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Influence of different mulches on weed count, fruit yield and economics of tomato

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Abstract
Research on weed count studies at fortnightly interval revealed least number of weeds under Black Polyethylene mulch (BPM) followed by Straw Mulch (SM) under midhills condition of Himachal pradesh. BPM also impacted the resulting fruit yield and recorded highest fruit yield of 36.14 kg/plot and 631.78 q/ha followed by Transparent Polyethylene Mulch (TPM) with 32.15 kg/plot and 561.99 q/ha. Further mulch thickness and alignment also significantly appreciated the growth and yield parameters. Analysis of the combined mulch treatments showed that M2m5 (Black polyethylene mulch 50 micron intra-row) as the most effective treatment in terms of yield parameters. Use of BPM recorded the highest BC ratio of 2.49 followed by TPM with 2.05.

Keywords: mulching, polyethylene, soil temperature, soil moisture, weed count, mulch levels, fruit yield

Introduction
Tomato (*Solanum lycopersicum* L.) one of the important members of the solanaceaae family is widely grown crop throughout the world. The midhills condition of Himachal Pradesh with sub-temperate to sub-tropical climate is conducive for the cultivation of tomato during off season (March-August). The cultivation is quite popular amongst the small farmers of the area due to the high net returns. Though cultivation is beset with problems such as availability of irrigation water, quality seeds, labour and pests and diseases. However identification of suitable variety, effective utililization of irrigation water though soil and water management practices and cutting the labour costs may enhance the net returns of the farmers. Mulching an important soil management practice is reported to reduce water use, suppress weed growth (Ramakrishna and Long, 2006) [13] and enhance the soil temperature and soil moisture (Das *et al*., 2015) [3] and improve crop yield in okra (Mahadeen, 2014) [9], chilli (Sathiyamurthy *et al*., 2017) [15], brinjal (Kaswala *et al*., 2012) [8] and tomato (Tipu *et al*., (2015) [16] and (Rashidi and Arabsalmani, 2016) [13]. 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 few workers have reported the influence of various mulch thickness and alignment of polyethylene mulches and its comparison with conventional straw mulch on plant biometrics of tomato. The current investigation focuses the role of various mulch material, thickness levels and alignment on weed count, yield and cost of cultivation of tomato under the prevailing conditions of Himachal Pradesh.

Materials and Methods
The current investigation was carried out 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 ^{0}-51'N latitude and about 77^0 -e zone of Himachal Pradesh. Nauni experiences sub temperate to sub-tropical climate with hottest period during May and June and coldest during December to January. Analysis of the physicochemical properties of the soil was worked out by collection of the soil samples at 0-15 cm depth taking into consideration of the variation of the soil characteristics. The soil as silt-loam in texture with a $_p$H content of 6.83. The available nitrogen was 390.40 kg/ha, phosphorus 52.60 kg/ha, potassium at 255.36 kg/ha. The experiment was laid out as randomized block design and treatments were split into orthogonal components for comparison studies. There were 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

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). Analysis of the data was done by Panse and Sukhatme (1985) [10] method and results interpreted on basis of F-test and treatments tested at 5 % level of significance.

Naveen, an early high yielding indeterminate hybrid variety released by Indo American hybrid seeds India private limited, Bengaluru was the variety under investigation. The 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 m^2. Fertilizer management was done as per recommendations. Mulching was done prior to transplanting in May1998. 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 ie. 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 105^0C 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 ^{0}C were recorded daily for minimum at 0730 hrs and maximum at 1430 hrs. Data on weed count were collected from each net plot of all replicates. For weed count half meter square (0.50 x 0.50 m) was fixed randomly before the emergence of weeds. Total numbers of weeds growing within the area were counted. The observations were recorded 30 days after transplanting. Weed infestation was worked out as per cent reduction over control. The total yield of marketable fruits harvested from per plant and per hectare was recorded and expressed in kg/plot and kg/ha. The cost of cultivation were recorded and expressed as BC ratio for individual treatments.

Results and Discussions

Weed count

Influence of straw mulching and polyethylene mulching on weed count is depicted in fig 1 and table 1 As evident from fig 1, least number of weeds were exhibited in the order BPM >TPM>SM>UM. The data shows that weed numbers were significantly affected by the different mulch materials.

