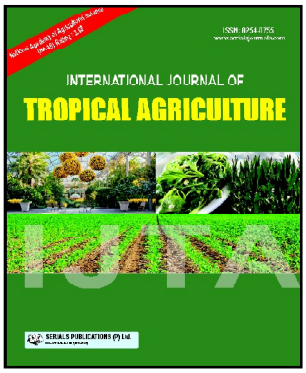

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Evaluation of Different Mulch Materials on Growth and Yield of Summer Tomato (*Solunum lycopersicum* L.)

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Abstract: The field experiment was carried out during the spring-summer season (January-April) in the year 2016 and 2017 to evaluate the efficacy of different mulch materials on growth and yield of summer tomato. The treatments consisted of black/silver plastic, straw, jute non-woven agricultural fabric and no mulch (control). The results showed that the soil temperature remained slightly higher under black/silver plastic mulch than other treatments throughout the experimental period whereas, soil moisture retention ability is quite higher under black/silver plastic mulch followed by jute mulch. Black/silver plastic mulch also suppressed weed growth up to 97% than unmulched field. The growth and development of tomato plant were increased remarkably by all the mulches over control and among the mulches, black/silver plastic mulch significantly enhanced all the growth characters. The highest plant height (138.8 cm at 70 DAT), stem base diameter (1.34 cm), number of primary braches per plant (4.8), number of leaves per plant (80.8) were observed under black/silver plastic mulch. Again, number of marketable fruits and total fruits (17.4 and 22.6, respectively), average fruit weight (65.2 g) and yield (48.38 t/ha) were also recorded significantly highest with black/silver plastic mulch followed by jute mulch. About 48% yield increment over control was found by black/silver plastic mulch.

Key words: Mulch, Tomato, Soil temperature, Soil moisture, Weed population.

INTRODUCTION

Tomato (*Solunum lycopersicum L.*), universally treated as 'Protective Food' and used both in fresh and processed condition, is being extensively grown as a popular vegetable all over the world. Leading tomato growing states in India are Karnataka, Maharashtra, Haryana, Punjab, Bihar, Uttar Pradesh and West Bengal. Tomatoes are grown widely in tropical and sub-tropical regions where they often experience high temperatures during fruit set. It has been well

documented that heat stress can occur at mean daily temperatures of 28-29°C, which are just a few degrees above the optimum temperature range of 21-24°C.

Tomato is one of the important vegetable crops in West Bengal, where climate is tropical humid. Winter is short lived and temperature starts rising after mid February. Productivity of the crop is largely influenced by the genetic characteristics of the cultivar, growing environment and management practices. The best crops of tomato under West Bengal condition are generally raised with October planting and bulk harvesting is completed within February. Tomato offers higher economic return for farmers especially when grown during summer season. But when grown during Spring-Summer months (February-May) with some promising heat tolerant varieties it fetches high temperature resulting poor fruit-set and production. In summer, water deficit often limits growth and development of tomato and high weed infestation is another problem. Cost of cultivation increases for farmers due to higher irrigation requirement and weed management. Presently different mulches are commonly used in many vegetables production to reduce such problems.

Mulching is a cultural practice that involves placing organic or synthetic materials on the soil around plants to provide more favourable environment for growth and production. Uses of mulches offer great hope because of its moisture conserving ability and also its moderate soil temperature (Hooda, *et. al.,* 1999). Polythene mulches are widely used in vegetable production and have contributed significantly for reduction of losses due to weed competition (Ngouajio and Ernest, 2004). Black polythene mulch is the standard plastic mulch used in vegetable production (Gordon *et. al.,* 2010). Plastic mulches also reduce attack of few diseases and pests to the crop. Mulching has some role for preventing soil erosion and increasing quality of the produces. The natural mulching materials such as paddy straw or sugarcane trash have also some positive effects like weed control (Kwon *et. al.,* 1998). Non-woven biodegradable fabric made from some natural fibres such as jute non-woven agricultural fabric developed by ICAR-NIRJAFT, Kolkata has some positive effect for conserving moisture and controlling weeds when used as mulch. Degradable mulch is developed to help with disposal problem. Root zone temperature is another important factor for growth and development of plants as it affects physiological processes in roots such as uptake of water and nutrients (Dodd *et. al.,* 2000). Different types of mulches maintain root zone temperature differently which may improve physiological processes of roots. The cost of using mulch is compensated by savings in weed removal and reduced irrigation.

