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# Estimation of heterosis for yield and yield attributing traits in tomato crossed with line and tester method

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## Abstract

This study was conducted to estimate heterosis for the yield and yield contributing traits of 32 cross combinations involving 12 diverse lines of some Bangladeshi tomato genotypes considering line x tester mating fashion at the experimental field of Sher-e-Bangla Agricultural University, Dhaka in 2016-2017 and 2017-2018 winter season. The experiment was designed in a Randomized Complete Block Design (RCBD) with three replications. The analysis of variance (ANOVA) showed highly significant difference for all the characters suggesting the presence of genetic variability among the studied materials. Four cross combinations ($L_1xT_1$, $L_3xT_2$, $L_3xT_3$, $L_5xT_1$) showed desirable negative significant heterosis for days to first flowering in both relative heterosis (RH) and heterobeltiosis (HB) ranged from -2.56% to -19.05%, respectively. Highest positive significant heterosis in both RH and HB was observed in four crosses $L_4xT_4$ (63.48% and 48.25%), $L_5xT_2$ (46.77% and 46.27%), $L_5xT_4$ (62.58% and 34.78%) and $L_8xT_3$ (37.39% and 35.12%) for individual fruit weight (g), while six crosses $L_1xT_2$, $L_1xT_4$, $L_3xT_2$, $L_4xT_4$, $L_5xT_4$ and $L_6xT_1$ exhibited highest positive significant heterosis for yield per plant (kg) in both HB and RH ranged from 16.09% to 88.46% respectively. Heterotic hybrids with maximum number of studied desirable yield contributing traits (8) of both RH and HB were identified only two crosses $L_1xT_2$ and $L_4xT_4$.

**Key words**: Heterosis, tomato, heterobeltiosis, yield

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## Introduction

Tomato (*Solanum lycopersicum* L) is one of the most important vegetable crops in Bangladesh considering both nutritional and economical point of view. The fruit is relatively nutritious and contains moderate quantities of vitamin C (Vallareal, 1980). In Bangladesh tomato is widely grown during winter season as prevailing favorable temperature for its optimum growth and yield. A number of tomato varieties have been released by Bangladesh Agricultural Research Institute (BARI) and different private seed companies as well as imported exotic hybrids are also available here for reaching existing vegetable demand. Presently the farmers of Bangladesh are very much interested to grow hybrid variety for having short durational, high yielding with quality of fruits.

Since the discovery of hybrid vigour by Shull (1908), a tremendous progress was observed in the development of potential hybrids in tomato. Heterosis in tomato was first observed for higher yield and more number of fruits. Since then heterosos for yield, its components and quality traits were extensively studied by Mondal *et al.* (2009), Kurian *et al.* (2001), Ahmed *et al.* (2011), Shalaby (2013), Kumar *et al.* (2017), and Mohammad l.Al-Daej (2018).The advantages of tomato hybrids are uniformity in shape and size, increased vigor, early maturity, high yielding and resistance to specific pests and pathogens (Allard, 1960; Hageman *et al*. 1967). It is further mentioned that exploitation of hybrid vigor in tomato is resulted in increased yield of 20 to 50% (Chowdhury *et al*. 1965). The yielding ability of any genotype is the result of its interaction with the environment. The diverse variation of agro-climatic condition in different regions of Bangladesh and the effect of global climate change affects the growing conditions, thus the performance of different tomato genotypes and released varieties also varies greatly. In Bangladesh most of the breeding programs on tomato have been conducted using BARI released varieties and imported exotic varieties as parental materials. Besides, some local genotypes of tomato are existing which are highly adaptive to adverse environment, short durational, less susceptible to insect pest and diseases, high yielding, and bearing quality fruits. No efforts have been observed yet to develop hybrid varieties using local genotypes of Bangladesh. Considering above mentioned characteristics some Sher-e-Bangla Agricultural University (SAU) identified genotypes were used as parental lines to estimate heterosis towards development of hybrid varieties using Line x Tester mating design.

