The Bioscan 11(4):3207-3211,2016(Supplement on Genetics and Plant Breeding) www.thebioscan.com
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES

ESTIMATION OF HETEROSIS FOR QUALITY TRAITS IN TOMATO (*SOLANUM LYCOPERSICUM* L.)

MANOJ KUMAR[1]*, V. SRINIVASA[1], MEENAKSHI KUMARI[3], MANISH KUMAR[2] AND M. S. HEENA[1]
[1]Department of Vegetable Science, College of Horticulture,
Mudigere (University of Agricultural and Horticultural Sciences, Shivamogga - 577 132, Karnataka, INDIA
[2]Division of Vegetable Sciences, ICAR- Indian Agricultural Research Institute, New Delhi - 110 012, INDIA
[3]Department of Vegetable Science,
Chandra Shekhar Azad University of Agriculture & Technology, Kanpur - 208 002, Uttar Pradesh, INDIA
e-mail: manoj000.hk21@gmail.com

KEYWORDS
Tomato
Line x tester
Quality
Heterobeltiosis
Heterosis

Received on :
20.10.2016

Accepted on :
27.12.2016

***Corresponding author**

ABSTRACT
The present experiment was conducted at the experimental research farm of Department of Vegetable Science, College of Horticulture, Mudigere to find out the magnitude of heterosis by line × tester analysis for quality traits in tomato. The sum total of 24 hybrids, evolved from 8 lines and 3 testers, along with 11 parents and a standard check were evaluated during *Rabi* season of the year 2016. Results indicated that the hybrid AR-29 × UK Local-2 showed negative significant heterosis (-3.70%) over commercial check for number of locules per fruit whereas, for TSS significant positive heterosis check was Tommy Toe × Pant T-3 (0.56%) and AR-29 × Pant T-3(0.56%). The crosses Black Prince × UK Local-2 (55.30%), AR-4 × UK Local-2 (47.08%) and Podlandt Pink × UK Local-2 (31.42%) exhibited significant positive heterosis for lycopene content and only one hybrid Bony Best × Pant T-3 indicated considerable amount of heterosis (15.77%) for ascorbic acid content.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most popular warm season fruit vegetable crops grown throughout the world because of its wider adaptability, high yield potential and suitability for variety of cuisines in fresh as well as in processed form. It is a member of Solanaceae family (2n = 24). Center of origin of tomato is considered to be the Peru Ecuador region (Rick, 1969). It is mostly considered as "Protective food" based on its nutritive value, antioxidant molecules such as carotenoids, lycopene, ascorbic acid, vitamin E and phenolic compounds specially flavonoids (Septa *et al.,* 2013). Tomato is also a good dietary source of some minerals like calcium, iron and phosphorous (Saleem *et al.,* 2013). Tomato is a typical day neutral and short lived perennial herbaceous plant. Though it is a self-pollinated crop, heterosis is being commercially exploited on large scale . Selection of genetically diverse parental lines is necessary in any hybridization programme to develop the potential germplasm with all the desirable traits. (Pedapati *et al.,* 2013 and Singh *et al.,* 2013). At present in tomato, exploitation of heterosis by use of F_1 hybrids is getting more and more importance (Baishya *et al.,* 2001). There has been increasing interest in the production of hybrids and as high as 100 per cent increase in yield of tomato has been achieved due to manifestation of hybrid vigour. The utilization of hybrid vigour as mean of maximizing the yield of vegetable crops has become one of the most important techniques in vegetable breeding. In view of this, the present experiment was undertaken to identify best combiner parents and best cross combinations to develop the desirable F_1 hybrids with hybrid vigour using Line x Tester mating design.

MATERIALS AND METHODS

The present investigation was carried out during Rabi season of the year 2016 at the research farm of Department of Vegetable Science, College of Horticulture, Mudigere. The experimental material consisted of 8 genetically diverse female parents (Tommy Toe, AR-4, AR-29, Black Prince, Bony Best, Podlandt Pink, AR-28 and AR-56) and three male parents (UK Local-2, Sioux and Pant T-3), which were crossed in line × tester mating design to ultimately provide 24 hybrids. The evaluation of all these 24 hybrids along with 11 parents and one commercial check (Arka Samrat) was done in randomized block design during *Rabi* season in two replications. The observations were recorded such as locules per fruit, pericarp thickness, total soluble solids, lycopene content and ascorbic acid content. The mean data were subjected to statistical analysis for estimating heterosis using line × tester model as described by Kempthorne (1957).