Therefore the main objective of the present experiment was to assess the influence of different mulch materials on growth and yield of tomato in terms of controlling weed growth, soil moisture and soil temperature.

MATERIAS AND METHODS

The experiment was carried out at Instructional Farm of Krishi Vigyan Kendra, Hooghly and infarmers' field of two villages of Hooghly district, West Bengal in the year 2016 and 2017 during Spring-Summer season (January-April). The experimental site comes under subtropical humid region. The average temperature ranges from 25°-37°C during summer months. The soil of the experimental field was clay loam having high water holding capacity with pH around 6.5. The tomato variety taken was 'Tanuja' which is a promising high temperature tolerant variety. The treatments of the experiment consisted o f

(i) Black/Silver plastic mulch (30 micron),

(ii) Straw mulch (Natural biodegradable product),

(iii) Juten on-woven agricultural fabric (400 gsm, biodegradable product) and

(iv) Control (without mulch).

The experiment was laid out in a Complete Randomized Block Design with seven replications. Seedlings were transplanted during third week of January in double row bed system with spacing of 60cm in between rows and 50cm in between plants. The unit plot size was 10m × 10m. Irrigation channels are laid out in between two crop rows. Inorganic fertilizer was applied to the all plots @ 100:60:60 (N:P:K) kg/ha along with vermicompost @ 3t/ha as basal application. After application of fertilizers, mulch materials were placed and then planting was done at specified distance. Later foliar spray of water soluble fertilizers like 19:19:19 (N:P:K) was done @ 5g/L at 30 DAT (days after transplanting) and 50 DAT. Micronutrient mixture was sprayed twice @ 2g/L at 40 DAT and 60 DAT. Staking was done to all plants with bamboo sticks. Equal irrigation was given to all plots at an interval of 7-10 days. Pesticide like Acephate @ 0.75 g/L was sprayed to control leaf minor pest and Carbendazim + Mncozeb @ 2.0 g/L was sprayed to control early blight disease. Harvesting of the crop was started at 75 days after planting. The observations were recorded accordingly and the data of different parameters were statistically analyzed.

Determination of Soil Physical Properties

Soil moisture content was taken before and after each irrigation with soil moisture meter. Three random samples were taken from each plot and average reading was considered. Soil temperature was determined at 15 days interval with a soil thermometer inserted at 5cm depth at 2.00 PM.

Determination of Weed Population

Weed samples were collected at 50 DAT from three quadrates (50cm × 50cm) randomly laid per plot. Weeds were identified as per leaf characters and clipped at soil surface, oven dried at 75°C for 48 hours and weighed to determine the dry matter. The data was presented per square meter area.

Observations on Growth and Yield

Five plants per replication (plot) were selected at random for recording observations on plant and fruit characters. The observations recorded were Plant height (cm), Number of primary branches per plant, Main stem base diameter (cm), Number of leaves/ plant, Days to first flowering, Number of marketable fruits/plant, Number of total fruits/plant, Fruit diameter (cm), Average fruit weight (g), Yield/plant (kg) and Yield/ha (tonnes).

RESUTS AND DISCUSSION

Soil Physical Properties

Temperature of soil under mulches was higher than that of control plots during all the experimental time (Figure 1). Among the mulches, black/silver plastic mulch retained higher soil temperature than other organic mulches. Straw and jute mulch had recorded similar pattern of soil temperature. There were significant differences in soil warming ability among mulches as reported by Diaz-Perez and Batal, (2002).

Higher soil warming ability of plastic mulch might be due to trapping of some solar radiation inside it. Though soil temperature under black/silver plastic mulch was not so increased as it allowed minimum radiation to pass through it. This finding is supported by Rajablariani *et. al.* (2012) who opined that among different plastic mulches black/silver plastic mulch increased lowest soil temperature. The polythene mulches allowed part of the radiation to pass through it but acted as barriers against outgoing thermal radiation (Park *et al.*, 1987).