## Materials and Methods

The experiment was conducted in the research field of Genetics and Plant Breeding department, Sher-e-Bangla Agricultural University, Dhaka during the winter season of 2016-2017 and 2017-2018. In first year, twelve diverse SAU identified genotypes of tomato were used for making crosses following Line x Tester design. The parental genotypes (eight lines and four testers) and their thirty-two $F_1$ generations were evaluated during Robi season of 2017-2018. Thirty days old seedlings were transplanted in the main plot on 20 November in each year. The experiment was laid out in RCBD design with three replications having plot size of4.0 sq. m providing a spacing of 60 × 40 cm on 1 m wide bed. Data were recorded on days to first flowering, days to maturity, plant height at last harvest (cm), cluster per plant, fruits per cluster, fruits per plant, individual fruit weight (g), yield per plant (kg), fruit length (mm), fruit diameter (mm). The analysis of variance was carried out as per the methods described by Panse and Sukhatme (1967). Heterosis (%) over mid parent or relative heterosis (RH) and better parent (HB) was calculated after computing heterosis of respective parent by using the following equations:

Heterosis over better parent (%) = $\frac{F1-BP}{BP}$ x 100…….(1)

Here, $F_1$=Mean of $F_1$ individuals
BP=Mean of the better parent values

Heterosis over mid parent (%)= $\frac{F1-MP}{MP}$x 100 ………(2)

Here, $F_1$=Mean of $F_1$ individuals
MP=Mean of the mid parent values

Significance of heterosis was tested with the help of standard error using ‘t’ test.

## Results and Discussion

Analysis of variance due to genotypes and its components (parents, line vs. tester, crosses, female in hybrids, male in hybrids, lines x testers, Parents Vs Crosses) were highly significant for all the traits studied (Table 1). These results indicated a wide diversity between the parental materials used in this study. It also reflected that variance due to lines was highly significant for 5 out of 10 characters (days to first flowering, plant height (cm), cluster per plant, fruit per cluster, and fruit per plant) while it was insignificant in other four traits (fruit length, fruit diameter, individual fruit weight, and yield per plant). The variance due to testers was significant or highly significant in plant height (cm), cluster per plant, fruit per cluster and fruit per plant while insignificant in other six traits (days to first flowering, days to maturity, fruit length, fruit diameter, individual fruit weight and yield per plant).

**Table 1**. Analysis of variances for 10 different growth characters in tomato under line x tester method.

| Parameters | df | DFF | DM | PH (cm) | CPP | FPC | FPP | FL (mm) | FD (mm) | IFW (g) | YPP (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 2 | 0.08 | 0.01 | 0.01 | 0.04 | 0.03 | 4.88 | 0.83 | 0.002 | 1.48 | 0.01 |
| Genotypes | 43 | 55.94** | 52.98** | 1281.03** | 10.49** | 2.22** | 434.67** | 70.23** | 91.75** | 212.68** | 0.45** |
| Parents | 11 | 59.93** | 51.77** | 2359.35** | 17.16** | 5.30** | 1039.80** | 45.42** | 53.73** | 172.93** | 0.55** |
| Lines | 7 | 75.98** | 61.40* | 2188.41** | 20.75** | 3.30** | 1236.42** | 37.06 | 56.77 | 172.97 | 0.55 |
| Testers | 3 | 32.02 | 16.42 | 3393.03** | 14.39* | 6.23** | 342.05* | 43.95 | 32.24 | 227.82 | 0.26 |
| Line vs tester | 1 | 31.27** | 90.43** | 454.91** | 0.35** | 16.47** | 1756.66** | 108.31** | 96.88** | 7.94** | 1.41** |
| Crosses | 31 | 52.26** | 54.97** | 939.51** | 6.56** | 1.20** | 195.34** | 80.54** | 105.85** | 217.13** | 0.43** |
| Female in hybrids | 7 | 175.72** | 164.71** | 1336.80** | 14.85** | 1.75** | 445.33** | 130.76** | 197.69** | 465.76** | 0.81** |
| Male in hybrids | 3 | 43.72** | 12.34** | 5608.71** | 2.94** | 1.33** | 170.66** | 92.68** | 139.04** | 405.95** | 0.16** |
| Lines X Testers | 21 | 12.33** | 24.48** | 140.06** | 4.32** | 1.00** | 115.54** | 62.07** | 70.50** | 107.28** | 0.34** |
| Parents vs Crosses | 1 | 126.18** | 4.74** | 6.72** | 58.78** | 0.16** | 1197.30** | 23.67** | 72.80** | 512.10** | 0.01** |
| Error | 86 | 0.03 | 0.02 | 0.01 | 0.01 | 0.01 | 0.71 | 0.75 | 0.001 | 0.88 | 0.002 |

