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Influence of Mulching on Growth and Yield of Tomato (*Solanum lycopersicum* L.) under Protected Environment

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Authors' contributions

This work was carried out in collaboration between all authors. Authors PS and PK designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors HS and NSD managed the literature searches, conducted research and collected the data. Author BSS performed the statistical analysis and helped in framing the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To determine the effect of various mulches on growth and yield of tomato and to work out the economics of cultivation under protected environment.
Study Design: Randomized Block Design with three replications.
Place and Duration of Study: Research farm, Department of Vegetable Science and Floriculture, CSK HPKV, Palampur during 2016 and 2016-17.
Methodology: The experiment consists of nine different mulch treatments. The observations were recorded *viz.,* days to 50 per cent flowering, days to first harvest, number of nodes/plant, internodal length, plant height, number of fruits/plant, average fruit weight, yield per meter square, harvest duration, net returns and output: input ratio. Observations were recorded on 5 plants chosen at random in each entry and replication.
Results: Significantly highest fruit yield of 10.9 kg/m^2 was obtained in M_7 i.e. double shaded plastic mulch and was statistically at par with M_6 i.e. black colour plastic mulch (10.2 kg/m^2). Mulch showed

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significant variation in a number of fruits/plant. M_7 i.e. double shaded plastic mulch (40.4) remained statistically at par with M_6 (39.5) and M_1 (38.6) produced significantly more number of fruits/plant. Significantly highest net returns (Rs.147.6/m^2) were observed in M_7, as compared to other mulches.
Conclusion: It can be concluded that use of double shaded and black colour synthetic mulch significantly increased the growth, yield and yield contributing characters in addition to net returns in tomato under the protected environment.

Keywords: Growth; mulches; plant height; protected environment; tomato; yield.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the most popular and widely grown vegetables in the world, ranking second followed by potato. Tomato plays an important role in human nutrition by providing essential amino acids, vitamins and minerals [1] and it is considered a protective food because of its particular nutritive value, as it provides important nutrients such as lycopene, beta-carotene, flavonoids, vitamin 'C' and hydroxycinnamic acid derivatives. Furthermore, this crop has achieved tremendous popularity especially in recent years with the discovery of lycopene's anti-oxidative activities and anti-cancer functions [2] and [3]. Over the last century, tomato as an important vegetable crop has attained a tremendous popularity because it can be grown in most places all over the world, like growing in open fields, greenhouses and net houses. In polyhouse, microclimate surrounding the plant is controlled partially or fully, as per the requirement of the plant species [4]. Protected cultivation of tomato has been gaining importance in Himachal Pradesh from the last 10 years on account of favourable growing conditions inside. Generally consumers do not prefer poor quality vegetable produce, which fetches less price in the market. Hence, techniques like use of synthetic mulches in green houses, low tunnels, high density planting etc. are best alternative to raise the high quality vegetables. Mulching is one of important techniques or practices of covering the soil to make more favourable conditions for plant growth, development and efficient crop production. It also reduces the weed population, moderates soil temperature and improves the microbial activity of the soil by improving the environment around the root zone. Black films, commonly used for this purpose, ensure weed free conditions, limit evaporation and increase soil temperature. Black polyethylene plastic mulch was reported as standard plastic mulch for vegetable production. Polyethylene mulches are widely used in open field conditions also for vegetable production and have contributed significantly to reduce yield losses due to weed competition. On his research on tomatoes, [5] reported a significant difference between mulch treatment on number of tomato fruits, marketable, unmarketable and fruit yield/ha. Research continues on the use of different coloured synthetic mulches, which have distinct optical characteristics and thus reflect different radiation patterns into the canopy of a crop, thereby affecting plant growth and development. Therefore, the present study was conducted to determine the effect of various mulches on growth and yield of tomato under protected environment.

