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SS Solankey
Department of Horticulture (Vegetables & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Shirin Akhtar
Department of Horticulture (Vegetables & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Pallavi Neha
[1)] Department of Horticulture (Vegetables & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India
[2)] Department of Division of Post-Harvest Technology and Agricultural Engineering, Indian Institute of Horticultural Research, Hessaraghatta, Bangalore, Karnataka, India

Meenakshi Kumari
[1]Department of Horticulture (Vegetables & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India
[3)] Department of Vegetable Science, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, Uttar Pradesh, India

Radheshyam Kherwa
Department of Horticulture (Vegetables & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Correspondence
SS Solankey
Department of Horticulture (Vegetables & Floriculture), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

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Screening and identification of heat tolerant tomato genotypes for Bihar

SS Solankey, Shirin Akhtar, Pallavi Neha, Meenakshi Kumari and Radheshyam Kherwa

Abstract
Tomato (*Solanum lycopersicum* L.) is one of the most important fruit vegetable crop in most regions of the world. Though, tomato is basically warm season crop, it often experiences high temperature stress during fruit-set when grown beyond its optimal temperature range of 21-24°C. Moderately elevated temperature stress (28-29°C) may not disrupt biochemical reactions fundamental for normal cell functioning since the temperature are still in the range that a tomato plant would grow normally. Lack of tolerance to high temperature in most tomato cultivars presents a major limitation for tomato growers. Increase in optimal temperature up to 2 to 4°C adversely affects gamete development and inhibits ability of pollinated flowers to develop into seeded fruits, resulting in reduced yield. High temperature stress adversely affects the vegetative as well as reproductive stages of tomato and ultimately reduces yield and quality of the fruits. In this respect a total of 200 cultivated and wild tomato genotypes were collected from various institutes and screened out during the summer season under open field condition for their heat tolerance. The findings indicate that under heat stress Selection-18 is the most promising genotypes for fruit yield followed by Cheku Grande, EC-620444, CLN-1621-L and EC-620519. Moreover, the wild species *Solanum peruvianum* performed best for number of fruits per plant followed by EC-528372, EC-538455, *S. pimpinellifolium,* Rio Grande and CLN-1621-L.The genotype IIHR-2754 contains highest TSS (6.73%) followed by EC-109764, Arka Samrat, Selection-18 and EC-529080. The correlation studies indicate that days to first flowering, days to 50% flowering, days to first fruit set, fruit setting (%) and number of fruits per plant were found as the major yield contributing characters under heat stress. These better performing genotypes can be a better donor for future hybrid breeding programme of tomato for heat tolerance.

Keywords: Heat stress, tomato, genotypes, morphological traits, biochemical traits

Introduction
Temperature is a wide spread abiotic agent, which severely limits the plant growth and development of all kind of vegetation, but vegetables are more sensitive to this stress. High ambient temperature has adverse effects on plant vegetative and reproductive development and reduces crop yield (Xu *et al*., 2017) [12]. Tomato (*Solanum lycopersicum* L.) is an important vegetable crop in most regions of the world. The optimal daily mean temperature for tomato fruit set under standard field conditions is between 21 to 24^{0}C (Geisenberg and Stewart 1986) [4], but the cultivation of this crop in subtropical regions inevitably results in plants being exposed to higher day and night temperatures for successive days or even weeks during the reproductive growth phase, which can greatly hamper fruit set (Sato *et al*. 2006) [7]. Lack of tolerance to high temperature in most tomato cultivars presents a major limitation for tomato growers. Increase in optimal temperature up to 2 to 4°C adversely affects gamete development and inhibits ability of pollinated flowers to develop into seeded fruit of tomato and eventually affecting yield (Solankey *et al*., 2017) [10]. In general, most of the cultivated tomato genotypes showed stigma exertion or tip burn under high temperature condition. Fruit number and fruit weight were the important yield components, which were severely affected under high temperature stress and ultimately yield was markedly reduced. Yield potential of the genotypes also depends upon fruit set and fruit weight that severely reduced under high temperature stress (Singh *et al*., 2015) [8]. However, there are many factors responsible for fruit setting

process which are needed to be explored under high temperature stress. Comparative performances of the genotypes under normal and high temperature conditions are also needed for better understanding of the reaction of individual component factor of pollen viability, fruit setting and yield attributing parameters aiming to select suitable heat tolerant genotypes. To develop cultivars for hot summer, screening and identification of genotypes which are capable of setting fruits under heat stress is greatly needed. Therefore, considering the present need, the study was under taken to screen the genotypes in respect of different quantitative and qualitative traits under high temperature condition for identification of superior heat tolerant genotypes, as genetic sources for incorporation in a breeding program of tomatoes to be grown during summer season under high temperature condition.

