FLORAL CHARACTERISTICS OF HEAT TOLERANT AND HEAT SENSITIVE TOMATO CULTIVARS AT HIGH TEMPERATURE

D. P. Lohar[1] and W. E. Peat
Department of Biological Sciences, Wye College, Wye, Ashford, Kent, TN25 5AH, U.K.

ABSTRACT

Experiments were carried out to investigate the response of heat sensitive (Pusa Ruby) and heat tolerant (CL-1131) tomato varieties to four different temperature regimes to identify floral characteristics affected by high temperatures. There was an earlier anthesis in variety CL-1131 than in Pusa Ruby at 35/30°C (day/night) regime. Flower bud number in the first four trusses and total flower number at 35/30°C were significantly lower than at normal temperatures (22/17°C) in Pusa Ruby but these were the same in CL-1131. Stigma exsertion at high temperatures (28/23 and 35/30°C) was the same in both varieties. Many floral anomalies such as stigma exsertion without anthesis, empty flowers and persistent flowers without fruit set were also observed at 35/30°C regime. Antheridial cone splitting was not observed. The use of stigma exsertion and antheridial cone splitting as criteria for selecting against fruit set at high temperature may be misleading while selecting for heat tolerance in tomato.

Additional Key Words: ***Lycopersicon esculentum***, **vegetables, anthesis, pollen, stigma**

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is an important vegetable in most regions of the world. Although tomato plants can grow under a wide range of climates, fruit set is interrupted above 26/20°C day/night temperatures (El Ahmadi, 1977). Genetic variation in the ability of tomatoes to produce crops under high temperature conditions (El Ahmadi and Stevens, 1979b) has made selection for heat tolerance possible. Villareal *et al.* (1978) defined heat tolerance in tomato as "the ability to set fruits under night temperatures not lower than 21°C".

In the past, the identification of heat tolerance in tomato has been accomplished by evaluating genotypes for flowering and fruit set because these two processes are sensitive to heat and relate directly to yield (El Ahmadi and Stevens, 1979a; Abdul-Baki, 1991). Flower production, gamete viability, pollen production and dehiscence, floral morphology (style elongation, antheridial cone splitting, etc.) are important. However, a definite association between these floral characteristics and heat tolerance differs between experiments. Some workers have observed reductions at high temperatures (Charles and Harris, 1972), even in cultivars classed as heat tolerant (Abdul-Baki, 1991), while others have reported no effect (Abdalla and Verkerk, 1968) or mixed effects where some cultivars showed reductions but not all (El-Ahmadi and Stevens, 1979a). It suggest that any cultivar likely to be grown under high temperature regimes should be tested for its flowering response. This study was conducted to associate some floral characteristics in tomato varieties with known responses to high temperatures under four different temperature regimes.

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1 Present address: Horticulturist, Horticultural Research Station, Malepatan, Pokhara, Kaski, Nepal

MATERIALS AND METHODS

Two cultivars of tomato, Pusa Ruby and CL-1131 were selected for the study. Pusa Ruby is highly popular and heat sensitive variety during the rainy season in Nepal at Lumle Agricultural Research Centre. Cl-1131 is good for summer and rainy season cultivation because of its tolerance to high temperatures (Abdul-Baki, 1991).

One seedling of each variety was transplanted in each of 16 pots (15 cm diameter and 15 cm depth) filled with standard compost mixture (Irish moss peat- 4 parts, grit- 1 part, and Bio P Base- 9.07 g/litre of Irish moss peat; Pan Britannica Industries Ltd. Britannica House, Waltham Cross, Herts) 26 days after sowing and maintained in growth cabinets at temperatures of 15/10, 22/17, 28/23, and 35/30°C day/night, and 13 h day light. Thus, there were four plants of each variety at each temperature regime as replicates and managed as far as possible so that there were no differences among cabinets except their temperatures.

