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Hybridization Studies in Tomato (*Solanum lycopersicum* L.)

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ABSTRACT

The present investigation was analysed to study the extent of heterosis in fifteen cross combinations for yield and quality characters. Six diverse tomato cultivars/ lines viz, AVTO-9001, LC-9, Sioux, Solan Lalima, Arka Meghali and LC-4 selected on the basis of high yield coupled with high quality aspects were crossed in 6×6 half diallel fashion with Arka Rakshak as check cultivar/line. Solan Lalima × Sioux was the best cross combiner among fifteen cross combinations with significant positive heterosis for all three types with respect to marketable fruit yield per plant and for quality aspects such as (TSS, Ascorbic acid and Pericarp thickness). Most of the hybrids manifested significant heterosis for number of fruit clusters per plant, number of fruits per cluster and number of fruits per plant. AVTO-9001× Sioux had the significant standard heterosis for fruit volume which has direct impact with average fruit weight. All cross combinations showed negative standard heterosis for whitefly infestation indicating more resistance in hybrids than check.

Keywords: *Heterosis, Half diallel fashion.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) (2n = 2x = 24) is one of the most popular and widely grown vegetable crop of the world next to potato. Tomato probably originated in Peru-Ecuador region[12]. Tomato being a moderate nutritional crop is considered as an important source of vitamin A and C and minerals which are important ingredients for table purpose, sambar preparation, chutney, pickles, ketchup, soup, juice, puree etc.[13] and hence it is called as *Protective Food*[14]. In India, tomato hybrids have became popular among farming community due to its number of advantages along with higher yield potential in comparison to pure lines and cover approximately 50% of the total cultivated area under tomato[15].

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Plant breeders have extensively explored and utilized heterosis to boost tomato yield. Exploitation of hybrid vigour depends on the direction and magnitude of heterosis, and ease with which hybrid seeds can be produced. Therefore the present research has been undertaken with the objective to analyze extent of heterosis in cross combinations.

MATERIALS AND METHODS

Six diverse tomato cultivars/lines *viz,* AVTO-9001, LC-9, Solan Lalima, Sioux, Arka Meghali and LC-4 were crossed in a 6×6 half diallel fashion to obtain fifteen cross combinations. The seedlings of parents were raised in March, 2016 were further transplanted in poly house to attempt crossing and generate F_1's. The fifteen F_1's along with their parents and one check cultivar F_1 hybrid Arka Rakshak were further planted during December, 2016 for their evaluation. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were 6 plants of each entry in each replication in a plot of 1.2 x 1.35 m^2 with a spacing of 60 cm x 45 cm. The standard cultural practices were followed to raise the tomato crop. Analysis of variance (ANOVA) was performed [3].

RESULTS AND DISCUSSION

The analysis of variance for all the traits under study showed significant differences among parents and crosses. The magnitude of heterosis of fifteen F_1's over better parent, mid parent and percent increase or decrease over the check cultivar, Arka Rakshak has been presented character-wise in Table 1 to 4. The results obtained for different traits are described below:

Plant Height (cm)

Plant height determines ideotype and contributes towards higher economic yield. Highest significant positive heterosis over mid parent was observed in Sioux × Arka Meghali (25.37%). None of the cross combinations showed significant heterosis over better parent. Significant positive heterosis over check was observed in AVTO-9001 × LC-4 (19.65%). Positive heterosis over mid and check has also been reported by Kumari *et al.*[6], Kumari and Sharma[5], Ahmed *et al.*[2] and Kumar *et al.*[7].

Number of Fruit Clusters per Plant

The heterosis over better parent ranged from -11.89 (Sioux × LC-4) to 51.36 (LC-9 × Solan Lalima) percent. Fourteen crosses among the fifteen cross combinations showed significant positive heterosis over better parent. The heterosis over mid parent ranged from -4.42 (Sioux × LC-4) to 59.55 (Arka Meghali × LC-4) percent. The minimum standard heterosis was observed in Sioux × LC-4 (-24.14%) and maximum in LC-9 × Solan Lalima (14.36%). These results are in line with the work of Patwary *et al.*[11], Marbal *et al.*[10] and Kumar *et al.*[7].

