Air and soil temperature pattern in crop canopy of tomato varieties across the different dates of sowing

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SUMMARY

A field experiment was conducted during the winter season at Horticulture Research Farm, IGAU, Raipur to find out the air temperature and soil temperature analysis in tomato crop canopy. To provide different thermal environment, the crop was sown in different dates starting from last week of September to second week of November, five tomato varieties *viz* NS-815, Punjab Chhauhara, Pusa Early Dwarf, Pusa Ruby and Punjab Kesri were sown on 15th September (D_1), 10th October (D_2), 25th October (D_3) and 10th November (D_4). Average maximum and minimum temperature were higher in D_1 during early stage of tomato crop as compared to D_3 and D_4. But it increased drastically during maturity stage *i.e.* first picking to last picking across the sowing dates. In variety NS-815 average maximum temperature was 28.1^{0}C D_1, 29.8^{0}C in D_2 33^{0}C in D_3 and 35.6^{0}C in D_4, whereas average minimum temperature was 10.7^{0}C in D_1, 13.2^{0}C in D_2,15.2^{0}C in D_3 and 16.7^0 C in D_4 similar trend found in other varieties too. Under delayed sowing condition crop faced severe winter condition in initial stages but later at maturity temperature increased drastically. It is clear that tomato crop under Raipur condition, faces thermal stress. If sowing is delayed indicate impact on number of fruit pant^{-1} and fruit wet pant^{-1} is seen. This indicates that D_1 ideal sowing for NS-815 and the other verities of tomato hybrid NS-815 proved superior over the four variety in term of yield. The soil temperature both at 5 cm and 10 cm depth were higher in D_4 sown crop as compared to D_1, D_2 and D_3 sown crop. There was increase in temperature in afternoon hours at later part of crop across sowing dates. There was clear cut change in the morning and afternoon hour temperature in D_1 to D_3 while in D_4 difference between morning hour and afternoon hour soil temperature was not much.

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Vegetable is an indispensable part of the vegetarian human diet. India is the second largest vegetable producer of tomato in world. Tomato (*Lycopersicon esculantum* Mill) is one of the most important industrial vegetable crop because of its outstanding processing qualities. It is good source of vitamins and minerals. It is also consider as a medicinal plant as the pulp and juice are easily digestible, a promoter of gastric section, blood purifier and an important antiseptic too. The growth and development of any crop including tomato is influenced by three major regimes *viz*. moisture, thermal and light regimes, under irrigated condition the influence of moisture is nullified, the light regime influences its growth while the thermal regime influences the developmental activities in a crop. In the latitude belt of 18–22^o N the winter span is less and temperature fluctuation is also very high. As a result of thermal stress, tomato crop during *rabi* season is often affected by temperature fluctuations in Chhattisgarh state. Thermal stress during *rabi* season reduces the duration of each developmental stage and there by the productivity. In Raipur, vegetable like tomato is widely grown in *rabi* season and production is utilized by fruit processing industries to export tomato pulp. However, due to short span of winter in Raipur, the temperature shoot up in February on wards. As a result the productivity, quantity and weight of fruit decreases abruptly. Taking in to consideration the present experiment was conducted.

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MATERIALS AND METHODS

The field experiment was conducted at the Research Farm of Indira Gandhi Agricultural University, Raipur (C.G.) at 21.16^0 N Lat. 81.36^{0}E long. and 289.56 m. altitude, during *rabi* season of 2001- 2002 on tomato genotypes *viz*. NS-815 (Hybrid), Punjab chhauhara, Pusa early dwarf, Pusa ruby and Punjab kesri under different thermal environments *viz*. 25th September (D_1), 10th October (D_2), 25th October (D_3) and 10th November (D_4).

The main plot treatmentent considered of four date of sowing D_1, D_2, D_3, D_4 and sub plot treatments included five genotypes of tomato crops *viz*. NS-815 , Punjab Chhauhara,

Pusa Earl dwarf, Pusa ruby and Punjab kesri. Seeds were raised in the nursery bed on the treatments after proper land preparation. Thirty days tomato seedlings were transplanted at the spacing of 50cm ×50 cm.