*, ** Significant at 0.05 and 0.01 probability level, respectively; df=degree of freedom, DFF=days to first flowering, DM=days to maturity, PH (cm)=plant height (cm), CPP=cluster per plant, FPC=fruit per cluster, FL=fruit length, FD=fruit diameter, IFW=individual fruit weight, and YPP=yield per plant.

Data in Table 2 illustrated percent heterosis observed in $F_1$ generation over relative (RH) and better parent (HB), and discussed here. The earliness is one of the prime criterions in any crop improvement programme. Present study also brought out certain hybrids with significant earliness in days to first lowering. Negative heterosis is desirable for this trait over mid parent and better parent. Among 32 crosses desirable negative significant heterosisfor days to first flowering was observed in both RH and HB insix crosses $L_1xT_1$ (-3.42% and -4.09%), $L_2xT_3$ (-2.59% and -11.99%) $L_3xT_2$ (-2.56% and -6.63%), $L_3xT_3$, (-3.10% and -5.40%), $L_5xT_1$ (-7.85% and -19.05%) and $L_6xT_1$ (-0.336% and -3.25%). Only desirable negative HB was observed in ten crosses $L_1xT_4$, $L_2xT_1$, $L_3xT_4$, $L_5xT_2$, $L_6xT_1$, $L_6xT_2$, $L_6xT_4$, $L_8xT_1$, $L_8xT_2$, and $L_8xT_4$ranged from -2.91% to -11.68%. Similar trends of earliness were reported by Padma *e al*. (2002), Shanker *et al.* (2013), Madhavi *et al*. (2013) and Ramana *et al.* (2018).

A total of 14 crosses out of 32 showed desirable negative significant heterosis for days to maturity ranged from -0.10% to -6.39% in RH and -1.40% to -8.72% in HB. While only five crosses showed negative significant HB heterosis ranged from -1.13% to -3.43% in case of same trait. Nine crosses showed positive significant RH, ranged from 1.03% to 7.59% and HB ranged from 1.64% to 6.06 %. Kurganskya and Agentova (1974) found that heterosis for earliness occurred most often when both the parents were early. Therefore, the observed lateness can be attributed to the strong influence of male parents which were late. In concurrence with the observed lateness, Kurian *et al.* (2001) also reported delayed maturity in hybrids.

In case of plant height (cm) it is evident that only two crosses $L_1xT_4$ and $L_5xT_2$ showed desirable positive significant RH and HB ranged from 7.44% to 1.29% respectively. Fifteen crosses out of 32 showed positive significant RH ranged from 0.989% to 15.83%. Singh and Asati (2011, Yadav *et al*. (2013) and Ahmed *et al.* (2011) also reported positive significant heterosis for plant height in tomato. No cross combinations showed positive significant heterosis in both RH and HB for cluster per plant. Only very few crosses i.e. $L_1xT_2$,

$L_2xT_3$, $L_4xT_3$, $L_4xT_4$, $L_6xT_3$, $L_6xT_4$ showed positive significant RH ranged from 2.81% to 7.92%.

Total number of fruits per cluster is of great significance for the improvement of fruit yield in tomato. Eight crosses showed positive significant heterosis in both HB and RH ranged from 1.36% to 42.62% respectively for the trait fruit per cluster. Ten crosses exhibited positive significant RH ranged from 10.00% to 27.37%. These results are in conformity with Shanker *et al.* (2013), Madhavi *et al.* (2013) and Ahmad *et al.* (2011) in respect of fruits per cluster.