Number of Fruits per Cluster

Number of fruits per cluster indicates the percent fruit set. The heterosis over better parent ranged from -25.86 to 19.75 percent. Out of fifteen cross combinations six crosses exhibited significant positive heterosis over better parent while seven crosses showed the significant positive heterosis over mid parent. The heterosis over mid parent ranged from -20.96 to 37.82 percent. The minimum heterosis over standard parent was observed in AVTO-9001 × LC-9 (-42.21%) and the maximum in Solan Lalima × LC-4 (19.7%). These results are in confirm finding of Solieman *et al.*[18], Yadav *et al.*[19], Agarwal[1], Kumar and Singh[8], Kumar *et al.*[7] and Marbal *et al.*[10].

Number of Fruits per Plant

Number of fruits per plant is the most important component trait, which is necessary for witnessing the increased yield per plant. The heterobeltosis ranged from -20.79 (LC-9 × LC-4) to 128.34 (Sioux × Arka Meghali). Out of fifteen cross combinations, eleven cross combinations were observed to have significant positive better parent heterosis. The

heterosis over mid parent ranged from -11.12 (Sioux × LC-4) to 135.52 (Sioux × Arka Meghali) percent. The highest standard heterosis was observed for Sioux × Arka Meghali (28.42%) and lowest in AVTO-9001 × LC-9 (-57.26%). Significant positive heterosis over check was observed in only two cross combinations namely, Sioux × Arka Meghali (28.42%) and Solan Lalima × LC-4 (23.37%).These findings are in close agreement with Kumari and Sharma[5], Singh and Sastry[16]**,** Khan and Jindal[4], Kumar *et al.*[7] and Kumar and Singh[8].

Fruit Length (mm)

Fruit length is a vital character influencing fruit quality. The heterosis over better parent ranged from -32.41 (Sioux × LC-4) to 17.09 (LC-9 × Arka Meghali) percent while, heterosis over mid parent ranged from -27.09 (Sioux × LC-4) to 17.75 (LC-9 ×Arka Meghali) percent. None of the cross combinations showed significant positive standard heterosis for fruit length. These findings of significant positive heterosis over mid and better parent are in line with the findings of Singh *et al.*[17] and Kumar and Singh[8].

Fruit Breadth (mm)

The significant positive better parent heterosis was observed in three cross combinations *viz*, LC-9 × Sioux (10.01%), Solan Lalima × Sioux (2.34%), AVTO-9001 × Sioux (1.30%) while, heterosis over better parent ranged from -21.98 to 10.01 percent. The mid parent heterosis ranged from -15.63 (Solan Lalima × LC-4) to 10.13(LC-9 × Sioux) percent while the standard heterosis for cross combinations ranged from -1.82 (Arka Meghali × LC-4) to 19.41 (AVTO-9001×Arka Meghali) percent. Among fifteen cross combinations, thirteen crosses exhibited significant positive standard heterosis. The results of heterosis for fruit breadth are in close agreement with the findings of Kumar *et al.*[7] and Kumar and Singh[8].

Average Fruits Weight (g)

This is also the direct yield influencing trait which directly results in increased yield on positive nature. The heterosis over mid parent ranged from -33.63% (Arka Meghali × LC-4) to 18.07% (AVTO-9001 × Sioux).Significant positive heterosis over mid parent was observed in three cross combinations while none of the crosses showed significant positive heteosis over better parent. The standard heterosis varied from -25.08% (Arka Meghali × LC-4) to 26.31% (AVTO-9001 × Sioux). These findings of positive heterosis over mid parent and check co-relate with the findings of Ahmed *et al.*[2] Kumari and Sharma[5] and Marbal *et al.*[10].

