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STUDY OF HETEROSIS FOR GROWTH AND QUALITY TRAITS IN TOMATO (*SOLANUMLY COPERSICUM* L.)

D. Triveni*, P. Saidaiah[1], K. Ravinder Reddy[2] and S.R. Pandravada[3]

[*]Department of Vegetable Science, College of Horticulture, Sri Konda Laxman Telangana State Horticulture University, Rajendranagar, Hyderabad-500030, (Telangana) India
[1]Department of Genetics and Plant Breeding, SKLTSHU, Rajendranagar, Hyderabad-500030 (Telangana) India
[2]Department of Vegetable Science, SKLTSHU, Rajendranagar, Hyderabad-500030 (Telangana) India
[3]Economic Botany, NBPGR Regional Station, Rajendranagar, Hyderabad-500030 (Telangana) India

Abstract

Seven diverse lines of tomato crossed with three testers in line × tester mating design to study the estimates of average heterosis, heterobeltiosis and standard heterosis for growth and quality characters in tomato. The parent material was sown to generate F_1s during *Rabi* season 2016-17 and the parents along with F_1s were raised in early *Summer* 2017 in Randomized Block Design with three replications at college of horticulture, SKLTSHU, Telangana. The results revealed that analysis of variance indicated highly significant differences for all the characters, indicating that there is a variation between the characters studied. The two cross combinations EC 620494 × ArkaVikas and EC 620494 × Pusa Ruby were found to be promising for fruit yield per plant. These heterotic hybrids found superior over better parent and three standard checks have the potential to be exploited commercially.

Key words : Tomato, Heterosis, growth, quality.

Introduction

Tomato (*Solanumly copersicu*m L.) is one of the most important vegetable crop belongs to the family solanaceae and chromosome number 2n=2×=24. It acquired the status of world's most popular vegetable crop due to its wider adaptability to various agro climatic conditions (Gupta *et al.,* 2015). Tomato is a perennial plant but commonly cultivated as an annual (Rick, 1978). It is considered as a protective food because it has rich source of minerals, vitamins and organic acids. Tomato is one of the rich sources of lycopene, which imparts red colour to ripe tomatoes, reported to possess anticancerous properties and it is powerful natural antioxidant (most efficient quencher of singlet oxygen) used in pharmaceuticals (Srinivasan *et al*., 2010). Although tomato is a self pollinated crop, heterosis is being commercially exploited on large scale. Tomato is a potential vegetable crop and has a plenty of scope for its improvement in India because of having varied agro climatic conditions. New cultivars have been developed to meet the diverse needs and their suitability to different agro climatic conditions. But there is huge gap between national average yield of India, when compared with average yield of Telangana. The low yield is due to non availability of high yielding varieties and lack of quality seed. To increase productivity of this crop, there is a need for development of hybrids and varieties with improvement in yield and quality. Heterotic crosses usually show increase in size, vigour, seed producing ability, increased metabolic activity and usually better resistance to insect pests, diseases or extreme temperatures and thus ultimately result in better performance of hybrids than parents. Usually, these hybrids show better fitness and breeding value as compared to parents from which they are made. Higher yield and better fruit quality are universally desired.

***Author for correspondence :** E-mail : triveni23dharoor@gmail.com

Materials and Methods

Experimaental material

The experimental material consists of seven diverse genotypes of tomato *viz.,* EC 620408, EC 620494, EC 654289, EC 620639, EC 631410, EC 631407 and LA 3667

was crossed with three testers *viz.,* Pusa Ruby, Arka Vikas and Arka Megahli in line × tester mating design to obtain twenty one cross combinations. The 21 hybrids along with parents and three standard checks (Arka Rakshak, US 440 and Punjab Chhuhara) were evaluated during early *Summer* 2017 at PG students Research farm, College of Horticulture, Sri kondaLaxman Telangana State Hortcultural University, Rajendranagar, Hyderabad-30. The experiment was laid out in a Randomized Block Design with three replications. Crosses were made manually using the standard procedure of hand emasculation and pollination.

Traits evaluated

F_1s were evaluated along with their parents and standard checks to study estimates of average heterosis, heterobeltiosis and standard heterosis for growth traits like plant height (cm) and number of primary branches per plant and quality traits *viz.,* TSS (^{0}Brix), pH, ascorbic acid (mg/100g) and lycopene (mg/100g).

Results and Discussion

Analysis of variance indicated significant differences among parents and hybrids for all the characters under study. Percentheterosis for each character over mid parent, better parent and three standard checks for yield and yields components are presented in table 1 to 3.