For the trait number of fruit per plant, three crosses $L_1xT_2$, $L_1xT_4$ and $L_6xT_1$ performed positive significant HB and RH ranged from 17.26% to 49.25% respectively. Maximum positive RH and HB observed in cross $L_1XT_2$ 49.25% and 28.21% respectively. Some other crosses showed positive significant RH ranged from 9.85% to 34.88%. While the rest of the crosses showed negative significant heterosis in both RH and HB. Similar findings were also reported by Legon *et al.* (1984), Jamwal *et al.* (1984) and Ahmad *et al.* (2011) for higher fruit number per plant.

**Table 2**. Relative heterosis (RH) and heterobeltiosis (HB) in 32 hybrids.

| Hybrids | DFF | | DM | | PH (cm) | | CPP | | FPC | |
|---|---|---|---|---|---|---|---|---|---|---|
| | RH | HB | RH | HB | RH | HB | RH | HB | RH | HB |
| $L_1XT_1$ | -3.42** | -4.09** | -4.11** | -4.48** | 0.77** | -24.78** | -37.12** | -53.59** | 21.67** | 1.36** |
| $L_1XT_2$ | 9.54** | 4.25** | -3.81** | -3.71** | 15.83** | -15.93** | 3.56** | -25.94** | 29.73** | 3.76 |
| $L_1XT_3$ | 8.17** | 6.34** | 7.59** | 5.60** | 0.98** | -19.63** | -26.14** | -41.50** | 12.75** | -2.18 |
| $L_1XT_4$ | 0.73 | -8.90** | -1.35** | -3.84** | 4.87** | 1.29** | -9.96** | -17.45** | 42.62** | 28.34** |
| $L_2XT_1$ | 3.07** | -6.01** | -1.72** | -2.38** | -4.78** | -23.28** | -24.42** | -40.62** | 10.00** | -18.07** |
| $L_2XT_2$ | 12.90** | 8.64** | -1.51** | -2.45** | -2.18** | -23.69** | -43.17** | -56.92** | 13.73** | -18.07** |
| $L_2XT_3$ | -2.59** | -11.99** | -5.39** | -8.09** | 3.98** | -9.84** | 2.81* | -12.58** | -18.07** | -18.07** |
| $L_2XT_4$ | 19.80** | 17.89** | 0.16 | -3.37** | 9.22** | -4.37** | -17.07** | -17.07** | -28.39** | -43.14** |
| $L_3XT_1$ | 4.17** | 2.72** | 5.42** | 2.47** | -12.53** | -16.43** | -29.90** | -29.90** | 15.13** | -8.45** |
| $L_3XT_2$ | -2.56** | -6.63** | 1.03** | -1.51** | -1.00** | -1.30** | -10.07* | -14.42** | 26.78* | -2.91 |
| $L_3XT_3$ | -3.10** | -5.40** | 4.43** | 3.79** | 3.48** | -9.02** | -1.75 | -10.83** | -15.06** | -22.31** |
| $L_3XT_4$ | 1.20** | -7.89** | 2.35** | 2.25** | 7.10** | -24.05** | 1.64 | -20.15** | 13.12** | -3.34 |
| $L_4XT_1$ | 18.58** | 15.03** | 6.52* | 4.77** | -3.98** | -16.73** | -33.37** | -36.59** | 18.69* | -15.96** |
| $L_4XT_2$ | 12.37** | 9.43** | 3.29** | 1.89** | 9.68** | -8.26** | -27.78** | -27.78** | -2.84 | -33.22** |
| $L_4XT_3$ | 13.99** | 9.50** | 6.70** | 6.06** | 0.99** | -4.96 | 5.37** | -8.52** | -24.72** | -30.37** |
| $L_4XT_4$ | 11.04** | 2.61** | -0.10 | -1.40** | 12.15** | -8.86** | 7.92** | -18.20 | 11.07** | -16.71** |
| $L_5XT_1$ | -7.85** | -19.05** | -3.27** | -4.48** | -20.68** | -20.74** | -50.35** | -56.88** | -0.63 | -27.96** |
| $L_5XT_2$ | 1.74** | -5.92** | -5.15** | -6.07** | 7.44** | 3.01** | -34.42** | -40.46** | 4.85* | -26.34** |
| $L_5XT_3$ | 1.43* | -11.68** | -5.98** | -6.90** | -13.44** | -20.73** | -24.42** | -39.51** | -5.98** | -9.79** |
| $L_5XT_4$ | 24.18** | 21.03** | 3.38** | 1.64** | 2.79** | -25.04** | -3.96 | -31.77** | 15.45** | -11.09** |
| $L_6XT_1$ | -0.36 | -3.25** | -3.02** | -5.17** | -1.50** | -19.96** | -5.20** | -9.43** | 34.23** | 17.93** |
| $L_6XT_2$ | 1.76** | -6.42** | -6.39** | -8.72** | 2.26** | -19.58** | -31.59** | -37.66** | 40.26** | 17.93** |
| $L_6XT_3$ | 16.74** | 14.48** | 1.43** | -2.97** | -8.41** | -19.82** | 4.82** | -0.67 | -6.50** | -23.01** |
| $L_6XT_4$ | 10.00** | -3.69** | 1.63** | -3.43** | 11.05** | -3.69** | 7.33** | -12.67** | 27.07** | 21.29** |
| $L_7XT_1$ | 20.16** | 13.56** | -0.64** | -5.33** | -17.40** | -18.07** | -28.19** | -30.98** | 0.33 | -17.71** |
| $L_7XT_2$ | 14.11** | 2.31** | -0.13 | -5.11** | 2.64** | -0.87** | -16.78** | -23.72** | 33.01** | 4.85* |
| $L_7XT_3$ | 19.57** | 14.11** | 7.14** | -0.07 | -17.12** | -24.62** | -17.85** | -22.62** | -13.54** | -23.72** |
| $L_7XT_4$ | 19.34** | 2.03** | 6.70** | -1.13** | 12.86** | -18.08** | -7.44** | -25.06** | -7.05** | -17.78** |
| $L_8XT_1$ | 8.08** | -2.91** | 2.40** | 0.13 | -5.83** | -20.61** | -12.32** | -20.15** | -2.64 | -22.37** |