Fruit Volume (mL)

Fruit volume decides the overall fruit weight since the hybrids have more water content in them deciding quality and yield. The maximum heterosis over better parent was observed in LC-9 × Sioux (80.00%) and the minimum was observed in Solan Lalima × LC-4 (-51.91%). The mid parent heterosis ranged from -37.78% to 85.65%. The standard heterosis for fruit volume was observed minimum in AVTO-9001 × Solan Lalima (-53.18%) and maximum in AVTO-9001 × Sioux (33.25%). These findings are in close association with the findings of Makani *et al.*[9].

Marketable Fruit Yield per Plant (Kg)

Yield is a complex quantitative character which depends on yield contributing characters. The heterosis over better parent ranged from -27.85% (Sioux × LC-4) to 78.88% (LC-9 × Sioux). Among fifteen cross combinations nine cross combinations were found to have significant positive better parent heterosis. Fourteen cross combinations out of fifteen crosses exhibited the significant positive heterosis over mid parent, the highest being in LC-9 × Sioux (101.05%). The standard heterosis varied from -30.99 to 33.47 percent. These findings are in close agreement with the findings of Kumari and Sharma[5],

Marbal *et al.*[10], Kumar and Singh[8], Khan and Jindal[4], Kumar *et al.*[7].

Harvest Duration (days)

Longer harvest duration ensures the continuous supply of produce and good price of tomato for over a longer period. It also keeps a balance between the demand and supply, thereby avoiding glut in the market and fall in prices. All the fifteen cross combinations exhibited significant positive heterosis over better, mid and over check. Positive heterosis for this trait was also reported by Kumari and Sharma[5] and Khan and Jindal[4].

Shelf Life (days)

Shelf life has been identified as an important component of longer keeping quality in tomato. The minimum better parent heterosis was observed in Solan Lalima × LC-4 (-18.36%) and maximum in AVTO-9001 × Sioux (1.57%). The relative heterosis ranged from -15.96 to 6.73 percent. The significant mid parent heterosis was observed in all cross combinations but the positive heterosis was observed in only five The standard heterosis was found minimum and maximum in Arka Meghali × LC-4 (-21.78%) and AVTO-9001 × Sioux (10.91%), respectively and only five cross combinations were found to have significant positive standard heterosis. This study of positive heterosis was also found by Patwary *et al.*[11] and Yadav *et al.*[19].

Pericarp Thickness (mm)

Pericarp thickness has been globally identified as an important component of keeping quality and whole fruit firmness in tomato. The better parent heterosis for pericarp thickness ranged from -36.41% to 13.14%. The significant positive heterosis was observed in only three crosses. On the other hand heterosis over mid parent ranged from -30.32% to 23.78%. The standard heterosis varied from -48.61% (Arka Meghali × LC-4) to 6.79% (LC-9 × Solan Lalima). Five cross combinations among fifteen exhibited significant positive standard heterosis. These results are in accordance with the works of Kumari and Sharma[5] and Khan and Jindal[4].

Total Soluble Solids (^{0}B)

Total Soluble Solids is one of the most important quality parameters in the processing industry. The heterosis over better parent ranged from -20.57 (AVTO-9001 × LC-9) to 52.11(LC-9 × Solan Lalima) percent. Seven cross combinations showed significant positive heterobeltosis. The relative heterosis ranged from -15.47(AVTO-9001 × LC-9) to 62.41(LC-9 × Solan Lalima) percent. The standard heterosis ranged from -37.50 (AVTO-9001 × LC-9) to 28.71 (LC-9 × Solan Lalima) percent. Only four cross combination showed significant positive standard heterosis. Similar findings for total soluble solids were observed by Kumari and Sharma[5] and Khan and Jindal[4].

Ascorbic acid (mg/100g)

The better parent heterosis ranged from -8.56 to 27.99 percent. Six cross combinations were observed with significant positive better parent heterosis. The heterosis over mid parent ranged from -8.17 (Arka Meghali × LC-4) to 37.13 (AVTO-9001 × Sioux) percent. Standard heterosis ranged from -22.00 to 10.52 percent. Only three cross combinations *viz*, Solan Lalima × Sioux (10.52%), AVTO-9001 × Sioux (7.01%) and LC-9 × Solan Lalima (4.81%) showed significant positive standard heterosis. Positive heterosis for ascorbic acid was also reported by Singh *et al.*[15] and Kumari and Sharma[5].

