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Impact of different mulching material and weed management practices on weed dynamics, growth, fruit yield and economics of tomato (*Solanum lycopersicum*)

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Abstract
A field experiment was conducted to assess the impact of different mulching practices on growth and yield of tomato (*Solanum lycopersicon*) at College of Horticulture, Rajendranagar, Hyderabad, Telangana during 2015. The experiment was laid out in Randomized Block Design with seven treatments in three replications. Growth and fruit yield (28.37 tha^{-1}) were highest under black polythene mulch followed by reflective polythene mulch. Similarly, weed density, weed dry weight and weed control efficiency were significantly lowest with black polythene mulch at 20 and 40 Days after transplanting (DAT) while paddy husk recorded significantly lowest weed control efficiency. Highest Benefit Cost ratio (2.10) was recorded in black polythene mulch whereas lowest (1.04) was recorded in unweeded plot. These results indicated that black polythene mulch and reflective polythene mulch were effective for better growth and yield in tomato.

Keywords: mulching, growth, yield, weed count, economics, tomato

Introduction
Tomato (*Solanum lycopersicum*) is one of the important commercial vegetable crops widely grown throughout India and being cultivated by small and marginal farmers in Telangana. Lycopene, the red pigment of tomato, phenols and flavonoids have received great interest during the last few years because of their antioxidant properties in relation to free radicals suggesting protective roles in reducing risk of chronic diseases such as cancer and cardiovascular diseases (Rao and Agarwal, 2000). Though tomato cultivation is beset with problems such as non- availability of quality seed, irrigation water and pests and diseases, identification of suitable variety, effective utilization of irrigation water, soil and water management practices may enhance the net returns of the farmers. (Nair, 2018) [11]. Mulching is an effective method of manipulating crop growing environment to increase yield and improve product quality by controlling weed growth, ameliorating soil temperature (Arun *et al.* 2020) [1], conserving soil moisture (Das *et al*., 2015) [6], reducing soil erosion, improving soil structure and enhancing organic matter content (Awodoyin and Ogunyemi, 2005) [2]. Considering the importance of tomato, effect of weeds in terms of yield reduction, expenditure on their control and the many options available for weed control, farmers in India need more information about the effectiveness and economics of methods for managing weeds in tomato. Hence the present study has been undertaken to assess the impact of different mulching practices on performance of tomato.

Material and Methods
The experiment was carried out at College Farm, College of Horticulture, Rajendranagar, Hyderabad during 2015 using tomato cv. Arka Vikas in a randomized block design with three replications consisting of seven treatments *viz.*, T_1 - Control (Unweeded check), T_2 - Recommended practices for weed management in tomato (Pendimethalin (PE) @1.0 kg a.i. ha^{-1} + hand weeding at 30 DAT), T_3 - Black polythene mulch (30 microns) T_4 - Reflective polythene mulch (30 microns), T_5 - Paddy straw mulch (10 cm thickness), T_6 - Paddy husk mulch (5 cm thickness) and T_7 - Hand weeding two times (20 DAT & 40 DAT). Thirty days old seedlings were transplanted at the spacing of 60 cm x 50 cm. Black polythene and reflective polythene mulch of 30 microns thickness were spread over on raised plots of T_3 and T_4 treatments respectively. For the purpose of transplanting seedlings, holes of 4–5 cm diameter were made in the film at the recommended spacing and 3–5 cm of moist soil was put at the base of stem of transplanted seedling to conserve moisture and temperature. Paddy straw

mulch of 10 cm thickness was created manually by spreading straw as carpet on raised plots of T_5 treatment 5 days after planting. Paddy husk mulch of 5 cm thickness was also created similarly on raised plots of T_6 treatment. Mulch material was kept in the respective plots until the final harvest of tomato. For establishment of the crop, a light irrigation was given immediately after transplanting. All the later irrigations were given using drip irrigation. The crop was raised as per the recommended package of practices of tomato and need based plant protection measures were taken to raise the healthy crop. Data were collected on five randomly selected plants in each plot and replication and the recorded data were analyzed statistically by the technique of Analysis of Variance and significance was tested at 5% level of significance (Gomez and Gomez, 1984) [8].

Weed density: In each experimental plot, two quadrates of 1 x 1 m were selected in the middle of plot and the weeds from each quadrate were counted. The weed density was expressed as number per square meter.

Weed dry matter: Weed samples were taken from the sampling area and dried in shade for 2 days, followed by sun drying for 3 days. After sun drying, the samples were kept in oven at 70°C till they recorded the constant weight and dry weight of weeds was recorded for each treatment and expressed in g m^{-2}.