| Hybrids | FPP | | FL (mm) | | FD (mm) | | IFW (g) | | YPP (kg) | |
|---|---|---|---|---|---|---|---|---|---|---|
| $L_8XT_2$ | 7.34** | -8.24** | 4.97** | 2.36** | 2.22** | -16.76** | -26.19** | -35.72 | 27.37** | -2.22 |
| $L_8XT_3$ | 12.91** | 2.35** | 6.88** | 2.25** | -6.60** | -14.82** | -40.54** | -40.76** | 7.30** | 18.80** |
| $L_8XT_4$ | 11.97** | -8.45** | 5.30** | 0.06 | 9.63 | -8.49** | -4.26** | -18.83** | 36.36** | 16.87** |
| **Hybrids** | **FPP** | | **FL (mm)** | | **FD (mm)** | | **IFW (g)** | | **YPP (kg)** | |
| | **RH** | **HB** | **RH** | **HB** | **RH** | **HB** | **RH** | **HB** | **RH** | **HB** |
| $L_1XT_1$ | -17.65** | -29.37** | 6.72* | 5.94 | 6.91** | 6.58** | -2.80 | -9.57** | -21.58** | -36.74** |
| $L_1XT_2$ | 49.25** | 28.21** | 6.49* | 6.10 | 16.78** | 8.53** | 3.58 | -17.67** | 62.86** | 48.44** |
| $L_1XT_3$ | -19.95** | -42.79** | 19.21** | 13.08** | 0.02 | -6.74** | 2.16 | -12.87** | -12.20* | -29.43** |
| $L_1XT_4$ | 29.67** | 27.04** | 3.53 | -10.04** | 6.69** | -6.74** | -2.66 | -7.41** | 26.46** | 18.23* |
| $L_2XT_1$ | -8.31** | -14.88** | 22.22** | 14.21** | 3.82** | 0.62** | 0.41 | -11.80** | -6.62 | -12.14* |
| $L_2XT_2$ | -26.23** | -31.63** | 6.53* | 0.57 | 10.94** | 6.55** | 38.18 | 15.42** | 0.92 | -20.65** |
| $L_2XT_3$ | -15.80** | -28.39** | 23.80** | 22.73** | 16.99** | 12.74** | 2.39 | -7.71* | -12.16** | -17.72** |
| $L_2XT_4$ | -40.65** | -52.87** | 36.01** | 24.91** | 25.50** | 13.10** | -7.94** | -6.73 | -44.92** | -55.80** |
| $L_3XT_1$ | -19.30** | -35.83** | -0.60 | -5.87* | 1.83** | -2.15** | 5.87* | -9.84** | -10.50** | -17.69** |
| $L_3XT_2$ | 15.84** | -8.02** | -31.23** | -35.54** | -19.92** | -28.07** | 46.18** | 25.84** | 63.09** | 16.09** |
| $L_3XT_3$ | -15.76** | -16.46** | -8.14** | -17.76** | -4.34** | -13.80** | -3.26 | -9.85* | -18.72** | -24.93** |
| $L_3XT_4$ | 9.85** | -22.82** | -0.42 | -17.85** | -4.94** | -19.48** | 1.35 | -3.44 | 13.33** | -17.96** |
| $L_4XT_1$ | -22.53** | -46.70** | -0.54 | -1.46 | 5.27** | 0.62** | 7.76** | -12.07** | -7.27* | -26.05** |
