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Evaluation of Tomato Cultivars (*Lycoperiscon Esculentum Mill*) Under High Temperature Conditions

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ABSTRACT. An experiment was carried out to test the ability of tomato cultivars to set fruit under high temperature (32-36°C day) and (20-24°C night). The experiment was carried out in a greenhouse where the temperature is controlled by an evaporative cooling system.

The response of the tomato cultivars to high temperature varied greatly. The Burgess cultivar produced the highest yield and best quality fruit under the high temperature regime. The Saladette cultivar showed good performance and produced satisfactory results in a variety of characteristics such as the ability to set fruit, resistance to splitting, and absence of an exerted style protruding from the anteridial-cone. The S_{6916} variety has excellent ability to set fruit and produce a high flower number. However, the fruits were very small and highly susceptible to splitting. The Michigan-Ohio cultivar seeded more than any other strain or cultivar. $N_{59}F_1$ and Carmello F_1 produced the highest percentage of total soluble solids in the fruit juice.

The results of this research indicate that several cultivars were suitable for use in arid regions, and it will be possible to develop a cultivar with superior qualities which produces high yield under arid conditions.

Introduction

In arid and semi-arid regions of Saudi Arabia, the summer temperature and low humidity limit the production of tomato to the cooler part of the year. To extend the season of production, it is necessary to know the nature of growth, flowering and fruiting of plant in relation to high temperature conditions. This study was focussed

on understanding of the physiological factors limiting yield and quality in the tomato (*Lycopersicon esculentum Mill*) under high temperature conditions.

It has long been known that high temperature in tomato production, usually above 30°C, causes blossom drop and failure of fruit-set (Smith 1932). High temperature fruit set is directly related to adaptability problems in the tomato. High temperature limits or prevents production of tomatoes in many tropical and subtropical regions of the world (Anonymous 1974). Thus, high temperature fruit set capability makes an important contribution to adaptability. Most cultivars with superior high temperature fruit-set capability were developed in regions where it is difficult to produce tomatoes.

There have been extensive studies on the effects of high temperature on fruit production in the tomato. In certain genotypes, flower production is restricted by high temperature (Abdallah and Verkerk 1968, Aung 1976, Charles and Harris 1972, Iwahor and Takahashi 1964, Sugiyama 1966). Flower production decreases with increased temperature up to 27°C, regardless of any heat-tolerance in terms of fruit-set ability (Charles and Harris 1972). High temperatures depress yield in principal production areas because of flower drop. Depending on the genotype and other environmental conditions, such as humidity and soil moisture, temperature more than 30°C can cause blossom drop in most tomato varieties. As little as 4 hours exposure to 40°C causes blossom drop in most varieties (Iwahori and Takahashi 1964).

Several investigations have demonstrated that position of the stigma in the tomato flower can affect fruitfulness. If, for instance, the stigma is sufficiently exerted beyond the mouth of the anther tube as in the ex-mutant (Rick and Robinson 1951), little pollen reaches the stigma, and consequently, few flowers set fruit. Levey (1978) reported that no fruit was set by flowers with the style protruding more than 1 mm out of antheridial cone due to maximum high temperature. Style elongation is a prime factor contributing to low fruit-set at high temperature (Rick and Demsey 1969).

Coyne (1968) found that low moisture conditions were conductive to stigma exertion in some cultivars. Stigma exertion has been considered as an aid to outcrossing under natural conditions (Lesley 1924) or for controlled pollination for hybrid production (Bukovac and Hanma 1967, Currence 1944).

Material and Methods

An evaporative cooled greenhouse was used to test 14 cultivars and lines performance in setting fruit under high temperature regimes. These cultivars and lines were: Burgess, Bonus, Y_{207}, Y_{297}, Michigan-Ohio, Helani, Carmello F_1, $N_{59}F_1$, Sunny, CL_1, CL_3, Saladette, BL 6807, and S_{6916}.

