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Assessment of Performance on Yield and Yield Contributing Attributes of Summer Tomato Genotypes in Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author SM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors MMR and MSI managed the analyses of the study. Authors JH and MSR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Twenty three tomato genotypes were evaluated during summer season of 2011 to characterize and evaluate the yield performance under high temperature conditions. Days to first flowering ranged from 41.00 to 51.33 days among the studied genotypes. The highest number of fruits per plant (45.27) was recorded from the genotype FP5 × WP10 followed by C41 ×TLB182 (30.90) while it was the lowest (2.27) for the genotype TLB182. The genotype C41 × VRT004 had the highest fruit weight (80.81 g) closely followed by C51 × VRT004 (79.75 g). The genotype FP5 × WP10 yielded the highest amount of fruits per plant (1.90 kg) followed by C71 × VRT004 (1.61 kg). The corresponding yield (t/ha) was also the highest (64.6 t/ha) for FP5 ×WP10 followed by C71 ×VRT004 (54.74 t/ha).

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1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the family Solanaceae having the chromosome number of 2n = 24. It is a self-fertilized annual crop. They contain lycopene, one of the most powerful natural antioxidants [1]. The total production of tomato in Bangladesh was about 387.65 thousand tons from 28.21 thousands hectares of land with an average yield of 13.74 t ha^{-1} in 2018-19 [2] which is very low as compared to the other tomato producing countries. In India, tomato occupies an area of 5.213 lakh ha with production of 90.64 lakh tons and productivity of 17.387 t/ha [3]. The causes of low yield of tomato in Bangladesh is particularly due to several major factors viz., lack of good variety, limited availability of good quality seeds of improved varieties, absence of hybrid variety, pest and disease infestation. Tomato is grown in winter months of Bangladesh as the temperature is congenial at that period of time 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 far from the requirements especially in summer season. Although tomato plants can grow under a wide range of climatic conditions, they are extremely sensitive to hot and wet growing conditions, the weather which prevails in the summer rainy seasons of Bangladesh [4]. Fruit setting in tomato is reportedly interrupted at temperature above $26/20^0$C day/night, respectively and is often completely arrested above $38/27^0$C day/night [5]. The optimum fruit growth and development in tomato occur when night temperature is between 15 and 20^0C and the day temperature at about 25^0C [6].Tomato can be grown during rainy summer in Bangladesh using heat tolerant tomato hybrids under polytunnel production system [7].

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 [8]. Bangladesh Agricultural Research Institute (BARI) has developed two summer tomato hybrids, which are grown during summer-rainy season under polytunnel with appreciable yield [7]. The organization has also developed many new hybrids [9]. Hence, the experiment was undertaken to evaluate the growth, fruit setting and yield potential of developed tomato genotypes in summer season.

2. MATERIALS AND METHODS

The experiment was conducted at the experimental field of Olericulture Division of Horticulture Research Centre (HRC), BARI, Gazipur, Bangladesh during October 2010 to September 2011. Fifteen genotypes of tomato were used as plant materials along with 8 parental lines and all these materials were collected from Olericulture Division of HRC, BARI for the present study where these 15 genotypes were developed under line × Tester mating design from 8 parental lines. The experiment was laid out in Randomized Complete Block Design (RCBD) with 3 replications. The unit plot size was 2.3 m ×4.8 m having 2 row per bed and 12 plants per row and 24 plants per plot. Seeds of 15 cross combinations of tomato and 8 parental lines were sown in raise seed bed on May 5, 2011. Twenty five day old seedlings were transplanted in the experimental field in the field under transparent polyethylene shed tunnel on May 30, 2011. Data was recorded on plant height, days to first and 50% flowering, flowers per cluster, fruit length and width, locules per fruit, total soluble solids, fruits per plant, fruit weight, fruit yield per plant and yield per hectare. The collected data were analyzed with the help of MSTAT-C software program for analysis of variance and mean separation was completed using DMRT.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

All the studied genotypes of tomato were significantly different according to plant height (Table 1). The range of plant height varied from 71.33 cm to 165.00 cm. The cross combination C41 X VRT004 was the tallest (165.00 cm) which was significantly different from all the other genotypes. The cross combination C41 X VRT004 was taller than both of its parents C41 (99.67 cm) and VRT004 (91.67 cm). The genotype FP5 was the shortest (71.33 cm) which was also significantly different from all other genotypes. Phookan et al. [10] when studied with 29 tomato genotypes grown in summer under plastic house condition reported plant height range of 46.00 cm to 95.00 cm. The plant height

of the studied genotypes was higher than the reported result. These differences might be due to difference in the cultivars as well as in the growing environment used in the present study.

