

Original Research Article

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Effect of Mulching on Hydrothermal Regime and Fruit Yield of Tomato (*Lycopersicon esculentum* Mill)

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ABSTRACT

Four mulch types (black polyethylene mulch, transparent polyethylene mulch, straw mulch and un mulched) were evaluated to assess the effect caused on soil temperature, soil moisture and fruit yield of tomato. The experiment was carried out during Kharif season under midhills condition of Himachal Pradesh. The results showed that application of polyethylene mulches significantly influenced the hydrothermal regimes viz., soil temperature and soil moisture. Transparent polyethylene mulched plots of (TPM) recorded an increase in maximum temperature and Black polyethylene mulched plots (BPM) showed increase in minimum temperature as compared to un mulched plots of tomato. Data on soil moisture revealed maximum soil moisture conservation under black polyethylene mulch followed by transparent polyethylene mulch and straw mulch. Black polyethylene mulch recorded 13.08 % higher soil moisture content as compared to un mulched plots. Observations on fruit yield/plot showed yield increase of 50.66 % in plots mulched with black polyethylene mulch over un mulched plots followed by transparent polyethylene mulch. Amongst the various treatments, intra-row aligned plots of 50 micron thickness of BPM (M2) recorded the maximum fruit yield (38.67 kg/plot)

Keywords

Mulching, Soil temperature, Soil moisture, Hydrothermal regime, Polyethylene, Mulch levels, Fruit yield

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Introduction

Crop production is closely related to the varietal type, region, weather conditions of the place, nutrient status, soil productivity and management practices which may influence the microclimate of the crop. Mulching; a important management practice have been reported to improve the growth and yield of vegetable crops through changes in the hydrothermal regime of the soil. Polyethylene mulches have been reported to improve soil moisture status (Vinuta *et al.*, 2016), increase

in soil temperature and reduced light availability (Bakht *et al.*, 2014) control weeds (Abul-Soud *et al.*, 2010) and greater marketable yield (Rajablariani *et al.*, 2012) in vegetable crops. Tomato (*Lycopersicon esculentum* Mill) one of the important members of the solanaceae family is widely grown crop throughout the world. In India the crop is cultivated in an area of 760.1 thousand hectares and 16,385 thousand metric tonnes with a productivity of 24.2 metric tonnes/hectare (Anonymous, 2016). In Himachal Pradesh, tomato is one of the major

off season crop cultivated mostly in the low and mid hills. As such the farmers fetch a premium price by supplying tomatoes during the off season to the plains. Besides diseases and insect pests, weeds are a major contributor to overall losses and problem in its cultivation. The first 3-6 weeks after transplanting is the critical period for weed competition in tomato cultivation and unrestricted weed competition may reduce tomato fruit yield by 40-60 % (Adigun, 2005). Various workers have reported the beneficial effect of both organic mulches viz., straw and inorganic mulches viz., polyethylene mulches on growth and yield parameters in tomato and alteration in the hydrothermal regime of the crops and suppression of weed growth. However research on the influence of various mulch thickness and alignment of polyethylene mulches and its comparison with conventional straw mulch on plant biometrics is limited. In view of the prevalent yield constraining factors and beneficial aspects of different mulches as reported by various workers a field experiment was conducted to examine the role of mulches on hydrothermal regime viz., soil temperature and soil moisture, weed count and fruit yield of tomato var. naveen.

Materials and Methods

Experimental site

The field study was conducted during the Kharif season of 1998 at the Department of Vegetable crops, Dr. Y.S. Parmar University of Horticulture and Forestry Nauni, Solan Himachal Pradesh. The experimental farm situated in Nauni is 15 km away from Solan at 30°-51'N latitude and about 77°-11'E longitude. The place has a elevation of 1260 m above mean sea level and falls under the mid hill zone of Himachal Pradesh. The climate of Nauni is sub temperate to sub-tropical, May and June being the hottest months and December to January the coldest months.

