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Bell pepper (*Capsicum annuum* L.) grown on raised bed, plastic mulch and sprayed with NAA @ 15 ppm: Effects on crop growth, yield, soil moisture and temperature

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Abstract

A field study was conducted in Himachal Pradesh during the year 2017-18 with twelve treatments in order to evaluate the effect of planting methods, mulches and NAA application on growth and yield components of bell pepper (*Capsicum annuum* L.). Results showed that all the treatments significantly influenced the yield and yield contributing traits. Maximum plant height (73.66 cm), minimum days to 50 per cent flowering (27.25), maximum fruit length (7.35 cm), fruit breadth (6.39 cm), fruit weight (51.26 g), number of fruits per plant (25.10), yield per plot (53.90 kg) and yield per hectare (380.25 q) was recorded in T₃ (Raised bed + silver polythene mulch + NAA application @ 15 ppm 30 and 45 day after planting). Maximum soil moisture and temperature was recorded in plots which were covered with silver and black polythene mulches. Similar plots also produced maximum yield.

Keywords: Bell pepper, yield, soil moisture, soil temperature

Introduction

Bell pepper has attained an important status and special significance in the mid-hills of Himachal Pradesh where it is cultivated as an off-season crop during summer months. Bell pepper is looked upon as luxury vegetable as its consumption is greater in and around the cities. However, productivity and quality of produce is low because of fluctuating environment prevalent during its cultivation in open. Productivity of a crop is greatly affected by the cultural and physiological factors which are environment dependent. Among cultural factors, mulching and raised bed cultivation during summer and rainy season are necessary to optimize the cropping conditions thus ensuring commercial quality of the produce. Since the beginning of civilization, man has developed different agro-technologies to increase the efficiency of food production where soil tillage plays a role of considerable interest. The increased number of soil tillage operations that are normally performed during vegetable production, together with the low organic matter content and the agricultural vehicle traffic, can often lead to soil compaction and fertility depletion that greatly affect the potential yield of crops (Hamza and Anderson, 2005) ^[1]. The soil compaction results in reduced water penetration, changes in the activity of soil microorganisms, lower activity of earthworms, difficult penetration of the roots in deeper layer of soil, water stagnation and reduced air content in the soil (Soane and Ouwerkerk, 1994; Unger and Kaspar, 1994 ^[2, 3]). To overcome these drawbacks, the use of raised beds is showing interest among the farmers. Vegetable production using raised beds is a common production method in many regions of India. Wilkes and Hobgood (1969) ^[4] were some of the first researchers to examine the use of a raised bed on cotton (*Gossypium hirsutum*) production. Yields of tomatoes increased with bed height, most likely due to improved drainage and reduction of anoxic stress (Pena and Hughes, 2007) ^[5]. The use of mulch in commercial vegetable production is one of the traditional techniques that have been used since 1950's. The primary purpose for using mulches is for weed suppression in the crop to be grown. In addition, temperature regulation of the root zone and above ground growing environment, reduced nutrient leaching, altered insect and disease pressures and in some instances reduced soil compaction or improved soil organic matter are other benefits of mulching (Ngonuajio and McGiffen, 2004) ^[6].

Mulching stimulates soil micro-organisms such as algae, mosses, fungi, bacteria, actinomycetes and other organisms like earth worms etc., owing to loose, well aerated soil conditions, uniform moisture and temperatures thus resulting in a more rapid breakdown of organic matter in the soil and release of plant nutrients for crop growth. Under the mulch layer, earth worms proliferate and help to improve the soil aggregate stability and infiltration etc. (Bhardwaj, 2013) [7].

Among physiological factors, hormonal imbalance in the plant is very important which decides extent of flower and fruit drop under unfavourable conditions (Singh and Lal, 1995) [8]. The metabolism of auxins and growth promoters generate the energy-rich phosphate and precursors of metabolic processes, which may be the factors in the initiation of enhanced growth processes. The increased growth and delayed senescence in turn, favours increase in yield as most of the assimilates were translocated from the source to the sink under a stimulated environment. As the growth of the plants and the yield components are effectively enhanced, the resultant effect on yield is significantly improved (Rhodes and Ashworth, 1952) [9].

