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Influence of colored plastic mulching and drip irrigation levels on soil temperature, plant growth and fruit quality of tomato (*Solanum Lycopersicum*)

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Abstract

Plastic mulching has significantly enhanced vegetable production worldwide since the 1950. It is used extensively due to its properties improved soil, plant growth, fruit quality properties and low cost. A field experiment was conducted to evaluate the influence of various color plastic mulches (white on black, silver on black and black on silver) and irrigation levels (60, 80 and 100 per cent ET_c) on plant growth parameters and weed suppression in tomato (*Solanum lycopersicum*) cultivation at Madurai district, TamilNadu. The experiment was laid out according to factorial randomized block design with three replications. The results observed were soil temperature increased about 2-4°C under the colored plastic mulches as compared to control plot(Without mulch). Growth parameters of tomato such as plant height, number of branches per plant and leaf area index and total soluble solids of tomato were significantly influenced by colored plastic mulching and different irrigation levels. The maximum plant height (123.2 cm), maximum number of branches per plant (22.8), highest leaf area index (3.01) and highest chlorophyll (56.58) were recorded under white on black plastic mulch with 80 per cent Etc of drip irrigation when compared to other treatments.

Keywords: soil temperature, plastic colour mulches, fruit quality, total soluble solids

Introduction

Polyethylene is used for mulching because of its high strength, elasticity, relatively impermeable, fog obstacles on the soil surface, changing the pattern of heat flow and evaporation (Tripathi and Katiyar, 1984) [24]. Past 10 years use of plastic mulches in agriculture has increased dramatically due to its benefits such as increase in soil temperature, reduced weed pressure, moisture conservation, reduction of certain insect pests, high crop yields and efficient use of soil nutrients (Kasirajan and Ngouajio, 2012) [11]. Variety of colour mulches has been used by growers and researchers in vegetable production. For instance, white plastic mulch has shown to generate cooler soil temperature than black plastic (Diaz-Perez and Batal, 2002) [5]. Park *et al.*(1996) [18] observed an increase of 2.4°C in average soil temperature at 15 cm depth under transparent film and an increase of 0.8°C under black film. The type of PE mulch considerably affects soil temperature at 5 cm depth depending on the mode of mulch heating and heat transferring (Lament, 1993; Soltani *et al.*, 1995; Romic *et al.*, 2003) [16, 21, 19]. (Kumar, 2001) [15] reported that the pod yield of vegetable pea was 42.5, 33.8, and 18.0, per cent more with black polyethylene, white polyethylene and pine needle respectively over control. Though various colour influences the soil temperature and crop growth, color selection of mulch material is been limited to silver on black, white on black and black on silver.

During the year 2016-17, in India tomato crop occupies an area of 799 million hectares with an estimated production of 19.542 million tonnes and Tamilnadu accounts for 17.79 milion hectors and 479.22 Million Tonnes (India, 2018) [10]. To our best knowledge, there is very few acute information published to address the problem, because this was never been the issue of researcher in the country.

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Therefore, thinking the importance of different color mulching in tomato crop, the present study was carried out to study the effect of different color plastic mulching and different irrigation levels on soil temperature, plant growth and fruit quality of tomato.

Materials and Methods

Experimental Site

Field experiments were carried out during the year 2017-18 at Agriculture College and Research Institute, Madurai, Tamil Nadu. The experimental site is geographically located at 9° 54' N latitude and 78° 80' E longitude at an altitude of 147 m above mean sea level.

Details of experimental design and treatments

The field experiment was laid out in a factorial randomized block design (FRBD) with 12 treatments (Table 1). The test crop of hybrid tomato (Ishwarya) was transplanted on 17.11.2017.

Measurement of soil temperature

Soil temperature was measured during the experiment using digital soil thermometer. The soil temperature was taken at 10 cm depth from soil surface for all treatments at 10:00 am and 2:00 pm. Temperature was recorded to know the effect of different mulches on soil temperature which indirectly affect the crop production.

