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Exploration of effect of different mulches on okra (*Abelmoschus esculentus* L.) variety Punjab Suhavani in sub-tropical regions of Punjab, India

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Abstract

The present research was carried out at Experimental Farm, Department of Agriculture, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab (India) during summer season of 2022. The maximum germination was recorded under the black polythene mulch (73.00%), followed by transparent polythene mulch (71.33%), silver polythene mulch (70.33%). Among all organic mulches the maximum germination was recorded under the treatment paddy straw mulch. The maximum fruit diameter 1.97 cm was recorded under the treatment black polythene mulch at par with silver polythene mulch (1.95 cm) followed by transparent polythene mulch (1.74 cm). Among all organic mulches maximum fruit diameter was recorded under sugarcane trash mulch (1.66 cm). The maximum fruit weight was also recorded under silver polythene mulch (16.73 g) followed by black polythene mulch (15.53 g) and transparent polythene mulch (13.73 g). The maximum fruit yield per hectare was observed under silver polythene mulch (31.40 tons ha^{-1}) followed by black polythene mulch (27.78 tons ha^{-1}), transparent polythene mulch (22.72 tons ha^{-1}), rice husk mulch (18.57 tons ha^{-1}) while minimum yield was recorded under control (11.01 tons ha^{-1}). The chlorophyll content of leaves recorded maximum under the silver polythene mulch (3.84 mg 100 g^{-1}) followed by black polythene mulch (2.77 mg 100 g^{-1}), transparent polythene mulch (2.37 mg 100 g^{-1}), sugarcane trash mulch (1.92 mg 100 g^{-1}), while least was recorded under control (1.49 mg 100 g^{-1}). The maximum soil temperature was recorded under the treatment silver polythene mulch (25.8 °C) and black polythene mulch (25.6 °C) which was followed sugarcane trash mulch (24.4 °C) and paddy straw mulch (24.4 °C). The maximum net return was recorded under silver polythene mulch (Rs. 343000 ha^{-1}) followed by black polythene mulch (Rs. 288700 ha^{-1}), sugarcane trash mulch (Rs. 121600 ha^{-1}) and was minimum recorded under the control (Rs. 85150 ha^{-1}) and saw dust mulch (Rs. -184966 ha^{-1}).

Keywords: Punjab, crop, mulch, parameters, yield, okra

Introduction

Okra (*Abelmoschus esculentus* L.) is an economically essential vegetable crop grown in tropical and sub-tropical regions of the world, belongs to family *Malvaceae*. This crop is suitable for cultivation as a garden crop in addition to on big industrial farms. Okra flora are grown commercially in many nations together with India, Japan, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Myanmar, Malaysia, Thailand, Brazil, Ethiopia, Cyprus and in the Southern United States (Singh *et al* 2014) ^[21]. In India, it is cultivated over an area of 5.33 lakh hectare with annual production of 63.46 lakh MT. The major okra growing states in India are Andhra Pradesh (20%), West Bengal (15%), Bihar (14%), Odisha (11%) and rest in other states (Dhaliwal, 2020) ^[9]. In Punjab, the Okra is grown in an area of 5.31 thousand hectares. The annual production is 54.88 thousand tones with the average productivity of 103.44 q ha^{-1} (Anonymous, 2021) ^[5].

Mulching is the practice of covering the ground to make more favorable condition for plant growths, development and efficient crop production. Natural mulches such as leaf, straw, dead leaves and compost have been used for centuries. Mulching effectively manipulates crop growing environment leading to better growth, yield and improved quality of the product with the aid of suppressing weeds, ameliorating soil temperature, protecting soil moisture, decreasing soil erosion, improving soil structure. (Awodoyin *et al* 2010) ^[6].

The studies on the effect of different organic and inorganic mulches on okra were not undertaken in this region, such studies would provide much needed information for boosting their productivity and production, thus the results of present research will provide technical information on the effect of different type of mulches on growth, yield, and quality of okra.

Materials and Methods

Experimental location: The present research was carried out at Experimental Farm, Department of Agriculture, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab during summer season of 2022.

Experimental details

The field experiment was laid out in Randomized Block Design (RBD). To minimize the errors the treatments were replicated three times. In this experiment nine treatments were selected for study which consisted of various types of mulches *viz.* paddy straw, sugarcane trash, black polythene mulch, transparent polythene mulch, silver polythene mulch, saw dust, rice husk, dry leaves and control. The size of each plot was 2.5 m x 2.5 m (6.25 m²). The okra crop was sown in month of March and the data recorded at 30 days interval (30, 60 and 90 DAS).

Soil analysis: The soil sample from the field was collected to check the initial fertility status of soil before preparing the field and sowing of crop. The soil samples were sent to Krishi Vigyan Kendra Fatehgarh Sahib for analysis. Soil pH, soil EC, available organic carbon, nitrogen phosphorous and potash was analysed.

Growth parameters: Growth parameters such as germination percentage (%), plant height (cm), plant height (cm), number of Leaves, leaf area (cm²), stem diameter (cm), number of branches plant, fruit diameter (cm), fruit length (cm), fruit weight (g), Number of pods plant and Pod yield (t ha⁻¹) were studied at different intervals.

Quality parameters

Chlorophyll content (mg 100 g⁻¹)

Leaf chlorophyll (a+b) was measured at 60 days after sowing. Leaf chlorophyll (a+b) was measured using the method of Yoshida *et al* (1976) [24].

Pod Dry matter (%)

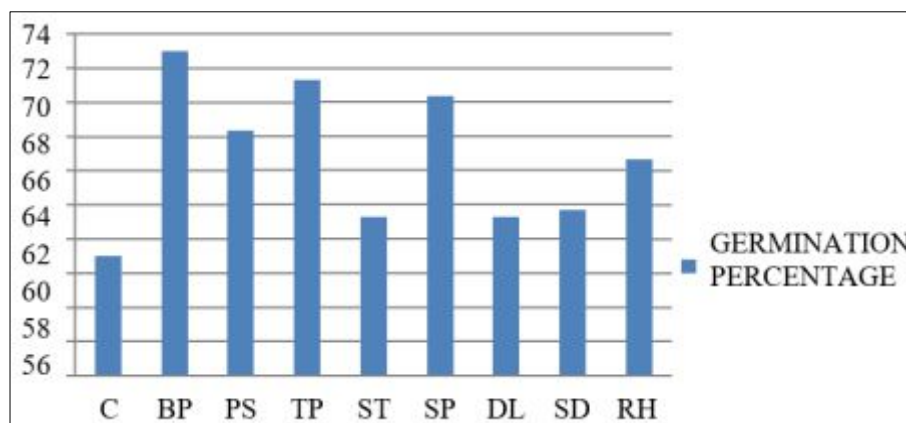
$$\text{Dry matter (\%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Pod moisture content (%)