Table 1. Mean performance on plant characteristic of 8 parental lines and 15 cross combinations of tomato

Plant characteristic	
Genotypes	**Plant height (cm)**
Parental lines	
C11	102.00h-k
C41	99.67i-k
C51	86.67k
C71	107.30g-j
FP5	71.33l
VRT004	91.67jk
TLB182	93.00i-k
WP10	109.00f-i
Cross combinations	
C11 X VRT004	129.70b-e
C11 X TLB182	136.00b-d
C11 X WP10	143.30bc
C41 X VRT004	165.00a
C41 X TLB182	130.00b-e
C41 X WP10	124.00d-f
C51 X VRT004	134.70b-d
C51 X TLB182	145.30b
C51 X WP10	128.30c-e
C71 X VRT004	127.30c-e
C71 X TLB182	117.30e-h
C71 X WP10	128.00c-e
FP5 X VRT004	141.00bc
FP5 X TLB182	101.70h-k
FP5 X WP10	122.30d-g
F-test	**
CV (%)	5.59

*(Means bearing the same letter(s) do not differ at 1% level of probability); ** Significant at 1% level of probability*

3.2 Days to First Flowering

Days to 1st flowering was significantly varied among the 23 tomato genotypes (Table 2). It ranged from 41 days to 51.33 days. The earliest flowering (41.0 days) was observed in the cross combinations C41 X WP10 and FP5 X WP10. Parental line VRT004 took the highest number of days (51.33 days) for first flowering which was statistically different from the rest of the genotypes. Ahmed [11] observed that some tomato varieties bloomed within 57- 67 days after seed sowing. Variation was observed between the reported and present findings. This variation might be due to the difference of genetic make-up of lines used in the present study.

3.3 Days to 50% Flowering

Days to 50% flowering showed significant variation among the genotypes (Table 2). It ranged from 45 days to 52.67 days. The minimum period (45.0 days) for 50% flowering was observed in the cross combination FP5 X WP10 which was earlier than it's both parents FP5 (47.33 days) and WP10 (51.67 days). Parental line TLB182 and cross combination C71 X VRT004 took maximum days (52.67 days) for 50% flowering. Alam et al. [12] reported that, days to 50% flowering range from 45 to 48 days when studied with 8 hybrid lines of tomato for summer season. The findings of the present study also support this result.

3.4 Fruit Length (cm)

Significant difference was found in fruit length among the tomato genotypes (Table 3). Fruit length of different genotypes ranged from 3.63 cm to 5.72 cm. From this observation it was found that the parental line C71 had the highest fruit length (5.72 cm). The lowest fruit length (3.63 cm) was recorded from the genotypes C51 X WP10 and C41. Ahmed [4] conducted an experiment of 49 genotypes of tomato in summer season; he found that fruit length of tomato ranges from 1.94 cm to 5.46 cm. Reported result is within the range of present result regarding the fruit length of tomato.

3.5 Fruit Width (cm)

Fruit width was significantly different among the tomato genotypes (Table 3). Fruit width of different genotypes ranged from 3.65 cm to 6.43 cm. It was the highest for the genotype WP10 (6.43 cm) which was followed by the genotype C51 X VRT004 (5.66 cm). The lowest fruit width was recorded from the parental line C41 (3.65 cm) which was statistically similar to the parent C71 (3.67 cm) and C11 (3.71 cm). Patwary [13] reported that the fruit width of tomato varied from 4.08 cm to 4.14 cm during summer season. Reported result is within the range of present result regarding the fruit width of tomato.

3.6 Locules Per Fruit

The tomato genotypes showed variation in case of locules per fruit (Table 3). Locule number of different genotypes ranged from 2.19 to 5.33. The cross combination C51 X VRT004 produced the maximum (5.33) locules per fruit which was higher than both of its parents C51 (4.80) and

VRT004 (4.50). The cross combination C11 X TLB182 produced the lowest (2.19) locules per fruit which is followed by parental line FP5 (2.23). Rahman et al. [14] mentioned that the locule number of tomato ranged from 4.40 to 11.70. The present result is different than the reported result. It might be due to the difference of genetic make-up of lines used in the present study.

