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Research Article

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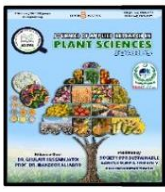

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Effect of Different Mulching Materials on Weed Emergence and Quality of Strawberry under Rainfed Conditions

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Abstract

Strawberry is one of the most attractive fruits among berries. It possess unique place among cultivated berry fruits due to its attractive red color, taste, flavor and high nutritional value. For commercial production plants are propagated from runners but weed infestation is the biggest problem of strawberry crop. In this regard, the current study was designed to use different mulching materials on weed control, morphological and physico-chemical characteristics of strawberry cv. Chandler under rain fed conditions of Rawalakot. The experiment was laid out in randomized complete block design (RCBD) with six mulching treatments. Data was recorded for various parameters including weed control, morphological characteristics, physical characteristics and biochemical characteristics. Results showed that maximum weed control (10.33) was found in strawberry plants grown in black polythene mulch. However, maximum survival percentage (95.75), leaves per plant (8.0), flowers per plants (7.33),fruits per plant (5.33), runners per plant(8.33), chlorophyll a (8.55 g/mL), chlorophyll b (9.26 g/mL), total chlorophyll (18.14 g/mL), fruit weight (2.93g), fruit diameter(2.73 cm) were found in strawberry plants grown in mulching material amended with coconut coir. Bio chemicals parameters like total soluble solids (TSS) (8.50%), titratable acidity (TA) (1.89%), vitamin C (0.25 mg/100g), total anthocyanins (40.06 mg/100g), total phenolics (0.60 mg gallic acid/100 g), total flavonoids (2.86 mg/100gFW), and antioxidant activity (0.89 µg/100 mg FW) were also found maximum in plants grown in coconut coir. Based on current findings it can be concluded that mulching material black polythene was found better for weed control and coconut coir was found better for morphological and physico-chemical characteristics of strawberry.

Keywords: Chandler, Mulching, Rawalakot, Strawberry, Weed control.

Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the best fruit among soft fruits and cultivated in temperate, subtropical and tropical regions a significant, tasteful and tender fruit amongst berries which belongs to Rosaceae family. It has an exclusive habitation among all berry fruits due to its appealing red color, flavor, aroma and nutritional properties. Strawberries are the major source of vitamin, potassium, fiber, phenolics, flavonoids (Sharma and Sharma, 2004). It is fully loaded with glutathione (Anwar *et al*., 2017). There are more than 20 species and 600 varieties of strawberries around the world (Mondal, 2010). All these varieties differ in their nutritional composition, size, flavor and color (Mahmood *et al*., 2012). Strawberry is non-climacteric, true berry fruit. Normally, it is categorized under three classes, i.e. ever-bearing, June bearing and day-neutral (Finn and Strik, 2008). Botanically strawberry is considered as perishable aggregate. In temperate climatic conditions, its plants appearance is like a minor perennial herb having shallow roots, while, in sub-tropical climatic conditions, it acts as an annual plant (Finn and Strike, 2008). It contains high amount of health promoting compounds such as flavonoids and phenolics (Hakkinen and Torronen, 2000). The world production of strawberry is approximately 9.2 million tons (Aziz *et al*., 2018). The major producer of strawberries in the world is China with production of 3.7 million tons followed by USA and Mexico (FAO, 2018). Pakistan produces very low about 609 tons of strawberry which is very low in comparison with other countries of the world (Aziz *et al*., 2018). Only 1055 tons of strawberry was produced in Pakistan from 395 ha of land during 2018 to 2019 (GOP, 2019). Though, it is not a major cultivated crop, even then its production increased manifold in Pakistan during recent years (Anwar *et al*., 2017). Strawberry yield, quality and weed control is influenced by many factors such as planting date, mulching, temperature and irrigation regime (Angami *et al*., 2020). Weeds infestation is one of the biggest problems in strawberry cultivation (Kumar *et al*., 2019). Different weeds such as *Chenopodium* grasses, chickweed and milk thistle are most devastating weeds and reduce yield and quality of different crops (Quin *et al*., 2015; Jayswal *et al*., 2018). Mulching is the significant exercise which directly affect hydro-thermal regimes of soils and help in suppressing conquering weeds, conservation of soil moisture and modify soil physical properties by increasing soil fertility, reducing water evaporation and preventing diseases and pests (Tarara, 2000). Most of the economic losses in strawberry crop are caused due to weeds rather than any insect pest attack. So weeds should be managed all over the lifespan of the strawberry plant, from pre-planting until final harvest. Organic farms usually avoid using herbicides so weed control needs intensive labor during whole season of strawberry production. Strawberries are highly susceptible to weed competition, at the initial stage. After plantation small plants need frequent irrigation which provides suitable conditions for weeds to germinate. Some common weeds having wind-blown seeds (broad-leaf weeds and grass) e.g. hairy fleabane, annual sow thistle, everlasting cudweed, and common groundsel becomes very problematic.

