

## Original Research Article

### Influence of plastic mulching and irrigation levels on soil temperature, moisture and water use efficiency of tomatocrop (*Solanumlycopersicum*)

#### Abstract

Farmers in India rarely employ plastic mulches in tomato cultivation, despite the fact that it has the potential to save irrigation water, manage weeds, and increase output. The precision of irrigation water for tomato production using various colour plastic mulches was evaluated in an experimental farm at UAS-Raichur. Because of the effect of irrigation levels, the 120 percent evapotranspiration based irrigation treatment had the most soil moisture availability, while the 60 percent evapotranspiration irrigation by drip had the lowest, and optimal soil moisture was maintained using plastic colour mulches. The maximum temperature was recorded in white on black plastic colour mulch ( $3.69^{\circ}\text{C}$ ), which absorbs 100 percent of solar radiation, and the highest temperature was measured in black plastic colour mulch ( $3.69^{\circ}\text{C}$ ), which absorbs 100 percent of solar radiation ( $2.25^{\circ}\text{C}$ ). The water use efficiency was highest when 80 percent ET was combined with white on black plastic colour mulch ( $26.77 \text{ kg/m}^3$ ).

**Key words:** Irrigation water, precision, evapotranspiration, water use efficiency

#### 1. Introduction

Plasticulture, or the use of plastic mulch in agriculture, is becoming increasingly popular in Indian agriculture to increase crop productivity. Today, agricultural tactics are oriented towards increasing crop output through environmentally sensitive technologies and better water management by using high-yielding varieties, intensive fertilizer, and pesticides. The use of mulch over the soil surface maintains a beneficial soil-water-plant relationship. Mulch has a considerable impact on the physical soil structure, moisture, erosion, thermodynamic environment, insect and disease incidence,

crop growth, and yield in the microclimate around the plant and soil. Organic mulches are commonly employed in our nation for moisture conservation and soil temperature regulation, but they only affect weed growth. The disadvantages of organic mulch can be illustrated by the fact that it would take 50 m<sup>3</sup> to spread sawdust 2.54 cm deep over 20 percent of a hectare. A similar amount of plastic mulch film would cover more than 250 hectares. The impermeability of plastic mulch, which limits direct moisture evaporation from the soil and reduces water losses, is a major benefit (Akbari et al., 2009). Plastic mulch has been made out of HDPE, LDPE, and LLDPE. Plastic LDPE mulches are most typically employed in the above categories. LLDPE has recently outperformed LDPE as a mulch material due to its two linked qualities of greater down gauging and puncture resistance and the fact that it inhibits weed development. Several novel colours - yellow, silver, green, red, and infrared transmitting mulch - have been studied for early tomato production in various parts of India (Rudich, et al, 1978). The results have been inconsistent year to year, especially with mulch colours. As the world becomes increasingly dependent on the production of irrigated lands, irrigated agriculture faces serious challenges that threaten its suitability. It is prudent to make efficient use of water and bring more area under irrigation through available water resources. This can be achieved by introducing advanced and sophisticated methods of irrigation and improved water management practices (Zaman *et al.*, 2001). Among the management practices for increasing water use efficiency one of them is mulching. Any material spread on the surface of soil to protect it from rain drop, solar radiation or evaporation is called mulch. Different types of materials like wheat straw, rice straw, plastic film, grass, wood, sand, etc. are used as mulch (Khurshid *et al.*, 2006). Mulch provides a better soil environment, moderates soil temperature (Sarkar and Singh, 2007), increases soil porosity and water infiltration during intensive rain (Glab and Kulig, 2008), and controls runoff and soil erosion (Bhatt and Khera, 2006).

In both the on-season and off-season, vegetable cultivation is one of the burgeoning industries in India. The income is significantly higher than that of other crops, ranging

from 3 to 5 times that of other crops. There has been an effort to enhance productivity per unit area. Tomatoes (*lycopersiconesculentum*) are the Solanaceae family's *Lycopersicon* genus.

Tomato is a herbaceous, sprawling plant with a weak woody stem that grows to a height of 1-3 m. The flowers are yellow, and the fruits of cultivated cultivars range in size from 1–2 cm in diameter cherry tomatoes to 10 cm or more in diameter beefsteak tomatoes. When ripe, most varieties produce crimson fruits. The tomato is a Peruvian and Mexican native. Though there are no definitive records of when and how it arrived in India, the Portuguese may have been responsible. Because of their high nutritional value, tomatoes are one of the most significant "protective foods." It is one of the most adaptable vegetables with a wide range of applications in Indian cuisine. Tomatoes are used in soups, salads, pickles, ketchup, puree, sauces, and various other dishes. They can also be eaten raw as a salad vegetable. In light of the preceding, a field trial was conducted from 2015 to 2016 at the College of Agricultural Engineering, Raichur, utilizing the widely used US-800 (Jawari) tomato variety.

