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Effect of different sowing dates on growth, flowering and yield parameters in tomato

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ABSTRACT

The present investigation was conducted to study the effect of three different sowing dates on plant height, number of branches, leaves, flowers and fruits in tomato (*Lycopersicon esculentum* Mill.) var. Pusa Ruby. The seeds for the first crop were sown on 18th September and duration of the crop was September-January (34.3-2.8 ºC), and for the second crop seeds were sown on 25th October and duration of the crop was October-January (33.4-9.4 ºC day/night temperature). The seeds for third crop were sown on 26th November and crop lasted between November-March (31.4-16.0 ºC day/night temperature). There was no significant difference in the number of days taken for seed germination and for the development of first floral bud in the plants of all the three crops. However, there was significant difference in height of plants, number of flowers/plant; number of fruits/plants, fruit weight, total yield and the number of seed/fruit of plants. The plants of second crop grown from seeds sown between October-January (33.4-9.4ºC day/night temperature) produced significantly higher number of flowers and fruits/plant as compared to other two crops indicating that day/night temperature of 33.4-9.4ºC is most suitable for the flowering and fruiting.

Keywords : Tomato, sowing period, day-night temperature, plant height, flowering, fruiting, yield.

The sowing date defines the environmental conditions to which the crop will be exposed to critical periods for yield and quality components (Connor and Sadras 1992). Indeed, different sowing dates might subject the crop to different environmental conditions during flowering and fruiting determining different phenological stages depending on the temperature, radiation and day length. Agronomists have developed new cultivation practices adapted to late planting with the aim of accelerating the crop cycle, while reducing the vegetative vigor, thus, agronomic management does not promote excessive crop growth that delay maturity. Therefore, optimum sowing date for a cultivar in a region is considered to be the most important manageable and crucial factor that strongly influence crop production (Golla *et al*. 2018).

Tomato (*Lycopersicon esculentum* Mill; family Solanaceae) is very sensitive to environmental conditions and grown in a wide range of ecological zones and a number of factors; cultivars, plant density, sowing time, nutrients and water management practices are involved to influence yield. Tomato can be grown almost all the year round and the planting seasons vary from place to place of the country. In general, most tomato varieties need 100 days to full maturity, but there are good tomato varieties that only need 50-60 days to mature. Planting tomato late in the season, the varieties with shorter days to maturity will be suitable.

Tomato is a warm season vegetable crop and requires long season to produce a profitable crop. Planting tomatoes to produce early fruits may also expose the plants to unexpected late frosts killing tomato. The mean temperatures below 16°C and above 27°C are not suitable for tomato growth.

Present investigation was undertaken to study the effect of three different sowing dates on plant height, number of flowers and fruits/plant and yield in tomato.

MATERIALS AND METHODS

The experiment was conducted at, Department of Botany, School of Life Sciences, Dr. B.R. Ambedkar University, Khandari Campus, Agra during a period of three years between 2006, 2007 and 2008.

Seedbed preparation—Well-drained, sandy loam soil with 6.0-7.0 pH with receiving full sunlight for 8-10 h daily was selected. Farm Yard Manure (FYM) @ 1-1.5 t per acre was added in the soil. The seed bed was dough about 20-25 cm deep. The raised seedbeds of 3-4 meter long, 120 cm in width and about 15 cm in height were prepared in September, October and November for first, second and third crops respectively.

Seeds—Seeds of tomato var. Pusa Ruby were obtained from the Division of Horticulture, ICAR-Indian Agricultural Research Institute, New Delhi.

Sowing—Before sowing, the seeds were treated with 0.2 per cent Agrosan GN @ 2 g/kg of seeds. Seeds were sown on three different dates. The standard agronomic procedure was followed for raising the seedlings in nursery and transplanted in the seed beds. After germination a regular sprays of Dithane M-45 was made on the seedlings. Dose of 90-100 kg nitrogen, 60-70 kg P_2O_5, and 50-60 kg K_2O/hectare was applied. The other does of nitrogen were applied in equal quantity 25-30 and 45-50 days after transplanting.

Sowing dates—Seeds for first crop were sown on of 18th September with day/night temperature at 34.3/25.0ºC. For second crop, the seeds were sown on 25th October with day/night temperature of 33.4-17.4 ºC. The seeds for third crop were sown on 26th November with day/night temperature of 31.4–11.8 ºC.