2. MATERIALS AND METHODS

The experiment was carried out in a modified naturally ventilated polyhouse experimental farm of Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during spring-summer 2016 and autumn-winter season 2016-17. The experiment was laid out in a Randomized Block Design (RBD) with three replications, consisting of nine treatments i.e., red colour plastic mulch (M1), yellow colour plastic mulch (M2), blue colour plastic mulch (M3), green colour plastic mulch (M4), transparent plastic mulch (M5), black colour plastic mulch (M6) and double shaded plastic mulch (M7) along with straw (M8) and control (no mulch) (M9). The plot size of experiment was 4.50 m^2 where plants were arranged in row to row and plant to plant spacing of 70 and 45 cm respectively. For the present investigation hybrid Palam Tomato Hybrid-1 was selected and seeds were sown in plastic plug trays by using soilless media having cocopeat, perlite and vermiculite in the ratio of 3:1:1, respectively inside the growth chamber to get healthy and disease free seedlings of tomato. The observations were recorded on the traits *viz.,* days to 50 per cent flowering, days to first harvest, number of nodes/plant, internodal length, plant height, number of fruits/plant, average fruit weight, yield per meter square, harvest duration, net returns

and output: input ratio. Observations were recorded on 5 plants chosen at random in each entry and replication. The data pertaining to the present investigation were statistical analyzed using the standard procedures of the Randomized Block Design (RBD). The treatment effects were tested at 5% level of significance.

3. RESULTS AND DISCUSSION

Plants under M_6 i.e. black colour plastic mulch took lesser number of days (83.2 days) to first picking being statistically at par with plants under M_7 (84.0 days), M_1 (84.1 days), M_3 (84.9 days), M_2 (85.3 days) and M_5 (85.5 days) (Table 1). In the present study, mulches could accelerate the time of harvesting by 4 to 5 days. The reason was that fruits get ripe quicker in following mulches because of increase in temperature of soil and it thereby contributes to the absorption and transfer of minerals to the plant through its roots. Significantly higher number of nodes/plant (39.5), minimum internodal length (6.4) and maximum plant height (245.8) were recorded in M_7 i.e. double shaded plastic mulch (39.5) treatments (Table 2). The more number of nodes/plant in double shaded plastic mulch can be attributed to more plant height which is result of high canopy temperature due to reflecting nature of double shaded mulch increases photosynthesis activity result in more growth and development further short internodal distances increases the number of nodes/plant thus enhance the yield. [6] also recorded higher number of nodes/vine in watermelon plants under double shaded plastic mulch. Short internodal length in double shaded plastic mulch was on account of increased up take of more nutrients and build up of sufficient photosynthates at canopy level of plants [7]. Working on tomatoes attributed these findings to the mulch color`s effects on internodes length suggesting a role for surface reflected light on plant development.

Mulch showed significant variation in number of fruits/plant. M_7 i.e. double shaded plastic mulch (40.4) remained statistically at par with M_6 (39.5) and M_1 (38.6) produced significantly more number of fruits/plant (Table 3). The results are in close conformity with the findings of [8] and [9] who also recorded more number of fruits/plant in double shaded plastic mulch and black colour plastic mulch, respectively. The fruits produced by the plants using M_7 i.e. double shaded plastic mulch (61.7 g) had significantly more average fruit weight (Table 3). Similar findings were also reported by [10]. This was largely due to the increased length and breadth of fruits produced by the plants under particular mulch. The superiority of these mulches in producing highest fruit weight can be attributed to their capability of moisture conservation and nature of producing high canopy temperature. Mulch material had also significant effect on harvest duration which was maximum in M_7 (85.6 days) being statistically at par with M_3 (83.9 days) and M_6 (83.8 days) (Table 4). This might be due to more vegetative and reproductive growth which leads to more number of fruits and hence prolonged harvest duration. Fruit yield/m^2 is a major contributor to the higher productivity of tomato inside the polyhouse. Significantly highest fruit yield of 10.9 kg/m^2 was obtained in M_7 i.e. double

