Studies on different thermal regimes and thermal sensitivity analysis of tomato genotypes

G.N. GOTE AND P.R. PADGHAN

Asian Journal of Environmental Science, Vol. 3 No. 2 : 158-161 (Dec., 2008 to May, 2009)

See end of the article for authors' affiliations

Correspondence to :
P.R. PADGHAN
Department of Plant Pathology, Vivekanand Agriculture College, (Bk.) Hiwara, Tq. Mehkar, BULDANA (M.S.) INDIA

SUMMARY

The effects of different thermal regimes on yield attributes and yield of tomato genotypes sown at four different dates were studied and thermal sensitivity analysis of the same was worked out. The temperature tolerance of the tomato genotypes has been worked out on the basis of crop duration under four different thermal environments by using Thermal Sensitivity Index. The tomato genotypes at different sowing dates were evaluated on the basis of TSI and it was observed that NS-815 was moderately tolerant whereas Punjab chhauhara, Pusa earl dwarf, Pusa ruby and Punjab kesri were moderately susceptible to thermal stress. It was observed that D_1 (25th September) sowing recorded higher yield at average maximum 30^0C temperature and minimum 12^0C temperature. Whereas average maximum 35^0C temperature and minimum temperature 16^0C temperature during maturity period led to 50 % decrease in yield per plant^{-1} and yield ha^{-1} in D_4 (10th November sowing). Thus the average increase in temperature by 5^0C caused 50 % reduction in yield of tomato crop.

Key words : Thermal regimes, Thermal sensitivity, Index, Tomato, Genotypes.

Accepted :* *October, 2008

In Chattisgarh plains, a large number of progressive farmers grow vegetables in *rabi* season that follows rice crop. Tomato is important usually planted in the 3rd week of October. Vegetable of this region and when fields are occupied by rice crop, tomato planting is possible in the 3rd week of November.

Tomato processing *i.e.* conversion of tomato into pulp for export is a major industry in this region. But due to the short span of winter particularly in Raipur, the atmospheric temperature shoots up February onwards causing a drastic reduction in tomato production and hence hampers the tomato supply to these units. Thus, the increasing temperature reduces the duration of each developmental stage of the crop. Hence it is necessary to develop a yard stick or a measuring unit to assess the thermal sensitivity of tomato crop.

The growth and development of any crop including tomato is influenced by three major regimes *viz.* moisture, thermal and light regime. Under irrigated conditions the influence of moisture nullified. The thermal regime influences the developmental activities while light regime influences the growth of the corp. In the latitude belt of 18-22°N the winter span is less and temperature fluctuations are very high, as a result of this thermal stress, the production potential of the crop is adversely affected in the state.

The short span of winter in Raipur that causes a thermal stress during *rabi* season reduces the duration of developmental stage and thereby the crop productivity. Besides this, the quality (size, and shape of fruit) and fruit weight decreases abruptly. In view of this an experiment was conducted to study the influence of different thermal regimes on different tomato genotypes and to assess the thermal sensitivity of the crop.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season of 2001-2002 at the Research Farm of Indira Gandhi Agricultural University, Raipur (C.G.) on tomato genotypes. The climate of the region was sub-humid type and varied from moist sub humid to semi arid with an annual rainfall of 1280 mm. Five tomato verities were selected for the experiment of which one was hybrid. Four different planting dates were aimed at providing different thermal environments to tomato plants during various developmental stages *i.e.* from fertilization to maturity. The details regarding the main plot treatments and sub plot treatments are discussed below.

Main plot treatments (Dates of sowing):

Sr. No	Date of sowing	Notation
1.	25th September	D_1
2.	10th October	D_2
3.	25th October	D_3
4.	10th November	D_4

Sub plot treatments (Tomato genotypes):

Sr. No	Tomato genotypes
1.	NS-815 (Hybrid)
2.	Punjab chhauhara
3.	Pusa early dwarf
4.	Pusa ruby
5.	Punjab kesri

Observations regarding number of fruits per plants, fruit weight, mean fruit weight and fruit yield were recorded selecting ten plants from each plot of the five tomato genotypes. Maximum and minimum temperature were recorded using Stevenson's screen installed at centre of the field. Thermal sensitivity index (TSI) was worked out for the various tomato genotypes on the basis of crop duration *i.e.* from sowing to maturity of the crop. The TSI values were used for rating thermal sensitivity ranging from < 5 to >15 and the genotypes under study were grouped on the basis of their sensitivity the thermal stress. Thus TSI was used as a parameter to estimate variability in duration of the crop under different thermal environments.