Observations recorded—Data on days to plant height, date of floral initiation; number of flowers/plant, their color and size, number and length of stamens; size and shape of pistil (ovary, style and stigma); days taken for the fruit formation, number of fruits/plant, their size and weight and total yield/plant were recorded from the plants grown under three different periods as described above.

Statistical analyses—Data obtained from various studies were subjected to the t-test to determine two sets of data are significantly different from each other (Rice 2006).

RESULTS

Days taken for seed germination—Number of days taken for seed germination, crop duration with day/night temperature in three different crops is described in the following paragraphs and shown in Table 1.

First crop—Seeds for the first crop were sown on 18th September with day/night temperature at 34.3/25.0ºC. Germination took 10±3 days (35.2/25.4ºC day/night temperature) and the seedlings were transplanted after 10±1 days (29.2/12.0ºC) in the fields. Duration of crop period was September-January (34.3-2.8ºC).

Second crop—Seeds for the second crop were sown on 25th October. Germination took 9±2 days (32.6-14.8ºC) and the seedlings were transplanted after 24±1 days (30.1-11.0ºC). Duration of crop period was October-January (33.4-9.4ºC day/night temperature). Duration of crop period was October-January (33.4-9.4 ºC day/night temperature).

Third crop—Seeds for the third crop were sown on 26th November. Germination took 18±5days (23.2-5.1ºC) and the seedlings were transplanted after 19±3days (19.2-3.9ºC). Duration of crop period was November-March (31.4-16.0ºC day/night temperature).

There was no significant difference in number of days taken by seeds to germinate after sowing on three different dates.

Plant height—The plants of crop II attained maximum height (106.94±7.3). On the other hand, the plants of crop III were smallest (96.11±8.38). The difference in plant height of plants of all the three crops was significantly different among them and the height of plants of crop III was highly significant with that of crops I and II (Table 2).

Table 2—Effect of different sowing time on plant height grown under different day/night temperatures.

I crop	II crop	III crop
September-January	October-January	November-March
Day/night temperature (ºC)		
34.3-2.8	33.4-9.4	31.4-16.0
Plant height (cm) (n = 84)		
102.42±7.8	106.94±7.3	96.11±8.38
'P' value by 't' test		
I crop Vs II crop	II crop vs III crop	I crop vs III crop
*0.0067	**0.0001	*0.0011

±standard deviation, * Significant and **highly significant

Days taken in the initiation of first floral bud— First floral buds were initiated the plants of first, second and third crops in 35±3, 35±3 and 39±2.9 days after transplanting in to the fields respectively and the differences are not significant.

Floral morphology—The inflorescence is racemose cyme bearing 7-12 flowers. The floral organs are arranged in a spiral manner of four turns around the receptacle. The calyx consists of a short tube surmounted by six linear to lanceolate lobes. The number may be five or even seven. The corolla is a short tube bearing six broadly lanceolate lobes. There are six stamens adnate to corolla tube and form a cone around the pistil and inserted on the throat of the corolla. Anthers dehisce by introrsely longitudinal slit. The gynoceum is composed of six united pistils. Multi-cellular non-glandular hairs occur on calyx, corolla, stamens and style. Stomata are present on the calyx, pedicel, and style, but absent from corolla and ovary.

The flowers exhibit various morphological changes in the number, size and colour of floral parts of plants in crops raised by different sowing peroids. With the rise in day/night

Table 1—Effect of different date of sowing on germination, seedlings transplanted , crop duration and day/night temperature

S. No.	Date of sowing	No. of days for germination (day/night temperature)	No. of days old seedlings transplanted	Duration of crop and day/night temperature).
I Crop	18th September	10±3days (35.2/25.4ºC)	10 days (29.2/12.0ºC).	September-January (34.3-2.8 ºC).
II Crop	25th October	9±2days (32.6-14.8 ºC)	24±3days (30.1-11.0 ºC).	October-January (33.4-9.4 ºC day/night temperature).
III crop	26th November	18±5days (23.2-5.1 ºC)	19±3days (19.2-3.9ºC)	November-March (31.4-16.0 ºC day/night temperature).

temperature there is a reduction in the number, size of corolla and androecium. On the other hand, with the rise in temperature, the pistils are affected most as their number increases and the ovary swells and become deformed. The number of the stigmatic lobes is the same as the number of ovaries and usually it is 5-6. However, the number of stigmatic lobes increases but their size and the size of their papillae are reduced in flowers of plants at low day/night temperature.