Materials and Methods

The experimental materials used in the study was comprised 200 tomato genotypes including two wild species (*S. peruvianum* and *S. pimpinellifolium*) and four check varieties (Arka Vikas, Arka Meghali, Kashi Vishesh, Pusa Rohini) collected from various research institutes of India were screened in Augmented Block Design (ABD) comprising 5 blocks and 5 replications. Seedlings were raised in portrays filled with potting mixture. The transplanting of 26 days old seedlings of each genotype were done in the 3rd week of March in open field at the spacing of 60 cm x 50 cm during summer season, 2013-14 at Vegetable Research Area, Bihar Agricultural University, Sabour for their heat tolerance.

Sabour is located at a longitude of 87º 2‟ 42” E, latitude of 25º 15‟ 40” N and an altitude of 45.57 m above mean sea level in the heart of the Indo-Gangetic plains of Eastern India. This location is under subtropical region and is slightly semi-arid, characterized by dry summer and moderate rainfall. The soil of the experimental area was sandy loam in texture having good fertility with 6.7 pH. The data of each genotype were taken as per DUS guidelines of tomato from the middle 5 plants leaving plants on either ends of the row to avoid the border effects.

The measurements of different morphological parameters *viz.*, days to first flowering, days to 50% flowering, days to first fruit set, fruit setting (%), plant height (cm), number of fruits/ plant, fruit yield/ plant (g), average fruit weight (g), number of branch/ plant, pericarp thickness (mm), number of locules/ fruit, fruit length (cm), fruit diameter (cm) and biochemical parameters *viz.*, total soluble solids (TSS) content (%) were taken during the month of April when average temperature was as high as 38.9^{0}C (Fig. 1) however the optimum temperature for growth and yield in tomato is 21-24^{0}C (Table 1). Pooled data from 5 samples were utilized for statistical analysis. Simple linear correlation coefficient was measured for different characters for detecting the intensity and direction of association among the characters. The TSS content of fruit (%) was analysed by the help of digital Refractometer. Tomato juice was collected from red ripe fruits. A drop of juice was placed over the prism of digital Refractometer and value was noted in per cent.

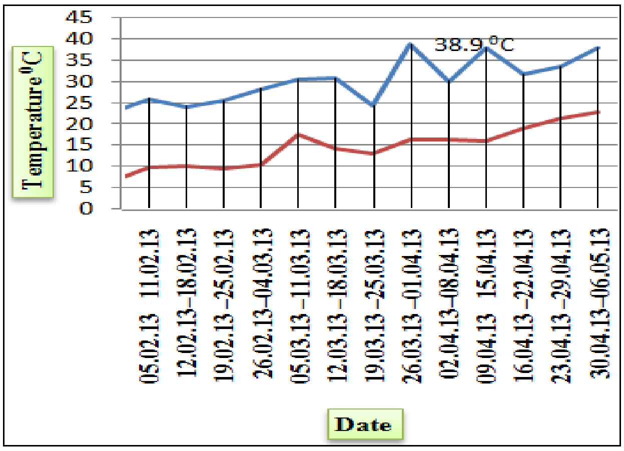

Fig 1: Temperature (^{0}C) during the crop growing season (Summer Season, 2013)

Table 1: The effect of temperature on flowering, pollination, fruit set and colour development in tomato.

Temperature (°C)	Effect on flowering, pollination, fruit set and colour development
Below 10°C	Fruits are unable to develop red colour
10°C - 20°C	Optimum for good colour development
Below 18°C day and 12°C night	Chilling injury and low fruit setting
21°C	Optimum for pollination
25°C day and 18°C night	Best for flowering and fruit setting
Above 30°C	Red colour start to disappear and fruits become yellowish red colour
Above 32°C day and 22°C night	Affect fruit set adversely
Above 40°C	Lycopene is completely destroyed

Source: Major parts adapted from Fageria *et al.* (2003).