Whitefly Infestation (%)

The significant negative heterobeltosis was observed only among three cross combinations. The significant relative heterosis ranged from -36.62 to 63.17 percent. The significant negative relative heterosis was observed in crosses *viz*, Solan Lalima × Arka Meghali (-36.62%), AVTO-9001 × Arka Meghali (-33.68%) and LC-9 × Arka Meghali (-20.31%). All fifteen cross combinations showed significant negative standard heterosis ranging from -128.54% (Solan Lalima × Arka Meghali) to -3.38% (AVTO-9001 × LC-9).

Table 1: Heterotic response for Plant height (cm), Number of fruit clusters per plant, Number of fruits per cluster and Number of fruits per plant

	Fruit length			Fruit Breadth			Average Fruit Weight			Fruit Volume		
Cross	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**
1	-9.55**	-12.27**	-42.86**	-3.31**	-5.08**	2.48**	12.27*	10.08	15.82**	1.71	0.00	-34.62**
2	-14.13**	-23.39**	-36.53**	1.68**	-0.07	7.16**	-8.98	-10.11	-4.60	-7.86	-12.12*	-53.18**
3	4.70**	0.34	-4.26**	6.24**	1.30**	16.93**	18.07**	9.87	26.31**	40.76**	3.00	33.25**
4	0.62	-12.51**	-11.39**	3.11**	-2.43**	19.41**	-17.83**	-19.31**	10.16	7.73	-9.54	32.41**
5	-13.58**	-25.21**	-30.30**	-3.57**	-12.33**	10.31**	-26.86**	-35.94**	-13.16**	8.66	-20.99**	22.61**
6	-0.28	-7.47**	-23.33**	1.07**	-5.20**	11.23**	-18.02**	-24.59**	-7.37	-30.11**	-47.21**	-30.24**
7	-10.50**	-17.90**	-27.40**	10.13**	10.01**	15.85**	2.02	1.28	8.51	85.65**	80.00**	22.61**
8	17.75**	17.09*	-12.61**	-2.06**	-6.12**	6.15**	0.32	-10.73	15.78**	-1.01	-17.42**	-8.98*
9	-14.32**	-17.25**	-17.77**	-5.16**	-12.39**	10.25**	5.95	-6.19	22.73**	-21.08**	-44.27**	-9.73*
10	4.92**	0.22	-13.86**	7.22**	2.34**	17.77**	12.17*	5.09	22.95**	32.76**	-0.86	30.65**
11	-14.35**	-20.12**	-42.86**	-6.15**	-8.25**	8.29**	-21.10**	-23.91**	1.18	-29.44**	-37.77**	-10.48**
12	-16.20**	-25.52**	-30.87**	-15.63**	-21.98**	-0.79*	-32.97**	-40.27**	-21.36**	-33.16**	-51.91**	-27.14**
13	-0.19	-10.51**	-16.89**	2.65**	0.07	11.95**	-25.16**	-32.66**	-11.65*	23.08**	-1.12	8.98*
14	-27.09**	-32.41**	-44.18**	-11.80**	-14.69**	7.82**	-22.83**	-26.87**	0.87	-37.78**	-41.22**	-4.03
15	-1.54**	-3.98**	-30.53**	-11.33**	-13.47**	-1.82**	-33.63**	-39.89**	-25.08**	-11.95**	-27.53**	-24.19**
SE±	0.27	0.33	0.31	0.23	0.25	0.24	4.96	6.20	5.25	4.47	5.18	4.11

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

1. AVTO-9001 × LC-9, **2.** AVTO-9001 × Solan Lalima, **3.** AVTO-9001 × Sioux, **4.** AVTO-9001 × Arka Meghali, **5.** AVTO-9001 × LC-4, **6.** LC-9 × Solan Lalima, 7**.** LC-9 × Sioux, **8.** LC-9 × Arka Meghali, **9.** LC-9 × LC-4, **10.** Solan Lalima × Sioux, **11.** Solan Lalima × Arka Meghali, **12.** Solan Lalima × LC-4, **13.** Sioux × Arka Meghali, **14.** Sioux × LC-4, **15.** Arka Meghali × LC-4.

