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Heterosis for quality traits in tomato

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ABSTRACT

In the present study, a total of 43 entries consisting of 13 diversified genotypes of tomato along with their 30 F1 hybrids were evaluated during spring- summer season. Data on fruit quality characters were recorded and per cent mid-parent heterosis and better-parent heterosis were determined. Heterosis over mid parent and better parent, however, for most of the characters were in negative direction. Some of the parents having good potentiality for generating high cross combination for most of the quality traits under study have been identified. Selection of crosses on the basis of performance per se seems to be reliable than selection based on the manifestation of heterosis alone. Highest significant heterobeltiosis was expressed by the F_1 hybrids Selection 06-01 × Punjab Chhuhara (for TSS at immature and turning stage), Selection 06-01 x PT-3 (for TSS at red ripe stage), CLN2070A × PT-3 (for number of locules per fruit) and CLN2070A × Sweet-72 (for pericarp thickness). The Fl hybrids, though showed improved fruit quality in terms of TSS at immature stage, TSS at turning stage, TSS at red ripe stage, number of locules and pericarp thickness.

Key words: relative heterosis, heterobeltiosis, heterosis, TSS, locule and pericarp thickness.

INTRODUCTION

Tomato is one of the most important vegetable crops cultivated all over the world for both table and processing purposes. India ranks second in the world with an area under tomato cultivation of 1204 thousand hectares, annual production of 19402 thousand metric tonnes and total productivity of 21.2 metric tonnes per hectare (Anon, 2013-14). This increase in productivity is principally due to the cultivation of F_1 hybrids which yield higher than open pollinated varieties. This is so because this self-pollinated crop has tremendous potential for heterosis and high price of hybrid seed is compensated for by the realized higher profits obtained from cultivation of F_1 hybrids. The term heterosis was coined by (Shull, 1914). Heterosis in tomato was first observed by Hedrick and Booth (1907) for higher yield and more number of fruits. Since then, heterosis for yield, its components and quality traits were extensively studied. Choudhary *et al.*, (1965) emphasized the extensive utilization of heterosis to step up tomato production.

MATERIALS AND METHODS

The study was conducted during Spring-Summer season of 2013 and 2014 at Vegetable Research Centre (VRC) of the G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experimental material for this study consisted of 13 genotypes which were selected based on their diversity for various traits. From these 13 genotypes, 30 crosses were evolved in a line x tester mating design with 10 genotypes as female parents (lines) and 3 genotypes as male parents (testers). F1 hybrids with their parents were evaluated in a randomized block design

with three replications. Mean values of ten plants in each entry, selected at random were obtained for quality. Heterosis over better parent (heterobeltiosis) and mid-parent (relative heterosis) were worked out as suggested by Turner (1953) and Hayes *et al*., (1956). The formula used for estimation of heterosis given by Fonseca and Patterson (1968).

RESULTS AND DISCUSSION

Tomato ranks first among processed vegetables in the world. High TSS is one of the major factors considered for manufacture of processed products. One per cent increase in TSS content of fruits results in 20 per cent increase in recovery of processed product (Berry and Uddin, 1991). Since high total soluble solids content is correlated with small fruit size and oval fruit shape (Roy and Choudhury 1972), such fruits have better transport and keeping qualities. The mean performance of parents and hybrids are presented in Table 1. Perusal of data revealed that the mean values for TSS at immature stage ranged from 3.37 to 5.57°Brix. Among the hybrids generated, the maximum value for the same trait was noticed in cross combination, Selection 06-01 × Punjab Chhuhara (5.57°Brix) and the minimum value in AC-576 × PT-3 (3.37°Brix). Heterobeltiosis and relative heterosis for TSS at immature stage are presented in Table 2. Heterosis over mid-parent and better parent value ranged from -17.84 to 28.96 per cent and -27.74 to 27.48 per cent, respectively. Selection 06-01 × Punjab Chhuhara (28.96%) exhibited highest positive heterosis over mid-parent, while CLN2237A × Sweet-72 (-17.48%) exhibited highest negative heterosis over mid-parent. Cross combinations exhibiting significant positive relative heterosis were ARTH-3 × PT-3 (6.61%), EC-519784 × PT-3 (7.11%), EC-519784 × Punjab Chhuhara (8.17%), ARTH-3 × Sweet-72 (9.23%), CLN2070A × Sweet-72 (11.63%), PT-7 × PT-3 (13.93%), Selection 06-01 × Sweet-72 (17.37%), CLN2070A × Punjab Chhuhara (19.38%), CLN2070A × PT-3 (20.83%), Selection 06-01 × PT-3 (21.99%) and ARTH-3 × Punjab Chhuhara (23.08%).

