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Growth, yield and quality of strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler as influenced by various mulching materials

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Studies were carried out to evaluate the effect of different mulching materials on growth, yield and quality of strawberry cv. Chandler having seven treatments with three replications in Randomized Block Design during 2010 and 2011. The treatments comprised of paddy straw, wheat straw, dry grass, transparent polyethylene, black polyethylene and no mulch (control). The results revealed that strawberry is very responsive to the different mulching materials. All the treatments improved the vegetative growth, yield and quality of strawberry, but black polythene mulch gave the best results in terms of reducing weed population (1.00/m^2), increasing plant height (21.67 cm), plant spread (31.24 cm), number of leaves per plant (18.33), number of flowers per plant (28.33), number of fruits per plant (12.12), number of achenes/fruit (317.70), fruit weight (11.83 g), fruit length (3.93 cm), fruit breadth (3.00 cm), yield (143.38 g/plant), total soluble solids (7.63 ^{0}B), total sugars (7.00 %), vitamin-C (57.77 mg/100 g) and crude protein (9.64%). However, higher acidity (0.80%) and achene density/fruit (17.34) was observed in fruits grown without mulch.

Key words: Strawberry cv. Chandler, mulching, growth, quality, yield.

INTRODUCTION

The modern cultivated strawberry (*Fragaria* x *ananassa* Duch.) is a hybrid of two largely dioecious octoploid species, *Fragaria chelonesis* Duch and *Fragaria varginiana* Duch. Basically, it is herbaceous perennial and short day plant grows predominantly in the temperate climate. Its fruits are rich source of vitamin and minerals. Strawberry is known for its pleasant aroma. It is amongst the few crops, which gives quick and very high returns per unit area on the capital investment, as the crop is ready for harvesting within six months of planting. Investigation on impact of different mulching materials on growth, yield and quality has indicated that strawberry is very responsive to the different mulching materials. Ensured high yield is only obtained if plants are in good state of health. Mulching is a practice, which helps in proper growth and development of the plants by modifying soil temperature, by providing better nutrient availability and by better moisture conservation (Kher et al., 2010). Mulching has strong influence on yield, quality and duration of harvesting, which is primarily due to better soil and moisture conservation, changes in soil temperature, improved nutrient availability, and suppression in number and growth of weeds, protection from frost injury and reduction in number of dirty and diseased berries (Sharma, 2002). The yield of Tioga strawberry increased by 68 and 33% when plants were mulched with clear plastic and pine needles over control (Badiyala and Aggrawal, 1981). As strawberry is a

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temperate fruit, its production in tropical and sub-tropical region is drastically low resulting in higher market price. Due to these bottlenecks, the poor people cannot afford it and also the farmers seldom go for its cultivation. Keeping this in view, the present studies were carried out to study the impact of different mulching materials so as to ascertain the treatments, which can increase its production as well as quality and provide opportunity to the farming community to grow it commercially.

MATERIALS AND METHODS

Study site

These present investigation was conducted at the Research Farm of Division of Fruit Science, Faculty of Agriculture at Udheywalla, SKUAST-Jammu, India during 2011 and 2012. The experimental site was situated at 32.43° North latitude and 74.54° East longitude and at an elevation of 300 m above mean sea level. The climate of the site can be characterized as sub-tropical with hot dry summer, hot humid, rainy and cold winter months. The minimum and maximum temperatures ranged from 1 to 45°C and with average annual rainfall of 1,000 to 1,200 mm.

Soil status

Soil of the experimental field was sandy loam in texture having pH: 7.1, organic carbon: 0.52%, available N: 216.02 kg/ha, phosphorus: 13.68 kg/ha and potassium: 135.0 kg/ha. Soil was thoroughly ploughed and raised beds of 25 cm height, 1.5 m in length and 2.0 m width were prepared at a distance of 45 cm.

Selection of plant

Healthy and disease free runners of 'Chandler' strawberry were planted on 3rd October, 2011 and 3rd October, 2012 at a distance of 30 cm × 45 cm. Five plants were selected and marked with metal tag for recording observation.