3.7 Total Soluble Solids (TSS)

The 23 genotypes of tomato showed variation in case of total soluble solids (Table 3). The variation of TSS (%) among the genotypes ranged from 3.17% to 5.05%. The highest TSS (5.05%) was recorded in the cross combination C41 X VRT004 which was higher than both of its parents C41 (4.74%) and VRT004 (4.20%). The parental line TLB182 produced the lowest TSS (%) which was 3.17%. Patwary [13] reported that the TSS (%) ranged from 3.39 to 4.77% during summer season in tomato. The reported result is within the range of the present result.

3.8 Number of Fruits Per Plant

The result revealed that there was a wide variation in fruits per plant among the 23 tomato genotypes (Table 4). Fruits per plant of different genotypes ranged from 2.27 to 45.27. It was found that the cross combination FP5 X WP10 had maximum fruits per plant (45.27) which was higher than both of its parents FP5 (32.07) and WP10 (7.60) which implies that FP5 X WP10 is more heat tolerant among the genotypes. The parental line TLB182 produced the minimum fruits per plant (2.27), which is perhaps an indication of lesser heat tolerance which was statistically similar to the parent VRT004 (3.50). Phookan et al. [10] conducted an experiment to evaluate 29 genotypes of tomato in relation to 8 different growth and yield attributing parameters under plastic house condition during summer season and found that fruit number ranging from 2.67 to 70.00. Ahmed [11] reported that the fruits per plant of tomato ranged from 17.80 to 179.59. Roy [15] mentioned the number of fruits per plant

Table 2. Mean performance on floral characteristics of 8 parental lines and 15 cross combinations of tomato

	Floral characteristics		
Genotypes	**Days to first flowering**	**Days to 50% flowering**	**Flowers per cluster**
Parental lines			
C11	42.67c-e	46.33b-d	6.00
C41	43.67b-e	47.67a-d	5.33
C51	42.00de	48.33a-d	6.00
C71	46.00bc	50.67a-d	6.33
FP5	43.33b-e	47.33a-d	5.67
VRT004	51.33a	51.00a-c	4.00
TLB182	45.33b-d	52.67a	5.67
WP10	45.33b-d	51.67ab	4.67
Cross combinations			
C11 X VRT004	43.67b-e	49.00a-d	5.60
C11 X TLB182	44.67b-e	50.33a-d	6.17
C11 X WP10	41.67de	46.67b-d	7.13
C41 X VRT004	45.33b-d	50.67a-d	5.27
C41 X TLB182	42.67c-e	48.33a-d	5.93
C41 X WP10	41.00e	45.33cd	6.73
C51 X VRT004	42.67c-e	47.67a-d	5.27
C51 X TLB182	41.67de	46.67b-d	5.47
C51 X WP10	42.33c-e	45.67 cd	5.73
C71 X VRT004	46.67b	52.67a	5.53
C71 X TLB182	43.00b-e	47.67a-d	5.53
C71 X WP10	42.33c-e	47.00a-d	6.67
FP5 X VRT004	43.67b-e	49.00a-d	6.13
FP5 X TLB182	42.33c-e	47.00a-d	6.87
FP5 X WP10	41.00e	45.00d	7.27
F-test	**	**	NS
CV (%)	3.39	4.59	18.09

*(Means bearing the same letter(s) do not differ at 1% level of probability); ** Significant at 1% level of probability*

Table 3. Fruit characteristics of 8 parental lines and 15 cross combinations of tomato

