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Estimation of heterosis for quality traits in tomato (*Solanum lycopersicum* L.)

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Abstract
An experiment was conducted at the Experimental Research Farm, RHR&TS, Jachh, Kangra, Himachal Pradesh to estimate heterosis for quality traits in tomato by involving 10 lines and two testers. The results revealed that the cross, EC-620410 × Solan Lalima had maximum heterobeltiosis as well as standard heterosis for fruits shape index. For number of locules per fruit, the crosses EC-191531 × Solan Lalima and EC-37239 × Solan Lalima recorded maximum negative heterobeltiosis and negative standard heterosis, respectively. BT-1-1× FT-5 showed maximum positive heterobeltiosis pericarp thickness and ascorbic acid content, whereas, EC-37239 × FT-5 recorded maximum standard heterosis for pericarp thickness. The cross, LE-79-5 × FT-5 had maximum positive heterobeltiosis and standard heterosis for total soluble solids content. Based on the results, these superior hybrids may further be tested in multiple locations for yield and quality traits in order to exploit heterosis at commercial level in tomato.

Keywords: tomato, heterosis, heterobeltiosis, standard heterosis, quality traits

Introduction

Tomato (*Solanum lycopersicum* L.) is probably the most important vegetable crops in terms of its area, production, consumption and its nutritive values. Mature fruits are mainly consumed as salad, cooked or processed to several products ketchup, puree, paste and also as a whole canned fruits. It is a day neutral crop originated in Peru Ecuador Bolivia Region of Andes, South America (Rick, 1969) [2]. Being in rich in β-carotene, lycopene and other antioxidants, it is also considered as ‘protective food’. In India, it is cultivated in an area of 799 thousand hectares, yielding 19,542 thousand metric tonnes of fresh produce (Anonymous, 2017) [1]. Thus, India has emerged as the second largest producer of tomato in the world just after China.
A considerable proportion of the fresh produce is lost every year due to market glut and unsuitability of the most of the cultivated varieties for processing purpose. For processing, the tomatoes should meet certain quality criteria such as high total soluble solids, lycopene and ascorbic acid content, high acidity (low pH), more dry matter content, longer shelf life etc. Keeping in view these facts in mind, the present experiment was formulated to estimate the heterotic potential for those quality traits in tomato by adopting line × tester mating design (Kempthorne, 1957) [3], involving ten lines and two testers.

Materials and Methods

The present experiment was conducted at the Experimental Research Farm, RHR&TS, Jachh, Kangra, Himachal Pradesh. During *Rabi*, 2015, twenty crosses were made in a line × tester fashion involving ten lines *viz.*, EC-8910155, EC-191531, EC-191535, EC-620410, EC-174913, EC-267727, EC-37239, LE-79-5, Yalabingo, BT-1-1 and two testers *viz.*, Solan Lalima and FT-5, which were procured from different sources and are being maintained at the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. The resulting 20 F_1 hybrids and the parents were evaluated in a Randomized Complete Block Design (RCBD) with three replications during *Kharif*, 2016. The row to row and plant to plant spacing was 90 cm and 30 cm, respectively; keeping 20 plants per plot (2.7 m × 2.0 m) in each entry. Standard cultural practices for raising healthy crop of tomato were followed (Anonymous, 2013) [4]. Naveen 2000+, which is the leading commercial variety of Himachal Pradesh, was taken as standard check.
Observations were recorded from ten random fresh, marketable fruits harvested from third harvest for important quality traits *viz.*, fruit shape index, fruit colour, number of locules per fruit, pericarp thickness (mm), total soluble solids (TSS) (°B) and ascorbic acid content (mg/100g of fresh tissue). Fruit shape index (P:E) was estimated by dividing polar diameter by equatorial diameter as suggested by Roy and Choudhary (1972) [5], where, fruits with index value more than 1.00 was considered as oval, between 0.99 to 0.86 as spherical, between 0.85

to 0.71 as flat round and less than 0.70 as flat shaped. Colour of the fruits was observed visually with the help of the colour chart of the Royal Horticultural Society, London. Locule numbers were counted after cutting transverse section of the fruit. Pericarp thickness was measured with the help of a digital vernier caliper. TSS was estimated with the help of hand refractometer (ERMA, Japan) and ascorbic acid was estimated by titration method as described by Ranganna (1986) [6]. The ascorbic acid content was calculated by adopting the following formula-

$$\text{mg of ascorbic acid per 100g of fresh tissue} = \frac{\text{Titrate} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{Volume of sample taken for estimation}}$$

Results and Discussions

The analysis of variance, as presented in Table 1, showed significant differences among the lines, testers and the line × testers for all the quality traits under study. Range, number of desirable hybrids, best cross combinations and mean performance with respect to heterobeltiosis and standard heterosis for different quality traits in tomato has been presented in Table 2 and Table 3, respectively.

