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Effect of Mulching on Growth, Yield and Economics of Watermelon (*Citrullus lanatus* Thunb)

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Abstract To study the effect of different mulching material and mulch color on growth and yield of watermelon an experimental investigations have been undertaken during 2015-16. Organic mulch (paddy straw) and six different colors plastic mulch films of 30 micron were used in the study by adopting drip irrigation. Plant growth and yield parameters were found to be higher with silver polyethylene mulch while, plants without mulch (control) resulted poor growth and yield. Water and fertilizer use efficiency were found to be 60% higher over the no mulch condition. Economic analysis of the study indicated that the adoption of silver mulch in watermelon production resulted in highest net returns.

Keywords Plastic mulch, Watermelon, Water, Fertilizer use efficiency.

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Introduction

Watermelon (*Citrullus lanatus* Thunb.) is one of the important cucurbitaceae vegetable crops grown extensively in India and in tropical and sub tropical countries of the world. India has favorable ecological conditions for enough production of vegetables for her growing human populations, but the resource poor farmers are facing serious problems of price fluctuations, inclement weather conditions such as dry spell, moisture shortage, high temperature and solar radiation regimes, glut due to poor storage conditions, biotic and abiotic stresses, scourge of high pest and disease incidence, physiological disorders such as fruit crack and sun scotch, all of which affect vegetable crop production in India. In view of this, some cultural practices such as mulching is used to regulate the soil temperature, moisture content, weeds, pests and diseases control. It is known that plant development and yield increase occur with balance of soil temperature when there are differences between night and day time temperatures, in which mulching plays great role, to increase yields, promote early harvest. reduce fruit defects, reduce evaporation from the soil surface, prevent weed growth, modify soil temperature and reduce insect number in vegetable production [1], the effectiveness of which depends on the type of mulching materials used.

The greatest benefit from plastic mulch is that the soil temperature in the planting bed is raised, promoting faster crop development and earlier harvest. Black plastic mulch can give a harvest earlier by some

7-14 days, while clear plastic may advance the harvest date by 21 days. Soil water loss is reduced under plastic mulch. As a result, more uniform soil moisture is maintained and irrigation frequency can be reduced. The growth of plants on mulch can be twice that of plants in un-mulched soil. Because larger plants will require more water, mulching is not a substitute for irrigation. Black and white on black mulches will reduce light penetration to the soil. Weeds cannot generally survive under such mulch. Excess water runs off the impervious mulch. Fertilizer beneath the mulch is not lost by leaching, so that fertilizers are optimally used and not wasted. The soil under plastic mulch remains loose, friable and well-aerated. Roots have access to adequate oxygen and microbial activity is enhanced. Cultivation is eliminated, except in the area between the mulched strips. Plastic mulch has been reported to increase watermelon stem growth early and total yields [2]. The effect of mulch color on crop yield has been studied on several crops including tomato and pumpkin [3].

Therefore, considering the importance of different mulching in various vegetable crops, the present investigation was carried out study the effect of different mulching material on growth, yield, water and fertilizer use efficiency of watermelon.

Materials and Methods

Description of study area

The research work was carried out at ICAR Central Institute of Agricultural Engineering, Bhopal. Soils of the experimental site are classified as heavy clay soils with clay content varying between 49.7 to 53.7% and with the field capacity ranging from 28.5 to 31% which was situated at North of Bhopal at $77^0 24´ 10´´$ E, $23^0 18´ 35´´$ N at an elevation of 495 m above mean sea level. The climate of Bhopal is pleasant throughout the year. During winter, ambient temperature varies between 10^0C and 25^0C and in summer ambient temperature between 25^0C and 44^0C. The annual rainfall in the region is about 1200 mm.

Layout of experimental design

The drip irrigation system having gravel filter, screen filters. Main line 90 mm in diameter (OD) sub-main lines with 75 mm diameter (OD) were connected to deliver irrigation water through LDPE laterals of 16 mm (OD) of 40 m length, on-drippers with discharge of 21ph spacing a 1.5 m. The irrigation system was operated at 1.0 kg/cm^2 pressure. The experimental treatments include the different colors of mulch. The layout details of the experimental design are shown as in Figure 1.

Fig. 1. Layout of experimental field.