Genotypes	Fruit characteristics			
Parental lines	**Fruit length (cm)**	**Fruit width (cm)**	**Locules per fruit**	**TSS (%)**
C11	3.91gh	3.71e	2.50e-g	4.24a-e
C41	3.63h	3.65e	2.57e-g	4.74a-c
C51	3.83gh	4.74b-e	4.80a-c	4.81a-c
C71	5.72a	3.67e	2.83d-g	4.97ab
FP5	4.20f-h	3.82de	2.23g	3.77c-e
VRT004	4.32e-g	4.35b-e	4.50a-c	4.20a-e
TLB182	4.75c-f	4.33c-e	3.37c-g	3.17e
WP10	4.18f-h	6.43a	4.77a-c	4.27a-e
Cross combinations				
C11 X VRT004	5.31a-c	5.05b-d	4.92ab	4.73a-c
C11 X TLB182	4.97b-d	3.99c-e	2.19g	4.06a-e
C11 X WP10	4.89c-e	4.89b-e	3.78b-f	4.08a-e
C41 X VRT004	5.30a-c	4.97b-e	3.67b-g	5.05a
C41 X TLB182	4.85c-e	4.46b-e	2.33fg	3.56de
C41 X WP10	4.33e-g	4.70b-e	3.80b-f	4.13a-e
C51 X VRT004	4.64d-f	5.66ab	5.33a	4.24a-e
C51 X TLB182	4.21f-h	4.90b-e	4.00a-e	3.88b-e
C51 X WP10	3.63h	4.75b-e	4.16a-d	4.35a-d
C71 X VRT004	5.53ab	4.12c-e	3.55b-g	4.93ab
C71 X TLB182	5.49ab	4.43b-e	2.66d-g	4.33a-d
C71 X WP10	5.09b-d	4.53b-e	3.55b-g	3.97a-e
FP5 X VRT004	5.05b-d	4.92b-e	3.44b-g	4.58a-d
FP5 X TLB182	4.97b-d	4.24c-e	2.67d-g	4.05a-e
FP5 X WP10	4.98b-d	5.21bc	3.44b-g	4.24a-e
F-test	**	**	**	**
CV (%)	5.45	11.29	17.17	10.20

*(Means bearing the same letter(s) do not differ at 1% level of probability); ** Significant at 1% level of probability*

of tomato ranged from 35 to 76.39. Variation was observed between the reported and present findings regarding the fruits per plant of tomato. This difference might be due to the difference in the genotypes as well as in the growing environment used in the present study.

3.9 Fruit Weight (g)

There was a great variation in fruit weight among the 23 tomato genotypes (Table 4). Fruit weight of different genotypes ranged from 24.97 g to 80.81 g. The highest fruit weight was recorded in the cross combination C41 X VRT004 (80.81 g) which was statistically identical to cross combination C51 X VRT004 (79.75g). The lowest fruit weight was (24.97 g) obtained from the parental line C41 which is followed by parental lines FP5 (25.04 g) and C11 (27.63 g). Ahmed [4] found the range of individual fruit weight varied from 5.25 g to 43.38 g among 23 heat tolerant tomato genotypes. Roy [15] mentioned that the individual fruit weight of tomato ranged from 32.87 g to 46.35 g. The present result is different than the reported results regarding the fruit weight of tomato. It might be due to the difference of genetic make-up of lines used in the present study.

3.10 Fruit Yield Per Plant (kg)

Significant variation was observed among 23 genotypes in respect of fruit yield per plant (Table 4). Fruit yield per plant of different genotypes ranged from 0.10 kg to 1.90 kg. From the present observation it was found that the cross combination FP5 X WP10 yielded the highest amount of fruit (1.90 kg/plant) which was statistically identical to C71 X VRT004 (1.61 kg/plant). The cross combination FP5 X WP10 yielded higher amount of fruit than both of its parents FP5 (0.80 kg/plant) and WP10 (0.40 kg/plant). The genotype TLB182 yielded the minimum (0.10 kg/plant). Baki [16] conducted an experiment on heat tolerant tomato under high temperature conditions (39°C day/28°C night) and reported that yield of tomato varied depending on the level of heat tolerance of the hybrids. Findings of Sumaia (2012) also support

the results of this trial. Phookan et al. [10] conducted an experiment under plastic house condition in summer season with 29 genotypes of tomato. He reported that, yield per plant ranges from 0.21 kg to 1.60 kg. The present finding of the experiment confirms the result of the previous report.

3.11 Fruit Yield (t/ha)

Fruit yield (t/ha) of 23 genotypes of tomato ranged from 3.4 t/ha to 64.6 t/ha (Fig. 1). From the present study it was found that the cross combination FP5 X WP10 yielded the highest (64.6 t/ha) followed by C71 X VRT004 (54.74 t/ha). On the other hand the lowest yield (3.4 t/ha) was obtained from the genotype TLB182.

Lower fruit yield under high temperature is mainly due to limiting carbohydrate supply [17]. Deljit et al. [18] mentioned that the fruit yield of tomato was ranged from 27.41 t/ha to 84.47 t/ha. Roy [15] mentioned that fruit yield of tomato varied from 52.02 to 99.85 t/ha. Variation was observed between the reported and present findings. These variations in fruit yield might happen due to the inherent genetic make-up of the variety used in the present study.

