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RESEARCH ARTICLE

Effect of Mulching on Growth, Yield and Economics of Strawberry (*Fragaria × ananassa*) under Subtropical Conditions of Uttarakhand

Ankit Semwal[1], Suneeta Singh[1], Pankaj Nautiyal[2*] and Shivangi Pandey[1]

[1]Department of Horticulture, School of Agricultural Sciences, SGRR University, Dehradun Uttarakhand, India
[2]ICAR- Krishi Vigyan Kendra, (ICAR- VPKAS) Chinyalisaur, Uttarkashi, Uttarakhand, India

*Corresponding author: pankajnautiyal2009@gmail.com (**ORCID ID:** 0000-0002-1149-4005)

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ABSTRACT

Present experimental research was conducted during the year 2020-21 in the Horticulture Research Block, Department of Horticulture, School of Agriculture Sciences, SGRR University, Dehradun, Uttarakhand, India to study the effect of mulching on growth, yield and economics of strawberry. The runners of strawberry cv. Chandler were planted in the first week of November. The experiment was laid out in randomized block design with three treatments and three replications. The treatments were comprised with different mulching materials viz. control as without mulching (T_1), straw mulching (T_2) and polythene mulching (T_3). The various parameters of growth, yield and economics were recorded at 30, 60, 90, 120, 150 DAT and at final harvest. Significant results were obtained for different attributes of growth, yield as well as in terms of economics under black polythene mulching (T_3). The black polythene mulching results in maximum number of leaves per plant (26.95), number of flower per plant (24.08), leaf area (955.99 cm^2), number of runners per plant (16.00), number of fruits per plant (15.5), fruit weight (15.10 g), total yield per plot (2.82 kg/plot), total yield per hectare (20.34 q/ha) and B:C ratio (1:2.73). From this we can say that black polythene mulching is more suitable for growth and yield attributes of strawberry cultivation.

HIGHLIGHTS

- The black polythene mulch was found to be most effective for influencing various growth parameters of strawberry.
- The black polyethylene mulch also checks all types of weeds in addition to soil moisture conservation.

Keywords: Strawberry, economics, mulching, growth, runners, leaf area, total yield per plot

Strawberry (*Fragaria ananassa*) belongs to the family Rosaceae and sub family Rosoideae, is one of the important soft fruit of the world and has resulted from a cross between two wild strawberries i.e. *Fragaria virginiana* (Meadow strawberry) and *Fragaria chiloensis* (Chilean strawberry). In India, it was introduced in the early 1960's (Sharma and Sharma 2004) and it has now acclimatized well in different parts of India. It is an herbaceous perennial plant which can be successfully cultivated in wide range of agro climatic conditions from subtropics to temperate climate. All the cultivated varieties are octaploid (2× = 56). Strawberry plant has crowns from which all leaves, roots, flowers and runners grow (Bowling 2000). It is a rich source of Vitamin A (60 IU/100 g of edible fruit), Vitamin C (30-120 mg/100g of edible portion), Vitamin B_1, niacin, proteins and minerals like phosphorous, potassium, calcium and iron. The presence of ellagic acid, which prevents cancer and occurrence of heart diseases

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and the abundance of anthocyanins have made it a more valuable fruit. The heart-shaped silhouette of the strawberry is the first clue that this fruit is good for health. These potent little packages protect your heart, lower your blood pressure and guard against cancer. Packed with vitamins, fibres and particularly high levels of antioxidants known as polyphenols helps in wrinkle-prevention, strawberries are a sodium-free, fat-free, cholesterol-free, low-calorie food. They are among the top 20 fruits in antioxidant capacity and are a good source of manganese and potassium (Singh 2019). Mulching reduces soil temperature in summer and raises it in winter. It prevents the extremes of temperatures. During summer, mulching conserves the soil moisture due to reduced evaporation. The cooling effect of soil promotes root development. In general, the effect of mulching on the temperature regime of the soil varies according to the capacity of the mulching material to reflect and transmit solar energy. Mulches results in greater water content and lower the evaporation. White mulches decrease soil temperature while clear plastic mulches increase soil temperature. The soil temperature can be higher up to 7^0C under clear mulch compared to bare soil. At night, condensation on the underside of the mulch absorbs the long wave radiation emitted by the soil thereby slowing cooling of the soil (Lamont 2005). The ability of clear mulches to produce soil temperatures high enough to control weeds, plant pathogens and nematodes forms the basis for the soil solarization process. The plastic materials used as mulch are poly vinyl chloride or polyethylene films. Owing to its greater permeability to long wave radiation it can increase temperature around the plants during night in winter.