Materials and Methods

A field experiment was carried out at the Experimental Farm of the Department of Vegetable Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP. Experiment was conducted in randomized block design factorial during *Khraif* seasons (April to August) of 2017-18. The experiment comprised of 12 treatments which replicated thrice. Treatment details were viz. T₁ (Raised bed + Black polythene mulch + NAA application @ 15ppm 30 and 45 day after planting), T₂ (Raised bed + Black polythene mulch + No NAA application), T₃ (Raised bed + silver polythene mulch + NAA application @ 15ppm 30 and 45 day after planting), T₄ (Raised bed + silver polythene mulch + No NAA application), T₅ (Raised bed + No mulch + NAA application @ 15ppm 30 and 45 day after planting), T₆ (Raised bed + No mulch + No NAA application), T₇ (Flat bed + Black polythene mulch + NAA application @ 15ppm 30 and 45 day after planting), T₈ (Flat bed + Black polythene mulch + No NAA application), T₉ (Flat bed + silver polythene mulch + NAA application @ 15ppm 30 and 45 day after planting), T₁₀ (Flat bed + silver polythene mulch + No NAA application), T₁₁ (Flat bed + No mulch + NAA application @ 15ppm 30 and 45 day after planting), T₁₂ (Flat bed + No mulch + No NAA application or Control). The height of the raised bed was 15 cm above the ground level and two beds were separated by 45 cm distance. Seedlings were transplanted on well prepared plots on April, 2017 and 2018 at a spacing of 60×45 cm in a plot having dimensions of 1.20×9.45 m, accommodating 42 plants per plot. Black and silver polythene mulch of 50µ (200 gauge thickness) were applied in plots according to the treatments. After covering the plots with mulches, the holes were made on the mulch as per the recommended spacing of the plants.

Bell pepper cultivar "Solan Bharpur" was used in the present study. This cultivar is released by the Department of Vegetable Science, Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan.

Soil moisture calculation

For calculating soil moisture content, soil samples were drawn at fortnightly intervals. Soil moisture content was determined from 0-30 cm soil depth by gravimetric method. After taking fresh weight of samples, these were dried in aluminium boxes in the oven at 105-120°C till constant

weight and soil moisture percentage was achieved. Soil moisture content was then calculated on oven dry weight basis with the help of formula below.

$$Mp = \frac{Fw - Dw}{Fw} \times 100$$

Where

Mp = Moisture percentage on oven dry weight basis

Fw = Fresh weight of soil sample

Dw = Dry weight of soil sample

Soil temperature calculation

Platinum resistance thermometers were installed in the centre of each plot of each treatment at 10-15 cm depth. The temperature in °C was recorded daily for minimum at 7.30 hours and maximum at 14.30 hours.

Results and Discussion

Yield and yield contributing characters

It is clear from the data presented in Table. 1 that there was a significant effect of different treatment on plant height, days to 50 per cent flowering, fruit length, fruit breadth, fruit weight, number of fruits per plant, yield per plot and per hectare (Table 1). Tallest plants (73.66 cm) were produced in raised bed + silver plastic mulch + NAA application @ 15 ppm at 30 and 45 days after transplanting (T₃) which was statistically at par (71.79 cm) with T₁, and smallest (49.56 cm) plants were produced by T₁₂ (control). Increased plant height may be because of assimilation of macro and micro nutrients as well as more developed root system caused by tillage and greater nutrient availability in raised bed (Arvidson, 1999) [10]. The raised beds does not allow the soil to get compact and the plants are less damaged due to restricted cultural operations. This results in improved soil structure and control trafficking which results into better plant growth (Berle and Westerfield, 2013) [11].

Lamont *et al.* (1990) [12] and Dickerson (2012) [13] also stated that reflective silver or aluminium mulches also contribute cooler comfortable soil temperature to the root zone during hot summer conditions which ultimately result in improved growth of the plant. The increase in plant height due to auxin application may be attributed to increased plasticity of cell wall which is a non-reversible process, resulting in cellular elongation (Heyn, 1931; 1940 and Galson and Davies, 1969) [14-16]. The results are in conformity with the findings of Raj *et al.* (2015) [17] in tomato, Patel *et al.*, (2016) [18] in chilli cv. Kashi Anmol and Singh *et al.* (2017) [19] in chilli. They concluded that increase in plant height is due to its effect on stem elongation by rapid cell elongation and multiplication of cells in sub-apical meristem. Similarly early flowering (27.25 days) was recorded in T₃ which was at par (27.82 days) with T₁ and late flowering (35.95 days) was recorded in T₁₂. Similar are the findings of Thakur (2000) [20] and Jamatia (2013) [21] in bell pepper who observed easy assimilation of micro and macro nutrients, more developed root system and greater availability of nutrients as valid reasons for earliest flowering when the crop was grown on raised bed. Singh and Aulakh (2018) [22] conducted a study at LPU, Punjab in bitter gourd, who concluded that plastic mulch had taken less number of days to first flower development. According to them first flower could be attributed to the increased soil temperature of plastic mulch which was directly related to early initiation of flower. Ujjwal *et al.* (2018) [23] in tomato who reported maximum days taken to first flower initiation was estimated under control treatment and minimum by NAA

