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PERFORMANCE OF HEAT TOLERANT TOMATO HYBRID LINES UNDER HOT, HUMID CONDITIONS

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Abstract

Eight hybrid tomato lines bred for heat tolerance by the Olericulture Division, BARI were studied to observe their fruit setting ability and yield performance under the hot, humid conditions at the Olericulture Farm of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur during summer 2005. Percent fruit set in the lines was found to be within the range of 30 to 45 except C-7 (3×7) in which this was 52.85. The tallest plants having larger number of branches and the lowest flower drop were also observed in C-7 (3×7). Pollen viability ranged from 27.63 to 61.52 percent among the hybrids. The highest weight of individual fruits (56.02 g) and firmness (1.41 kg) was observed in C-5 (2×5). The largest fruit in respect of length and diameter was produced by C-8 (5x5). No significant variation was found among the lines in respect of days to 50% flowering and percent TSS. Significant difference wa observed for fruit number per plant ranging from 27 to 51. All of the lines produced remarkably high yields and C-7 (3x7) gave the highest yield per plant (1.73 kg) as well as per hectare (41.5 tons). The highest gross return (1867500 Tk/ha) and the maximum net return (1486748 Tk/ha) having the highest BCR (3.90) were recorded in C-7 (3×7).

Keywords: Heat tolerant, tomato hybrid, hot, humid.

Introduction

The inability of most tomato *(Lycopersicon esculentum)* cultivars to set fruit under high night and day temperatures has been a limiting factor for tomato production in the tropical and the subtropical areas of the world. Although tomato plants can be grown under a wide range of climatic conditions, they are extremely sensitive to hot and wet conditions, the type of weather that prevails in the summer season of Bangladesh (Ahmad, 2002). Fruit setting in tomato is reportedly interrupted at temperature above 26/20°C day/night, respectively, and is often completely arrested above 38/27°C day/night. (Steven and Rudich, 1978; El Ahmadi and Stevens, 1979a; Kuo *et al.*, 1979). But limited efforts have been made so far to overcome the high temperature barrier which prevents fruit set in

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summer rainy season. Presently high price of tomato in summer created a great demand among the farmers for summer variety.

Very 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). Differences existed among the cultivars in their ability to transmit their fruit setting ability under high temperatures to their immediate hybrid progenies. Hybrid progenies appeared to have better cosistency of performance, especially under adverse growing conditions (Yordamov, 1983). Hybrid bred for heat tolerance might have better performance over any open pollinated varieties/lines but should be evaluated under particular situation i.e., hot, humid conditions as the heat tolerant genes are easily influenced by environment (Villereal and Lai, 1979). Hence, the experiment was undertaken to evaluate the growth, fruit setting and yield potential of BARI developed hybrid lines in summer season.

Materials and Method

Eight heat tolerant tomato hybrid lines C-1 (l×1), C-2 (1×3), C-3 (2×1), C-4 (2×3), C-5 (2×5), C-6 (3×3), C-7 (3×7), and C-8 (5×5) were grown in the summer of 2005 in a sandy clay loam soil at the Olericulture farm of the Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Seeds of each line were sown in seed bed and were allowed to grow for about 25 days before field transplanting during last week of May 2005 under transparent poly tunnels. The poly tunnels were 2.3 meter wide having two 1.0 meter wide bed with 30 cm drain in between, which served as irrigation channel. A randomized complete block design was followed with 12 plants in each treatment of 3 replications. Each plot was 1.0 m wide and 3.0 m long. Plants within each plot were spaced 60cm × 40cm apart and were pruned and staked. Soil was fertilized with 10 tons cowdiing, 450 kg urea, 250 kg TSP, and 150 kg MP per hectare. Half of the cowdung and entire quantity of TSP were applied during the final land preparation. The remaining cowdung and one third of MP were applied in pits. Top dressing was done in three equal installments at 10, 25, and 40 days after transplanting to apply the entire urea and the reaming-two-thirds of MP. Six flower clusters of each five randomly selected plants were tagged to determine number of flowers per cluster, flower drop, and fruit set. Pollen grains were collected from 10 freshly anthesised flowers of each line. Collected pollen grains were prepared and stained (Bodo, 1991) and percentage of normal pollen was calculated. The number of fnaits per plant was counted from the fruits harvested at different dates of five randomly selected plants. Ten ripe fruits were randomly harvested from each time to measure length, breadth, firmness, and weight and the seeds were removed and counted. Firmness was determined by digital firmness tester; model PENFEEL, DFT-14, AGRO TECHNOLOGY. Climatic