Plant height (cm):

Taller plants in tomato had added advantage due to increase in yield. Hence, positive heterosis is desirable for plant height. The observed range of midparentalheterosis and heterobeltiosis among hybrids was -23.08% (LA 3667 × Pusa Ruby) to 86.21 % (EC 620494 ×Arka Meghali) and -32.26% (EC 620408 × Pusa Ruby) to 85.02% (EC 620494 × Arka Meghali), respectively. When compared to the Arka Rakshak and US 440, fourteen and eighteen hybrids registered significant and positive standard heterosis respectively. These results are in accordance with the earlier findings of Angadi *et al.* (2012) and Shankar *et al.* (2014) over standard heterosis.

Number of primary branches per plant:

Number of primary branches per plant is an important trait by which vigour of the plants are measured. The range of standard heterosis over Arka Rakshak was -3.88% in EC 620408 × Arka Meghali to 37.39 % in EC 654289 × Pusa Ruby. As many as sixteen hybrids showed significant and positive heterosis over the standard check, Arka Rakshak. Similar results were also reported by Angadi *et al.* (2012) and Shankar *et al.* (2014).

TSS (^{o}Brix):

Total soluble solids directly influences flavour of tomato and is an important quality parameter in the processing industry. Eleven hybrids were showed significant and positive average heterosis and eight hybrids showed significant and positive heterobeltiosis. Standard heterosis ranged from -22.48 % in LA 3667 × Pusa Ruby to 32.21% in EC 654289 × Arka Meghali. Eight hybrids manifested positive heterosis over ArkaRakshak. Over US 440 eight hybrids recorded significant and positive standard heterosis. As many as 20 hybrids showed positive and significant Standard heterosis over Punjab Chhuhara. Vinodkumar *et al.* (2013) and Agarwal *et al.* (2014) and Nadeem *et al.* (2014) also reported similar findings.

pH:

For pH negative heterosis was desirable. Only three hybrids, LA 3667 ×Arka Meghali (-15.79%), LA 3667 × Pusa Ruby (-5.02) and LA 3667 × ArkaVikas (-2.96%) exhibited significant and negative standard heterosis over ArkaRakshak. None of the hybrid registered significant and positive heterosis over standard check Punjab Chhuhara.

Ascorbic acid (mg/100g):

Ascorbic acid content is nutritionally an important constituent. Small fruited genotypes are generally richer in ascorbic acid content. Only one hybrid exhibited superior heterosis over their better parent. Standard heterosis over ArkaRakshak was ranged from -17.97 % in EC 620408 × ArkaMeghali to 6.60 % in EC 620639 × Pusa Ruby. Over ArkaRakshak, four hybrids exhibited superior heterosis. Except EC 620408 × ArkaMeghali, all hybrids showed significant and positive standard heterosis over US 440. None of the hybrid exhibited superior heterosis over Punjab Chhuhara. Kumari and Sharma (2011) found similar results for ascorbic acid content.

Lycopene (mg/100g):

High lycopene content imparts deep red colour to the tomato, which is preferred for table as well as processing purpose. Moreover, lycopene had greatest antioxidant property among all carotenoids and is valued for its anti-cancer property, since it acts as a scavenger of free radicals. When compared to Arka Rakshak, nine hybrids were registered positive and significant standard heterosis. Standard heterosis over US 440 was ranged from -59.76 % in EC 620494 × Pusa Ruby to 40.55% in EC 654289 × Arka Meghali. Six hybrids were superior in positive direction over Punjab Chhuhara. The present

Table 1: Average heterosis (%), heterobeltiosis (%) and standard heterosis (%) for plant height (cm) and number of branches in Tomato.

