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Performance of Tomato (*Solanum lycopersicum* L.) Hybrids for Yield and its Contributing Traits under Mid-hill Conditions of Himachal Pradesh

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Abstract

With an objective to estimate the performance of tomato hybrids with respect to their yield and yield contributing traits, an experiment was conducted at the experimental farm of RHR&TS, Jachh, Kangra, Himachal Pradesh with 20 hybrids along with their 12 diverse parents and standard check Naveen 2000+, which is a leading commercial tomato hybrid in Himachal Pradesh. The hybrids were produced during *Rabi* 2015 by following line×tester mating design and were evaluated during *kharif*, 2016. The later experiment was designed in Randomized Complete Block Design (RCBD) with three replications. The obtained results revealed that the hybrid, EC-620410×Solan Lalima was earliest among all the entries in terms of days to 50% flowering, while both the hybrids between EC-8910155 and FT-5 were earliest in terms of days taken to marketable maturity. The hybrid between BT-1-1×FT-5 had maximum number of fruits cluster^{-1} as well as maximum yield plant^{-1}. For average fruit weight, the hybrids of BT-1-1×Solan Lalima were found best among all the hybrids and their parents. The hybrid, LE-79-5×FT-5 produced maximum number of marketable fruits plant^{-1}. Moreover this hybrid recorded minimum severity of *Alternaria* blight (early blight). Hence, for commercial exploitation of heterosis for earliness and yield in tomato, these hybrids are needed to be tested in multiple locations for stability before releasing as varieties.

Keywords: Tomato, hybrids, performance, mid-hills, line×tester

1. Introduction

Tomato, *Solanum lycopersicum* L., a member of family Solanaceae, is one of the most important, popular and widely grown vegetable crop in the world. The crop is mainly valued for its mature fruits which are eaten fresh as salad and also processed into several products like puree, paste, ketchup or whole canned fruits. Owing to its nutritional value and antioxidant properties, due to presence of lycopene and flavanoides, tomato is universally treated as 'protective food' (Sepat et al., 2013).

Although India is second largest producer of tomato just after China, our national productivity (21.2 t ha^{-1}) is far lower than that of world average (33.99 t ha^{-1}) (Anonymous, 2015). One of the main reasons for this might be due to less exploitation of the genetic potential of this crop by heterosis breeding. To minimize the gap of productivity of this crop, there is an urgent need to come up with desirable and superior hybrid varieties suited for different agro-ecological zones of India. Keeping in view these facts, the present experiment was formulated to develop superior tomato hybrids by involvingten diverse lines and two testers.

2. 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 (Kempthorne, 1957) involving ten diverse lines viz. EC-8910155, EC-191531, EC-191535, EC-620410, EC-174913, EC-267727, EC-37239, LE-79-5, Yalabingo, BT-1-1and two testers viz. Solan Lalima and FT-5, procured from different sources and are being maintained at Department of Vegetable Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh. The parents and their 20hybrids along with a standard check variety, Naveen 2000+, which is the leading commercial hybrid in Himachal Pradesh, 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 twenty plants plot^{-1} (2.7×2.0 m^2) in each entry in each replication. Standard cultural practices for raising healthy crop of tomato were followed (Anonymous, 2013).

Observations were recorded from five randomly selected plants (for plant characters) and from ten random fruits (for fruit characters), selected from the third harvest from each entry in each replication for traits *viz.,* days to 50% flowering, days to marketable maturity, number of fruits cluster^{-1}, number of marketable fruits plant^{-1}, average fruit weight (g), plant height (cm), harvest duration (days), *Alternaria* blight severity (%) and fruit yield plant^{-1} (g). *Alternaria* blight severity was recorded from 10 randomly selected leaves in each five random plants in each entry by adopting 0-5 scale (Shekhawat and Chakarvarti, 1974), where, grade 0 indicated 0% infected leaf area and 5 implied more than 75.1% infected leaf area. The Percent Disease Index (PDI) was calculated according to the following formula (McKinney, 1923),

PDI of Alternaria (%)=Sum of all disease ratings/ (Total number of ratings×Highest disease grade)

The recorded data was subjected to analysis by MS-EXCEL and OPSTAT software (Sheron et al., 1998).