Soil Analysis

Composite soil samples were collected at 0-15 cm depth before transplanting from each replication and analysed for their physico-chemical properties. Physico-Chemical properties of soil revealed the soil as silt-loam in texture, medium in N content, high in P₂O₅ and medium in K₂O content with a pH content of 6.83.

Treatment details

The experimental design was randomized block design and treatments were split into orthogonal components so that the different classes of effect to which the experimental material is subject was capable of direct and separate estimation. The treatments comprised of 10 mulch material combinations with mulch thickness and alignment and replicated thrice. The different treatments were M0- un mulched (UM), M1- Straw mulch (SM), M2m2 -Black polyethylene mulch (BPM) 30 micron (μ) inter- row), M2m3 (black polyethylene mulch 30 μ intra- row), M2m4 (black polyethylene mulch 50 micron (μ) inter- row) M2m5 (black polyethylene mulch 50 (μ) intra- row), M3m6-transparent polyethylene mulch (TPM) 30 (μ) inter-row), M3m7 transparent polyethylene mulch 30 (μ) intra-row), M3m8 (transparent polyethylene mulch 50 (μ) inter-row), M3m9 (transparent polyethylene mulch 50 (μ) intra-row). The data was analysed by procedure followed by Panse and Sukhatme (1985) and results interpreted on basis of F-test and treatments tested at 5 % level of significance.

Cultural practices and observations

Seeds were sown in nursery beds in the month of March and seedling transplanted on first week of May at 4-5 leaf stage. 18 seedlings were transplanted at a spacing of 90 x 30 cm in a plot size of 4.86 m². Fertilizer management was done as per

recommendations. Mulching was done prior to transplanting in May 1998. Straw mulch (SM), polyethylene mulches viz., Black (BPM) and Transparent (TPM) of 30 and 50 μ thickness each were used to cover the experimental plots along with their method of placement i.e. inter row and intra row. Minimum space of at least 4 inches was maintained between 2 successive strips to allow for transplanting. Soil moisture content (%) was determined from 0-15 cm soil depth by gravimetric method by drying soil samples in aluminium boxes in oven at 105⁰C for 48 hrs and data were recorded at fortnightly interval. Soil temperature was observed by fixing platinum resistance thermometers at 5, 10 cm depth. The temperatures in ⁰C were recorded daily for minimum at 0730 hrs and maximum at 1430 hrs. The total yield of marketable fruits harvested from net plot area was recorded and expressed in kg/plot.

Results and Discussion

Soil temperature

As evident from figure 1 and 2 application of different mulch materials significantly influenced the soil thermal regimes at both 5 and 10 cm depth. Soil temperature was found to be higher in plots mulched with TPM, BPM and UM plots than the air temperature whereas it was lower in SM plots. TPM raised the maximum temperature at 1430 hrs by 1.5 to 4.5⁰C and minimum temperature at 0730 hrs by 1.5 to 4.4⁰C over UM plots. The reason attributed is that TPM permits the incoming short wave radiation to pass through but its transmissivity to long wave radiation is highly reduced due to formation of water droplets on its lower surface. In contrast, BPM did not alter appreciably the maximum temperature however it caused an increase in minimum temperature by 1.0 to 3.1⁰C over un mulched plots. This may be due to the fact that BPM absorbs much of the incident radiation due its