Table-2 Heterotic response for Fruit length (mm), Fruit breadth (mm), Average fruit weight (g) and Fruit volume (mL)

	Marketable Fruit Yield per Plant			Harvest Duration			Shelf Life			Pericarp Thickness		
Cross	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**
1	15.07**	13.46**	-30.99**	5.43**	4.30**	12.37**	-8.97**	-11.43**	-13.44**	-22.85**	-23.53**	-36.26**
2	51.97**	36.92**	-11.67**	21.98**	21.98**	23.42**	-3.90**	-11.01**	-1.69**	-4.42**	-9.90**	-2.25**
3	95.10**	47.90**	33.47**	18.48**	17.20**	22.02**	4.63**	1.57*	10.91**	8.21**	-7.29**	0.51**
4	21.29**	5.98**	15.42**	13.83**	10.31**	20.56**	-6.96**	-16.36**	-11.07**	5.52**	-16.50**	-2.97**
5	23.81**	-1.80**	8.72**	10.64**	7.22**	18.27**	-4.73**	-10.69**	-4.02**	-30.32**	-36.41**	-35.01**
6	21.39**	-0.25	1.38**	18.48**	17.20**	22.02**	4.71**	-0.27	3.64**	23.78**	11.76**	6.79**
7	101.05**	78.88**	16.93**	20.65**	19.35**	23.42**	6.60**	1.30	10.67**	0.84	-5.73**	2.16*
8	32.38**	18.10**	-1.53**	15.38**	15.38**	19.05**	-1.96*	-6.27**	-13.31**	0.00	-14.71**	-22.15**
9	23.47**	-9.24**	1.23**	18.09**	14.43**	23.42**	-15.96**	-17.04**	-9.08**	-19.10**	-21.84**	-9.87**
10	66.49**	38.37**	28.90**	16.13**	16.13**	21.30**	1.13	-1.06	2.86**	23.68**	12.57**	5.90**
11	7.14**	-2.48**	-0.88*	14.13**	12.90**	19.05**	3.01**	-5.98**	-2.22**	20.62**	13.14**	-14.12**
12	21.10**	-2.93**	7.67**	13.68**	11.34**	21.30**	-15.16**	-18.36**	-13.79**	8.31**	-1.94**	12.33**
13	82.22**	48.42**	19.21**	23.08**	23.08**	24.11**	6.73**	-5.16**	4.58**	-2.56**	-20.83**	-16.37**
14	-24.48**	-27.85**	-24.24**	8.42**	6.19**	17.48**	-9.87**	-11.37**	-4.82**	-4.37**	-20.39**	-7.86**
15	23.04**	11.16**	-7.86**	17.39**	16.13**	21.30**	-11.43**	-17.50**	-21.78**	-17.07**	-28.74**	-48.61**
SE±	0.31	0.34	0.33	1.43	1.55	1.36	0.57	0.67	0.47	0.07	0.08	0.06

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

1. AVTO-9001 × LC-9, **2.** AVTO-9001 × Solan Lalima, **3.** AVTO-9001 × Sioux, **4.** AVTO-9001 × Arka Meghali, **5.** AVTO-9001 × LC-4, **6.** LC-9 × Solan Lalima, 7**.** LC-9 × Sioux, **8.** LC-9 × Arka Meghali, **9.** LC-9 × LC-4, **10.** Solan Lalima × Sioux,**11.** Solan Lalima × Arka Meghali, **12.** Solan Lalima × LC-4, **13.** Sioux × Arka Meghali, **14.** Sioux × LC-4, **15.** Arka Meghali × LC-4.