Table 1. Effect of mulch materials on days to 50 per cent flowering and day to first harvest (pooled data of two years)

Treatment	Days to 50 per cent flowering			Day to first harvest		
	2016	2017	Pooled	2016	2017	Pooled
Mulch materials						
M_1	35.8	33.7	34.8	74.3	93.8	84.1
M_2	36.0	34.2	35.1	76.3	94.3	85.3
M_3	35.7	33.5	34.6	76.8	93.0	84.9
M_4	36.2	33.8	35.0	76.7	96.8	86.8
M_5	36.8	33.5	35.2	76.7	94.3	85.5
M_6	34.7	32.3	33.5	74.5	91.8	83.2
M_7	35.2	31.8	33.5	74.5	93.5	84.0
M_8	35.8	33.8	34.8	77.0	96.5	86.8
M_9	35.7	34.7	35.2	78.7	97.2	87.9
SEm±	-	-	-	1.0	1.1	0.7
CD(P=0.05)	NS	NS	NS	2.7	3.1	2.1

NS = Non-significant

Table 2. Effect of mulch materials on number of nodes/plant, internodal length (cm) and plant height (cm) (pooled data of two years)

Treatment	Number of nodes/plant			Internodal length (cm)			Plant height (cm)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Mulch materials									
M_1	31.4	26.7	29.1	7.6	8.3	7.9	238.3	220.4	229.3
M_2	34.9	25.6	30.2	6.8	8.7	7.7	233.8	220.3	230.7
M_3	38.1	28.0	33.0	6.5	8.0	7.3	247.9	224.8	236.3
M_4	32.5	25.5	29.0	6.7	8.2	7.5	217.0	208.5	212.8
M_5	39.1	28.8	33.9	6.0	7.7	7.0	235.0	222.1	228.6
M_6	39.2	29.1	34.1	6.4	7.9	7.2	248.1	230.3	239.2
M_7	45.2	33.8	39.5	5.6	7.1	6.4	250.9	240.7	245.8
M_8	36.1	27.1	31.6	6.8	8.3	7.5	241.1	223.6	228.7
M_9	33.4	28.2	30.8	6.2	7.8	7.0	205.7	218.0	211.9
SEm±	1.2	0.6	0.7	0.2	0.2	0.1	1.2	0.9	0.8
CD(P=0.05)	3.4	1.8	1.9	0.6	0.5	0.4	3.4	2.6	2.1

shaded plastic mulch and was statistically at par with M_6 i.e. black colour plastic mulch (10.2 kg/m^2) (Table 3). The higher fruit yield (kg/m^2) and comparatively better performance of Palam Tomato Hybrid-1 in double shaded plastic mulch could be ascribed to more number of nodes/plant, more number of fruits/plant, maximum average fruit weight, and longer harvest duration. Similar results were reported for fruit yield in black and double shaded mulch has also been reported by [11-14] and [8] respectively. Earlier workers also reported that mulch provides many benefits to crop production through soil and water conservation, enhanced soil biological activity and improved chemical and physical properties of the soil [15-16] and improved microclimate both beneath and above the soil surface [17], effectively controlled the weed growth and increased soil temperature resulting in faster emergence, early canopy development and higher yield [18].

The net profit from the mulched treatment was much higher than from non-mulched treatment (Table 5). Significantly highest net returns (Rs.147.6/m^2) were observed in M_7, as compared to other mulches. The higher returns from the plants under double shaded plastic mulch may be attributed to its better performance w.r.t. yield and related traits, which ultimately resulted in an increase in fruit yield/m^2

Table 3. Effect of mulch materials on fruits/plant, fruit weight (g) and yield per meter square (kg/m^2) (pooled data of two years)