applied treatments. This earliness in anthesis may be because of NAA treatments which increased the number of leaves and promoted vegetative growth and thus there was translocation to other plant parts and might have facilitated early flowering. Again maximum fruit length (7.35 cm) was observed in P₁M₂N₁, followed by P₁M₁N₁ (7.19 cm) and minimum (5.36 cm) in P₂M₃N₂. Greater value (6.39 cm) for fruit diameter was found in T₃ and this was at par with T₁ (6.26 cm) followed by T₉, T₇, T₄, T₂ and T₁₀, i.e., 6.09 cm, 6.02 cm, 6.00 cm, 5.75 cm and 5.69 cm, respectively, while lower value (4.36 cm) was found in control treatment. Again heavy fruit (51.26 g) was noticed in T₃ and less fruit weight (41.91 g) in T₁₂. Similar treatment produced more number of fruits (25.10) which was significantly at par 25.00, 24.62 and 23.97 with T₁, T₉ and T₇, respectively. Less number of fruits (20.31) was produced in T₁₂. Greater yield per plot (53.90 kg) and per hectare (380.25 quintals) was recorded in plants having raised bed, silver mulch and NAA application which were at with T₁, T₉ and T₇, respectively. Minimum produce was observed in plants grown on flat bed, no mulch and no NAA application, i.e., 34.23 kg/ plot and 241.48 q/ha. Studies conducted by Ram *et al.* (2005) [24] under Ludhiana conditions are similar to the present findings. According to them raised bed offer the potential to reduce water logging, stress through improved surface drainage, reduced tillage cost, improved soil structure and nutrient status resulting from reduction in oxidation of soil organic matter and disruption of bio pores during tillage. All these factors contributed congenial conditions for plant growth and development and ultimately increased yield. Similar findings have also been reported by Hatterman-Valenti and Hendrickson (2006) [25] in onion, Ghosh *et al.* (2007) [26] in rice, Kumar and Gill (2010) [27] in turmeric and Islam *et al.* (2018) [28] in potato. Increased yield of bell pepper grown on aluminium painted mulch was attributed to increased amount of photo-synthetically active radiation (PAR) being reflected into the plant canopy (Porter and Etzel, 1982) [29]. Almost similar results have also been

observed by Olarewaju and Showemino (2006) [30] in sweet pepper, Iqbal *et al.* (2009) [31] in chilli, Belel (2012) [32] in sweet pepper, Rajablarini *et al.* (2012) [33], and Edgar *et al.* (2016) [34] in green pepper. Studies conducted by Verma *et al.* (2016) [35] revealed that use of silver black plastic mulch significantly increased yield due to minimum weeds, better soil moisture retention, optimum root zone temperature and better nutrient availability to the plants. These factors not only increase yield but were also responsible for increased plant height, earliest flowering, growth and over all development of the plant. Increased yield of bell pepper grown on aluminium painted mulch was attributed to increased amount of photo-synthetically active radiation (PAR) being reflected into the plant canopy (Porter and Etzel, 1982) [29]. According to Decoteau *et al.* (1990) [36] mulch surface colour that reflect light affected the growth of bell pepper plants by influencing the amount and quantity of upwardly reflected light in addition to modification of soil temperature which is responsible for increased yield and yield characters. The results obtained in the present findings may be explained on the basis that NAA treated plants remained physiologically more active to build up sufficient food material for developing more number of flowers and fruits, ultimately leading to more fruit setting and consequently more yield of better quality fruits Fathima and Denesh (2014) [37]. The significant and positive effect of NAA like increase in plant height, intermodal length, increase in fruit set and number of fruits are well known. All these factors contribute to increased yield through various processes/biochemical reactions being controlled by auxins within the plant cell. Similar results were found by Kannan *et al.* (2009) [38] in paprika cv. KtPI-19, Parthasarathi (2010) [39] in chilli. Mohammad *et al.* (2017) [40] reported the significant effect of NAA on plant processes like vascular tissue differentiation, root initiation, apical dominance, fruit setting and flowering. All these processes are directly or indirectly responsible for increase in yield and yield contributing characters.