Experimental design

Experiment was laid out in a Randomized Block Design with seven treatments *viz*.: T_1 (paddy straw), T_2 (wheat straw), T_3 (cut grass), T_4 (saw dust), T_5 (transparent polythene), T_6 (black polythene), T_7 no mulch (control). All the treatments were replicated thrice. The watering was done for seven continuous days with watering cane and gap filling was done up to one week. The different mulching materials were applied after two weeks of transplanting.

Statistical analysis

The data were subjected to statistical analysis as per the method of Gomez and Gomez (1996). Critical Difference (C.D) at 5% level was used for finding the significance differences if any, among the treatment means.

Weed count

A permanent 30 × 30 cm quadrant (0.9 m^2) was fixed in each treatment plot before emergence of weeds. Monocot and dicot weeds were counted at 30, 60 and 90 days after the treatment application. The data recorded on weed count was analysed statistically using √n+1 transformation.

Plant height

The average height of plant was measured with a measuring scale from the crown level to the apex of primary leaves and results were expressed in centimeters.

Plant spread

Plant spread was measured in two directions, that is, East-West (E-W) and North-South (N-S) and the mean was taken as the actual plant spread average values were expressed in centimeter.

Number of leaves per plant

Data on number of leaves were recorded from ten plants of two rows in the centre of the each bed and results were expressed as leaf number per plant.

Number of flowers per plant

Data on numbers of flowers per plant were recorded from ten plants in each treatment and expressed as average number of flowers per plant.

Number of fruits per plant

The number of fruits that is, primary, and secondary, tertiary was counted per plant at the time of fruit maturity and were expressed as number of fruits per plant.

Fruit weight

To ascertain the berry weight, ten berries from each treatment were randomly selected and average weight of berry was recorded on electronic balance and expressed as mean fruit weight in gram.

Fruit length

The length of ten randomly selected fruits from each replication was measured in cm from calyx plug to the pointed end or apex of the fruit.

Fruit breadth

The breadth of ten randomly selected fruits from each replication was measured in centimeter.

Total yield per plant

The total fruit production in each treatment was recorded from ten plants per plot and yield per plant was calculated and expressed in grams.

Number of achenes per fruit

The total number of achenes per berry was recorded in ten

Table 1. Effect of different mulching treatments on weed population (m^2) (pooled data of 2 years).

Treatment	30 DAP*	60 DAP	90 DAP
T_1: Paddy straw	22.0 (4.80)**	55.2 (7.48)	100.2 (10.03)
T_2: Wheat straw	22.2 (4.80)	44.3 (6.69)	55.3 (7.48)
T_3: Cut grass	11.4 (3.46)	33.2 (5.83)	67.4 (8.25)
T_4: Saw dust	44.2 (6.67)	78.4 (8.89)	111.2 (10.58)
T_5: Transparent polythene	0 (1.00)	0 (1.00)	0 (1.00)
T_6: Black polythene	0 (1.00)	0 (1.00)	0 (1.00)
T_7: Control	89.4 (9.49)	122.4 (11.09)	144.4 (12.04)
$C.D_{(0.05)}$	1.25	1.07	0.92

*****DAP: days after planting and ** Figures in parenthesis are transformed values.

randomly selected berries in each treatment. The average number of achenes per berry was expressed in numbers.

Achene density per fruit

To determine achene density, pieces of one cm^2 berry skin from three different sides of berry were taken and number of achene was counted. The results were expressed in number of achenes per square centimeter.

Total soluble solids

Total soluble solids of the fresh fruits were recorded by using a digital refractometer at room temperature and expressed in ^{0}Brix. The refractometer was cleaned with distilled water after each observation.

Sugars

25 ml of the fresh fruit solution used for the estimation of reducing sugars was taken and 2.5 ml of concentrated HCl was added and kept overnight. Next day, the solution was neutralized with 1N NaOH and the volume was made up to 75 ml. It was then titrated against Fehling's solution A and B (5 ml each) as done in case of reducing sugars. From the following formula, total sugar was calculated (Ranganna, 1997):

$$\text{Total sugar as invert sugar (\%)} = \frac{\text{Mg of invert sugar} \times \text{dilution} \times 100}{\text{Titre value} \times \text{Weight or volume of sample}}$$

Acidity

Total titratable acidity of fresh fruits was estimated by taking 10 ml of juice which was diluted with distilled water to make the final volume 100 ml. 10 ml of this sample was titrated against N/10 NaOH using phenolphthalein as the indicator (AOAC (1980)).