The fruit shape index of the lines, testers and the resultant hybrids have been presented in table 4. For this trait, among the crosses, EC-620410 × Solan Lalima outperformed all other crosses (10.27% and 44.16%), followed by EC-620410 × FT-5 (7.62% and 40.69%) both in terms of heterobeltiosis and standard heterosis respectively, giving an oval shaped fruit, whereas, most of the crosses had spherical to flat round fruits. Oval or pear shaped fruits are preferred over the spherical ones by the processing industries, whereas, spherical shaped tomatoes are preferred for fresh consumption. Based on our results, market demands and the target of the breeder, the particular cross may be taken up for further evaluation.

Table 1: Analysis of variance for different quality traits in tomato

Sources of Variation	Mean Sum of Squares								
	Replications	Treatments	Parents (P)	Crosses (C)	P *vs* C	Lines	Testers	Lines × Testers	Error
Degrees of freedom	2	31	11	19	1	9	1	9	62
Traits									
Fruit shape index	0.001	0.032*	0.026*	0.036*	0005*	0.070*	0.0004	0.007*	0.0002
Number of locules per fruit	0.001	1.05*	0.78*	1.25*	0.19*	0.92*	6.27*	1.03*	0.02
Pericarp thickness	0.02	3.60*	3.59*	2.18*	30.85*	3.55*	0.27*	1.02*	0.01
Total soluble solids	0.004	0.63*	0.33*	0.83*	0.09*	1.09*	4.22*	0.21*	0.01
Ascorbic acid content	2.40	29.58*	19.32*	26.85*	194.16*	49.81*	10.31*	5.73*	0.32

*Significant at 1% level of significance

Table 2: Range, number of desirable hybrids, best crosses and mean performance with respect to heterobeltiosis for quality traits in tomato.

Traits	Range of heterosis over BP (%)	Number of desirable hybrids	Best crosses based on heterobeltiosis (%)	Mean performance of the crosses
Fruit shape index	-21.28 (EC-191535 × Solan Lalima) to 10.27 (EC-620410 × Solan Lalima)	3	EC-620410 × Solan Lalima (10.27)	1.11
			EC- 620410 × FT-5 (7.62)	1.08
			EC-191531 × Solan Lalima (5.67)	0.99
Number of locules per fruit	-38.74 (EC-191531 × Solan Lalima) to 43.16 (LE-79-5 × FT-5)	15	EC-191531 × Solan Lalima (-38.74)	2.27
			Yalabingo × Solan Lalima (-27.08)	2.33
			EC-191535 × Solan Lalima (-25.74)	2.50
Pericarp thickness	-60.19 (EC-620410 Solan Lalima) to 26.54 (BT-1-1× FT-5)	2	BT-1-1× FT-5 (26.54)	5.20
			EC- 8910155 × FT-5 (18.91)	4.88
Total soluble solids	-22.37 (EC- 8910155 × Solan Lalima) to 20.44 (LE-79-5 × FT-5)	7	LE-79-5 × FT-5 (20.44)	4.71
			BT-1-1 × FT-5 (17.55)	4.60
			EC-37239 × FT-5 (13.69)	4.65
Ascorbic acid content	-19.33 (EC- 620410 × Solan Lalima) to 25.89 (BT-1-1 × FT-5)	9	BT-1-1 × FT-5 (25.89)	31.77
			Yalabingo × FT-5 (23.91)	30.23
			EC-191535 × FT-5 (17.49)	28.67

For number of locules per fruit, the cross EC-191531 × Solan Lalima showed maximum negative heterobeltiosis (-38.74%) followed by Yalabingo × Solan Lalima (-27.08) and the cross EC-37239 × Solan Lalima recorded maximum negative standard heterosis (-47.50%) followed by EC-267727 × Solan Lalima (-46.67%). The tester, Solan Lalima with different lines gave the higher heterosis for both the cases. Therefore the obtained results might be due to the effect of the tester, Solan Lalima. The hybrids with lesser number of locules might be due to the effect of the tester. Fruits with lesser number of locules tend to pear or oval shaped fruit with more dry matter and less moisture content that provide better transportation ability and storage life, therefore preferred for processing. Significant negative heterosis for this trait was reported by Singh *et al.* (2005) [7], Saeed *et al.* (2014) [8] and Aisyah *et al.* (2016) [9].

