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Hybrid vigour for yield and quality traits in tomato (*Lycopersicon esculentum* L.)

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Abstract: An experiment on heterosis for yield and other component characters of 50 F_1 hybrids of tomato derived from the crosses between 10 lines and 5 testers through line x tester technique was conducted at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during 2012-13 and 2013-14. The analysis of variance indicated significantly higher amount of differences among treatments for all the characters studied, suggesting the presence of genetic variation among the studied genotypes. In this study, among crosses, the cross Punjab Varkha Bahar-2 x Hisar Lalit (0.400), EC 620383 x Palam Pink (0.383) and BBWR-10-3-18 x Hisar Lalit (0.382) showed higher early fruit yield per plant (kg) as compared to standard checks. The cross EC 620380 x Punjab Chhuhara (0.133 kg) produced the minimum early yield and the cross EC 620391 x Punjab Chhuhara (0.886 kg) the maximum total yield per plant, manifesting higher heterosis for yield per plant. The cross EC 620533 x Arka Meghali exhibited positive desirable heterosis over best parent for ascorbic acid content (30.58%) and the cross EC 620391 x Arka Vikas (54.25%) for total soluble solids **.** The cross EC 620380 x Arka Vikas showed the highest negative heterosis over best parent for acidity (-17.12%) and the cross Punjab Varkha Bahar-2 x Hisar Lalit (33.78%) exhibited the significantly highest positive heterosis over best parent for acidity.

Keywords: Heterosis, *Lycopersicon esculentum* L., quality traits, yield

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is the most widely grown vegetable of the World. India is the second largest tomato producer in the world after China. The pulp and juice are digestible, promote gastric secretion and help in blood purification. It is universally treated as *Protective Food* since it is a rich source of minerals, vitamins, antioxidants and organic acids (Simon, 1992). The nutritional importance of tomato indicates that there is a need to formulate breeding programme and to develop cultivars for processing traits with high quality of fruit as well as yield. 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. The reproductive biology and production of appreciable quantity of seeds per fruit provide ample scope for manifestation of heterosis in tomato (Agarwal *et al*., 2014). Hedrick and Booth (1908) first observed heterosis in tomato for higher yield and more number of fruits. Since then, heterosis for yield, its components and quality traits was extensively studied by various workers who emphasized the extensive utilization of heterosis to develop tomato hybrids (Ahmad *et al*., 2011). Present investigation was undertaken to ascertain the nature and extent of heterosis for yield and its component characters. The heterosis breeding will be useful in the development of varieties/ hybrids having high fruit quality traits.

MATERIALS AND METHODS

The experimental material comprising 15 genotypes (10 lines, 5 testers and 2 checks) was sown in nursery during 2012. The crosses were made in a line x tester fashion, and the F_1 seed was extracted during 2013. The seeds of fifty F_1 crosses along with 15 parents and standard checks were sown in the nursery during 2013 and the seedlings were transplanted at a spacing of 75 cm × 45 cm in randomized block design with three replications accommodating 14 plants in each treatment. All the recommended cultivation practices and plant protection measures were adopted to raise the crop successfully. Crosses were made manually by using standard procedure of hand emasculation and pollination. The F_1 crosses were evaluated along with their parents for various traits. Observations were recorded on average fruit weight, number of locules per fruit, early fruit yield per plant (kg), total fruit yield per plant (kg), total soluble solids (%), acidity (%) and ascorbic acid content (mg/100 g fruit). The mean values were subjected to statistical analysis and heterosis was determined as increase or decrease of F_1 hybrids over standard check variety Hisar Arun and Avinash II. Heterosis over superior parent and mid parent for different characters under study was

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calculated as per standard procedures.

RESULTS AND DISCUSSION

Average fruit weight: Average fruit weight plays a key role in the acceptance of produce by the consumer. Heterosis over best parent ranged from -34.33 to 40.04% (Table 1.1). The most heterotic cross combination was BBWR-11-1 x Palam Pink (40.04) followed by Punjab Varkha Bahar-2 x Hisar Lalit (35.89) and EC 620445 x Punjab Chhuhara (34.88). Heterosis over better parent ranged from -38.32 to 47.15%. Only three crosses showed desirable heterosis over better parent. The cross EC 620534 x Arka Meghali (47.15) showed heterosis over better parent followed by Punjab Varkha Bahar-2 x Arka Meghali (30.03) and Punjab Varkha Bahar-2 x Hisar Lalit (25.89). Similar results exhibiting positive heterosis in tomato for improved average fruit weight were explained by Padmini and Vadivel (1997). Kumari and Sharma, *(*2011) also reported negative heterosis for average fruit weight in tomato.