Table 1: Effect of different treatments on yield and yield contributing traits of bell pepper

Treatments	Plant height (cm)	Days to 50 per cent flowering	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Number of fruits per plant	Yield per plot (kg)	Yield per hectare (q)
T ₁ (P ₁ M ₁ N ₁)	71.79	27.82	7.19	6.26	50.73	25.00	53.34	376.30
T ₂ (P ₁ M ₁ N ₂)	69.01	30.27	6.37	5.75	50.34	22.17	46.76	329.88
T ₃ (P ₁ M ₂ N ₁)	73.66	27.25	7.35	6.39	51.26	25.10	53.90	380.25
T ₄ (P ₁ M ₂ N ₂)	70.21	30.25	6.49	6.00	50.46	22.29	47.32	333.83
T ₅ (P ₁ M ₃ N ₁)	63.46	34.60	5.87	4.78	44.80	21.52	40.46	285.43
T ₆ (P ₁ M ₃ N ₂)	49.89	35.93	5.67	4.52	43.91	20.33	37.52	264.69
T ₇ (P ₂ M ₁ N ₁)	70.41	29.47	6.70	6.02	50.47	23.97	50.82	358.52
T ₈ (P ₂ M ₁ N ₂)	67.96	31.22	5.91	5.34	49.92	21.60	45.36	320.00
T ₉ (P ₂ M ₂ N ₁)	70.84	28.72	6.91	6.09	50.54	24.62	52.36	369.38
T ₁₀ (P ₂ M ₂ N ₂)	68.21	30.94	6.18	5.69	50.12	21.82	45.92	323.95
T ₁₁ (P ₂ M ₃ N ₁)	50.48	35.26	5.71	4.56	44.48	20.60	38.50	271.60
T ₁₂ (P ₂ M ₃ N ₂)	49.56	35.95	5.36	4.36	41.91	20.31	35.56	250.86
CD _{0.05}	2.37	1.15	0.37	0.75	1.85	1.42	53.74	26.35

P₁: Raised bed planting method, P₂: Flat bed planting method, M₁: Black polythene mulch, M₂: Silver polythene mulch, M₃: No mulch, N₁: NAA application @ 15ppm at 30 and 45 day after transplanting, N₂: No NAA application

Soil moisture

The data on soil moisture content under different treatments, recorded during the cropping period of *Kharif* 2017-18 at 0-15 cm soil depth is shown in Figure 1 & Table 2. All the mulch materials combined with flat bed planting method was found to be effective in conserving the soil moisture content. However, the magnitude of moisture conservation varied with the type of mulch materials and planting methods. Moisture content was taken at every fortnight interval at 0-15 cm soil

depth during the crop growing season. Maximum soil moisture conservation was observed under silver polythene mulched plots followed by black polythene mulch as compared to unmulched plots (control). The soil moisture per cent during the crop growing period of 2017-18 in the month of May, June, July and August at fortnight interval was calculated as 20.12, 22.81, 25.90, 25.98, 26.83, 26.88, 27.92 and 27.95 per cent, respectively in the treatment combination T₁₀, T₉, T₇ and T₈ as compared to T₅ and T₆. Kumar *et al.*

(2010) also recorded low soil moisture under raised bed than flat bed planting. This might be due to rapid drying of soil of raised bed in comparison to flat bed which resulted into higher soil moisture content in flat beds. Less moisture depletion under the mulches was due to prevention of contact between the soil and dry air, which reduced water loss into the atmosphere through evaporation. Also, mulches reduce impact of rain drops and splashes, thereby preventing soil compaction, reducing surface runoff and increasing water infiltration (Ravinder *et al.*, 1997). All these factors resulted in increased soil moisture content and reduced moisture depletion. As moisture depletion is least under the plastic mulches, so the rate of moisture recharging ability was also least because water infiltration was prevented. Capillary movement of water molecules through the soil pores from the water table supplied water to the root zone of the crop grown under plastic mulch (Hochmuth *et al.*, 2001).

Soil temperature

Data on mean weekly maximum and minimum soil temperature at 0-5 cm soil depth under different mulch materials and planting methods was recorded at 7.30 hours (Table 3 & Figure 2) and 14.30 hours (Table 4 & Figure 3) during the year 2017-2018. Results revealed that, raised bed planting method with black polythene mulched plots i.e. T₁ and T₂ increased soil temperature by 5.09 °C, 4.88 °C, 2.78 °C, 2.83 °C, 3.94 °C, 3.91 °C, 3.17 °C, 3.76 °C, 4.13 °C, 4.70 °C, 4.42 °C, 4.83 °C, 3.88 °C, 3.26 °C and 3.12 °C over flat bed planting method without mulched plots i.e. T₁₁ and T₁₂ at morning hours (07:30 hrs) in the every week of May, June, July and August, respectively.