black colour but transmits less energy to the soil surface owing to bad conducting air between mulch and the soil surface. In SM plots; a decrease of 0.4 to 3.5⁰C in maximum temperature and increase of 0.5 to 2.7⁰C in minimum temperature was noted over UM plots respectively. Similar observations were noted by Eruola *et al.*, (2012) under grass mulch as compared to UM plots in yams. The decrease in the maximum temperature under SM may be due to the higher albedo as a result of greater conversion of solar energy into evaporative flux and increase in the diffusion path of heat transfer to the soil. The increase in the minimum soil temperature may be due to the reduction in the negative flux from the soil. Similar observations on modification of the soil thermal regimes have been explained in light of views expressed by Ham *et al.*, (1993) and Gupta and Acharya (1993). These results are in consonance with the findings of Ramakrishna *et al.*, (2006) who has reported that polyethylene mulch increased the soil temperature by about 6⁰C at 5 cm depth and 4⁰C at 10 cm depth in groundnut. Research on straw mulching in tomatoes by Kosterna (2014) revealed an increase of 1.3⁰C at 0800 hrs and 1.7⁰C at 1400 hrs as compared to un mulched. Liu *et al.*, (2014) and Abhivyakti *et al.*, (2016) reported an increase of 1-3⁰C in maize and 1-10⁰C in tomato respectively in plots mulched with polyethylene mulches as compared to un mulched. In the present studies soil temperature noted at 10 cm depth followed similar trend as 5 cm depth.

Soil moisture %

The data on soil moisture content under different mulch materials recorded during the cropping period for 0-15 cm soil depth is shown in table 1. The data revealed that the mulch material under investigation was found effective in conserving soil moisture. Figure 1 shows the mean soil moisture recorded under mulches in the order BPM>TPM>SM>NM.

Table.1 Effect of mulch materials on soil moisture content at 0-15 cm depth under different mulch materials for the quarterly period (May-August)

Date	UM	SM	BPM	TPM
17 May	15.20	16.00	18.60	18.31
02 June	15.18	16.20	18.39	17.87
18 June	16.20	16.80	20.35	19.30
02 July	16.50	17.00	19.80	19.00
17 July	17.30	17.70	18.34	18.13
2 August	18.46	18.60	19.39	18.87
17 August	16.00	16.38	17.29	16.84
Total	114.84	118.68	132.16	128.32
Mean	16.41	16.95	18.88	18.33
% increase	-	3.18	13.08	10.47

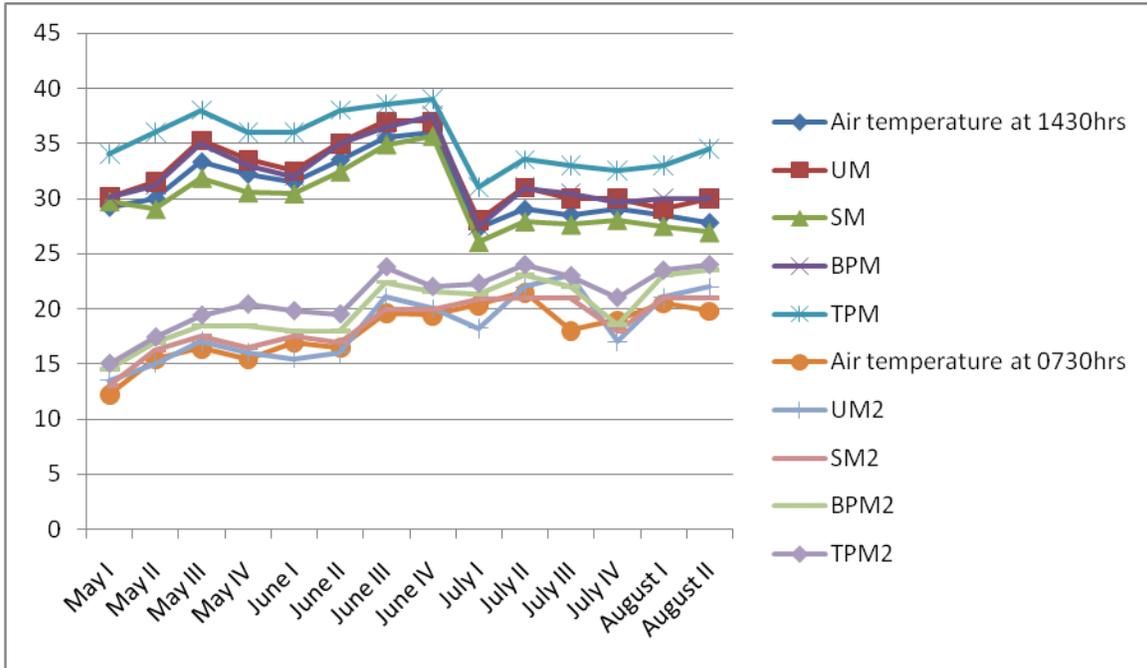
Figures in %, UM = Un-Mulched, SM = Straw Mulch, BPM - Black Polyethylene Mulch, TPM - Transparent Polyethylene Mulch