Weed control efficiency: The weed control efficiency (WCE) was calculated by the following formula suggested by Patil and Patil 1993 [13] and expressed in percentage.

$$WCE = \frac{DMC - DMT}{DMC} \times 100$$

Where, DMC, DMT = Dry Matter of weed in control and treated plot,

WCE=Weed Control Efficiency

Weed index: The weed index (WI) was worked out as per Gill and Vijay Kumar 1966 [7] and expressed in percentage.

$$WI = \frac{X - Y}{X} \times 100$$

Where,
X = yield from minimum weed competition plot
Y = yield from the treated plot
WI= Weed index.

Results and Discussion

Weed Density: The black polythene mulch (T_3) has recorded significantly lowest weed density at 20 DAT (3.73 m^{-2}) and 40 DAT (5.60 m^{-2}) which was on par with reflective polythene mulch (T_4) at 20 and 40 Days after transplanting (Table 1). Unweeded /Control has recorded highest weed density of 39.93 m^{-2} and 42.10 m^{-2} at 20 and 40 DAT respectively. As black polythene mulch act as physical barrier and prevents light to enter the soil, which ultimately checks the weed seed germination and growth hence, the weed density was minimum. Low number of weeds under black polythene mulch may be due to high temperature and reduced light availability compared to other mulches (Mishra *et al.*, 2020) [10]. These results are in line with the earlier workers, Ngouajio *et al.*, 2008 [12] who reported complete elimination of weeds with the use of black polyethylene mulch.

Table 1: Effect of different mulches and weed management practices on weed growth in tomato

Treatment	Weed density (number m^{-2})		Weed dry matter (g m^{-2})		Weed Control Efficiency (%)		Weed Index (%)
	20 DAT	40 DAT	20 DAT	40 DAT	20 DAT	40 DAT	
T_1 - Control (Unweeded check)	39.93 (6.39)	42.10 (6.56)	29.37 (5.50)	74.07 (8.66)	0.00	0.00	48.38
T_2 - Pendimethalin (PE) @1.0 kg a.i. ha^{-1} + hand weeding at 30 DAT.	13.83 (3.85)	21.47 (4.74)	9.10 (3.17)	25.07 (5.10)	68.77	66.15	10.13
T_3 - Black polythene mulch	3.73 (2.17)	5.60 (2.56)	2.37 (1.83)	7.27 (2.87)	91.93	90.18	0.00
T_4 -Reflective polythene mulch	3.93 (2.21)	6.17 (2.67)	3.37 (2.08)	7.97 (2.99)	88.37	89.24	3.33
T_5 - Paddy straw mulch	18.50 (4.41)	25.83 (5.17)	14.07 (3.88)	35.73 (6.06)	51.96	51.71	23.82
T_6 - Paddy husk mulch	18.83 (4.45)	26.20 (5.21)	14.90 (3.98)	36.87 (6.15)	48.95	50.21	25.26
T_7 - Hand weeding two times (20 DAT & 40 DAT)	13.67 (3.82)	20.71 (4.65)	8.90 (3.14)	24.83 (5.08)	69.54	66.45	13.16
SE (m)±	0.08	0.08	0.07	0.05	-	-	-
CD at 5%	0.26	0.25	0.23	0.17	-	-	-

*Figures in parenthesis are indicating transformed values

Weed dry matter: Significantly lowest weed dry matter at 20 DAT (2.37 gm^{-2}) and 40 DAT (7.27 gm^{-2}) was recorded by Black polythene mulch (T_3) which was on par with reflective polythene mulch (T_4) at 20 DAT and 40 DAT while control (T_1) has recorded highest weed dry matter (Table 1). These results showed that use of black polythene mulch could be an excellent method for weed control as minimum weed dry matter was observed. The results are in agreement with the findings of Rajablariani *et al.*, 2012 [14] in tomato.

Weed control efficiency: Highest was observed at 20 DAT (91.93%) and 40 DAT (90.18%) in black polythene mulch (T_3) which was followed by reflective polythene mulch (T_4) while Paddy husk mulch (T_6) recorded lowest weed control efficiency Table 1). Lesser weed germination and weed infestation by restricting the penetration of solar radiation under black polythene mulch resulted in higher weed control efficiency. Similar results were reported by Bakht *et al.*, 2014 [3] in tomato.

Growth and yield of Tomato

Black polythene mulch (T_3) has recorded significantly highest plant height (90.47cm), number of branches per plant (9.50), less number of days to 50% flowering (33.47), less number of days to first harvest (60.93) and longest fruiting period (122.33) which was at par (Table 2) with reflective polythene mulch (T_4). Maximum growth in terms of plant height, more number of branches, early flowering and fruiting and long

harvesting period in black polyethylene mulch might be attributed to suppression of weed growth, reduced fertilizers loss due to leaching and increased mineral nutrient uptake through improved root temperatures. These results are in conformity with those reported by Bora and Babu (2014) [5] in tomato.