Using the variation from sowing to last picking under different dates of sowing the thermal sensitivity index (TSI) has been developed to asses the thermal sensitivity of tomato.

$$\text{TSI} = \frac{\text{Range of duration}}{\text{Average duration}} \times 100$$

Based on TSI the thermal sensitivity was categorized as follows–

TSI value	Thermal sensitivity
< 5	Tolerant
5- 10	Moderately tolerant
1- 15	Moderately susceptible
>15	Susceptible

RESULTS AND DISCUSSION

Number of fruits plants^{-1}:

The data pertaining to the number of fruits produced by the plants is given in the Table 1. In all the number of fruit plant^{-1} decreased in D_2(10th October), D_3 (25thOctober) and D_4 (10th November) sowing dates as compared to D_1 (25th September) sowing which can be attributed to the thermal stress during the flowering and fruit setting period of the crop due to delayed sowing. However, the genotypes NS-815, Punjab chhauhara and Punjab kesri produced greater number of fruits in D_3 (25th October) sowing as compared to D_1(25th September) sowing which was due to favourable thermal conditions during flowering and fruit setting period. The genotype NS-815 Punjab chhauhara , Pusa early dwarf, Pusa ruby and Punjab kesari showed decrease in number of fruits plants^{-1} from 31.4 to 22.90, 43.80 to 26.80, 32.00 to 44.60, 38.02 to 20.70 and 25.40 to 19.10, respectively from D1(25th September) to D_4(10th November) sowing.

The per cent decrease in number of fruits plants^{-1} was found to be higher in D_4 (10th November) sowing as compared to D_1 (25th September) sowing among all the genotypes. But it was found to be maximum decrease in 10th November sowing in Pusa ruby followed by Punjab chhauhara, NS-815, Punjab kesri and Pusa early dwarf. Similar results were also obtained by Kalloo (1996) and Marey and Michael (1996). More and Thomas (1952) reported higher temperature limits the production where days are warmer than 32^{0}C and nights are warmer than 21^{0}C. Because of the higher temperature fruit set is an important limiting factor for tomato production in tropics.

Total fruit yield plants^{-1}:

The fruit yield (g) plants^{-1} under four dates of sowing of five varieties are also shown in Table 1. It is obvious that the fruit yield drastically decreased in D_4 (10th November) sowing as compared to D_1 (25th September) sowing *i.e.* from 1671.90 g to 631.3 g plants^{-1} in Pusa ruby followed by Pusa early dwarf 1452 g to 696.40 g plants^{-1}, Punjab chhauhara (1576.40 g to 759.70 g plants^{-1}), Punjab kesri (1661.16 g to 811.50 g plants^{-1}) and NS-815 (1807.60 g to 903.40 g plants^{-1}). The same trend was observed in case of 10th October (D_2) sowing in all varieties due to the higher temperature during maturity period *i.e.* first picking to last picking. But in D_3 (25th October) sowing there was slight increase in wet plants^{-1} in varieties, Punjab kesri , Punjab chhauhara and NS-815. During fruiting period, there was severe winter that's why number of fruit per plant was increased.

Mean fruit weight in all the five varieties decreased right from D_1 to D_4 in all dates of sowing in all varieties. Highest fruit wet was decreased in D_4 (10th November) for all varieties followed by D_3 (25th October) and D_2 (10th October) due to highest average maximum temperature (35^{0}C) and minimum (16^{0}C) temperature. This clearly indicate that higher temperature effects the

Table 1 : Effect of different thermal environments on number of fruits plant^{-1} mean fruit weight (g) and fruit yield hectare^{-1}(q)