Crosses	Plant height (cm)					Number of primary branches				
	Average heterosis (%)	Hetero-beltiosis (%)	Standard heterosis (%) over			Average heterosis (%)	Hetero-beltiosis (%)	Standard heterosis (%) over		
			Arka Rakshak	US440	Punjab Chhuhara			Arka Rakshak	US440	Punjab Chhuhara
EC 620408 × Pusa Ruby	-20.95**	-32.26**	-6.32**	4.84*	-5.4**	-16.00 **	-21.50 **	0.18	-3.5	2
EC 620408 × ArkaVikas	-11.32**	-29.44**	-2.43	9.19**	-1.47	10.42 **	5.97 **	17.53 **	13.21 **	19.67 **
EC 620408 × ArkaMeghali	-10.07**	-28.18**	-0.68	11.15**	0.29	-10.34 **	-13.33 **	-3.88	-7.41 **	-2.13
EC 620494 × Pusa Ruby	48.22**	36.91**	35.18**	51.28**	36.51**	11.46 **	-10.00 **	14.85 **	10.63 **	16.94 **
EC 620494 × ArkaVikas	47.22**	45.53**	21.77**	36.27**	22.96**	44.22 **	27.60 **	30.11 **	25.33 **	32.48 **
EC 620494 × ArkaMeghali	86.21**	85.02**	54.81**	73.25**	56.33**	43.18 **	25.86 **	30.29 **	25.50 **	32.67 **
EC 654289 × Pusa Ruby	24.26**	11.42**	10.01**	23.11**	11.09**	30.10 **	7.66 **	37.39 **	32.34 **	39.89 **
EC 654289 × ArkaVikas	5.87**	3.66	15.26**	-5.17**	-14.43**	-16.07 **	-23.63 **	22.12 **	-24.99 **	-20.70 **
EC 654289 × ArkaMeghali	1.33	-1.29	18.46**	-8.75**	-17.66**	-16.83 **	-24.83 **	22.18 **	-25.04 **	-20.77 **
EC 620639 × Pusa Ruby	20.85**	16.33**	24.15**	38.93**	25.37**	24.02 **	3.88 *	32.56 **	27.69 **	34.97 **
EC 620639 × ArkaVikas	-0.38	-12.03**	-6.12**	5.06*	-5.2**	-20.13 **	-26.32 **	24.87 **	-27.63 **	-23.50 **
EC 620639 × ArkaMeghali	2.2	-9.35**	-3.26	8.27**	-2.31	3.74	-4.95 *	-1.61	-5.23 *	0.18
EC 631407 × Pusa Ruby	3.89**	-3.21*	10.69**	23.87**	11.78**	-19.08 **	-22.90 **	-1.61	-5.23 *	0.18
EC 631407 × ArkaVikas	-18.53**	-30.15**	20.12**	10.6**	-19.33**	-36.79 **	-40.51 **	31.25 **	-33.77 **	-29.99 **
EC 631407 × ArkaMeghali	-1.42	-15.11**	-2.92	8.65**	-1.96	-21.72 **	-25.80 **	14.25 **	-17.40 **	-12.69 **
EC 631410 × Pusa Ruby	21.62**	15.52**	26.77**	41.87**	28.02**	-3.91 *	-16.64 **	6.38 *	2.47	8.32 **
EC 631410 × ArkaVikas	1.3	-11.62**	-3.01	8.54**	-2.06	-1.31	-5.26 *	-3.4	-6.95 **	-1.64
EC 631410 × ArkaMeghali	-11.28**	-22.25**	14.67**	-4.51*	-13.84**	15.99 **	10.54 **	14.43 **	10.22 **	16.51 **
LA 3667 × Pusa Ruby	-23.08**	-25.69**	21.28**	11.91**	-20.51**	-22.42 **	-33.32 **	14.91 **	-18.04 **	-13.36 **
LA 3667 × ArkaVikas	15.88**	2.66	8.75**	21.7**	9.81**	30.81 **	24.27 **	26.71 **	22.06 **	29.02 **
LA 3667 × ArkaMeghali	10.62**	-1.56	4.28*	16.69**	5.3**	20.31 **	13.48 **	17.47 **	13.15 **	19.61 **

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

Table 2: Average heterosis (%), heterobeltiosis (%) and standard heterosis (%) for TSS and pH in Tomato.