The air temperature over the crop canopy was measured by Stevenson's screen, which was installed in the middle of tomato crop field, which is identical to the Stevenson's screen installed in the weather station. Maximum and minimum air temperature was recorded every day and the average values at different growth stages of a five varieties of tomato during the four dates of sowing had been recorded temperature during nursery stage, transplanting to first flower initiation, first flower initiation to 50% flowering, 50% flowering to first picking and first picking to last picking.

RESULTS AND DISCUSSION

The air temperature:

The air temperature on crop canopy at different stages is shown in Table 1, as obvious the temperature of five varieties under nursery in four dates of sowing were same. The average temperature during the period from transplanting to first flowered initiation revealed that was higher in D_1 sowing than D_2, D_3 and D_4 sowing. This is clear indication during initial stages; the temperature was higher in D_1 as compared to the other dates of sowing. Similar situation was observed during the period from first flower initiation to 50% flowering and from 50% flowering to first picking. It is interesting to note that the maximum temperature across the sowing dates was decreased. This

Table 1 : Effect of different thermal environments on average maximum and minimum air temperature at different stages of tomato varieties

Dates of sowing	25 Sept.		10 Oct.		25 Oct.		10 Nov.	
Temperature ^{0}C	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Average temperature during Nursery stage								
NS-815	32.1	22.6	32.1	19.4	31.2	17	29.8	13
Punjab chhauhara	32.1	22.6	32.1	19.4	31.2	17	29.8	13
Pusa early dwarf	32.1	22.6	32.1	19.4	31.2	17	29.8	13
Pusa ruby	32.1	22.6	32.1	19.4	31.2	17	29.8	13
Punjab kesri	32.1	22.6	32.1	19.4	31.2	17	29.8	13
Average temperature during transplanting to first flower initiation								
NS-815	32.1	18.6	30.5	18.2	29.4	10.0	28.6	9.5
Punjab chhauhara	32.3	18.3	30.4	17.1	29.4	10.0	28.6	9.5
Pusa early dwarf	32.0	18.0	30.2	15.3	29.6	10.4	27.9	8.8
Pusa ruby	32.3	18.3	29.7	13.8	29.6	10.4	28.2	8.9
Punjab kesri	31.4	17.8	29.7	13.8	29.5	10.3	27.6	8.7
Average temperature during first flower initiation to 50% flowering								
NS-815	31.6	17.2	29.8	12.2	30.8	12.1	18.0	8.5
Punjab chhauhara	31.9	17.2	29.5	12.0	30.8	12.1	18.0	8.5
Pusa early dwarf	30.0	17.6	29.3	11.9	28.6	8.8	25.5	8.2
Pusa ruby	31.4	17.4	29.3	8.2	27.4	8.6	25.3	7.8
Punjab kesri	30.0	12.4	29.3	8.2	26.6	8.5	25.3	8.7
Average temperature during 50% flowering to first picking								
NS-815	29.3	11.7	28.3	9.1	27.6	9.7	28.6	11.3
Punjab chhauhara	28.6	10.6	28.3	9.6	27.6	9.8	28.7	11.4
Pusa early dwarf	28.6	10.8	28.3	9.7	27.7	10.2	29.5	12.4
Pusa ruby	28.6	10.8	28.1	9.7	28.5	10.9	29.5	12.3
Punjab kesri	28.3	9.5	28.3	9.7	27.5	10.0	29.6	12.4
Average temperature during first picking to last picking								
NS-815	28.1	10.7	29.8	13.2	33.0	15.2	35.6	16.7
Punjab chhauhara	30.1	13.1	30.8	13.8	34.2	15.6	35.3	16.6
Pusa early dwarf	29.7	12.6	30.4	13.2	34.5	15.6	35.3	16.0
Pusa ruby	30.5	13.0	32.4	14.6	35.3	16.5	35.3	16.5
Punjab kesri	30.3	13.0	31.7	14.0	33.8	15.3	35.1	16.0

was obvious that the later sown crops faced relatively severe winter condition in the initial stages. In case of D_3 sowing 50% flowering to first picking average maximum temp is less than D_1, D_2 and D_4 sowing. It was favorable to fruit setting and number of fruits per plant increased in D_3 sowing shown in all varieties Table 1.