Results and Discussion

Out of 200 tomato genotypes many were not produced the fruits therefore, identification of promising genotypes as per their fruit yield was important and depicted in Table 2. The genotypes *viz.*, Selection-18, Cheku Grande, EC-620444, CLN-1621-L, EC-109764, Arka Samrat, EC-620519, Rio Grande, EC-677070, EC-529080, Azad T-2, Azad T-6, EC-362948, DNT-1, B-10-2, H-28-78-3, B-9-2, EC-620377, IIHR-2754, IIHR-2618, IIHR-2619, EC-538439, IIHR-2275, IIHR-2754, EC-528372, EC-538455, *S. peruvianum*, *S. pimpinellifolium* and check variety Arka Vikas were performed outstandingly against heat stress (>35^{0}C) in field condition.

The findings (Table 2) indicate that the tomato genotype Azad T-6, EC-538439 and EC-625644 expressed the earliest days to first flowering (59 days) as well as the genotype EC-538439 also expressed the earliest days to 50% flowering (66 days). Moreover, for days to first fruit set the genotype EC-625644 showed the earliest days to first fruit set (70 days) however, among checks the variety Arka Meghali was the earliest i.e. 77 days. Wani *et al.*, (2015) [11] reported that some early tomato cultivars developed for cool environments have heat tolerance during fruit set. It is also reported that most of the morphological and physiological strictures were obviously reduced under heat stress condition.

Heat stress not only affects the yield even the vegetative growth of the plant also suffers and in the present investigation the highest plant height was observed in the genotype EC- 677070 (114.33 cm) while the number of branches per plant was highest in the genotype B-10-2 (12.60). Fruit setting (%) is very much useful criteria for heat tolerance and among promising genotypes EC-538455 has the highest fruit setting (%) i.e. 87.96 %. Among promising genotypes highest number of fruits per plant was observed in EC-538455 (28.30) followed by Rio Grande (27.40) while among checks *S. peruvianum* has the highest number of fruits per plant (40.50). Several workers also reported that high temperatures cause significant loss in tomato productivity due to reduced fruit set, number of fruits and poor-quality fruit (Akhtar *et al*., 2012; Nahar and Ullah, 2012; Solankey *et al*., 2017) [1, 6, 10].

The fruit size is significant criteria of tomato not only for yield even for quality and consumers preference. In present investigation the genotype Cheku Grande (6.20 cm) have the highest fruit length followed by EC- 620519 (5.43 cm) while the genotype B-10-2 has the highest fruit diameter (15.00 cm) followed by B-9-2 (14.67 cm). The average fruit weight also affects due to high temperature and that ultimately distresses the yield and in this research the genotype DNT-1 and B-9-2 has the highest average fruit weight (57.74g) while among check the genotype Arka Meghali has the highest average fruit weight (59.01 g). The genotype which has highest fruit length and diameter sometimes may not have highest average fruit weigh because of puffy fruits that also exist due to improper pollination during heat stress. The promising genotypes were arranged as per their fruit yield (Table 2) because fruit yield is utmost target in this research work. Among promising genotypes the highest fruit yield was observed in Selection-18 (930 g) followed by Cheku Grande (750 g), EC- 620444 (685 g) and CLN-1621-L (575 g) while among checks the variety Arka Vikas has the highest fruit yield (406.67 g). The tomato genotype CLN-1621-L that was identified by AVRDC, Taiwan has already been reported to have heat tolerance by Comlekcioglu *et al*. (2010) [2]. Xu *et al*. (2017) [12] revealed that fruit set directly influenced the number of fruits and yield in tomato crop moreover; there is no significant correlation between vegetative and reproductive traits.

During heat stress the vegetative growth of the plant is restricted with limited foliage that unable to cover each fruits from the direct sun light therefore, for avoiding the Sun Scaled disorder in tomato the pericarp thickness played an important role, that means more pericarp thickness support the heat tolerance and among all promising genotypes EC-538455 has the highest pericarp thickness (4.77 mm) followed by B-10-2 (4.50 mm). Moreover, the highest number of locules per fruit was observed in the variety Selection- 18 and Cheku Grande (5.00) and these were found to have top yielder genotypes. In general it is reported in tomato that during heat stress the tolerant genotypes have more total soluble solids (TSS) content as compare to susceptible genotypes and in the present investigation the variety Selection- 18 has the highest TSS (6.70%) followed by EC- 677070 (5.77%) and IIHR-2275 (5.20%). The genotype Selection-18 has highest number of locules, TSS and yield that means locles and TSS are the most important criteria for identifying heat tolerant genotype of tomato. As well as it is also reported that the heat tolerant genotypes of tomato have more TSS content as compare to susceptible genotypes (Hazra *et al*., 2007, Solankey *et al*., 2015, 2017) [5, 9, 10].