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

Results and Discussion

The experiment was carried out during the 2021-2022 at Experimental Farm, Sri Guru Granth Sahib World University, Fatehgarh Sahib, Punjab, India. It is evident from data in Fig. 1 that the application of different organic and inorganic mulching significantly increased the germination percentage over the control. The maximum germination percentage was recorded under black polythene mulch. Among organic mulches maximum germination percentage was recorded under the paddy straw mulch. The maximum germination percentage (73.00%) was recorded under black polythene mulch followed by transparent polythene mulch (71.33%), silver polythene mulch (70.33%), paddy straw mulch (68.33%), rice husk (66.66%), saw dust (63.66%), sugarcane trash mulch (63.33%), dry leaves mulch (63.33%), while minimum germination percentage was recorded under the treatment control (61.00%). The average germination percentage was recorded 66.70%. It might be due to good soil moisture availability which leads to more availability of water for softening seed coat and good micro climate which leads to increase embryo germination. The results are in conformity to that with Aniekwe (2013) [3] who revealed that the good temperature modulation by the black plastic mulch resulted in the high percentage germination rate observed in both years (90% in 2008 and 86% in 2009). The lower germination was reported in the unmulched plots (control). Abu-Bakr *et al* (2003) [1] carried out a study to evaluate the effects of black, clear and green plastic mulches on growth and yield of okra (*Abelmoschus esculentus* L.) during winter and concluded that the seedling emergence percentage was significantly higher in the mulched plots. It was 20.8%, 16.6% and 15.2% more in the clear, green and black mulches compared to the control, respectively.



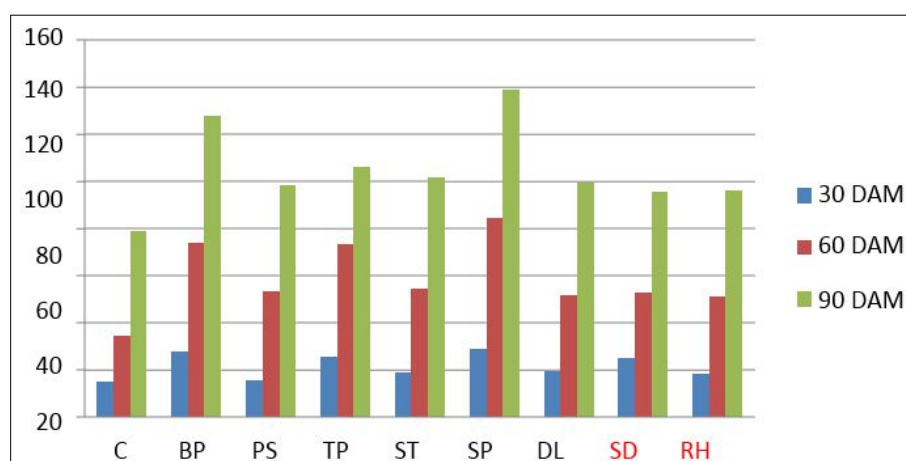
C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 1: Effect of mulching material on germination percentage of okra cv. Punjab Suhavani.

The data regarding plant height influenced by different mulching material presented graphically in Fig. 2 revealed that plant height (at 30, 60 and 90 DAS) increased significantly due to mulch over no mulching (control). At 30 days after mulching, the highest plant height was recorded under the silver polythene mulch (29.23 cm), at par with black polythene mulch (27.83 cm), followed by transparent polythene mulch (25.63 cm), saw dust (24.73 cm), dry leaves (19.43 cm), sugarcane trash (18.96 cm) rice husk (18.43 cm), paddy straw (15.70 cm) and the minimum plant height was recorded under control (15.20 cm). However, height with paddy straw was at par with the control. At 60 days after mulching, maximum plant height was observed under silver polythene mulch (84.66 cm) followed by black polythene mulch (73.66 cm), transparent polythene mulch (73.00 cm), sugarcane trash (54.33 cm), paddy straw (53.33 cm), saw dust (52.66 cm), dry leaves (52.00 cm), rice husk (51.00 cm) while minimum plant height was recorded under control (34.33 cm).

Similar results were found at 90 days of mulching, all organic and inorganic mulches showed significant difference, the maximum plant height was observed under

the silver polythene mulch (138.66 cm) followed by black polythene mulch (127.66 cm), transparent polythene mulch (106.00 cm), sugarcane trash (101.66 cm), dry leaves (99.33 cm), paddy straw (98.33 cm), rice husk (96.33 cm), saw dust (95.16 cm) and minimum plant height was recorded under the treatment control (79.00 cm). The average plant height was 104.68 cm. The data showed that all the three polythene mulches performed better than organic mulches. All the organic mulches showed the similar effect on plant height and also at par with each other but all the organic and inorganic mulches showed significant increase in plant height over control. The results were in accordance with Puri *et al* (2022) ^[19] who concluded that the all mulching treatments significantly increased plant height over control with maximum plant height (148.7 cm) recorded with silver plastic mulch due to retention of moisture. The availability of moisture also led to better uptake of nutrients for correct bloom, development of flora and resulted higher growth of plant. Anjali *et al* (2019) ^[4] also revealed that among all the treatments silver polythene mulch showed significantly highest plant height (114.93 cm).