conditions during the test period are presented in Table 1. Collected data were analyzed statistically and treatment means were compared by Duncun Multiple Range Test (DMRT).

Table 1. Weather conditions during the experiment.

	May	June	July	August
Air temperature (^{0}C)				
Av. max.	33.17	33.60	31.74	32.33
Av. mn.	23.60	26.77	26.15	26.73
Relative air humidity (%)				
Max.	84.00	84.00	86.33	88.00
Mn.	77.35	76.72	81.24	82.58
Average monthly rainfall (nun)	137	90	214	159

Results and Discussion

Plant height of eight hybrid lines of tomato under field conditions at final harvest showed significant differences (Table 2). It ranged from 115.9 cm to 139.5 cm. The line C-7 (3×7) had the tallest plants (139.5 cm) and C-8 (5×5) the shortest (115.9 cm). Phookan *et al.* (1990) reported variations among the hybrids in plant height when tomato was grown in summer under plastic house condition. The number of branches per plant differed significantly among the lines of tomato at final harvest (Table 2) and it varied from 4.3 to 6.7 per plant. The line C-7 (3×7) showed the highest (6.7) number of branches per plant, which was significantly different from the others. The lowest (4.3) branching was observed in C-l (1×1). Phookan *et al* (1990) reported similar results. There was no significant difference among the hybrids in respect of days to 50% flowering which varied from 45 to 48 days (Table 2). Marked variation was observed among the lines in case of number of flowers per cluster (Table 2). The maximum (7.5) flowers per cluster was produced by C-7 (3×7) and the minimum (5.7) by the C-4 (2×3). Percent viable pollen grain varied significantly among the lines (Table 2). The highest (61.52%) number of viable pollen grains was produced by C-5 (2×5), the second highest (56.88%) by C-7 (3×7). The lowest (27.63%) number was produced by C-2 (l×3). This result indicated that some of the lines have the capability to produce high percentage of viable pollen grains as per carmino acetic acid viability test which gives an apparent indication of pollen viability. Bodo (1991) reported that the production of viable pollen decreased with the increase of day temperature. Flower drop due to high temperature varied from 16.4 to 36.7% among the

lines (Table 3), which is significantly distinct. The maximum (36.7%) and the minimum (16.4%) flowers were observed in C-5 (2×3) and C-7 (3×7), respectively. Smith (1982) reported a big increase in blossom drop resulting from hot and dry wind and low humidity.

Table 2. Growth and flowering characters of summer tomato hybrid lines.

Treatments	Plant height (cm)	No. of branches /plant	Days to 50% flowering	No. of flowers/ cluster	Pollen viability (%)	Flower drop (%)
C- 1 (1×1)	122.3 cd	4.3 c	48	7.1 ab	34.35 cd	23.6 c
C-2 (1×3)	128.7 bc	5.4b	46	5.8 b	27.63 d	27.5bc
C- 3 (2×1)	127.7 be	4.6 c	45	5.8 b	36.31 bc	28.2 bc
C-4 (2×3)	129.2bc	4.8c	47	5.7b	42.33b	32.4ab
C-5 (2×5)	119.5d	5.5b	47	6.3ab	61.52a	36.7a
C-6 (3×3)	133.1 ab	4.8c	46	5.8b	34.94cd	30.5b
C-7 (3×7)	139.5a	6.7a	48	7.5a	56.88a	16.4d
C-8 (5×5)	115.9d	4.6c	45	6.3ab	33.62cd	28.Sbc
CV(%)	2.29	3.80	3.27	8.22	6.94	7.82
Level of significance	**	**	NS	**	**	**