Several methods such as fumigation and weedicides are used for weed management in strawberry production. In most of warm areas soil solarization is a common practice for killing of weed seeds. But this solarization is not successful in cold and coastal areas where mulching is an alternative technique used to control weeds. In most cases black, blue or brown plastic sheets are used as mulching but due to harmful effects of plastic mulching different organic mulches are used in some area. Type and quality of mulch varies with area, soil topography, crops and weather conditions of the specific area (Teasdeale *et al*., 2002). Mulching provides significant effects on yield, quality and controlling of weeds in strawberry crops. All these positive effects are predominantly due to better soil temperature, upgraded nutrient availability, protection from frost injury, reduced number of weeds and dirty berries (Bakshi *et al*., 2014). Though, all the surface mulches effects positively on soil characteristics but it depend upon type, quantity and structure of the mulch (Teasdeale *et al*., 2002). Recently, organic mulches are using in numerous aromatic and medicinal crops to increase growth and yield of crops (Mulamba and Lal, 2008). Furthermore, mulches can suppress weed growth by contending for water, nutrients and light (Teasdeale *et al*., 2002). Different mulching treatments produce allopathic compounds which in turn suppress weeds production and can also reduce herbicide application in crop. Besides, weed management mulching is found effectual in decreasing hydric loss through evaporation (Sing *et al*., 2001). Rawalakot is a subtropical high land climatic zone and it is hypothesized that strawberry can be grown successfully in this region. In Rawalakot heavy rainfall are occur approximately 507mm entire year and with the increase in rainfall, weed population exceeds (GOP, 2019). So far, no studies have been reported for weed control, morphological and physico-chemical characteristics of strawberries with the use of different mulching materials in Rawalakot, Azad Jammu and Kashmir. Hence the study has been designed to gauge the efficiency of diverse mulching materials on weed control in strawberries. Examine the effectiveness of different mulching materials on morphological and physico-chemical characteristics of strawberries.

Materials and Methods

Experimental site and treatments: The experiment was conducted at the Department of Horticulture, University of Poonch Rawalakot, to evaluate the effects of different mulching materials on the strawberry cultivar Chandler. Runners of cv. Chandler were collected from NARC Islamabad and transplanted in an open field using a randomized complete block design (RCBD) with three replications. The treatments included control (T1), poplar leaves (T2), wood chips (T3), coconut coir (T4), newspaper (T5), and black polythene (T6). Mulching was applied prior to transplanting on raised beds (15 ft × 6 ft) with a plant-to-plant distance of 20 cm and bed-to-bed spacing of 2 ft. Fertilizers, including FYM (20 t/ha) and SSP (300 kg/ha), were applied. Soil moisture and temperature were monitored on alternate days, while weed control, morphological, and physico-chemical traits of strawberries were recorded at harvest. The study aimed to assess the impact of mulching on strawberry growth and yield under field conditions.

Weed Control: Weeds (monocot and dicot) were counted after 90 days of transplantation of runner.

Morphological Characteristics

Survival of Plants (%): Plants survival was calculated by using following formula:

Plants survival (%)=

$$\frac{\text{Total number of plants survived}}{\text{Total number of runners transplanted}} \times 100$$

Leaves per plant, flowers per plant, and fruits per plant and runners per plant were counted and their mean will be record**.** Chlorophyll a, b and total chlorophyll of leaves were calculated using the method of Zahid *et al*. (2014).

Physical Characteristics: Selected fruits were weighed by using digital weighing balance and were expressed in grams. Vernier caliper was used to measure the diameter of selected fruits and means was recorded in cm.

Biochemical Characteristics: Digital refractometer (Kyoto Company, Japan) was used to measure the Total Soluble Solids (TSS) as described in Method no. 960.20 Association of Official Analytical Chemists (AOAC, 1990) and readings were expressed in percentage (%). Method No. 9720.21 from

Association of Official Analytical Chemists was used to measure Titratable Acidity (TA). (AOAC, 1990). Strawberry fruit (5 g) was used from random fruits, mixed with 20 mL of purified water and homogenized. The 5 mL aliquot of was titrated against sodium hydroxide (0.1 N standard) by using phenolphthalein. Method No.967.22 from Association of Official Analytical Chemists was used for Assessment of Vitamin C (AOAC, 1990). An indophenol dye was used to determine vitamin C. Fruit juice (5 mL) plus 4.0 % metaphosphoric acid (5 mL) were mixed in 100 mL of conical flask and titrated against 2, 6-dichlorophenol indophenol dye until appearance of pink colour. Total anthocyanin was measured by two dilutions method (Zheng *et al*., 2007). First dilution was prepared by mixing 0.5 mL of fruit juice and 3.5 mL of potassium chloride (pH 0.1) and second dilution was prepared by mixings (0.5mL sample extract and 3.5mL sodium acetate (pH 4.5). These mixtures were allowed to react for 15 min. Absorbance of both dilutions were measured at 515 and 700 nm by using spectrophotometer. Total anthocyanin was calculated using formula. Results were obtained articulated in mg of cyanidin-3-glucoside per liter. Total phenolics were measured by spectrophotometric method. Fruit juice (0.1 mL) was mixed with Folin-Ciocalteaus Reagent (0.5 mL) plus sodium carbonate (1.5 mL). Volume of solution was ended up to 10 mL by addition of distilled water. Solution was allowed to react for 2 hours in a water bath at 40 °C. Absorbance was recorded at 765nm by using spectrophotometer and results were articulated in µg of gallic acid per. Total flavonoids were assessed using the method given by Chang *et al*. (2002). Fine pulverized sample (0.1g) was mixed in 10 mL of hot water and 0.1M potassium acetate, 0.1 mL of aluminum chloride and 2.8 mL of distilled water was added subsequently. Mixture was allowed to react for 30 min and activity was recorded at absorption 430 nm using spectrophotometer. Results were calculated by using quercentin curve. Antioxidant activity were calculated by using the ferric reducing antioxidant power FRAP assay. The fruit juice 0.04ml was added to 3ml of FRAP reagent and incubated in the dark (37 C) for 4min. Absorbance was recorded at 593 nm in spectrophotometer. Results were calculated by using a standard curve of ferrous sulphate per gram fresh weight of fruit.

