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HETEROTIC RESPONSE AND COMBINING ABILITY EFFECT IN TOMATO (*SOLANUM LYCOPERSICUM* L.) FOR TRAITS GOVERNING FRUIT QUALITY UNDER MID-HILL CONDITIONS

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ABSTRACT

Tomato is a very popular and important crop which is rich in minerals and vitamins due to which it has many medicinal properties. Apart from this, a pigment called lycopene is also found in it. The experiment was carried out at the Vegetable Research and Demonstration Block, Department of Vegetable Science, VCSG UUHF, Bharsar, during the *Kharif* season. The experimental material for the present study included five parents and ten F_1 crosses, which were developed by crossing these five diverse tomato lines (Pant T-3, Solan Lalima, Roma, LC-1 and Arka Alok) in half-diallel design (excluding reciprocals). All the parents and their hybrids along with the commercial check (PS-2255) were planted in a Randomized Complete Block Design with three replications for their evaluation. Significant differences were found among genotypes for all quality traits under study such as shelf life, pericarp thickness, TSS, lycopene content, ascorbic acid. Significant heterobeltiosis, average heterosis and standard heterosis observed in a desirable direction for all the traits. Four crosses exhibited positive heterosis over better parent and standard parent for all the traits. The parent Pant T-3 emerged as a good general combiner for lycopene content. Whereas, Solan Lalima was observed as good general combiner for shelf life and ascorbic acid content. While, Pant T-3 × Solan Lalima cross combination showed the best specific combiner in quality attributing traits in desirable direction. The three F_1 hybrid combinations Pant T-3 × Roma, Solan Lalima × Arka Alok and LC-1 × Arka Alok can be recommended for commercial cultivation after multi-locational testing.

***Keywords*:** Tomato (*Solanum lycopersicum* L.), Heterotic response, combining ability

Introduction

Tomato (*Solanum lycopersicum* L.) is the most popular and a member of the Solanaceae family having a chromosome number of 2n = 2x = 24. It is widely grown vegetable crop in the world next to potato. The origin of tomato was Peru - Equador region (Rick and Holle, 1990). In India, tomato occupies an area of 8.01 lakh hectares with production of 223.37 lakh tonnes (Anonymous, 2018). Uttarakhand is one of the tomatoes growing state covering an area of 8550.15 hectare with a production of 93.22 thousand metric tonnes with an average productivity of 12.42 metric tonnes per hectares (Anonymous, 2018). Tomato production scenario has changed tremendously over past two decades with the increase and popularity of hybrids in commercial cultivation. Heterosis breeding is a tool for genetic improvement in tomato which has been up holder by several research workers ever since the phenomenon of hybrid vigour was noticed by Hedrick and Booth (1907). Exploitation of hybrid vigour depends on and magnitude and direction of heterosis, and ease with which hybrid seeds can be produced. Exploitation of heterosis is primarily dependent on the selection of available germplasm that is generally done by putting them in diverse combinations (Hannan *et al.*, 2007). The major objective was done to estimate the extent of heterosis

and combining ability in tomato for quality traits under mid hill condition.

Materials and Methods

The experiment was carried out at the Vegetable Research and Demonstration Block, Department of Vegetable Science, Veer Chandra Singh Garhwali Uttarakhand University of Horticulture and forestry, Bharsar, Pauri Garhwal (U.K.) during the *Kharif* season. Five diverse tomato parents *viz.*, Pant T-3, Solan Lalima, Roma, LC-1, Arka Alok were crossed in a half diallel fashion to obtain the seeds of 10 different F_1 cross combinations. The seedlings of parents were raised in October 2017 and were further transplanted in polyhouse to make crosses and generate F_1 hybrids. The seeds of crosses were harvested in April-June, 2018. In the early autumn of 2018, the fifteen cross combinations along with a popular standard check (PS-2255) were planted in RCBD with three replications. The seeds were sown in month of August further transplanting was carried out with three replications. Analysis of Variance (ANOVA) was performed with the help of O.P. Stat software as explained by the formula Gomez and Gomez (1983).

Results and Discussion

The character-wise results obtained have been presented here. The variance due to genotypes (crosses and parents) was significant at p=0.05 and p=0.01 for all the parameters *viz.*, pericarp thickness (mm), total soluble solids (°Brix), ascorbic acid (mg/100g), shelf life (days) and lycopene content (mg/100g).

Shelf life (Days)

Among the ten cross combinations, two crosses have shown significant positive heterosis over better parent. The heterosis over better parent ranged from -11.76 % to 6.63 %. The percent of trait increase or decrease over check cultivar ranged from -8.67 % to 11.57 %. The cross combinations, Pant T-3 × Solan Lalima (11.57 %), LC-1 × Arka Alok (7.52 %) and Pant T-3 × Roma (6.94 %) and Solan Lalima × Roma (1.73 %) showed significant positive heterosis over standard check. Among the parents, Solan Lalima (0.28) possessed significantly positive GCA effects which found good general combiner capacity and Pant T-3 × Solan Lalima (1.27), Pant T-3 × Roma (0.94), LC-1 × Arka Alok (0.88) cross combinations showed good specific combiner as they possessed significant positive SCA effects. The finding for shelf life was also observed by Kulkarni (2003), Mahendrakar (2004), Premalakshmi *et al.* (2006) and Kumar and Gowda (2016).