Table 1: Details of different treatments in the experiment

T1 (M1I1)	Black plastic mulch of 25 μ thickness with 60% ET _c
T2 (M2I1)	White on black plastic mulch of 25 μ thickness with 60% ET _c
T3 (M3I1)	Silver on black plastic mulch of 25 μ thickness with 60% ET _c
T4 (M4I1)	Without mulch with 60% ET _c (Control)
T5 (M1I2)	Black plastic mulch of 25 μ thickness with 80% ET _c
T6 (M2I2)	White on black plastic mulch of 25 μ thickness with 80% ET _c
T7 (M3I2)	Silver on black plastic mulch of 25 μ thickness with 80% ET _c
T8 (M4I2)	Without mulch with 80% ET _c (Control)
T9 (M1I3)	Black plastic mulch of 25 μ thickness with 100% ET _c
T10 (M2I3)	White on black plastic mulch of 25 μ thickness with 100% ET _c
T11 (M3I3)	Silver on black plastic mulch of 25 μ thickness with 100% ET _c
T12 (M4I3)	without mulch with 100% ET _c (Control)

Total chlorophyll

Chlorophyll content was measured with (SPAD-502) chlorophyll meter designed by

The Soil Plant Analytical Development (SPAD) section, Minolta, Japan. Measurements were taken from randomly selected plants at 60 days after transplanting.

Growth parameters

Plants were tagged from each treatment for biometric observations such as plant height, number of branches per plant and leaf area index.

Quality parameters

Total soluble solids or brix is the refractometer reading indicating the percentage of dissolved solids restrained in the fruit juice being measured as an indication of sugar content. Vitamin C (Ascorbic acid)(mg/100 g f.w.) was estimated by titration with 2,6- dichlorophenol indophenol dye according to (Sadasivam and Manickam, 2005) [20].

Statistical analysis

From the experiments, data on soil temperature, plant height, number of branches per plant and leaf area index were recorded at 30, 60 and 90 DAT. The data were statistically analyzed and interpreted as described by Panse and Sukhatme (1995) [22].

Results and Discussion

Effect of color of mulch on soil temperature

Due to the effect of colored plastic mulches soil temperature increased 1.5 to 3°C compared to without mulch (Table. 2). The highest soil temperature was recorded in black on silver mulch at 10 am (29.8), 2 pm (33.2) and lowest soil temperature was observed in control plot at 10 am (27.2), 2

pm (29.8). Soil temperature under different colored plastic mulches were higher than the without mulch. Use of darker colors increases soil temperature through superior high temperature absorbance while lighter colors reflect more solar radiation which is likely to minimize changes in soil temperature while increasing the irradiance under the plant canopy.

White on black mulch maintained less soil temperature as compared to without mulch, because they reflect back into the plant canopy most of the incoming solar radiation (Ham *et al.*, 1993; Csizinszky *et al.*, 1997) [9, 4]. Soil warming at early spring favours suitable environment for growth of tomato seedlings and earliness. Optimum temperature in the white on black mulch at the end of growing season increased plants survival. This is in line with findings of (Gough, 2001; Ashrafuzzaman *et al.*, 2011) [7, 2].

Table 2: Average soil temperature (°C) at 10 cm depth during the experimental period

Mulch color/ Time	10.00 AM	2.00 PM	Mean
Black on silver color	29.8	33.2	31.5
White on black color	27.9	31.1	29.5
Silver on black color	28.3	31.9	30.1
without mulch	27.2	29.8	28.5

Total chlorophyll content as influenced by different color mulches

The effect of colored plastic mulches and irrigation levels increased the total chlorophyll content in tomato crop the values are given in table 3. At 60th day after transplanting, the chlorophyll content of white on black color mulch treatment was highest and the control plot was lowest. Similar results were reported by Sun *et al.* (2015) [23] in peanut crop.

