	107.67	0.94	6.60	1.42	-24.38	-12.73	49.13	12.61	-6.37	3.73	-6.67	19.15	4.22	-15.71 *	-2.54
JTL-15-02 × JT-3	50.67	50.00**	50.00**	102.67	-3.75	1.65	2.73	68.17 **	68.17 **	48.41	-7.74	-7.74	4.80	44.00 **	53.19 **	3.67	-15.32	-15.32
JTL-15-02 × AT-3	40.67	9.91	28.42	104.33	-2.19	3.30	1.99	47.77 *	22.59	44.49	13.66	-15.21	2.93	-12.00	-6.38	4.89	-1.41	12.86
JTL-15-02 × DVRT-2	64.00	56.10 **	102.11 **	104.33	-2.19	3.30	3.54	37.92 **	118.07 **	52.21	1.20	-0.51	3.20	-4.00	2.13	5.23	14.78	20.79 *
JTL-15-02 × Punjab Chhuhara	69.33	100.00 **	118.95 **	103.33	-3.13	2.31	3.72	206.04 **	128.75 **	52.73	34.71 *	0.49	3.13	-6.00	0.00	3.86	-22.90 **	-10.85
JTL-12-02 × JT-3	36.67	15.79	15.79	107.33	-4.73	6.27	1.94	19.51	19.51	53.66	2.26	2.26	4.20	16.67	34.04 *	4.25	-13.14	-1.77
JTL-12-02 × AT-3	29.67	-19.82	-6.32	112.67	0.00	11.55 **	1.73	28.71	6.78	48.05	29.41	-8.44	3.27	-9.26	4.26	4.39	-11.57	1.23
JTL-12-02 × DVRT-2	42.67	4.07	34.74	110.33	-2.07	9.24 *	1.85	-27.66 *	14.37	43.84	-15.02	-16.46	3.47	-3.70	10.64	4.09	-16.47 *	-5.54
JTL-12-02 × Punjab Chhuhara	30.33	-12.50	-4.21	109.33	-2.96	8.25 *	1.44	18.13	-11.70	45.98	31.68	-12.38	3.93	9.26	25.53	4.35	-13.12	0.46
JTL-16-05 × JT-3	44.67	41.05 *	41.05 *	109.00	-2.39	7.92 *	3.42	110.68 **	110.68 **	69.72	32.87 **	32.87 **	4.13	24.00	31.91 *	4.36	0.61	0.77
JTL-16-05 × AT-3	43.33	17.12	36.84	116.00	3.88	14.85 **	2.17	60.89 **	33.47	48.66	9.97	-7.27	3.73	12.00	19.15	4.11	-17.01 *	-5.00
JTL-16-05 × DVRT-2	46.67	13.82	47.37 *	109.33	-2.09	8.25*	2.17	-15.32	33.88	44.65	-13.45	-14.92	2.93	-12.00	-6.38	4.66	2.27	7.62
JTL-16-05 × Punjab Chhuhara	45.33	30.77	43.16 *	99.67	-10.75**	-1.32	1.54	26.65	-5.34	33.97	-23.23	-35.27 **	3.73	12.00	19.15	5.43	8.39	25.33**
JTL-16-08 × JT-3	53.33	58.42 **	58.42 **	105.00	-5.97	3.96	2.19	35.11	35.11	41.33	-21.25	-21.25	3.07	-2.13	-2.13	4.85	-1.36	12.01
JTL-16-08 × AT-3	11.33	-69.37 **	-64.21 **	108.00	-3.28	6.93	0.55	-59.41 *	-66.32 **	39.91	7.48	-23.95	3.67	22.22	17.02	4.63	-6.66	6.85
JTL-16-08 × DVRT-2	16.67	-59.35 **	-47.37 *	115.67	3.58	14.52**	0.76	-70.26 **	-52.98 **	47.40	-8.12	-9.67	3.60	10.20	14.89	4.34	-11.73	0.23
JTL-16-08 × Punjab Chhuhara	14.00	-59.62 **	-55.79 **	110.67	-0.90	9.57**	0.62	-49.32	-61.81 **	33.91	-7.82	-35.37 **	3.20	6.67	2.13	4.41	-11.98	1.77
JTL-17-06 × JT-3	33.67	6.32	6.32	110.00	6.11	8.91*	2.05	26.28	26.28	47.67	-9.17	-9.17	2.80	-33.33 **	-10.64	4.50	-2.46	3.85
JTL-17-06 × AT-3	29.33	-20.72	-7.37	108.00	4.18	6.93	1.44	6.93	-11.29	43.93	14.43	-16.29	3.67	-12.70	17.02	4.41	-10.96	1.92
JTL-17-06 × DVRT-2	41.33	0.81	30.53	108.00	2.21	6.93	2.17	-15.32	33.88	48.39	-6.19	-7.78	2.93	-30.16 **	-6.38	5.29	14.68	22.09 *