Table 3: Heterotic response for Marketable fruit yield per plant (Kg), Harvest duration (days), Shelf life (days) and Pericarp thickness (mm)

	Plant Height			**No. of fruit clusters per plant**			**No. of fruits per cluster**			**No. of fruits per plant**		
Cross	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**
1	0.42	-7.25	10.87	16.44**	13.87**	-10.55**	-20.96**	-21.61**	-42.21**	-5.80	-5.97	-57.26**
2	-12.49	-19.38	-2.54	30.98**	27.44**	2.24**	19.68**	7.64**	-3.55**	51.92**	40.49**	-5.25
3	3.94	1.30	8.07	18.45**	16.15**	-7.26**	29.17**	8.48**	12.59**	51.71**	27.91**	6.62
4	7.93	-4.76	-5.93	34.65**	14.23**	4.24**	-4.23**	-7.29**	0.64	28.81**	5.87	0.60
5	13.10	2.88	19.65*	36.87**	25.27**	12.68**	10.05**	0.49	8.34**	43.03**	22.41**	14.03**
6	5.19	-0.71	16.74	52.56**	51.36**	14.36**	-3.47**	-10.68**	-6.16**	36.06**	22.98**	2.88
7	14.13	13.82	14.28	31.52**	30.84**	4.78**	32.16**	19.75**	5.37**	78.10**	64.98**	10.04
8	-5.71	-23.31	-7.80	28.45**	18.10**	-11.53**	6.23**	0.00	1.60	30.97**	24.73**	-18.55**
9	-6.66	-7.95	-6.58	11.44**	4.64**	-4.54**	-10.69**	-25.86**	-24.25**	-1.26	-20.79**	-32.85**
10	16.56	13.90	18.24	45.78**	43.68**	12.39*	-1.90*	-9.91**	-5.24**	42.56**	28.64**	7.15
11	23.99*	5.76	11.95	57.79**	44.03**	10.00**	-7.84**	-9.52**	-4.80**	37.99**	19.42**	-0.02
12	10.13	8.32	9.92	19.22**	11.41**	1.82**	26.67**	14.81**	19.77**	60.70**	37.32**	23.37**
13	25.37*	9.31	10.25	57.28**	41.04**	11.66**	37.82**	17.51**	16.26**	135.52**	128.34**	28.42**
14	15.24	10.80	15.96	-4.42**	-11.89**	-24.14**	-7.21**	-8.53**	-0.70	-11.12**	-16.40*	-25.88**
15	-1.94	-14.71	-14.39	59.55**	43.74**	12.42**	-1.33	-7.83**	-6.76**	72.41**	64.48**	9.77
SE±	10.74	12.34	9.45	0.58	0.60	0.61	0.83	0.90	0.88	4.88	5.10	5.12

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

1. AVTO-9001 × LC-9, **2.** AVTO-9001 × Solan Lalima, **3.** AVTO-9001 × Sioux, **4.** AVTO-9001 × Arka Meghali **5.** AVTO-9001 × LC-4, **6.** LC-9 × Solan Lalima, 7**.** LC-9 × Sioux, **8.** LC-9 × Arka Meghali, **9.** LC-9 × LC-4, **10.** Solan Lalima × Sioux, **11.** Solan Lalima × Arka Meghali, **12.** Solan Lalima × LC-4, **13.** Sioux × Arka Meghali, **14.** Sioux × LC-4, **15.** Arka Meghali × LC-4.

Table 4: Heterotic response for Total soluble solids (^{0}B), Ascorbic acid (mg/100g) and Whitefly infestation (%)