RESULTS AND DISCUSSION

The analysis of variance indicated highly significant differences

Table 1: Analysis of variance for quality traits in line × tester study in tomato

Source	Mean sum of square							
	Replications	Parents	Lines	Testers	Line x tester	Hybrids	Parent Vs. hybrids	Error
Degrees of freedom	1	10	7	2	1	23	1	34
Locules per fruit	2.56**	2.90**	1.29**	3.12**	13.74**	0.50**	1.68**	0.19
Pericarp thickness (mm)	0.01	1.39**	1.06**	0.35**	5.77**	0.57**	4.42**	0.01
Total soluble solids (°brix)	0.03	1.67**	1.70**	0.76**	3.26**	0.59**	3.79**	0.50
Lycopene (mg/100g)	0.02	7.25**	7.79**	1.25**	14.94**	3.50**	2.44**	0.02
Ascorbic acid(mg/100g)	0.17	138.73**	138.49**	34.27**	349.31**	100.54**	67.71**	0.23

(*Significance at 5 % and ** Significance at 1 %)

Table 2: *Per se* performance of parents for different quality characters

Parents	Locules per fruit	Pericarp thickness (mm)	Total soluble solids (°brix)	Lycopene (mg/g)	Ascorbic acid (mg/g)
Tommy Toe	3.00	3.28	5.73	3.90	42.00
AR-4	3.30	3.88	4.95	8.62	30.01
AR-29	2.50	4.06	4.81	5.16	56.07
Black Prince	3.00	1.78	6.56	2.64	52.82
Bony Best	2.50	3.55	5.35	3.85	42.04
Podlandt Pink	2.90	4.03	6.41	3.27	46.73
AR-56	5.00	3.48	3.68	2.65	48.40
AR-28	2.80	3.34	5.32	3.27	38.24
UK local-2	4.50	4.98	4.33	6.39	57.83
Sioux	3.90	4.13	3.96	5.02	49.58
Pant T-3	6.30	4.62	5.17	6.64	53.05
Arka Samrat	2.70	5.51	5.37	5.30	56.32

Table 3: Heterobeltiosis for quality components in tomato

Character	Range (%)	Number of desirable heterotic hybrids	Top three best hybrid combinations along with their heterobeltiosis
Locules per fruit	-57.14to 37.78	17	AR-4 × Pant T-3(-57.14%), AR-29 × Pant T-3(-50.79%) and AR-29 × Pant T-3(-50.79%).
Pericarp thickness (mm)	-29.62 to 28.05	05	AR-28 × Sioux(28.05%), Podlandt Pink × Pant T-3(16.02%)and Black Prince × Sioux(15.36%)
Total soluble solids (°brix)	-45.27to 13.38	02	AR-56 × Sioux (13.38%) and AR-56 × UK Local-2 (12.01%)
Lycopene (mg/100g)	-44.49 to 27.05	03	Black Prince × UK Local-2(27.05%), AR-29 × Pant T-3 (22.57%) and Podlandt Pink × UK Local-2 (8.91%)
Ascorbic acid (mg/100g)	-40.62to 22.92	01	Bony Best × Pant T-3 (22.92%)

Table 4: Standard heterosis for quality related traits in tomato

Character	Range %	Number of desirable heterotic hybrids	Top three best hybrid combinations along with their standard heterosis
Locules per fruit	-3.70to 77.77	01	AR-29 × UK Local-2 (-3.70%)
Pericarp thickness (mm)	-37.75 to 2.92	00	-
Total soluble solids (°brix)	-33.15 to 0.56	02	Tommy Toe × Pant T-3(0.56%)andAR-29 × Pant T-3(0.56%),
Lycopene (mg/100g)	-37.64 to 55.30	06	Black Prince × UK Local-2 (55.30%), AR-4 × UK Local-2 (47.08) and Podlandt Pink × UK Local-2 (31.42%).
Ascorbic acid (mg/100g)	-39.03 to 15.77	01	Bony Best × Pant T-3 (15.77%)

among the parents and crosses for all the five different traits studied (Table 1). Among the different diverse parents, both male and female parents exhibited significant differences for all the characters and the variance for parents vs. hybrids was also found significantly positive for all the five characters studied. The contribution of lines × testers also showed significant variation for all characters.