Impact of different day/night temperatures on various parameters on floral morphology (days to first flowering, number of flowers/plant, morphology of floral parts, pollen fertility, number of fruits/plant, size, and weight and number of seeds/fruit have been shown in Table 3.

Table 3—Effect of different sowing dates on number of flowers/plant, size of flower and their parts grown with different day/night temperatures.

I crop	II crop	III crop
September-January	October-January	November-March
Day/night temperature (°C)		
34.3-2.8	33.4-9.4	31.4-16.0
No. of flowers/plant		
393.39±30.51	417.68±37.78	364.2±23.50
'P' value by 't' test		
I crop Vs II crop	II crop vs III crop	I crop vs III crop
*0.0028	**0.0001	**0.0001
Size of flower (cm)		
2.42±0.5	2.36±0.5	2.39±0.5
*0.0027	0.3870	0.0909
Length of stamen (cm)		
1.96±0.067	1.89±0.110	1.89±0.093
*0.0020	0.9129	**0.0004
Length of style (cm)		
2.01±0.098	1.75±0.113	1.86±0.098
**0.0001	**0.0001	**0.0001

±standard deviation, * Significant and **highly significant

Number of flowers/plant—The plants of second crop produced maximum number of flowers/plant (417.68±37.78) as compared to that in the plants of other two crops. The plants in the first crop produced 393.39±30.51 flowers/plant, while minimum number of flowers/plants was recorded in plants of third crop (364.2±23.50). The statistical analyses indicated that the number of flowers/plant in crop I and II are significantly different and the difference in the number of flowers/plant in crop II and III and I and III crops is highly significant (Table 3).

The flowers of plants grown in all the three crops were pale yellow in color. The size of the flowers, except that of stamen and style length in plants of all the three crops grown in different periods is not significantly different. The largest flowers (2.42±0.5 cm) are produced by plants in the first crop. The flowers of plants of third crop are 2.39±0.5 cm in size while, the flowers of plants in the second crop are smallest (2.36±0.5). The size of flowers is significantly different between the plants of crop I and II. On the other hand, there is no significant difference in the flower size in plants of crop II and III and those of crop I and III (Table 3). The length of stamens in the plants of crop I and II and crop I and III are significantly different, while those of II and III fail to show any significant difference. The difference in the length of style in crop I and II and I and III is significant, while between the plants of crop II and III the difference is highly significant (Table 3).

Yield—Number of fruits/plant, fruit weight, total yield/plant and number of seeds/fruit in plants of three different crops are described in the following paragraphs and data is shown in Table 4.

Table 4— Effect of different sowing dates on number of fruits/plant, fruit weight, total yield/plant and number of seeds/fruit in plants grown during different day/night temperatures.

I crop	II crop	III crop
September-January	October-January	November-March
Day/night temperature (°C)		
34.3-2.8	33.4-9.4	31.4-16.0
No. of fruits/plant (n=150)		
142.69±14.77	191.08±24.16	127.73±22.52
'P' value by 't' test		
I crop Vs II crop **0.0001	II crop vs III crop **0.0001	I crop vs III crop **0.0007
Single fruit weight (g) n=100		
65.33±8.02	61.38±7.50	58.88±8.67
I crop Vs II crop *0.0256	II crop vs III crop 0.1717	I crop vs III crop **0.0009
Total fruit weight/plant (kg) (n=150)		
8.189±0.814	9.581±1.00	6.277±0.849
I crop Vs II crop **0.0001	II crop vs III crop **0.0001	I crop vs III crop **0.0001
No. of seeds/fruit (n=150)		
299.83±42.48	252.53±36.82	282.75±30.48
I crop Vs II crop **0.0001	II crop vs III crop **0.0001	I crop vs III crop 0.0713

±standard deviation, * Significant and **highly significant

It is evident from the data in Table 4 that the plants of second crop produced maximum number of fruits/plants

(191.08±24.16), while lowest number of fruits/plant (127.73±22.52) were produced in plants of third crop. The plants of first crop there were 142.69±14.77 fruits/plant. The difference in the number of fruits/plant all the three crops is highly significant (Table 4).

