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# Evaluate the effect of mulches on soil temperature, soil moisture level and yield of capsicum (*Capsicum annuum*) under drip irrigation system

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■ **ABSTRACT :** Drip irrigation with mulches is the best suitable approach for conservation of moisture and for producing higher yield to fulfill the food demand in the country. Therefore, this experiment was laid out to evaluate the effect of mulches on soil temperature, soil moisture level and yield of capsicum (*Capsicum annum*) at Precision Farming Development Centre of Indira Gandhi Krishi Vishwavidyalya, Raipur. The daily soil temperature observation were taken from 15 January, 2010 to 03 March, 2011 at 7:30 AM and 2:00 PM. Soil thermometer was used for the measurement of soil temperature. The black plastic mulch (BPM), paddy straw mulch (PSM) and without mulch (WM) with four level of irrigation were taken to study the effect on growth and yield of capsicum. It is concluded from the study that at 7:30 AM the average soil temperature under black plastic mulch (BPM) was 1.29 and 1.93°C higher as compared to the paddy straw mlch (PSM) and without mulch (WM), respectively. At 2:00 PM under BPM the average soil temperature increased by 4.6 and 1.62 °C compared to under PSM and WM condition, respectively. At the same time the average soil temperature of under WM was 3.0°C more as compared to PSM condition. PSM kept the soil temperature less than WM. It was also found that the soil temperature under PSM was higher than the WM condition, when the atmospheric temperature was low in the morning. From the analysis it is concluded that BPM saved significantly higher soil moisture (49 %) as compared to paddy straw mulch at 15 cm soil depth, similarly BPM saved 44 per cent more soil moisture as compared to paddy straw mulch at 30 cm soil depth. BPM with 80 per cent irrigation level gave maximum yield 20802.40 kg/ha, followed by BPM+100 per cent irrigation level which gave 20000.00 kg/ha. Minimum yield was found in without mulch with control irrigation condition.

■ **KEY WORDS :** Mulch, Soil temperature, Soil moisture, Yield, Drip irrigation

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Efficient utilization of available water resources is crucial for country like India which shares about 17 per cent of the global population with only 2.4 per cent of land and 4.0 per cent of the water resources. Drip irrigation system alongwith mulching is most suitable approach for cultivation of capsicum (*Capsicum annum*). The drip irrigation system is efficient irrigation method in terms of application and water use efficiency. The efficiency of the drip irrigation system is around 90 per cent whereas, it is only 25 to 30 per cent for surface irrigation. The plant growth is faster by 49 per cent and invariably results in early fruiting with uniform and improved fruits. Mulching, a surface covered cultivation is a recommended practice of moisture conservation for arid and semi arid regions. Mulches of various kinds have been used to modify hydrothermal regime in the crop root zone. Mulching reduces the water evaporation by interfering the radiation falling on the soil surface. Thus, mulching delays the drying of the soil and reduces the soil thermal regime during the day time (Mane and Umrani, 1981).

Continuous use of mulches is helpful in improving the organic matter content of soil which in turn improves the water holding capacity of the soil. Plastic mulch on the surface of the soil causes a change in the microclimate in its vicinity. This results in moisture conservation, less soil compaction, and higher $CO_2$ levels around plants. Plastic mulch maintains higher soil temperature in the night which favours the root activity. It also reduces the weed population and improves the microbial activities of the soil by improving the environment around the root zone.

The evapotranspiration (ET) is a combination of two separate processes in which water evaporates from the soil surface at the same time it transpires to the atmosphere from plants. ET information is important and critical for system design (application rate and flow rate) and for water management (irrigation scheduling, salinity control etc.). ET information is useful to determine how much water has evaporated from the cropped field. In most situations, daily evapotranspiration by crop equals the depletion of water from the soil that day. Therefore, the records of accumulated evapotranspiration in between two watering can be used to determine when and how much irrigation is needed to the crop.

Rational use of irrigation water for agriculture is important for increasing productivity and to save irrigation water, which is costly and scarce resource. This can be achieved by advanced method of irrigation like micro irrigation coupled with other improved water management practices. Drip irrigation is based on the fundamental concept of irrigating root zone of crop rather than entire land surface, which results in higher water use efficiency and crop yield. Thus, drip irrigation minimizes conventional losses like deep percolation, runoff and soil evaporation. It also permits the utilization of fertilizer, pesticides and other water-soluble chemicals alongwith irrigation water with better crop response. In the present the study an attempt has been made to quantify the effect of mulches on soil temperature using soil thermometer, difference in soil moisture level and yield of capsicum (*Capsicum annum*) under different level of irrigation.