But average maximum and minimum temperatue increased drastically across the sowing dates in late sown crop from first picking and from first picking to last picking *i.e*. maturity period for example, in case of variety NS-815 the average maximum temperature in D_1 was 28.1^{0}C and gradually increased in D_2, D_3 and D_4 with averages 29.8^{0}C, 33.0^{0}C and 35.6^{0}C, respectively. This indicates that during maturity period there was thermal stress at later dates of sowing. Similarly the average minimum temperatue during the maturity period of variety NS-815 at D_1 was 10.7^{0}C and again it increased in D_2, D_3 and D_4 with average values 13.2^{0}C, 15.2^{0}C and 16.7^{0}C, respectively. Similar trend was found in other four varieties too.

The average maximum and minimum temperature increased drastically across the sowing dates.Thus it is clear from this that under Raipur condition, tomato crop faces thermal stress conditions at the later part of the crop if sowing is delayed. That is why the impact of thermal stress on some varieties was seen in respect of the fruit quality it is shown in Table 3.in which mean fruit weight decreased across dates of sowing in respect of

Table 2 : Weekly pattern of soil temperature from sowing to maturity at 5 and 10 cm under different sowing dates

Dates of sowing	25 Sept.				10 Oct.				25 Oct.				10 Nov.			
Depth	5 CM		10 CM		5 CM		10 CM		5 CM		10 CM		5 CM		10 CM	
SMW	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
39	20.0	27.7	21.0	26.1	-	-	-	-	-	-	-	-	-	-	-	-
40	25.8	32.4	26.6	30.1	-	-	-	-	-	-	-	-	-	-	-	-
41	26.6	36.1	27.8	33.4	26.3	34.1	27.6	33.0	-	-	-	-	-	-	-	-
42	26.4	32.1	25.6	31.3	24.2	33.1	27.7	31.1	-	-	-	-	-	-	-	-
43	22.1	31.6	23.3	29.6	21.6	31.6	23.3	29.7	21.9	31.6	23.2	29.6	-	-	-	-
44	22.7	32.4	23.7	30.2	22.2	30.7	23.3	29.2	21.4	32.3	23.2	29.8	-	-	-	-
45	21.6	29.6	22.6	28.0	21.4	27.9	22.6	26.6	20.8	27.8	22.4	26.3	22.1	25.0	25.5	24.0
46	21.6	28.4	22.2	27.1	20.9	30.3	21.6	29.9	22.2	28.2	22.6	26.4	24.2	24.8	23.9	25.7
47	19.7	26.6	21.3	25.1	19.0	27.4	20.6	25.4	19.0	26.7	20.6	24.1	23.4	24.4	22.7	25.3
48	17.2	24.0	16.9	22.7	16.9	25.7	18.8	23.6	16.6	26.6	18.2	23.3	20.4	21.1	20.6	22.6
49	16.1	23.9	19.3	21.9	15.4	25.2	16.9	22.6	15.9	26.4	17.7	23.0	20.0	21.1	19.9	22.4
50	17.2	24.4	18.7	21.9	14.4	23.7	19.1	21.8	17.7	26.3	18.0	23.4	21.6	22.4	21.3	23.9
51	14.3	23.0	16.4	21.3	15.6	24.1	17.3	22.0	16.2	23.6	18.2	22.1	19.9	21.1	20.0	22.8
52	14.6	21.2	15.9	19.6	14.5	22.2	16.4	20.5	14.1	23.6	16.0	21.4	19.2	20.1	18.8	21.7
1	13.4	18.6	14.7	17.6	13.1	20.7	14.9	19.2	14.6	21.8	16.9	20.0	19.2	20.4	18.3	20.2
2	14.4	20.3	16.0	20.4	13.8	22.7	16.6	20.4	14.3	22.6	16.6	21.0	19.3	20.3	18.9	21.7
3	16.0	22.9	17.7	20.9	16.1	24.2	17.6	22.0	16.3	26.1	18.0	21.6	20.2	21.2	19.9	22.0
4	17.1	24.0	18.7	21.7	16.7	25.3	17.7	23.5	16.6	24.6	17.8	22.3	21.4	22.2	21.1	23.2
5	14.4	24.4	16.9	21.0	14.7	23.6	16.9	21.2	14.6	22.6	16.4	21.3	19.8	21.1	19.9	23.0
6	16.1	24.8	17.8	22.9	16.2	23.7	17.7	22.1	16.2	24.3	17.6	21.9	21.0	21.7	20.4	22.7
7	18.3	26.9	20.4	26.1	16.9	25.6	18.6	23.7	16.4	26.0	17.8	22.7	22.4	22.9	20.9	23.2
8	20.0	29.9	21.2	26.6	19.7	27.4	19.9	25.1	19.2	29.4	20.1	26.9	24.8	25.4	23.6	26.0
9	20.7	29.1	23.0	26.9	20.0	27.3	21.3	25.0	19.9	28.8	21.2	29.9	25.4	26.9	24.1	26.7
10	20.7	29.1	21.9	27.0	20.5	29.6	21.6	27.1	19.7	29.8	20.9	27.0	24.9	26.6	24.2	27.3
11	22.0	33.0	22.4	28.8	20.8	33.3	22.1	29.5	21.3	32.0	22.6	28.6	26.4	27.2	25.7	29.0
12	21.8	34.8	23.3	34.9	21.2	34.0	22.3	30.0	22.2	33.7	23.3	29.9	28.4	29.0	27.6	31.5
13	-	-	-	-	-	-	-	-	23.6	33.9	26.0	31.6	28.6	30.3	29.7	32.3