Similarly pattern was noticed at 14:30 hrs, where soil temperature increased by 4.27 °C, 5.16 °C, 4.22 °C, 4.22 °C, 6.30 °C, 6.34 °C, 6.80 °C, 6.78 °C, 4.61 °C, 4.78 °C, 4.18 °C, 2.85 °C, 4.45 °C, 4.99 °C and 5.51 °C, respectively in raised bed with black polythene mulched plots T₁ and T₂ as

compared to flat bed without mulched plots T₁₁ and T₁₂.

According to data recorded on soil temperature at 07:30 and 14:30 hours, maximum soil temperature was recorded in raised bed covered with black polythene mulch, whereas, minimum was recorded in flat bed and non mulched plots. Locher *et al.* (2003) concluded that average soil temperature was highest in the covered raised bed treatment, while it was the lowest in the uncovered raised bed and in the uncovered level ground beds. In case of raised bed, mulch covering caused an increase of about 2 °C in the average soil temperature compared to the level ground. This difference was supposed to be caused by the bigger surface of the raised bed. Ashrafuzzaman *et al.* (2011) reported that soil temperature at 5 to 10 cm depth was different due to the presence of mulch and mulch colour. Soil temperature varied significantly with type of mulching, time of the day and the depth of soil. Soil temperature was low in the early morning and gradually increased until peak at 15:00 hours in all the treatments and then declined. Temperature under mulches was higher than that of the control plots for all the times. The maximum difference in temperatures between mulched and control plots were 5.1 to 5.7 °C at 0-5 cm soil depth at 15:00 hours. The consistent high temperature under black plastic mulch was due to the green house effect that trapped little radiant energy and penetrated into the soil. Little energy was lost through evaporation, resulting in a net gain of soil heat during the day. Though, the temperature on the bare plot was low, the poor crop performance obtained on the plot can be explained by the explanation that there was stiff competition between crop and weeds. Colour of plastic mulch material determines the energy-radiating factors, by influencing the surface temperature of the mulch and the underlying soil temperature. However, the effect of mulching materials on soil temperature was highly variable. The timing of soil temperature measurements and mulching thickness also caused variation in soil temperature.

Table 2: Soil Moisture (%) content at 0-15 cm depth under different treatments during 2017-2018

Treatment code	Month	May		June		July		August	
		01-May	16-May	01-June	16-June	01-July	16-July	01-August	16-August
T ₁ (P ₁ M ₁ N ₁)		19.80	20.89	24.33	25.41	26.19	26.00	26.21	26.81
T ₂ (P ₁ M ₁ N ₂)		19.86	20.44	24.11	25.69	26.10	25.82	26.34	26.89
T ₃ (P ₁ M ₂ N ₁)		19.85	20.56	23.34	25.66	26.18	26.25	26.18	26.85
T ₄ (P ₁ M ₂ N ₂)		19.94	20.28	25.21	25.52	26.11	26.01	26.30	26.83
T ₅ (P ₁ M ₃ N ₁)		17.00	17.01	20.15	20.76	21.95	22.55	22.01	22.90
T ₆ (P ₁ M ₃ N ₂)		17.02	17.00	19.12	20.98	22.16	22.62	22.15	22.90
T ₇ (P ₂ M ₁ N ₁)		20.01	22.10	25.90	25.48	26.61	26.80	27.65	27.90
T ₈ (P ₂ M ₁ N ₂)		20.00	22.20	25.25	25.98	26.83	26.82	27.91	27.91
T ₉ (P ₂ M ₂ N ₁)		20.11	22.81	25.62	25.85	26.82	26.88	27.92	27.95
T ₁₀ (P ₂ M ₂ N ₂)		20.12	22.25	25.88	25.95	26.79	26.85	27.90	27.94
T ₁₁ (P ₂ M ₃ N ₁)		17.21	17.70	21.12	21.10	22.23	23.30	22.69	23.60
T ₁₂ (P ₂ M ₃ N ₂)		17.12	17.85	21.00	21.21	22.25	23.50	22.80	22.99

P₁: Raised bed planting method, P₂: Flatbed planting method, M₁: Black polythene mulch, M₂: Silver polythene mulch, M₃: No mulch, N₁: NAA application @ 15ppm at 30 and 45 day after transplanting, N₂: No NAA application

Table 3: Mean weekly soil temperature (°C) at 07:30 hrs under different treatments at 0-5 cm depth during 2017-2018