On the contrary the fruit weight of (65.33±8.02 g) as compared to that of second and third crops with 61.38±7.50 and 58.88±8.67 g respectively. There was a significant difference in the single fruit weight in plants of crop I and II, and the difference is highly significant in the plants of crop I and III. On the other hand, there is no significant difference in fruit weight of plants of crop II and III (Table 4).

Since the number of fruits/plant was higher in the plants of second crop Total fruit weight (yield) in the plants of second crop was highest (9.581±1.00 kg). This can be attributed to the highest number of fruits/plant in this crop. On the other hand, the total yield in the plants of first crop was 8.189±0.814 kg, and the lowest total yield in the plants of third crop was lowest (6.277±0.849 kg). The difference in total yield of plants of all the three crops is highly significant. The number of seeds/fruit was highest in plants of first crop (299.83±42.48), second highest in the third crop plants (282.75±30.48) and lowest in the plants of second crop (252.53±36.82/fruit). Statistically, difference in the number of seed/fruit in between the plants of crop I and II and those of plants II and III is highly significant, while there is no significant difference in the number of seeds/fruit in between the plants of crop I and crop III (Table 4).

DISCUSSION

The present investigation was undertaken to study the effect of three different sowing dates on plant height, and number of reproductive parameters in tomato var. Pusa Ruby. The first crop was raised by seeds sown on 18th September and duration of the crop was September-January (34.3-2.8 ºC). For the second crop, the seeds were sown on 25th October and the duration of the crop was October-January (33.4-9.4ºC day/night temperature). The seeds for third crop were sown on 26th November and crop lasted between November-March (31.4-16.0ºC day/night temperature). These result clearly indicated that the plants of second crop grown from seeds sown between October-January (33.4-9.4ºC day/night temperature) produced significantly higher number of flowers and fruits/plant as compared to the other two crops indicating that day/night temperature of 33.4–9.4ºC is most congenial for the flowering and fruiting.

The observations of the present investigation indicated that there was no significant difference in the number of days taken for seed germination and floral initiation in crops. There was significant difference in the height of plants of different crops and plants of second crop were taller than the other two. The plants of second crop grown from seeds sown between October-January (33.4-9.4ºC day/night temperature) produced significantly higher number of flowers and fruits/plant as compared to other two crops indicating that day/night temperature of 33.4—9.4ºC is most suitable for flowering and fruiting.

The physiology of reproduction in flowering plants is closely under the control of environmental factors (light and temperature), nutrition of soil and these influence flowering and fruiting (Heslop-Harrison 1972). Many metabolic processes of tomato plants are determined by temperature (Abdulla and Verkerk 1968). Good fruit-setting in tomato generally requires half a day of sunlight per day. Poor fruiting can also be attributed to fertilization under suboptimal conditions.

Effect of different sowing dates on seed germination, plant height, floral development and yield in tomato has been studied by Hossain *et al*. (1986). El Ahamadi and Stevens (1979a, b) have also observed that reproductive responses of heat-tolerant tomatoes to high temperatures (38/27°C day/night). Flower production was reduced in all the cultivars studied. One of the cultivars failed to show stigma exertions, resulting in functional male sterility.

The effect of air temperature on flowering and yield in cultivars in green house tomato has been studied by Papadopoulos and Tissen (1983). Temperature at 19°C (day) / 14°C (night), failed to reduce yield as compared with 22°/17°C air temperature. A 13°/8°C air temperature during spring crop drastically reduced yield compared with the 19°/14°C air temperature.

Rylski *et al.* (1994) have recorded flowering, fruit set, fruit development and fruit quality under different environmental conditions in tomato and pepper crops. The effect of sowing date on growth of maize (*Zea mays* L.) has been studied by Cirilo and Andrade (1994). A commercial hybrid (DK636) was grown in the field at four sowing dates (mid September through mid December) for 3 years. Delays in sowing date hastened development between seedling emergence and silking, decreasing cumulative incident radiation on the crop during the vegetative period. However, late sowings increased crop growth rate during the vegetative period because of high radiation use efficiency and higher per cent radiation interception. Conversely, late sowings decreased the crop growth rate during grain filling because of low radiation use efficiency and low incident radiation. Late sowings affected grain yield by decreasing kernel weight and kernel number per unit area. Thus, delaying the sowing date strongly decreased dry matter partitioning to grain.