## ■ METHODOLOGY

Field experiment was carried out in winter season at research field of Precision Farming Development Centre (PFDC), Department of Horticulture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Raipur is situated in the central part of Chhattisgarh at latitude 21.16º N and longitude 81.36 º E at an altitude of 289.56 meters above the mean sea level. Replicated planting of capsicum (variety indira hybrid) was planted utilizing four irrigation level by drip irrigation (0.6VEpan, 0.8VEpan and 1.0VEpan) and control by furrow irrigation. A Split Plot Design, with irrigation as main plot treatment and mulching [black plastic mulch (BPM), paddy straw mulch (PSM) and without mulch (WM)] as the subplots treatments was utilized. Total experimental area 1375m$^2$ (55 m × 25 m) in which row to row spacing 1m and plant spacing 0.45 m were taken. The drip irrigation system consisted of drip tubing placed in each row of plants. During irrigation, water pressure in the system was maintained at 1.2 kg/cm$^2$. The furrow irrigation system consisted of the typical furrow method of irrigation with plants on the top of the bed.

### Mulching :

The black LDPE film of 25 μ was laid on the surface of strip of 0.6 m width and 3.5 m length on 1$^{st}$ of November using black plastic mulch of 25 micron and paddy straw mulch as per the layout. The LDPE film of 25 μ was laid in such a way that it would not touch the rows of capsicum. A cut of 10 cm diameter was provided around each seedling on polyethylene mulch and mulch was laid carefully. To avoid the nuisance of prevailing wind the film was covered by soil from all the sides. Drip laterals were laid under the mulching film and irrigation was applies daily on climatologically approach through the drip system.

### Crop water requirement :

Drip irrigation plots were irrigated as per water requirement of the crop. Crop water requirement was calculated daily with the help of meteorological data

**Fig. A : Soil temperature recorded on plastic, paddy and without mulch**

recorded by meteorological observatory of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.). Pan "A" evaporation method where the daily water requirement was calculated using the formula. The crop co-efficient for various crop growth stages were selected (Doorenbos and Pruitt, 1977 and Rao, 1993). The water requirement was estimated by multiplying the reference evapotrinpiration, crop co-efficient, area under each plant and wetting fraction. The crop water requirement of the Capsicum (*Capsicum annum*) crop was estimated using the following equation.

$$V=(ET0 \times Kc \times Ap) - (Ap \times Re)$$

where, V = Net irrigation requirement, l/day, $ET_0$ = Reference evapotranspiration, mm/day, Kc = Crop co-efficient, A = Area allocated to each plant (spacing between plants and rows), Ap = A × $W_p$ = effective area to be irrigated, Wp = Wetting fraction (0.90 to 1.0 for close growing vegetable crops, varies with crop growth stage), Re = Effective rainfall, mm/day. The water requirement was estimated for the growing season of capsicum (*Capsicum annum*) *i.e.* from November to March. The daily time of operation of the system was also worked out.

### Measurement of soil temperature :

Soil thermometer was used for the measurement of soil temperature. Soil thermometer was inserted below the soil surface up to the depth of 10 cm. Three different thermometers were individually used in black plastic mulch (25 μ), paddy straw mulch, and without mulch on the field (Fig. A). The daily records from 15$^{th}$ January to 3$^{rd}$ March the soil temperature were taken at 7:30 AM and 2:00 PM. The study was done to know the effect soil temperature on different mulches in growth and production of crop.

### Soil moisture measurement :

Soil samples were collected randomly from the field at 15 and 30cm depth from the surface of the soil. Moisture content of the soil was determined by gravimetric method using the following relation. The soil samples of the experimental plots were collected from the specified locations and moisture contents of each soil sample was determined using standard methods.

$$\text{Moisture content (percentage db)} = \frac{(W_1 - W_2)}{W_2} \times 100$$

where, $W_1$ = Wet mass of soil (g), $W_2$ = Dry mass of soil, (g).