Hence, polyethylene film mulch is preferred as mulching material for crop production. Now a day application of black plastic mulch film is becoming popular and very good results have been achieved particularly in rain fed agriculture. The black polyethylene mulch also checks all types of weeds in addition to soil moisture conservation therefore; black plastic mulch is more beneficial (McCann *et al.* 2007). Polythene mulch with black side facing upward is the most effective for improving plant growth.

Fruit yield and quality (Lalruatsangi and Hazarika 2018). There are different types of cultivation methods used for cultivation of strawberry in different regions according to their climatic requirement. That's why it is very important to select the suitable method for growing in a particular season with the use of mulching to minimize the probability of getting damage or yield loss. Keeping these aims in view, the present investigation was conducted to assess the growth, yield and economics of strawberry under subtropical conditions of Dehradun.

MATERIALS AND METHODS

The present field experiment was conducted during 2020-21 in Horticulture Research Block of School of Agricultural Sciences, SGRR University, Dehradun, Uttarakhand, India. The experimental site was located in the north western region of Uttarakhand at an altitude of 650 m above mean sea level (MSL) and 3088 square kilometre in size. Geographically, the location of Dehradun is in between 29°58′ and 31°2′30″ North latitude and 77° 34′45″ and 78°18′30″ East longitudes. The climate of the trial site can be characterized as sub-tropical with hot dry summer, cold winter months. The atmospheric temperature occasionally reaches up to 38°C. The soil of experimental site is classified as 'sandy loam' with characteristics as deep, well drained, coarse loamy cover over fragmental soils and of medium fertility and having pH 7.12. Healthy and disease free runners of strawberry cv. Chandler were planted in first week of November, 2020 at a distance of 30 × 22.5 cm. Five plants were selected and marked with aluminium tag for recording observations. Experiment was laid out in Randomized block design with three treatments viz.: T_1 (Control or without mulching), T_2 (Paddy straw mulching) and T_3 (Black polyethylene mulching). All the treatments were replicated thrice. The average numbers of leaves per plant were recorded from five plants of each bed and results were expressed as leaf number per plant. To determine the number of flowers per plant, total number of flowers at five days interval was recorded and average numbers of flowers per plant were calculated. The observations on leaf area were recorded at the end of the growing season where five leaves per plant were collected randomly from five plants per treatment and out of the pooled 25 leaves; five leaves were further selected at random for measuring leaf area. The leaf area was studied on a graph paper and average leaf area was expressed by counting squares in square

centimetres (cm^2). The total leaf was worked out by multiplying number of leaves with an average leaf area. Numbers of runners produced in five tagged plants were counted starting from 30 to 150 DAT at 30 days interval and the mean numbers of runners produced per plant were worked out. To determine the number of fruits per plant, total number of fruits at five days interval was recorded and average number of fruits per plant was calculated. The weight of fruit was measured by placing fruit on the digital weighing balance and expressed in grams (g). The total fruit production in each treatment was recorded from five tagged plants per plot and the average fruit yield was calculated and estimated the total fruit yield per plot was expressed in kg/ plot. The average fruit yield was calculated and was expressed in q/ ha as total yield per hectare. The experiment was laid out in randomized block design with three replications. Each replication consisted of three treatments. All the treatments were randomized separately in each replication.

RESULTS AND DISCUSSION

The findings of the present investigation were recorded and are thoroughly discussed below:

Number of leaves per plant

The data recorded on number of leaves at different growth stages are presented in the Table 1 and depicted through Fig. 1.