Treatment code	Month	May				June				July				August		
		1 st week	2 nd week	3 rd week	4 th week	1 st week	2 nd week	3 rd week	4 th week	1 st week	2 nd week	3 rd week	4 th week	1 st week	2 nd week	3 rd week
T ₁ (P ₁ M ₁ N ₁)		22.20	22.99	21.90	22.35	23.92	23.53	24.25	24.78	24.90	24.83	24.12	23.58	23.12	23.02	23.00
T ₂ (P ₁ M ₁ N ₂)		22.03	22.85	22.00	22.23	23.90	24.09	24.18	24.69	24.90	24.88	24.23	23.61	23.00	23.11	23.14
T ₃ (P ₁ M ₂ N ₁)		21.90	20.93	21.90	21.49	22.92	22.88	23.60	23.85	23.00	23.12	23.65	22.76	22.90	22.48	23.00
T ₄ (P ₁ M ₂ N ₂)		21.85	20.45	21.93	22.05	23.00	23.29	23.61	23.87	22.80	22.95	23.66	23.00	23.00	22.59	23.00
T ₅ (P ₁ M ₃ N ₁)		18.60	19.31	19.60	20.00	20.40	20.68	21.14	21.42	20.80	20.72	20.00	19.73	20.56	20.24	21.20
T ₆ (P ₁ M ₃ N ₂)		18.71	19.00	20.00	20.22	20.00	20.36	20.58	21.50	21.20	21.00	20.04	19.58	19.58	20.25	22.20
T ₇ (P ₂ M ₁ N ₁)		21.90	21.99	21.52	22.01	23.00	23.01	23.98	24.18	23.90	24.02	24.00	22.11	22.00	22.00	22.81

T ₈ (P ₂ M ₁ N ₂)	21.91	22.21	21.61	22.00	23.08	23.11	24.00	24.21	23.90	23.71	23.91	22.15	22.00	22.12	22.83
T ₉ (P ₂ M ₂ N ₁)	20.50	20.63	21.51	21.11	22.60	22.81	23.50	23.70	22.60	22.82	23.52	21.69	21.84	21.76	22.00
T ₁₀ (P ₂ M ₂ N ₂)	20.00	20.23	21.42	21.18	22.58	22.75	23.33	23.61	22.70	22.93	23.45	21.71	21.71	21.59	21.80
T ₁₁ (P ₂ M ₃ N ₁)	17.11	18.11	19.22	19.73	20.00	20.25	21.11	21.02	20.77	20.18	19.81	18.78	19.24	19.88	20.02
T ₁₂ (P ₂ M ₃ N ₂)	17.21	18.18	19.34	19.52	19.98	20.18	21.08	21.11	20.80	20.53	19.95	19.00	18.56	19.85	20.10

P₁: Raised bed planting method, P₂: Flatbed planting method, M₁: Black polythene mulch, M₂: Silver polythene mulch, M₃: No mulch, N₁: NAA application @ 15ppm at 30 and 45 day after transplanting, N₂: No NAA application

Table 4: Mean weekly soil temperature (°C) at 14:30 hrs under different treatments at 0-5 cm depth during 2017-2018

Treatment code	May				June			July				August			
	1 st week	2 nd week	3 rd week	4 th week	1 st week	2 nd week	3 rd week	4 th week	1 st week	2 nd week	3 rd week	4 th week	1 st week	2 nd week	3 rd week
T ₁ (P ₁ M ₁ N ₁)	30.50	31.62	31.22	31.49	31.80	32.11	30.00	30.28	28.50	28.26	28.00	27.86	27.98	27.25	26.50
T ₂ (P ₁ M ₁ N ₂)	30.20	30.63	31.20	31.42	31.20	31.42	31.60	31.89	28.61	28.77	27.91	27.88	28.05	27.32	26.51
T ₃ (P ₁ M ₂ N ₁)	30.00	30.23	29.90	30.14	30.10	30.34	30.00	30.29	27.80	27.54	27.13	26.95	27.42	26.29	26.00
T ₄ (P ₁ M ₂ N ₂)	29.50	29.89	30.00	30.25	29.40	29.61	29.10	29.36	27.74	27.29	26.69	26.24	27.91	26.63	25.90
T ₅ (P ₁ M ₃ N ₁)	27.30	27.51	27.60	27.86	27.30	27.52	25.50	25.78	25.60	25.19	24.45	24.13	24.35	23.31	22.20
T ₆ (P ₁ M ₃ N ₂)	27.80	27.95	28.20	28.47	26.80	27.06	26.20	26.44	24.91	24.98	25.28	25.00	24.21	23.18	22.00
T ₇ (P ₂ M ₁ N ₁)	29.10	30.25	30.20	30.49	30.80	31.11	29.10	29.37	27.90	27.73	26.82	26.52	27.51	26.42	25.40
T ₈ (P ₂ M ₁ N ₂)	29.60	29.79	29.34	29.55	30.40	30.68	29.20	30.43	27.25	27.01	26.88	26.61	27.80	25.26	25.70
T ₉ (P ₂ M ₂ N ₁)	28.80	29.00	28.70	28.91	28.21	28.57	28.20	28.51	27.00	26.32	25.63	25.36	26.22	24.63	24.80
T ₁₀ (P ₂ M ₂ N ₂)	28.91	29.11	28.90	29.13	28.24	28.51	27.50	27.73	26.81	26.55	25.90	25.51	26.00	24.17	24.00
T ₁₁ (P ₂ M ₃ N ₁)	26.23	26.46	27.00	27.28	25.50	25.78	25.00	25.24	24.00	23.42	23.99	25.11	23.63	22.35	21.00
T ₁₂ (P ₂ M ₃ N ₂)	26.77	26.94	27.00	27.27	25.50	25.77	24.80	25.11	24.10	23.99	23.82	25.03	23.60	22.33	21.00