The *per se* performance of parents, heterobeltiosis and heterosis has been presented in Table 2, 3 and 4 respectively. The results showed that heterobeltiosis and standard heterosis (Table 3 and 4 respectively) for locules per fruit varied from -57.14 to 37.78 per cent and -3.70 to 77.77 per cent respectively. From the economic point of view less number of locules or negative heterosis is beneficial. The highest significant negative heterobeltiosis was found in hybrid AR-4 × Pant T-3 (-57.14 %) which was followed by AR-29 × Pant T-3(-50.79%) and AR-29 × Pant T-3 (-50.79%). Whereas, the hybrid AR-29 × UK Local-2 (-3.70%) registered highest

Table 5: *Per se* performance and magnitude of heterosis for number of locules and pericarp thickness

Parents	Number of locules			Pericarp thickness (mm)		
	Per se value	Heterosis % over BP	SC	*Per se* value	Heterosis % over BP	SC
Tommy Toe × UK Local-2	3.10	-31.11**	14.81**	3.50	-29.62**	-36.39**
Tommy Toe × Sioux	3.10	-20.51	14.81**	3.43	-17.05**	-37.75**
Tommy Toe × Pant T-3	3.80	-39.68**	40.74**	3.93	-14.83**	-28.58**
AR-4 × UK Local-2	3.10	-31.11**	14.81**	4.39	-11.95**	-20.42**
AR-4 × Sioux	2.90	-25.64*	7.40	3.98	-3.63	-27.68**
AR-4 × Pant T-3	2.70	-57.14**	0.00	4.12	-10.93**	-25.32**
AR-29 × UK Local-2	2.60	-42.22**	-3.70*	4.96	-0.30	-9.89**
AR-29 × Sioux	2.90	-25.64*	7.40	4.02	-2.66	-26.95**
AR-29 × Pant T-3	3.10	-50.79**	14.81**	3.64	-21.32**	-34.03**
Black Prince × UK Local-2	2.80	-37.78**	3.70	4.22	-15.26**	-23.41**
Black Prince × Sioux	3.10	-20.51	14.81**	4.77	15.36**	-13.43**
Black Prince × Pant T-3	3.00	-52.38**	11.11**	4.62	0.00	-16.15**
Bony Best × UK Local-2	3.10	-31.11**	14.81**	4.55	-8.73**	-17.51**
Bony Best × Sioux	2.70	-30.77**	0.00	3.63	-12.21**	-34.12**
Bony Best × Pant T-3	3.70	-41.27**	37.03**	4.41	-4.55*	-19.96**
Podlandt Pink × UK Local-2	3.30	-26.67*	22.22**	4.84	-2.91	-12.25**
Podlandt Pink × Sioux	3.60	-7.69	33.33**	4.57	10.64**	-16.97**
Podlandt Pink × Pant T-3	3.10	-50.79**	14.81**	5.36	16.02**	-2.92
AR-56 × UK Local-2	3.90	-22.00*	44.41**	4.09	-17.97**	-25.86**
AR-56 × Sioux	3.50	-30.00**	29.62**	4.66	12.82**	-15.34**
AR-56 × Pant T-3	3.50	-44.44**	29.62**	3.92	-15.15**	-28.86**
AR-28 × UK Local-2	4.00	-11.11	48.41**	3.80	-23.69**	-31.03**
AR-28 × Sioux	3.20	-17.95	18.51**	5.30	28.05**	-3.90*
AR-28 × Pant T-3	4.80	-23.81**	77.77**	4.09	-11.36**	-25.68**
Arka Samrat	2.70			5.51		
S.Em ±	0.32	0.44	0.44	0.07	0.10	0.10
C.D. at 5%	0.93	0.91	0.91	0.20	0.20	0.20
C.D at 1%	1.25	1.23	1.23	0.27	0.28	0.28

(* Significance at 5 % and ** Significance at 1 %)

significant negative standard heterosis for the locules per plant because the female parent AR-29 (2.50) used for this has lowest *per se* value (Table 5). This might be due to the parent AR-29 which recorded lowest *per se* value for locules per fruit (2.50). These results were in accordance with the findings of Virupannavar (2009), Saeed *et al*. (2014) and Aisyah *et al*. (2016) in tomato.