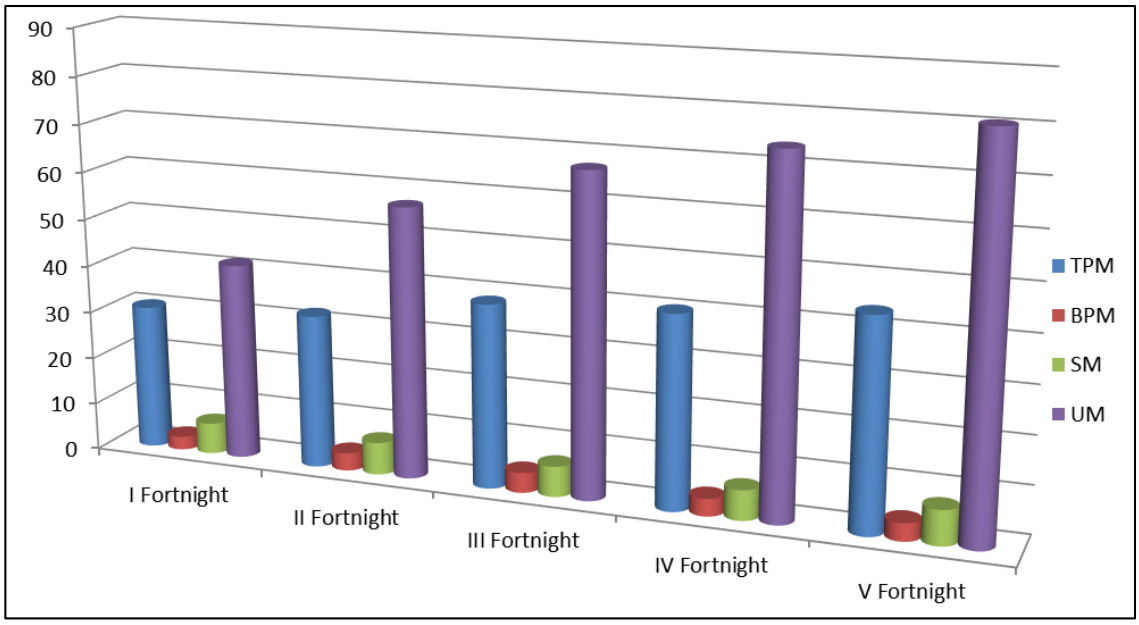

Fig 1: Influence of mulching on weed count under various mulches at fortnightly interval

Table 1: Effect of mulching on weed count at fortnightly interval.

Interval	Thickness	Number of weeds per plot						Overall mean	% weed reduction
		30 µ		Mean	50 µ		Mean		
Fortnight	Alignment Mulch	Inter-row	Intra-row		Inter-row	Intra-row			
I	Transparent (M3)	31.43	32.67	32.05	25.89	32.37	29.13	30.59	26.29
	Black (M2)	3.88	2.64	3.26	3.02	1.66	2.34	2.80	93.25
	Straw (M1)							6.50	84.33
	Un mulched (M0)							41.5	-
	Mean							20.34	
II	Transparent (M3)	33.11	33.11	33.11	31.67	33.03	32.35	32.73	42.46
	Black (M2)	4.73	3.64	4.19	3.06	3.37	3.22	3.71	93.48
	Straw (M1)							6.80	88.05
	Un mulched (M0)							56.88	-
	Mean							25.03	
III	Transparent (M3)	48.92	38.33	43.63	33.00	34.00	33.50	38.57	42.62
	Black (M2)	5.43	4.07	4.75	3.53	3.78	3.66	4.21	93.74
	Straw (M1)							6.40	90.48
	Un mulched (M0)							67.22	-
	Mean							29.10	

IV	Transparent (M3)	48.67	40.33	44.50	34.00	38.67	36.34	40.42	45.38
	Black (M2)	4.67	3.67	4.17	3.00	3.33	3.17	3.67	95.04
	Straw (M1)							6.33	91.45
	Un mulched (M0)							74.00	-
	Mean							31.10	
V	Transparent (M3)	50.33	44.33	47.33	37.67	43.67	40.52	43.93	45.54
	Black (M2)	4.67	3.50	4.09	3.00	3.83	3.42	3.76	95.34
	Straw (M1)							7.33	90.91
	Un mulched (M0)							80.67	-
	Mean							33.92	