Combination Selection 06-01 × Punjab Chhuhara (27.48%) exhibited highest positive heterobeltiosis, while CLN2237A × PT-3 (-27.74%) exhibited highest negative heterobeltiosis for TSS at immature stage. Cross combinations, ARTH-3 × Sweet-72 (8.40%), CLN2070A × Sweet-72 (9.92%), CLN2070A × PT-3 (14.17%), Selection 06-01 × PT-3 (14.84%), Selection 06-01 × Sweet- 72 (16.03%), CLN2070A × Punjab Chhuhara (17.56%) and ARTH-3 × Punjab Chhuhara (22.14%) showed significant positive heterosis over better parent. Most promising cross combination for higher TSS at immature stage is Selection 06-01 × Punjab Chhuhara as it exhibited the highest heterosis over both mid-parent and better parent. Among different hybrids evaluated, 19 combinations exhibited significant relative heterosis and 17 combinations exhibited significant heterobeltiosis. These results are in accordance with the findings of Kumari and Sharma (2011), Chattopadhyay and Paul (2012) and Yadav *et al*., (2013).

The mean values for TSS at turning stage ranged from 3.53 to 5.69°Brix. Among the hybrids generated, the maximum value for the same trait was noticed in cross combination, Selection 06-01 × Punjab Chhuhara (5.69°Brix) and the minimum value in AC-576 x PT-3 (3.53°Brix). Heterobeltiosis and relative heterosis for TSS at turning stage are presented in Table 2. Heterosis over mid-parent and better parent value ranged from -14.52 to 29.02 per cent and -20.91 to 27.57 per cent, respectively. Selection 06-01 × Punjab Chhuhara (29.02%) exhibited highest positive heterosis over mid-parent, while AC-576 × PT-3 (-14.52%) exhibited highest negative heterosis over mid-parent. Cross combinations exhibiting significant positive relative heterosis were, EC-519784 × PT-3 (4.84%), CLN2070A × Sweet-72 (8.29%), EC-519784 × Punjab Chhuhara (8.86%), PT-7 × PT-3 (10.90%), Selection 06-01 × Sweet-72 (15.68%), CLN2070A × Punjab Chhuhara (16.35%), CLN2070A × PT-3 (22.19%), ARTH-3 × Punjab Chhuhara (22.83%) and Selection 06-01 × PT-3 (27.05%).

Combination Selection 06-01 × Punjab Chhuhara (27.57%) exhibited highest positive heterobeltiosis, while CLN2237A × PT-3 (-20.91%) exhibited highest negative heterobeltiosis for TSS at turning stage. Cross combinations, EC-519784 × Punjab Chhuhara (6.05%), CLN2070A × Sweet-72 (7.12%), Selection 06-01 × Sweet-72 (12.31%), CLN2070A × PT-3 (15.45%), CLN2070A × Punjab Chhuhara (15.45%), Selection 06-01 × PT-3 (22.24%) and ARTH-3 × Punjab Chhuhara (22.42%) showed significant positive heterosis over better parent. Most promising cross combination for higher TSS at turning stage is Selection 06-01 × Punjab Chhuhara as it exhibited the highest heterosis over both mid-parent and better parent. Among different hybrids evaluated, 14 combinations exhibited significant relative heterosis and 15 combinations exhibited significant heterobeltiosis. Desirable heterosis for TSS was also reported by Kumari and Sharma (2011), Chattopadhyay and Paul (2012) and Yadav *et al*., (2013).
The mean values for TSS at red ripe stage ranged from 4.14 to 5.90°Brix. Among the hybrids generated, the maximum value for the same trait was noticed in cross combination, Selection 06-01 × PT-3 (5.90°Brix) and the

minimum value in AC-576 × PT-3 (4.13°Brix). Heterobeltiosis and relative heterosis for TSS at red ripe stage are presented in Table2. Heterosis over mid-parent and better parent value ranged from -21.79 to 36.15 per cent and -25.73 to 34.09 per cent, respectively. Selection 06-01 × PT-3 (36.15%) exhibited highest positive heterosis over mid-parent, while CLN2237A × Sweet-72 (-21.79%) exhibited highest negative heterosis over mid-parent. Cross combinations exhibiting significant positive relative heterosis were Selection 06-01 × Sweet-72 (14.86%), PT-8 × Punjab Chhuhara (15.09%), CLN2070A × PT-3 (15.97%), EC-519784 × Punjab Chhuhara (18.12%), ARTH-3 × Punjab Chhuhara (19.57%), Selection 06-01 × Punjab Chhuhara (31.09%) and CLN2070A × Punjab Chhuhara (32.88%).