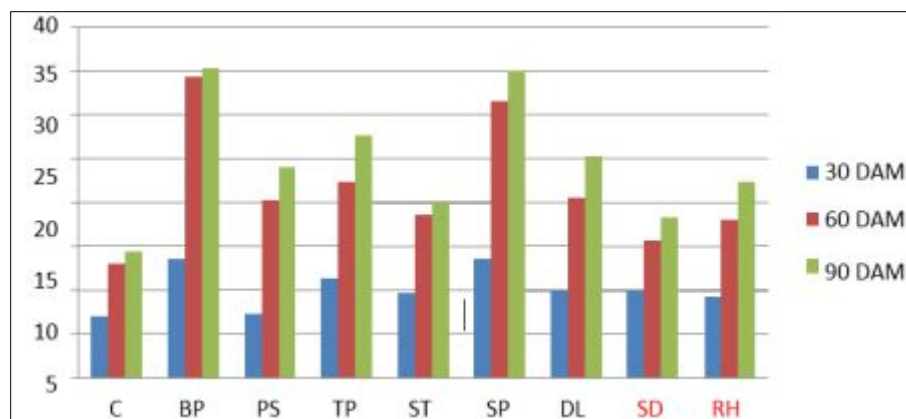


C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice

Fig 2: Effect of mulching material on plant height (cm) of okra cv. Punjab Suhavani

From study of data presented in Fig. 3 it is observed that at 30 days after mulching maximum number of leaves were recorded under the treatment black polythene mulch (13.6 leaves plant⁻¹) and silver polythene mulch (13.6 leaves plant⁻¹), followed by transparent polythene mulch (11.3 leaves plant⁻¹), dry leaves mulch (10.0 leaves plant⁻¹), saw dust mulch (10.0 leaves plant⁻¹), sugarcane trash (9.6 leaves plant⁻¹), rice husk (9.3 leaves plant⁻¹) and paddy straw (7.3 leaves plant⁻¹) while the minimum number of leaves were counted under the treatment control (7.0 leaves plant⁻¹). At 60 days after mulching the maximum number of leaves was counted under the treatment black polythene mulch (34.3 leaves plant⁻¹) followed by silver polythene mulch (31.6 leaves plant⁻¹), transparent polythene mulch (22.3 leaves plant⁻¹), dry leaves (20.6 leaves plant⁻¹), paddy straw (20.3 leaves plant⁻¹), sugarcane trash (18.6 leaves plant⁻¹), rice husk (18.0 leaves plant⁻¹), saw dust (15.6 leaves plant⁻¹) and minimum leaf number was recorded under control (13.0 leaves plant⁻¹).

It was inferred from data showed in Fig 3 that different mulching material significantly increased the number of leaves at 90 days after mulching. The maximum number of leaves were recorded under the black polythene mulch (35.3 leaves plant⁻¹) which is closely related to silver polythene mulch (35.0 leaves plant⁻¹) followed by transparent polythene mulch (27.6 leaves plant⁻¹), dry leaves (25.3 leaves plant⁻¹), paddy straw (24.3 leaves plant⁻¹), rice husk (22.3 leaves plant⁻¹), sugarcane trash (20 leaves plant⁻¹), saw dust (18.3 leaves plant⁻¹) and minimum number of leaves were recorded under the treatment control (14.3 leaves plant⁻¹). The results were in conformity with Puri *et al* (2022) ^[19] concluded that the maximum number of leaves (42.5 leaves plant⁻¹) were recorded under silver plastic mulch, while least were recorded under control. Akhila *et al* (2018) ^[2] observed that the maximum number of leaves were noticed under black polythene mulch (21 leaves plant⁻¹) followed by control (19 leaves plant⁻¹) and coconut coir mulch (17 leaves plant⁻¹) while minimum was recorded under the treatment shade with plastic mulch (13 leaves plant⁻¹).

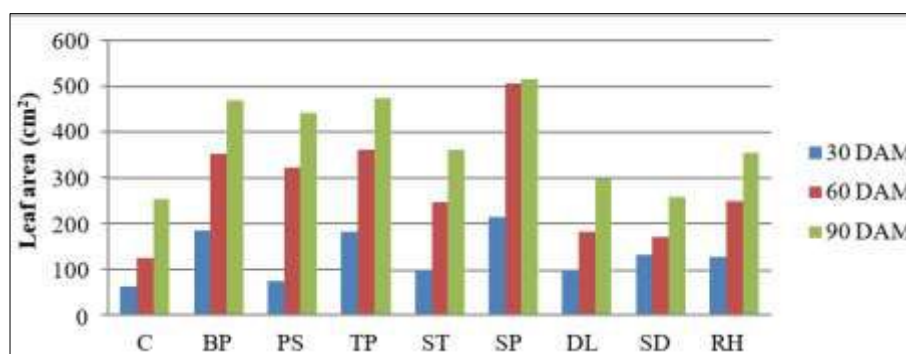


C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 3: Effect of mulching material on number of leaves of okra cv. Punjab Suhavani

It is inferred from data presented in Fig. 4 that the application of different mulching material significantly increased the leaf growth over the control. At 30 days after mulching the maximum leaf area was recorded under silver polythene mulch (215.21 cm²) followed by black polythene mulch (184.79 cm²), transparent polythene mulch (183.01 cm²), paddy straw mulch (132.19 cm²), rice husk (126.44 cm²), sugarcane trash (98.12 cm²), dry leaves (95.17 cm²), paddy straw mulch (73.81 cm²) and minimum was recorded under control (62.14 cm²). At 60 days after mulching the maximum leaf area was recorded under the silver polythene mulch (506.00 cm²), followed by transparent polythene mulch (362.00 cm²), black polythene mulch (352.08 cm²), paddy straw mulch (324.40 cm²), rice husk (248.30 cm²), sugarcane trash mulch (247.08 cm²), dry leaves mulch (183.25 cm²) and saw dust (171.58 cm²) while minimum

leaf area was recorded under the control (124.30 cm²). It is evident from the data presented in Fig. 4 that the maximum leaf area at 90 days after mulching was recorded under black polythene mulch (515.60 cm²), followed by black polythene mulch (469.00 cm²), transparent polythene mulch (475.60 cm²), paddy straw mulch (442.30 cm²), sugarcane trash mulch (361.36 cm²), rice husk (355.00 cm²), dry leaves mulch (298.30 cm²), saw dust (257.60 cm²) and was minimum recorded under the treatment control (255.00 cm²). The maximum leaf area under inorganic mulches might be due to good soil moisture availability which might have increased the root growth, nutrient uptake and photosynthesis and ultimately the leaf area of plant. Olabode *et al* (2007) [16] stated that the highest leaf area per plant was recorded under plastic mulch followed by grass mulch.

