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Original Research Article

STUDIES ON HETEROSIS FOR HEAT TOLERANCE IN TOMATO

ABSTRACT

An investigation was carried out with a view to characterizing, evaluating and estimating heterosis for yield and yield attributes under high temperature conditions at the experimental field of Horticulture Department, Faculty of Agriculture during May to August 2013. The better parent heterosis was estimated for ten characters. Considering better parent heterosis, the cross C41 X FP5 (203.22%) exhibited highest positive heterosis for fruit yield plant^{-1} and lowest from the hybrid of C51 X C1 (32.61%). Again the hybrid C41 X C51 showed the highest heterobetiotic effect of 0.72 for days to first flower. Out of 10 hybrids, C51 X C71 showed the highest positive heterosis (85.12) on number of fruits plant^{-1}. The cross FP5 X C71 exhibited the highest significant and positive heterosis (69.31) on individual fruit weight which indicate suitable combinations for improving fruit weight. The positive and the highest heterosis for pericarp thickness was recorded from the cross combination C11 X C71(56.25), while the cross combination of C51 X C11 and C51 X C71 exhibit the positive and significant heterosis for the length and fruit width, respectively.

Keywords: Hybrid, heterosis, tomato, Solanum lycopersicon L.

INTRODUCTION

Tomato (Solanum *lycopersicon* L.) belongs to the family Solanaceae having the chromosome number of 2n= 24. It is one of the most popular and nutritious vegetable crop all over the world including Bangladesh (Ahmed, 2002). It is a self-fertilized annual crop. Tomato is grown in winter in Bangladesh, as the temperature is congenial at that period for optimum growth and yield. But it has great potentiality to grow in summer also. Due to its palatability and vitamin content its demand remains high throughout the year, while its production is too low than requirements especially in summer season. In summer' availability of fresh tomato is less due to agro-ecological constraints. Cultivation of summer tomato are affected due to excessive rainfall, temperature, wind storm, etc. during the monsoon season. Therefore, special thrust is needed to increase summer vegetables production and thereby also increase cash flow to the farm family. Heterosis or hybrid vigour is an important biological phenomenon refers to the manifested superiority of the F1 hybrid resulting from the cross of genetically dissimilar homozygous parents. Now days, heterosis breeding is one of the most efficient tool to exploit the heterotic response for several traits. Many hybrids of the crops like bean, cucumber, eggplant, onion, watermelon,

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cabbage, and radish are frequently grown on large scale (Singh *et al*., Bhatt *et al*., 1999). Substantial amount of heterosis for many traits in tomato have been reported by several authors. Hence, attempt can be made to exploit heterosis for better yield and quality of tomato. Though heterosis for a number of economic characteristics of tomato have been reported by several researchers, but its feasibility and utilization for commercial production is still lacking which need to be initiated in this country. Recently Bangladesh Agricultural Research Institute (BARI) has strengthened the programme for year round tomato variety development and already succeeded to develop some heat tolerant hybrids (Anon., 2003). But research is continuous process and attempt can be made to develop new hybrid combinations which might be superior over the existing hybrid varieties. Therefore, present investigation was to undertaken to study the heterosis for yield and yield attributes.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at the experimental field of Horticulture Department, Sylhet Agricultural University, Bangladesh during May to August 2013. It is located 275 km north-east of Dhaka. The study area is located on latitude $24^0$54'N to 33.67" and longitude $91^0$54' to 95.88" E. The soil of experimental site belongs to the AEZ-20: Eaturan Surma Kushiyara Floodplain. Soil was brown hill soil in texture and highly acidic (P^H 4.83) in nature. The climate of the experimental site was subtropical characterized by heavy rainfall during May to October and scanty during rest of the year. During the experimental period the monthly average rainfall (cm) and air temperature (^oC) from May to August were 34.2 cm, 26.9 cm, 18.9 cm and 26.55^oC, 29.85^oC , 29.59^oC, 29.1^oC. The mean monthly relative humidity ranged from 46 to 80% with the peak occurring between July and August.