Table1. Mean performance of parental lines of tomato for TSS, number of locules and pericarp thickness

Character	TSS at Immature Stage (°Brix)	TSS at Turning Stage (°Brix)	TSS at Red Ripe Stage (°Brix)	Number of Locules	Pericarp Thickness (mm)
CLN2070A×PT-3	4.83	5.23	5.57	3.67	1.80
CLN2070A×Sweet-72	4.80	4.96	5.53	3.00	3.88
CLN2070A×Punjab Chhuhara	5.13	5.23	6.53	3.67	4.75
PT-8×PT-3	4.33	4.43	4.63	2.67	2.25
PT-8×Sweet-72	4.43	4.96	5.53	3.00	3.36
PT-8×Punjab Chhuhara	4.43	4.63	5.47	2.67	2.70
EC-519784×PT-3	4.27	4.33	4.63	3.33	3.37
EC-519784×Sweet-72	4.04	4.16	4.27	3.00	3.64
EC-519784×Punjab Chhuhara	4.63	4.73	5.43	2.67	3.39
Selection 06-01×PT-3	4.90	5.33	5.90	2.67	3.59
Selection 06-01×Sweet-72	5.07	5.20	5.67	2.00	2.72
Selection 06-01×Punjab Chhuhara	5.57	5.69	5.83	2.67	3.38
ARTH-3×PT-3	4.30	4.40	4.57	3.67	2.64
ARTH-3×Sweet-72	4.73	4.93	5.23	2.67	3.22
ARTH-3×Punjab Chhuhara	5.33	5.46	5.50	3.00	1.78
PT-7×PT-3	4.63	4.73	4.80	2.33	2.35
PT-7×Sweet-72	4.27	4.46	4.53	2.67	1.88
PT-7×Punjab Chhuhara	4.13	4.26	4.33	3.33	2.49
AC-824×PT-3	3.83	4.33	4.67	3.00	2.83
AC824×Sweet-72	4.17	4.43	4.60	2.33	2.48
AC-824×Punjab Chhuhara	4.30	4.56	4.77	2.67	2.38
AC-576×PT-3	3.37	3.53	4.14	3.00	2.96
AC-576×Sweet-72	3.93	4.16	4.63	3.33	2.44
AC-576×Punjab Chhuhara	4.17	4.36	4.63	2.33	2.41
CLN2237A×PT-3	3.73	4.16	4.23	3.00	1.67
CLN2237A×Sweet-72	3.93	4.26	4.37	2.33	2.90
CLN2237A×Punjab Chhuhara	4.57	4.60	4.73	3.67	2.93
PT 2007-09×PT-3	3.93	4.20	4.33	2.67	3.43
PT 2007-09×Sweet-72	4.57	4.63	4.77	3.00	3.02
PT 2007-09×Punjab Chhuhara	4.47	4.70	4.83	2.33	3.71
CLN2070A	4.23	4.53	5.33	2.33	1.13
PT-8	4.47	4.66	5.00	2.66	3.67
EC-519784	4.20	4.23	4.70	2.33	1.42
Selection 06-01	4.27	4.36	4.40	2.33	2.96
ARTH-3	4.30	4.43	4.70	2.66	1.30
PT-7	4.37	4.50	4.86	4.33	2.76
AC-824	4.53	4.63	4.93	2.33	2.26
AC-576	4.13	4.23	4.63	3.00	2.52
CLN2237A	5.17	5.26	5.70	2.33	3.45
PT 2007-09	4.53	4.66	4.73	3.66	4.52
PT-3	3.76	4.03	4.26	3.33	4.16
Sweet-72	4.37	4.63	5.46	2.66	2.27
Punjab Chhuhara	4.37	4.46	4.50	3.66	4.42
Mean	4.40	4.60	4.92	2.82	2.86
C.V.	3.28	3.23	4.48	17.58	8.83
S.E.	0.83	0. 86	0.12	0.28	0. 14
C.D. at 5%	0.23	0. 24	0.35	0.80	0.41
Range Lowest	3.36	3.53	4.13	2.00	1.13
Range Highest	5.57	5.69	5.90	4.33	4.75