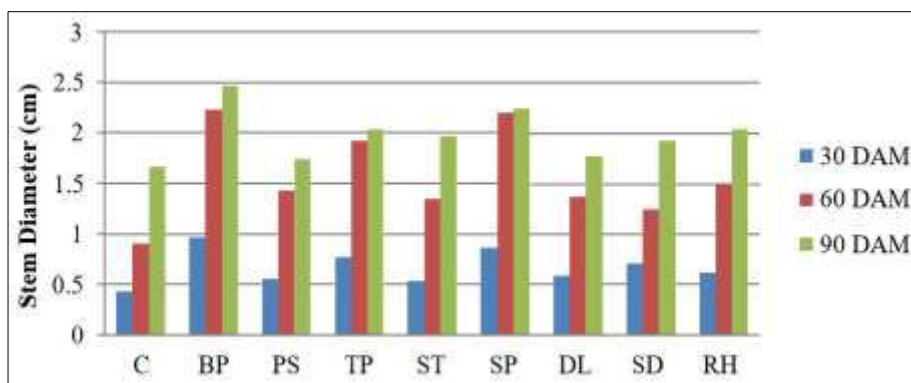


C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 4: Effect of mulching material on leaf area (cm²) of okra cv. Punjab Suhavani

It is evident from data presented in Fig. 5 that different mulching material increased the stem diameter over the control. The maximum stem diameter at 30 days after mulching was recorded with black polythene mulch (0.97 cm), followed by silver polythene mulch (0.86 cm), transparent polythene mulch (0.77 cm), saw dust mulch (0.71 cm), rice husk (0.61 cm), dry leaves mulch (0.59 cm), paddy straw mulch (0.55 cm), sugarcane trash mulch (0.53 cm) and minimum stem diameter was recorded under control (0.43 cm). At 60 days after mulching, the maximum stem diameter was recorded under black polythene mulch (2.23 cm), followed by silver polythene mulch (2.20 cm),

transparent polythene mulch (1.92 cm), rice husk (1.50 cm), paddy straw mulch (1.43 cm), dry leaves mulch (1.37 cm), sugarcane trash mulch (1.35 cm) and saw dust (1.25 cm) while minimum stem diameter was recorded under control (0.90 cm). After 90 days of mulching the maximum stem diameter was recorded under black polythene mulch (2.47 cm), followed by silver polythene mulch (2.24 cm), transparent polythene mulch (2.04 cm), rice husk mulch (2.03 cm), sugarcane trash mulch (1.97 cm), saw dust mulch (1.92 cm), dry leaves mulch (1.77 cm), paddy straw mulch (1.74 cm) and the minimum was recorded under the control (1.66 cm).

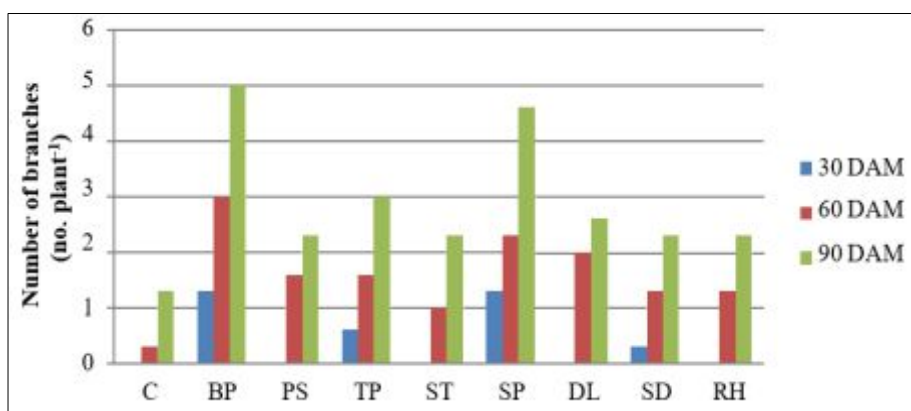


C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 5: Effect of mulching material on stem diameter (cm) of okra cv. Punjab Suhavani.

The perusal of data present in Fig. 6 revealed that different organic and inorganic mulching treatments showed the significant difference among number of branches. The maximum number of branches were recorded under the black polythene mulch and silver polythene mulch while the minimum branch count were recorded under the treatment control. At 30 days after mulching the recorded data shows that maximum number of branches were noted similar in both black polythene mulch and silver polythene mulch (1.3 branches plant⁻¹) followed by transparent polythene mulch (0.6 branches plant⁻¹) and saw dust mulch (0.3 branches plant⁻¹). Among remaining mulching treatments no side branches were found at 30 days after mulching. After 60 days of mulching it is inferred from the recorded data that the maximum branch count was found under black polythene mulch (3.0 branches plant⁻¹) which is closely related to silver polythene mulch (2.3 branches plant⁻¹), followed by dry leaves mulch (2.0 branches plant⁻¹), transparent polythene mulch (1.6 branches plant⁻¹), paddy straw mulch (1.6 branches plant⁻¹), saw dust (1.3 branches plant⁻¹), rice husk (1.3 branches plant⁻¹) and sugarcane trash

(1.0 branches plant⁻¹) while the minimum were under the control (0.3 branches plant⁻¹). At 90 days after mulching the maximum number of branches was noticed under the treatment black polythene mulch (5.0 branches plant⁻¹) at par with silver polythene mulch (4.6 branches plant⁻¹), followed by dry leaves (2.6 branches plant⁻¹) and paddy straw mulch (2.3 branches plant⁻¹) while the minimum number of branches was recorded under the treatment control (1.3 branches plant⁻¹). The results were same as findings of Mahadeen (2014) [15] who examined the effect of black polythene mulch on growth and yield of okra and stated that maximum number of branches were recorded under the treatment black polythene mulch (14.9 branches plant⁻¹) while minimum was recorded under treatment control (11.4 branches plant⁻¹). Anjali *et al* (2019) [4] studied the effect of different types of mulches on growth, yield and quality of okra (*Abelmoschus esculentus* L.). The results revealed that among all the treatments silver polythene mulch showed significantly highest number of branches (3.13 branches plant⁻¹).



C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

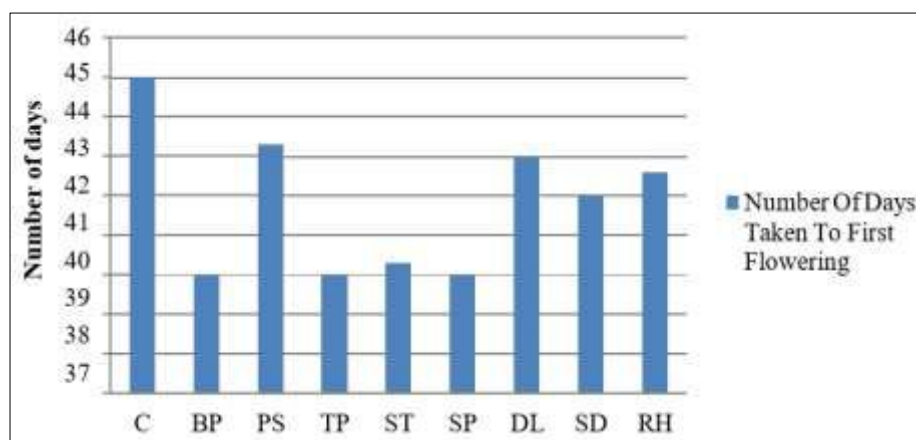
Fig 6: Effect of mulching material on number of branches plant⁻¹ of okra cv. Punjab Suhavani