Table.2 Effect of mulch materials on fruit yield/plot

Thickness	30 μ			50 μ			Overall mean	% yield increase
	Inter-row	Intra-row	Mean	Inter-row	Intra-row	Mean		
Alignment Mulch								
Transparent (M3)	30.83	33.10	31.97	30.33	34.33	32.33	32.15	44.54
Black (M2)	34.57	34.60	34.59	36.73	38.67	37.70	36.14	50.66
Straw (M1)							22.90	22.14
Un mulched (M0)							17.83	-
Comparison								
Mulch	Treatments		SE (d)	CD _{0.05}				
	M0 vs M1		1.50	3.14				
	M1 vs M2		1.18	2.48				
	M1 vs M3							
	M0 vs M3							
	M0 vs M2							
	M2 vs M3		0.75	1.57				
Thickness Levels	T1 vs T2		1.06	2.22				
Alignment Levels	I1 vs I2		1.50	3.14				

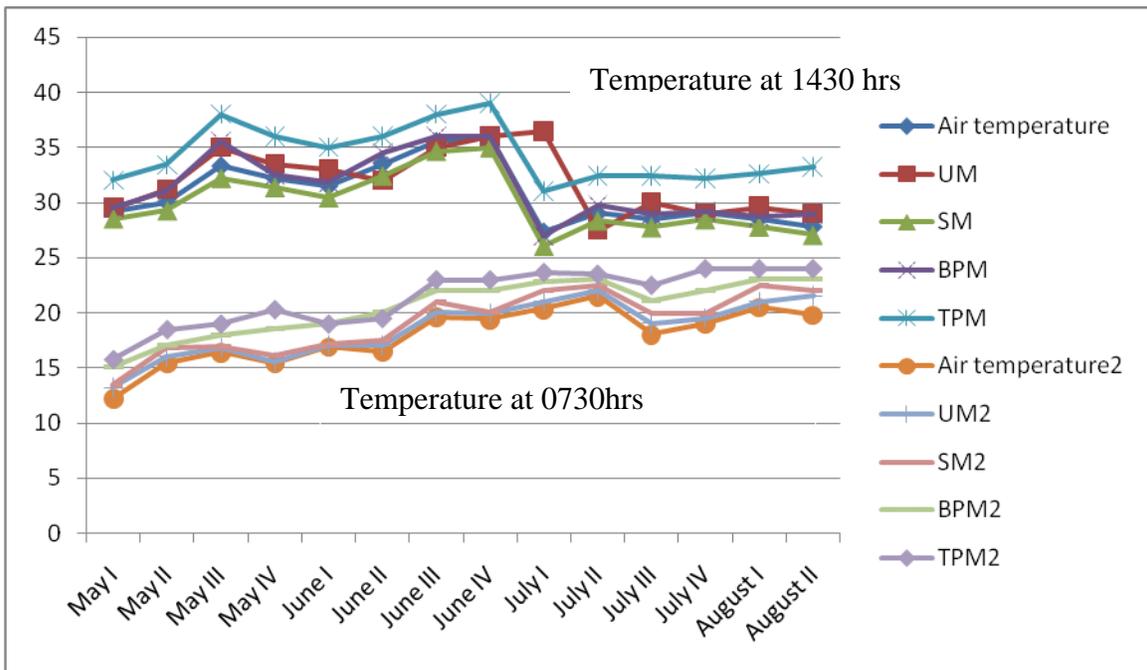
Fruit yield in KG/PLOT, μ=MICRONS

Fig.1 Mean weekly soil temperature at 5 cm depth under different mulch and un mulched treatments