	Comparison	SE (d)	$CD_{0.05}$
Time		2.01	2.79
Mulch	M0 vs M1	6.36	12.46
	M1 vs M2	5.03	9.85
	M1vsM3		
	M0vsM3		
	M0vsM2		
	M2vsM3	3.18	6.23
Thickness levels	T1vs T2	4.49	8.81
Alignment levels	I1vs I2	6.36	2.79

µ=micron (thickness of polyethylene mulches)

Mean of the data showed least number of weeds under BPM (3.63/0.25m^2) which was statistically significant over TPM (37.24/0.25m^2) and SM (6.67/0.25m^2). Interestingly straw mulch was statistically superior to TPM in suppressing the weed growth. Un mulched plots recorded the maximum number of weeds (64.05/0.25m^2). Similar results were obtained by Pramanick *et al*., (2006) [12] and Jamkar (2014) [7]. All the mulches were effective in checking the weed growth except TPM. More number of weeds under TPM may be due to the fact that transparent mulch absorbs only 5 % of short wave radiation, reflects 11 % and transmits 84 % radiation (Aman and Rab, 2013)[1]. The cessation of weed growth under mulches might be due to the dark barrier and subsequent photosynthesis inhibition. Low number of weeds under BPM may be due to high temperature and reduced light availability as compared to other mulches (Bakht *et al*., 2014) [2], reduced germination of light responsive seeds and physically blocking the emergence of most weeds (Edgar 2017) [6].

Thickness of mulch also played a significant role on weed count/plot. 50 µ thickness of BPM revealed minimum average number of weeds (3.15/0.25 m^2) which was statistically superior when compared to 30 µ thickness of BPM (4.088/0.25 m^2). Similar trend was observed in TPM wherein 50 µ mulch thickness was better in surpassing weed as compared to 30 µ thickness. The less no of weeds under 50 µ as compared to 30 µ may be due to less penetration of light thereby providing unfavourable environment for growth of weeds. Mulch alignment was also found to have a significant effect on number of weeds/plot. Inter-row alignment at 50 µ thickness of BPM supported minimum average number of weeds 3.12/0.25 m^2 and was at par with intra-row alignment of the same thickness 3.19/0.25 m^2. Inter-row alignment of 30 µ thickness of TPM registered more number of weeds (42.49/0.25 m^2) as compared to intra-row alignment at same thickness of TPM (37.75/0.25 m^2).Weed count data at fortnight interval revealed that weed population was significantly lower on date to first count (20.34/0.25 m^2) and maximum on the date of fifth count (33.92/0.25 m^2). It was further observed that BPM was able to reduce weed growth up to 95.34 % in comparison to un mulched control followed by SM (91.45 %) and TPM (45.54 %).

The weed count under sub-treatments showed corresponding influence on the fruit yield. The effectiveness of the mulch treatments noted for yield attributes were in the order M2 (BPM)>M3 (TPM) >M1(SM) >M0 (UM). Straw mulching in tomato plots caused both significant and non-significant values for the yield parameters as compared to un mulched. The data on weed count as influenced by various type of mulches also exhibited corresponding differences on fruit yield (Table 2).

Table 2: Fruit yield and economics of different mulch materials ₹ /ha recorded in tomato var naveen.

Treatments	Fruit yield Kg/plot	Fruit yield q/ha	Gross income ₹	Expenditure ₹ /ha	Net returns ₹ /ha	B:C Ratio
M0m0 No mulch/control	17.83	311.73	124692	70037.1	54654.29	0.78
M1m1 Straw mulch	22.90	400.29	160116	79296.96	80819.04	1.02
% yield increase over un mulched	28.4					
M2m2	34.57	604.23	241692	71901.06	169790.94	2.36
M2m3	34.60	604.89	241956	71901.06	170054.94	2.37
M2m4	36.73	642.10	256840	73143.17	183696.83	2.51
M2m5	38.67	675.89	270356	73143.17	197212.83	2.70
Mean M2 (Black polyethylene mulch)	36.14	631.78	252711	72522.12	180188.89	2.49
% increase over un mulched	102.70	102.66				
M3m6	30.83	538.97	215588	72767.75	142820.25	1.96
M3m7	33.10	578.59	231436	74587.83	158668.25	2.18
M3m8	30.33	530.23	212092	74587.83	137504.17	1.84
M3m9	34.33	600.15	240060	74587.83	165472.17	2.22
Mean M3 (Transparent polyethylene mulch)	32.15	561.99	224794	74132.81	151116.21	2.05
% increase over un mulched	80.31	80.28	-	-	-	-

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).