JTL-17-06 × Punjab Chhuhara	42.67	23.08	34.74	109.67	5.11	8.58*	1.90	56.32 *	16.84	44.02	14.67	-16.12	3.60	-14.29	14.89	4.91	-1.93	13.39
Mean	38.87			107.48			1.99			47.35			3.44			4.60		
C.D (5%)	12.54			7.44			0.63			14.86			0.78			0.75		
C.V %	19.88			4.26			19.63			19.34			14.09			10.1		

Table.2 (Contd.) Mean value for yield and yield attributing traits of the F₁ hybrids

Genotype	Total numbers of picking			Fruit polar diameter (cm)			Fruit equatorial diameter (cm)			Days to last harvest			Total Soluble Solids (°Brix)			Acidity %		
	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)	Mean	H ₁ (%)	H ₂ (%)
ITL-15-05 × JT-3	10.67	14.29	23.08	4.06	-1.46	-1.46	4.14	-10.78	-10.78	186.00	6.69	11.16	5.64	2.42	12.80	0.75	8.17	8.17
ITL-15-05 × AT-3	9.33	0.00	7.69	4.50	-1.03	9.05	4.94	7.38	6.69	178.00	2.10	6.37	5.32	-3.33	6.47	0.78	-25.00 **	12.50
ITL-15-05 × DVRT-2	10.33	0.00	19.23	4.47	9.02	8.41	4.88	6.48	5.18	183.67	1.29	9.76	4.89	-11.26	-2.27	0.65	-4.39	-5.77
ITL-15-05 × Punjab Chhuhara	6.67	-28.57 *	-23.08	4.18	-32.74 **	1.46	4.67	2.04	0.79	147.33	-15.49 *	-11.95	5.18	-10.59	3.60	0.90	-11.20	28.85 *
ITL-12-07 × JT-3	8.67	-10.34	0.00	4.14	0.40	0.40	4.65	0.29	0.29	174.67	-3.68	4.38	4.99	-6.02	-0.13	0.69	-1.44	-0.96
ITL-12-07 × AT-3	7.00	-27.59 *	-19.23	3.99	-12.25 *	-3.31	4.67	1.37	0.72	183.67	1.29	9.76	5.29	-0.38	5.87	0.66	-36.54 **	-4.81
ITL-12-07 × DVRT-2	8.67	-16.13	0.00	3.74	-8.41	-9.30	4.07	-5.13	-12.29	183.67	1.29	9.76	4.49	-15.56	-10.27	0.82	18.66	19.23
ITL-12-07 × Punjab Chhuhara	6.00	-37.93 **	-30.77 *	3.96	-36.39 **	-4.04	4.70	9.49	1.22	143.67	-20.77 **	-14.14 *	5.12	-11.62	2.40	0.61	-24.07 *	-12.02
ITL-16-03 × JT-3	8.33	-10.71	-3.85	4.11	-0.32	-0.32	4.56	-1.51	-1.51	168.67	-5.77	0.80	5.65	12.93	12.93	0.64	-8.17	-8.17
ITL-16-03 × AT-3	7.67	-17.86	-11.54	4.92	8.29	19.32 **	4.84	5.21	4.53	174.33	-2.61	4.18	4.78	-4.40	-4.40	0.76	-26.92 **	9.62
ITL-16-03 × DVRT-2	8.67	-16.13	0.00	4.19	5.28	1.54	4.47	10.83	-3.59	183.67	1.29	9.76	5.16	5.02	3.20	0.58	-14.15	-15.38
ITL-16-03 × Punjab Chhuhara	6.33	-32.14 *	-26.92	4.10	-34.03 **	-0.49	4.39	17.38*	-5.32	143.67	-19.74 **	-14.14 *	4.83	-16.69	-3.47	0.76	-5.39	9.62
ITL-16-07 × JT-3	10.00	15.38	15.38	4.36	5.74	5.74	4.86	4.74	4.74	181.33	2.64	8.37	4.05	-30.71 **	-19.07	0.67	-18.70	-3.85
ITL-16-07 × AT-3	10.00	11.11	15.38	4.20	-7.63	1.78	5.11	10.93	10.21	176.67	0.00	5.58	4.07	-30.25 **	-18.53	0.66	-36.86 **	-5.29
ITL-16-07 × DVRT-2	8.67	-16.13	0.00	4.10	3.19	-0.49	5.14	27.36**	10.78	169.67	-6.43	1.39	4.61	-21.00 *	-7.73	0.68	-17.07	-1.92
ITL-16-07 × Punjab Chhuhara	7.67	-14.81	-11.54	4.18	-32.85 **	1.29	4.39	11.14	-5.32	161.33	-8.68	-3.59	5.16	-11.64	3.20	0.72	-11.79	4.33