Number of locules per fruit: Heterosis over mid, better and best parent for number of locules per fruit ranged from -57.42 to 97.03, -61.38 to 84.25 and -53.71 to 24.44%, respectively (Table 1.2). Heterotic effects by three crosses over best parent were registered for this character. The highest heterosis in desirable direction was recorded for BBWR-10-3-17 x Hisar Lalit (24.44%) followed by the cross Punjab Varkha Bahar-2 x Arka Vikas (22.51%) and EC 620445 x Hisar Lalit (21.20%). For number of locules per fruit, Singh *et al.* (1998) found that the hybrids with high shape index possessed fewer number of locules per fruit, whereas, Singh *et al.* (2008), Ahmad *et al*. (2011) and Farzane *et al*. (2012) reported an increased number of locules per fruit due to the effect of heterosis in tomato.

Early fruit yield per plant (kg): The range of heterosis varied from -52.15 to 147.05, -62.10 to 147.05 and -64.62 to 6.38% over mid, better and best parent, respectively (Table 1.3). The highest positive heterosis over best parent was noted for Punjab Varkha Bahar-2 x Hisar Lalit (6.38%) followed by the cross EC 620383 x Palam Pink (1.86%) and BBWR-10-3-18 x Hisar Lalit (1.59). None of the crosses surpassed standard check variety for early yield, exhibiting no heterosis over standard check Hisar Arun. The early harvest increased profit margin from the crop and thus considered an important factor in tomato crop improvement programme. The results obtained for early fruit yield per plant in this study are in conformity with the findings of Jamwal *et al*. (1984), Farzane *et al*. (2012) and Agarwal *et al*. (2014). Prevalence of negative heterosis for early yield per plant in tomato has been reported by Kanthaswamy and Balkrishnan (1989).

Total fruit yield per plant (kg): The range of heterosis expressed over mid, better and best parent was from -85.16 to 34.65, -85.33 to 31.87 and -81.19 to 35.47%, respectively (Table 1.4). The desirable heterosis was shown by the crosses over best parents. The cross combination EC 620391 x Punjab Chhuhara (35.47%) followed by EC 620383 x Arka Vikas (28.59%) and BBWR-10-3-17 x Punjab Chhuhara (25.38%) recorded high heterosis for total fruit yield per plant. The fruit yield is the resultant manifest of its component traits, and heterosis observed for them contributes ultimately towards this complex character. The results of this investigation show that the total fruit yield per plant was significantly higher for heterosis, which confirms the study of Gul *et al*. (2010), Farzane *et al*. (2012), Agarwal *et al*. (2014) and similarly, Chauhan *et al*. (2014) also reported significantly higher heterosis for improved fruit yield in tomato.

Total soluble solids (%): The estimates of heterosis over mid, better and best parent extended from -25.60 to 68.41, -9.39 to 50.51 and -28.09 to 54.25%, respectively (Table 1.5). The number of cross combinations exhibiting positive heterosis over best parent was EC 620391 x Arka Vikas (54.25%) followed by EC 620391 x Punjab Chhuhara (52.29%) and BBWR-11-1 x Punjab Chhuhara (47.70%). A proper blend of acidity and TSS is more important in tomato both for fresh table use and processing purposes. Kumari and Sharma (2011) and Droka *et al*. (2012) estimated higher heterosis over mid, better and best parent for TSS. Singh *et al*. (2008) and Agarwal *et al*. (2014) found negative heterosis for total soluble solids in tomato.