### Soil moisture depletion :

$$= \frac{(F.C. - M.C.) \times \text{Root zone depth} \times B.D}{100}$$

F.C. - Field capacity, M.C. -Moisture content, B.D. - Bulk density.

### Fruit yield per hectare (kg) :

The fruit were weighed separately from each plant and the total yield was worked out by multiplying the number of plants and then per hectare yield of fruit was calculated in t ha$^{-1}$.

## RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

### Effect of different mulches on soil temperature :

During the study period, the soil temperature was recorded at 7:30 AM and 2:00 PM. The soil temperature status at 10 cm depth is presented in Fig. 1 and 2. From the histogram, it is seen that the soil temperature of black plastic mulch (BPM) was found to be increasing till the last seventh week of study period with increase in atmospheric temperature. Soil temperature of BPM follows increasing trend with the daily atmospheric temperature. Similar trend was found in soil temperature from 1st to 7th week in case of paddy straw mulch (PSM) and without mulch (WM).

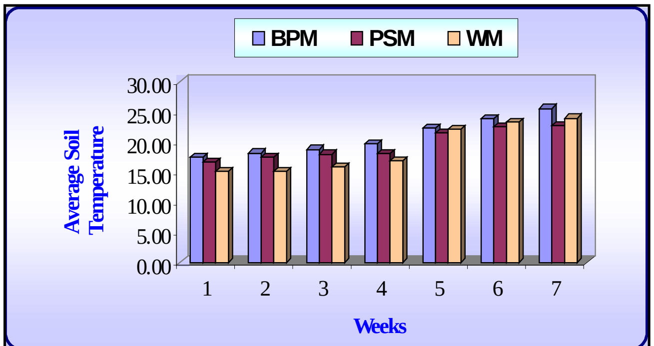


**Fig. 1 : Average weekly soil temperature at 7:30 AM**

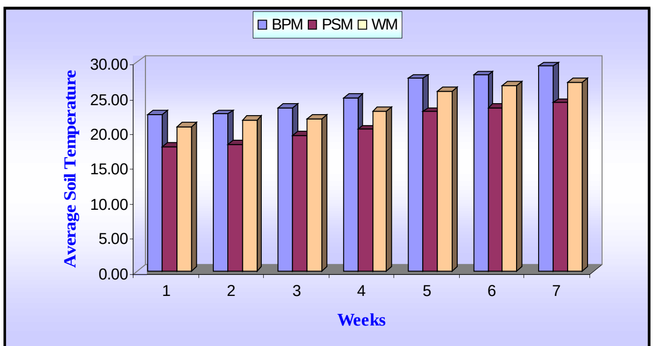


**Fig. 2 : Average weekly soil temperature at 2:00 PM**

From visualization of Table 1 it can be observed that in first four weeks of study period, soil temperature followed similar increasing trend in all three mulches as the atmospheric temperature was very low. From the 5th week of study period, the atmospheric temperature increase the soil temperature of paddy straw mulch reduced till the 7th week as compared to soil temperature in WM condition which still follows the increasing trend.

In all the mulches BPM, PSM and WM, the soil temperature was recorded at 2 PM from 1st to 7th week during the study period. It can be observed from the Fig. 1 that the soil temperature in BPM followed increasing trend and showed the highest value of soil temperature as compared to PSM and WM. Also the soil temperature of PSM followed increasing trend but showed lowest value of recorded soil temperature than BPM and WM. Hence, from the above observation it can be concluded that the PSM kept the soil temperature less than WM and BPM and when atmospheric temperature was low, paddy straw mulch increased the soil temperature and when the atmospheric temperature was high it reduced the soil temperature. Similarly black plastic mulch increased the temperature of soil both day and night period.

It is concluded that at 7:30 AM the average soil temperature of BPM was 1.29 and 1.93°C higher as compared to the PSM and WM, at 2:00 PM the BPM increased the average soil temperature by 4.6 and 1.62°C for PSM and WM, respectively. At the same time the average soil temperature of WM was 3.0°C more as compared to the PSM. PSM kept the soil temperature less than WM. It was also found that the soil temperature by PSM was higher than the WM when the atmospheric temperature was low in the morning. On comparison of variation in soil temperature between 7:30 AM and 2:00 PM for BPM, PSM and WM, it was found that the 3.83 to 5.21°C and 3.17 to 6.07° C for BPM and WM, respectively but the variation in PSM was found to be 0.79 to 2.21 which was very less as compared to the BPM and WM. From the visualization it was also found that because of increased temperature in the BPM,