The soil moisture content in the experimental plots under different mulches was measured within 0-10 cm depth before and after each irrigation. Results revealed that all the mulches retained higher amount of soil moisture compared to the control (Figure 2). But among the mulches, there was no significant difference in soil moisture content. The black/silver polythene mulch apparently showed highest moisture (average 16.25% at before irrigation

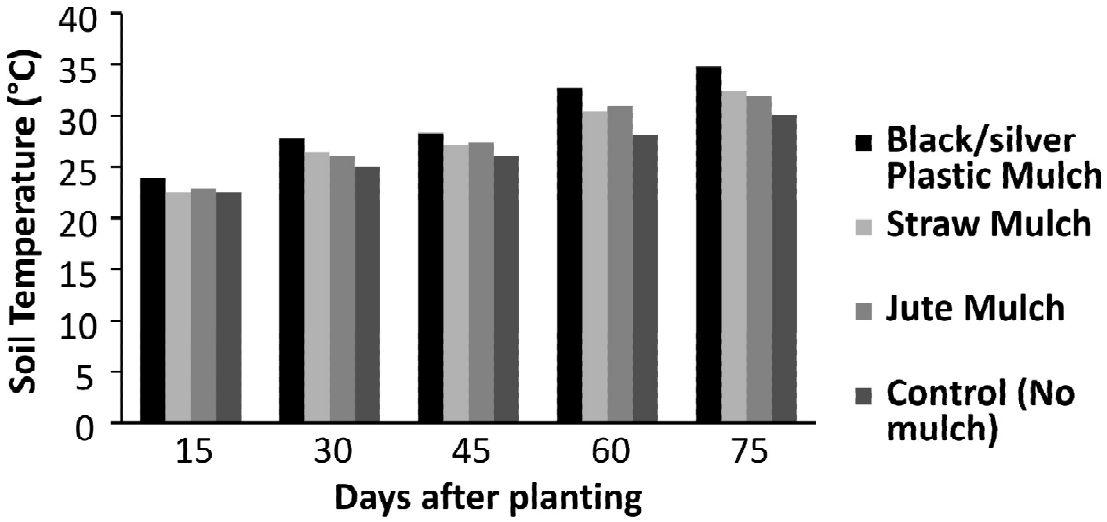

Figure 1: Effect of different mulch materials on soil temperature

and 26.6% at after irrigation), followed by jute mul chand straw mulch. Increased moisture retention capacity under polythene mulch could be attributed to less evaporation from the soil and in jute it is due to hygroscopic nature which retained moisture for long time. The moisture content in the control plots (no mulch) was gradually decreased towards maturity of the crop due to increasing air temperature which leads to high evaporation from soil. In support of the present investigation Ogundare *et.al.* (2015) reported higher soil moisture content under polythene mulches than organic mulch in tomato. Wang *et al.* (1998) reported that all type of polythene mulch increased the soil moisture content in chilli field compared to control.

Weed Population

The growth of different weeds under different treatments was presented in Table 1. The highest number of weeds including grasses and broad leaf weeds per sq.mtr. (385.8) and weeds dry weight (2.76 g) were recorded in control plots followed by straw and jute mulches and the lowest was in black/ silver plastic mulch (11.5 and 0.07g, respectively)