Treatment	Fruits/ plant			Fruit weight (g)			Yield/ meter square (kg/m^2)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Mulch materials									
M_1	40.7	36.5	38.6	53.8	56.2	55.0	9.6	9.0	9.3
M_2	38.3	37.4	37.8	55.7	57.2	56.5	9.7	9.6	9.6
M_3	39.1	35.4	37.3	56.4	59.3	57.9	9.6	9.4	9.5
M_4	38.5	36.5	37.5	54.6	55.4	55.0	9.7	9.1	9.4
M_5	36.9	35.7	36.3	56.0	58.0	57.0	9.3	9.5	9.4
M_6	40.9	38.1	39.5	57.3	59.4	58.3	10.4	10.1	10.2
M_7	42.6	38.3	40.4	58.6	61.7	60.2	11.2	10.6	10.9
M_8	37.0	35.4	36.2	53.5	56.0	54.7	8.9	8.9	8.9
M_9	37.0	36.0	36.5	53.2	53.6	53.4	8.9	8.5	8.7
SEm±	1.2	0.7	0.7	0.5	0.7	0.4	0.3	0.2	0.2
CD(P=0.05)	3.4	1.9	1.9	1.3	2.4	1.2	0.9	0.7	0.7

Table 4. Effect of mulch materials harvest duration (days) and output: input ratio

Treatment	Harvest duration (days)			Output: Input ratio		
	2016	2017	Pooled	2016	2017	Pooled
			Mulch materials			
M_1	72.2	88.7	80.4	2.7	2.5	2.6
M_2	73.0	87.7	80.3	2.7	2.7	2.7
M_3	77.3	90.5	83.9	2.6	2.5	2.6
M_4	72.2	89.3	80.8	2.7	2.5	2.6
M_5	61.8	89.5	75.7	2.5	2.6	2.6
M_6	77.0	90.7	83.8	2.9	2.8	2.9
M_7	77.7	93.5	85.6	3.1	3.0	3.1
M_8	71.2	88.3	79.8	2.6	2.6	2.6
M_9	71.5	84.8	78.2	2.6	2.5	2.5
SEm±	0.9	1.1	0.7	0.1	0.1	0.1
CD(P=0.05)	2.6	3.1	2.0	0.2	0.2	0.2

Table 5. Effect of mulch materials on fruit yield (kg/m^2), cost of cultivation (Rs./m^2), gross returns (Rs./m^2) and net returns (Rs./m^2)

Treatment	Cost of cultivation (Rs./m^2)			Gross returns (Rs./m^2)			Net returns (Rs./m^2		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
				Mulch materials					
M_1	70.4	70.4	70.4	191.8	179.4	185.6	121.4	109.0	115.2
M_2	70.5	70.5	70.5	194.4	191.6	193.0	123.9	121.1	122.5
M_3	72.7	72.7	72.7	191.6	187.9	189.7	118.9	115.2	117.1
M_4	71.1	71.1	71.1	193.7	181.4	187.5	122.6	110.3	116.5
M_5	72.1	72.1	72.1	186.8	190.5	188.7	116.5	120.2	118.3
M_6	70.3	70.3	70.3	207.4	201.0	204.2	135.3	129.0	132.1
M_7	70.2	70.2	70.2	224.1	211.4	217.8	154.0	141.2	147.6
M_8	68.5	68.5	68.5	178.9	178.5	178.7	110.4	110.0	110.2
M_9	67.8	67.8	67.8	178.4	170.7	174.5	110.6	102.9	106.7
SEm±	0.8	0.8	0.8	5.6	1.9	3.0	2.8	2.1	1.8
CD(P=0.05)	2.3	2.4	2.4	16.0	5.4	8.5	8.1	6.0	4.9

and gross return/m^2. Highest Output: Input ratio (3.1) was observed in M_7 being statistically at par with M_6 (2.9) (Table 4 above). The higher Output: Input ratio from the plants under double shaded plastic mulch may be attributed to its better performance in yield per plant which ultimately resulted in an increase in fruit yield/m^2 and net return/m^2. Similarly higher net returns and Output: Input ratio was also reported from plants under double shaded plastic mulch by [8].