Pericarp thickness is an important trait in tomato as it gives the ability to stand long distance transportation. For this trait, the hybrid BT-1-1× FT-5 recorded maximum positive heterobeltiosis (26.54%) followed by EC- 8910155 × FT-5 (18.91%), whereas, EC-37239 × FT-5 was the only cross with positive standard heterosis (6.23%). Different lines with FT-5 as a tester gave desirable heterotic hybrids; therefore the obtained results might be due to the effect of the tester on the lines. These results are in accordance with Gaikwad and Cheema (2010) [10], Kumari and Sharma (2011) [11], Kumar *et al.* (2013) [12], Rajan (2014) [13] and Aisyah *et al.* (2016) [9].

A total soluble solid (TSS) content is one of the most important criteria which determine the suitability of a tomato variety for processing. With respect to this trait, the hybrid between LE-79-5 × FT-5 recorded maximum positive heterobeltiosis (20.44%) as well as standard heterosis (4.74%) followed by BT-1-1 × FT-5 for heterobeltiosis (17.55%) and EC-37239 × FT-5 for standard heterosis (3.33). Significant increase in TSS content was observed in most of the hybrids derived from different lines with the same tester, FT-5. Therefore, the obtained results might be due to the effect of the tester on this trait. Earlier, Sharma *et al.* (2001) [14], Kumar *et al.* (2009) [15], Duhan *et al.* (2005) [16] Kumar *et al.* (2013) [17] and Aisyah *et al.* (2016) [9] also found positive heterosis for this trait in tomato.

Ascorbic Acid is an important and indispensible constituent of our daily diet. As the vitamin is thermo-sensitive, it gets destroyed while cooking. Other than cooked, tomatoes are also eaten raw as salad, which makes it a potent crop for supplying our daily requirement of this vitamin. For ascorbic acid content, the cross BT-1-1 × FT-5 recorded highest heterobeltiosis (25.89%) but with respect to standard heterosis, none of the crosses showed significant increase over the standard check Naveen 2000+. These findings are in line with Duhan *et al.* (2005) [16], Singh *et al*. (2005) [7], Kumari and Sharma (2011) [11], Kumar *et al*. (2013) [12] and Saeed *et al*. (2014) [8].

Ripe fruit colour of lines, testers and their hybrids have been presented in table 5. The line LE-79-5 performed better with both the testers and gave dark red fruit colour (Red Group 45-A). Therefore, in order to improve fruit colour, the genotype LE-79-5 may be used in future breeding programmes.

Table 3: Range, number of desirable hybrids, best crosses and mean performance with respect to standard heterosis for quality traits in tomato.

Traits	Range of heterosis over standard check (%)	Number of desirable hybrids	Best crosses based on heterobeltiosis (%)	Mean performance of the crosses
Fruit shape index	-3.90 (EC-191535 × Solan Lalima) to 44.16 (EC-620410 × Solan Lalima)	16	EC- 620410 × Solan Lalima (44.16)	1.11
			EC- 620410 × FT-5 (40.69)	1.08
			LE-79-5 × Solan Lalima (38.10)	1.06
Number of locules per fruit	-47.50 (EC-37239 × Solan Lalima) to 13.33 (LE-79-5 × FT-5)	16	EC-37239 × Solan Lalima (-47.50)	2.10
			EC-267727 × Solan Lalima (-46.67)	2.13
			EC-8910155 × FT-5 (-45.00)	2.20
Pericarp thickness	-51.23 (EC- 620410 × Solan Lalima) to 6.23 (EC-37239 × FT-5)	1	EC-37239 × FT-5 (6.23)	5.46
Total soluble solids	-30.59 (EC-8910155 × Solan Lalima) to 4.74 (LE-79-5 × FT-5)	4	LE-79-5 × FT-5 (4.74)	4.71
			EC-37239 × FT-5 (3.33)	4.65
			EC-267727 × FT-5 (2.81)	4.63
Ascorbic acid content	None of the crosses were found significant for standard heterosis with respect to this trait.			

Table 4: Fruit shape index of the parents as well as the resultant crosses of tomato.

Fruit shape index	Shapes	Genotypes
1 or more	Oval	EC-267727, EC-620410, LE-79-5, EC-267727 × FT-5, EC-620410 × FT-5, LE-79-5 × FT-5, EC-267727 × Solan Lalima, EC-620410 × Solan Lalima and LE-79-5 × Solan Lalima
0.86-0.99	Spherical	EC-191531, Yalabingo, FT-5, Solan Lalima, EC-37239 × FT-5, EC-191531 × FT-5, Yalabingo × FT-5, EC-191531 × Solan Lalima, Yalabingo × Solan Lalima and EC-37239 × Solan Lalima
0.71-0.85	Flat round	EC-174913, EC-8910155, EC-37239, EC-191535, BT-1-1, EC-174913 × FT-5, EC-8910155 × FT-5, EC-191535 × FT-5, BT-1-1 × FT-5, EC-174913 × Solan Lalima, EC-8910155 × Solan Lalima, EC-191535 × Solan Lalima, BT-1-1 × Solan Lalima and Naveen 2000+

Table 5: Ripe fruit colour of the lines, testers and the crosses as per the Colour Chart, Royal Horticultural Society, London.