Experimental Design and Planting

Seeds of ten cross combinations of tomato were selected in this study. Seeds were sown in three different seed beds on May 15, 2013. After seed sowing the seed bed was given partial shade with black net. The seed bed was also covered by a fine white net (60 × 60 mesh) to protect seedlings from insect attack. Eight days old seedlings were transplanted in polythene bag for hardening of the seedlings. Twenty five days old seedlings were transplanted in the experimental field on June 10, 2013. The experiment was laid out in Randomized Complete Block (RCB) Design with three replications. The unit bed was made

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almost 15 cm in height with a view to prevent the crop from moist condition during heavy rain. The land was previously cultivated with county bean. The unit plot size was 2.3 m × 4.8 m which was again divided into two beds and each bed there were 12 plants row^{-1} and 24 plants plot^{-1}. Plants were spaced at 60 cm × 40 cm between plant to plant and row to row, respectively. The unit plot and blocks were separated by 50 cm and 75 cm drain, respectively. The land was fertilized with 15 t well decomposed cowdung 300 kg urea, 200 kg TSP and 150 kg MoP hectare^{-1}, respectively. Half of the quantity of cow dung and the entire amount of TSP were applied during land preparation. The remaining cowdung and half of MoP were applied before 5 days of planting. The whole of urea and half of MP were applied in 3 equal splits as top dressing at 15, 30 and 50 days after transplanting. Light irrigation of each seedling was given just after transplanting for better establishment of the plants. To protect the crop from heavy rain polytunnel was provided over the crop during entire cropping period. The height of the polytunnel at the middle of the bed was 6.0 feet while it was 4.5 feet at both sides. The structure of the polytunnel was made of bamboo where transparent polythene used over the structure. Stacking was provided to keep the plant erect. Weeding, irrigation, Pruning, mulching and other intercultural operations were done as and when necessary.

Estimation of heterosis

For estimation of heterosis in each character the mean values of 10 F_1's have been compared with better parent (BP) for heterobeltosis. Percent heterosis was calculated as –

For better parent heterosis,

$$H\ (\%) = \frac{(F_1 - BP)}{BP} \times 100$$

Where, F_1= Mean of F_1 generation

BP= Mean of better parent

The significance test for heterosis was done by using the following formulae:

Critical difference (CD) for heterosis over better parent

$CD = \sqrt{2MSE/r} \times t$

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Where, MSE= Error mean square

r = Number of replication

t= Tabulated value of t at error df at1 % and 5% level of significance

CD was used to compare the observed differences among different treatments. If the difference was greater than CD value, it was considered as significant or vice-versa.

Results and discussion

Analysis variance (Table 1) revealed that the days to first harvesting, the estimated heterosis over better parent revealed that out of 10 cross combinations negative heterosis for days to first harvesting was not found. Among the 10 cross combinations, 5 hybrids showed significant and positive heterosis for days to first flowering (Table 2). The highest positive heterosis for this trait was observed in the cross combination C41 × C71 (11.67%). Heterobeltiotic for this trait ranged from 0.72% to 11.67%. In case of harvesting, the estimated heterosis over better parent revealed that out of 10 cross combinations negative heterosis was found in C41 × C51. The negative heterosis observed in the cross combination C41 × C51 (-3.03%). Heterobeltosis for this trait ranged from -3.03% to 7.70%. There was no significant negative heterosis, 8 hybrids showed the positive heterosis for this traits. Heterosis for this trait ranged from 0% to 85.12%. The highest positive heterosis was found in cross C51 × C71 (85.12%). Choudhury and Khanna (1972), Jamwal *et al.* (1984) and Legon *et al.* (1984) also reported heterobeltosis for tomato fruits per plant under high temperature growing environment. Nine cross combinations out of 10 cross combinations exhibited significant positive heterotic value for fruit weight over better parent. Heterosis for this trait ranged from 2.25% to 69.31%. The highest significant positive heterosis was found in cross combination FP5 × C71 (69.31%). Heterosis for this trait ranged from 28.26% to 203.22%. The highest positive heterosis was found in cross combination C41 × FP5 (203.22%). Chaudhury and Khanna (1972) reported 73.77% and Sidhu and Singh (1993) reported 71.7% heterobeltosis for yield per plant in tomato.