ITL-15-02 × JT-3	8.33	-3.85	-3.85	3.28	-20.45 **	-20.45 **	4.40	-5.10	-5.10	166.33	-0.60	-0.60	4.59	-13.35	-8.27	0.78	12.50	12.50
ITL-15-02 × AT-3	8.33	-7.41	-3.85	4.13	-9.02	0.24	3.99	-13.46	-14.02 *	176.67	2.71	5.58	4.33	-18.14	-13.33	0.67	-35.58 **	-3.37
ITL-15-02 × DVRT-2	9.67	-6.45	11.54	4.35	9.22	5.34	4.69	10.62	1.08	176.67	-2.57	5.58	4.07	-23.05 *	-18.53	0.87	27.80 *	25.96 *
ITL-15-02 × Punjab Chhuhara	9.33	3.70	7.69	4.21	-32.21 **	2.26	4.42	4.41	-4.60	181.33	8.37	8.37	4.13	-28.65 **	-17.33	0.74	-7.88	6.73
ITL-12-02 × JT-3	8.00	-7.69	-7.69	4.36	5.66	5.66	4.72	1.87	1.87	174.33	4.18	4.18	5.53	10.53	10.53	0.67	-2.40	-2.40
ITL-12-02 × AT-3	8.00	-11.11	-7.69	4.20	-7.63	1.78	4.75	3.11	2.44	174.33	1.36	4.18	4.15	-17.07	-17.07	0.66	-36.86 **	-5.29
ITL-12-02 × DVRT-2	9.67	-6.45	11.54	4.04	1.68	-1.94	4.26	-1.99	-7.98	183.67	1.29	9.76	4.79	-0.69	-4.13	0.70	2.93	1.44
ITL-12-02 × Punjab Chhuhara	7.67	-14.81	-11.54	4.69	-24.54 **	13.82 *	4.81	10.57	3.81	174.33	4.18	4.18	4.35	-24.97 *	-13.07	0.67	-16.18	-2.88
ITL-16-05 × JT-3	8.33	-3.85	-3.85	4.33	-1.29	5.01	4.49	-3.09	-3.09	186.00	11.16	11.16	3.81	-23.73 *	-23.73 *	0.93	35.10 **	35.10 **
ITL-16-05 × AT-3	8.00	-11.11	-7.69	4.00	-11.96 *	-2.99	4.42	-3.98	-4.60	183.67	6.78	9.76	4.12	-17.60	-17.60	0.75	-27.56 **	8.65
ITL-16-05 × DVRT-2	8.67	-16.13	0.00	4.26	-3.04	3.15	4.81	8.67	3.67	186.00	2.57	11.16	4.60	-7.38	-8.00	0.79	16.59	14.90
ITL-16-05 × Punjab Chhuhara	9.67	7.41	11.54	4.39	-29.47 **	6.39	4.35	-1.73	-6.25	181.33	8.37	8.37	5.06	-12.66	1.20	0.66	-17.84	-4.81
ITL-16-08 × JT-3	9.33	7.69	7.69	4.25	-2.60	2.91	4.14	-10.91	-10.78	174.33	4.18	4.18	4.21	-15.87	-15.87	0.66	-9.17	-4.81
ITL-16-08 × AT-3	5.00	-44.44 **	-42.31 **	4.31	-5.28	4.37	4.58	-1.29	-1.15	167.33	-2.71	0.00	4.53	-9.47	-9.47	0.70	-33.01 **	0.48
ITL-16-08 × DVRT-2	5.67	-45.16 **	-34.62 *	4.43	1.53	7.28	5.15	10.98	11.14	159.00	-12.32 *	-4.98	4.80	4.96	-4.00	0.67	-7.80	-3.37
ITL-16-08 × Punjab Chhuhara	5.67	-37.04 **	-34.62 *	4.15	-33.33 **	0.57	4.05	-12.92	-12.80	146.33	-12.55	-12.55	5.13	-11.51	2.53	0.71	-11.62	2.40
ITL-17-06 × JT-3	8.33	-3.85	-3.85	4.40	1.69	6.71	4.49	-3.16	-3.16	181.33	8.37	8.37	5.05	-1.49	1.07	0.72	3.37	3.37
ITL-17-06 × AT-3	8.00	-11.11	-7.69	4.07	-10.34 *	-1.21	4.52	-1.88	-2.52	170.67	-0.78	1.99	5.54	7.99	10.80	0.53	-49.36 **	-24.04 *
ITL-17-06 × DVRT-2	9.00	-12.90	3.85	4.18	-3.31	1.46	4.20	-8.83	-9.49	179.00	-1.29	6.97	4.31	-16.05	-13.87	0.58	-15.46	-15.87
ITL-17-06 × Punjab Chhuhara	10.00	11.11	15.38	3.89	-37.46 **	-5.66	4.42	-3.91	-4.60	183.67	9.76	9.76	5.16	-10.93	3.20	0.75	-6.64	8.17
Mean	8.21			4.21			4.48			172.64			4.85			0.707		