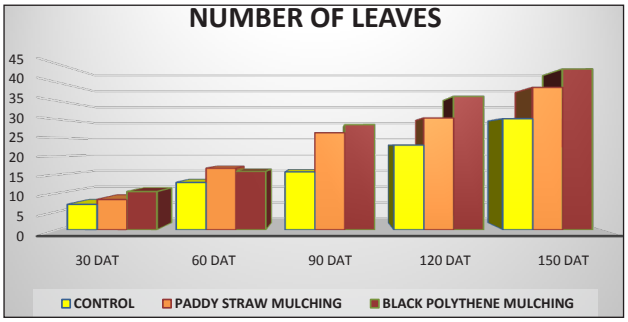

Fig. 1: Number of leaves per plant as influenced by different mulching materials in strawberry

The observation of number of leaves was recorded at 30 DAT, 60 DAT, 90 DAT, 120 DAT, 150 DAT and at final harvest, the results were significantly differs among the treatments. At 30 days after transplanting, the maximum number of leaves was observed in treatment T_3 (10.39) which was at par with T_2 (8.24). However, the minimum number of leaves per plant was recorded in treatment T_1 (6.90). At 60 days after transplanting, the maximum number of leaves was observed in treatment T_3 (16.73) which was at par with T_2 (15.89) and the minimum number of leaves per plant was counted in treatment T_1 (12.86). At 90 days after transplanting, the maximum number of leaves was observed in treatment T_3 (28.56) which was at par with T_2 (26.36). Whereas the minimum number of leaves per plant was recorded in treatment T_1 (15.73). At 120 days after transplanting, the maximum number of leaves was observed in treatment T_3 (36.23). However, the minimum number of leaves per plant was reported in treatment T_1 (23.01). At 150 days after transplanting, the maximum and minimum number of leaves was observed in treatment T_3 (43.66) and T_1 (30.17), respectively. The maximum number of leaves was might be due to the reason that the black polythene mulch 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) and Singh *et al.* (2010) also reported higher number of leaves in strawberry under black polythene mulch.

Number of Flowers per plant

The perusal of data recorded on number of flowers are presented in the Table 1 and depicted through Fig. 2.

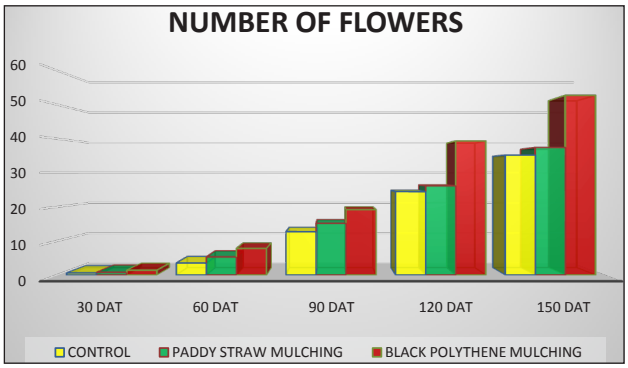

Fig. 2: Number of flowers per plant as influenced by different mulching materials in strawberry

At 30 days after transplanting, the maximum number of flowers was observed in treatment T_3 (1.41) which was at par with T_2 (0.85). However, the minimum number of flowers per plant was recorded in treatment T_1 (0.60). At 60 days after transplanting, the maximum number of flowers was observed

Table 1: Effect of mulching materials on number of leaves per plant and number of flowers per plant of strawberry at different harvest intervals

Treatment	Number of leaves per plant						Number of flowers per plant					
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	MEAN	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	MEAN
T_1	6.9	12.86	15.73	23.01	30.17	17.73	0.60	3.52	12.72	24.45	35.18	15.30
T_2	8.24	16.73	26.36	30.36	38.66	24.07	0.85	5.32	15.17	26.17	37.41	16.97
T_3	10.39	15.89	28.56	36.23	43.66	26.95	1.41	7.81	19.18	39.32	52.71	24.08
C.D. (P=0.05)	4.29						5.91					
SE(m) ±	1.29						1.78					
SE(d) ±	1.83						2.52					
C.V.	12.65						19.25					

Table 2: Effect of mulching materials on leaf area and number of runners per plant of strawberry at different harvest intervals