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Table 1. Analysis of variance for hybrids on different characters of tomato

Source of variation	DF	Days to first flowering	Days to harvest	No. of fruits plant^{-1}	Individual fruit weight	Fruit length	Fruit width	TSS (%)	Locule fruit^{-1}	Pericarp thickness
Replication	2	0.62	5.49	15.96	9.21	0.04	0.04	0.04	0.02	0.01
Genotype	14	11.93**	10.16**	122.97**	207.60**	0.91**	1.02**	0.72**	2.07**	0.06**
Error	28	1.81	1.58	0.24	1.93	0.02	0.01	0.03	0.36	0.01

Table 2 Percent heterosis over better parent of 10 tomato cross combinations for different characters

Hybrids	Days to first flowering	Days to harvest	No. of fruits plant^{-1}	Individual fruit weight	Pericarp thickness
C41 × C51	0.72	-3.03	46.08**	24.03**	13.33
C41 × C11	4.38	4.45	67.10**	45.24**	43.76**
C41 × FP5	8.76**	5.27	59.22**	29.78**	26.66
C41 × C71	11.67**	7.70	38.80**	46.30**	60**
C51 × C11	2.17	1.14	0.43	2.25	23.52
C51 × FP5	1.45	3.24	43.60**	18.51**	17.70
C51 × C71	4.28	2.84	85.12**	55.23**	23.52
C11 × FP5	8.76**	2.03	0	25.76**	18.75
C11 × C71	10.08**	7.28	17.28**	64.84**	56.25**
FP5 × C71	10.95**	2.03	13.46**	69.31**	46.16
CD 5%	2.25	2.1	0.52	2.32	0.13
CD 1%	3.03	2.83	1.10	3.13	0.17

** indicates significant at 1% level of probability.

In case of fruit length, eight cross combinations showed significant negative heterosis. Heterosis for this trait ranged from -36.36% to 6.70%. The only positive heterosis was found in cross combination C51 × C11 (6.70%). In case of fruit width, the cross combination C51 × FP5 and C51 × C71 showed significant positive heterosis (4.02%) and 1 cross combinations out of 10 cross combinations showed significant negative heterosis. Heterobeltosis for this trait ranged from -26.10% to 5.31%. Heterobeltosis for total soluble

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solids revealed that only one cross combinations (C41 × FP5) out of 10 cross combinations showed significant negative heterosis. Heterosis for this trait ranged from -35.78% to 8.70%. The highest negative heterosis (-35.78%) was found in cross combination C41 × FP5 and the two cross combinations positive better parent heterosis for TSS was observed in two crosses. It was C11 × FP5 (8.7%) and FP5 × C71 (2.01%). Heterobeltosis for locules per fruit, the estimated heterosis over better parent revealed that 3 cross combinations out of 10 crosses showed significant negative heterosis. Heterosis for this trait ranged from -33.33% to 16.67%. The highest negative heterosis (- 33.33%) was found in cross combination C41 × FP5 and C41 × C71. Heterobeltosis for pericarp thickness of fruit, the estimates of heterosis over better parent revealed that 3 cross combinations out of 10 crosses showed significant positive heterosis. Heterosis for this trait ranged from 13.33% to 60%. The highest positive heterosis (60%) was found in cross combination C41 × C71 followed by C11 × C71 (56.25%).

Table 3. Percent heterosis over better parent of 10 tomato cross combinations for fruit characteristics

Hybrids	Fruit length	Fruit width	TSS (%)	Locule fruit^{-1}	Fruit yield plant^{-1}
C41 × C51	-17.65**	-2.52	0.79	-33.32	183.33**
C41 × C11	-16.34**	5.31	-1.25	-22.23*	141.30**
C41 × FP5	-25.69**	-17.07	-35.78**	-33.33*	203.22**
C41 × C71	-17.64**	-1.64	0*	-33.33*	97.06**
C51 × C11	6.70**	-4.018*	2.03	16.67	32.61**
C51 × FP5	-4.54	4.018*	-0.61	8.32	119.44**
C51 × C71	-21.27**	4.018*	2.01	-8.32	155.55**
C11 × FP5	-6.14*	-26.10*	8.7**	-22.23	28.26**
C11 × C71	-21.27**	-26.10**	1.41	-22.23	93.48**
FP5 × C71	-36.36**	-24.39**	2.01*	-11.10	100**
CD 5%	0.23	0.17	0.27	0.99	0.007
CD 1%	0.311	0.225	0.36	1.33	0.101

** indicates significant at 1% level of probability, * indicates significant at 5% level of probability

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Considering above results in discussion, the hybrid combinations, C41 × FP5, C41 × C51 and then for further evolution alas with available heat tolerant variety to recommend form level production.

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