Days from sowing to the first (in one plant) and complete (in all four plants) flower bud appearance, first anthesis, and complete anthesis were recorded in each cabinet for each variety. Similarly, floral bud and flower production per truss for the first four trusses, number of flowers with exserted stigmas, antheridial cone splitting and other floral anomalies were recorded in all four plants of both varieties in each cabinet. A factorial completely randomized design was followed for data analysis.

RESULTS AND DISCUSSION

Days to the flower bud appearance and anthesis

The first flower bud appearance was the earliest in variety Pusa Ruby at 28/23°C and the last in variety CL-1131 at 15/10°C. Similarly, complete flower bud appearance was earliest at temperatures 22/17°C and 28/23°C in both varieties, and the last at 15/10°C in variety CL-1131 (Table 1). Earlier anthesis in variety CL-1131 at 35/30°C as compared to Pusa Ruby can be considered a good character for heat tolerance which enables CL-1131 to produce an earlier crop. According to Kalloo (1991), meiosis 7 to 8 days before anthesis is highly sensitive to high temperatures. Thus, this earliness can also help escape the problem of high temperature in an area where temperature rises gradually with the onset of summer.

Limited anthesis in variety Pusa Ruby at 35/30°C indicated that this regime is very severe for flowering in this variety. Though 35°C day temperature is not uncommon in many tomato growing sub-tropical areas, it may be the effect of high night temperature (30°C). A heat sensitive cultivar produced only aborted flowers at 38/27°C day/night temperature (El Ahmadi and Stevens, 1979a).

Flower bud and flower production

The effects of temperature, variety and temperature x variety interaction were significant (Fig. 1). It was statistically the same at 22/17°C (31.3) and 15/10°C (27.4), and 35/30°C (22.3) and 28/23°C (20.5). Variety CL-1131 had significantly higher number of flower buds (31.4) than Pusa Ruby.

Table 1. Days to the first and complete flower bud appearance

Temperature (°C, day/night)	Vaariety	Number of days to		
		First flower bud appearance	Complete flower bud appearance	First anthesis
15/10	Pusa Ruby	48	55	62
	CL-1131	52	60	75
22/17	Pusa Ruby	42	46	55
	CL-1131	42	46	58
28/23	Pusa Ruby	39	46	47
	CL-1131	42	46	51
35/30	Pusa Ruby	42	52	72
	CL-1131	44	52	59

Flower bud production in tomato genotypes in response to different temperature regimes has not been reported. However, the estimation of flower buds is essential for calculating the proportion of different floral anomalies including flower bud drop. Non-reduction of flower bud production in CL-1131 at 35/30°C relates to its heat tolerance.

Table 2. Effect of four temperature regimes on the total number of flowers per plant produced 83 days after sowing in tomatoes.

Temperature (°C day/night)	Number of flowers*		
	Pusa Ruby	CL-1131	Mean
15/10	3.89(15.3)b	1.77(3.3)cd	2.83(9.3)
22/17	3.58(13.0)b	5.95(35.3)a	4.76(24.1)
28/23	3.72(13.8)b	6.15(38.3)a	4.94(26.0)
35/30	1.06 (1.0)d	3.15(10.8)bc	2.10 (5.9)
Mean	3.06(10.8)	4.25(21.9)	2.06(16.3)
SED temperature		0.475	
SED variety		0.336	
SED TXV		0.671	
Probability (TXV)		0.000	
CV%		25.95	

* Analysis was performed on the square root of data + 0.5 and figures in parentheses are untransformed means. Any two means having a common letter are not significantly different at 5% level of Duncan's Multiple Range Test (DMRT).