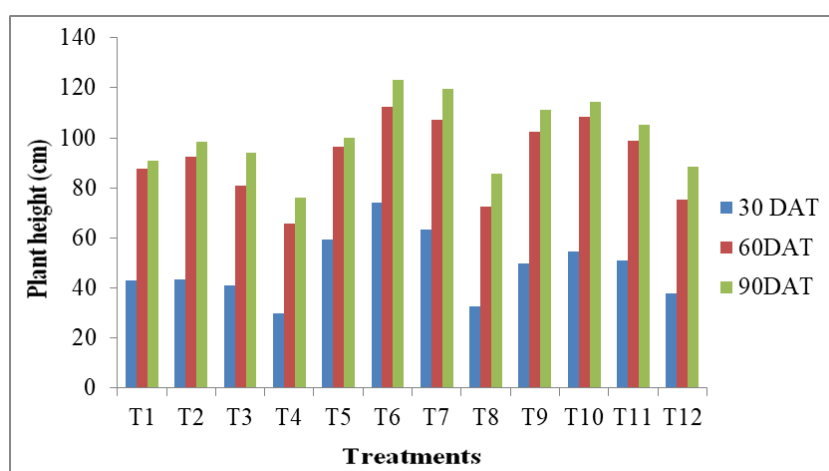
Table 3: Effect of color mulch on fruit quality and SPAD value

Mulch color	TSS (%Brix)	Moisture (%)	Ascorbic acid	SPAD value
Black on silver color	5.55	46.0	44.23	53.4
White on black color	5.69	48.2	48.56	58.3
Silver on black color	5.57	46.35	46.25	53.8
Without mulch	5.12	43.21	41.01	43.3

Plant height

The effect of different colored plastic mulches, irrigation levels and their interaction on plant height are given in the table 4 and shown in fig. 1. The mean value of plant height ranged from 83.5 to 112.1 cm. The highest plant height of 112.1 cm was recorded in the treatment white on black color mulch (M_2) followed by silver on black color mulch (M_3) 6 cm and the lowest plant height of 83.5 cm was recorded in control plot. In the case of irrigation levels, the mean plant height ranged from 90.0 to 107.2 cm. The highest plant height of 107.2 cm was recorded in receiving 80% ET_c (I_2) followed by 100% ET_c (I_3). The study results are in agreement with the results of Gottam Kishore *et al.* (2018) [12].

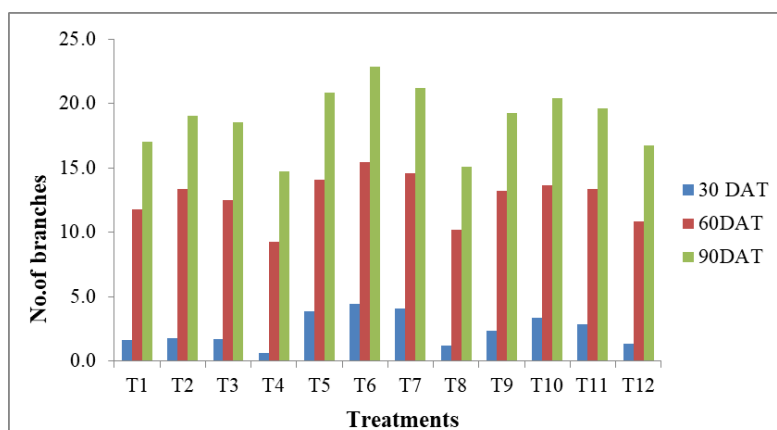
From the results, it was found that the interactive effect of mulches and irrigation levels had a positive influence on the plant height and the values ranged from 76.2 to 123.2 cm. The highest plant height of 123.2 cm was registered in the treatment receiving white on black mulch with 80% ET_c level (M_2I_2). Plastic mulch encourages the early crop emergence, so it increases the biomass production in the early stages of the crop growth than control plot. The plant height in drip irrigation at 80% ET_c might due to the optimum availability of moisture and air at appropriate soil temperature (Gupta *et al.*, 2010) [8]. This further might have facilitated the triggers plant growth and development (vegetative growth).

**Fig:** Treatments 1

Number of branches

The results indicated that the colour of mulch and the irrigation levels increased the number of branches and the mean value ranged from 15.5 to 20.8. The maximum number of branches (20.8) were recorded in the white on black color mulch (M_2) followed by silver on black color mulch (M_3). Among the irrigation levels, maximum number of branches (20.0) were recorded in treatments receiving 80% ET_c (I_2) followed by 19.0 Nos 100% ET_c (I_3) and minimum number of 17.3 Nos per plant was recorded in 60% ET_c (I_3).