The data regarding number of days taken to first flowering present in Fig. 7 revealed that early flowering occurred in polythene mulch treatments and some other organic mulches than control or unmulched treatment. The data showed minimum number of days (40.0 DAS) to first flowering was found under the treatments black polythene mulch, transparent polythene mulch, silver polythene mulch and at par with sugarcane trash mulch (40.3 DAS) followed by saw

dust mulch (42.0 DAS), rice husk mulch (42.6 DAS), dry leaves mulch (43.0 DAS) and paddy straw mulch (43.3 DAS) while maximum number of days taken to first flowering was recorded under the treatment control (45.0 DAS). From study of above data, it is concluded that the early flowering occurs in many organic and inorganic mulches due to better performance and growth of plants under these mulches. The difference between the minimum

and maximum days taken to first flowering was five days. Under the control the flowering delayed due to poor growth of plants. Abu-Bakr *et al* (2003) ^[1] carried out a study to evaluate the effects of black, clear and green plastic mulches on growth and yield of okra (*Abelmoschus esculentus* L.) during winter and concluded that plastic mulch resulted in earlier flowering. The appearance of the first flower was

13.1, 8.5 and 7.6 days earlier in the black, green and clear mulches, respectively, compared to the control. Mahadeen (2014) ^[15] examined the effect of black polythene mulch on growth and yield of okra and stated that the flowering occurs in 44.4 days after sowing under black polythene mulch while under the treatment control flowering occurs after 48 days after sowing.



C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 7: Effect of mulching material on number of days taken to first flowering of okra cv. Punjab Suhavani

The perusal of data depicted in Fig. 8 showed that the maximum fruit diameter was recorded under the inorganic mulches while all the organic mulches also performed well and have significantly higher fruit diameter than control. The minimum fruit diameter was recorded under control. Among all organic mulches maximum fruit diameter was recorded under the treatment sugarcane trash mulch and saw dust mulch. The maximum fruit diameter was recorded under black polythene mulch (1.97 cm), at par with silver polythene mulch (1.95 cm), followed by transparent polythene mulch (1.74 cm), sugarcane trash mulch (1.66 cm) or saw dust mulch (1.61 cm), rice husk mulch (1.52 cm), paddy straw mulch (1.40 cm), dry leaves mulch (1.30 cm) and minimum fruit diameter was recorded under control (1.29 cm), whereas paddy straw and dry leaves mulches were at par with control. The results were in conformity with Bhutia *et al.* (2017) ^[7] who recorded maximum fruit diameter under black polythene mulch (4.95 cm), followed by green plastic mulch (4.75 cm) and minimum under organic mulch (4.51 cm).

It is evident from data present in Fig. 8 the application of different organic and inorganic mulches influenced the fruit length of okra. The maximum fruit length was recorded under silver polythene mulch and black polythene mulch while minimum fruit length was recorded under control. The maximum fruit length of 15.56 cm was recorded under the treatment silver polythene mulch, at par with black polythene mulch (15.10 cm), followed by sugarcane trash mulch (13.90 cm), saw dust mulch (13.33 cm), rice husk mulch (13.33 cm), transparent polythene mulch (12.46 cm), dry leaves mulch (11.83 cm) and paddy straw mulch (11.83 cm) while minimum fruit length was recorded under control (11.66 cm), while paddy straw and dry leaves mulch were at par with control. The results were in accordance with Puri *et al.* (2022) ^[19] who concluded that silver mulch treatment produced maximum average fruit length (12.54 cm) than other treatments.

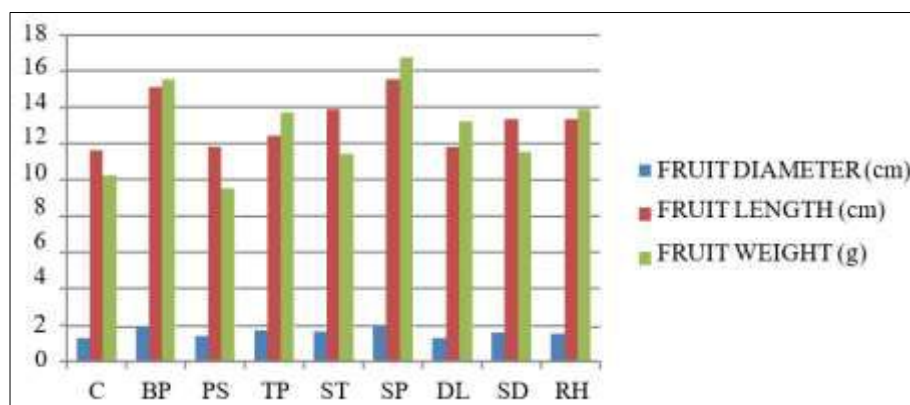
From the study of data present in Fig. 8, it is clear that the different mulching treatments influenced the fruit weight. The fruit weight ranged from 9.53 g to 16.73 g. The maximum fruit weight was recorded under the treatment silver polythene mulch (16.73 g), at par with black polythene mulch (15.53 g), followed by rice husk (13.90 g), transparent polythene mulch (13.73 g), dry leaves mulch (13.20 g), saw dust (11.53 g), sugarcane trash (11.43 g) and control (10.26 g), whereas paddy straw, sugarcane trash and saw dust mulches were at par with control. From study of data it is found that the rice husk mulch performed better than other organic mulches in terms of fruit weight. Kim *et al.* (2016) ^[13] concluded that the fruit weight was 16.9 g in black polythene mulch which was highest for that period. Abu-Bakr *et al.* (2003) ^[1] concluded that plastic mulch significantly increased the number of pods per plant, average pod weight and total yield, compared to the control, with no significant difference between the clear and green transparent mulches. The maximum average pod weight was observed in the black mulch (6.91 g) followed by green mulch, clear mulch and weeded control (6.60 g, 6.49 g and 6.21 g, respectively).