Soil Moisture: Soil moisture was measured using gravimetric method (Sudheer *et al*., 2016). Soil temperature was also recorded using a bimetal thermometer.

The moisture contents will be calculated by:

$$\text{Soil moisture}(\%) = \frac{\text{Weight of fresh soil} - \text{Weight of oven dry soil}}{\text{Weight of oven dry soil}} \times 100$$

Statistical Analysis: A randomized complete block design (RCBD) with three replications was used to set the experiment. Analysis of variance (ANOVA) was done for collected data using statistical software (Statistix 8.1). Means were separated using Tukey's test at $P \leq 0.05$ (Steel *et al*., 1997).

Results and Discussion

Weed Control: Different mulching materials showed significant ($P \leq 0.05$) effect on the growth patterns of strawberry cv. chandler. Figure 1 showed that maximum weeds control was found in strawberry plants treated with T_6 (Black polyethylene) (10.33) which was followed by T_5 (Newspaper) (8.66) and that was at par with T_4 (Coconut coir) (8.66), T_3 (Wood chips) (7.33) and T_2 (Popular leaves) (7.00), while the minimum weeds of strawberry plants cv. Chandler was observed in T_1 (Control) (3.33) plants. Results showed that black polythene mulch is helpful in suppressing weed population which might be due to the fact that temperature in the black polythene mulch increased and this high temperature is harmful for plant growth (Singh *et al*. 2001). It was also stated that black polythene mulch reduced penetration light which in turn stops photosynthesis and results in death of weeds. Black polythene blocked the weeds germination, except a few, which appeared from the planting holes (Schonbeck, 1998).

Morphological Characteristics: The maximum survival percentage was found in strawberry plants treated with T_4 (Coconut coir) (95.75%) which was followed by T_3 (Wood chips) (95.75%) and that was at par with T_2 (Popular leaves) (93.61%) and T_5 (Newspapers) (92.22%), T_1 (Control) (92.22), while the minimum survival of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (57.66%) plants. Coconut coir showed highest survival percentage of plants (Figure 2). This might be due to the fact that coconut coir has the ability to conserve moisture in soil which helps to maintain the optimum temperature of the soil which is required for growth of strawberry plants (Nagalakshmi *et al*, 2003). All the mulching material show significant ($P \leq 0.05$) difference then that of control. This showed that mulching material has the ability to conserve moisture in the soil as compare to naked soils (Kumar *et al*., 2018).

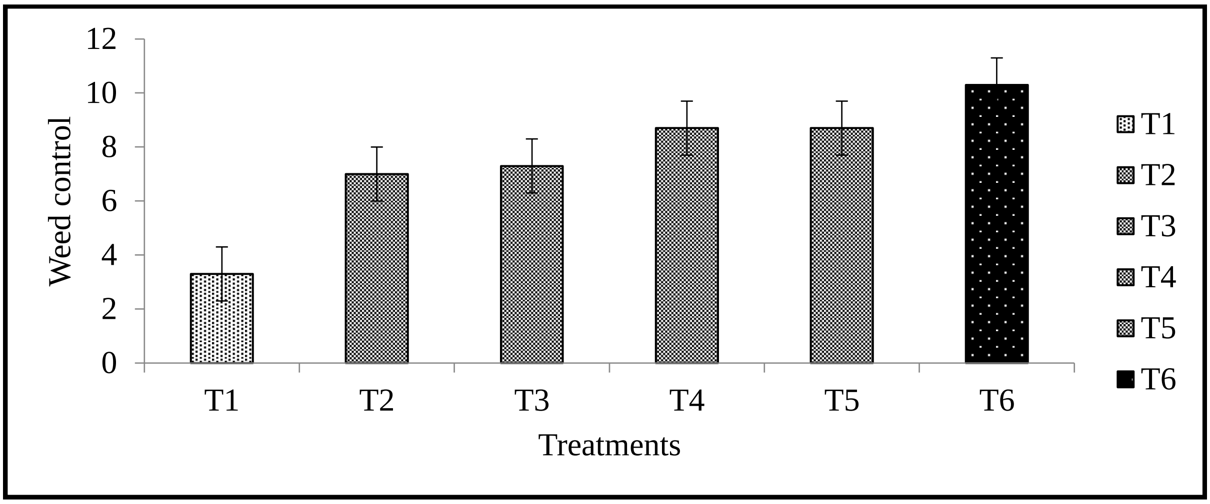

Figure 1: Impact on weeds control of strawberry using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

