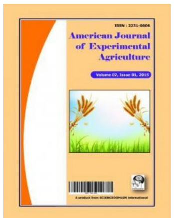

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Studies on Heterosis for Summer Season Tomato Production

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Authors' contributions

This work was carried out in collaboration between all authors. Author AB designed the study, collected the data, interpreted and wrote the first draft of the manuscript. Author MSI supervised the experiment, performed the statistical analysis and corrected the manuscript. Authors AAS and SD managed the analyses of the study and reviewed the experimental design. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out with a view to estimating heterosis for yield and its attributes under high temperature conditions at the experimental field of Horticulture, Department of Agriculture, Sylhet Agricultural University, Bangladesh during hot summer season (May to August) of 2013. In this study ten tomato hybrids developed from half diallel crossing fashion among five parental lines of tomato in winter season of 2012- 2013 (October 2012 to February 2013). These ten tomato hybrids along with five parental lines were evaluated under RCB design with three replications to estimate better parent heterosis for ten characters. Significant better parent heterosis was found for all characters except days to first harvest. The maximum better parent heterosis for number of fruits per plant was observed for the cross combination of C51 × C71 (85.12%) followed by C41 × C11 (67.10%). The highest heterosis for individual fruit weight was recorded (69.31%) from FP5 × C71 indicating this combination is important for improvement of individual fruit weight of heat tolerant

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tomato. The highest positive significant heterosis for pericarp thickness was found for the cross combination of C41 × C71 (60%) followed by C11 × C71 (46.25%). Positive and significant heterosis for TSS (%) was estimated from the cross C11 × FP5 (8.7%). All the cross combinations showed positive and significant heterobeltiotic effect for fruit yield per plant of which C41 × FP5 exhibited the highest heterosis (203.22%) closely followed by C41 × C51 (183.33%). Therefore, this two cross combinations can be taken for further evaluation under high temperature condition for recommending summer season cultivation in Bangladesh.

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

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* L.) is one of the most popular and nutritious vegetable crops all over the world including Bangladesh [1]. This crop is mostly grown during winter season in Bangladesh due to presence congenial atmospheric conditions. Due to its palatability, vitamin content and processing characteristics its demand remains high throughout the year. Supply of tomato in winter is very high while very scanty during summer. Price of tomato also very high at summer season as production is very limited in Bangladesh. Production of tomato during hot summer season in Bangladesh is very difficult due to high temperature, high rainfall and high humidity [1]. To improve tomato production during summer, Bangladesh Agricultural Research Institute (BARI) has developed some heat tolerant tomato hybrids which are getting popularity among the growers [2]. However, yield of the varieties is not up to the mark due to flower and fruit dropping tendency at high temperature condition. To improve yield of tomato during summer, special thrust to be given to develop new high heat tolerant variety. Heterosis or hybrid vigor is an important biological phenomenon referring to the manifested superiority of the F_1 hybrid resulting from the cross of genetically dissimilar parents. Now a days heterosis breeding is one of the most efficient tool to exploit heterosis for several traits including abiotic stresses [3]. Hence, attempt can be made to exploit heterosis for better yield and quality of tomato for hot summer condition in Bangladesh. Therefore, the present investigation was undertaken to determine heterotic effect of newly develop ten tomato hybrids along with their five parental lines for yield and yield attributes under hot summer condition in Bangladesh.

2. MATERIALS AND METHODS

2.1 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 noth-east of capital city Dhaka. The study area was located on latitude 24°54´ to 33°67˝ N and longitude 91°54´ to 95° 88˝ E. The soil of experimental site belongs to the AEZ 20: Eaturan Surma Kushiyara Floodplain. Soil was brown hill in texture and acidic in nature (pH 4.83). The climate of the experimental site was subtropical characterized by heavy rainfall during May to October and scanty during rest of year. The mean monthly rainfall, air temperature and humidity are presented in Table 1.

2.2 Experimental Material and Design

Seeds of ten tomato hybrid combinations (F_1) along with their five involving parents were used in this study. Seeds of ten hybrids were produced through crossing among five tomato parental lines in half diallel crossing fashion in winter season of 2012-2013 under close supervision of Horticulture Department of Sylhet Agricultural University, Bangladesh. This study was conducted in RCB design with three replications. Seeds of 15 tomato genotypes (10 hybrids and 5 parental lines) were sown in well prepared seed bed on 15 May 2013. Soon after germination of seeds, partial shade was given with black net. The seedbed was also covered with a fine white net (60 mesh) to protect seedlings from insect attack. Eight day old seedling was transplanted in polybag for hardening of seedlings. Twenty five day old seedlings were transplanted in the main field. The land was well prepared by ploughing thrice. The land was fertilized with 15 tons of well decomposed cow dung, 300 kg urea, 200 kg Triple super phosphate (TSP) and 150 kg Muriate of potash (MoP). Half of the quantity of cowdung and the entire amount of TSP were applied during land preparation. The remaining cowdung and half of MoP were applied 5 day before planting. The whole urea and half of MoP were applied in three equal splits as top dressing at 15, 30 and 50 day after transplanting. The unit plot size was 2.3 m × 4.8 m which was again divided into two sub beds and the bed was almost 15 cm in height with a view to prevent the

Table 1. Mean monthly maximum and minimum temperature, rainfall and humidity during the cropping period

Month	Temperature		Rainfall (cm)	Humidity (%)
	Maximum (℃)	Minimum (℃)		
May	30.4	22.7	34.2	78
June	33.9	25.8	26.9	75
July	33.3	25.8	18.9	78
August	32.6	25.6	17.8	80
September	32.8	25.3	14.0	78
October	31.5	23.1	29.6	74