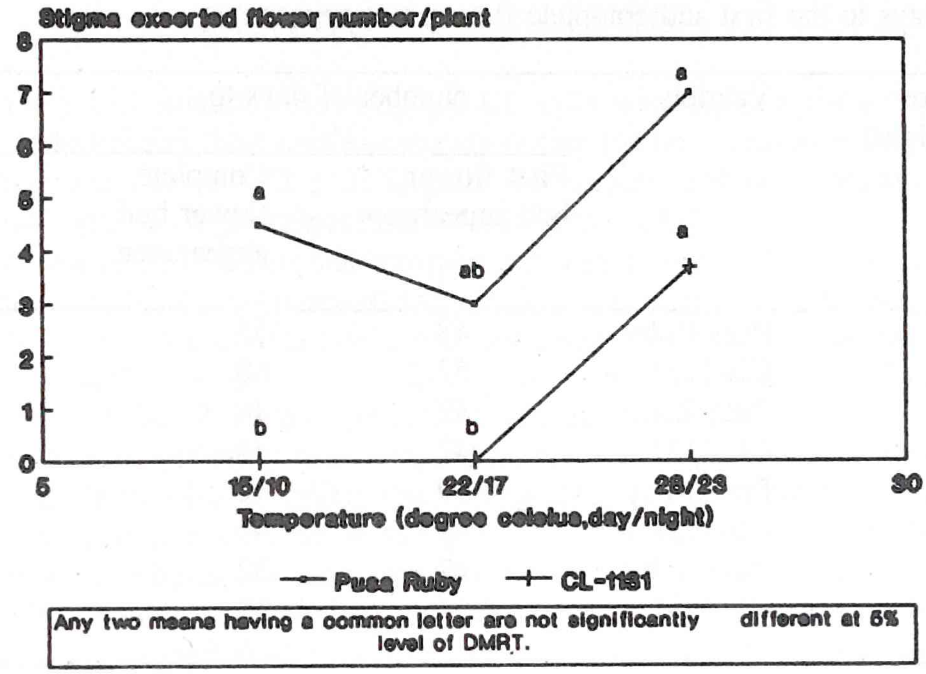

Figure 2 Number of flowers with exserted stigma per plant in different treatment combinations.