Acidity (%): Heterosis for acidity is considered in both the directions, *i.e*., low and high acidity. The range of heterosis over mid, better and best parent varied from -23.41 to 33.15, -26.75 to 27.98 and -17.12 to 33.78%, respectively (Table 1.6). The highest negative heterosis for acidity over best parent was recorded in cross EC 620380 x Arka Vikas (-17.12%) followed by EC 620533 x Arka Meghali (-15.60%) and EC 620533 x Palam Pink (-14.69%). Heterosis for reduced acidity in fruits of tomato hybrids was demonstrated by Kanthaswamy and Balkrishnan (1989) and Kurian and Peter (1997). High positive heterosis for acidity was noticed over best parent. The significantly highest positive heterosis over best parent was exhibited by cross Punjab Varkha Bahar-2 x Hisar Lalit (33.78%) for acidity. Similarly, high acidity of fruits was also revealed by Shrivastava (1998). Droka *et al*. (2012) also reported heterosis for higher acidity in tomato fruits.

Ascorbic acid content (mg/100 g fruit): The heterotic effects of crosses for ascorbic acid content over mid, better and best parent varied from -23.37 to 54.13, -27.83 to 41.78 and -22.72 to 30.58%, respectively (Table 1.7). The positive desirable heterosis marked over best parent was exhibited in cross EC 620533 x Arka Meghali (30.58%) followed by EC 620380 x Arka Vikas (29.50%) and BBWR-10-3-18 x Palam Pink (28.30%). Earlier, Singh *et al.* (1979) observed the heterosis range of 2.0 to 45.95% with maximum for the cross Pusa Early Dwarf x HS-101. Bhatt *et al.*

Table 1. Range of heterosis, total heterotic, and important cross combinations showing high and desirable heterosis values for various characters in a line x tester set of tomato.

1.1 Average fruit weight (g)							
Heterosis (%) over MP		**Heterosis (%) over BP**		**Heterosis (%) over Hisar Arun**		**Heterosis (%) over Avinash II**	
Range (-34.05 to 56.03)		Range (-38.32 to 47.15)		Range (-34.33 to 40.04)		Range (-4.87 to 102.86)	
EC 620534 x Arka Meghali	56.03	EC 620534 x Arka Meghali	47.15	EC 620445 x Punjab Chhu-hara	34.88	EC 620445 x Punjab Chhuhara	95.38
Punjab Varkha Bahar-2 x Arka Meghali	37.46	Punjab Varkha Bahar-2 x Arka Meghali	30.03	Punjab Varkha Bahar-2 x Hisar Lalit	35.89	Punjab Varkha Bahar-2 x Hisar Lalit	96.84
Punjab Varkha Bahar-2 x Hisar Lalit	30.88	Punjab Varkha Bahar-2 x Hisar Lalit	25.89	BBWR-11-1 x Palam Pink	40.04	BBWR-11-1 x Palam Pink	102.86
1.2. Number of locules per fruit							
Heterosis (%) over MP		**Heterosis (%) over BP**		**Heterosis (%) over Hisar Arun**		**Heterosis (%) over Avinash II**	
Range (-57.42 to 97.03)		Range (-61.38 to 84.25)		Range (-53.71 to 24.44)		Range (-25.91 to 99.18)	
BBWR-10-3-17 x Hisar Lalit	97.03	BBWR-10-3-17 x Hisar Lalit	84.25	EC 620445 x Hisar Lalit	21.20	EC 620445 x Hisar Lalit	93.99
BBWR-10-3-17 x Palam Pink	77.51	BBWR-10-3-17 x Palam Pink	66.72	Punjab Varkha Bahar-2 x Arka Vikas	22.51	Punjab Varkha Bahar-2 x Arka Vikas	96.09
EC 620534 x Palam Pink	84.15	EC 620534 x Palam Pink	59.62	BBWR-10-3-17 x Hisar Lalit	24.44	BBWR-10-3-17 x Hisar Lalit	99.18
1.3. Early fruit yield per plant (kg)							
Heterosis (%) over MP		**Heterosis (%) over BP**		**Heterosis (%) over Hisar Arun**		**Heterosis (%) over Avinash II**	
Range (-52.15 to 147.06)		Range (-62.10 to 147.05)		Range (-64.62 to 6.38)		Range (-50.92 to 47.60)	
EC 620380 x Arka Vikas	147.05	EC 620380 x Arka Vikas	147.05	BBWR-10-3-18 x Hisar Lalit	1.59	BBWR-10-3-18 x Hisar Lalit	40.95
EC 620533 x Arka Vikas	135.54	EC 620533 x Arka Meghali	104.64	EC 620383 x Palam Pink	1.86	EC 620383 x Palam Pink	41.32
EC 620533 x Arka Meghali	116.12	EC 620533 x Palam Pink	89.41	Punjab Varkha Bahar-2 x Hisar Lalit	6.38	Punjab Varkha Bahar-2 x Hisar Lalit	47.60
1.4. Total fruit yield per plant (kg)							
Heterosis (%) over MP		**Heterosis (%) over BP**		**Heterosis (%) over Hisar Arun**		**Heterosis (%) over Avinash II**	
Range (-85.16 to 34.65)		Range (-85.33 to 31.87)		Range (-81.19 to 35.47)		Range (-81.19 to 35.47)	
EC 620380 x Palam Pink	5.28	BBWR-10-3-18 x Punjab Chhuhara	31.87	BBWR-10-3-17 x Punjab Chhuhara	25.38	BBWR-10-3-17 x Punjab Chhuhara	25.38
BBWR-10-3-17 x Arka Meghali	64.12	BBWR-10-3-17 x Punjab Chhuhara	31.41	EC 620383 x Arka Vikas	28.59	EC 620383 x Arka Vikas	28.59
BBWR-10-3-18 x Arka Meghali	34.65	BBWR-10-3-18 x Palam Pink	19.46	EC 620391 x Punjab Chhuhara	35.47	EC 620391 x Punjab Chhuhara	35.47