Table 2: Effect of different mulching and weed management practices on growth and yield of Tomato

Treatments	plant height (cm)	No. of branches per plant	Days to 50% flowering	Days to first harvest	Days to last harvest	No. of fruits/ plant	Average fruit weight (g)	Fruit yield per plant (kg)	Fruit yield per hectare (t)
T_1 - Control (Unweeded check)	71.20	7.40	40.43	74.00	110.23	14.40	43.03	0.62	14.62
T_2 - Pendimethalin (PE) @1.0 kg ai. ha^{-1} + hand weeding at 30 DAT	86.03	8.57	36.80	64.67	113.33	25.67	53.57	1.33	25.46
T_3 - Black polythene mulch	90.47	9.50	33.47	60.93	122.33	32.47	57.37	1.83	28.37
T_4 -Reflective polythene mulch	88.77	9.37	34.20	62.20	120.37	29.53	55.60	1.60	27.44
T_5 - Paddy straw mulch	81.83	8.47	38.73	66.87	117.70	21.23	49.67	1.04	21.62
T_6 - Paddy husk mulch	78.10	8.43	39.53	67.73	118.47	20.20	49.07	1.00	21.15
T_7 - Hand weeding two times (20 DAT & 40 DAT)	86.87	8.77	37.20	65.67	114.10	23.10	54.93	1.25	24.59
SE (m)±	1.46	0.15	0.58	0.69	1.05	0.89	0.56	0.03	0.96
CD at 5%	4.56	0.47	1.82	2.17	3.29	2.78	1.76	0.10	3.00

The results from Table 2 indicated that significantly more number of fruits per plant (32.47), highest average fruit weight (57.37 g), highest fruit yield per plant (1.83 kg) and fruit yield per hectare (28.37 t) were recorded under Black polythene mulch (T_3) which was on par with reflective polythene mulch (T_4) for fruit yield (27.44 t ha^{-1}) and T_2- pendimethalin (PE) @ 1.0 kg a.i ha^{-1} + hand weeding at 30 DAT (25.46 t ha^{-1}) whereas control (T_1) has recorded lowest fruit yield per hectare (14.62 t ha^{-1}). These results are also in agreement with those of Sarkar and Singh (2007) [16] who concluded black plastic mulch reduced leaching of nutrients, reduced weed problems, reduced evaporation of soil water and increased water use efficiency. Arun *et al.*, (2020) [1] also reported that black polythene mulches are more effective in increasing soil temperature due to greater net radiation so that plants can increase growth resulting in earlier and higher yields compared to bare soil. The effect of mulching material on fruit yield per plant in this study is in agreement with those reported by Bhujbal *et al*., (2015) [4] in tomato.

Benefit Cost Ratio

Economics of different mulching practices (Table 3) showed that black polythene mulch(T_3) has recorded highest net returns of Rs 96,122ha^{-1} with B:C ratio of 2.1 followed by reflective polythene(T_4) mulch with mean net returns of Rs 91,472 ha^{-1} and B:C ratio of 2.0. Control/unweeded (T_1) has recorded lowest mean net returns of Rs 37,372/ ha with B:C ratio of 1.04. These results are in conformity with the findings of More *et al*., (2014) [9] and Nair (2018) [11].

Table 3: Effect of different mulching and weed management practices on Benefit: Cost ratio of tomato

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1 - Control (Unweeded check)	35,728/-	73,100/-	37,372/-	1.04
T_2 - Pendimethalin (PE) @1.0 kg a.i. ha^{-1} + hand weeding at 30 DAT.	42,778/-	1,27,000/-	84,222/-	1.96
T_3 - Black polythene mulch	45,728/-	1,41,850/-	96,122/-	2.10
T_4 -Reflective polythene mulch	45,728/-	1,37,200/-	91,472/-	2.00
T_5 - Paddy straw mulch	41,728/-	1,08,100/-	66,372/-	1.59
T_6 - Paddy husk mulch	41,328/-	1,05,750/-	64,422/-	1.55
T_7 - Hand weeding two times (20 DAT & 40 DAT)	43,728/-	1,22,950/-	79,222/-	1.81

Price of tomato fruits – Rs.5 kg^{-1}

Conclusions

From the present investigation it can be concluded that use of black polythene mulch followed by reflective mulch benefited the crop with minimum weed density, weeds dry matter and maximum weed control efficiency, highest plant height, number of branches, minimum days to 50% flowering and first fruit harvest, maximum harvest period, highest number of fruits per plant, average fruit weight, fruit yield per plant and per hectare and ultimately resulting in maximum gross returns, net returns and Benefit Cost ratio.

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