The range of heterobeltiosis and standard heterosis for pericarp thickness varied from -29.62 to 28.05 per cent and -37.75 to 2.92 per cent respectively with AR-28 × Sioux (28.05%) exhibited positive and highly significant heterobeltiosis, while none of the hybrids were found significantly positive for standard heterosis.The highest *per se* value for pericarp thickness was observed in the cross Podlandt Pink × Pant T-3 (5.36) which was followed by AR-28 × Sioux (5.30) (Table 5). It may be due to both the parents having high pericarp thickness. These findings were similar with the results of Sharma *et al*. (2006) and Aisyah *et al*. (2016).

Total soluble solids content is also one of the most important quality parameter in the processing industry. With respect to total soluble solids the range of heterobeltiosis and standard heterosis varied from -45.27 to 13.38 per cent and -33.15 to 0.56 per cent respectively. The highly significant heterosis over the check Arka Samrat was observed in the crosses Tommy Toe × Pant T-3 (0.56%) and AR-29 × Pant T-3 (0.56%) which is presented in Table 6. It might be due to both male and female parent have better *per se* value for total soluble solids. These results were in confirmation with the findings of Sharma *et al*. (2006) and Aisyah *et al*. (2016) in tomato crop.

Fruit colour as a component of quality parameter is important to the growers as it affects product appearance and ultimately consumer acceptance in tomato. The heterobeltiosis and standard heterosis for lycopene content ranged from -44.49 to 27.05 per cent and -37.64 to 55.30 per cent, respectively. The highest positively significant heterobeltiosis and standard heterosis was observed in the hybrids Black Prince × UK Local-2 (27.05%) and Black Prince × UK Local-2 (55.30%), respectively which is given in Table 3 and 4 respectively. The highest *per se* value for lycopene content (Table 6) was observed in the cross Black Prince × UK Local-2 (8.13mg/ 100g) which was followed by AR-4 × UK Local-2 (7.79mg/ 100g). It may be due to both the parents having high lycopene content. Heterosis for this character was also reported by Kurian and Peter (2001) and Naveen *et al*. (2008) in tomato.

The *Per se* performance, Heterobeltiosis and Standard heterosis for ascorbic acid content is presented in Table 7. The hybrid Bony Best × Pant T-3 (65.21 mg/100g) exhibited the highest *per se* value for this character which was followed by AR-29 × Sioux (56.06 mg/100g). The magnitude of heterobeltiosis and standard heterosis for ascorbic acid content was ranged from -40.62to 22.92 per cent and -39.03 to 15.77 per cent respectively. The positively significant heterobeltiosis and heterosis were observed only in one hybrid Bony Best × Pant T-3 (22.92%) and Bony Best × Pant T-3 (15.77%)

Table 6: *Per se* performance and magnitude of heterosis for Total soluble solids (°brix) and Lycopene content (mg/100g)