Contd….

1.5. Total soluble solids (%)

Heterosis (%) over MP		Heterosis (%) over BP		Heterosis (%) over Hisar Arun		Heterosis (%) over Avinash II	
Range (-25.60 to 68.41)		Range (-42.67 to 52.46)		Range (-28.09 to 54.25)		Range (-1.01 to 116.72)	
EC 620380 x Palam Pink	1.01	EC 620391 x Chhuhara	50.51	BBWR-11-1 x Punjab Chhuhara	47.70	BBWR-11-1 x Punjab Chhuhara	107.52
EC 620391 x Punjab Chhuhara	68.41	EC 620380 x Hisar Lalit	41.19	EC 620391 x Punjab Chhuhara	52.29	EC 620391 x Punjab Chhuhara	113.96
EC 620380 x Hisar Lalit	58.08	BBWR-10-3-17 x Arka Vikas	46.55	EC 620391 x Arka Vikas	54.25	EC 620391 x Arka Vikas	116.72

1.6. Acidity (%)

Heterosis (%) over MP		Heterosis (%) over BP		Heterosis (%) over Hisar Arun		Heterosis (%) over Avinash II	
Range (-23.41 to 33.15)		Range (- 26.75 to 27.98)		Range (-17.12 to 33.78)		Range (-1.29 to 63.51)	
EC 620380 x Palam Pink	5.34	BBWR-10-3-18 x Arka Vikas	27.97	EC 620383 x Arka Vikas	23.78	EC 620383 x Arka Vikas	51.29
BBWR-10-3-18 x Arka Vikas	27.97	EC 620383 x Arka Vikas	22.50	BBWR-10-3-17 x Palam Pink	23.78	BBWR-10-3-17 x Palam Pink	51.29
EC 620383 x Arka Vikas	33.15	EC 620383 x Palam Pink	21.39	Punjab Varkha Bahar-2 x Hisar Lalit	33.78	Punjab Varkha Bahar-2 x Hisar Lalit	63.51

1.7. Ascorbic acid (mg/100 g)

Heterosis (%) over MP		Heterosis (%) over BP		Heterosis (%) over Hisar Arun		Heterosis (%) over Avinash II	
Range (-23.37 to 54.13)		Range (- 27.83 to 41.87)		Range (-22.72 to 30.58)		Range (-0.89 to 67.46)	
EC 620534 x Arka Vikas	48.93	EC 620534 x Arka Vikas	41.78	BBWR-10-3-18 x Palam Pink	28.30	EC 620380 x Arka Vikas	66.08
EC 620534 x Hisar Lalit	36.25	EC 620534 x Hisar Lalit	36.17	EC 620380 x Arka Vikas	29.50	EC 620533 x Arka Meghali	67.46
EC 620445 x Hisar Lalit	39.32	EC 620445 x Hisar Lalit	31.66	EC 620533 x Arka Meghali	30.58		

Table 2. ANOVA of the hybrid analysis for various characters in a line x tester set of tomato.