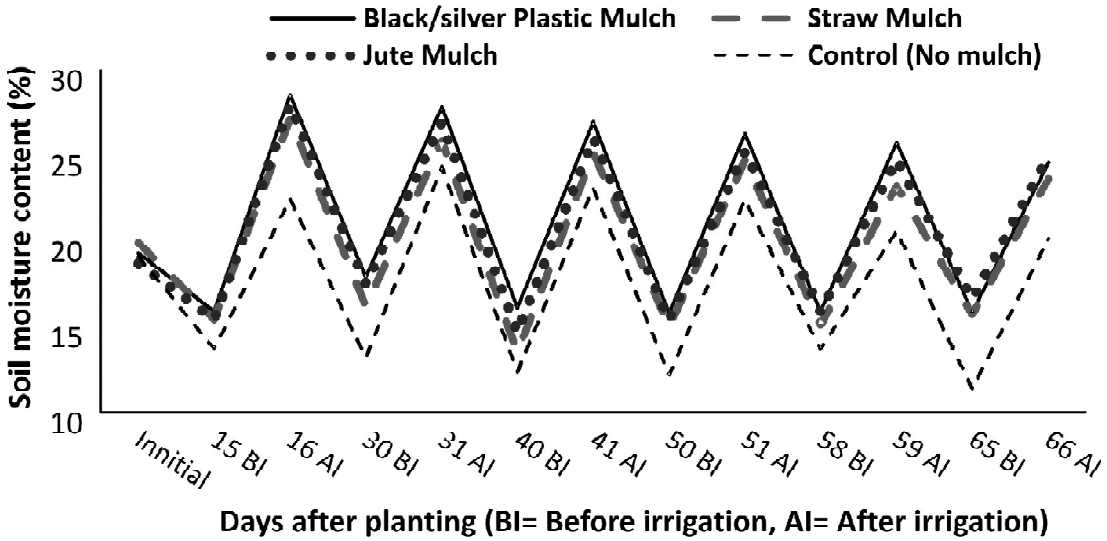

Figure 2: Variation in soil moisture content under different mulch materials

indicating black plastic mulch was more effective than other mulches in suppressing weed growth. In fact, Black/silver plastic mulch produced weeds only through the punch hole and no weed was found above the plastic, which might be due to lack of percentage of light passed through black plastic. A portion of photosynthetic radiation was blocked by the black plastic which suppressed weed growth. Jute mulch though it is a continuous sheet could not block all weeds to grow and it might be due to some diffused light passed through it and it was porous in nature. About 98% weed control was found under black/silver plastic mulch as reported by Rajablariani *et. al.* (2012) that supported the present findings. Ashrafuzzaman *et. al.* (2011) also recorded lowest number of weeds in black plastic mulch as compared to other mulch. Plastic mulch application is effective for conserving soil moisture and weed control as reported by Zhang *et. al.* (2007). Complete elimination of weeds with black plastic mulch was reported by Ngouajio and Ernest (2004).

Table 1
Growth of weeds as affected by different mulches

	Number of Weeds (per sq.mtr.)			
Treatments	*Grasses*	*Broad leaf weed*	*Total*	*Total Dry Weight (g)*
Black/silver plastic mulch	4.6	6.9	11.5	0.07
Straw mulch	32.5	50.1	82.6	0.32
Jute mulch	40.8	26.7	67.5	0.25
Control (No mulch)	251.2	134.6	385.8	2.76

Vegetative Growth Characters

Plant height

Plant height was measured at 50 DAT and 70 DAT as shown in Figure 3. The plant height was varied significantly due to different mulches at different growth stages and increased with plant's age. Black/silver plastic mulches showed largest plant height than other mulches and control, indicating that mulches had positive effect on the growth and development of tomato. At 70 DAT, the tallest plant (138.8 cm) was observed in black/silver plastic followed by jute mulch (128.4 cm). The smallest plant (111.2 cm) was observed in control plot at 70 DAT. The increased plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. Tegen *et. al.* (2016) reported that tomato plant's height was significantly higher under plastic mulch than grass mulch or no mulch fields. Changes in the plant height have been observed by using different mulches and plastic mulch increased more plant height than other mulches (Shinde *et al.*, 1999). Less soil compaction and hence improved aeration under mulched soil have also contributed to increased plant growth (Lamont Jr., 1993).

Number of primary branches per plant

It was observed that mulches did not produce any significant effect on the number of primary branches per plant (Table 2) indicating it is varietal character. Though highest number of primary branches per plant (4.8) was found in black/silver plastic and jute mulch whereas lowest number was found in control (3.8). It was reported that mulched tomato plants had more branches than that of unmulched plants (Srivastava *et al.*, 1994 and Rajablariani *et. al.,* 2012).