From the above discussion it may be concluded that, 23 genotypes (8 parents and 15 cross combinations) of tomato have shown wide range of variability among them for yield and its component characters. The cross combinations FP5 X WP10, C71 X VRT004, C41 X VRT004, C41 X TLB182, C71 X WP10, C51 X WP10 performed better as they had fairly high fruit yield per plant under the hot summer condition in Bangladesh. Yield potentiality of these genotypes during summer clearly indicated that these genotypes could be grown during summer.

Table 4. Mean performance on yield component characteristics of 8 parental lines and 15 cross combinations of tomato

Yield component characteristics			
Genotypes	**Fruits per plant**	**Fruit weight (g)**	**Fruit yield per plant (kg)**
Parental lines			
C11	17.80h	27.63k	0.57hi
C41	22.53ef	24.97k	0.37ij
C51	7.03ij	40.07ij	0.26ij
C71	7.13ij	33.15jk	0.24ij
FP5	32.07b	25.04k	0.80gh
VRT004	3.50jk	52.93d-i	0.19j
TLB182	2.27k	43.17h-j	0.10j
WP10	7.60i	52.87d-i	0.40ij
Cross combinations			
C11 X VRT004	15.60h	67.15bc	1.05d-g
C11 X TLB182	16.80h	50.08e-i	0.84gh
C11 X WP10	24.07de	55.64c-h	1.36b-d
C41 X VRT004	18.27gh	80.81a	1.48bc
C41 X TLB182	30.90bc	47.67f-i	1.45bc
C41 X WP10	22.63ef	57.63c-g	0.81gh
C51 X VRT004	18.87f-h	79.75a	0.99e-g
C51 X TLB182	24.13e	53.95c-h	1.28b-e
C51 X WP10	27.87cd	51.96e-i	1.42bc
C71 X VRT004	22.00e-g	71.87ab	1.61ab
C71 X TLB182	18.60f-h	66.04b-d	1.23c-f
C71 X WP10	23.80e	59.53b-f	1.43bc
FP5 X VRT004	22.07e-g	61.96b-e	0.93fg
FP5 X TLB182	30.67bc	45.15g-j	1.37b-d
FP5 X WP10	45.27a	44.17g-j	1.90a
F-test	**	**	**
CV (%)	8.36	10.33	15.00

*(Means bearing the same letter(s) do not differ at 1% level of probability); ** Significant at 1% level of probability*

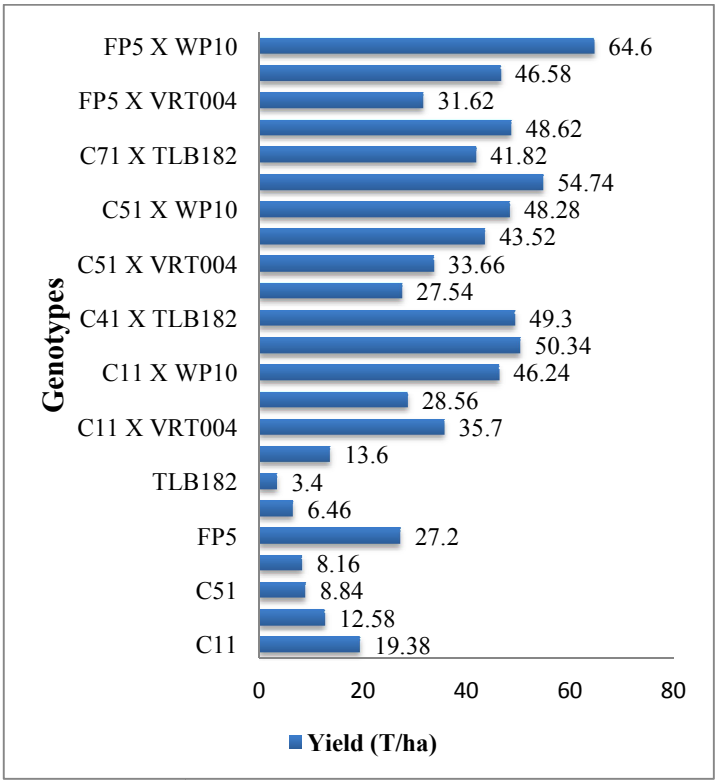

Fig. 1. Fruit yield (t/ha) of 23 genotypes of tomato grown during summer season

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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