Character	Mean square						
df	Replications	Genotypes	Females	Males	Hybrids	Male Vs. female	Parent Vs. hybrids
	2	14	9	4	49	1	1
Average fruit weight (g)	4.477	59.476**	64.187**	63.681**	65.508**	0.261	61.596**
Number of locules per fruit	0.457	2.994**	2.457**	4.557**	3.509**	1.581**	10.355**
Early fruit yield per plant (kg)	0.002	0.002**	0.016**	0.042**	0.018**	0.002*	0.001*
Total fruit yield per plant (kg)	0.010*	0.049**	0.048**	0.055**	0.113**	0.038**	2.537**
Total soluble solids (%)	0.002	4.547**	4.410**	4.149**	4.109**	7.367**	11.566**
Acidity (%)	0.001	0.017**	0.017**	0.017**	0.017**	0.016**	0.022**
Ascorbic acid (mg/100 g)	0.187	45.373**	28.730**	79.214**	28.309**	59.804**	76.347**

*,**P ≤ 0.05 and 0.01, respectively

(1998) observed maximum heterosis of 13.35% over top parent and also identified three best heterotic combinations for higher ascorbic acid content of fruits. Similarly, Kumari and Sharma (2011) and Droka *et al*. (2012) observed low ascorbic content in all the crosses for ascorbic acid content in tomato.

Heterosis in hybrid plants has often been exploited as an efficient tool for increasing yield. Among other vegetables, heterotic hybrids have been commercially used in tomato. The analysis of variance (Table 2) was significant for characters showing considerable amount of genetic variability among females, males and hybrids. However, both additive and non-additive gene effects were present for yield and the quality traits. In present study, different promising crosses for different yield and quality traits, which have been mentioned above, could be exploited for effective selection and heterosis breeding to augment the production potential of tomato crop. Rai *et al*. (1996) reported that hybrids for the estimates of dominance components were higher than the estimates of additive components for average fruit weight, fruit length, TSS and yield per plant. Rai and Syamal (1998) advocated heterosis breeding for the genetic improvement of tomato. Rao *et al*. (2007) obtained significantly higher tomatoyield from inter-varietal crosses assessed in their studies. The *per se* performance indicates that the hybrids with high mean value could be utilized for commercial exploitation. Kumari and Sharma (2011) advocated heterosis breeding for the genetic improvement of tomato. Similar other combinations for respective traits could be exploited for commercial use.

Conclusion

The ANOVA showed significantly higher amount of differences among treatments for all the characters studied. In this study, among crosses, the cross Punjab Varkha Bahar-2 x Hisar Lalit (0.400) was found best for higher early fruit yield per plant (kg). The cross EC 620380 x Punjab Chhuhara (0.133 kg) produced the minimum early yield and the cross EC 620391 x Punjab Chhuhara (0.886 kg) the maximum total fruit yield per plant, manifesting higher heterosis for fruit yield per plant. The heterosis for ascorbic acid content exhibited higher in cross EC 620533 x Arka Meghali (30.58%). Positive heterosis over best parent was obtained in cross EC 620391 x Arka Vikas (54.25%) for total soluble solids. The significantly highest positive heterosis over best parent was exhibited by cross Punjab Varkha Bahar-2 x Hisar Lalit (33.78%) for acidity. The heterosis breeding can be used efficiently to improve yield together with its yield components in tomato.

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REFERENCES

Agarwal, A., Arya, D.N., Ranjan, R. and Ahmed, Z. (2014). Heterosis, combining ability and gene action for yield and quality traits in tomato (*Solanum lycopersicum* L.). *Helix*, 2: 511-515.

Ahmad, S.K., Quamruzzaman, M. and Islam, M.R. (2011). Estimate of heterosis in tomato *(Solanum lycopersicum* L.). *Bangladesh Journal of Agriculture Research*, 36(3): 521-527.

