ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Research Article

Effect of Various Mulching Materials on Yield and Quality of Okra (*Abelmoschus esculentus*) in Mahottari, Nepal

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Article Information

Received: 19 October 2024
Revised version received: 17 December 2024
Accepted: 19 December 2024
Published: 24 December 2024

Cite this article as:
S. Chaulagain et al. (2024) Int. J. Appl. Sci. Biotechnol. Vol 12(4): 207-114. DOI: 10.3126/ijasbt.v12i4.70914

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Peer reviewed under authority of IJASBT

Keywords: Growth, Mulching, Okra, Plastic, Yield.

Abstract

An experiment was conducted from April to July 2023 in the Mahottari district of Nepal to evaluate the influence of various mulching materials on the yield and quality of okra, specifically the Arka Anamika variety. The study employed a Randomized Complete Block Design (RCBD) with four replications and included five treatment variations: T1 (Control), T2 (Black plastic), T3 (Silver plastic), T4 (Rice straw), and T5 (Sawdust). The findings revealed that the type of mulch significantly affected all growth and yield parameters. Among all treatments, black plastic mulch yielded the highest seed germination rate at 89.01%, while the control plot had the lowest rate at 68.00%. At 35, 50, and 65 days after sowing (DAS), plants in black and silver plastic mulch plots were significantly taller than those in other treatments. Black plastic mulch also enhanced leaf number, promoted earlier flowering, and produced higher yields compared to bare soil, with silver plastic mulch being the next most effective. Crops grown with plastic mulch exhibited superior vegetative growth and yield attributes compared to those with organic mulches. The highest productivity was recorded in the black plastic mulch treatment (30.00 Mt/ha), followed by silver plastic mulch (27.00 Mt/ha). Moreover, black plastic mulch resulted in the highest net return and benefit-cost ratio (3.23), while the control plot had the lowest (1.8). Consequently, the use of plastic mulch, particularly black plastic mulch, is recommended to enhance vegetable production in the research area.

Introduction

Okra (*Abelmoschus esculentus*), commonly referred to as lady's finger, is a significant summer vegetable crop widely cultivated in Nepal for both commercial and subsistence purposes. This crop is a member of the Malvaceae family. (Maurya, 2013). Okra is native to Asia and Africa and is grown in many warm-weather regions across the world, including the tropics, subtropics, and certain temperate zones (Kochhar, 2017). Okra is regarded as a multipurpose crop because of its ability to be used for a variety of purposes, including fresh leaves, buds, flowers, pods, stems, and seeds (Das *et al*., 2018). Okra pods are suggested as a treatment for gonorrhea, diarrhea, and urinary problems (Elkhalifa *et al*., 2021). A 100g serving of edible okra fruit provides 145 kg/100g of energy and contains 90g of water, 2g of protein, 1g of fiber, and 7g of carbohydrates (Adhikari *et al*., 2023). Compared to other locations, the Terai region produces a lot more okra. With a yield of 11.95 tonnes per

hectare, the nation's total okra production was 112,260 metric tonnes under 9,397 hectares (MoALD, 2023).

Numerous parameters, including spacing, fertilizer dosage, irrigation rate, and mulching, affect the growth and productivity of okra (Adekiya *et al*., 2017). Mulching is essential for preserving soil moisture, reducing the need for water over a short period, and improving crop yield (Mauck *et al*., 2010). Mulching also decreased the frequency of foliar diseases and insect infestations in okra (Ammar & Abolmaaty, 2016). Mulching also lowers the emergence of weeds, which lowers the expense of weeding.

A range of readily available materials in the area can be used for mulching, including sawdust, rice straw, dried leaves, living mulches, etc. These substances enrich the soil with organic matter in addition to serving as a barrier against water loss. But today's market offers plastic mulch in a variety of gauge thicknesses for commercial use. Plastic mulches are commonly used in horticulture crop production to maintain soil moisture near the roots, suppress weed growth, and increase soil temperature (Hooda *et al*., 1997). Their use has significantly enhanced the height, leaf area, and fruit yield of okra plants (Adegunloye *et al*., 2007). Lack of awareness about mulching practices is a major reason for the low okra yield in Mahottari district. Without the use of mulches, issues like weed infestation, water loss, high evaporation rates, and reduced water use efficiency are reported, all of which contribute to decreased okra yields and delayed maturity (Thakur *et al*., 2020). Therefore, this study aims to identify appropriate mulching materials that will enhance okra yield and encourage farmers to adopt mulching practices for better crop production. Overall, this study on the efficacy of mulching on okra yield and yield parameters is relevant and necessary for improving okra production, promoting sustainable agriculture practices, and meeting the increasing demand for this crop in Nepal.