The seeds were planted directly in peat cubes in plastic flats. During the germination and early seedling stages, the plants were held in a naturally lighted, air conditioned greenhouse at 22-25°C day and 18-20°C night and relative humidity 50-60%. Fertilizer rapid growth 20-20-20 was added every 20 days from the time of plant

emergence until the end of the experiment. Seedlings were transplanted into two gallon plastic pots containing soil mixture of peat moss, vermiculite and sand in a 1:1:1 ratio. Drip irrigation system was used in watering plants.

Soil pH was 6.2, light intensity was 430-570 UE/m^{-2}/sec^{-1} with 14 hr photoperiod. Temperature was 32-36°C during the day and 20-24°C at night, and relative humidity 40-65%. A hygrothermograph was used to record temperature and relative humidity.

Data were recorded on each blossom cluster with respect to the number of flowers formed and number of fruit sets. As each fruit became red ripe, the fruit was then removed and weighed. Number of cracked fruit was also recorded. Seeds were extracted from 4 fruits of each plant and counted. Stigma exertion from the antheridial cone of flowers was also recorded in addition to mean weight and pH of fruits, and total soluble solids of juice.

Results and Discussion

The tomato cultivars studied under high temperature (32-36°C) day and (20-24°C) night were varied in their response to such temperature. Significant differences among tomato cultivars were found in number of clusters per plant, flower number, fruit set number and yield (Table 1). Burgess, S_{6916} gave the highest flower number, while Y297, $N_{59}F_1$ and Carmello F_1 had lower number of flower. Similar results were obtained by Abdalla and Verkerk (1968), Aung (1976), Charles and Harris (1972), Iwhari and Takahashi (1964), and Sugiyama (1966). High number of flowers failed to

TABLE 1. Means of cluster number, flower number, fruit number, yield and mean weight of tomatoes grown under high temperature regime (32-36°C day) and (20-24°C night).

Cultivars/lines	Cluster no.	Flower no.	Fruit no.	Yield (g)	Mean weight (g)
	*	*	*	*	*
1. Burgess	1. 7.89 A	1. 33.89 A	14. 28.00 A	1. 2260.22 A	1. 112.23 A
2. Bonus	14. 7.88 A	13. 27.80 B	1. 20.33 B	2. 1081.11 B	2. 93.78 B
3. Michigan-Ohio	10. 7.78 A	10. 25.33 BC	3. 14.20 C	3. 847.22 C	6. 77.82 C
4. Helani	13. 7.50 AB	11. 25.00 BC	10. 14.80 CA	4. 571.00 D	9. 74.57 CD
5. Y207	3. 7.33 ABC	4. 25.00 BC	12. 13.89 C	8. 495.00 DE	4. 68.66 DE
6. Y297	5. 7.22 ABC	14. 24.63 BC	3. 12.89 CD	9. 481.44 DE	8. 68.08 E
7. Sunny	9. 6.78 ABCD	3. 24.33 BC	2. 11.67 DE	7. 419.67 DEF	3. 65.56 E
8. Carmello F_1	8. 6.44 ABCD	12. 24.22 BC	11. 10.11 EF	6. 385.22 EFG	7. 65.00 E
9. $N_{59}F_1$	2. 6.33 ABCD	2. 24.11 BC	4. 8.56 FG	12. 379.44 EFG	5. 41.97 F
10. CL_1	4. 6.00 BCD	5. 22.89 C	5. 8.56 G	5. 355.67 FG	11. 30.03 G
11. CL_3	12. 6.00 BCD	8. 21.56 C	8. 7.33 G	11. 302.56 FG	12. 27.36 G
12. Saladette	11. 5.89 CD	7. 21.33 C	7. 6.56 GH	14. 297.50 FG	13. 19.03 A
13. BL6807	7. 5.44 DE	9. 20.78 CD	9. 6.44 GH	13. 266.50 FG	10. 16.72 H
14. S6916	6. 4.33 E	6. 17.11 D	6. 4.89 H	10. 232.67 G	14. 10.70 I
Mean	6.63	24.17	11.85	598.11	55.18
SE	0.203	1.116	0.688	42.8	2.709
CV	10.30	17.11	18.72	26.41	11.88

Means within the columns followed by the same letter are not significantly different at .05 Duncan's Multiple Range test.