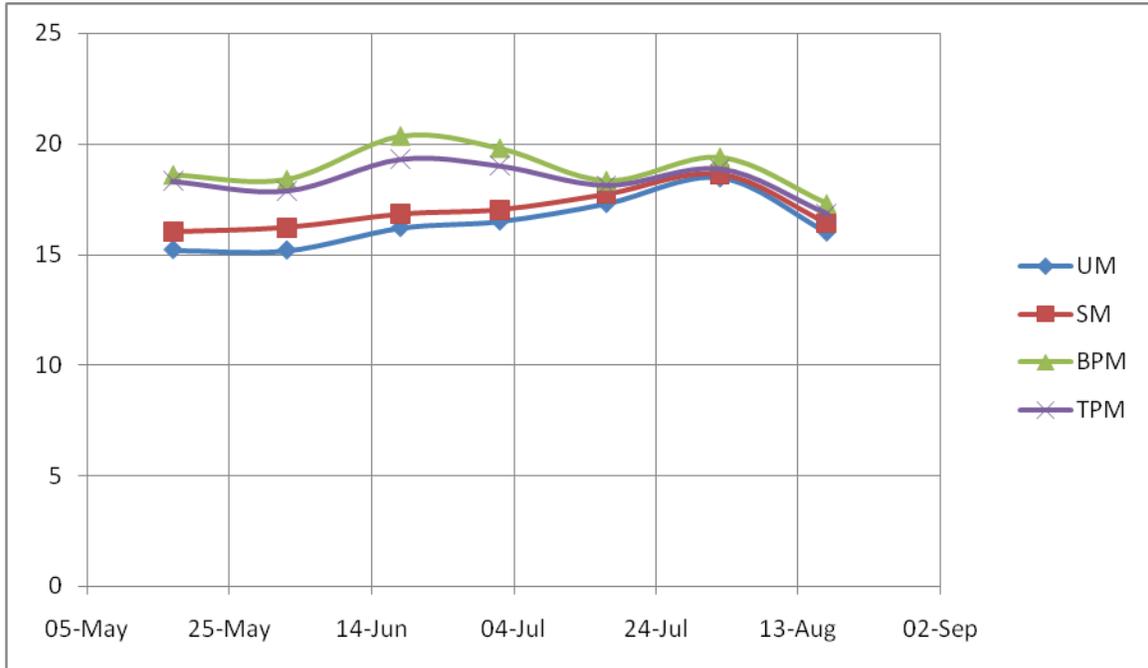
Air temperature and soil temperature at $^{\circ}\text{C}$, UM= un mulched, SM=straw mulch, BPM=Black polyethylene mulch, TPM=Transparent polyethylene mulch

Fig.2 Mean weekly soil temperature at 10 cm depth under different mulched and un mulched treatments



Air temperature and soil temperature at $^{\circ}\text{C}$, UM= un mulched, SM=straw mulch, BPM=Black polyethylene mulch, TPM=Transparent polyethylene mulch

Fig.3 Influence of mulching on soil moisture content (0-15 cm) depth under different mulch materials for the quarterly period (May-August)



Soil Depth at 0-15cm and expressed in percentage: UM = Unmulched, SM = Straw Mulch, BPM = Black Polyethylene Mulch, TPM = Transparent Polyethylene Mulch

Application of BPM retained 13.08 % higher soil moisture as compared to un mulched plots. The corresponding figures for TPM and SM were 10.47 % and 3.19 % moisture content as compared to UM plots (Fig. 3). The higher moisture content noted both under BPM and TPM may be due to formation of impermeable vapour barrier at soil surface as compared to SM which being porous allowed diffusion of water under vapour pressure gradient. These results are in accordance with findings of Alwis *et al.*, (2012) who had reported significant effect on mulching on soil moisture with a moisture content of up to 10.9 % at 30 cm depth under various mulches treatments in pineapple. In line with the present studies, Sun *et al.*, (2014) had reported significant improvement of soil moisture in 0-120 cm depth in watermelon and Teame *et al.*, (2017) at 0-60 cm soil depth in sesame as compared to un mulched. The role of mulch thickness and alignment of

polyethylene mulches was found to be non-significant on soil moisture content in the present investigation.