## 2. Material and Methods

### 2.1 Experimental area

Raichur is located in the Northeastern Dry Zone, which is part of Karnataka's Region 1's Zone II. This site is at an elevation of 389 meters above mean sea level and is located at 16° 15' N latitude and 77° 20' E longitude (MSL). The field experiment was designed as a split plot with three replications, four main treatments, and four sub treatments. The experimental field has clay textured soil and a pH of 7.9 and a good electrical conductivity of 0.98 dS m<sup>-1</sup> (Table 1). Before transplanting, soil has available nitrogen (180 kg ha<sup>-1</sup>), phosphorous (15.3 kg ha<sup>-1</sup>), and potassium (98.10 kg ha<sup>-1</sup>). After harvesting, the soil has available nitrogen (162.5 kg ha<sup>-1</sup>), phosphorous (14.85 kg ha<sup>-1</sup>) and potassium (96.10 kg ha<sup>-1</sup>). Each treatment combination resulted in a single seedling being planted. From the 5th day after transplanting to the 10th day, the mortality of the

seedlings in the field was monitored, and gap filling was done using seedlings from the same nursery to maintain the appropriate plant density.

## **2.2 Treatment details**

Four-irrigation levels and four mulch treatments were included to fulfil the objectives of the study –

- Main treatments

I<sub>1</sub>- water application at 60 per cent ET using drip irrigation

I<sub>2</sub>- water application at 80 per cent ET using drip irrigation

I<sub>3</sub>- water application at 100 per cent ET using drip irrigation

I<sub>4</sub>- water application at 120 per cent ET using drip irrigation

- Sub-treatments

M<sub>0</sub> –without mulch

M<sub>1</sub>– White on black

M<sub>2</sub> – Silver on black

M<sub>3</sub> –Black plastic mulch

## **2.3 Irrigation source and its quality, scheduling**

The irrigation water utilized in the experiment was pond water from a farm. The water was tested for irrigation suitability. Irrigation water had a pH of 7.82 and an electrical conductivity (EC) of 0.85 dS m<sup>-1</sup>. The irrigation was then delivered according to the irrigation treatments.

## **2.4 Soil moisture studies**

The moisture content in the soil sample of different level of irrigation was determined at 10 cm depth before irrigation. The samples were collected at 30, 60, 90 and 120 DAT using standard procedure. Gravimetric method was used to determine the soil moisture.

## **2.5 Soil temperature**

Soil temperature was recorded in the afternoon time. The soil temperature was measured using thermometer at surface and at 10 cm depth with mulch and without mulch treatments. The atmospheric temperature was also recorded simultaneously.

## 2.6 Water use efficiency (WUE)

For drip irrigation methods, the water use efficiency of each treatment was calculated using the formula below.

$$e_u = \frac{Y}{WR} \quad \dots (1)$$

Where,

$e_u$  = Water use efficiency, ( $\text{kgm}^{-3}$ )

Y = Crop yield, (kg)

WR = Total amount of water used in the field, ( $\text{m}^3$ )

## 3. Results and Discussions

### 3.1 Soil Moisture

The maximum soil moisture content(18.08), was observed in treatment  $I_4M_1$  followed by  $I_4M_3$  (18.02),  $I_3M_1$  (17.97) at 30 DAT. Similarly, 60 DAT, treatment  $I_4M_1$  recorded the maximum soil moisture content(16.79), whereas treatment  $I_1M_0$  recorded the least soil moisture content (14.52). 90 days later, treatment  $I_4M_1$  recorded the maximum soil moisture level(18.33), while treatment  $I_1M_0$  recorded the smallest soil moisture content (16.06). Finally, 120 DAT, treatment  $I_4M_1$  recorded the maximum soil moisture content(17.28), while treatment  $I_1M_0$  recorded the least soil moisture content (15.01). Because of the effect of irrigation levels, the 120 percent ET irrigation treatment had the most soil moisture availability, while the 60 percent ET irrigation by drip had the lowest, and optimal soil moisture was maintained using plastic colour mulches(**Table 2**). This is because moisture distribution under drip irrigation is a three-dimensional function that includes

vertical, lateral, and diagonal movements, whereas moisture distribution under surface irrigation is a one-directional movement (Badr, 2007).