	Total Soluble Solids			Ascorbic Acid			Whitefly Infestation		
Cross	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**	**MP**	**BP**	**Check**
1	-15.47**	-20.57**	-37.50**	4.36*	-5.94**	-16.37**	38.80**	43.29**	-3.38**
2	53.38**	42.28**	25.36**	35.29**	27.99**	-6.54**	33.94**	39.22**	-14.29**
3	5.23**	4.14**	-1.99*	37.13**	17.62**	7.01**	7.50**	13.48**	-54.10**
4	4.39**	0.67	-1.99*	4.46*	3.80*	-6.11**	-47.82**	-33.68**	-127.98**
5	5.84**	-3.33**	-6.21**	11.10**	1.00	-10.45**	21.82**	40.17**	-25.66**
6	62.41**	52.11**	28.71**	27.51**	14.90**	4.81**	24.71**	36.55**	-22.75**
7	27.97**	26.21**	15.85**	23.10**	5.63**	-3.63*	6.71**	14.36**	-34.47**
8	8.62**	2.66**	-7.68**	2.06	-7.75**	-19.39**	-29.19**	-20.31**	-68.01**
9	-5.08**	-6.67**	-9.99**	5.72**	-8.56**	-22.00**	34.63**	49.69**	-23.04**
10	15.90**	15.49**	6.11**	22.29**	22.24**	10.52**	-7.79**	3.91*	-55.63**
11	-3.31**	-4.23**	-13.24**	-5.40**	-5.73**	-16.02**	-47.95**	-36.62**	-128.54**
12	1.03	-2.00*	-4.76**	-1.23	-2.16	-11.88**	38.05**	63.17**	-3.95**
13	7.63**	5.52**	-0.65	18.21**	1.69	-8.31**	-5.15*	10.41**	-25.41**
14	0.00	-2.67**	-5.47**	-5.08**	-6.01**	-16.37**	46.71**	55.00**	-26.23**
15	-0.11	-0.71	-9.99**	-8.17**	-8.45**	-19.57**	6.67**	16.65**	-11.52**
SE±	0.47	0.59	0.58	1.69	1.84	1.66	1.90	1.82	1.66

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

1. AVTO-9001 × LC-9, **2.** AVTO-9001 × Solan Lalima, **3.** AVTO-9001 × Sioux, **4.** AVTO-9001 × Arka Meghali, **5.** AVTO-9001 × LC-4, **6.** LC-9 × Solan Lalima, 7**.** LC-9 × Sioux, **8.** LC-9 × Arka Meghali, **9.** LC-9 × LC-4, **10.** Solan Lalima × Sioux, **11.** Solan Lalima × Arka Meghali, **12.** Solan Lalima × LC-4, **13.** Sioux × Arka Meghali, **14.** Sioux × LC-4, **15.** Arka Meghali × LC-4

CONCLUSION

Best three cross combinations for marketable fruit yield per plant as per their mean performance are AVTO-9001 x Sioux, Solan Lalima x Sioux, LC-9 x Sioux and these cross combinations also expressed significantly positive standard heterosis. Solan Lalima x Sioux proved to be the best cross combiner for quality traits as it has significant positive heterosis for all three types for both ascorbic acid and total soluble solids. For pericarp thickness significant positive heterosis of all three kinds was expressed by Solan Lalima x Sioux and LC-9 x Solan Lalima but for shelf life AVTO-9001 x Sioux was observed significant as it has positive heterosis. For average fruit weight, AVTO-9001 x Sioux and Solan Lalima x Sioux, proved to be the best hybrids which has expressed significant positive heterosis results for mid parent and over check. LC-9 x Sioux found to be the best cross combination which have significant heterosis of all three types for fruit volume and vital yield attributing traits, *i.e*., number of fruits per cluster and number of fruit clusters per plant in spite of that for number of fruits per plant, it hasn't expressed significant heterotic results in favourable direction.