The effect of different sowing dates on okra (*Abelmoschus esculentus* L. variety Pusa Sawani) was studied by Amjad *et al.* (2001). Seeds were sown in the field on

various dates i.e. April 15, April 25 and May 5. Maximum germination percentage was observed in crop raised by seed sowing on either April 25 or May 5. Plant height, number of days to flower and length of green pods were not affected by the sowing dates. Number of leaves per plant, number of pods per plant and green pod yield were higher when crop was raised from seeds sown on April 15 or May 5. Germination percentage, number of days to flower and length of green pods were not influenced by the interaction between sowing time and fertilizer dose. Maximum plant height, number of leaves per plant, number of pods per plant and green pod yield was recorded in the crop sown on May 5.

The relationship between flowering and fruit setting with environmental factors on consecutive clusters in green house tomato was studied by Pek and Helyes (2003). Gul and Ahmad (2007) investigated the effect of sowing date on the growth of canola (*Brassica napus* L.) cv. Oscar and Rainbow. The proper sowing time of Canola in Sind was September to late October for good yield in terms of seed weight per plant. The yield obtained from the seeds sown in the month of November was considerably reduced in both the cultivars.

A study was conducted by Hossain *et al.* (2014) to observe the sowing date effect on flowering and fruiting in some varieties of tomato. The seeds were sown on three different dates viz., October 1, 15 and 30. Seed sown on October 1 was found better in respect of yield (74.75 t/ha) when compared to October 15 (58.55 t/ha) and October 30 (24.60 t/ha) sowing.

Mirzaei *et al.* (2016) evaluated the effect of different sowing times and plant densities in marigold. The effect of three sowing times (May 10, May 26 and June 10) was studied on yield. This study showed that sowing on May 26 is suitable for highest flower yield of marigold.

The effect of planting date in *Brassica napus*, has been studied by Zhang *et al.* (2016). A field experiment was conducted using three planting dates (15 September, 1 October and 15 October). However, on the basis of these results no guidelines could be offered for planting canola varieties to maximize effective flower numbers.

Xiong *et al.* (2018) have conducted laboratory and field experiments to determine the effects of environmental factors on germination and emergence of velvet leaf (*Abutilon theophrasti*). Maximum seed germination (>90%) was observed at alternating temperatures of 40/30◦C.

Two trials were performed by Silva *et al.* (2018) to assess the effect of two sowing date (SD1, SD2) and two irrigation treatments (IT1, IT2) on the growth in *Salvia hispanica* L., in central Chile. They measured leaf area (LA) and dry matter (DM) as primary parameters and relative growth rate (RGR), net assimilation rate (NAR), leaf weight ratio (LWR), crop growth rate (CGR) and specific leaf weight (SLW) as secondary parameters. Both LA and DM reached maximum values between 640 and 1150 accumulated degree days (ADD). However, LA and DM were 25% greater for sowing dates than for available water. Flowering date was also not affected by sowing date or water availability; plants flowered at 1140 and 942 accumulated degree days (ADD) in SD1 and SD2 respectively, and at 499 ADD in the water availability trial.

Patel *et al.* (2019) studied the effect of different sowing dates on phenology, growth and yield in rice and reported that maximum yield potential of rice crop was exposed to the most appropriate temperature range, which can be controlled by sowing at proper time.

Tomato is a warm season vegetable and requires long season to produce higher yield. The optimum range of temperature is 21-24º C. The mean temperatures below 16º C and above 27º C are not desirable. The minimum and optimum soil temperatures for seed germination are 10º C, 30º C, respectively. Seed germination occurs at 24º C. Maximum fruit setting occurs at night temperature of 15-20º C. Flowers fail to set fruit below 13º C and beyond 38º C. Tomato is grown in many type of soil from sandy to heavy clay. A well-drained fairly fertile loam with a fair moisture holding capacity is ideal for growing of good crop of tomato. Tomato crop prefers a soil reaction from pH 6.0 to 7.0. In acidic soil, liming is beneficial.

Present investigation has shown that tomato crop raised between October-January (33.4-9.4ºC day/night temperature) produced significantly higher number of flowers and fruits/plant thus, day/night temperature of 33.4–9.4ºC is most congenial for the flowering and fruiting.

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