C.D (5%)	2.47			0.47			0.60			23.63			1.08			0.20		
C.V %	18.55			6.99			8.32			8.44			13.74			18.15		

Heterosis over standard check ranged from -42.31 per cent (JTL-16-08 × AT-3) to 23.08 per cent (JTL-15-05 × JT-3). Heterosis over better parent for fruit polar diameter (cm) ranged from -37.46 per cent (JTL-17-06 × Punjab Chhuhara) to 9.22 per cent (JTL-15-02 × DVRT-2). Heterosis over standard check ranged from -20.45 per cent (JTL-15-02 × JT-3) to 19.32 per cent (JTL-16-03 × AT-3). Significant positive heterosis has been also reported Droka *et al.*, (2013), Yadav *et al.*, (2013). Heterosis over better parent for fruit equatorial diameter (cm) ranged from -13.46 per cent (JTL-15-02 × AT-3) to 27.36 per cent (JTL-16-07 × DVRT-2). Heterosis over standard check ranged from -14.02 per cent (JTL-15-02 × AT-3) to 11.14 per cent (JTL-16-08 × DVRT-2). Significant positive has been also reported by Gul *et al.*, (2010), Chattopadhyay and Paul (2012), Singh *et al.*, (2012), Droka *et al.*, (2013), Yadav *et al.*, (2013), Sharma and Singh (2018). Heterosis over better parent for days to last harvest ranged from -20.77 per cent (JTL-12-07 × Punjab Chhuhara) to 11.16 per cent (JTL-16-05 × JT-3). Heterosis over standard check ranged from -14.14 per cent (JTL-12-07 × Punjab Chhuhara and JTL-16-03 × Punjab Chhuhara) to 11.16 per cent (JTL-15-05 × JT-3, JTL-16-05 × JT-3 and JTL-16-05 × DVRT-2). Heterosis over better parent for total soluble solid (°Brix) ranged from -30.71 per cent (JTL-16-07 × JT-3) to 12.93 per cent (JTL-16-03 × JT-3). Heterosis over standard check ranged from -23.73 per cent (JTL-16-05 × JT-3) to 12.93 per cent (JTL-16-03 × JT-3). Heterosis over better parent for acidity (%) ranged from -49.36 per cent (JTL-17-06 × AT-3) to 35.10 per cent (JTL-16-05 × JT-3). Heterosis over standard check ranged from -24.04 per cent (JTL-17-06 × DVRT-2) to 35.10 per cent (JTL-16-05 × JT-3). Significant positive heterosis has been reported by Chattopadhyay and Paul (2012), Garg *et al.*, (2013), Panchal *et al.*, (2017), Sureshkumara *et al.*, (2017), Sundharaiya *et al.*, (2018).

In conclusion, the present investigation suggests that study resulted into identification of hybrid for tomato fruit yield & its component traits. The cross JTL-15-02 × Punjab Chhuhara exhibited the highest desirable heterosis over better parent followed by JTL-15-05 × DVRT-2. These hybrids exhibited desirable heterosis for important yield attributes suggesting that the heterosis for marketable yield was associated with heterosis for component characters.

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