P₁: Raised bed planting method, P₂: Flatbed planting method, M₁: Black polythene mulch, M₂: Silver polythene mulch, M₃: No mulch, N₁: NAA application @ 15ppm at 30 and 45 day after transplanting, N₂: No NAA application

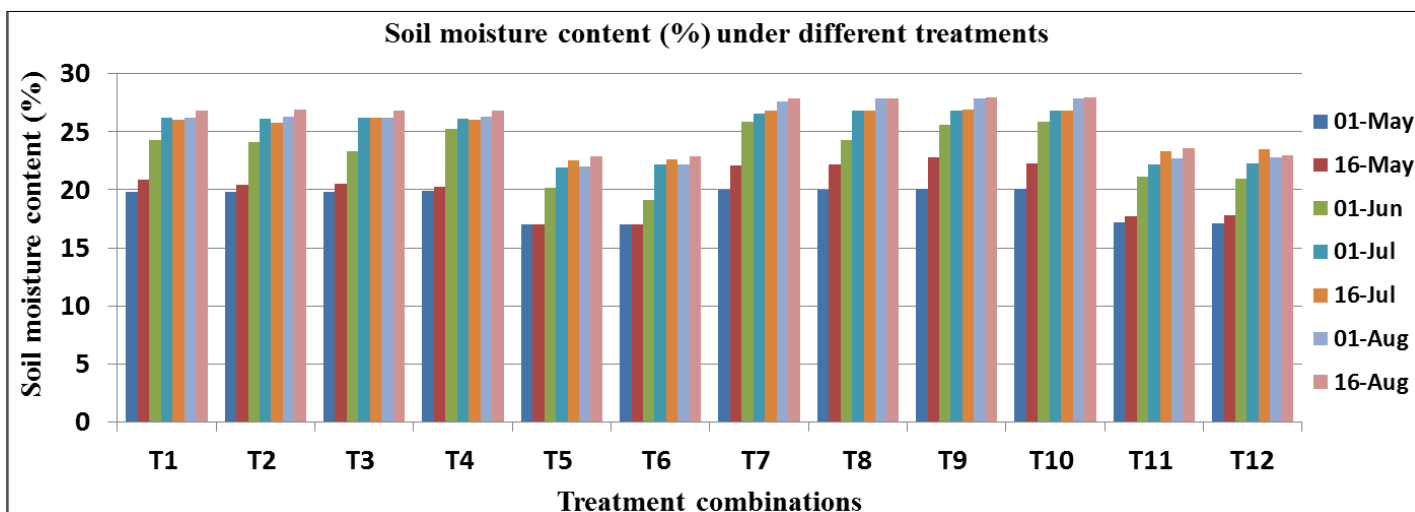


Fig 1: Soil moisture content (%) at 0-15 cm soil depth under different treatments during 2017-2018