Table 2
Effect of different mulches on vegetative growth and earliness of summer tomato

Mulch materials	*Number of primary braches/plant*	*Number of leaves/ plant*	*Stem base diameter (cm)*	*Days to first flowering*
Black/silver plastic mulch	4.8	80.8	1.34	24.4
Straw mulch	4.6	59.4	1.26	27.8
Jute mulch	4.8	61.4	1.24	26.2
Control (No mulch)	3.8	42.2	1.12	30.2
SEm (±)	0.356	1.431	0.034	0.934
CD (at 5%)	1.097	4.408	0.106	2.877

Figure 3: Effect of different mulches on plant height in summer tomato

Main stem base diameter

Stem base diameter in tomato plants was influenced by the different mulches (Table 2). All mulches significantly increased stem base diameter than control but among the different mulches there was no significant variation. At 70 DAT plastic mulched plants had a higher base diameter (1.34 cm) than that in control (1.12 cm) followed by straw mulch. This result was in conformity with the report of Easson and Fearnehough (2000) on forage maize.

Number of leaves per plant

Leaf number per plant was significantly increased under mulches (Table 2). Maximum number of leaves per plant (80.8) was recorded under black/silver mulch followed by jute and straw. Maximum number of leaves under black/silver plastic mulch was also reported by Rajablariani *et. al.* (2012). Higher number of leaves/plant might be due to improved microclimatic condition under plastic mulch. According to Ogundare *et.al.* (2015) black polythene mulch recorded better performance in terms of plant height, number of branches, number of leaves and stem girth.

Days to first flowering

Mulches resulted slight earliness of the crop as compared to unmulched plots (Table 2). Least days (24.4) required for first flowering from planting with black/silver plastic much treatment, followed by jute mulch (26.2), whereas most days (30.2) required to first flowering by control treatment. Earliness under plastic mulch is supported by Tegen *et. al.* (2016) and Ogundare *et.al.* (2015). Higher soil temperature under plastic mulch forced plants to produce early flower.

Fruit Characters and Yield

Fruit Diameter

Fruit diameter under mulch treatments was found significantly larger over control (Table-3) and highest fruit diameter (5.44 cm) was observed under black/silver plastic much and least fruit diameter (5.10 cm) was recorded in control. Ogundare *et.al.*(2015) reported significantly higher fruit diameter and fruit weight under black polythene mulch.

Average fruit weight

Average fruit weight was influenced by mulching in tomato and black/silver plastic mulch resulted significantly highest fruit weight (65.2 g) as compared to no mulch (57.6 g) as shown in Table 3. However results among the different mulches were statistically similar. Rajablariani *et. al.* (2012) reported that there was no significant difference in the average fruit weight among mulch treatments, however largest fruit produced on the black/silver mulch which was significantly larger than fruits of bare ground.

Table 3
Effect of different mulches on fruit character and yield of summer tomato

Mulch materials	*Fruit diameter (cm)*	*Average fruit weight (g)*	*Yield/plant (Kg)*	*Yield/ha (t)*
Black/silver plastic mulch	5.44	65.2	1.44	48.38
Straw mulch	5.22	60.8	1.14	38.40
Jute mulch	5.38	62.6	1.24	39.58
Control (No mulch)	5.10	57.6	0.94	32.82
SEm (±)	0.059	1.439	0.038	0.424
CD (at 5%)	0.184	4.435	0.116	1.307

Number of fruits per plant

Results presented in Figure 4 indicated that all mulch treatments produced significantly more tomato fruits (both marketable and total fruits) than unmulched bare plots (control). So mulching had positive influence on fruit setting in tomato. The highest number of marketable fruits (17.4) and total fruits (22.6) per plant was observed in black/silver plastic mulch, followed by jute mulch (14.4 and 19.6, respectively). In contrast, control showed the lowest marketable and total fruits per plant (11.0 and 14.8, respectively). Diaz-Perez and Batal (2002) mentioned that black plastic mulch increased number of fruit in tomato by 5 fruits per plant compared to bare ground. Ravinder *et al.* (1997) reported that mulching significantly improved the number of fruits per plant and reduced the percentage of fruit abortion compared to unmulched control that supported the present experimental results. Again, Kayum *et. al.* (2008) reported that among different indigenous mulches tomato plants with straw mulch produced highest number of fruits per plant.

Improved microclimate both beneath and above the soil surface and conservation of moisture might be associated with increase in the number of fruits per plant of mulched plot. This favourable condition enhanced the plant growth and development and produced increased fruit bearing nodes compared to the control. Considering relationship between the soil moisture content and fruit number, it was clear that fruit number was strongly related with soil moisture content (Figure 1).