*Cultivar number.

set fruit due to high temperature for all cultivars. However, the tomato cultivars vary greatly in their response to high temperature regimes. S_{6916} and Burgess were the best in fruit set among all cultivars and Y_{297}, $N_{59}F_1$ and Sunny were the least. Similar results were found by Abdalla and Verkerk (1968), and Charles and Harris (1972). Burgess had the highest yield among all other cultivars due to large size of fruits in addition to a high number of fruit set, followed by Bonus and Michigan-Ohio. S_{6916} BL6807 were the least in yield due to the small size of their fruits (Table 1).

Tomato cultivars vary greatly for style elongation under high temperature conditions (Table 2). Style elongation the most profound effects of high temperature due to exertion of the stigma through the mouth of the antheridial cone. When this occurs normal pollination is prevented and consequently, flower drop usually results. These responses were much more pronounced in susceptible cultivars such as S_{6916}, $N_{59}F_1$, and Carmello F_1 and Michigan-Ohio (Table 2) than that in other cultivars. Stigma exertion was found in very few flowers of Burgess and BL_{6807}, and in none of Saladette. Several investigators have shown that genotypes vary for style-elongation under high temperature regime (Coyne 1968, Howlett 1939, Johnson and Hall 1953, and Rick and Demsey 1969). Levy (1978) found that no fruit was set by flowers with the style protruding more than 1 mm out of the antheridial cone due to high maximum temperatures of 36-39°C. It is found in this experiment that about 28% of the flowers with exerted styles dropped.

TABLE 2. Means of style elongation, seed-set number and cracked fruits number, for tomatoes grown under high temperature regime (32-36°C day) and (20-24°C night).

Cultivars/lines	Style elongation (%)	Seed set no.	Cracked fruits no.
1. Burgess	12. 0.0 A	12. 0.0 A	3. 86.89 A
2. Bonus	1. 15.1 B	1. 0.21 A	12. 80.22 AB
3. Michigan-Ohio	13. 15.40 B	8. 0.44 BA	1. 71.33 BC
4. Helani	2. 18.89 CB	9. 0.44 BA	10. 69.67 C
5. Y 207	6. 22.11 CD	2. 0.91 BC	7. 67.22 C
6. Y 297	14. 24.63 CD	6. 1.22 C	14. 65.25 C
7. Sunny	5. 25.56 D	7. 1.22 C	4. 64.89 C
8. Carmello F_1	11. 27.44 DE	4. 1.89 D	5. 52.11 D
9. $N_{59}F_1$	10. 31.78 EF	5. 2.00 D	2. 51.56 D
10. CL_1	7. 33.89 F	11. 2.11 D	11. 45.78 DE
11. CL_3	3. 36.44 FG	10. 2.44 D	9. 41.78 EF
12. Saladette	8. 36.7 FG	13. 3.10 F	13. 41.30 EF
13. BL6807	9. 37.00 FG	3. 3.22 F	8. 37.11 EF
14. S6916	4. 40.56 G	14. 6.75 G	6. 34.56 F
Mean	26.03	1.83	57.64
SE	1.91	0.165	2.184
CV	23.70	25.41	16.09

Means within the columns followed by the same letter are not significantly different at .05 Duncan's Multiple Range test.

Significant differences occurred in seed number due to pollen source and its viability (Dempsey and Boynton 1964). In this study it was found that the tomato cultivars varied greatly in their production of seeds (Table 2). Michigan-Ohio cultivar gave

the highest number of seeds followed by Saladette and Burgess, while Y_{297} cultivar gave the lowest number. The results showed that there was no relation between fruit size and seed set number (Tables 1 and 2). A similar result was obtained by Schaible (1962) which showed small fruits with seeds resulting from high temperature treatments. It appears from the results of this study that there is no relation between number of seed set and size of tomato fruits (Tables 1 and 2).