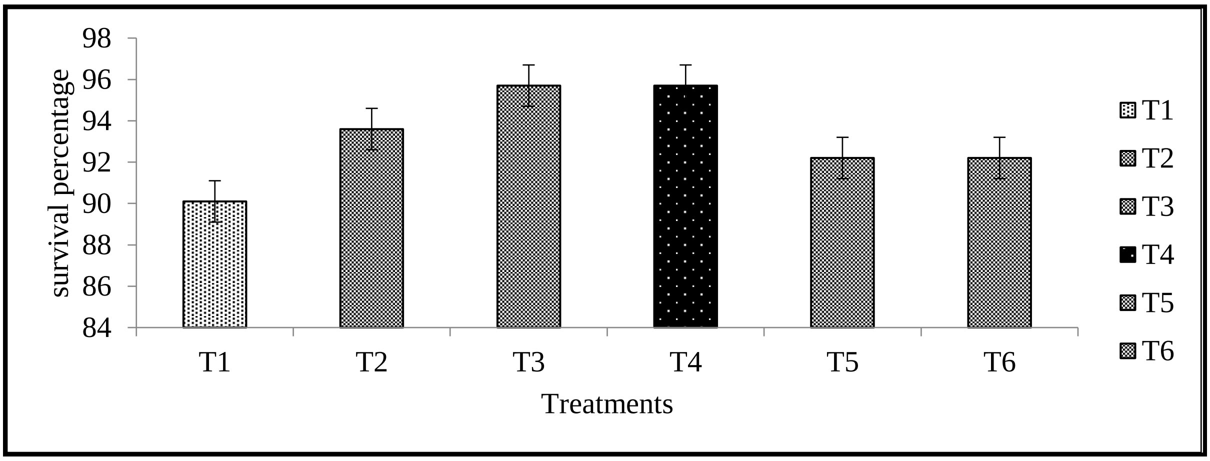

Figure 2: Evaluation of survival percentage of strawberry using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

Number of leaves per plant showed in Table (1) that the maximum leaves per plant was found in strawberry plants treated with T_4 (Coconut coir) (8.00) which was followed by T_3 (Wood chips) (6.00) and that was at par with T_2 (Popular leaves) (5.33) , T_5 (Newspaper) (4.67), T_6 (Black polythene) (4.33) , while the minimum leaves per plant of strawberry plants cv. Chandler was observed in T_1 (Control) (4.33) plants. Significantly higher number of leaves was produced with different mulching materials in comparison with control. In our results coconut coir mulch followed by the wood chips mulch showed the highest number of leaves. These results showed that the microclimate conditions provided by mulching are suitable for vegetative growth of plants hence produces more number of flowers (Izakovic, 1989).

Similarly, the maximum number of flowers per plant was found in strawberry plants treated with T_4 (Coconut coir) (7.33) and that was at par with T_3 (Wood chips) (6.33), T_5 (Newspaper) (5.33) and was followed by T_1 (Control) (4.33) and was at par with T_2 (Popular leaves) (2.33), while the minimum number of flowers per plant of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (2.33) plants (Table 1). Results of coconut coir showed significant flower production followed by the wood chips. This might be due to the fact that coconut coir has ability to restore moisture in the soil and also helps to maintain the optimum temperature of soil which increases the uptake of nutrients and woodchips suppressed the weeds production which eventually increases the flower production (Quin *et al*., 2015).

Again, the maximum number of fruit per plant was found in strawberry plants treated with T_4 (Coconut coir) (5.33) and that was at par with T_3 (Wood chips) (5.33) and was followed by T_2 (Popular leaves) (3.33), T_5 (Newspaper) (3.00), T_1 (Control) (2.67), while the minimum survival of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (1.67) plants (Table 1). Results, coconut coir showed highest fruits per plants. The increased number of fruits per plant treated with mulching is most likely due to improved moisture conservation and microclimate both below and above the soil surface. As compare to the control, mulch improved the plant growth and development and produced increased fruit bearing nodes.

Similar results were found in a study by Singh *et al*. (2012) who reported that the type of mulch used on the plantation affects the yield and quality of the fruit for the fresh tomato market.

The maximum runners per plant was found in strawberry plants treated with T_4 (Coconut coir) (8.33) and that was at par with T_2 (Popular leaves) (7.33), T_3 (Wood chips) (7.00), T_5 (Newspaper) (4.66) and T_1 (Control) (4.00), while the minimum number of runners per plant of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (3.33) plants.

Our results coconut coir showed the significant differences. The highest number of runners recorded in coconut coir might be due to the fact that they have ability to conserve moisture and good aeration which help to maintain the temperature and increased the growth of plants. Similar results were found by Ercisli *et al*. (2006) where they reported that polyester wool had better aeration and lower water tension and higher water holding capacity which helped in development of roots and ultimately affected the overall crop growth.

Physical Characteristics: The different mulching materials used provoked significant differences ($P \leq 0.05$) in the fruit weight and fruit diameter of the strawberries (Table 1). The higher fruit weight was found in strawberry fruits grown at T_4 (Coconut coir) (2.933g) which was followed by T_3 (Wood chips) (2.63g) and that was at par with T_2 (Popular leaves) (2.20g) and was followed by T_5 (Newspaper) (1.96g), T_1 (Control) (1.50g), while the minimum average fruit weight of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (1.23g) plants.

The influence of different plastic mulches on fruit weight per plant show significant differences in comparison to control. The average fruit weight was also affected by different mulching materials but among the mulching treatments highest fruit weight was showed in coconut coir.

The result is coinciding with the higher fruit weight is due to the strong plant growth and development under microclimate condition which results in improved nutrient uptake (Nagalakshmi *et al.*, 2002).

The maximum average fruit diameter was found in strawberry plants treated with T_4 (Coconut coir) (2.73 cm) which was followed by T_3 (Wood chips) (2.73cm) and that was at par with T_2 (Popular leaves) (2.50 cm), T_5 (Newspaper) (1.86 cm), T_1 (Control) (1.46 cm), while the minimum average fruit diameter of strawberry plants cv. Chandler was observed in T_6 (Black polyethylene) (1.26 cm) plants (Table1).

It was reported that mulch plants have higher diameter than that in control in all growth phases. The plants have no mulch had the smallest diameter on all growth phase (Kumar *et al.*, 2018).