Parents	Total soluble solids (°brix)			Lycopene (mg/g)		
	Per se value	Heterosis % over BP	SC	*Per se* value	Heterosis % over BP	SC
Tommy Toe × UK Local-2	5.10	-10.99**	-5.03*	6.08	-5.00	14.62**
Tommy Toe × Sioux	5.07	-11.52**	-5.59*	4.17	-17.11**	-21.42**
Tommy Toe × Pant T-3	5.40	-5.76**	0.56	4.19	-37.02**	-21.04**
AR-4 × UK Local-2	4.49	-9.29**	-16.39**	7.79	-9.62**	47.08**
AR-4 × Sioux	4.06	-17.98**	-24.39**	6.68	-20.29**	29.72**
AR-4 × Pant T-3	3.68	-28.82**	-31.47**	6.51	-24.52**	22.83**
AR-29 × UK Local-2	4.80	-0.21	-10.61**	5.25	-17.90**	-0.94
AR-29 × Sioux	4.20	-12.68**	-21.79**	4.94	-4.26	-6.79*
AR-29 × Pant T-3	5.40	4.45	0.56	5.14	22.57**	-2.92
Black Prince × UK Local-2	3.59	-45.27**	-33.15**	8.13	27.05**	55.30**
Black Prince × Sioux	4.54	-30.79**	-15.46**	4.74	-5.77	-10.66**
Black Prince × Pant T-3	5.20	-20.73**	-3.17	4.04	-39.13**	-23.68**
Bony Best × UK Local-2	4.41	-17.57**	-17.88**	4.79	-25.18**	-9.72**
Bony Best × Sioux	3.72	-30.47**	-30.73**	4.90	-2.49	-7.55**
Bony Best × Pant T-3	5.04	-5.79*	-6.15**	5.33	-19.86**	0.47
Podlandt Pink × UK Local-2	5.01	-21.84**	-6.70**	6.96	8.91**	31.42**
Podlandt Pink × Sioux	5.35	-16.54**	-0.37	4.87	-3.18	-8.21*
Podlandt Pink × Pant T-3	4.77	-25.59**	-11.17**	3.95	-40.63**	-25.57**
AR-56 × UK Local-2	4.85	12.01**	-9.68**	3.55	-44.49**	-33.02**
AR-56 × Sioux	4.49	13.38**	-16.39**	3.98	-20.90**	-25.00**
AR-56 × Pant T-3	4.04	-21.86**	-24.77**	4.38	-34.01**	-17.26**
AR-28 × UK Local-2	4.49	-15.60**	-16.39**	3.98	-37.84**	-25.00**
AR-28 × Sioux	4.79	-9.96**	-10.80**	3.31	-34.23**	-37.64**
AR-28 × Pant T-3	4.25	-20.11**	-20.86**	4.07	-38.83**	-23.30**
ArkaSamrat	5.37			5.30		
S.Em ±	0.07	0.11	0.11	0.11	0.15	0.15
C.D. at 5%	0.22	0.23	0.23	0.32	0.32	0.32
C.D at 1%	0.29	0.31	0.31	0.44	0.44	0.44

(* Significance at 5 % and ** Significance at 1 %)

Table 7: *Per se* performance and magnitude of heterosis for ascorbic acid content (mg/100g)

Parents	ascorbic acid content (mg/100g)		
	Per se value	Heterosis % over BP	SC
Tommy Toe × UK Local-2	34.34	-40.62**	-39.03**
Tommy Toe × Sioux	47.63	-3.95**	-15.45**
Tommy Toe × Pant T-3	43.53	-17.95**	-22.72**
AR-4 × UK Local-2	39.07	-32.45**	-30.64**
AR-4 × Sioux	39.46	-20.42**	-29.94**
AR-4 × Pant T-3	35.62	-32.86**	-36.76**
AR-29 × UK Local-2	47.08	-18.59**	-16.41**
AR-29 × Sioux	56.06	-0.04	-0.48
AR-29 × Pant T-3	51.37	-8.40**	-8.81**
Black Prince × UK Local-2	41.47	-28.30**	-26.38**
Black Prince × Sioux	39.13	-25.93**	-30.53**
Black Prince × Pant T-3	45.61	-14.02*	-19.02**
Bony Best × UK Local-2	42.49	-26.53**	-24.56**
Bony Best × Sioux	47.16	-4.89**	-16.27**
Bony Best × Pant T-3	65.21	22.92**	15.77**
Podlandt Pink × UK Local-2	52.01	-10.06**	-7.66**
Podlandt Pink × Sioux	43.67	-11.93**	-22.47**
Podlandt Pink × Pant T-3	52.17	-1.66	-7.38**
AR-56 × UK Local-2	49.84	-13.82**	-11.51**
AR-56 × Sioux	38.94	-21.46**	-30.86**
AR-56 × Pant T-3	43.47	-18.06**	-22.82**
AR-28 × UK Local-2	41.65	-27.98**	-26.05**
AR-28 × Sioux	36.89	-25.60**	-34.51**
AR-28 × Pant T-3	42.86	-19.22**	-23.91**
ArkaSamrat	56.32		
S.Em ±	34.34	0.48	0.48
C.D. at 5%	47.63	1.00	1.00
C.D at 1%	43.53	1.36	1.36

(* Significance at 5 % and ** Significance at 1 %)

respectively, over the check Arka Samrat. This might be due to female parent (AR-29) and male parent (Pant T-3) exhibited better *per se* value for ascorbic acid content. Similar findings were also noted by Duhan *et al*. (2005) and Saeed *et al*. (2014) in tomato.