Fruit cracking in tomato is one serious problem affecting marketable yield. However, tomato cultivars differ greatly in their resistance to cracking. Saladette and Burgess were the best among all cultivars, followed by Carmello F_1 and $N_{59}F_1$, while S_{6916} was the most susceptible to cracking and all other cultivars had little resistance.

pH of fruit juice (pH) and total soluble solids (TSS) of tomato fruits are two important characteristics affecting the processing tomato quality. The content of tomato fruits of different cultivars had no differences in pH and TSS of fruit juice (Table 3).

TABLE 3. Means of pH of fruit juice and total soluble solids in fruit juice for tomatoes grown under high temperature regime (32-36°C day) and (20-24°C night).

Cultivars / lines	pH of fruit juice		T.S.S.	
	"		"	
1. Burgess	5.	4.04 A	9.	6.60 A
2. Bonus	15.	4.10 B	8.	6.59 A
3. Michigan-Ohio	1.	4.13 B	10.	6.57 A
4. Helani	3.	4.19 D	11.	6.46 B
5. Y 207	7.	4.20 D	6.	6.40 C
6. Y 297	8.	4.20 D	14.	6.28 D
7. Sunny	9.	4.20 D	2.	2.27 D
8. Carmello F_1	10.	4.20 D	3.	6.27 D
9. $N_{59}F_1$	12.	4.20 D	1.	6.21 E
10. CL_1	13.	4.20 D	7.	7.20 E
1. CL_3	4.	4.20 D	12.	6.20 E
2. Saladette	2.	4.21 D	13.	6.1 F
13. BL 6807	6.	4.27 E	4.	4.02 G
14. S 6916	11.	4.27 E	5.	5.02 G
Mean		4.19		6.29
SE		0.007		0.014
CV		0.76		0.80

Conclusion

Comprehensive studies of tomato genotypes are needed which vary in their ability to set fruit under high temperature conditions. This study showed that certain genotypes have genetic potential for improving the essential processes of fruit set under high temperature stress. Attempts have also been made to screen parents and progeny under field conditions in Riyadh and western region of Saudi Arabia. These attempts have been less successful because the temperatures are either too high or not high enough during critical periods, in addition to very strong wind sand storms.

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تقييم أصناف محصول الطماطم تحت ظروف الحرارة العالية

صالح حسين بياري

قسم زراعة المناطق الجافة ، كلية الأرصاد والبيئة وزراعة المناطق الجافة ، جامعة الملك عبد العزيز
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المستخلص . تحت ظروف البيوت المحمية المغطاة بالبلاستيك بالتبريد الصحراوي ، تم تقييم مقدرة أصناف الطماطم على الإثمار تحت درجة الحرارة العالية (٣٢-٣٦°م نهارًا) و (٢٠-٢٤°م ليلًا) .

كانت استجابة أصناف الطماطم لدرجة الحرارة العالية متباينة تباينا كبيرا . الصنف بورجس (Burgess) أعطى أعلى وأفضل محصول . بعض أصناف الطماطم أظهرت مقدرة جيدة على الإثمار تحت تأثير الحرارة العالية . والصنف سالديت (Saladette) كانت له مقدرة جيدة على الإثمار ومقدرة ممتازة على مقاومة التشقق . ولم يخرج السداه من فتحة مجموعة مخروط الأسدية (Antheridial-Cone) . والصنف S6916 له مقدرة ممتازة في الإثمار والإزهار ، إلا أن ثمارة تتشقق بسهولة . والصنف متشقن أوهايو (Michi-gan-Ohio) أعطى أكبر عدد من البذور عن الأصناف أو السلالات الأخرى . وكذلك الصنفين كارملوف[1] و N59F1 أعطى أكبر نسبة من المواد الذائبة في عصير الطماطم .

النتائج أظهرت إمكانية تحسين أصناف طماطم ذات مقدرة عالية على الإنتاج بنوعية جيدة .