### 3.2 Soil temperature

It may be deduced that the average soil temperature recorded at ground surface level in the afternoon hours was  $33.91^{\circ}\text{C}$ , compared to an ambient temperature of  $32.75^{\circ}\text{C}$ . In comparison to the ambient temperature of  $32.75^{\circ}\text{C}$ , the greatest average soil temperature was found in the black plastic mulch treatment throughout the crop season ( $36.44^{\circ}\text{C}$ ), followed by silver on black mulch ( $35.46^{\circ}\text{C}$ ), and finally white on black plastic mulch ( $35.00^{\circ}\text{C}$ ). It may also be deduced that the average soil temperature at ground surface level during the afternoon hours was  $1.16^{\circ}\text{C}$  higher than the ambient temperature. When compared to the average atmospheric temperature, the black plastic mulch treatment had the greatest average soil temperature ( $3.69^{\circ}\text{C}$  higher), followed by silver on black mulch ( $2.71^{\circ}\text{C}$  higher), and finally white on black plastic mulch ( $2.25^{\circ}\text{C}$  higher). Increased radiation absorption and greater heat conductivity between the soil surface and the plastic mulch could explain the higher soil temperature under plastic colour mulches. These findings are consistent with Tapani et al (2015).

### 3.3 Water use efficiency (WUE)

The results show that treatment  $I_2M_1$  had the highest WUE ( $26.77 \text{ kg/m}^3$ ), followed by  $I_2M_2$  ( $25.09 \text{ kg/m}^3$ ) and  $I_1M_1$  ( $24.52 \text{ kg/m}^3$ ). Similarly, treatment  $I_4M_3$  had the lowest WUE ( $10.76 \text{ kg/m}^3$ ). Treatment  $I_2M_1$  had the highest WUE ( $25.47 \text{ q/ha-cm}$ ) in terms of yield achieved per unit depth of water applied (**Table 3**). This was owing to the fact that white and silver plastic colour mulch created a better environment for plant height, leaf population, and leaf metabolic activities, resulting in a higher crop production with the same water application rate as non-mulched treatments and temperature effects. The

current findings are consistent with those of and Patil and Patil (2009), as well as BayeBerihun (2011).

#### 4. Conclusion

Soil moisture can be maintained optimum by using plastic colour mulches in areas with high evaporation rates. The highest soil moisture was in mulched plots than the without mulched plot. The water vapours from the soil were trapped by the plastic sheet resulting in water vapour which again dropped into the upper soil layer. So the moisture retention capacity of the soil gets increases by reducing the evaporation losses. Plastic mulches are commonly used to modify the soil temperature, moisture regimes, control weeds, deter the immigration of insects, and possibly alter the photobiology of the plant. Plastic mulches primarily affect the field microclimate by modifying the radiation budget of the surface. These microclimate factors strongly affect the soil temperature and soil moisture in the root zone, which in turn, may influence plant growth and productivity. The black mulch treatment, with a water use efficiency of 120 percent  $10.76 \text{ kg/m}^3$ , had the lowest water use efficiency.

#### References

- Akbari, M., Dehghanisani, H. and Mirlatifi, S. M., 2009, Impact of irrigation scheduling on agriculture water productivity. *Iranian J. Irrig. and Drainage*, 1:69-79.
- Badr, M. A., 2007, Spatial distribution of water and nutrients in root zone under surface and subsurface drip irrigation and cantaloupe yield. *World J. Agril. Sci.*, 3(6): 747-756.
- BayeBerihun, 2011, Effect of mulching and amount of water on the yield of tomato under drip irrigation. *J. Hort. and Forestry*, 3(7):200-206.
- Bhatt, R. and Khera K.L., 2006. Effect of tillage and mode of straw mulch application on soil erosion in the sub-mountainous tract of Punjab, India. *Soil and Tillage Res.*, 88: 107-115.
- Glab, T. and Kulig B. 2008. Effect of mulch and tillage system on soil porosity under wheat (*Triticum aestivum*). *Soil and Tillage Res.*, 99:169-178.
- Khurshid, K., Iqbal M., Arif M.S. and Nawaz A. 2006, Effect of tillage and mulch on soil physical properties and growth of maize. *Int. J. Agric. Biol.*, 8: 593-596.
- Kumbar DS, Gasti VD, Raut N, Reddi SG, Gopali JB, Shantappa T, Ganiger VM. Impact of different levels of irrigation and mulches on yield of tomato, water use efficiency, weed density and soil moisture percentage in Northern dry zone of Karnataka.
- Li Y, Zhang Z, Wang J, Zhang M. Soil Aeration and Plastic Film Mulching Increase the Yield Potential and Quality of Tomato (*Solanum lycopersicum*). *Agriculture*. 2022 Feb 14;12(2):269.