| $L_4XT_2$ | -29.81** | -51.76** | -12.46** | -12.61** | 6.63** | 3.85** | 37.41** | 23.89** | -8.48** | -40.49** |
| $L_4XT_3$ | -21.64** | -36.29** | -14.96** | -19.17** | -18.90** | -20.75** | -10.92** | -12.64** | -30.88** | -44.68** |
| $L_4XT_4$ | 8.34 | -31.85** | 53.14** | 33.29** | 57.15** | 43.48** | 63.48** | 48.25** | 88.46** | 24.14** |
| $L_5XT_1$ | -53.34** | -68.93** | 26.14** | 17.65** | 35.39** | 24.84** | 59.24** | 20.31** | -11.81** | -27.33** |
| $L_5XT_2$ | -34.05** | -56.13** | 0.09 | -5.68 | -1.34** | -2.48** | 46.77** | 46.27** | -3.59 | -36.02** |
| $L_5XT_3$ | -29.68** | -45.42** | -16.84** | -17.72** | -12.56** | -13.87** | 8.01 | -0.57 | -22.15** | -35.61** |
| $L_5XT_4$ | -1.15 | -39.33** | 57.10** | 44.54** | 56.53** | 48.08** | 62.58** | 34.78** | 84.92** | 24.43** |
| $L_6XT_1$ | 28.09** | 17.26** | 0.62 | -4.20 | 10.23** | 7.24** | 2.36 | -10.15** | 32.66** | 26.52** |
| $L_6XT_2$ | -2.22 | -10.63** | -14.25** | -19.19** | -16.76** | -20.35** | -1.04 | -17.28** | -5.43 | -26.41** |
| $L_6XT_3$ | -0.84 | -14.60** | -19.62** | -27.67** | -16.63** | -19.96** | -6.95* | -16.07** | -6.00 | -10.76** |
| $L_6XT_4$ | 34.88** | 5.91 | -20.97** | -34.51** | -18.58** | -26.88** | -8.51** | -9.75** | 23.73** | -1.76 |
| $L_7XT_1$ | -27.31** | -38.42** | 19.98** | 10.98** | 16.01** | 4.47** | 5.67* | -0.52 | -24.27** | -38.94** |
| $L_7XT_2$ | 13.49** | -4.00 | 10.33** | 1.04 | 18.31** | 0.10 | 45.72** | 5.50* | 54.56** | 1.17 |
| $L_7XT_3$ | -28.39** | -33.23** | 27.41** | 11.58** | 23.47** | 4.76** | 43.66** | 10.35** | 5.20 | -14.87** |
| $L_7XT_4$ | -16.54** | -38.38** | 10.93** | -10.26** | 12.59** | -9.75** | 30.67** | 10.13** | 1.77 | -32.49** |
| $L_8XT_1$ | -12.47** | -24.56** | -3.10 | -4.60 | 7.88** | -0.03 | 22.86** | 0.02 | 11.30* | 3.83 |
| $L_8XT_2$ | -1.58** | -15.30** | -2.38 | -4.93 | 1.63** | 1.00** | -12.11** | -20.55** | -15.15* | -32.84** |
| $L_8XT_3$ | -36.20** | -41.63** | 9.86** | 1.99 | 19.24** | 18.09** | 37.39** | 35.12** | -12.10** | -18.35** |
| $L_8XT_4$ | 26.71** | -5.18 | -2.82 | -17.18** | -3.22** | -8.91** | -3.80 | -12.99** | 26.48** | 2.21 |