Treatment	Leaf area (cm^2)						Number of runners per plant					
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	MEAN	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	MEAN
T_1	293.18	345.48	512.44	710.62	960.55	564.45	1.27	4.26	10.96	14.58	21.01	10.416
T_2	333.47	434.89	755.42	891.33	1031.3	689.27	1.8	6.12	11.01	16.56	22.12	11.522
T_3	573.14	750.19	982.23	1114.2	1360.3	955.99	2.68	9.12	15.89	23.18	29.16	16.006
C.D.(P=0.05)	72.71						2.405					
SE(m) ±	21.95						0.726					
SE(d) ±	31.05						1.027					
C.V.	6.66						12.838					

in treatment T_3 (7.81) and the minimum number of flowers per plant was counted in treatment T_1 (3.52). At 90 days after transplanting, the maximum number of flowers was observed in treatment T_3 (19.18). Whereas the minimum number of flowers per plant was recorded in treatment T_1 (12.72). At 120 days after transplanting, the maximum number of flowers was observed in treatment T_3 (39.32). However the minimum number of flowers per plant was counted in treatment T_1 (24.45). At 150 days after transplanting, the maximum and minimum number of flowers was observed in treatment T_3 (52.71) and T_1 (35.18), respectively. The pragmatic improvement effect on flowering parameters due to black polythene mulching might be attributed to the benefit which led to decreased water loss and soil temperature, reduced soil erosion and suppressed weeds which in turn promoted vegetative growth which positively reflected on flowering traits. These observations seemed to be in confirmation with those reported by Ali and Radwan (2008), Arin and Ankara (2001) and Kaur and Singh (2009) in strawberry. The results of Soliman *et al.* (2015) in various strawberry cultivars, Bakshi *et al*. (2014) in strawberry cv. Chandler are also similar with the present results.

Leaf area (cm^2)

The observation of leaf area was recorded at different intervals were significantly differs among the treatments. At 30 days after transplanting, the maximum leaf area was observed in treatment T_3 (573.14 cm^2) and the minimum leaf area per plant was recorded in treatment T_1 (293.18 cm^2).

At 60 days after transplanting, the maximum leaf area was observed in treatment T_3 (750.19 cm^2) and the minimum leaf area per plant was counted in treatment T_1 (345.48 cm^2). At 90 days after transplanting, the maximum leaf area was observed in treatment T_3 (982.23 cm^2) whereas, the minimum leaf area per plant was recorded in treatment T_1 (512.44 cm^2). At 120 days after transplanting, the maximum leaf area was observed in treatment T_3 (1114.2 cm^2). However, the minimum leaf area per plant was counted in treatment T_1 (710.62 cm^2). At 150 days after transplanting, the maximum and minimum leaf area were observed in treatment T_3 (1360.3 cm^2) and T_1 (960.55 cm^2), respectively. The variation in leaf area per plant among the treatments could be attributed to variation in production of number of runners per plant, there by improved the supply of sufficient quantities of water and nutrients

to the plants throughout the crop growth period. These results were in conformity with the findings of Ali and Gaur (2013) in strawberry.

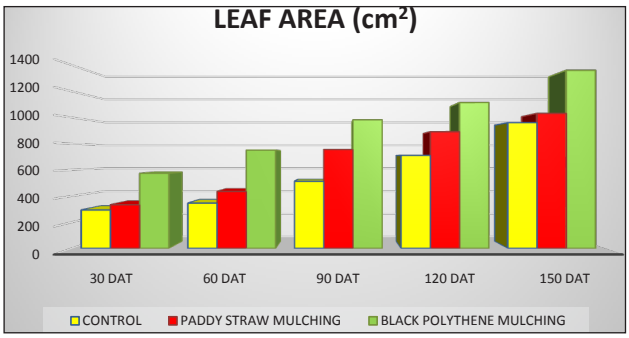

Fig. 3: Leaf area (cm^2) as influenced by different mulching materials in strawberry

Number of Runners

The data recorded on number of runners at different growth stages are presented in the Table 2 and depicted through Fig. 4.