It is evident from data present in Fig. 9 that the maximum number of fruits was observed under the silver polythene mulch and black polythene mulch. Among all organic mulches maximum number of fruits were noticed in sugarcane trash mulch. The maximum number of pods plant⁻¹ (21.00 fruits plant⁻¹) were recorded under silver polythene mulch almost similar in black polythene mulch (20.60 fruits plant⁻¹) followed by sugarcane trash mulch (18.60 fruits plant⁻¹), transparent polythene mulch and dry leaves mulch (16.60 fruits plant⁻¹), paddy straw mulch and rice husk (16.30 fruits plant⁻¹) and control (16.00 fruits plant⁻¹) while minimum number of fruits were recorded under the saw dust mulch (14.00 fruits plant⁻¹). The average number of fruits were recorded 17.37 fruits per plant. The results were in accordance with Anjali *et al.* (2019) ^[4] who conducted a field experiment to study the effect of different type of

mulches on growth, yield and quality parameters of okra (*Abelmoschus esculentus* L.). The result showed that maximum number of pods per plant (15.15 pods plant⁻¹) were recorded in silver polythene mulch. Other yield and growth characters are also recorded highest under silver polythene mulch. Patel *et al* (2009) [18] studied the effect of drip irrigation, mulch and nitrogen fertigation on yield and yield attributes of okra (*Abelmoschus esculentus* L.) and concluded that maximum number of pods (24.36) was recorded under black polythene mulch.

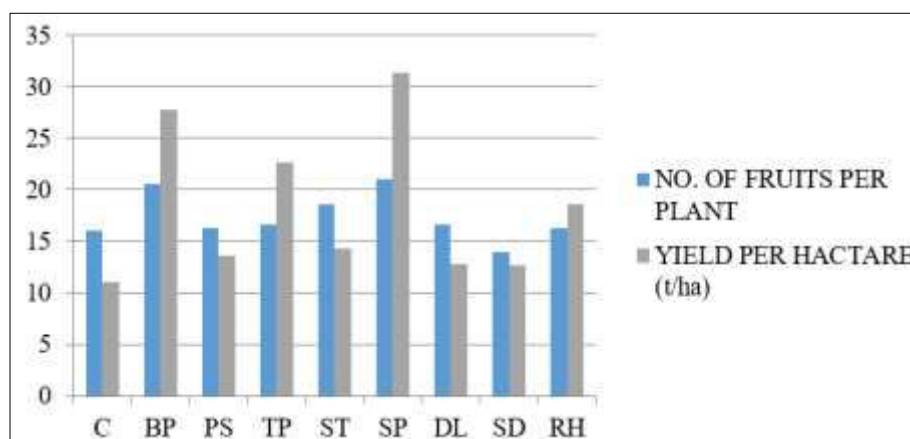
The data regarding fruit yield of okra as influenced by different organic and inorganic mulching material depicted graphically in Fig. 9 revealed that artificial material mulches proved significantly better than organic mulches in terms of their effect on fruit yield ha⁻¹. The maximum yield was recorded with silver polythene mulch (31.4 tonnes ha⁻¹), followed by black polythene mulch (27.78 tonnes ha⁻¹), transparent polythene mulch (22.72 tonnes ha⁻¹), rice husk mulch (18.57 tonnes ha⁻¹), sugarcane trash mulch (14.32 tonnes ha⁻¹), paddy straw mulch (13.56 tonnes ha⁻¹), dry leaves mulch (12.84 tonnes ha⁻¹) and saw dust (12.72 tonnes

ha⁻¹) while minimum yield per hectare was recorded under the control (11.01 tonnes ha⁻¹). However, paddy straw mulch, sugarcane trash, dry leaves mulch and saw dust were at par in respect of pod yield. Moreover, dry leaves mulch and saw dust mulch did not increase pod yield significantly over the control. Therefore, the highest yield was obtained with silver polythene mulch, followed by black polythene mulch whereas organic mulch proved inferior to artificial material mulches. Among the organic mulches, rice husk mulch was found superior to sugarcane trash and paddy straw mulches. Maximum yield under the silver polythene mulch might be due to better moisture retention and reflective effect, which in turn increased the flower primordial growth, production of more carbohydrates and absorption of nutrients which ultimately led to increase in fruit yield. The results are in accordance with Jha *et al* (2018) [11] who also obtained the highest yield (8104 kg ha⁻¹) under silver plastic mulch. Puri *et al* (2022) [19] also recorded maximum yield under the silver polythene mulch followed by black polythene mulch, rice straw mulch and rice husk mulch.



C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 8: Effect of mulching material on fruit diameter (cm), fruit length (cm) and fruit weight (g) of okra cv. Punjab Suhavani



C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 9: Effect of mulching material on number of pods plant⁻¹ and yield hectare⁻¹ of okra cv. Punjab Suhavani

The data presented in Fig. 10 related to chlorophyll content of leaves revealed significant differences due to the various mulch treatments. The results indicate that the highest chlorophyll content in leaves (3.84 mg 100 g⁻¹) was recorded with silver polyethylene mulch and was significantly superior over rest of the treatments under study. The lowest (1.49 mg 100 g⁻¹) chlorophyll content was

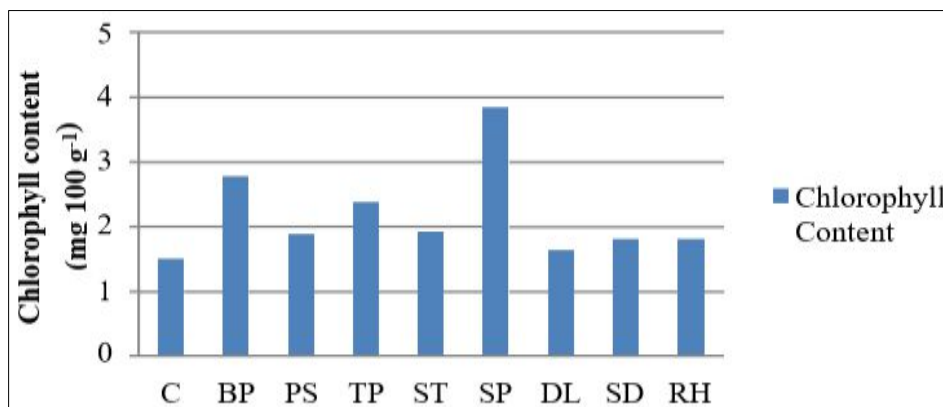
recorded in control. It might be due to good soil moisture availability which leads to better growth of roots and nutrients uptake which resulted into better plant growth and increase in chlorophyll content. Panchal *et al.* (2001) [17] noticed that black polythene mulch was found best for total chlorophyll content among the organic and inorganic mulches. Shivaraj *et al.* (2018) [20] also found that the

Chlorophyll - a Chlorophyll - b were more in white on black plastic color mulch followed by silver on black plastic color mulch and black plastic color mulch as compared with control bed.