Mulched plots showed significant increase in fruit as compared to un mulched plots. Amongst the mulched plots yield/plot and yield/ha was found significantly higher in BPM (M2) 36.14 kg/plot and 631.78 q/ha followed by TPM (M3) with 32.15 kg/plot and 561.99 q/ha. SM (M1) plots exhibited lower fruit yield as compared to polyethylene mulches however it was significantly better than un mulched plots (M0) which recorded lowest yield. As compared to un mulched plots, highest yield increase up to 102.70 % was recorded by BPM plots followed by TPM with 80.31 % yield increase. SM fared better than un mulched plots with a 28.4 % increase in fruit yield, 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 Pinder, *et al*., 2016 [11] and Dhaliwal *et al*., 2017 [5] whom have attributed highest early yield and total yield under BPM as a result of increased temperature, net radiation, better development of roots, vegetative growth and better nutrient uptake. Investigations on the role of thickness of polyethylene mulches on fruit yield revealed a significant trend. 50 µ thickness of BPM (M2) recorded the highest mean fruit yield of 37.70 kg/plot and 675.89 q/ha followed by 30 µ thickness of BPM with a fruit yield of 34.59 kg/plot and 642.10 q/ha. Increase in thickness level had a direct effect on fruit yield and higher thickness of polyethylene mulches 50 µ both under BPM (M2) and TPM (M3) fared significantly better over 30 µ thickness levels. More moisture under 50 µ thickness could have increased CO_2 level thereby causing phytosynthate partioning to flowering and fruit yield (Decoteau *et al*., 1989) [4]. Examination of alignment of mulches revealed that intra-row mulched plots of BPM and TPM were significant over inter-row mulched tomato plants. The combination studies of the sub-treatments showed that 50 µ thickness of BPM (M2m5) aligned intra row recorded the highest fruit yield of 38.67 kg/plot and 675.89 q/ha followed by inter-row aligned mulch of the same thickness(M2m4) with 36.73 kg/plot and 642.10 q/ha. Further data interpretation revealed that TPM 30 µ aligned inter-row (M3m6) recorded lowest yield of 30.83 kg/plot and 604.23q/ha at par with TPM 50 µ inter-row (M3m8) with 30.33 kg/plot and 604.89 q/ha.

Economic analysis

The primary objective of the economic analysis is to determine the relative profitability of the different mulches. Investigations on the economics (table 2) of different mulch materials showed that irrespective of the mulch thickness levels and alignment levels, black polyethylene mulch (M2) recorded highest mean net returns of ₹ 1,80,188.89/ha with B:C ratio of 2.49 followed by transparent polyethylene mulch (M3) with mean net returns of ₹ 1,51,116.21/ha and B:C ratio of 2.05. Control/no mulch (M0m0) recorded the lowest mean returns of ₹ 54,654.29/ha followed by straw mulch (M1m1) with a mean net returns of ₹ 80819.04. Comparing thickness levels 50 micron both under black polyethylene mulch and transparent mulch recorded higher net returns and B:C ratio as compared to 30 micron thickness respt. Investigations on the alignment levels showed that the intra row arrangement of polyethylene mulches (M2m3, M2m5 of black PE mulches and M3m7 and M3m9 of transparent PE mulches respt.) was found to be economical as compared to inter row arrangement of polyethylene mulches. (M2m2, M2m4 of BPM and M3m6, M3m8 of TPM respt.).

Conclusions

From the results discussed in the current study it can be concluded that use of different mulches were effective in reducing the weed count and significantly increased the fruit yield of tomato var naveen. The studies have also demonstrated that for high yield and net returns; black polyethylene mulch at 50 micron thickness was the most suitable for commercial cultivation of tomato under mid hill conditions of Himachal Pradesh.

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