**Table 1 : Weekly average soil temperature recorded under different mulches**

| Weeks | Soil temp. (°C) at 7:30 AM | | | Soil temp. (°C) at 2:00 PM | | |
|---|---|---|---|---|---|---|
| | BPM | PSM | WM | BPM | PSM | WM |
| 1. | 17.50 | 16.71 | 15.14 | 22.50 | 17.86 | 20.79 |
| 2. | 18.21 | 17.43 | 15.07 | 22.57 | 18.21 | 21.71 |
| 3. | 18.79 | 18.00 | 15.86 | 23.43 | 19.43 | 21.86 |
| 4. | 19.71 | 18.14 | 16.93 | 24.93 | 20.36 | 23.00 |
| 5. | 22.36 | 21.43 | 22.14 | 27.71 | 22.93 | 25.86 |
| 6. | 23.86 | 22.50 | 23.36 | 28.14 | 23.43 | 26.64 |
| 7. | 25.58 | 22.75 | 24.00 | 29.42 | 24.17 | 27.17 |

increased growth rates of plants, healthy leafs, size, shape and quality of fruit is good as compared to the WM condition for capsicum crop. It is also concluded that BPM is best suited for winter season as it maintains high soil temperature and PSM is good in summer season because of it maintains low soil temperature. Also it is found that the variation in soil temperature in PSM condition was very less as compared to BPM condition under the atmospheric condition at 7:30 AM and 2:00 PM.

**Soil moisture depletion pattern :**

The average moisture depletion of soil from the field for 0.6V Epan, 0.8V Epan, 1.0V Epan and control levels of irrigation with three types of mulch for 15 cm and 30 cm soil depth was determined as presented in Table 1. Soil moisture depletion for BPM at 15 cm depth below the surface was found 1.64, 1.33, 0.98 and 1.89 mm and similarly the water saving observed was 25.44, 29.68, 38.37 and 22.53 per cent for 60, 80, 100 per cent and control plots, respectively. For PSM soil moisture depletion was found 1.94, 1.65, 1.29 and 2.04 mm and similarly the water saving observed was 11.99, 12.42, 19.25 and 16.51 per cent for 60, 80, 100 per cent and control plots, respectively. Also for WM soil moisture depletion was found 2.20, 1.89, 1.59 and 2.44 mm for 60, 80, 100 per cent and control plots, respectively.

Soil moisture depletion for BPM at 30 cm depth below the surface was found 2.73, 2.51, 2.01 and 3.54 mm and similarly the water saving observed was 28.06, 27.25, 37.84 and 23.69 per cent for 60, 80, 100 per cent and control plots, respectively. For PSM soil moisture depletion was found 3.25, 2.89, 2.60 and 3.93 mm and similarly the water saving observed was 14.34, 19.71, 16.40 and 14.48 per cent for 60, 80, 100 per cent and control plots, respectively. Also for WM soil moisture depletion was found 3.80, 3.45, 3.24 and 4.64 mm for 60, 80, 100 per cent and control plots, respectively.

From the analysis it is also concluded that the BPM saved significantly higher soil moisture (49 %) as compared to paddy straw mulch at 15 cm soil depth. Similarly, BPM saved the soil moisture 44 per cent more as compared to paddy straw mulch at 30 cm soil depth.

From the result it is evident that under black plastic mulch higher yield was obtained compared to the paddy straw mulch and without mulch condition. BPM with 80 per cent irrigation level gave maximum yield 20802.40 kg/ha, followed by BPM + 100 per cent irrigation level