Crosses	TSS (°Brix)					pH				
	Average heterosis (%)	Hetero-beltiosis (%)	Standard heterosis (%) over			Average heterosis (%)	Hetero-beltiosis (%)	Standard heterosis (%) over		
			Arka Rakshak	US440	Punjab Chhuhara			Arka Rakshak	US440	Punjab Chhuhara
EC 620408 × Pusa Ruby	-0.32	-9.40 **	11.18 **	10.25 **	45.44 **	-2.11	-2.98 *	-0.82	-3.13 *	-5.34 **
EC 620408 × ArkaVikas	13.31 **	9.58 **	9.98 **	9.06 **	43.87 **	0.32	-1.35	2.47	0.08	-2.2
EC 620408 × ArkaMeghali	15.91 **	14.97 **	15.38 **	14.42 **	50.94 **	-2.5	-4.04 **	-0.49	-2.81	-5.02 **
EC 620494 × Pusa Ruby	-14.63 **	-19.69 **	-1.44	-2.26	28.93 **	-3.59 **	-4.43 **	-0.58	-2.89 *	-5.10 **
EC 620494 × ArkaVikas	0.6	-6.11 **	1.56	0.72	32.86 **	-2.14	-2.21	1.73	-0.64	-2.90 *
EC 620494 × ArkaMeghali	-5.90 **	-10.00 **	-2.64	-3.46	27.36 **	-3.48 **	-3.64 *	0.25	-2.09	-4.32 **
EC 654289 × Pusa Ruby	-5.52 **	-15.28 **	3.97	3.1	36.01 **	-0.68	-1.12	1.97	-0.4	-2.67
EC 654289 × ArkaVikas	8.18 **	6.17 *	3.37	2.5	35.22 **	-2.26	-2.61	1.15	-1.2	-3.45 *
EC 654289 × ArkaMeghali	34.85 **	33.90 **	32.21 **	31.11 **	72.96 **	-3.54 **	-3.81 *	-0.25	-2.57	-4.79 **
EC 620639 × Pusa Ruby	6.74 **	-8.42 **	12.38 **	11.44 **	47.01 **	-2.1	-4.59 **	-2.47	-4.74 **	-6.91 **
EC 620639 × ArkaVikas	23.76 **	19.87 **	12.38 **	11.44 **	47.01 **	0.94	-2.38	1.4	-0.96	-3.22 *
EC 620639 × ArkaMeghali	3.06	-2.62	-3.85	-4.65	25.79 **	0.29	-2.93 *	0.66	-1.69	-3.92 **
EC 631407 × Pusa Ruby	-1.82	-20.67 **	-2.64	-3.46	27.36 **	-0.94	-2.25	-0.08	-2.41	-4.63 **
EC 631407 × ArkaVikas	36.27 **	23.08 **	15.38 **	14.42 **	50.94 **	1.74	-0.4	3.45 *	1.04	-1.26
EC 631407 × ArkaMeghali	36.50 **	20.51 **	18.99 **	18.00 **	55.66 **	2.55 *	0.48	4.19 **	1.77	-0.55
EC 631410 × Pusa Ruby	2.58	-17.24 **	1.56	0.72	32.86 **	-3.56 **	-4.18 **	-2.06	-4.34 **	-6.51 **
EC 631410 × ArkaVikas	8.07 **	-2.56	-8.65 **	-9.42 **	19.50 **	-1.12	-2.53	1.23	-1.12	-3.38 *
EC 631410 × ArkaMeghali	18.78 **	4.69	3.37	2.5	35.22 **	-0.72	-2.06	1.56	-0.8	-3.06 *
LA 3667 × Pusa Ruby	-28.39 **	-36.83 **	-22.48 **	-23.12 **	1.42	1.76	-7.08 **	-5.02 **	-7.23 **	-9.34 **
LA 3667 × ArkaVikas	5.74 *	5.70 *	-0.84	-1.67	29.72 **	3.06 *	-6.57 **	-2.96 *	-5.22 **	-7.38 **
LA 3667 × ArkaMeghali	-1.75	-4.2	-5.41 *	-6.20 *	23.74 **	-10.49 **	-18.79 **	-15.79 **	-17.75 **	-19.62 **

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

Table 3: Average heterosis (%), heterobeltiosis (%) and standard heterosis (%) for ascorbic acid and lycopene in Tomato.