Table 1: Effect of different mulching materials on morphological and physical characteristics of strawberry under rainfed conditions at Rawalakot Azad Jammu and Kashmir

Treatment	Leaves per plant	Flowers per plants	Fruits per plants	Runners per plants	Fruit Weight	Fruit Diameter
T1(Control)	4.3 ± 0.88 b	4.3 ± 0.32 c	2.6 ± 0.67b	4.0 ± 1.00 bc	1.5 ± 0.12cd	1.4 ± 0.09 bc
T2	5.3 ± 0.33 b	2.3 ± 0.28 c	3.3 ± 0.33 ab	7.3 ± 0.33 ab	2.2 ± 0.25abc	2.5 ± 0.06 a
T3	6.0 ± 0.58 ab	6.3 ± 0.33 ab	4.0 ± 0.58 ab	7.0 ± 0.58 ab	2.6 ± 0.42 ab	2.7 ± 0.09 a
T4	8.0 ± 0.58 ab	7.3 ± 0.33 a	5.3 ± 0.33 a	8.3 ± 0.67 a	2.9 ± 0.20 a	2.7 ± 0.09 a
T5	4.6 ± 0.67 b	5.3 ± 0.33 bc	3.0 ± 3.0 ab	4.6 ± 0.88 bc	1.9 ± 0.12 bcd	1.8 ± 0.15 b
T6	4.3 ± 0.33 b	2.3 ± 0.28	1.6 ± 0.33 b	3.3 ± 0.88 c	1.2 ± 0.28 d	1.2 ± 0.20 c

T_1: Control; T_2: Popular Leaves; T_3: Wood Chips; T_4: Coconut Coir; T_5: Newspaper; T_6: Black Polythene.

Biochemical Characteristics: Significant differences among treatments at 0.05% probability for total soluble solids showed in figure 3. The maximum total soluble solids were found in strawberry plants treated with T_4 (Coconut coir) (8.50%) which was followed by T_2 (Popular leaves) (7.16%) and that was at par with T_5 (Newspaper) (7.00%), T_3 (Wood chips) (5.83%), T_1 (Control) (5.50%), while the minimum total soluble solids of strawberry plants cv. Chandler were observed in T_6 (Black polythene) (4.66%) plants.

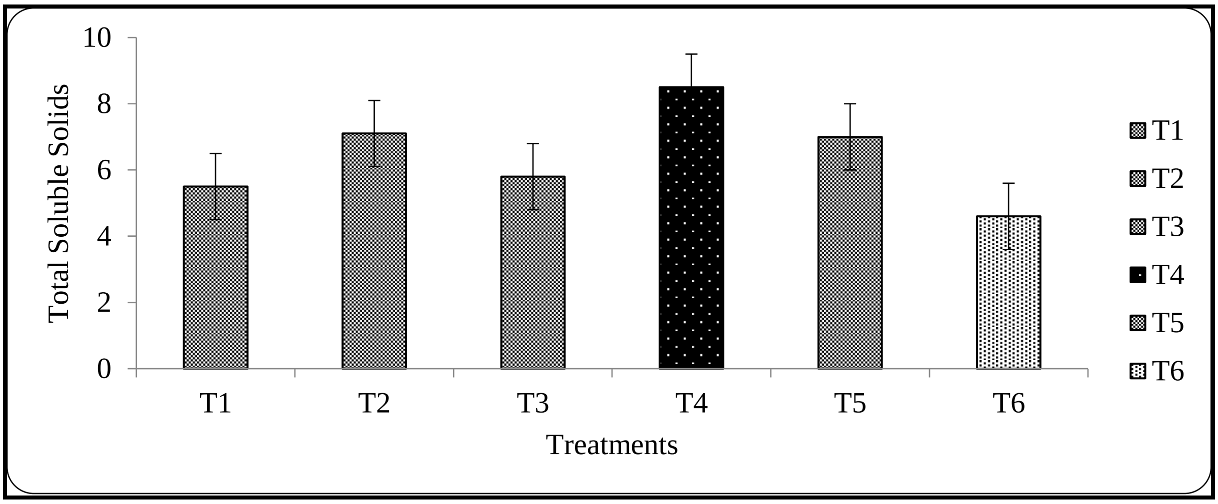

Figure 3: Evaluation of total soluble solids using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

Titratable acidity of strawberry cv. Chandler is shows in figure 4. The maximum titratable acidity was found in strawberry plants treated with T_4 (Coconut coir) (1.89%) which was followed by T_3 (Wood chips) (1.18%) and that was at par with T_2 (Popular leaves) (1.13%), T_5 (Newspaper) (1.05%), T_1 (Control) (0.92%), while the minimum titratable acidity of . strawberry plants cv. Chandler was observed in T_6 (Black polythene) (0.91%) plants (Figure 4). The increased in titratable acidity might be due the changes in microenvironment temperature, moisture and different enzymatic activity. Wang *et al*. (1996) stated increase that fruits from black polythene had maximum titratable acidity as compare with control