Details of crop

Field experiments were conducted on watermelon crop belongs to cucurbitaceae family Sugar baby variety. Plant growth beds were prepared 1.5 m apart from each other. Different color polyethylene mulches were laid down on the beds and holes were opened at 1 m × 1 m for planting of the seedlings. Thirty days old seedlings prepared in portrays were transplanted in the first week of January in experimental plots. The required cultural practices were made during the growing period. The soil temperatures at 10 cm depth of different treatments were recorded at 14.00 h during growing periods of the plants.

The experiment was laid out in randomized block design with three replications. There were total eight treatment of mulching materials viz., control (T_1), paddy straw (T_2), yellow mulch (T_3), pink mulch (T_4), blue mulch (T_5), red mulch (T_6), black mulch (T_7) and silver mulch (T_8). The thickness of all polyethylene mulch was 30 micron.

Inorganic fertilizers were applied in all the treatments for the recommended doses of 200:100:100 kg/

ha NPK using urea, DAP, MOP and other water soluble fertilizers such as urea phosphate (17:44:0), sulfate of potash (0:0:50) and 19:19:19 were also applied. Half portion of nitrogen, potassium and phosphorus were applied at the time of transplanting and remaining fertilizers were applied after each 15 days interval.

Data collection

Five plants were randomly selected from each experimental plot for recording no. of lateral branches, vine length, number of fruits per plant, soil temperature, fruit weight, fruit width, fruit length and total yield (t/ha) were recorded.

Plant morphological data

No. of lateral branches and vine length were measured by the meter scale. Chlorophyll content was measured with a SPAD-502 chlorophyll meter (Konica, Minolta), which measures chlorophyll content in arbitrary units. Measurements were taken from apical leaves at 45 days after transplanting from the bottom of the plants. Soil temperature was measured by soil thermometer at a depth of 10 cm.

Water use efficiency and fertilizer use efficiency

Water productivity of each treatment was calculated using the following equations :

Water Use Efficiency (WUE) (kg/ha-mm) =CY/CW

Where CY=Crop Yield (kg/ha), CW=Water applied through irrigation (mm).

Fertilizer Use Efficiency (FUE) (%) = CY/FA

CY = Crop Yield (kg/ha), FA = Total fertilizer applied (kg/ha).

Results and Discussion

Effect of different color of mulch on growth and yield attributing characters

The results showed that different types of mulching materials significantly influenced the growth parameters of watermelon viz., number of lateral branches per vine and main vine length over control. Among different mulching treatments, T_8 (silver plastic mulch) resulted higher number of branches per vine (12.1) as well as increased main vine length (136.4 cm). However control recorded the minimum growth. The increase in growth parameters was attributed to sufficient soil moisture near root zone resulted from minimization of evaporation loss as well as reduced weed growth due to mulching. The extended retention of moisture and availability of moisture also lead to higher uptake of nutrient for proper growth and development of plants, resulted higher growth of plant, as compared to no mulch condition. The changes in soil temperature below plastic mulch could be attributed to different manners of heating and heat transfer to soil and also to heat accumulation during day and loss during night. Similar findings have also been

Table 1. Effect of different color of mulch on growth and yield parameters.

Treatments	No. of lateral branches	Main vine length (cm)	SPAD value	Soil temp (^{0}C)	Length of fruits (cm)	Width of fruits (cm)	No. of fruits	Fruit weight (kg)	Yield t/ha
Open field	5.9	98.9	40.95	32.45	15	40	1.1	2	15.31
Paddy straw	6.7	100.2	42.87	32.33	25.5	50.3	1.5	3	21.33
Yellow mulch	9.3	103.6	47.26	31.86	30.5	55.1	1.6	3.1	24.71
Pink mulch	9.5	108.8	47.67	31.42	30.6	55.3	1.7	3.4	25.66
Blue mulch	9.6	112.3	49.37	31.06	32.4	55.4	1.8	3.5	27.51
Red mulch	10.2	114.1	51.95	30.75	32.7	56.2	2.4	3.6	29.87
Black mulch	10.7	123.7	53.66	30.42	33.6	57.2	2.8	4.5	32.44
Silver mulch	12.1	136.4	59.33	20.11	35.9	60	2.8	5.2	35.57
SEm ±	1.70	12.56	6.56	4.23	2.56	2.68	0.25	0.89	4.23
CD (0.05%)	5.08	37.50	19.60	NS	7.62	8.0	0.72	2.63	12.61