Table 2: *Per se* performance, mid-parent heterosis and better parent heterosis for TSS at immature, turning and ripe stage

Crosses	TSS at immature stage		TSS at turning stage		TSS at red ripe stage	
	Mid parent	Better parent	Mid parent	Better parent	Mid parent	Better parent
CLN2070A×PT-3	20.83**	14.17 **	22.19**	15.45 **	15.97**	4.38
CLN2070A×Sweet-72	11.63**	9.92 **	8.29**	7.12 *	2.47	1.22
CLN2070A×Punjab Chhuhara	19.38**	17.56 **	16.35**	15.45 **	32.88**	22.50 **
PT-8×PT-3	5.26	-2.29	1.95	-4.93	0.00	-7.33
PT-8×Sweet-72	0.38	-0.75	6.78	6.43	5.73	1.22
PT-8×Punjab Chhuhara	0.38	-0.75	1.53	-0.64	15.09**	9.33 *
EC-519784×PT-3	7.11*	1.59	4.84*	2.36	3.35	-1.42
EC-519784×Sweet-72	-5.76*	-7.56 *	-6.09*	-10.15 **	-16.07**	-21.95 **
EC-519784×Punjab Chhuhara	8.17**	6.11	8.86**	6.05 *	18.12**	15.60 **
Selection 06-01×PT-3	21.99**	14.84 **	27.05**	22.24 **	36.15**	34.09 **
Selection 06-01×Sweet-72	17.37**	16.03 **	15.68**	12.31 **	14.86**	3.66
Selection 06-01×Punjab Chhuhara	28.96**	27.48 **	29.02**	27.57 **	31.09**	29.63 **
ARTH-3×PT-3	6.61*	0.00	4.01	-0.67	1.86	-2.84
ARTH-3×Sweet-72	9.23**	8.40 *	8.83	6.47	2.95	-4.27
ARTH-3×Punjab Chhuhara	23.08**	22.14 **	22.83**	22.42 **	19.57**	17.02 **
PT-7×PT-3	13.93**	6.11	10.90**	5.11	5.11	-1.37
PT-7×Sweet-72	-2.29	-2.29	-2.30	-3.67	-12.26**	-17.07 **
PT-7×Punjab Chhuhara	-5.34	-5.34	-4.91	-5.33	-7.47	-10.96 **
AC-824×PT-3	-7.63*	-15.44 **	0.00	-6.47	1.45	-5.41
AC824×Sweet-72	-6.37*	-8.09 *	-4.31	-4.31	-11.54**	-15.85 **
AC-824×Punjab Chhuhara	-3.37	-5.15	0.33	-1.51	1.06	-3.38
AC-576×PT-3	-14.77**	-18.55 **	-14.52**	-16.54 **	-7.12	-10.79 *
AC-576×Sweet-72	-7.45*	-9.92 **	-6.09	-10.15 **	-8.25*	-15.24 **
AC-576×Punjab Chhuhara	-1.96	-4.58	0.34	-2.24	1.46	0.00
CLN2237A×PT-3	-16.42**	-27.74 **	-10.44**	-20.91 **	-15.05**	-25.73 **
CLN2237A×Sweet-72	-17.48**	-23.87 **	-13.85**	-19.01 **	-21.79**	-23.39 **
CLN2237A×Punjab Chhuhara	-4.20	-11.61 **	-5.34	-12.54 **	-7.19*	-16.96 **
PT 2007-09×PT-3	-5.22	-13.24 **	-3.33	-.987 **	-3.70	-8.45 *
PT 2007-09×Sweet-72	2.62	0.74	-0.32	-0.64	-6.54	-12.80 **
PT 2007-09×Punjab Chhuhara	20.83**	14.17 **	22.19**	15.45 **	4.69	2.11

** Significant at 5%* *** Significant at 1%*

Combination Selection 06-01 × PT-3 (34.09%) exhibited highest positive heterobeltiosis, while CLN2237A × PT-3 (-25.73%) exhibited highest negative heterobeltiosis for TSS at red ripe stage. Cross combinations, PT-8 × Punjab Chhuhara (9.33%), EC-519784 × Punjab Chhuhara (15.60%), ARTH-3 × Punjab Chhuhara (17.02%), CLN2070A × Punjab Chhuhara (22.50%) and Selection 06-01 × Punjab Chhuhara (29.63%) showed significant positive heterosis over better parent. Most promising cross combination for higher TSS at red ripe stage is Selection 06-01 x PT-3 as it exhibited the highest heterosis over both mid-parent and better parent. Among different hybrids evaluated, 15 combinations exhibited significant relative heterosis and 17 combinations exhibited significant heterobeltiosis. Desirable positive heterosis obtained in this experiment is in close agreement with the findings of Kumari and Sharma (2011), Chattopadhyay and Paul (2012) and Yadav *et al*., (2013).