Ascorbic acid

Ascorbic acid content was determined by using 2, 6-Dichlorophenol-indophenol dye method of Freed (1966). 5 g of the fresh fruit sample was grounded with about 25 ml of 4% oxalic acid and filter through Whatman no. 4 filter paper. The filtrate was collected in a 50 ml volumetric flask and the volume was made up with 4% oxalic acid and titrated against the standard dye to a pink point. The amount of ascorbic acid was calculated using the following formula and expressed as mg/ 100 g.

$$\text{Ascorbic acid (mg/ 100 g)} = \frac{\text{Titre value} \times \text{dye factor} \times \text{volume make up} \times 100}{\text{Aliquot} \times \text{weight of the sample}}$$

Crude protein

The percent crude protein was determined as per method outlined by Ranganna 1997 by employing the following formula:

Crude protein (%) = weight of nitrogen × 6.25

Physiological loss in weight

Initial weight of twenty fruits in each treatment was recorded at the time of harvesting. Weight loss was recorded after 6 h at ambient temperature till fruits become unmarketable and results were expressed in percentage.

RESULTS AND DISCUSSION

Effect of organic and inorganic mulches on weed count, growth and flowering of strawberry

Among the different mulching treatments, black polythene mulch and transparent polythene mulch showed significant superiority in reducing weed population (Table 1) over rest of the treatments. This effect may be due to smothering effect and causing physical barrier to photosynthetic activity imparted by polythene mulches. The data presented in Table 2 clearly indicate that plants mulched with black polythene recorded the maximum plant height (21.67 cm) which was significantly superior over other mulching treatments. This could possibly be due to the suppression of weeds under black polythene mulch due to which plant performance may have improved by better nutrient uptake by the plants. Plant

Table 2. Effect of different mulches on growth and flowering in strawberry cv. Chandler (pooled data of 2 years).

Treatment	Plant height (cm)	Plant spread (cm)	Number of leaves/plant	Number of flowers/plant	Number of fruits per plant
T_1: Paddy straw	18.26	28.90	17.08	24.33	10.97
T_2: Wheat straw	18.13	28.82	17.33	24.00	9.76
T_3: Cut grass	18.44	28.05	17.67	24.67	9.63
T_4: Saw dust	18.00	28.05	16.33	24.00	8.54
T_5: Transparent polythene	20.26	30.98	17.33	25.67	11.52
T_6: Black polythene	21.67	31.24	18.33	28.33	12.12
T_7: Control	16.33	26.61	15.74	22.33	7.38
$C.D_{(0.05)}$	1.10	1.21	1.16	1.34	0.83

Table 3. Effect of mulching on physical parameters and yield of strawberry cv. Chandler (pooled data of 2 years).

Treatment	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Total yield per plant (g)	Number of achenes/fruit	Achene density/fruit
T_1: Paddy straw	9.00	3.40	2.34	98.73	281.30	16.24
T_2: Wheat straw	9.67	3.30	2.42	94.38	288.00	15.82
T_3: Cut grass	9.17	3.50	2.82	83.31	289.70	14.24
T_4: Saw dust	9.67	3.52	2.34	82.58	303.00	13.82
T_5: Transparent polythene	10.00	3.30	2.74	115.20	310.00	13.10
T_6: Black polythene	11.83	3.93	3.00	143.38	317.70	12.30
T_7: Control	8.16	3.16	2.00	60.22	266.70	17.34
$C.D_{(0.05)}$	0.38	0.26	0.14	1.09	3.85	2.48

spread was found significantly maximum (31.24 cm) under black polythene mulch as compared to rest of the treatments but was statistically at par with the transparent polythene mulch. The presence of adequate moisture in the soil is vital for plant growth not only because plant needs water for their physiological processes but also for nutrient solubility and their availability in soil solution. The perusal of data in Table 2 depicts that maximum number of leaves (18.33) were observed under black polythene mulch which was found statistically at par with the T_2, T_3 and T_5 treatments.