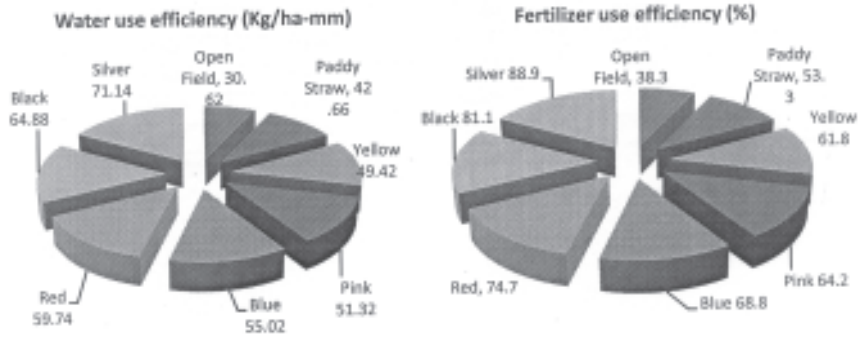

Fig. 2. Water use efficiency (kg/ha-mm) and fertilizer use efficiency (%) under the different color of mulch.

obtained earlier [4, 5] in watermelon, [6] in melon. The results indicated that the effect of different mulching material on fruit length and fruit width of watermelon is significant over control. Maximum fruit length and width were found in silver plastic mulch, whereas the minimum fruit length and width of watermelon were noted in under no mulch condition. These results were in consonance with those Johnson et al. [7] in watermelon.

It was found that all treatments of mulching material were significantly increased the average fruit weight (kg) and fruit yield of watermelon than no mulch condition. Among all mulching treatments, maximum average fruit weight and fruit yield (35.57 t/ha) was recorded in silver mulch (Table 1). Plants under polyethylene mulch (silver on top black at bottom) produced larger fruit and gave higher fruit yield per vine because of better plant growth due to favorable hydro-thermal regime of soil and complete weed free environment. These results were in consonance with [8] in watermelon.

Water and fertilizer use efficiency

Water use efficiency (WUE) is, simply the efficiency in which water is used to produce an economic yield. Water use efficiency of each treatment was determined after the marketable yield was obtained. The water use efficiency was calculated by dividing marketable yield by the volume of applied water. The same amount of water (500 mm) was applied in all treatments. The highest water use efficiency (71.14 kg/ha-mm) was recorded with black plastic mulch, whereas the lowest WUE (30.62) was obtained at without mulch treatment, which indicated that the plastic mulch distinctly improve the water use efficiency of tomato (Fig. 2). These results are in agreement with the results of Baye [9] who reported significantly higher WUE in the mulched plots compared to the no mulched plots.

Fertilizer use efficiency was found to be highest under the silver mulch. The magnitude of mean values is in order $T_8>T_7>T_6>T_5>T_4>T_3>T_2>T_1$ (Fig. 2). This may be due to the reason that under the plastic mulching plants absorbed nutrient more quickly. Same result was found to Jin et al. [10]. He concluded that the positive effect of fertigation was enhanced due to optimum soil moisture content in the soil, which facilitated maximum utilization of applied nutrients to crops.

Economic study

It can be seen from the Table 2 that highest net returns were obtained in different mulches as compared to control or no mulch condition. Watermelon under silver colored mulch film recorded higher net monitory returns (Rs 357050) and lowest net monitory return under no mulch condition (Rs 73150). The maximum cost benefit ratio was obtained with treatment silver mulch (3.02) as compared to no mulch (1.47). These findings are in close agreement with the results of Suresh and Kumar [11] in pointed guard and Singh et al. [12] in bitter gourd.

Table 2. Effect of different mulching material on economics of watermelon. Sale price : Watermelon @Rs 15 kg^{-1}, mulching material @ Rs 2 m^{-2}.

Treatments	Cost of cultivation (Rs/ha/ year)	Gross monetary return (Rs/ha/year)	Net monetary return (Rs/ha/ year)	B:C ratio
Open field	156500	229650	73150	1.47
Paddy straw	159500	319950	160450	2.01
Yellow mulch	176500	370650	194150	2.10
Pink mulch	176500	384900	208400	2.18
Blue mulch	176500	412650	236150	2.34
Red mulch	176500	448050	271550	2.54
Black mulch	176500	486600	310100	2.76
Silver mulch	176500	533550	357050	3.02

Conclusion

The study concludes that application of plastic mulches in water melon production will provide economically viable results as compared to no mulch conditions. Among the organic and inorganic mulches, inorganic mulches (plastic mulches) gave better performance over organic mulches. Among the color mulches, silver color mulch film produced the best results over other colored mulch films in water melon production.

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