A perusal of data in Fig. 11 revealed that different organic and inorganic mulching treatments showed the significant difference among pod dry matter. Maximum pod dry matter (%) was recorded under the silver polythene mulch (18.43%), followed by black polythene mulch (15.46%), transparent polythene mulch (15.21%), dry leaves (13.41%) and sugarcane trash (13.40%). Minimum pod dry matter was recorded in control (9.10%). Kareem *et al* (2012) ^[12] stated

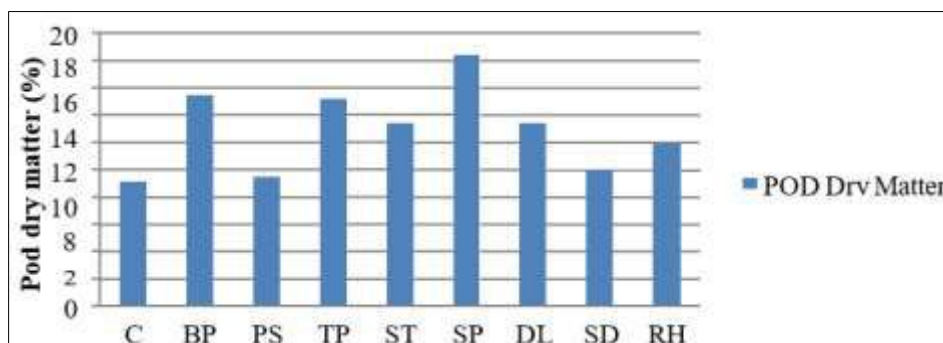
all mulched plots had maximum fresh and dry pod weight with plastic mulched plot having the highest value. However, the unweeded plot had the least pod biomass value.

It is inferred from data present under Fig. 12 that different organic and inorganic mulches influence the pod moisture. Maximum pod moisture per cent was recorded under the treatment control (90.90%), followed by paddy straw (90.54%), saw dust (90.04%), rice husk (88.14%) and black polythene mulch (84.54%) while minimum pod moisture was recorded under the treatment silver polythene mulch (81.57%).



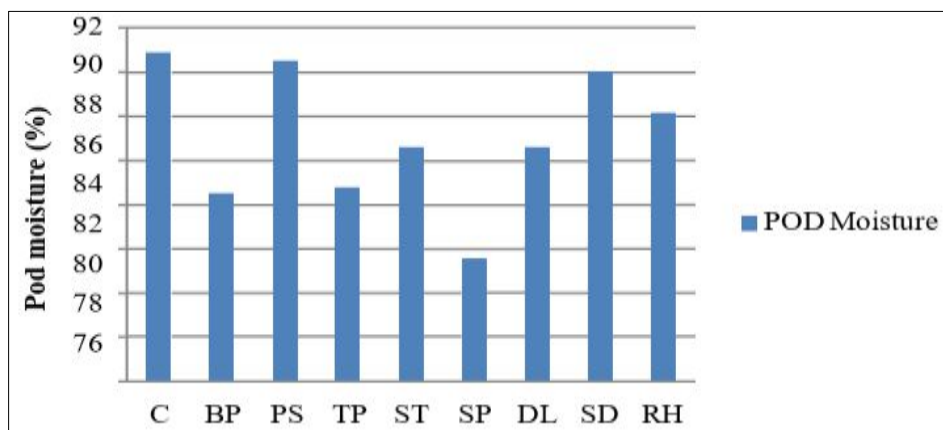
C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 10: Effect of mulching material on chlorophyll content (mg 100 g⁻¹) of okra cv. Punjab Suhavani



C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 11: Effect of mulching material on pod dry matter (%) of okra cv. Punjab Suhavani.



C = Control, BP = Black polythene, PS = Paddy straw, TP = Transparent polythene, ST = Sugarcane trash, SP = Silver polythene, DL = Dry leaves, SD = Saw dust, RH = Rice husk

Fig 12: Effect of mulching material on pod moisture (%) of okra cv. Punjab Suhavani

In the month of March maximum soil temperature was recorded under the silver polythene mulch (20.7 °C), followed by black polythene mulch (20.5 °C), transparent polythene mulch (20.5 °C), saw dust mulch (20.4 °C), paddy straw mulch (20.3 °C), rice husk mulch (19.9 °C), sugarcane trash mulch (19.26 °C), dry leaves mulch (19.2 °C) and the minimum soil temperature was recorded under treatment control (18.2 °C). In the month of April, the maximum soil temperature was recorded under the silver polythene mulch (22.7 °C) which is closely related to black polythene mulch (22.6 °C) and transparent polythene mulch (22.6 °C) followed by paddy straw mulch (21.5 °C), saw dust mulch (21.4 °C), rice husk (21.2 °C), dry leaves (20.71 °C), sugarcane trash (19.6 °C) and least soil temperature was found under control (19.1 °C). Same trends were found during the month of May, the maximum recorded soil temperature was 24.7 °C under the silver polythene mulch followed by black polythene mulch (24.2 °C) and transparent polythene mulch (23.9 °C). Under all the organic mulches almost similar temperature was recorded ranged from 23.22 °C to 23.56 °C while least soil temperature was recorded under control (21.55 °C). In the month of June, the maximum soil temperature was recorded under the silver polythene mulch (25.8 °C) which is at par with black polythene mulch (25.7 °C), sugarcane trash mulch (24.5 °C), paddy straw mulch (24.4 °C), transparent polythene mulch (23.7 °C), rice husk mulch (23.6 °C), saw dust mulch (23.5 °C) and dry leaves mulch (22.9 °C) while least was recorded under the treatment control (21.9 °C). Kim *et al* (2016) [13] found that black coloured mulching material showed the highest average temperature of 23.1 °C. Abu-Bakr *et al* (2003) [1] concluded that the soil temperature was significantly higher under the plastic mulches than the control. It increased by 5.6 °C, 5.2 °C and 3.9 °C in the morning and 6.1 °C, 5.7 °C and 3.3 °C at mid-day under the clear, green and black mulches, respectively as compared to the control. Plastic mulches absorb comparatively large amounts of the incoming radiation and transmit a considerable part of it to the soil underneath (Tarara, 2000) [22]. Harender and Bhardwaj (2000) [10] reported that the mulching with transparent polythene increases the temperature of soil in vegetables. The temperature was 4 °C higher in mulched plots compared to un-mulched plots. In the month of March, the maximum soil moisture was recorded under the black polythene mulch (12.94%)