REFERENCES

1. Agarwal, A., Arya, D.N., Ranjan, R. and Ahmed, Z., Heterosis, combining ability and gene action for yield and quality traits in tomato (*Solanum lycopersicum* L.). *Helix*, **2:** 511- 515 (2014).
2. Ahmad, S., Quamruzzaman, A.K.M. and Islam, M.R. Estimate of herosis in tomato (Solanum lycopersicum L.). *Bangladesh J. Agric. Res.*, **36(3):** 521-527(2011).
3. Gomez, K.A. and Gomez, A.A. Statistical Procedures for Agricultural Research.2nd edition. *John Wiley and Sons, New York*, pp. 357-342 (1983).
4. Khan, A. and Jindal S.K. Exploiting yield potential in tomato (*Solanum lycopersicum* L.) through heterosis breeding. *Plant Gene and Trait*, **7(8):** 1-7(2016).
5. Kumari, S. and Sharma, M.K. Exploitation of heterosis for yield and its contributing traits in tomato (*Solanum lycopersicum* L.) *Int. J. Farm Sci.*, **1(2):** 45- 55(2011).
6. Kumari, N., Srivastava, J. P., Singh, B. and Deokaran. Heterotic expression for yield and its component in tomato (*Lycopersicon esculentum* Mill.). *Ann. of Horti.*, **3:** 98-101(2010).
7. Kumar, P., Paliwal, A., Pant, S.C., Bahuguna, P. and Abrol, G. Heterosis studies in tomato (*Lycopersicon esculentum* Mill.) for yield and yield attributing traits for further implications in crop improvement. *J. Bio In.*, **5(6):** 959-972 (2016).
8. Kumar, C. and Singh, S.P. Heterosis and inbreeding depression to identify superior F_1 hybrids in tomato (*Solanum*

lycopersicum L.) for the yield and its contributing traits. *J. App. and Nat. Sci.*, **8(1):** 290 – 296 (2016).

9. Makani, A.Y., Patel, A.L., Bhatt, M.M. and Patel, P.C. Heterosis for yield and its contributing attributes in brinjal (*Solanum melongena* L.). *The Bioscan,* **8(4):** 1369-1371 (2013).
10. Marbhal, S.K., Ranpise, S.A. and Kshirsagar, D.B. Heterosis study in cherry tomato for quantitative traits. *Int. Res. J. Multidiscip. Stud.*, **2(2):** 1-6 (2016).
11. Patwary, M.M.A., Rahman, M.M., Ahmad, S., Miah, M.A.K. and Barua, H. Study of heterosis in heat tolerant tomato (*Solanum lycopersicum* L.) during summer *Bangladesh J. Agric. Res,*. **38(3):** 531-544 (2013).
12. Rick, C.M. and Holle, M. Andean *Lycopersicon esculentum* var. *cerasiforme*: genetic variation and its evolutionary significance. *J. Eco. Bot.,* **43(3):** 69-78 (1990).
13. Sekhar, L., Prakash, B.G., Salimath, P.M., Channayya, H.P., Sridevi, O. and Patil, A.A. Implications of heterosis and combining ability among productive Single cross hybrids in tomato. *Elec. J. Plant. Breed.*, **1(4):** 706-711(2010).
14. Simon, J.A. Vitamin C and cardiovascular disease: A review. *J. American. College of Nutrition.* 11: 107-125 (1992).
15. Singh, A.K., Pan, R.S. and Rai, M. Combining ability studies of yield and its contributing traits in tomato (*Lycopersicon esculentum* Mill.). *Veg. Sci.,* **32(1):** 82-83(2005).
16. Singh, J. and Sastry, E.V.D. Heterosis and stress susceptibility index for fruit yield and contributing traits in tomato (*Lycopersicon esculentum* Mill.). *Indian J. Agric. Sci.*, **81(10):** 957-966 (2011).
17. Singh, N.B., Paul, A., Wani, S.H. and Laishram, J.M. Heterosis studies for yield and its components in tomato (*Solanum lycopersicum* L.) under valley conditions of Manipur. *Int. J. Life Sci.*, **1:** 224-232 (2012).
18. Solieman, T.H.I., El-Gabryb, M.A.H. and Abidob, A.I. Heterosis, potence ratio and correlation of some important characters in tomato (*Solanum lycopersicum* L.). *Scie. Horti.*, **150:** 25-30 (2013).
19. Yadav, S.K., Singh, B.K., Baranwal, D.K. and Solankey, S. S. Genetic study of heterosis for yield and quality components in tomato (*Solanum lycopersicum* L.). *African J. Agric. Res.*, **8:** 5585-5591 (2013).