Fruit colour	Genotypes
Orange Red Group 30 A	EC-174913 × FT-5
Orange Red Group 33 A	EC-191535, EC-8910155, Yalabingo, Solan Lalima, EC-37239 × FT-5, EC-37239 × Solan Lalima, EC-191535 × FT-5, EC-191535 × Solan Lalima, EC-267727 × FT-5
Orange Red Group 33 B	EC-620410 × Solan Lalima
Orange Red Group 34 A	BT-1-1, EC-191531, EC-174913, EC-620410, FT-5, BT-1-1 × FT-5, EC-8910155 × FT-5, EC-8910155 × Solan Lalima, EC- 174913 × Solan Lalima, EC-191531 × FT-5, EC-191531 × Solan Lalima, Yalabingo × FT-5, EC-620410 × FT-5
Orange Red Group 34 B	EC-267727
Red Group 39 A	LE-79-5
Red Group 40 A	Yalabingo × Solan Lalima
Red Group 44 A	EC-37239, BT-1-1 × Solan Lalima, EC-267727 × Solan Lalima, Naveen 2000+ (Standard Check)
Red Group 45 A	LE-79-5 × FT-5, LE-79-5 × Solan Lalima

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References

1. Rick CM. Origin of Cultivated Tomato, Current Status and the Problem. Abstract, XI International Botanical Congress. 1969; 180.

2. Anonymous. Third advance Estimate of Area and Production of Horticultural Crops in India. Department of Agriculture, Cooperation and Farmers Welfare, Government of India, New Delhi. 2017; 4.
3. Kempthorne O. An Introduction to Genetic Statistics, John Wiley and Sons Inc. New York. 1957; 458-471.
4. Anonymous. Package of Practices for Vegetable Crops. Directorate of Extension Education, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan. 2013; 202.
5. Roy SK, Choudhary B. Studies on physiochemical characteristics of few varieties in relation to processing. J Food Sci. Tech. 1972; 9(3):151-153.
6. Ranganna S. Vitamins. In: Handbook of Analysis and Quality Control for Fruit and Vegetable Production. 1986; 2:105-106.
7. Singh A, Gautam JPS, Upadhyay M, Joshi A. Heterosis for yield and quality characters in tomato. Crop Res. Hissar. 2005; 29(2):285-287.
8. Saeed A, Hasan N, Shakeel A, Saleem MF, Khan NH, Zaif K, *et al*. Genetic analysis to find suitable parents for development of tomato hybrids. Sci. Pub. Researcher. 2014; 6(6):77-82.
9. Aisyah SI, Wahyuni S, Syukur M, Witono JR. The estimation of combining ability and heterosis effect for yield and yield components in tomato (*Lycopersicon esculentum* Mill.) at lowland. J Crop Breeding and Genet. 2016; 2(1):23-29.
10. Gaikwad AK, Cheema DS. Studies on heterosis using heat tolerant lines in tomato. J Res. Punjab Agriculture University. 2010; 47(1-2):53-57.
11. Kumari S, Sharma MK. Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.). Int. J Farm Sci. 2011; 1(2):45-55.
12. Kumar R, Srivastava K, Singh RK, Kumar V. Heterosis and quality attributes in tomato (*Lycopersicon esculentum* Mill.). Vegetos. 2013; 56(1):101-106.
13. Rajan EB. Heterosis for some quality traits in tomato (*Lycopersicon esculentum* Mill.). Plant Archives. 2014; 14:101-104.
14. Sharma DK, Chaudhary DR, Sharma PP. Studies on hybrid vigour in tomato. Haryana J Hort. Sci. 2001; 30(3-4):236-238.
15. Kumar YKH, Patil SS, Dharmatti PR, Byadagi AS, Kajjidoni ST, Patil RH. Estimation of heterosis for *tospo* virus resistance in tomato. Karnataka J Agricultural Sci. 2009; 22(5):1073-1075.
16. Duhan D, Pratap PS, Rana MK, Dudi BS. Combining ability study for growth and yield characters in tomato. Haryana J Hort. Sci. 2005; 34(1-2):128-134.