**Table 2 : Moisture depletion under different treatments in the experimental field**

| Mulch | Irrigation level | 15 cm depth | | 30 cm depth | |
|---|---|---|---|---|---|
| | | M.C. (%) | Soil moisture depletion (MM) | M.C. (%) | Soil moisture depletion (MM) |
| Black plastic mulch (25μ) | 0.6V Epan | 22.50 | 1.64 | 23.80 | 2.73 |
| | 0.8V Epan | 23.98 | 1.33 | 24.31 | 2.51 |
| | 1.0V Epan | 25.60 | 0.98 | 25.48 | 2.01 |
| | Control | 21.34 | 1.89 | 21.90 | 3.54 |
| Paddy straw mulch | 0.6V Epan | 21.11 | 1.94 | 22.59 | 3.25 |
| | 0.8V Epan | 22.45 | 1.65 | 23.43 | 2.89 |
| | 1.0V Epan | 24.17 | 1.29 | 24.10 | 2.60 |
| | Control | 20.65 | 2.04 | 20.99 | 3.93 |
| Without mulch | 0.6V Epan | 19.87 | 2.20 | 21.30 | 3.80 |
| | 0.8V Epan | 21.35 | 1.89 | 22.10 | 3.45 |
| | 1.0V Epan | 22.73 | 1.59 | 22.60 | 3.24 |
| | Control | 18.76 | 2.44 | 19.32 | 4.64 |

**Table 3 : Yield of capsicum with combination of mulches and different level of irrigation**

| Sr. No. | Treatments (Black plastic mulch) | Yield (kg./ha) | Sr. No. | Treatments (Paddy straw mulch) | Yield (kg./ha) | Sr. No. | Treatments (without mulch) | Yield (kg./ha) |
|---|---|---|---|---|---|---|---|---|
| 1. | BPM +0.6V Epan | 16826.6 | 5. | PSM + 0.6V Epan | 12103.4 | 9. | WM + 0.6V Epan | 13899 |
| 2. | BPM +0.8V Epan | 20802.4 | 6. | PSM + 0.8V Epan | 16225 | 10. | WM + 0.8V Epan | 15529.8 |
| 3. | BPM +1.0V Epan | 20000 | 7. | PSM + 1.0V Epan | 17739.8 | 11. | WM + 1.0V Epan | 13915.3 |
| 4. | BPM + Control | 12349.1 | 8. | PSM +Control | 10522.9 | 12. | WM +Control | 10299.8 |

which gave 20000.00 kg/ha. Minimum yield was found in without mulch with control irrigation condition (Table 3). The benefit cost ratio for BPM + 0.6V Epan, BPM + 0.8V Epan, BPM + 1.0V Epan and BPM + control were found as 2.1, 2.6, 2.5 and 1.7, respectively. For PSM + 0.6V Epan, PSM + 0.8V Epan, PSM + 1.0V Epan and PSM + control it was found as 1.7, 2.3, 2.5 and 1.6, respectively. For WM + 0.6V Epan, WM + 0.8V Epan, WM + 1.0V Epan and WM + control the benefit cost ratio was 2.0, 2.3, 2.0 and 1.6, respectively.

Sazabo (1979) highlighted the usefulness of polyethylene film that the mulches increases soil temperature by 3-5ºC and soil moisture content by 2-3 per cent, suppressed weeds. Advance cropping and increased yields, black PVC was found to be the best in capsicum crop. Lee and Yoon (1975) reported that the maximum soil temperature was increased 2ºC and 6ºC under black and clear plastic, respectively, whereas, the soil temperature was reduced 3ºC by straw mulch. The author also reported that pepper yield was increased up to 30 per cent when plastic mulches were used. Similar results have been obitained by Parthasarathi and Mohandass (2014) on tomato; Mahant *et al.* (2012) on banana; Godara *et al*. (2013) on fennel and Bhagyawant *et al.* (2012) on cauliflower.

**Conclusion :**

It is concluded that by comparing soil temperature at 7:30 AM and 2:00 PM for BPM, PSM and WM, it was found that the variation in temperature was in the range of 3.83°C to 5.21°C and 3.17°C to 6.07°C for BPM and WM, respectively. But in PSM it was found to be 0.79°C to 2.21°C which is very less as compared to the BPM and WM. It is also noted that PSM maintained less soil temperature than WM. It was also found that the soil temperature under PSM was higher compared to the WM when the atmospheric temperature was low in the morning. The BPM saved significantly higher soil moisture almost 49 per cent as compared to paddy straw mulch at 15 cm soil depth. Similarly, BPM saved 44 per cent more soil moisture as compared to paddy straw mulch at 30 cm soil depth. The present study results black plastic mulch with 80 per cent irrigation level gives maximum yield by enhancing the aviability of soil moisture during critical stages for growth and development of plants. Drip irrigation with mulching is a cost effective and economical viable technology for farmers.

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