From the above results it was revealed that variation for tolerance to heat stress exists in tomato. Although a limited number of germplasm were assessed, the genotypes appeared to have differences in tolerating heat stress are Selection-18, Cheku Grande, EC-620444, CLN-1621 L, and EC-620519, showed higher degree of heat tolerance. Thus, potential exists for breeding tomato genotypes with increased tolerance to heat stress to sustain tomato production in the hot summer conditions.

Table 2: Promising tomato genotypes under heat stress condition during summer season (heat stress condition)

Genotypes	Days to first flowering	Days to 50% flowering	Days to 1st fruit set	Fruit setting (%)	Plant height (cm)	No. of fruits/ plant	Fruit yield/ plant (g)	Average Fruit (g)	No. of branch/ plant	Pericarp thickness (mm)	No. of locules	Fruit length (cm)	Fruit diameter (cm)	TSS (%)
Selection- 18	60	67	71	58.89	49.33	20.10	930.00	38.61	6.80	3.28	5.00	3.40	13.57	6.70
Cheku Grande	61	67	75	75.56	50.33	17.60	750.00	36.91	7.40	5.62	5.00	6.20	11.00	4.37
EC-620444	61	67	74	61.27	40.33	18.70	685.00	30.72	10.40	3.60	3.40	3.60	13.50	3.40
CLN-1621-L	64	67	71	66.67	40.00	21.10	575.00	25.20	7.00	3.37	3.00	3.40	12.00	4.27
EC-620519	58	68	73	56.11	71.67	11.40	575.00	44.29	8.00	3.96	2.00	5.43	14.13	5.00
Rio Grande	64	67	79	82.22	42.33	27.40	560.00	20.80	7.20	3.25	3.85	4.05	13.35	3.40
EC-677070	66	69	76	53.33	114.33	18.90	550.00	23.10	3.80	1.42	2.00	4.23	8.47	5.77
Azad T-2	64	68	74	41.11	50.00	15.90	532.50	27.88	10.40	2.68	3.40	3.80	9.80	3.25
Azad T-6	59	68	72	62.10	42.33	15.65	525.00	29.47	5.80	3.77	3.00	4.70	12.00	3.43
EC-362948	60	68	71	63.81	88.33	19.70	510.00	22.67	10.00	3.07	4.00	3.10	12.33	3.43
DNT-1	63	67	73	75.56	36.33	6.80	505.00	57.54	8.00	3.15	3.50	4.27	13.25	3.80
B-10-2	62	71	75	85.00	51.67	10.85	500.00	43.32	12.60	4.50	2.00	4.83	15.00	4.33
B-9-2	65	70	74	58.89	65.00	7.60	480.00	57.74	10.40	3.67	4.00	4.60	14.67	2.43
EC-620377	62	67	77	65.56	54.33	11.05	477.50	44.95	5.60	3.43	4.00	4.20	10.67	4.27
IIHR-2618	64	69	77	54.92	67.33	13.70	470.00	33.87	5.60	2.63	3.00	3.53	11.33	4.17
IIHR-2619	65	69	75	47.78	42.33	12.00	430.00	32.74	9.40	2.70	3.00	3.60	11.12	3.80
EC-538439	59	66	71	52.38	56.67	11.40	422.50	30.67	5.60	3.20	2.00	3.74	12.00	3.27
EC-538455	61	68	76	87.96	81.67	28.30	350.00	11.18	10.20	4.77	4.00	3.40	10.23	4.33
IIHR-2275	66	71	78	73.89	40.00	18.80	420.00	17.64	6.00	2.77	2.00	3.13	9.33	5.20
EC-625644	59	67	70	61.67	50.00	7.00	315.00	36.65	6.40	5.20	4.00	3.97	14.00	2.63
EC-521080	62	70	74	62.22	71.67	20.30	307.50	13.30	10.80	2.70	2.00	2.17	9.33	4.53
S. Peruvianum	66	72	78	64.44	45.00	40.50	300.00	8.06	6.80	1.40	2.00	2.07	8.00	3.27