More number of locules per fruit is associated with bigger fruit size and flat-round fruit shape and such fruits are preferred for processing purposes. Hybrid vigour has been discussed by considering more locules per fruit as a desirable attribute. Mean values for number of locules per fruit ranged between 2.00 and 4.33. Among the F_1 hybrids evaluated, the maximum value for number of locules was noticed in cross combination, PT-8 × Sweet-72 and EC519784 × Punjab Chhuhara (4.00). The minimum value for the same character was noticed in cross combination Selection 06-01 × Sweet-72 (2.00). Perusal of data presented in Table 3 revealed that relative heterosis and heterobeltiosis for number of locules per fruit ranged from -30.43 to 57.14 per cent and -38.46 to 57.14 per cent, respectively. The maximum positive heterosis over mid-parent for number of locules was recorded in CLN2237A × PT-3 (57.14%) and the maximum negative heterosis over mid-parent was recorded in EC-519784 × Punjab Chhuhara (-30.43%). Cross combination ARTH-3 × PT-3 (46.67%) exhibited significant positive relative heterosis. The highest positive value for heterobeltiosis for number of locules was observed in CLN2070A × PT-3 (57.14%) and the highest negative value was observed in EC-519784 × Punjab Chhuhara (-38.46%). Significant negative heterosis over better parent was observed in cross combination EC-519784 × Sweet-72 (-30.77%).

Since amount of juice increases with an increase in locule number, processing industries favour more loculated fruits. Significant increase in locule number was noticed in cross combination CLN2070A × PT-3 with respect to

relative heterosis. In contrast less number of locules is favoured by farmers and consumers because these fruits will be firm. Most of the cross combinations exhibited negative heterosis indicating decrease in number of locules in hybrids, which is desirable from fruit quality point of view. Most significant decrease in locule number was noticed in cross combination EC-519784 × Punjab Chhuhara, which can be concluded as most promising. Results also revealed that 3 hybrid combinations showed significant relative heterosis and 3 hybrid combinations showed significant heterobeltiosis. Similar findings for number of locules were reported by Sekhar *et al.*, (2010), Ahmad *et al.*, (2011) and Chattopadhyay and Paul (2012).

Table 3: *Per se* performance, mid-parent heterosis and better parent heterosis for number of locules and pericarp thickness

Crosses	Number of locules		Pericarp thickness	
	Mid parent	Better parent	Mid parent	Better parent
CLN2070A×PT-3	57.14*	57.14*	-32.24 **	-56.88 **
CLN2070A×Sweet-72	28.57	28.57	127.37 **	70.53 **
CLN2070A×Punjab Chhuhara	29.41	10.00	70.76 **	7.30
PT-8×PT-3	-5.88	-20.00	-42.64 **	-46.08 **
PT-8×Sweet-72	5.88	-10.00	13.13	-8.36
PT-8×Punjab Chhuhara	-20.00	-20.00	-33.28 **	-39.01 **
EC-519784×PT-3	0.00	-23.08	20.62 **	-19.04 **
EC-519784×Sweet-72	-10.00	-30.77*	96.94 **	60.26 **
EC-519784×Punjab Chhuhara	-30.43*	-38.46**	15.83 *	-23.42 **
Selection 06-01×PT-3	14.29	14.29	0.75	-13.84 *
Selection 06-01×Sweet-72	-14.29	-14.29	4.08	-8.00
Selection 06-01×Punjab Chhuhara	-5.58	-20.00	-8.57	-23.72 **
ARTH-3×PT-3	46.67*	37.50	-3.60	-36.72 **
ARTH-3×Sweet-72	6.67	0.00	80.24 **	41.79 **
ARTH-3×Punjab Chhuhara	0.00	-10.00	-37.75 **	-59.71 **
PT-7×PT-3	0.00	0.00	-32.31 **	-43.68 **
PT-7×Sweet-72	14.29	14.29	-25.53 **	-32.17 **
PT-7×Punjab Chhuhara	17.65	0.00	-30.77 **	-43.75 **
AC-824×PT-3	12.50	0.00	-11.93	-32.08 **
AC824×Sweet-72	-12.50	-22.22	9.41	9.09
AC-824×Punjab Chhuhara	-15.79	-20.00	-28.91 **	-46.31 **
AC-576×PT-3	12.50	0.00	-11.37	-28.88 **
AC-576×Sweet-72	25.00	11.11	1.95	-3.04
AC-576×Punjab Chhuhara	-26.32	-30.00	-30.61 **	-45.56 **
CLN2237A×PT-3	20.00	12.50	-56.17 **	-59.92 **
CLN2237A×Sweet-72	-6.67	-12.50	1.40	15.93 *
CLN2237A×Punjab Chhuhara	22.22	10.00	-25.55 **	-33.73 **
PT 2007-09×PT-3	6.67	0.00	-21.06 **	-24.17 **
PT 2007-09×Sweet-72	20.00	12.50	-11.23	-33.31 **
PT 2007-09×Punjab Chhuhara	-22.22	-30.00	-17.09 **	-17.98 **

