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Identification of heat tolerant lines of tomato under West Bengal condition

S.H. ANSARY[1] AND P. HAZRA

[1]Hooghly Krishi Vigyan Kendra, Bidhan Chandra Krishi Viswavidyalaya
Department of Vegetable crops, Bidhan Chandra Krishi Viswavidyalaya
Mohanpur-741252,Nadia, West Bengal

ABSTRACT

Three consecutive field evaluations to screen 38 tomato genotypes for tolerance to high temperature stress under spring-summer season (February to May) in 27.3º to 42.3ºC range of day temperature and 13.8º to 22.9ºC night temperature, the average day/night temperature being 34.5º/19.2ºC revealed abnormal hastening in flowering (34%), marked reduction in number of truss/plant (35%), number of flowers/truss (25%), fruit set/truss (53%) and fruits/plant (71%) compared to that recorded in autumn-winter season under optimal temperature condition. Of the 16 genotypes that set fruits in high temperature stress three lines viz.,CLN 2413R, CLN 2116B and COML CR-7 emerged as heat tolerant genotypes considering pollen viability, pollen germinability, fruit set, fruit yield/plant.

Key words: Evaluation , genotype and tolerance,

The evidence of global warming has increased the interest in the cause of yield declines at temperatures only slightly above optimal in many crops like, rice (Baker and Allen, 1993), groundnut (Vara Prasad *et al*, 1999), cowpea (Craufurd *et al*, 1998), tomato (Peet *et al*, 1998), etc. Tomatoes are grown widely in tropical and sub-tropical regions where they often experience high temperatures during fruit set. It has been well documented that heat stress can occur at mean daily temperatures of 28-29ºC, which are just a few degrees above the optimum temperature range of 21-24ºC. Such moderately elevated temperature stress may not disrupt biochemical reactions fundamental for normal cell functioning since the temperatures are still in the range that a tomato plant would grow normally. However, reduced fruit set is the common response to such elevated temperatures mainly due to reduced pollen germination and release and disturbed microsporogenesis (Sato *et al*, 2002). The present investigation aims at screening of tomato genotypes for high temperature tolerance under field condition and studying the genetic control for important floral and fruit set traits under high temperature stress to frame a strategy for breeding tomato tolerant to high temperature stress.

MATERIALS AND METHODS

Concerted research works for breeding tomato for resistant to high temperature stress was carried out in the Department of Vegetable crops, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. Three consecutive field level screenings of 38 tomato genotypes were carried out in randomized block design with three replications at Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya situated at 22º57'N latitude and 88º20'E longitude with average altitude of 9.75 m above the mean sea level in autumn-winter season (October to February) under optimal temperature condition in 22.5º to 31.9ºC range of day temperature and 8.4º to 22.4ºC range of night temperature, the average day/ night being 27.6º/15.1ºC and spring-summer season (February to May) under heat stress in 27.3º to 42.3ºC range of day temperature and 13.8º to 22.9ºC night temperature, the average day/night temperature being 34.5º/19.2ºC. Five plants per replication were selected at random for recording observations on days to first flowering (C1), flower trusses/plant (C2) , flowers/truss (C3), fruits/plant (C7) and fruit yield/plant in kg (C9). Five opened flowers per plant have been sampled periodically on the day of anthesis to record observations on length of style in mm (C6), pollen viability percentage through acetocarmin stainability (C4) and *in vitro* pollen germination percentage (C5).

RESULTS AND DISCUSSION

In this tropical humid region of India day and night temperatures are not independent of the field condition. Hence, in the present investigation direct selection was followed through growing the tomato genotypes in summer for screening genotypes for fruit-set at high temperature condition. In the present investigation under autumn-winter season (October to February), the plants grew under optimal daily mean temperature of 21.3ºC (average day temperature 27.3ºC/ average night temperature 15.1ºC) showing satisfactory manifestations of both vegetative, reproductive, fruit characters. In spring-summer season, the plants were exposed to the daily mean temperature of 26.8ºC (average day temperature 34.3ºC/average night temperature 19.2ºC), which was higher than the optimal daily temperature. As expected, heat stress occurred in the tomato genotypes grown under spring-summer condition, which facilitated selection of heat tolerant tomato genotypes.