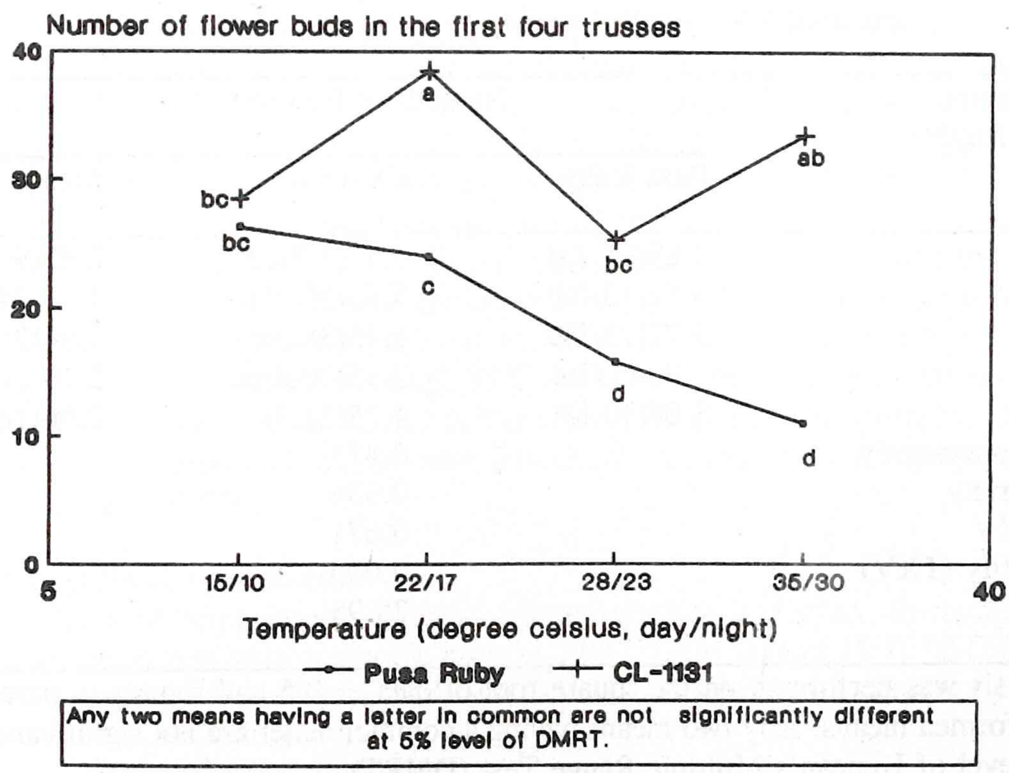

Figure 1 Effect of four temperatures on flower bud production in the first four trusses in tomatoes

The poor agreement between total flower bud production and total flower production in the experiment was a result of temperature effects. at 15/10°C, CL-1131 was very late to produce flower buds and therefore produced only few flowers 83 days after sowing. Similarly, at 35/30°C, very small number of flowers in Pusa Ruby were result of empty flowers.

There was no flowering (anthesis) in 1 plant of CL-1131 at 15/10°C and in 3 plants of Pusa Ruby at 35/30°C out of 4 plants. The SED values of temperature, variety and temperature x variety were 0.475, 0.336 and 0.671, respectively. This indicates the effects were highly significant (Table 2).

Stigma exsertion and other floral anomalies

There were significant effect of temprature (P=0.022) and variety (P=0.003) on this attribute (Fig. 2). Since there was anthesis in only one plant of Pusa Ruby at 35/30°C, this temperature regime was excluded from the statistical analysis. However, stigma exsertion was found in all flowers at this temperature regime irrespective of variety. among the remaining three temperature regimes, stigma exsertion at 28/23°C was significantly greater than at 22/17°C and 15/10°C (LSD = 2.75, SED on 18df = 1.31, CV = 86.65%). There was no statistical difference between 22/17°C and 15/10°C. There was a very large plant to plant variation within a treatment in this attribute as evident from extremely large coefficient of variation (86.65%).

At 35/30°C temperatures, there was stigma exsertion even without anthesis irrespective of variety. At 35/30°C, most of the flower buds, particularly in variety Pusa Ruby, had only a calyx and no petals, androecium or gynoecium. Similarly, most of the flowers at this temperature in variety CL-1131 contained only underdeveloped inner whorls restricted within the calyx. Such flowers were persistent with no abscission. Antheridial cone splitting was not found as a floral abnormality in this experiment.

Stigma exsertion in CL-1131 at high temperature indicates that this variety has a weakness in this character. However, El Ahmadi and Stevens (1979a) found stigma exsertion not to be a barrier to pollination at high temperature. Thus, this experiment also supports their view that selection for heat tolerance based on stigma exsertion can overlook valuable germplasm. Interestingly, a high stigma exsertion even at 15/10 and 22/17°C regime in Pusa Ruby and not in CL-1131 indicated that this character may be an inherent character of some genotypes.

The loss of flowers prior to their opening has been described as flower abortion by Atherton and Harris (1986). Here, flower abortion was observed only in cultivar Pusa Ruby at 28/23 and 35/30°C regime. Though Abdalla and Verkerk (1968) reported persistent flowers which failed to produce fruits, the persistent calyx and underdeveloped flowers as found in this study have not been reported in the literature. This situation may arise because of the failure of abscission layer formation in the pedicel (Kalloo, 1991). Empty flowers in Pusa Ruby and not in CL-1131 prove that the latter has heat tolerance.

Antheridial cone splitting has been reported to be a cause for the failure of self-pollination and fruit set by Levy *et al.* (1978). The lack of anther cone splitting in this experiment may be because of varietal dependence of this character or some other factors not studied in this experiment.

Thus, total flower bud and flower production, particularly in the first four trusses, may be a reliable criterion for heat tolerance selection. Stigma exsertion as a criterion for screening for heat tolerance is not recommended. Other floral anomalies observed in this experiment may be associated with the response of a particular variety to high temperature.

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