Arka Vikash (C)	67	71	78	62.96	57.78	11.10	406.67	54.46	9.60	3.50	3.00	3.30	14.00	3.80
Arka Meghali (C)	68	72	77	67.59	57.22	3.97	243.33	59.01	8.13	3.22	3.67	3.48	12.87	3.71
H-86 (C)	69	72	79	70.00	37.67	3.50	170.00	46.00	5.80	2.80	4.00	3.50	12.80	3.60
Pusa Rohini (C)	73	76	82	58.61	63.67	2.35	95.00	53.57	6.00	1.60	3.00	3.70	11.00	3.37
CD1	1.63	1.75	2.41	9.36	24.48	4.69	12.70	20.19	-	-	-	-	-	-
CD2	3.65	3.91	5.39	20.93	54.73	10.49	27.13	45.16	-	-	-	-	-	-
CD3	4.08	4.37	6.03	23.40	61.19	11.73	30.25	50.49	-	-	-	-	-	-
CD4	3.05	3.27	4.51	17.51	45.79	8.78	22.68	37.78	-	-	-	-	-	-

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References

1. Akhtar S, Ansary SH, Dutta AK, Karak C, Hazra P. Crucial reproductive characters as screening indices for tomato (*Solanum lycopersicum*) under high temperature stress. Journal of Crop and Weed. 2012; 8(1):114-117.
2. Comlekcioglu N, Simsek O, Boncuk M, Aka-Kacar Y. Genetic characterization of heat tolerant tomato (*Solanum lycopersicum*) genotypes by SRAP and RAPD markers. Genetics and Molecular Research. 2010; 9(4):2263-2274.
3. Fageria MS, Choudhary BR, Dhaka RS. Vegetable Crops: Production Technology, In: Solanaceous Vegetables, Tomato. Kalyani Publishers, New Delhi, 2003, II:25-40.
4. Geisenberg C, Stewart K. Field crop management. In: Atherton J, Rudich J (eds.) the tomato crop: a scientific basis for improvement. *Springer*, Netherlands, Dordrecht, 1986, 511-557.
5. Hazra P, Samsul HA, Sikder D, Peter KV. Breeding tomato (*Lycopersicon esculentum* Mill.) resistant to high temperature stress. International Journal Plant Breeding. 2007; 1(1):31-40.
6. Nahar K, Ullah SM. Morphological and physiological characters of tomato (*Lycopersicon esculentum* Mill) cultivars under water stress. Bangladesh Journal of Agricultural Research. 2012; 37(2):355-360.
7. Sato S, Kamiyama M, Iwata T, Makita N, Furukawa H, Ikeda H. Moderate increase of mean daily temperature adversely affects fruit set of *Lycopersicon esculentum* by disrupting specific physiological processes in male reproductive development. Annals of Botany. 2006; 97:731-738.
8. Singh U, Patel PK, Singh AK, Tiwari V, Kumar R, Rai N *et al*. Screening of tomato genotypes underhigh temperature stress for reproductive traits. Vegetable Science. 2015; 42(2):52-55.
9. Solankey SS, Singh RK, Baranwal DK, Singh DK. Genetic expression of tomato for heat and drought stress tolerance: an overview. International Journal of Vegetable Science. 2015; 21(5):496-515.
10. Solankey SS, Akhtar Shirin, Neha Pallavi, Kumari Meenakshi. Effect of high temperature stress on morpho-biochemical traits of tomato genotypes under polyhouse condition. Indian Journal of Ecology. 2017; 44(5):497-502.
11. Wani KFM, Shahid MA, Balal RM, Khan MW, Liaqat MR, Akram A *et al*. Morphological, physiological and nutritional responses of ten tomato genotypes at maturity stage under heat stress. Research Journal of Innovative Ideas and Thoughts. 2015; 4(2):63-78.
12. Xu Jiemeng, Wolters-Arts Mieke, Mariani Celestina, Huber Heidrun, Rieu Ivo. Heat stress affects vegetative and reproductive performance and trait correlations in tomato (*Solanum lycopersicum*). Euphytica. 2017; 213:156.