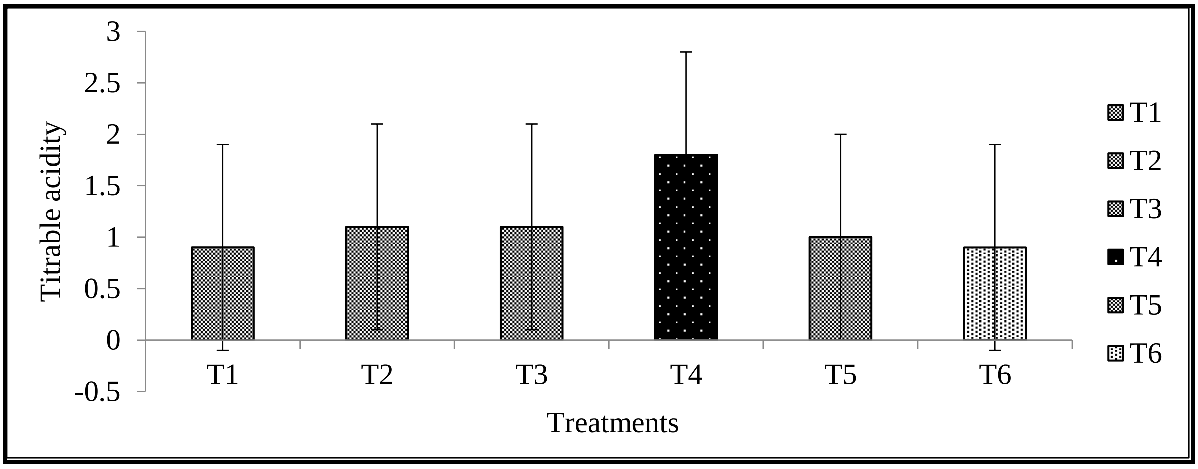

Figure 4: Evaluation of titratable acidity using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

Total anthocyanins of strawberry cv. Chandler showed in figure 5. The maximum total anthocyanins was found in strawberry plants treated with T_4 (Coconut coir) (40.06 mg/100 g FW) which was followed by T_2 (Popular leaves) (36.91 mg/100 g FW) that was at par with T_3 (Wood chips) (30.67 mg/100 g FW), T_5 (Newspaper) (26.95 mg/100 g FW) , T_1 (Control) (20.38 mg/100 g FW), while the minimum total anthocyanins of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (15.09 mg/100 g FW) plants (Figure 5). In an earlier study increased anthocyanin contents were observed in strawberries grown on plants on amended media with peat-coconut fiber. However, the enhanced anthocyanin contents of strawberry fruits produced in coconut coir mulch confirm that this mulch improved the plant development and digestion of evaluated compounds (Kumar *et al*., 2018).

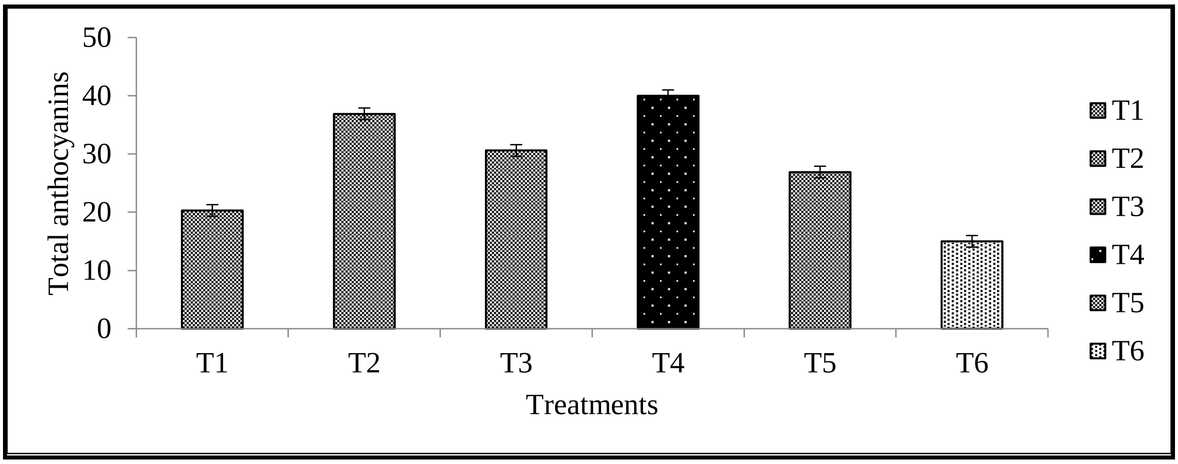

Figure 5: Evaluation of total anthocyanins using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

Significant differences ($P \leq 0.05$) were recorded for total phenolics (Figure 6).The maximum total phenolics was found in strawberry plants treated with T_4 (Coconut coir) (0.60 mg gallic acid/100 g) which was followed by T_3 (Wood chips) (0.58 mg gallic acid/100 g) and that was at par with T_2 (Popular leaves) (0.53 mg gallic acid/100 g), T_5 (Newspaper) (0.40 mg gallic acid/100 g), T_1 (Control) (0.39 mg gallic acid/100 g), while the minimum total phenolics of strawberry plants cv. Chandler was observed in T_6 (Black polyethylene) (0.33 mg gallic acid/100 g) plants (Figure 6). In strawberry phenols are considered as very important health-related compounds. Strawberry is an affluent source of polyphenols. Some researchers supported that polyphenols account for more than 50% of total phenols in strawberry. Fruits grown in coconut coir showed the highest significant amount of total phenols. This might be due to the fact that increases in chlorophyll content it increases the total phenol. Similar findings were found by (Zeng *et al*, 2007) who stated that strawberries grown in coir fiber had a higher level of total phenols.