In the interaction effect maximum number of branches were observed under drip irrigation level 80% ET_c with white on black color mulch M_2I_2 (22.8) followed by 80% ET_c with silver on black color mulch M_3I_2 (21.2). The results are in concordance with those obtained by Gottam Kishore *et al.* (2018) [12] and Edgar *et al.* (2016) [6]. The effect of colored mulches and irrigation levels on number of branches is presented in table 5 and fig 2.

**Fig:** Treatments 2

Leaf area index

Drip irrigation as well as coloured plastic mulching significantly improved Leaf area index (LAI). Index are calculated and presented in Table 6 at 30, 60, 90 DAT and fig.3. Due to the effect of plastic mulches, the highest LAI value of 2.69 was observed in white on black mulch followed by silver on black mulch (2.58) at 90 DAT. Lowest LAI value of 2.15 was observed in control (M_4).

The LAI at different irrigation levels were recorded higher in drip irrigation with 80% ET_c (2.70) followed by treatment drip irrigation with 100 per cent ET_c (2.47) and drip irrigation with 60 per cent ET_c (2.28) respectively. The results were in

consensus with the findings of Gottam Kishore *et al.* (2018) [12]. However, combination of irrigation levels and colored plastic mulches significantly influenced the leaf area index. Drip irrigation at 80% ET_c with white on black mulch M_{2I_2} registered highest leaf area index of 3.01. This might be due to the production of significantly maximum branches and expansion of leaves as compared to other irrigation levels and mulches. Lowest leaf area index was registered in 60 per cent ET_c with control treatment (2.08). Similar results were also reported by Konyeha *et al.* (2013) [14] and Awal *et al.* (2016) [3].

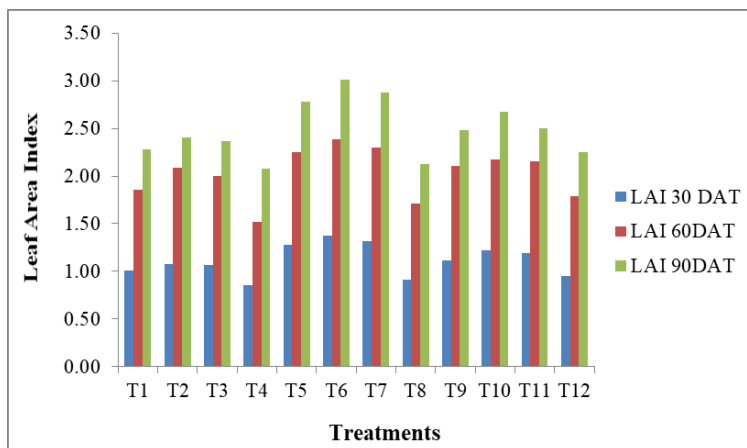


Fig: Treatments 3

Effect of color of mulch on fruit quality

Total soluble solids or brix is the refractometer reading indicating the percentage of dissolved solids restrained in the fruit juice being measured and an indication of sugar content. Influence of colored plastic mulches significantly increases the TSS percentage. The premier value was found in tomato grown with white on black plastic mulch (5.69%) followed by silver on black (5.57%) and black on silver (5.55%). lowest value was registered in control plot with 5.12% (Table.3). The increase in total soluble solids might be due to the exposure of fruit to different environmental conditions such as light, temperature and moisture and their combinations. These environmental factors correlate to the rate of sugar creation disturbing the sugariness of the vegetables and fruits as reported by Kleinhenz and Bumgarner,(2012) [12].

The data on ascorbic acid content indicated the increases of vitamin C under white on black mulch (48.56 mg/100 g) compared to control plot (41.01 mg/100). Among all treatments of mulching, maximum fruit moisture was observed in white on black mulch (48.2%) as compared to control plot (43.21%). The increase in moisture might be due to the mulched plants may further attributed to the reason that plants remain physiologically more active to build up sufficient food stock for the developing fruits. The results are in agreement with that of Moursi (2003) [17] and Aruna *et al.*(2007) [1].

Conclusion

Based on this study, we conclude that different color plastic mulches irrigation levels had significant effect on the plant height, number of branches per plant and Leaf Area Index (LAI). The color of the mulches influenced the soil temperature and the reflectance of the mulch enhanced the fruit quality parameters. Among the colored plastic mulches and irrigation levels, white on black color plastic mulch with

80% ET_c level gave superior performance as compared to other colored plastic mulches.

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