$^{**}$and$^{*}$ significant at 1% and 5% level, respectively.

Considering fruit length (mm) nine cross combinations showed positive significant HB and RH ranged from 10.98% to 57.10% respectively. More than 20% heterosis for both RH and HB was observed in crosses $L_2xT_3$ (23.80% and 22.73%), $L_2xT_4$ (36.01% and 24.91%), $L_4xT_4$ (53.14% and 33.29%) and $L_5xT_4$ (57.10% and 44.54%). Scott *et al.* (1986) also reported heterosis over better parent for fruit size in few cases in tomato.

In case of fruit diameter, 50% combinations (16 crosses) exhibited positive significant heterosis in both HB and RH ranged from 1.00% to 57.15% respectively. Highest positive heterosis was observed in crosses $L_4xT_4$ (57.15% and 43.48%) and $L_5xT_4$ (56.53% and 48.08%). Alverez (1985) and Ahmad *et al.* (2011) also reported heterosis in equatorial diameter in the majority of crosses.

Heterosis for fruit weight highest positive significant heterosis (more than 30%) in both RH and HB was observed in crosses $L_4xT_4$ (63.48% and 48.25%), $L_5xT_2$ (46.77% and 46.27%), $L_5xT_4$ (62.58% and 34.78%) and $L_8xT_3$ (37.39% and 35.12%). Mohammad l. Al-Daej, (2018), Mondal *et al*.(2009), Kumar *et al*. (2017), Savale *et al*.(2017), Kumari and Sharma (2011), Yadav *et al*. (2013), Agarwal *et al*. (2014), Chauhan *et al*. (2014), Shalaby (2012), Kumar *et al*. (2012), Hatem (2003) and Khalil (2004), Scott *et al.* (1986), Ahmad *et al.* (2011) and Yadav *et al*. (2013) also reported heterosis for individual fruit weight.

Six crosses $L_1xT_2$ (62.86% and 48.44%), $L_1xT_4$ (26.46% and 18.23%), $L_3xT_2$ (63.09% and 16.09%), $L_4xT_4$ (88.46% and 24.14%), $L_5xT_4$ (84.92% and 24.43) and $L_6xT_1$ (32.66 and 26.52) exhibited highest positive significant heterosis for yield per plant (kg) in both HB and RH ranged from 16.09% ($L_3xT_2$) to 88.46% ($L_4xT_4$) respectively. Yadav *et al.* (2013) also reported both two types of heterosis (RH and HB) for fruit yield per plant.

## Conclusion

Heterosis by cross pollination between line and testers would help to develop better hybrids with high yield potential acceptable to the consumers. The research findings of this study would also help the researcher to find out the critical areas for the development of new tomato hybrids that some of the investigators were not able to explore. Therefore, a new theory may be handy for many researchers in order to develop better hybrids by cross pollination between the line and testers. Besides, further investigation can be done to exploit hybrid vigor for effective improvement in yield potential of the traits of these tomato genotypes.

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