Table 3 : Effect of different thermal environments on number of fruits per plant, mean fruit weight (g)

Date of sowing	25 Sept.	10 Oct.	25 Oct.	10 Nov.
Number of fruit per plant				
Variety	D1	D2	D3	D4
NS-815	31.0	28.7	36.4	22.9
Punjab chhauhara	43.8	33.4	42.9	26.8
Pusa early dwarf	32.0	29.4	30.9	24.6
Pusa ruby	38.2	27.3	34.0	20.7
Punjab kesri	25.4	28.0	35.9	19.1
Mean fruit weight (g)				
NS-815	57.6	52.9	48.7	39.5
Punjab chhauhara	36.0	29.5	28.3	28.3
Pusa early dwarf	45.4	44.0	33.1	28.3
Pusa ruby	43.7	41.8	32.7	35.5
Punjab kesri	62.8	57.4	45.4	42.4

all varieties. In case of NS-815 average fruit wet in D_1 was 57.6 g and it gradually decreased in D_2, D_3 and D_4 with average fruit wet of 52.9 g, 48.7 g and 39.5 g, respectively. Similar trend was found in other four varieties More and Thomas (1952) reported higher temperature limits the tomato production when days are warmer than 32°C and night 20°C. Pookan and Shadeque (1996) found that per cent at fruit set per plant were reduced because of higher temperature.

This indicates that D_1 is ideal sowing for NS-815 and for the other varieties. It was obvious that in Raipur condition delayed sowing crop faced severe winter condition in initial stages, but at later stages of growth *i.e.* production under the maximum and minimum temperature increased drastically across the delayed sowing dates. In field experiment Rajan (1989) concluded February planted crop experienced higher maximum temperature and longer bright sunshine hour. Kalloo (1986) found that delayed planted crop suffered from higher maximum temperature and bright sunshine.

Soil temperature:

The daily soil temperature data at 5 and 10 cm depth under different sowing dates were averaged as per standard meteorological weeks (SMW) from 39 SMW (24 to 30 september) to 13 SMW (26 to 1 March). The weekly soil temperatures for different sowing dates are given in Table 2. It is clearly seen that the soil temperature decreased continuously up to first week of January and afterwards the soil temperature started increasing up to last picking. Same trend was observed at both depths and at both the time of observations. The trend was more or less similar in all the four dates of sowing. However in case of D_1 to D_3 their was a clear cut change in the morning and afternoon temperatures while in D_4 the difference between morning hour and afternoon hour temperatures was not much.

In D_1 (25 th September) the weekly average of soil temperatue during morning hours started decreasing from 26.6 °C in 41 SMW, 13.4°C in 1st SMW in 2nd SMW it again started increasing and went up to 21.8°C in 12th SMW. Similar trend was observed during the afternoon at 5thcm depth and soil temperature was highest 36.1°C during 41 SMW and lowest 18.6°C during 1st SMW. From 2nd SMW it again started increasing gradually up to 34.8°C in 12th SMW.