3. Results and Discussion

The analysis of variance (Table 1) showed significant variations in the parents as well as in their hybrids for all the traits under study.

The perusal of data, as presented in Table 2 revealed that, among the parents, days taken to 50% flowering ranged from 30.00 (EC-620410) to 34.67 days in both EC-37239and FT-5. Among the crosses, the values ranged from 26.33 (EC-620410 × Solan Lalima) to 34.67 days (Yalabingo×Solan Lalima).Former hybrid was statistically at par (p≤0.05) with BT-1-1×FT-5(26.67) and EC- 191531×FT-5 (26.67). This is an important horticultural trait which helps to determine the earliness of the genotype. Therefore negative heterosis is desired here. Out of the 20 resultant hybrids, 13 hybrids were found to be better than the standard check (33.00). Earlier, Kumari and Sharma (2011), Singh et al. (2012); Patwary et al. (2013) also found similar estimates for this trait while evaluating tomato hybrids. Days to marketable maturity are also a key determining factor of earliness which fetches remunerative returns to the farmers. The estimates ranged from 67.33 (EC-8910155) to 74.33 (Yalabingo and FT-5) among the parents. Among the hybrids, EC-8910155 × FT-5 took minimum (59.67) and EC-191531×Solan Lalima (67.67) took maximum number of days to reach first harvest. All the 20 crosses showed desirable negative standard heterosis for this trait. Number of fruits cluster^{-1} is an important yield determining trait in tomato as significant positive association of yield is often observed with this trait. In our study, among the parents,EC-174913 had maximum (5.53) and EC-37239 had minimum (3.90) number of fruits cluster^{-1}, whereas, among the hybrids, BT-1-1×FT-5 had maximum (6.93) whereas, EC-620410 × FT-5 had minimum

Table 1: Analysis of Variance for different traits in tomato

Characters/ sources of variation	Mean sum of squares			
	Replications	Genotypes	Error	Total
Degrees of Freedom	2	32*	64	98
Days to 50% flowering	1.45	19.38*	0.57	21.41
Days to marketable maturity	3.12	58.67*	0.29	62.08
No. of fruits cluster^{-1}	0.03	1.16*	0.02	1.22
No. of marketable fruits plant^{-1}	0.46	35.92*	0.24	36.62
Average fruit weight (g)	1.73	205.47*	0.55	207.76
Fruit yield plant^{-1} (g)	291.92	134700.25*	472.13	135464.30
Plant height (cm)	0.17	1197.74*	1.73	1199.64
Harvest duration (days)	0.28	7.06*	0.42	7.76
Alternaria blight severity (%)	76.69	126.68*	22.14	225.51

*Significant (p≤0.05)

(4.07) number of fruits cluster^{-1}. 18 hybrids were found superior than that of the standard check (4.13) with respect to this trait. Among the parents, LE-79-5 gave highest (20.83) and EC-191531 (12.53) gave lowest, whereas, the hybrid LE-79-5×FT-5 gave highest (28.50) and EC-37239×Solan Lalima gave lowest (12.33) number of marketable fruits plant^{-1}. Four cross combinations were found superior over Naveen 2000+ (19.87) for this trait. These results are in line with that of Patwary et al. (2013); Ahmad et al. (2015); Kumar and Singh (2016). For average fruit weight, among the parents, EC-191535 had highest (69.08) and EC- 620410 had lowest (51.37), whereas, among the crosses, average fruit weight was highest (85.58 g) in BT-1-1×Solan Lalima and was minimum (52.33 g) in LE-79-5×Solan Lalima. Exactly half of the hybrids were found better than the standard check (68.58 g) with respect to this trait. Fruit weight is generally considered as the direct contributor of fruit yield. Similar results have also been noted by Ahmed et al. (2011); Agarwal et al. (2014).