Patil, P. P. and Patil, V. S., 2009, Effect of mulching with drip irrigation on summer capsicum yield and economics, *Indian J. of Soil Cons.*, 37(1): 50-54.

Rudich, J., Elassar, G. and Shefi, Y. (1978) Optimal Growth Stages for the Application of Drip Irrigation to Muskmelon and Watermelon. *Journal of Horticultural Science*, 53, 11-15. <https://doi.org/10.1080/00221589.1978.1151478>

Sarkar, S. and Singh S.R. 2007. Interactive effect of tillage depth and mulch on soil temperature, productivity and water use pattern of rainfed barley (*Hordiumvulgare* L.). *Soil and Tillage Res.*, 92: 79-86.

TapaniHaapala, Paulina PalonenAnttiTamminen and JukkaAhokas, 2015, Effect of different mulches on soil temperature and yield of cucumber in the temperature zone. *Agric. and Food Sci.*, 24: 52-58.

Zaman, W.U., Arshad, M. and Saleem A. 2001. Distribution of nitrate-nitrogen in the soil profile under different irrigation methods. *Int. J. Agric. Bio.*, 3: 208-209.

**Table 1. Soil characteristics of the experimental plot**

Soil characteristics	Particulars	Composition
Textural composition	Sand, (percent)	14.68
	Silt, (percent)	40.10
	Clay, (percent)	46.32
	Available N, Kg/ha	180

Chemical properties	Available P <sub>2</sub> O <sub>5</sub> , Kg/ha	15.3
	Available K <sub>2</sub> O, Kg/ha	98.10
	pH	7.90
	EC (dSm <sup>-1</sup> )	0.98
Physical properties	Bulk density, g/cc	1.42
	Field capacity, per cent	23.15
	Permanent wilting point, per cent	10.22
	Infiltration rate, cm/hr	1.53

**Table 2. Effect of different irrigation levels and plastic colour mulches on soil moisture content at different DAT**

Treatments	30 DAT				60 DAT				90 DAT				120 DAT			
	M <sub>0</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>0</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>0</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>	M <sub>0</sub>	M <sub>1</sub>	M <sub>2</sub>	M <sub>3</sub>
<b>I<sub>1</sub></b>	15.81	16.77	16.22	16.09	14.52	15.48	14.93	14.80	16.06	17.02	16.47	16.34	15.01	15.97	15.42	15.29
<b>I<sub>2</sub></b>	16.42	17.86	17.63	17.16	15.13	16.64	16.35	15.88	16.67	18.18	17.89	17.42	15.62	17.13	16.84	16.37
<b>I<sub>3</sub></b>	17.08	17.97	17.74	17.44	15.79	16.69	16.45	16.15	17.33	18.23	17.99	17.69	16.62	17.18	16.94	16.64
<b>I<sub>4</sub></b>	17.21	18.08	17.83	18.02	15.92	16.79	16.54	16.74	17.46	18.33	18.08	18.28	16.41	17.28	17.03	17.23
<b>Mean</b>	16.63	17.97	17.73	17.54	15.61	16.71	16.45	16.26	17.15	18.25	17.99	17.80	16.22	17.20	16.94	16.75
	SEM		CD @5percent		SEM		CD @5percent		SEM		CD @5percent		SEM		CD @5percent	
	0.55		NS		0.40		NS		0.40		NS		0.37		NS	

**Table 3. Effect of different irrigation levels and plastic colour mulches on crop WUE**

<b>Treatments</b>	<b>Yield obtained (q/ha)</b>	<b>CropWUE (kg/m<sup>3</sup>)</b>
I <sub>1</sub> M <sub>0</sub>	604.93	23.04
I <sub>1</sub> M <sub>1</sub>	643.88	24.52
I <sub>1</sub> M <sub>2</sub>	614.22	23.39
I <sub>1</sub> M <sub>3</sub>	564.04	21.48
I <sub>2</sub> M <sub>0</sub>	703.14	20.13
I <sub>2</sub> M <sub>1</sub>	935.45	26.77
I <sub>2</sub> M <sub>2</sub>	876.53	25.09
I <sub>2</sub> M <sub>3</sub>	731.56	20.94
I <sub>3</sub> M <sub>0</sub>	712.13	16.33
I <sub>3</sub> M <sub>1</sub>	836.00	19.17
I <sub>3</sub> M <sub>2</sub>	752.49	17.25
I <sub>3</sub> M <sub>3</sub>	611.84	14.03
I <sub>4</sub> M <sub>0</sub>	584.74	11.18
I <sub>4</sub> M <sub>1</sub>	628.40	12.02
I <sub>4</sub> M <sub>2</sub>	582.58	11.14
I <sub>4</sub> M <sub>3</sub>	562.71	10.76