At 10 cm depth soil temperature was again higher 27.8°C in 41 SMW and lowest 14.7°C in 1st SMW. From 2nd SMW it again increased gradually up to 23.3°C in 12th SMW in morning hours. During the afternoon hour temperature varied from 33.4°C at 41 SMW to 17.6°C at 1st SMW (Fig.1).

It can be seen that the morning hours soil temperature at 5 cm depth were less compared to soil

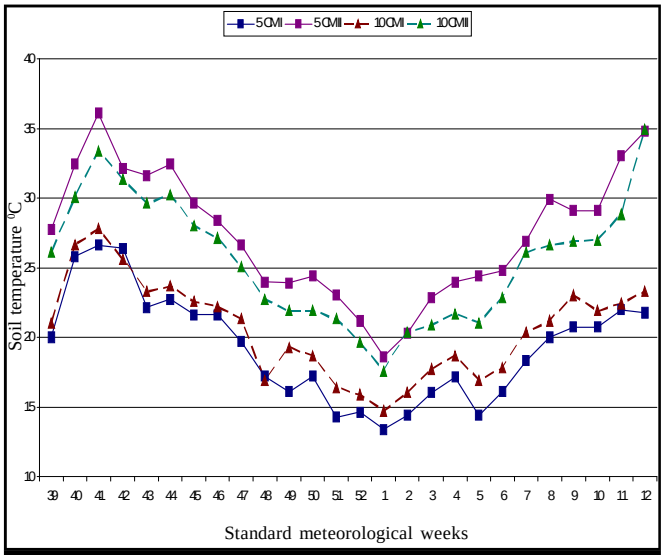

Fig. 1 : Pattern of average weekly soil temperature at 5 and 10 cm depths at 07:00 hrs (I) and 14 : 00 hrs (II) in tomato field in 25 Sept. sowing (D_1)

temperature during afternoon hours same trend was observed at 10 cm depth where the soil temperature at 10 cm depth at afternoon hour was higher as compared to the morning hours. Similar soil temperatures were also observed under different dates of sowing.

In case of D_2 the soil temperature during morning hours at 5 cm depth varied from 26.3°C at 41 SMW to 13.1°C at 1st SMW. During the afternoon hours the same

varied from 34.1°C at 41 SMW to20.7°C at 1st SMW 10 cm depth soil temperature during morning hours it varied from 27.6°C to 14.9°C and during afternoon hour the same varied from 33°C to 19.2°c during 41 and 1st SMW, respectively (Fig. 2).

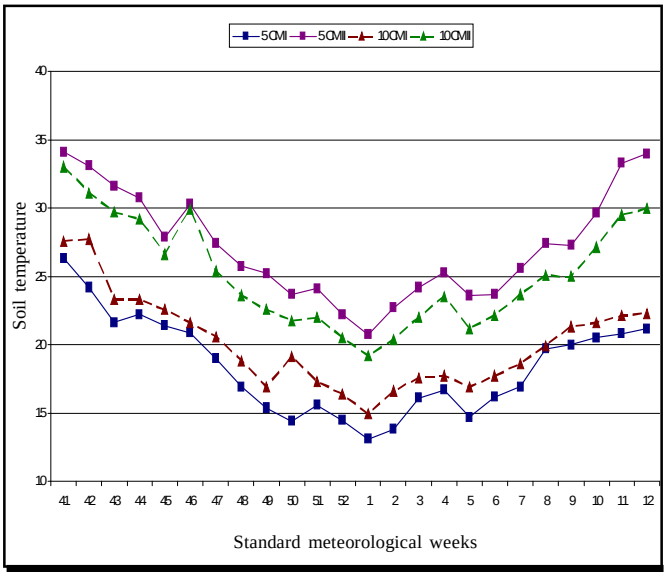

Fig. 2 : Pattern of average weekly soil temperature at 5 and 10 cm depths at 07:00 hrs (I) and 14 : 00 hrs (II) in tomato field in 25 Sept. sowing (D_2)

In D_3 (25th October) the weekly average of soil temperature during morning 5 cm depth started decreasing from 21. 9°C in 43 SMW to 14.1° C in 52 SMW from 2nd SMW it stared increasing and went high 23.6°C in 13 SMW. Similar trend was observed during the afternoon at 5 cm depth (started decreasing, 31.6°C at 43 SMW to 21.8°C in 1st SMW) and again started increasing. The soil temperature was highest 33.9°C during 13 SMW and lowest 21.8°C in1st SMW.