The ultimate goal of any breeding programme is to achieve maximum marketable yield. For this trait, wide variation was recorded from 776.67 g (EC-191531) to 1220 g (LE-79-5). Among the hybrids, BT-1-1 × FT-5 had highest (1676.67 g) and EC-620410 × Solan Lalima had lowest (913.33 g) yield plant^{-1}

Table 2: Mean performance of parents and their hybrids for earliness and fruit traits in tomato

Genotypes	Days to 50% Flowering	Days to marketable maturity	No. of fruits cluster^{-1}	Marketable fruits plant^{-1}	Average fruit weight (g)
BT-1-1	33.67	72.67	4.07	16.13	62.47
EC-37239	34.67	70.67	3.90	13.50	60.83
EC-191535	33.33	70.67	4.40	16.43	69.08
EC-8910155	30.67	67.33	4.33	15.60	56.63
EC-174913	33.67	71.33	5.53	17.83	65.17
EC-191531	32.33	73.67	4.73	12.53	61.45
Yalabingo	33.67	74.33	5.07	13.60	63.50
EC-267727	30.67	70.33	4.53	15.63	62.33
LE-79-5	30.67	70.67	4.93	20.83	57.80
EC-620410	30.00	72.00	4.23	19.70	51.37
FT-5	34.67	74.33	4.73	15.60	58.58
Solan Lalima	33.33	72.33	5.10	18.63	55.58
BT-1-1×FT-5	26.67	61.67	6.93	22.80	70.83
BT-1-1×Solan Lalima	30.67	63.33	4.33	15.13	85.58
EC-37239×FT-5	33.00	62.33	4.83	15.07	72.97
EC-37239×Solan Lalima	32.33	66.67	4.90	12.33	80.75
EC-191535×FT-5	34.33	67.33	4.57	16.80	71.92
EC-191535×Solan Lalima	28.67	61.33	5.13	18.67	79.08
EC-8910155×FT-5	30.00	59.67	4.93	21.00	60.95
EC-8910155×Solan Lalima	28.33	67.33	4.93	18.40	68.83
EC-174913×FT-5	30.33	60.67	5.17	15.60	69.50
EC-174913×Solan Lalima	33.00	66.00	5.73	15.20	66.58
EC-191531×FT-5	26.67	67.33	4.60	15.20	77.00
EC-191531× Solan Lalima	33.00	67.67	4.93	16.60	70.58
Yalabingo×FT-5	33.67	63.67	5.43	17.27	68.67
Yalabingo×Solan Lalima	34.67	66.33	5.63	18.73	74.08
EC-267727×FT-5	30.33	67.33	5.87	20.00	62.00
EC-267727×Solan Lalima	31.00	67.33	4.60	17.53	70.58
LE-79-5×FT-5	28.33	60.33	5.17	28.50	56.53
LE-79-5×Solan Lalima	28.67	61.67	5.43	25.40	52.33
EC-620410×FT-5	27.67	66.67	4.07	18.07	60.75
EC- 620410×Solan Lalima	26.33	60.67	5.03	15.77	56.83
Naveen 2000+	33.00	68.33	4.13	19.87	68.58
SEd±	0.62	0.44	0.12	0.40	0.61
CD (p=0.05)	1.22	0.86	0.24	0.79	1.19

(Table 3). Four cross combinations were found superior than the standard check (1350 g) for this trait. Similar estimates for this trait were also reported by Singh and Sastry, (2011) and Kumar and Singh (2016). Plant height is one of the most important factors that determines the harvest duration of the indeterminate tomatoes. Among the parents, Solan Lalima had maximum plant height (154.63 cm) and LE-79-5 had minimum (67.33 cm) plant height whereas, among the hybrids, maximum (134.66 cm) plant height was recorded in EC-174913 × FT-5, which was statistically at par (p≤0.05) with

Table 3: Mean performance of parents and their hybrids for yield and its contributing traits in tomato