Pericarp Thickness (mm)

The heterosis over better parent ranged from -3.20 % to 15.09 % in which, Pant T-3 × Solan Lalima (15.09 %), Pant T-3 × Roma (8.29 %), Solan Lalima × Roma (5.03 %) and Pant T-3 × LC-1 (1.97 %) hybrid combinations showed significant positive heterosis over better parent. For check, the standard heterosis varied from -5.85 % to 3.39 % where, all the cross combinations showed significant negative heterosis over the standard check except Pant T-3 × Solan Lalima (3.39 %). Arka Alok (0.19) parent was proved to be good general combiner as it exhibited significant positive GCA effect. The remaining other parents were found to have non-significant negative GCA effects, determining them to be average general combiner. Out of all the crosses, Pant T-3 × Solan Lalima (0.62) exhibited significantly superior positive specific combining ability effects. These results are in accordance with the works of Ghosh *et al.* (1997), Kulkarni (2003) and Thakur and Kohli (2005).

Lycopene content (mg/100 g)

Among the crosses, the heterosis over better parent ranged from -11.65 % to 73.66 %. Solan Lalima × Arka Alok (-11.65 %) was only one cross combination showed significant negative heterosis over better parent. Remaining nine cross combinations showed significant positive heterosis over better parent. For check, the standard heterosis varied from -44.54 % to 8.99 %. Pant T-3 × Arka Alok (8.99 %) F_1 cross showed significant positive heterosis over standard check. In parental lines, Pant T-3 (0.28) and Arka Alok (0.22) were found to be good general combiners as they exhibited significant positive GCA effects. In the crosses, Pant T-3 × Arka Alok (1.98) and Pant T-3 × Solan Lalima (0.63) observed good specific combining ability as it exhibited significant positive SCA effects. The heterosis for this trait was also given by Kumar *et al.* (2013) and Dagade *et al.* (2015) and Kumar *et al.* (2015).

Total Soluble Solid (°Brix)

Among the cross combinations, three have shown significant positive heterosis over better parent which varied from -15.05 % to 18.74 %. The positive heterosis over better parent was significantly shown by Roma × LC-1 (18.74 %), Pant T-3 × LC-1 (15.16 %) and Pant T-3 × Roma (10.04 %). Standard heterosis over check ranged from -9.48 % to 17.50 %. Over standard check, Roma × LC-1 (17.50 %), Pant T-3 × LC-1 (13.95 %), Pant T-3 × Roma (7.30 %) and Pant T-3 × Solan Lalima (4.58 %) showed significant and positive heterosis. Roma (-0.01) was recorded non-significant and negative GCA effects for general

combiner of parent. The two cross combinations, Roma × LC-1 (1.04) and Pant T-3 × LC-1 (0.65) observed superior specific combiner for the trait. Whereas, Solan Lalima × LC-1 (0.73) exhibited significant negative SCA effects which indicates it is poor specific combiners. Similar findings for total soluble solids were observed by Hannan *et al*. (2007) and Kumari and Sharma (2011), Joshi and Kohli (2006) and Figueiredo *et al*. (2015).

Ascorbic acid (mg/100g)

The heterosis for ascorbic acid over better parent varied from -27.15 % to 6.94 % in which Solan Lalima × Roma (6.94 %) and Solan Lalima × LC-1 (5.38%) showed significantly positive heterobeltiosis. Standard heterosis over check ranged from -17.89 % to 31.27 % where, Pant T-3 × Roma (-17.89 %), Pant T-3 × Solan Lalima (-6.86 %) and Pant T-3 × Arka Alok (-5.29 %), showed significantly highest negative standard heterosis. Remaining all cross combinations showed significant positive heterosis over standard check except Roma × Arka Alok (1.66 %) and Pant T-3 × LC-1 (1.19 %). Out of all the parents Solan Lalima (1.64) exhibited positive GCA effects which indicates that it was good general combiner. Among ten crosses, three crosses exhibited positive SCA effects *viz.*, Solan Lalima × Roma (2.14), Solan Lalima × LC-1 (1.38) and Solan Lalima × Arka Alok (1.37) which means they are good specific combiners. Whereas, LC-1 × Arka Alok (0.54) had average specific combining ability as it exhibited non-significant positive SCA effects. Positive heterosis for ascorbic acid was also reported by Tiwari and Lal (2004) and Kumari and Sharma (2011), Joshi and Kohli (2006) and Gautam *et al*. (2016).