Fruit Yield

Different mulches significantly increased fruit yield per plant and per hectare over control (Table-3). Black/silver plastic mulch produced significantly highest yield (1.44 Kg/plant and 48.38 t/ha) than other two mulch treatments which resulted statistically at per yield. Lowest fruit yield (0.94 Kg/

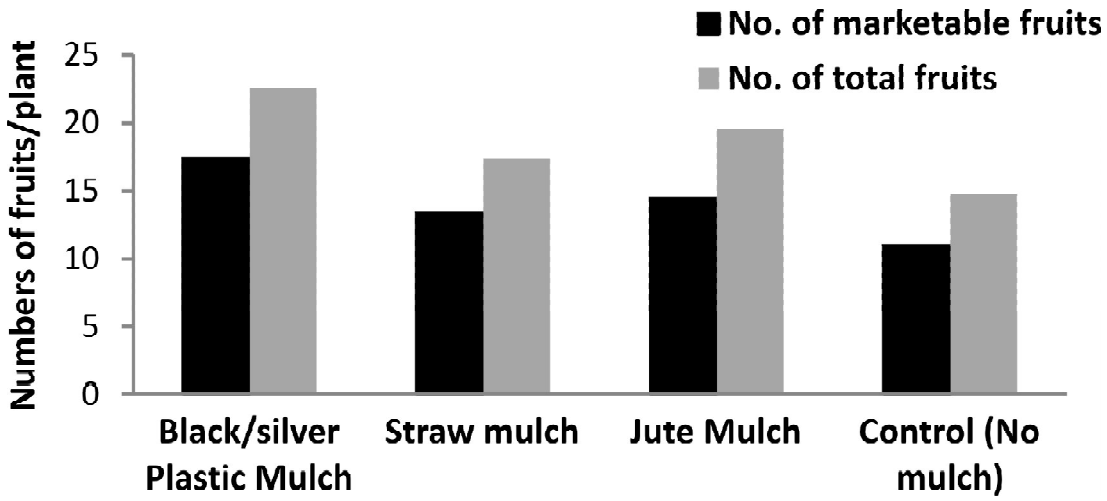

Figure 4: Effect of different mulches on number of fruits/plant in summer tomato

plant and 32.82 t/ha) was recorded in no mulch (control) field. Therefore it was indicated that the mulch had positive effect in increasing fruit yield. Rajablariani *et. al.* (2012) reported highest marketable fruit yield in tomato in black plastic mulch. Tegen *et. al.* (2016) opined that mulching materials resulted up to 23.43% higher fruit yield in tomato as compared to bare soil. Increased fruit yield was due to increased number of fruits per plant and fruit weight. Gordon *et.al.* (2010) reported that plastic mulch produced higher plant height, early and total yield than other mulches. This positive result under mulched plants might be associated with continuous supply of optimum soil moisture, moderating soil temperature, nutrient availability and suppression of weed growth which reduced crop-weed competition. All these factors promoted growth, development and fruit yield of the plants. These results coincided with those of Siborlabane (2000), who pointed out that the yield and quality of the fruit for the fresh tomato market varied according to the type of mulch used on the plantation. Yield benefits most often attributed to increased soil temperatures that enhance root's ability to assimilate nutrients such as phosphorus, a vital contributor to increase yield.

CONCLUSION

Based on the experimental results, it could be concluded that black/silver plastic mulches had tremendous effects on the growth and yield of tomato. Black/silver plastic mulch suppressed the weed growth, maintained good soil physical condition, better microclimate around the plants and thereby increased the fruits yield up to 48% over without mulch.

Therefore, the cultivation of tomato using black/silver plastic mulch could bring an ample scope for producing more crop yield. The jute non-woven fabric mulch had some positive effects for conserving soil moisture, maintaining soil temperature, reducing weed growth and increasing yield over bare fields and may be considered where environmental issues are concerned as it is a biodegradable product which enrich the soil with organic matter after decomposition. Again straw mulch which is also a biodegradable product had all the benefits of plastic mulch though in lesser amount may be considered by the farmers as it is readily available and very cost effective.

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