followed by transparent polythene mulch (11.98%), silver polythene mulch (10.86%), dry leaves mulch (10.62%), saw dust mulch (9.95%), sugarcane trash mulch (9.94%), rice husk mulch (9.84%), paddy straw mulch (9.30%) and the minimum soil moisture was recorded under treatment control (9.19%). In the month of April, the maximum soil moisture was recorded under the black polythene mulch (12.48%), followed by transparent polythene mulch (11.86%), dry leaves (10.37%), silver polythene mulch (10.36%), saw dust mulch (10.30%), sugarcane trash (10.02%), rice husk (9.8%), paddy straw (9.68%) and least soil moisture was found under control (9.20%). In May month, the maximum recorded soil moisture was 12.84% under the black polythene mulch followed by transparent polythene mulch (11.68%), silver polythene mulch (11.35%), dry leaves (10.61%), sugarcane trash (10.11%), saw dust (9.73%), rice husk (9.63%) and paddy straw (9.55%) while least was recorded in the control (9.33%). In the month of June the maximum soil moisture was recorded under the transparent polythene mulch (12.75%) which is at par with black polythene mulch (12.34%) followed by silver polythene mulch (10.73%), dry leaves mulch (10.66%), saw dust mulch (10.27%), sugarcane trash (9.80%), rice husk (9.66%) and paddy straw (9.54%) while least was recorded in the control (8.82%). Akhila *et al.* (2018) [2] observed the maximum soil moisture under black plastic mulch (17.53%), followed by that under coconut coir (16.24%), polythene mulch (16.5%) and least was found under the treatment control (14.23%). Bhutia *et al.* (2017) [7] concluded that highest soil moisture content at final harvest was recorded with black plastic mulch (14.22%), followed by that under green plastic mulch (13.62%) and organic mulch (12.94%). These were all significant over control (11.22%). Abu-Bakr *et al.* (2003) [1] reported that soil moisture at 10-20 cm soil depth was increased 2.05, 1.98 and 1.96 per cent by the black, clear and green mulches respectively over the control. Although moisture content under black mulch was always higher than that under clear and green mulches, the differences was not significant at any soil depth. Highest pH of soil (7.61) was recorded in treatment transparent polythene mulch and lowest (7.20) soil pH was recorded in treatment control. The soil pH of experimental plot before planting was (7.15).

Table 1: Cost of cultivation, gross return, net return and cost benefit ratio affected by different organic and inorganic mulches in okra cv. Punjab Suhavani

Treatments	Cost of cultivation (Rs. ha ⁻¹)					Market able yield (t/ha)	Income (Rs/ha)		Cost: Benefit ratio
	Common expenditure	Cost of mulching material	Cost of application of mulch	Cost of hand weeding	Total cost		Gross return	Net returns	
Control	78000	-	-	5000	83000	11.01	165150	85150	1.98
Black mulch	78000	48000	2000	-	128000	27.78	416700	288700	3.25
Paddy straw	78000	-	3100	2100	83200	13.56	203400	120200	2.44
Transparent mulch	78000	160000	2000	-	240000	22.72	340800	100800	1.42
Sugarcane trash mulch	78000	10000	3100	2100	93200	14.32	214800	121600	2.30
Silver mulch	78000	48000	2000	-	128000	31.40	471000	343000	3.67
Dry leaves mulch	78000	5000	3100	2280	88380	12.84	192600	104220	2.17
Saw dust mulch	78000	2,91,666	3100	3000	375766	12.72	190800	-184966	-0.49
Rice husk	78000	93,333	3100	2500	176933	18.57	278550	101617	1.57

From study of data presented in Table 1, it is clear that the maximum gross return was found under silver polythene mulch (Rs. 4,71,000), followed by black polythene mulch (Rs. 4,16,700) and transparent polythene mulch (Rs. 3,40,800). Among all organic mulches maximum gross return was found under the sugarcane trash mulch (Rs. 2,14,800), followed by paddy straw mulch (Rs. 2,03,400). The minimum gross return was recorded under the treatment control (Rs. 1, 65, 150). Christopher (2003) ^[8] revealed that plastic mulching recorded higher gross returns of Rs. 90,600 ha⁻¹ as compared to Rs. 74,600 ha⁻¹ under unmulched control. The higher gross returns recorded under plastic mulching was due to significantly higher yield recorded in this treatment.

From the perusal of data in Table 1. It is obvious that the maximum net return was found under silver polythene mulch (Rs. 3,43,000), followed by black polythene mulch (Rs. 2,88,700), sugarcane trash mulch (Rs. 1,21,000), paddy straw mulch (Rs. 1,20,000), dry leaves mulch (Rs.1,04,220), rice husk mulch (Rs. 1,01,617), transparent polythene mulch (Rs. 1,00,800) and control (Rs. 85,150) while minimum net return was recorded under the treatment saw dust mulch (Rs. -1,84,966). The net return was found minimum under the treatments saw dust due to higher mulching cost. Christopher (2003) ^[8] revealed that plastic mulch produced higher net return of Rs. 74,600 ha⁻¹ compared to control (Rs. 64,600 ha⁻¹). The budgetary analysis revealed that the mulch with *Azadirachta indica* gave the highest net income, followed by the plastic mulch while the least income was obtained from the control (Lbe *et al* 2012) ^[14].

It is evident from the data in Table 1., that maximum cost-benefit ratio was recorded under silver polythene mulch (3.67), followed by black polythene mulch (3.25), paddy straw mulch (2.44), sugarcane trash mulch (2.30), dry leaves mulch (2.17), control (1.98), rice husk (1.57) and transparent polythene mulch (1.42) while minimum cost benefit was recorded under treatment saw dust mulching (-0.49). Among all inorganic mulches the silver polythene mulch recorded maximum cost benefit ratio while among all the organic mulches the maximum cost benefit ratio was found under paddy straw mulching and sugarcane trash mulch. Tiwari *et al* (2021) ^[23] achieved maximum average benefit cost ratio by mulching with black polythene sheet (4.56), followed by mulching with paddy straw (3.77) and with sugarcane leaves (3.69) and minimum under control.

Conclusion

From the results of the present experiment on okra it can be concluded that mulching with the inorganic or organic material were beneficial in improving the growth and yield of okra. The highest fruit yield, quality and net profit from the crop was obtained with the silver polythene mulch, followed by black polythene mulch.

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