In conclusion, results from the present study clearly showed that there was a large variation for heterosis in all the hybrids with respect to quality traits. None of the hybrids studied was observed to be consistent heterotic for all the characters. But some amount of heterosis was found in desirable direction for most of quality traits. Out of 24 hybrids studied, Black Prince × UK Local-2, Tommy Toe × UK Local-2 and Bony Best × Pant T-3 were found superior for quality traits which need testing in replicated trials over locations for stability in performance prior to commercialization.

REFERENCES

Aisyah, S. I., Wahyuni, S., Syukur, M. and Witono, J. R. 2016. 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.* **2(1):** 23-29.

Baishya, K. C., Syamal, M. M. and Singh, K. P. 2001. Heterosis studies in tomato (*Lycopersicon esculentum* Mill.). *Veg. Sci*. **28:** 168-169.

Duhan, D., Partap, P. S., Rana, M. K. and Dahiya, M. S. 2005. Heterosis study for quality characters in a line × tester set of tomato. *Haryana J. Hort. Sci.* **34:** 371-375.

Kempthorne, O. 1957. An introduction to genetic statistics, John Wiley and Sons, 1stEdn., New York. pp. 456-471.

Kurian, A. and Peter, K. V. 2001. Line × tester analysis for yield and processing characters in tomato. *J. Trop. Agric*. **33:** 23-25.

Naveen, G., Devinder, S. C. and Ajmer, S. D. 2008. Genetics of yield, quality and shelf life characteristics in tomato under normal and late planting conditions. *Euphytica*. **159:** 275-288.

Pedapati, A., Reddy, R. V. S. K., Dilipbabu, J., Sudheerkumar, J. and Sunil, N. 2013. Combining ability analysis for yield and physiological drought related traits in tomato (*Solanum lycopersicum* L.) under moistures stress. *The Bioscan*. **8(4):** 1537-1544.

Rick, C. M. 1969. Origin of cultivated tomato, current status of the problem[Abstract]. In: XI International Botanical Congress; 1969 Aug. 24-Sept. 2; University of Washington, Seattle, U.S.A., p. 180.

Saeed, A., Hasan, N., Shakeel, A., Saleem, M. F., Khan, N. H., Zaif, K., Rana, A. M. K. and Nadeem, S. 2014. Genetic analysis to find suitable parents for development of tomato hybrids. *Sci. Pub. Researcher.* **6(6):** 77-82.

Saleem, M. Y., Asghar, M., Iqbal, Q., Rahman, A., Akram, M. 2013. Diallel analysis of yield and some yield components in tomato (*Solanum lycopersicum* L.) *Pak. J. Bot*. **45(4):** 1247-1250.

Septa, N. K., Septa, S. R., Septa, S. and Kumar, A. 2013. Energy use efficiency and cost analysis of tomato under greenhouse and open field production system at Nubra valley of Jammu and Kashmir. *Int. J. Environ Sci.* **3(4):** 1233-1241.

Sharma, J. P., Jha, A. K., Singh, A. K., Pan, R. S., Mathura, R. and Kumar, S. 2006. Evaluation of tomato against bacterial wilt (*Rastonia solanocearum*) in Jharkhand. *Indian Phytopath*. **59(4):** 405-409.

Singh, A. K., Pan, R. S. and Bhavana, P. 2013. Heterosis and combining ability analysis in Bittergourd (*momordica charantia* L.). The Bioscan. **8(4):** 1533-1536.

Virupannavar, H. S. 2009. Genetic studies for productivity and bacterial wilt resistance in tomato. M. Sc. (Agri.) Thesis, Univ. Agric. Sci. Dharwad (India).