Means in a column followed by the same letters or without latter's are not significantly different at 5% level by DMRT

*, Significant at 5% level; NS = Non-significant

Significant variation was found in individual fruit weight among the lines as shown in Table 3. The highest (56.02 g) average individual fruit weight was observed in C-5 (2×5) and the lowest (33.97g) in C-7 (3×7). Ahmad (2002) also found the range of individual fruit weight to be from 5.25 g to 43.38 g among 25 heat tolerant hybrids which supports the findings of the present study. Fruit size of the eight tomato lines was remarkably dissimilar (Table 3). The longest (4.72 cm) fruits were produced by C-8 (5×5) and the shortest (3.72 cm) by C-7 (3×7). The diameter of the fruit showed the same trend. It is revealed from these results that C-7 (3×7) produced smaller fruits than the others. Dane *et al.* (1991) stated that small fruited abundantly flowering genotypes were less affected by heat stress than larger fruited cultivars, which supports the results of this experiment. Firmness of tomato at full ripening stage was significantly identical among the lines. The line C-5 (2×5) showed the highest (1.41 kg) firmness of fruits and C-1 (1×l) gave the lowest (1.12 kg). TSS of the genotypes varied from 3.7% to 4.39% and the variation was insignificant. The number of seeds per fruit is an indicator of sensitivity of the ovules to heat. The significantly highest (67.7) number of fruits was counted in line C-7 (3×7) which implies that C-7 (3×7) is more heat tolerant among the lines. The lowest (21.7) number of seeds was counted in C-4

(2×3), which is perhaps and indication of lesser heat tolerance. Diversity was observed among the lines in respect of percent fruit set which significantly varied from 32.96 to 52.85 (Table 4). The highest percents of fruits (52.85%) was set by C-7 (3×7) and the lowest (32.96%) by C-4 (2×3). In an experiment, Baki and Stomuel (1993) found that fruit set in the heat tolerant hybrids of tomato ranged from 1.9 to 46.97% which supports the results of the present study. Significant difference was observed for fruit number per plant among the lines (Table 4). The number of fruits per plant varied from 27.00 to 51.00. The highest (51.00) number of fruits per plant was produced by the line C-7 (3×7), which was statistically different from the others. The lowest (27.00) number of fruits per plant was obtained from C-4 (2×3), C-5 (2×5), and C-6 (3×3). Phookan *et al.* (1990) conducted an experiment to evaluate 29 hybrids of tomato on the basis of eight different growth and yield attributing parameters under plastic house condition during the summer season and found fruit number ranging from 2.67 to

Table 3. Fruit characteristics of summer tomato lines.

Treatments	Individual fruit wt (g)	Fruit length (cm)	Fruit dia (cm)	Firmness (kg)	TSS (%)	No. of seeds/fruit
C- 1 (1×1)	47.88 be	4.06 abc	4.l4ab	1.12c	3.72	27.6de
C-2 (1×3)	51.91 ab	4.10 abc	4.09b	1.l6bc	3.96	39.2c
C-3 (2×1)	36.01 d	4.18 abc	4.11 ab	1.23 bc	4.02	30.3 d
C-4 (2×3)	44.97 c	4.00 bc	4.33 ab	1.22 bc	4.39	21.7 e
C-5 (2×5)	56.02 a	4.61 ab	4.52 ab	1.41 a	3.83	50.8 b
C-6 (3×3)	52.24 ab	4.03 bc	4.67 a	1.29 abc	3.83	43.8 c
C-7 (3×7)	33.97 d	3.72 c	3.26 c	1.17 be	3.71	67.7 a
C-8 (5×5)	39.09 d	4.72 a	4.68 a	1.32 ab	3.84	38.5 c
Level of significance	**	**	**	**	NS	**
CV(%)	4.64	6.00	5.00	4.80	6.77	7.20