Crosses	Ascorbic acid (mg/ 100g)					Lycopene (mg/ 100g)				
	Average heterosis (%)	Hetero-beltiosis (%)	Standard heterosis (%) over			Average heterosis (%)	Hetero-beltiosis (%)	Standard heterosis (%) over		
			Arka Rakshak	US440	Punjab Chhuhara			Arka Rakshak	US440	Punjab Chhuhara
EC 620408 × Pusa Ruby	-1.91	-3.34	-6.62 **	17.80 **	-12.31 **	-28.24 **	-30.94 **	-25.59 **	-46.06 **	-45.51 **
EC 620408 × ArkaVikas	-5.94 **	-7.73 **	-10.02 **	13.51 **	-15.51 **	62.04 **	53.84 **	70.57 **	23.66 **	24.92 **
EC 620408 × ArkaMeghali	-12.11 **	-12.55 **	-17.97 **	3.48	-22.97 **	-25.28 **	-27.10 **	-23.64 **	-44.64 **	-44.08 **
EC 620494 × Pusa Ruby	-6.39 **	-12.80 **	-15.76 **	6.27 **	-20.90 **	-46.68 **	-48.48 **	-44.49 **	-59.76 **	-59.35 **
EC 620494 × ArkaVikas	-4.44 *	-11.37 **	-13.57 **	9.03 **	-18.85 **	-33.09 **	-36.23 **	-29.29 **	-48.74 **	-48.21 **
EC 620494 × ArkaMeghali	4.90 **	-0.47	-7.56 **	16.61 **	-13.20 **	57.19 **	53.99 **	61.30 **	16.94 **	18.13 **
EC 654289 × Pusa Ruby	-0.34	-6.28 **	2.79	29.67 **	-3.48 *	-27.93 **	-31.26 **	-25.94 **	-46.31 **	-45.76 **
EC 654289 × ArkaVikas	-1.99	-7.42 **	1.54	28.09 **	-4.66 **	-9.36 **	-14.72 **	-5.44 *	-31.45 **	-30.75 **
EC 654289 × ArkaMeghali	-5.42 **	-12.66 **	-4.21 *	20.84 **	-10.05 **	91.46 **	85.09 **	93.86 **	40.55 **	41.98 **
EC 620639 × Pusa Ruby	6.03 **	2.04	6.60 **	34.48 **	0.1	-27.38 **	-35.79 **	-30.82 **	-49.85 **	-49.34 **
EC 620639 × ArkaVikas	4.27 **	0.79	5.30 **	32.84 **	-1.12	-16.38 **	-26.98 **	-19.04 **	-41.30 **	-40.70 **
EC 620639 × ArkaMeghali	6.25 **	0.35	4.84 *	32.25 **	-1.56	-30.01 **	-37.35 **	-34.38 **	-52.43 **	-51.94 **
EC 631407 × Pusa Ruby	7.40 **	5.71 **	5.45 **	33.02 **	-0.99	52.21 **	11.52 **	20.15 **	-12.89 **	-12.00 **
EC 631407 × ArkaVikas	-1.27	-2.37	-2.62	22.85 **	-8.56 **	7.32 *	-22.08 **	-13.60 **	-37.36 **	-36.72 **
EC 631407 × ArkaMeghali	3.52 *	-0.05	-0.3	25.77 **	-6.39 **	38.23 **	2.2	7.04 *	-22.40 **	-21.60 **
EC 631410 × Pusa Ruby	2.1	0.59	-2.83	22.58 **	-8.76 **	-24.28 **	-31.26 **	-25.94 **	-46.31 **	-45.76 **
EC 631410 × ArkaVikas	4.08 *	2.06	-0.47	25.55 **	-6.55 **	-22.25 **	-30.31 **	-22.73 **	-43.98 **	-43.41 **
EC 631410 × ArkaMeghali	2.34	1.87	-4.51 *	20.46 **	-10.34 **	76.18 **	61.98 **	69.67 **	23.00 **	24.26 **
LA 3667 × Pusa Ruby	-3.69 *	-11.15 **	-14.17 **	8.28 **	-19.40 **	10.02 **	6.00 *	23.22 **	-10.67 **	-9.75 **
LA 3667 × ArkaVikas	1.33	-6.92 **	-9.23 **	14.50 **	-14.77 **	34.17 **	31.07 **	52.37 **	10.47 **	11.59 **
LA 3667 × ArkaMeghali	4.18 *	-2.12	-9.10 **	14.67 **	-14.65 **	33.86 **	27.23 **	47.91 **	7.23 **	8.32 **

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

findings are in agreement with the findings of Narasimhamurthy *et al.* (2013) and Pawankumar and Paliwal (2016).

Conclusion

The overall results of average heterosis, heterobeltiosis and standard heterosis indicated that the parents involved in the crossing should have one high *per se* performing parent. The main reason ascribed is diversified parents involved in the cross combinations or uncommon genes for a trait is the cause to exploit the maximum exploitable level of heterosis in tomato. Based on heterotic results it can be emphasized that significant and higher standard heterosis over better check US 440 for fruit yield per plant was recorded in EC 620494 × Arka Vikas (10.46%). Over ArkaRakshak two hybrids, EC 620494 × ArkaVikas (12.71%) and EC 620494 × Pusa Ruby (11.39%) showed high and significant standard heterosis. Significant and high standard heterosis over Punjab Chhuhara was observed in ten crosses.

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