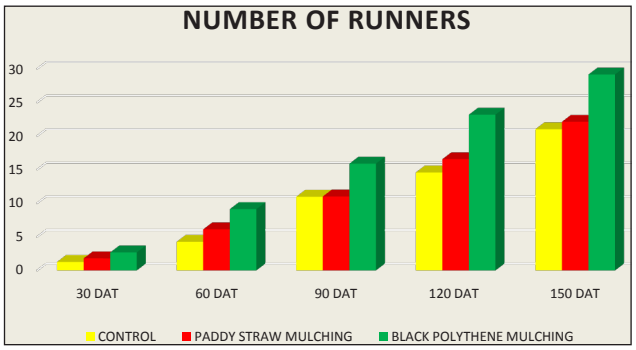

Fig. 4: Number of runners as influenced by different mulching materials in strawberry

Results reported that, at 30 days after transplanting, the maximum number of runners was observed in treatment T_3 (2.68) which was at par with T_2 (1.8). However, the minimum number of runners per plant was recorded in treatment T_1 (1.27). At 60 days after transplanting, the maximum number of runners was observed in treatment T_3 (9.12) and the minimum number of runners per plant was counted in treatment T_1 (4.26). At 90 days after transplanting, the maximum number of runners was observed in treatment T_3 (15.83). Whereas the minimum number of runners per plant was recorded in treatment T_1 (10.96). At 120 days after transplanting, the maximum number of runners was observed in treatment T_3 (23.18). However the minimum number of runners per plant was counted in treatment T_1 (14.58). At 150 days after transplanting, the maximum and minimum number of runners was observed in treatment T_3 (29.16) and T_1 (21.01), respectively. Among the different mulching treatments, black polythene mulch showed significant superiority in reducing weed population 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 above can clearly indicate that plants mulched with black polythene recorded the maximum number of runners in strawberry (Ali and Gaur 2013).

Number of fruits per plant

The data on number of fruits per plant recorded in different treatments are presented in Table 3 and depicted in Fig. 5.

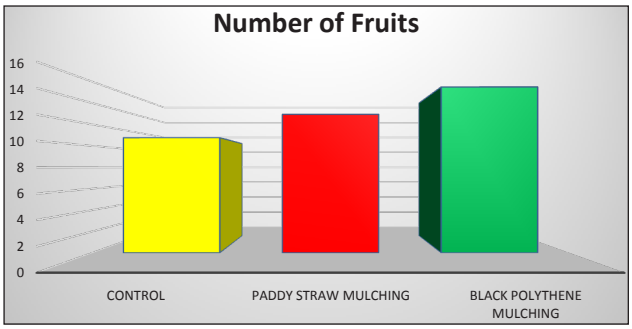

Fig. 5: Number of fruits per plant as influenced by different mulching materials in strawberry

Table 3: Effect of mulching materials on different yield attributes of strawberry

Treatment	Number of fruits per plant	Fruit weight (g)	Fruit yield (kg/ plot)	Fruit yield (q/ha)
T1	10.76	12.44	0.96	6.92
T2	12.95	13.62	1.45	10.46
T3	15.5	15.10	2.82	20.34
C.D. (P=0.05)	0.24	N/A	0.17	0.62
SE(m) ±	0.06	0.38	0.04	0.15
SE(d) ±	0.08	0.54	0.06	0.21
C.V.	0.79	5.06	4.34	2.11

The number of fruits per plant showed significant difference for different treatments. Among the treatment evaluated numerically maximum number of fruits per plant was recorded in T_3 (15.5) and minimum in the treatment T_1 (10.76). Plants under black polythene mulch produced higher yield per

plant because of larger fruits due to better plant 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 Kher *et al.* (2010). Also, the grades of the experiment verified that black polyethylene mulching increased the number of fruits per plant as compared to other mulches of sugarcane trash, paddy straw, grasses, sawdust and clear polyethylene. These observations are in confirmation with the findings of Shokouhian and Asghari (2015) who reported that application of black polythene mulch increased the number of fruits per plant in strawberry as compared to paddy straw and clear polyethylene mulch. This might be attributed to the fact that the black polyethylene enhanced the number of flowers due to the decreased water loss and soil temperature which in turn increased the number of fruits respectively. These findings are in line to the results of Pandey *et al.* (2016), Singh *et al.* (2010) and Bakshi *et al.* (2014) in strawberry plants.

Fruit weight (g)

It is clear from the Table 4 and Fig. 6, that the fruit weight of different treatments differed significantly and range from 12.44g to 15.10g. The maximum fruit weight was noted in the treatment T_3 (15.10g), which was at par with T_2 (13.62 g). The minimum weight of fruit (12.44g) was recorded in treatment T_1. 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).