Email:samshaque@rediffmail.com

The reproductive processes appeared to be much more sensitive to temperature stress than vegetative growth. Abnormal hastening in flowering (34%) and marked reduction in number of trusses/plant (35%), number of flowers/truss (25%), fruit set/truss (53%) and fruits/plant (71%) calculated from the average performance of the 38 genotypes in spring-summer season compared to those of optimal autumn-winter season clearly indicated involvement of disturbed carbohydrate supply and carbohydrate transport pathway, especially in specific organs and /or at specific development stages, reduced allocation of assimilates under high temperature stress, compare with normal temperature condition and reduced supply of photosynthates and poor production of growth regulators in sink tissues . The major cause of fruit set reduction was due primarily to pollen germinability, flower drop/fruit set problems as revealed from the correlation study (Table 2). So a strategy based on combining genes for fruit set components should succeed in this condition as advocated earlier by different workers (El-Ahmadi and Stevens, 1979, Stevens and Rudich, 1978; Hanson *et al.*, 2002).

All the flower and fruit characters have been adversely affected due to chronic high temperature stress as revealed in the present investigation which clearly indicated specific physiological processes of flower development were especially sensitive to chronic high temperature stress and limit fruit set (Table 1). Style elongation leading to protrusion of stigma over the antheridial cone under high temperature stress causing drastic reduction of fruit as recorded by many research workers did not find support from the results of the present investigation. Rather, pollen viability and germinability emerged as the major limiting factors for fruit set under chronic high temperature stress (Table 2).

In the present investigation, 22 genotypes (pollens of all of them did not germinate *in vitro* and 13 of which did not set fruits) could be regarded as heat susceptible genotypes. Altogether 16 genotypes set fruits in high temperature condition showing on an average of 70% reduction in yield compared to that recorded in autumn-winter condition under optimal temperature condition. Considering pollen viability, pollen germinability, fruit set and fruit yield/plant three lines (CLN 2413R, CLN 2116B and COML CR-7) emerged as heat tolerant genotypes.

The physiological causes of fruit set reduction in heat tolerant lines must be understood to improve heat tolerance and to address those constraints though breeding. The upper limit of heat tolerance in the heat tolerant lines should be fully characterized before using them in the combination breeding programmes.

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Table 1. Mean of the characters in three heat tolerant and two heat susceptible lines in two distinct seasons over three evaluations

Season	Characters				
	C1	**C2**	**C3**	**C4**	**C5**
HT(A-W)	41.87	44.11	6.03	93.2	76.17
HT (S-S)	29.23	29.73	5.12	51.67	24.02
HS (A-W)	49.56	36.21	5.35	85.51	64.14
HS (S-S)	35.22	23.73	3.71	29.59	0.00
Season	**Characters**				
	C6	**C7**	**C8**	**C9**	
HT(A-W)	7.22	46.45	49.72	1.95	
HT (S-S)	7.49	20.02	22.33	0.54	
HS (A-W)	7.25	34.61	59.16	1.91	
HS (S-S)	7.96	0.00	0.00	0.00	

HT: Average of 3 heat tolerant lines, HS: Average of two heat susceptible lines
A-W: Autumn-winter season, S-S: Spring-summer season C1- days to first flowering,
C2- flower trusses/plant, C3 - flowers/truss, fruits/plant, C4- pollen viability (%)
C5- in *vitro* pollen germination (%), C6- length of style (mm), C7- fruits/ plant,
C8- fruit weight (g), and C9- fruit yield/plant (kg)

Table 2. Prominent correlations among the characters of 38 genotypes under high temperature condition

Character pairs[1]	**Correlation coefficient (r)**
Flower trusses/plant and style length	-0.452*
Flower trusses/plant and fruits/plant	0.475*
Flowers /truss and fruit-set/truss	0.712**
Flowers/truss and pollen viability	0.447*
Fruit-set/truss and pollen viability	0.559**
Fruit-set/truss and pollen germination	0.454*
Fruit-set/truss and fruits/plant	0.424*
Pollen viability and pollen germination	0.610**
Pollen viability and fruits/plant	0.413*
Pollen germination and fruits/plant	0.541**
Fruits/plant and fruit weight	-0.543**
Fruit weight and yield/plant	0.645**

** Significant at 1% level; * significant at 5% level. [1] Average data over three evaluations used