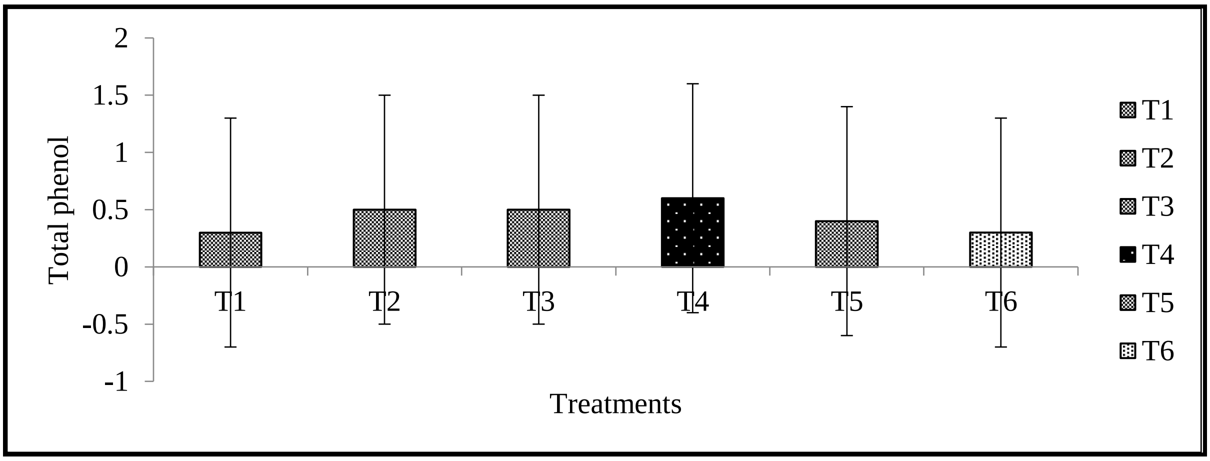

Figure 6: Evaluation of total phenol using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

Total flavonoids of strawberry cv. Chandler is shown in figure 7. The maximum total flavonoids was found in strawberry plants treated with T_4 (Coconut coir) (2.86 mg/100 g FW) which was followed by T_3 (Wood chips) (2.45 mg/100 g FW) and that was at par with T_2 (Popular leaves) (2.39 mg/100 g FW), T_5 (Newspaper) (1.67 mg/100 g FW), T_1 (Control) (1.13 mg/100 g FW), while the minimum total flavonoids of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (0.69 mg/100 g FW) plants (Figure 7).

In strawberry fruits total flavonoids contents is genetically inherited feature that is heavily influenced by genetic makeup of different mulching materials (Rahman *et al*., 2015).

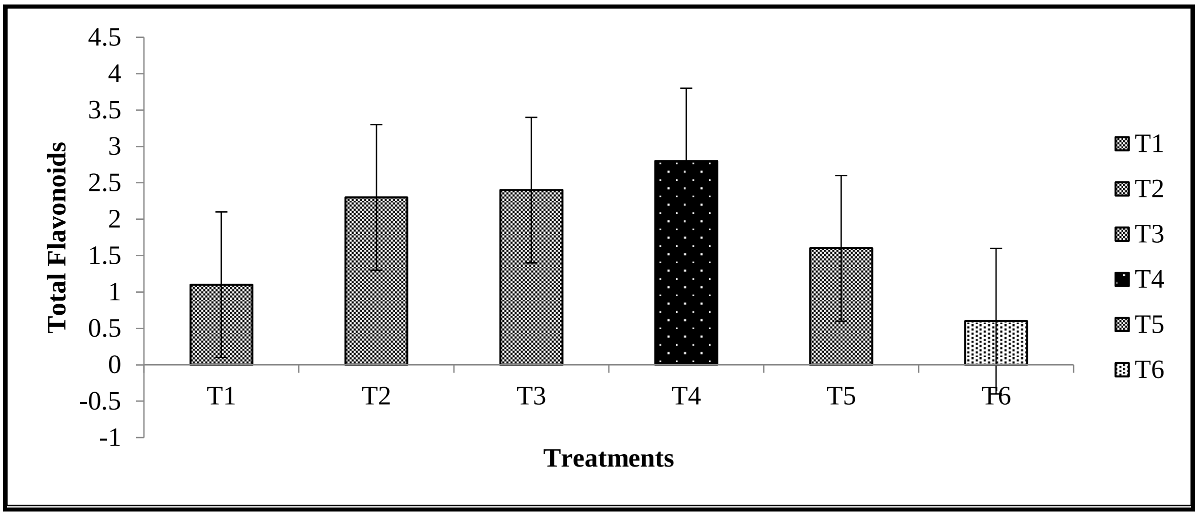

Figure 7: Evaluation of total flavonodies using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

The maximum antioxidant activity was found in strawberry plants treated with T_4 (Coconut coir) (0.89 µg/100 mg FW) which was followed by T_3 (Wood chips) (0.59 µg/100 mg FW) and that was at par with T_5 (Newspaper) (0.36 µg/100 mg FW), T_2 (Popular leaves) (0.36 µg/100 mg FW), T_1 (Control) (0.33 µg/100 mg FW), while the minimum antioxidant activity of strawberry plants cv. Chandler was observed in T_6 (Black polythene) (0.29 µg/100 mg FW) plants (Figure 8). This change in antioxidant activity in fruits is mainly dependent on ecological conditions such as temperature and light intensity during growing stage (Ariza *et al*., 2016).