4. CONCLUSION

Based upon present results, it can be concluded that use of double shaded and black colour synthetic mulch significantly increased the growth, yield and yield contributing characters in tomato under the protected environment. Plants under double shaded and black plastic mulch had higher number of fruits/plant and maximum yield/m^2. This was due to early days to first harvest and longer harvest duration.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Sainju MU, Dris R, Singh B. Mineral nutrition of tomato. Food Agri Environ. 2003;1(2):176-183.
2. Wu Z, Sun S, Wang F, Guo D. Establishment of regeneration and transformation system of tomato (*Lycopersicon esculentum* Mill.). Journal of Biotechnology. 2011;3(1):53-60.

3. Raiola A, Ragino MM, Calafior R, Frusciante L, Barone A. Enhancing the human promoting effects of tomato fruit fortified food. Corporation Mediators of inflammation; 2014.
DOI: 10.1155/2014/139873
4. Mishra GP, Singh N, Kumar H, Singh SB. Protected cultivation for food and nutritional security at Ladakh. J Defense Sci. 2010;61(2):219-225.
5. Baye B. Effect of mulching and amount of water on the yield of tomato under drip irrigation. J Horti Forestry. 2011;3(7):200-206.
6. Parmar HN, Polara ND, Viradiya RR. Effect of mulching material on growth, yield and quality of watermelon (*Citrullus lanatus* Thunb) Cv. Kiran. Universal J Agril Res. 2013;1:30-37.
7. Rajablariani H, Rafezi R, Hassankhan F. Using colored plastic mulches in tomato (*Lycopersicon esculentum* L.). International Proceedings of Chemical, Biological and Environmental Engineering. 2012;47:12-16.
8. Hedau N. Effect of nitrogen level and mulch material on yield and quality characters of tomato. M Sc Thesis. Department of Vegetable Science, Dr. YS. Parmar University of Horticulture and Forestry, Nauni, India. 1998;24.
9. Rahman MJ, Quamruzzaman M, Samsuddin M. Effect of different mulch materials on growth and yield of tomato. Bangladesh Horticulture. 2016;2:29-37.
10. Mutetwa M, Mtaita T. Effect of different mulch colors on cucumber production. J Glob Innov Agric Soc Sciences. 2014;2(4): 178-184.
11. Singh R. Influence of mulching on growth and yield of tomato (*Solanum lycopersicum* L.) in North Indian Plains. J. Veget Sci. 2005;32:55-58.
12. Mukherjee A, Kundu M, Sarkar S. Role of irrigation and mulch on yield, evapotranspiration rate and water use pattern of tomato (*Lycopersicon esculentum* L.). Agricultural water Management. 2010;98:182-189.
13. Singh AK, Kamal S. Effect of black plastic mulch on soil temperature and tomato yield in mid hills of Garhwal Himalayas. J Horti Forestry. 2012;4:78-80.
14. Ogundare SK, Babatunde IJ, Etukudo OO. Response of tomato variety (Roma) yield to different mulch materials and staking in Kabba, Kogi state, Nigeria. J Agril Studies. 2015;3:61-70.
15. Kumar SD, Lal BR. Effect of mulching on crop production under rainfed condition: A Review. Int J Res Chem Environ. 2012;2 (2):8-20.
16. Mahadeen AY. Effect of polyethylene black plastic mulch on growth and yield of two summer vegetable crops under rain-fed conditions under semi-arid region conditions. Am J Agric and Biol Sci. 2014; 9(2):202-207.
17. Mondani F, Golzardi F, Ahmadvand G, Ghorbani G, Moradi R. Influence of weed competition on potato growth, production and radiation use efficiency. Notulae Scientia Biologicae. 2011;3(3):42-52.
18. Bakht T, Khan IA. Weed control in tomato (*Lycopersicon esculentum* Mill.) through mulching and herbicides. Pak J Bot. 2014; 46(1):289-292.

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