This result is in conformity with earlier reports of mulching in strawberry (Gupta and Acharya, 1993; Kher et al. 2010). The black polythene mulch might have conserved higher soil moisture and temperature as well as reduced the nutrient losses by suppressing the weed population. Several workers, *viz*., Kher et al. (2010), Singh et al. (2010) and Kumar and Dey (2011) also reported higher vegetative growth in mulched plots especially under black polythene mulch. Higher number of fruits per plant (Table 2) was also observed under black polythene mulch (12.12). This may be attributed to more number of flowers produced by vigorous plants under black polythene mulch, which is in conformity with the findings of Nagalakshmi et al. (2002). All organic and inorganic mulches recorded higher number of flowers as compared to control. However, the maximum number of flowers per plant (28.33) was obtained under black polythene mulch.

Effect of organic and inorganic mulches on physical characteristics of strawberry

The average fruit weight was also influenced by different mulch material (Table 3), but among the mulching treatments the maximum average fruit weight was recorded in black polythene mulch (11.83 g), followed by transparent polythene (10.00 g). The higher fruit weight is attributed to vigorous growth of plants under black polythene mulches. Similar observations on larger fruits by mulching with black polythene have also been reported by Mathad and Jholgiker (2005) and Kumar et al. (2012). Fruit length (3.93 cm) and fruit breadth (3.00 cm) under black polythene was found significantly higher in comparison to all other treatments. The larger fruit size under black polythene mulch was attributed to more plant growth and development under micro-climatic condition resulting in better nutrient uptake. Increase in fruit size due to mulching had also been reported by Nagalakshmi et al. (2002). Yield is an important attribute of fresh fruits and mulches significantly increased yield per plant and total yield (Table 3). Maximum yield per plant was recorded in black polythene mulch (143.38 g/plant). Plants under black polythene mulch produced higher yield per plant because of larger fruits due to better plant

Table 4. Effect of mulching on chemical parameters of strawberry fruits cv. Chandler (pooled data of 2 years).

Treatment	TSS (^{0}B)	Total sugar (%)	Acidity (%)	Ascorbic acid (mg/100 g)	Crude protein (%)
T_1: Paddy straw	7.10	6.52	0.70	55.78	7.58
T_2: Wheat straw	7.00	6.44	0.78	55.45	7.82
T_3: Cut grass	7.30	6.88	0.70	55.24	8.92
T_4: Saw dust	6.93	6.34	0.73	54.20	7.20
T_5: Transparent polythene	7.20	6.74	0.74	56.24	9.13
T_6: Black polythene	7.63	7.00	0.64	57.77	9.64
T_7: Control	6.67	6.10	0.80	53.24	6.42
$C.D_{(0.05)}$	0.35	0.23	0.19	2.34	0.67

Table 5. Effect of mulching on physiological loss in weight (%) of harvested strawberry fruits cv. Chandler at ambient temperature (pooled data of 2 years).

Treatment	Hours			
	6	12	18	24
T_1: Paddy straw	5.01	7.92	12.64	15.25
T_2: Wheat straw	5.12	8.05	12.70	15.35
T_3: Cut grass	4.92	7.84	12.25	15.10
T_4: Saw dust	5.34	8.14	12.72	15.40
T_5: Transparent polythene	4.90	7.90	12.05	14.96
T_6: Black polythene	4.62	7.69	11.82	14.84
T_7: Control	5.89	8.25	12.85	16.24
$C.D_{(0.05)}$	0.25	0.15	0.37	0.31

growth owing to favourable hydrothermal regime of soil and complete weed free environment. Similar observation on increased yield with larger fruits, following mulching with black polythene has also been reported by Singh and Ahmed (2008) and Kher et al. (2010).

Effect of organic and inorganic mulches on chemical characteristics of strawberry

In Table 4 the data depicts that the application of black polythene mulch recorded maximum TSS (7.63°B), total sugars (7.00%), ascorbic acid (57.77 mg/100 g) and crude protein (9.64%). Higher fruit quality is related to weed free environment, higher moisture conservation and maximum nutrient uptake under black polythene mulch treatment. These results are in conformity with the findings of Mathad and Jholgiker (2005) and Singh et al. (2007). Minimum physiological loss in fruit weight was observed after 6, 12, 18 and 24 h in the treatment T_6 (black polythene mulch) which might be due to good response in terms of growth, flowering and quality traits under black polythene mulch (Table 5).

Conclusion

From the study it could be inferred that the performance of various organic as well as inorganic mulches was better than control. However, black polythene mulch resulted in maximum growth, yield and quality as well as reduction in weed population.

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