Source: Regional Meterological Office, Sylhet -3100

Fig. 1. Pictorial view of the experimental field

crop from moist condition during heavy rail. Plants were spaced at 60 cm × 40 cm between row to row and plant to plant, respectively accommodating 12 plants per row and 24 plants per sub bed. Seedlings were transplanted at after noon and light irrigation was given for better establishment of the seedlings. To protect the crop from heavy rain, a low cost poly-tunnel cover was provided over the crop during entire cropping period (Fig. 1 above). The height of the poly-tunnel at the middle of the bed was 6.0 feet while it was 4.5 feet at both sides. The structure of poly-tunnel was made of bamboo where transparent polythene used over the structure. Staking was provided to keep the plant erect. Weeding, irrigation, pruning, mulching and other intercultural operations were done as and when necessary. Data on 10 different yield and yield contributing characters were recorded from each replication of all genotypes. Complied data were subjected for statistical analysis to determine analysis of variance (ANOVA) and 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 heterobeltiosis.

3. RESULTS AND DISCUSSION

Analysis of variance for ten different yield and yield contributing characters of the 15 evaluating tomato genotypes (10 F_1's and 5 parental lines) are presented in Table 2. Analysis of variance indicated that there were existed significant variations among the genotypes for all the studied characters. Of course this variation would be useful indicator to plant breeder to select suitable one for better yield and quality. Evaluated of eight tomato hybrids and their involving parents during hot summer and found significant variation among hybrids and parents for fruit yield and yield attributes [4]. Similar significant variations also found among 12 newly developed tomato hybrids for different yield and yield contributing characters when studied during summer season [5].

Estimated heterosis for different characters on yield and yield attributes are presented in Table 3. The estimated better parent heterosis revealed that all the parameters exhibited significant and positive better parent heterosis except days to harvest. Though earliness for flowering and harvesting in tomato are useful parameters for early harvest, but in this study we did not found any negative and significant heterosis for these traits for any cross combinations. However, the only cross combination C41 × C51 exhibited negative heterosis for days to harvest (-3.03%) but not significant. Negative heterosis found for days to flower and days to harvest while working with tomato [6] and negative heterosis found for days to first flower and days to first harvest in summer tomato [7]. Eight out of ten tomato hybrids showed positive and significant better parent heterosis for number of fruits per plant. The cross combination C51 × C71 exhibited the maximum heterosis (85.12%) for number of fruits per plant followed by C41 × C11 (67.10%). Therefore these two cross combination can be considered for improvement of number of fruits per plant in heat tolerant tomato. Similar heterobeltiotic effect for number of fruit per plants was also found when worked with heat tolerant hybrids [7]. Nine cross combinations out of ten exhibited significant positive heterotic value for individual fruit weight over better parent. Heterosis for this trait ranged from 2.25% to 69.31%. The highest positive heterosis in this trait was found in cross combination FP5 × C71 (69.31%) closely followed by C11 × C71 (64.84%). The entire cross combinations exhibited positive heterosis for pericarp thickness and ranged from 13.3% to 56.25%. The highest positive and significant heterosis (60 %) was found for pericarp thickness in cross combination of C41 × C71 followed by C11 × C71 (56.25%) indicating improvement on fruit quality like pericarp thickness is possible with a significant manner through heterosis breeding and these two cross combinations are suitable for improving pericarp thickness of tomato.

Most of the cross combinations exhibited negative better parent heterosis (Table 4) for fruit length except C51 × C11 (6.70%). Similar trend was also observed for fruit width. This result is partial coincides with researcher who found negative heterosis for some cross combinations for fruit length and fruit diameter of tomato [7]. For Total Soluble Solid (TSS%), only two cross combinations C11 × FP5 (8.7%) and FP5 × C71 (2.01%) showed

Table 2. Analysis of variance for ten hybrids and five parents on different yield contributing characters of tomato

Source of variation	DF	Days to first flower	Days to first harvest	No. of fruits plant^{-1}	Individual fruit weight (g)	Pericarp thickness (mm)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Locule fruit^{-1}
Replication	2	0.62	5.49	15.96	9.21	0.01	0.04	0.04	0.04	0.02
Genotypes (Parents & F_1's)	14	11.93**	10.16**	122.97**	207.60**	0.06**	0.91**	1.02**	0.72**	2.07**
Error	28	1.81	1.58	0.24	1.93	0.01	0.02	0.01	0.03	0.36

Table 3. Percent heterosis over better parent of 10 cross combinations for different characters of tomato

Hybrids	Days to first flower	Days to first 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*

Table 4. Percent heterosis over better parent of 10 cross combinations for different characters of tomato

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*

significant positive heterosis. All the cross combinations exhibited significant and positive heterosis for fruit yield per plant and it was ranged from 28.26% to 203.22%. The hybrid C41 × FP5 produced the highest positive heterosis (203.22%) followed by C41 × C51 (183.33%) while the hybrid C11 × FP5 (28.26%) exhibited the lowest heterosis. Some researchers reported heterobeltosis for fruit yield per plant under high temperature growing condition [8,9]. Better parent heterosis was 13.58 % to 282.63% among 28 tomato hybrids when grown in hot summer season in Bangladesh [7]. It was reported that higher yield in the maximum cross combinations while studying heterosis in tomato [10].

4. CONCLUSION

Based upon the above results and discussion, an appreciable heterosis towards desirable direction was manifested by all the characters studied. Since the cross combinations C41 × FP5 (203.22%) and C41 × C51 (183.33%) exhibited the highest heterosis for fruit yield per plant and can be taken for yield comparison with existing heat tolerant tomato varieties for recommending commercial utilization.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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