Genotypes	Fruit yield plant^{-1} (g)	Plant height (cm)	Harvest duration (days)	Severity of Alternaria blight (%) #
BT-1-1	1010.00	95.33	29.33	15.55 (23.12)
EC-37239	820.00	70.33	29.67	35.55 (36.57)
EC-191535	1143.33	100.46	28.67	20.00 (26.35)
EC-8910155	876.67	91.44	32.33	28.89 (32.47)
EC-174913	1163.33	101.90	30.67	31.11 (33.86)
EC-191531	776.67	97.44	30.67	37.78 (37.89)
Yalabingo	886.67	77.56	34.33	26.67 (30.96)
EC-267727	986.67	83.20	31.33	31.11 (33.86)
LE-79-5	1220.00	67.33	33.67	24.45 (29.57)
EC-620410	1040.00	94.91	29.67	22.22 (28.06)
FT-5	920.00	122.11	31.33	24.45 (29.57)
Solan Lalima	1036.67	154.63	32.67	28.89 (32.47)
BT-1-1 × FT-5	1676.67	125.14	34.33	13.33 (20.97)
BT-1-1 × Solan Lalima	1300.00	120.39	33.33	20.00 (26.35)
EC-37239×FT-5	1123.33	133.58	33.33	26.67(30.96)
EC-37239×Solan Lalima	1026.67	110.65	33.67	35.55 (36.57)
EC-191535×FT-5	1226.67	126.18	33.33	20.00 (26.35)
EC-191535×Solan Lalima	1480.00	123.37	32.33	24.45 (29.57)
EC-8910155×FT-5	1273.33	94.55	33.00	20.00 (26.35)
EC-8910155×Solan Lalima	1233.33	108.77	33.33	22.22 (28.06)
EC-174913×FT-5	1086.67	134.66	32.33	24.45 (29.57)
EC-174913×Solan Lalima	990.00	124.36	32.33	28.89 (32.47)
EC-191531×FT-5	1146.67	115.56	33.67	26.67 (30.96)
EC-191531× Solan Lalima	1180.00	121.55	33.00	28.89 (32.47)
Yalabingo×FT-5	1196.67	124.92	33.33	26.67 (30.96)
Yalabingo×Solan Lalima	1400.00	120.62	34.33	20.00 (26.35)
EC-267727×FT-5	1253.33	100.38	32.00	15.55 (23.12)
EC-267727×Solan Lalima	1213.33	123.74	31.33	31.11 (33.86)
LE-79-5×FT-5	1620.00	102.70	33.00	11.11 (19.26)
LE-79-5×Solan Lalima	1333.33	114.28	33.67	24.45 (29.57)
EC-620410×FT-5	1103.33	96.95	31.67	28.89 (32.47)
EC-620410×Solan Lalima	913.33	97.45	32.33	35.55 (36.57)
Naveen 2000+	1350.00	138.43	34.33	22.22 (28.06)
SEd±	17.74	1.07	0.53	2.70
CD (*p*=0.05)	34.77	2.11	1.03	5.41

EC-267727×FT-5 (133.58 cm). Minimum plant height (94.55 cm) was recorded in EC-8910155×FT-5. However, none of the hybrids could exceed the plant height of Solan Lalima. Similar estimates were also reported by Kumar et al. (2009) and Kumari et al. (2010). Genotypes with longer harvest duration are preferred as these ensure continuous supply of produce over a longer period of time. It is also one of the key determining factors for the acceptability of a variety among the farmers. Among the parents, maximum harvest duration was recorded in Yalabingo (34.33 days), while minimum was

recorded in EC-191535 (28.67 days) among the parents, while, maximum harvest duration (34.33 days) was recorded in both Yalabingo×Solan Lalima and BT-1-1×FT-5 which was equal to the harvest duration of the line Yalabingo, while minimum harvest duration (31.33 days) was recorded in EC-267727×Solan Lalima. Similar estimates were also observed by Sharma and Thakur (2008); Kumari and Sharma (2011). The severity of *Alternaria* blight ranged from 15.55% (BT-1-1) to 37.78% (EC-191531) among the parents, while among the hybrids, blight severity was recorded minimum (11.11%) in LE-79-5×FT-5 which was statistically at par ($p \leq 0.05$) with two other hybrids. Maximum *Alternaria* blight severity (35.55%) was recorded in both EC-37239×Solan Lalima and EC-620410×Solan Lalima. Two hybrids were found better than the standard check, Naveen 2000+ with respect to this trait (22.22%). Earlier, Liu et al.(2004) and Mate et al. (2005) found that *Alternaria* blight in tomato and found that disease severity varied with the genotype and environmental interactions.

4. Conclusion

Yield improvement is the first and foremost objective in any crop breeding programme. The national productivity of tomato in India is much lesser than that of the world average. Finding a high yielding variety with disease tolerance or resistance is the way to minimize this productivity gap. Hence, the desirable hybrids, as reported in this study, may be tested in multiple locations before their release.

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