At 10 cm depth the soil temperature was higher (26.0°C) in 13th SMW and it was lowest (16.9°C) in 52nd SMW during morning hours. During the noon hour soil temperature varies from 31.6°C at 13 SMW to 20.0°C at 1th SMW (Fig. 3).

In case of D_4 (10th November) the weekly average of soil temperature during morning hours 5 cm depth decreased from 24.2°C in 46 SMW to 19.2°c in 52 SMW, From 2nd SMW it again stared increasing and went high 28.6°C in 13 SMW. Similar trend was observed during the afternoon at 5 cm depth and soil temperature was highest 30.0°C during 13 SMW and 21.1°C in (48, 49 and 51 SMW).

In 10cm depth the temperature was highest 29.7°C in 13 SMW and lowest 18.3°C in 1st SMW during morning

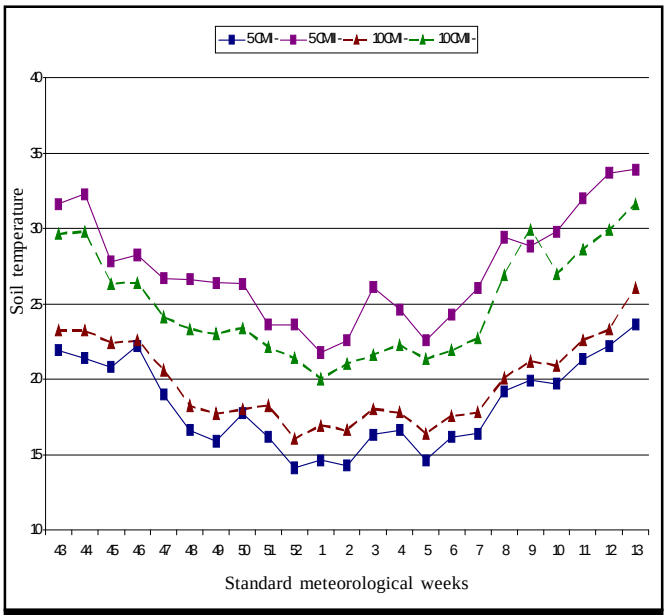

Fig. 3 : Pattern of average weekly soil temperature at 5 and 10 cm depths at 07:00 hrs (I) and 14 : 00 hrs (II) in tomato field in 25 Sept. sowing (D_3)

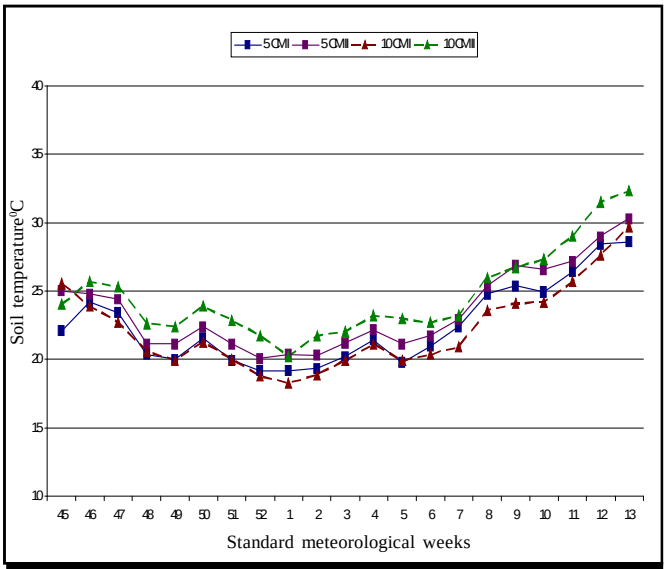

Fig. 4 : Pattern of average weekly soil temperature at 5 and 10 cm depths at 07:00 hrs (I) and 14 : 00 hrs (II) in tomato field in 25 Sept. sowing (D_4)

hour. During the noon hour soil temperature varied from 32.3 in13th SMW to 20.2°C in1st SMW (Fig. 4). The pattern of soil temperature showed that the morning hour's soil temperature at 5cm depth was less as compared to 10 cm depth while opposite trend was observed in the afternoon hours, where the temperature at 5cm depth was higher than 10 cm depth in all four date of sowing.

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