Bhatt, R.P., Biswas, V.R., Pandey, H. K., Verma, G.S. and Kumar, N. (1998). Heterosis for vitamin C in tomato (*Lycopersicon esculentum* Mill.). *Indian Journal of Agricultural Sciences*, 68: 176-178.

Chauhan, V.B.S., Kumar, R., Behera, T.K. and Yadav, R.K. (2014). Studies on heterosis for yield and its attributing traits in tomato (*Solanum lycopersicum* L.). *International Journal of Agriculture Environment and Biotechnology*, 7 (1): 95-100.

Droka, D., Kumar, R., Joshi, S. and Yadav, R.K. (2012). Genetic studies of quality traits in tomato (*Solanum lycopersicum* L.) under low temperature. *Vegetable Science*, 39(2): 189-191.

Farzane, A., Nemati, H., Arouiee, H., Kakhki, A. M. and Vahdati, N. (2012). The estimate of combining ability and heterosis for yield and yield components in tomato (*Lycopersicon esculentum* M.). *J. Biol. Environ. Sci.*, 6 (17): 129-134.

Gul, R., Rahman, H.U., Khalil, I.H., Shah, S.M.A. and Ghafoor, A. (2010). Heterosis for flower and fruit traits in tomato (*Lycopersicon esculentum* M.). *African Journal of Biotechnology*, 9(27): 4144-4151.

Hedrick, W.P. and Booth, N.O. (1908). Mendelian characters in tomatoes. *Proceedings of the American Society for Horticultural Sciences*, 5: 19-24.

Jamwal, R. S., Rattan, R. S. and Saini, S.S. (1984). Hybrid vigour and combining ability in tomato. *South Indian Hort.* 32 (2): 69-74.

Kanthaswamy, V. and Balakrishnan, R. (1989). Studies on hybrid vigour in F_1 and its retention in F_2 generation of tomato (*Lycopersicon esculentum* Mill.). *South Indian Horticulture*, 37(2): 77-83.

Kumari, S. and Sharma, M.K. (2011). Exploitation of heterosis for yield and its contributing traits in tomato, (Solanum lycopersicum L.). *International Journal of Farm Science*, 1 (2): 45-55.

Kurian, A. and Peter, K.V. (1997). Association of fruit shape index and quality characters in tomato. *Indian Journal of Genetics and Plant Breeding*, 57(1): 82-86.

Padmini, K. and Vadivel, E. (1997). Studies on genetic variability and heritability in F_2 generation of tomato (*Lycopersicon esculentum* Mill.). *South Indian Horticulture*, 45(1- 2): 1-4.

Rai, N. and Syamal, M.M. (1998). Genetic architecture of morphological traits in tomato. *Orissa Journal of Horticulture*, 26(2): 7-9.

Rai, N., Syamal, M.M. and Joshi, A.K. (1996). Combining ability and gene action studies for number of locule in tomato (*Lycopersicon esculentum* Mill.). *Vegetable Science*, 23(2): 156-161.

Rao, E.S., Munshi, A.D., Singh, B. and Kumar, R. (2007). Studies on heterosis and combining ability for yield and resistance to early blight in tomato. *Indian Journal of Horticulture*, 64(3): 331-334.

Shrivastava, A.K. (1998). Heterosis and inbreeding depression for acidity, total soluble solids, reducing sugar and

dry matter content in tomato (*Lycopersicon esculentum* Mill.). *Advances in Plant Science*, 11(2): 105-110.

Simon, J.A., (1992). Vitamin c and cardiovascular disease: A review. *Journal of American. Coll. Nutrition.,* 11:107-125.

Singh, B., Rawat, P.S. and Pant, P.C. (1979). Heterosis for ascorbic acid in tomato. *Indian Journal of Agricultural Sciences*, 49(3): 177-178.

Singh, C.B., Rai, N., Singh, R.K., Singh, M.C., Singh, A.K. and Chaturvedi, A.K. (2008). Heterosis, combining ability and gene action studies in tomato (*Solanum lycopersicum* L.). *Vegetable Science*, 35(2): 132-135.

Singh, S., Dhaliwal, M.S., Cheema, D.S. and Brar, G.S. (1998). Diallel analysis of some processing attributes in tomato. *Journal of Genetics and Plant Breeding*, 52(3): 265-269.