** Significant at 5% ** Significant at 1%*

Pericarp thickness is a desirable attribute as it imparts fruit firmness and such fruits suit for long distance transport, canning and better storage (Roy and Choudhury 1972, Gonzalez 1985 and Kalloo 1988). Singh *et al.* (1980) also reported the pericarp thickness of tomato as one of the most important component of keeping quality and transportability. The improved shelf-life resulting from thicker pericarp helps in reducing post harvest losses. Pericarp thickness exhibited variation among treatments which ranged from 1.13 to 4.75 mm. Among the hybrids evaluated, the maximum value for pericarp thickness was noticed in cross combination, CLN2070A × Punjab Chhuhara (4.75 mm). The minimum value for the same trait was recorded in CLN2237A × PT-3 (1.67 mm). Fruits having high pericarp thickness can withstand shipping and remain firm for more number of days as compared to thin fleshed fruits. The maximum positive heterosis over mid-parent for pericarp thickness was recorded in CLN2070A × Sweet-72 (127.37%) and the maximum negative heterosis over mid-parent was recorded in CLN2237A × PT-3 (-56.17%). Hybrid combinations, EC-519784 × Punjab Chhuhara (15.83%), EC-519784 × PT-3 (20.62%), CLN2070A × Punjab Chhuhara (70.76%), ARTH-3 × Sweet-72 (80.24%) and EC-519784 × Sweet-72 (96.94%) exhibited significant positive relative heterosis.

The highest positive value for heterobeltiosis for pericarp thickness was observed in CLN2070A × Sweet-72 (70.53%) and the highest negative value was observed in CLN2237A × PT-3 (-59.92%). Some combination of the hybrids CLN2237A × Sweet-72 (15.93%), ARTH-3 × Sweet-72 (41.79%) and EC-519784 × Sweet-72 (60.26%) exhibited

positive significant heterobeltiosis for the same trait. Among cross combinations evaluated, 19 hybrids exhibited significant relative heterosis and 25 hybrids exhibited significant heterobeltiosis for pericarp thickness. Most promising hybrid in terms of higher pericarp thickness was CLN2070A × Sweet-72with respect to relative heterosis and heterobeltiosis. Similar results were reported by Ahmad *et al*., (2011) and Chattopadhyay and Paul (2012).

CONCLUSION

For most of the quality traits under study, heterosis over mid parent and better parent were in negative direction indicating accumulation of decreasing alleles from both the parents involved in a cross. Less number of locules is favoured by farmers and consumers because these fruits will be firm.and most promising hybrid for number of locules was EC-519784 × Punjab Chhuhara which exhibited negative heterosis. High total soluble solids content is correlated with small fruit size and oval fruit shape such fruits have better transport and keeping qualities. Hybrid, Selection 06-01×Punjab Chhuhara showed most promising results for TSS at immature and turning stage, whereas, Selection 06-01 × PT-3 was most promising hybrid combination for the trait TSS at red ripe stage. The improved shelf-life resulting from thicker pericarp helps in reducing post harvest losses. Hybrid combination, CLN2070A × Sweet-72 exhibited most promising results with respect to heterosis for pericarp thickness.

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