Means in a colunm followed by the same letter(s) or without latter(s) are not sgniflcantly different at 1% level by DMRT

*, Significant at 5% level; NS = Non-significant

70.00, which are in good agreement with the result of the present study. The results also have similarity to the findings of Ahmad (2002). The difference regarding the parameter, days to first harvest was significant among the eight lines. The largest number of (99.7) days was required to harvest the first fruit in the line C-4 (2×3) and earliest the (89.3 days) harvest was done in the line C-1 (l×1). There was a significant difference and by the lines in fruit yield per plant which ranged from 1.20 kg to 1.73 kg (Table 4). The highest (1.73 g) fruit yield was obtained in the line C-7 (3×7) and the lowest (1.20 g) in 0-4 (2×3). Baki (1991) 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 Ahmad (2002) also support the results of this trial. Wider variation was found on yield (t/ha) among the hybrids and it varied from 28.8 to 41.5 t/ha. The lines C-7 (2×3) is the highest (41.5 t/ha) yielder and C-4 (2×3) the lowest (28.8 t/ha). The

Table 4. Yield and yield contributing characters of summer tomato hybrid lines.

Treatments	Fruit set (%)	No. of fruits/plant	Days to 1st harvest	Yield/plant (kg)	Yield (t/ha)
C- 1 (1×1)	40.78 be	33 d	89.3 c	1.59b	38.1 ab
C-2 (1×3)	44.93 b	28 e	93.7 bc	1.43 c	34.3 b
C-3 (2×1)	39.98bc	42b	92.7bc	1.52bc	36.4b
C-4 (2×3)	32.96 d	27 e	99.7 a	1.20 d	28.8 c
C-5 (2×5)	38.67 c	27 e	94.3 abc	1.50 bc	36.1 b
C-6 (3×3)	39.57 c	27 e	95.7 ab	1.42 c	34.2 b
C-7 (3×7)	52.85a	51a	94.3abc	1.73a	41.5a
C-8 (5×5)	37.18 cd	39 c	96.7 ab	1.52 bc	36.9 b
Level of significance	**	**	*	**	**
CV(%)	4.97	3.74	3.19	3.13	4.37

Means in a column followed by the same letter(s) or without letter(s) are not significantly different at 1% & 5% level by DMRT

*, Significant at 5% level; us = Non significant

Table 5. Cost and return analysis of the cultivation of summer tomato hybrid lines.

Treatments	Yield (t/ha)	Gross return	Total cost of production	Net return (Tk./ha)	Benefit cost ratio
C- 1 (1×1)	38.1	1714500	380752	1333748	3.5
C-2 (1×3)	34.3	1543500	380752	1162748	3.1
C-3 (2×1)	36.4	1638000	380752	1257248	3.3
C-4 (2×3)	28.8	1296000	380752	915248	2.4
C-5 (2×5)	36.1	1624500	380752	1243748	3.2
C-6 (3×3)	34.2	1539000	380752	1158248	3.0
C-7 (3×7)	41.5	1867500	380752	1486748	3.9
C-8 (5×5)	36.9	1660500	380752	1279748	3.4

Price of tomato: Tk. 45.00 per kg

remaining lines also produced remarkably high yield under hot, humid conditions. It indicates that the lines have different degrees of potentiality in respect of tolerance to heat. The present results revealed that C-7 (3×7) was superior and may be recommended for multi location trials. Economic return

from the cultivation of the lines is shown in Table 5. Comparative economics revealed that the highest gross return (1867500 Tk./ha) was from the line C-7 (3×7) which gave the maximum net return (1486748 Tk./ha). The highest BCR (3.90) was also obtained in the line. On the basis of economic return, it is apparent that the line C-7 (3×7) was more profitable than the rest.

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