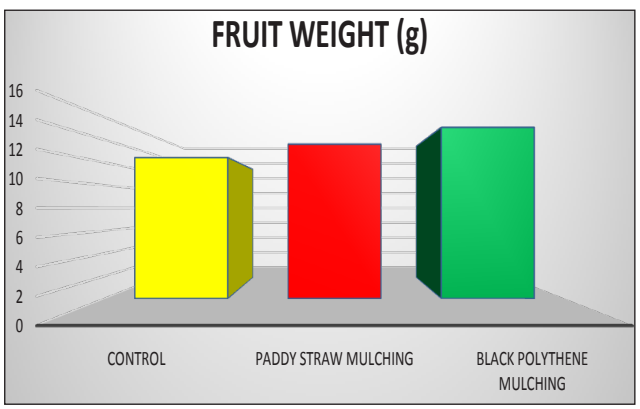

Fig. 6: Fruit weight (g) as influenced by different mulching materials in strawberry

Table 4: Economics of strawberry cultivation under different mulching materials

Treatment	Net return (₹ ha^{-1})	B:C ratio
T_1	62,100	1:1.17
T_2	2,54,438	1:1.68
T_3	7,73,461	1:2.73

Fruit Yield (kg/plot) and Fruit Yield (q/ha)

Among all the treatments, plants mulched with black polythene mulch (T_3) showed the maximum fruit yield per plot (2.82 Kg) as well as fruit yield per hectare (20.34 q/ha). Whereas, minimum fruit yield per plot as well as fruit yield per hectare were recorded in control. Increase in availability of nutrients and highly suppressed weeds as a reason for improved yield has been reported by Moor *et al*. (2004), Sharma and Khokhar (2006) and Nagalakshmi *et al*. (2002) in strawberry; Pandey *et al.* (2016), Soliman *et al.* (2015) and Bakshi *et al.* (2014) also reported the same results.

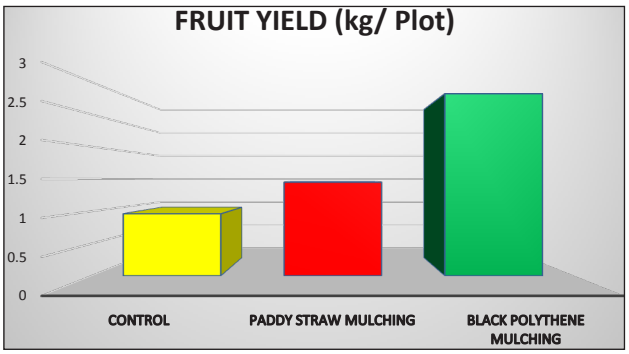

Fig. 7: Fruit yield (kg/plot) as influenced by different mulching materials in strawberry

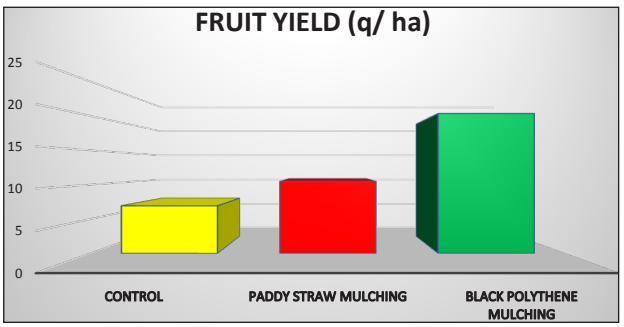

Fig. 8: Fruit yield (q/ha) as influenced by different mulching materials in strawberry

Economics

The benefit cost ratio ranged from 1:1.17 to 1:2.73 depending upon the different treatments (Table 4).

It was found to be highest under the treatments T_3 (Black polythene mulching) and lowest under the treatment T_1 (control). The increase in B: C ratio might be due to the application of different mulching materials, which increases the number of leaves per plant, leaf area, flowers per plant etc. in plant, which leading to enhance the yield.

CONCLUSION

On the basis of present experimental research on effect of mulching on growth, yield and economics of strawberry cultivar "Chandler" under subtropical conditions of Uttarakhand, it can be concluded that among different mulching materials, black polythene mulch (T_3) was found to be most effective for influencing various growth parameters such as- number of leaves per plant, number of flowers per plant, leaf area, number of runners per plant, yield parameters like number of fruit per plant, fruit weight, total yield per plot and total yield per hectare as well as in terms of economics also.

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