Dates of sowing	Number of fruit plant^{-1}	Mean fruit weight (g)	Fruit yield plant^{-1}(g)	Yield hectare (q)
NS-815				
D_1	31.4	57.6	1,807.6	723.0
D_2	28.7(8.6)	52.9(8.1)	1,521.1(15.8)	608.4(15.9)
D_3	36.4(15.9)	48.7(15.5)	1,770.8(2.0)	708.3(2.0)
D_4	22.9(27.2)	39.5(31.3)	903.4(50.0)	361.4(50.0)
Punjab chhauhara				
D_1	43.8	36.0	1,576.4	630.5
D_2	33.4(23.7)	29.5(18.0)	985.7(37.5)	394.3(37.5)
D_3	42.9(2.1)	28.3(21.2)	1,215.7(22.9)	486.3(22.9)
D_4	26.8(38.8)	28.3(21.3)	758.7(51.9)	303.5(51.9)
Pusa early dwarf				
D_1	32.0	45.4	1,452.1	580.8
D_2	29.4(8.1)	44.0(3.0)	1,296.9(10.7)	518.8 (10.7)
D_3	30.9(3.4)	33.1(27.1)	1,023.5(29.5)	409.4(29.5)
D_4	24.6(23.1)	28.3(37.6)	696.4 (52.0)	278.6(52)
Pusa ruby				
D_1	38.2	43.7	1,671.9	668.7
D_2	27.3(28.5)	41.8(4.5)	1,142.1(31.7)	456.8(31.7)
D_3	34.0(11.0)	32.6(25.5)	1,109.0(33.7)	443.6(33.7)
D_4	20.7(45.8)	30.5(30.20)	631.3(62.2)	252.1(62.2)
Punjab kesri				
D_1	25.4	62.8	1,661.1	664.4
D_2	28.0(10.2)	57.4(8.6)	1,610.3(3.1)	644.1(3.1)
D_3	35.9(+41.3)	45.4(27.6)	1,633.5(1.7)	653.4(1.7)
D_4	19.1(24.8)	42.4(32.5)	811.5(51.1)	324.6(51.1)

*(Values in parenthesis indicate per cent decrease in yield) Plant^{-1} – Per Plant

thermal stress. The result colaborates with the findings of Rajan (1989).

The fruit yield hectare^{-1}:

The fruit yield hectare^{-1} under four dates of sowing of five varieties from Table 1 has been observed that the yield hectare $^{-1}$ among different tomato varieties decreased with different dates of sowing. The yield pattern of NS-815, Punjab chhauhara and Punjab kesri was different than Pusa early dwarf and Pusa ruby. In earlier three verities maximum yield was recorded with third date as compared to second sowing date, while the yield of Pusa early dwarf and Pusa ruby decreased under all sowing date as compared to D_1 (25th September). This clearly indicates that thermal sensitivity of varieties varied with different thermal environments. The highest yield was noted in all the five varieties in D_1 (25th September) sowing followed by D_2 (10th October) , D_3(25th October) and D_4 (10th November). In D_3 (25th October) sowing less reduction observed due to the sustained winter condition during the flowering to fruit setting period. The yield in case of Pusa ruby decreased from 668.7 to 252.5 q. hectare^{-1} from D_1 (25th September) to D_4 (10th November) and in Pusa early dwarf the yield decreased from 580.8 to 278.6 q. hectare^{-1}. In other three verities it was decreased from 664.4 to 324.6 q hectare^{-1} in Punjab kesri, Punjab chhauhara from 630.5 to 303.5 q hectare^{-1} and from 723.0 to 361.40 q hectare^{-1} and NS-815. D_1 (25th September) sowing was the best for all the varieties but in D_4 (10th November) sowing yield drastically reduced due to higher temperature during maturity period.

The per cent decrease from sowing D_4 (10th November) as compared to D_1 (25th September) in case of Pusa ruby 62.2 % followed by Pusa early dwarf 25.0%, Punjab chhauhara 51.9%,Punjab kesri 51.1% and NS-815 50%. This clearly indicates that higher temperature has effect on the tomato production during growth and development stage. During development stage temperature is a detrimental factor. Rajan (1989) in field experiment also reported similar yield due to higher

maximum and minimum temperature and bright sunshine as compared to December planted crop.