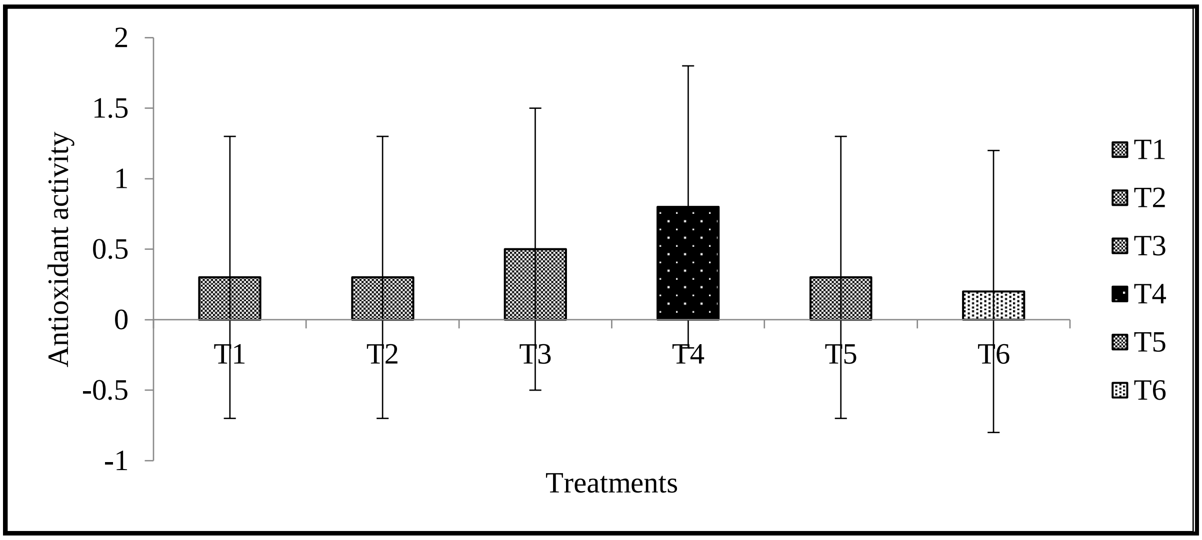

Figure 8: Evaluation of antioxidant activity using different mulching materials.
T1: Control; T2: Popular Leaves; T3: Wood Chips; T4: Coconut Coir; T5: Newspaper; T6: Black Polythene

Soil Moisture (%): Table 2 shows the soil moisture and soil temperature. On the contrary, significant differences were recorded for soil moisture and soil temperature for different mulching materials.

The maximum soil moisture content was found in coconut coir mulch with T_4 (Coconut coir) (17.33) which was followed by T_5 (Newspaper) (15.86) and that was at par with T_2 (Popular leaves) (15.63), T_6 (Black polythene) (15.00) and T_3 (Wood chips) (14.83), while the minimum soil moisture content was found in T_1 (Control) (14.76) plants. It was noticed that all the mulches had good effect in retaining higher amount of moisture in soils compared with control while all the mulches had almost similar results for maintain soil moisture contents. Coconut coir showed highest soil moisture content. This might be due to the efficacy of coconut coir which has the ability to conserve moisture and reduce loss of water from the soil. Mulching also helped in retaining of water which resulted in the formation of fog which was released later on into the upper layer of soil. Similar report was presented by Wang *et al*. (1996) where they found that as compared with control the soil moisture was increased when strawberry filed was covered with mulching material.

Table 2: Effect of different mulching materials on soil moisture and soil temperature

Treatment	Soil moisture	Soil temperature
T1	14.7 ± 0.29 c	17.3 ± 0.29 d
T2	15.6 ± 0.33 b	21.8 ± 0.35 ab
T3	14.8 ± 0.28 c	20.1 ± 0.33 bc
T4	17.5 ± 0.36 a	19.1 ± 0.30 cd
T5	15.8 ± 0.33 b	19.1 ± 0.32 cd
T6	15.0 ± 0.30 b	23.7 ± 0.33 a

[T_1: Control; T_2: Popular Leaves; T_3: Wood Chips; T_4: Coconut Coir; T_5: Newspaper; T_6: Black Polythene].

The maximum soil moisture content was found in coconut coir mulch with T_4 (Coconut coir) (17.33) which was followed by T_5 (Newspaper) (15.86) and that was at par with T_2 (Popular leaves) (15.63), T_6 (Black polythene) (15.00) and T_3 (Wood chips) (14.83), while the minimum soil moisture content was found in T_1 (Control) (14.76) plants. It was noticed that all the mulches had good effect in retaining higher amount of moisture in soils compared with control while all the mulches had almost similar results for maintain soil moisture contents. Coconut coir showed highest soil moisture content. This might be due to the efficacy of coconut coir which has the ability to conserve moisture and reduce loss of water from the soil. Mulching also helped in retaining of water which resulted in the formation of fog which was released later on into the upper layer of soil. Similar report was presented by Wang *et al*. (1996) where they found that as compared with control the soil moisture was increased when strawberry filed was covered with mulching material.

The highest temperature was found in strawberry plants treated with T_6 (Black polythene) (23.73) which was followed by T_2 (Popular leaves) (21.88) and that was at par with T_3 (Wood chips) (20.16), T_4 (Coconut coir) (19.10) and T_5 (Newspaper) (19.10), while the lowest soil temperature was recorded in T_1 (Control) (17.33) plants (Table 2). Black polyethylene produced higher soil temperature which affected the plants growth and wilting and dead plants were observed. This might be due to the fact that part of the radiation passed through the black polythene mulch. However, they provided a barrier to stop the thermal radiations from going outside (Park *et al*., 2015). Fortnum *et al*. (2014) studied a similar phenomenon when used different colored mulching materials which increased the soil temperature of upper few cm.

Authors Contribution

All authors are Equal Contribution

Conflict of Interest

No conflict of interest was reported by the author;s

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