Fruit yield

The present research showed significant increase in tomato fruit yield in mulched plots as compared to un mulched. Table 2 indicates that yield/plot was found significantly higher in BPM (M2) 36.14 kg/plot followed by TPM (M3) with 32.15 kg/plot. UM (M0) recorded the lowest fruit yield followed by SM (M1). BPM recorded the highest yield increase of 50.66 % over un mulched plots followed by TPM with 44.54 % over um mulched plots. SM recorded a 22.14 % increase in fruit yield over un mulched, the reason being, besides weed control, straw also acted as manure resulting in increased soil fertility. High yield under BPM as compared to other mulches may be due to favourable hydrothermal

regime and weed free environment thereby significantly influencing the fruit set and yield. The low yield under TPM may be due to more number of weeds as compared to BPM. These results support the findings of Ogundare *et al.*, (2015) and Sharma and Goel (2017) whom have reported maximum fruit yield in tomato and strawberry respectively under BPM as compared to other mulches. However contrary findings have been reported by Tegen *et al.*, (2016) wherein workers have reported high fruit yield in plants mulched with straw mulch as compared to black polyethylene mulch and white polyethylene mulch. Tswanya *et al.*, (2017) however reported non-significant fruit yield in plants mulched with various organic material. In the present studies; thickness of polyethylene mulch had played a significant role in influencing the fruit yield. Mean fruit yield data showed that 50 μ thickness of BPM recorded the highest mean fruit yield of 37.70 kg/plot followed by 30 μ thickness of BPM with a fruit yield of 34.59 kg/plot. 50 μ thickness of both BPM and TPM was found to be statistically significant over 30 μ thickness of either mulch type respectively. More moisture under 50 μ thickness could have increased CO₂ level thereby causing photosynthate partitioning to flowering and fruit yield (Decoteau *et al.*, 1989). However contrary findings have been reported by Pandian *et al.*, (2017) and Thenmozhi and Kottiswaran (2017) wherein 25 μ thickness of BPM along with drip irrigation recorded higher chilli fruit yield and capsicum fruit yield as compared to 50 μ thickness of BPM. Further investigations on alignment of mulch revealed that intra-row mulch alignment was significant over inter-row in both BPM and TPM. The combination studies of the sub-treatments showed that 50 μ thickness of BPM aligned intra row recorded the highest fruit yield of 38.67 kg/plot followed by inter-row aligned mulch of the same thickness with 36.73 kg/plot. Further data interpretation

revealed that TPM 30 μ aligned inter-row recorded lowest yield of 30.83 kg/plot at par with TPM 50 μ inter-row with 30.33 kg/plot.

In conclusion, the overall studies had revealed that mulches caused significant effect on the hydrothermal regime by appreciating soil moisture and soil temperature as compared to un mulched plots. Use of BPM recorded 13.08 % higher soil moisture content closely followed by TPM. Polyethylene mulches had recorded raise in maximum temperature in case of TPM and increase of minimum soil temperature in BPM as compared to un mulched treatment. The resulting alteration in the hydrothermal regime had also reflected on the fruit yield. Highest fruit yield was recorded in BPM plots with a yield of 36.14 kg/plot followed by TPM with 32.15 kg/plot. Combination studies had revealed that BPM (M2) with 50 micron thickness aligned intra-row was the best treatment in terms of fruit yield. As such under mid hills conditions of Himachal Pradesh, the practice of mulching particularly with black polyethylene mulch may be recommended for increased tomato fruit yield.

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