Crop duration and thermal sensitivity analysis:

The crop duration (number of days) from sowing to last picking under the four dates of sowing of the five tomato varieties are shown in Table 2. The total duration of the crop decreased in all the five varieties from D_1 to D_4. However, the decrease in duration varies from variety to variety under different sowing dates. In case of Pusa early dwarf there was decrease in duration from D_1(25^{th} September) to D_4 (10^{th} November) was 19 days in Punjab

Table 2 : Effect of thermal stress on total duration (days) of crop from sowing to last picking

Sr. No.	Variety	25 Sept.	10 Oct.	25 Oct.	10 Nov.
1.	NS-815	145	142	140	135
2.	Punjab chhauhara	159	150	152	140
3.	Pusa early dwarf	157	148	151	138
4.	Pusa ruby	164	159	150	144
5.	Punjab kesri	161	160	148	140

kesri 21 days, Pusa ruby 20 days, Punjab chhauhara 19 days NS-815 with 10 days. But in Punjab chhauhara and Pusa early dwarf the duration increased by 2 and 3 days in D_3 (25^{th} October) sowing as compared to D_2 (10^{th} October) sowing, respectively.

The crop duration (number of days) decreased in all five varieties from D_1 (25^{th} September) to D_4 (10^{th} November). However, decrease in duration within varieties was due to its genetic characters. But, the extent of decrease in duration in different dates of sowing was due to the increase in maximum and minimum temperature, during the crop growth. The highest decrease in duration was observed in D_4 (10^{th} November) sowing. Wada *et al.* (1998) also observed that higher minimum temperature advanced maturity, shortened the length of cultivation in tomato planting. Sharma and Tiwari (1996) reported that in tomato crop the number of days from sowing to harvesting was least in transplanting on 25^{th} March as compared to planting on 13^{th} February and 5^{th} March.

The TSI of the five tomato genotypes has been worked out and their thermal sensitivity was assessed and is shown below:-

From Table 3, it is observed that NS-815 was moderately tolerant to thermal stress and the other four verities, Punjab Chhauhara, Pusa Ruby, Punjab Kesri fallowed by Pusa early dwarf appeared moderately susceptible.The sensitivity was worked out based on the variability of the crop duration under different thermal environments using the TSI.

Table 3 : TSI values and sensitivity in different varieties of tomato

Sr. No.	Variety	TSI values	Sensitivity
1.	NS-815	7.11	Moderately tolerant
2.	Punjab chhauhara	12.16	Moderately susceptible
3.	Pusa early dwarf	14.89	Moderately susceptible
4.	Pusa ruby	12.48	Moderately susceptible
5.	Punjab kesri	13.79	Moderately susceptible

Authors' affiliations

G.N. GOTE, Department of Agricultural Meterology, Vivekanand Agriculture College (Bk.) Hiwara,Tq. Mehkar, BULDANA (M.S.) INDIA

REFERENCES

Kalloo (1996). *Tomato* (*Lycopersicon esculantum* Mill.) Allied Publisher Private Ltd., New Delhi: 373pp.

Mary, M.P. and Michael, B. (1996). Effect of night temperature on pollen characters, growth and fruits set in tomato. *J. American Soc. Hort. Sci.,* **12** (3): 514-519.

More, E.L. and Thomas, W.O. (1952). Some effects of shading pracholoropehnoxy acetic acid on fruitfulness of tomato. *Proc. American Soc. Hort. Sci.,* **60** : 289-294.

Rajan, N. (1989). Influence of date of planting on seed yield and quality under two fertilizer levels in tomato (*Lycopersicon esculantum* Mill.) M.Sc. (Hort) Thesis Kerala Agricultural University, Veliankara (Kerala).

Sharma, N.K. and Tiwari, R.S. (1996). Effect of time of planting in yield contributing characters of tomato *(Lycopersicon esculantum* Mill.*)* CV PUSA RUBY. *Recent Horticulture,* **3** (1):82-85.

Wada, T., Ikeda, H., Morimoto, K. and Furuka, H. (1998). Effect of minimum air temperatures on the growth, yield and quality of tomatoes growth on a single truss system. *J. Japanese Soc. Hort. Sci.,* **67**(3):420-425.