Conclusion

Two cross combinations were recorded for high significant positive heterosis compared to the better parents and were examined for pericarp thickness and shelf life, they are, Pant T-3 × Solan Lalima followed by Pant T-3 × Roma which indicates best hybrids for these traits. For lycopene content, Pant T-3 × Arka Alok was proved to be best cross for this trait as it exhibited high significant positive heterosis over the both. Roma × LC-1, Pant T-3 × Roma and Pant T-3 × LC-1, were recorded as superior hybrid for TSS as they found significant positive heterosis over better parent and standard check. Whereas for ascorbic acid, Solan Lalima × Roma and Solan Lalima × LC-1 significantly observed the best cross combinations over the same. Considering the overall performance in terms of GCA, Solan Lalima was proved to be best general combiner followed by Arka Alok and Pant T-3. The hybrid Pant T-3 × Solan Lalima was regarded as best specific combiner and thus, can be recommended for commercial cultivation under mid-hill regions of Uttarakhand.

Table 1 : Heterotic responses of crosses for quality traits in tomato

	Shelf life (days)		Pericarp thickness (mm)		TSS (°Brix)		Ascorbic acid (mg/100g)		Lycopene content (mg/100g)	
Crosses	**BP**	**SP**	**BP**	**SP**	**BP**	**SP**	**BP**	**SP**	**BP**	**SP**
Pant T-3 × Solan Lalima	6.63**	11.57**	15.09**	3.39**	45.87**	-20.58**	-1.86**	4.58**	-24.12**	-6.86**
Pant T-3 × Roma	4.52**	6.94**	8.29**	-3.48**	41.74**	-22.84**	10.04**	7.30**	-27.15**	-17.89**
Pant T-3 × LC-1	-11.23**	-4.04**	1.97**	-4.31**	8.25**	-39.48**	15.16**	13.95**	-10.21**	1.19
Pant T-3 × Arka Alok	-4.24**	-8.67**	0.31	-0.31	73.66**	8.99**	-4.17**	-6.56**	-15.95**	-5.29**
Solan Lalima × Roma	-2.76**	1.73**	5.03**	-5.64**	33.05**	-28.92**	-13.20**	-7.50**	6.94**	31.27**
Solan Lalima × LC-1	-7.49**	0	0.33	-5.85**	22.74**	-31.38**	-15.05**	-9.48**	5.38**	29.35**
Solan Lalima × Arka Alok	-6.63**	-2.31**	-3.20**	-3.79**	-11.65**	-44.54**	-5.67**	0.52	1.32	24.37**
Roma × LC-1	-11.76**	-4.62**	-0.22	-6.36**	25.96**	-29.59**	18.74**	17.50**	-2.06	7.16**
Roma × Arka Alok	-2.82**	-0.57	-0.21	-0.82**	15.23**	-27.67**	-1.00*	-7.19**	-7.09**	1.66
LC-1 × Arka Alok	-0.53	7.52**	-1.03**	-1.63**	6.09**	-33.41**	-8.53**	-9.48**	3.07	10.23**

* Significant at 5 % level, ** Significant at 1 % level

BP - Better parent heterosis, **SP** – Standard parent heterosis

Table 2 : General combining ability effects of parents for five quality traits in tomato

S.No.	Parents	Shelf life (days)	Pericarp thickness (mm)	TSS (°Brix)	Ascorbic acid (mg/100g)	Lycopene content (mg/100g)
1.	Pant T-3	-0.28**	-0.05	0.15	-1.20**	0.28**
2.	Solan Lalima	0.28**	-0.03	0.04	1.64**	-0.18
3.	Roma	0.08	-0.09	-0.01	-0.20	-0.12
4.	LC-1	0.19	-0.02	0.12	0.26	-0.21*
5.	Arka Alok	-0.27**	0.19**	-0.30**	-0.51	0.22**
	SE (gi)	0.128	0.048	0.113	0.366	0.117
	SE (gi-gj)	0.202	0.076	0.179	0.578	0.185

* Significant at 5 % level, ** Significant at 1 % level

Table 3 : Specific combining ability effects of parents for five quality traits in tomato

S.No.	Parents	Shelf life (days)	Pericarp thickness (mm)	TSS (°Brix)	Ascorbic acid (mg/100g)	Lycopene content (mg/100g)
1.	Pant T-3 × Solan Lalima	1.27**	0.62**	0.13	-2.83**	0.63*
2.	Pant T-3 × Roma	0.94**	0.22	0.35	-2.71**	0.44
3.	Pant T-3 × LC-1	-0.44	0.10	0.65**	-0.19	-0.46
4.	Pant T-3 × Arka Alok	-0.51	0.15	-0.25	-0.43	1.98**
5.	Solan Lalima × Roma	-0.22	0.06	-0.48	2.14**	0.53
6.	Solan Lalima × LC-1	-0.54	-0.02	-0.73**	1.38**	0.48
7.	Solan Lalima × Arka Alok	-0.34	-0.10	0.32	1.37**	-0.74**
8.	Roma × LC-1	-0.87**	0.00	1.04**	-0.25	0.52
9.	Roma × Arka Alok	0.06	0.15	-0.12	-0.33	0.21
10.	LC-1 × Arka Alok	0.88**	0.03	-0.40	0.54	-0.05
	SE (sij)	0.331	0.124	0.292	0.299	0.302
	SE (sij-sik)	0.496	0.185	0.438	1.416	0.453

* Significant at 5% level, ** Significant at 1% level

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Conflict of Interest: None

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