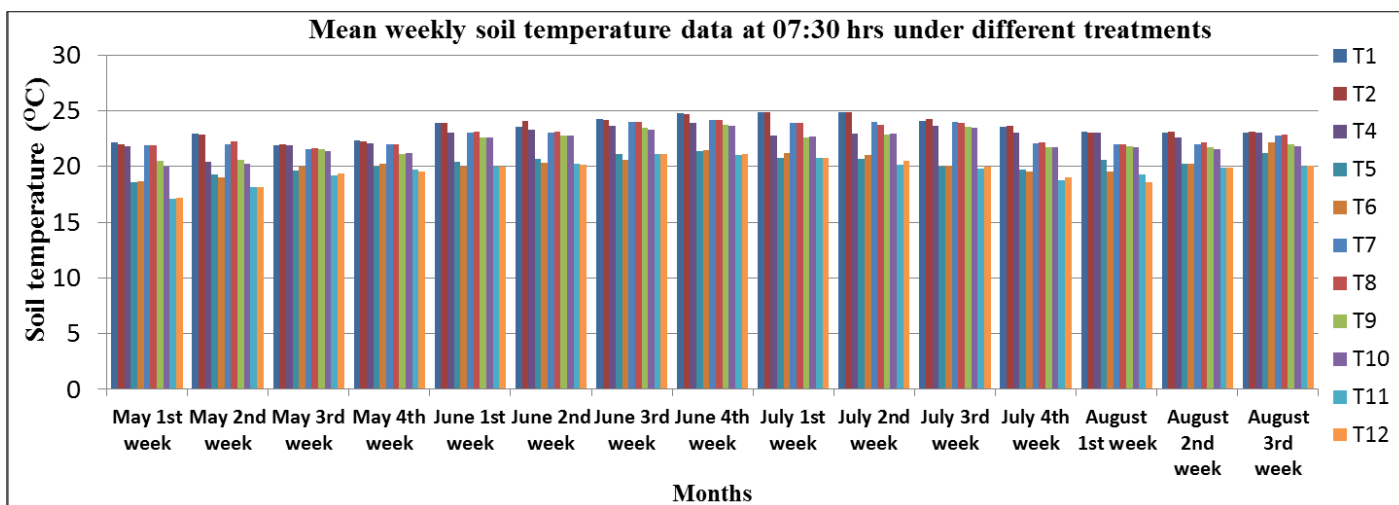


Fig 2: Mean weekly soil temperature (OC at 07:30 hrs) under different treatments at 0-5 cm soil depth during 2017-2018

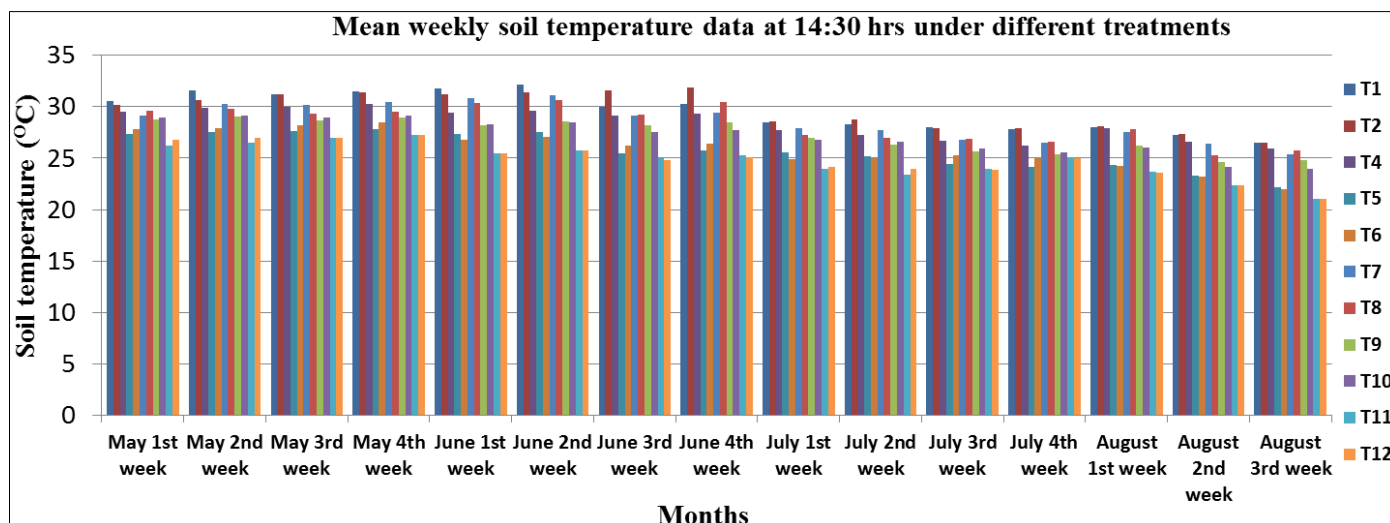


Fig 3: Mean weekly soil temperature ($^{\circ}\text{C}$ at 14:30 hrs) under different treatments at 0-5 cm soil depth during 2017-2018

Conclusion

It can be concluded from present study that bell pepper planted over raised bed combined with silver/black mulch and NAA @ 15 ppm at 30 and 45 days after transplanting and raised bed combined with black mulch and NAA @ 15 ppm at 30 and 45 days after transplanting is produced maximum yield as compared to control plots. This might be due to maintained and improved soil moisture and temperature conditions throughout the crop growing season which directly affect the crop growth and development and responsible for the producing maximum yield as compared to control plots.

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