Materials and Methods

Experimental Site Details

An experiment was conducted from April 5 to July 18 of 2023 in Jaleshwar-6, Mahottari, Nepal. This location is in the Terai region of Madhesh Province, at an elevation of 53 meters above sea level. The latitude and longitude of the research site are 26.39˚north and 85.46˚east. The research site is in the lower tropical zone, characterized by four distinct seasons: mild spring (March-May), Rainy (June-Aug), autumn (Sept- Nov), and cool winter (Dec-Feb).

Experimental Materials

Okra Variety:

The Arka Anamika hybrid variety of okra was chosen for the experiment. The plant could be 120 to 130 cm tall, erect, and well-branched, producing fruit length up to 15 to 20 cm having 5 rushes and lush green color. The variety was brought from the local market of Jaleshwar.

Mulching:

Mulching materials used in the study included black plastic mulch, silver plastic mulch, rice straw, and sawdust. The thickness of plastic mulch was 25 microns. After preparing the field, the mulching materials were evenly distributed over the designated plots, and sowing was then carried out at the predetermined distances calculated.

Fertilizers:

One ton of decomposed FYM and recommended doses of Urea, DAP, and MOP @ 6kg/ropani, 4kg/ropani, and 2kg/ropani respectively were applied (AITC, 2023). The full dose of phosphorus and potassium and 1/3rd of N was applied as basal in all plots at the time of seed sowing. The remaining 1/3rd dose of N was placed between the rows of standing crops 4 weeks after sowing and the remaining 1/3rd was applied at flowering and fruiting.

Treatment Details

The experiment employed a Randomized Complete Block Design (RCBD) with five treatments, each replicated four times. The treatments included black plastic mulch, silver plastic mulch, rice straw, sawdust, and a control. At the time of seed sowing, all plots received a basal application of one-third of the N and the entire dose of potassium and phosphorus. Four weeks after sowing, the remaining one-third of the N dose was spread between the rows of standing crops. And the final third was used for fruiting and flowering.

Table 1: Treatment details used in research

Symbols	Treatment Property
T0	Control (no mulching)
T1	Black Plastic Mulch
T2	Silver Plastic Mulch
T3	Rice straw mulch
T4	Saw dust Mulch

Experimental Design

The plants were spaced 50 cm apart between rows and 30 cm apart within rows. Each plot contained 40 plants arranged in 4 rows with 10 columns, covering a total area of 3m × 2m. A distance of 1m was maintained between replications and 0.5m between treatments. Out of the 4 rows, 2 rows were used as border plants, and data were collected from sample plants selected within the remaining 3 rows. The outer border of the plot was set 0.5m away from the edge.

Name of the Crop: Okra (*Abelmoschus esculentus*)

Variety: Arka Anamika

Design: Randomized Complete Block Design (RCBD)

Replications: Four

Treatments: Five

Total Number of Plots: 20 (5 treatments × 4 replications)

Plot Size: 3 m × 2 m (6 m²)

Total Plot Area: 18 m × 12 m

Row Spacing: 50 cm

Plant Spacing: 30 cm

Plants per Plot: 40 (arranged in 4 rows and 10 columns)

Total Number of Plants: 800

Vegetative Characters

Except border plants, five plants were chosen at random and tagged to record observations on the growth and yield metrics. The initial observations were made at 20 DAS, and subsequent observations were made every 15 days until the final harvest.

Plant Height (cm)

Plant height was recorded from the base of the plant to the tip of the apex or flower.

Number Of Leaves Per Plant

The number of fully developed fresh leaves attached to the plants was counted and measured.

Number of fruits per plant

The data was obtained by averaging the fruit yield from five randomly selected sample plots over the crop period. To calculate this average, the total number of fruits from the sample plants was divided by five.

Average Fruit Length (cm)

Fruit length was measured at harvest and then averaged to obtain the average fruit length.

Average Fruit Weight (g)

This value was calculated by dividing the total weight of fruits harvested from 5 tagged plants by the number of fruits produced by those same plants.

Yield Per Plant (g)

It was obtained by dividing the total yield obtained from plants under the net plot area by the total number of plants within the same area.

Productivity (mt/ha)

The net plot yield, which was measured from five plants excluding a single border plant on each side, was converted to metric tons per hectare (mt/ha) to assess productivity.

Benefit-Cost Ratio (B:C)

This was calculated by dividing the gross return by the total cost of cultivation.

Statistical Analysis

The experimental data was analyzed using Microsoft Excel and R Studio. Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) tests were employed for mean separation, while graphs were created using MS Excel.

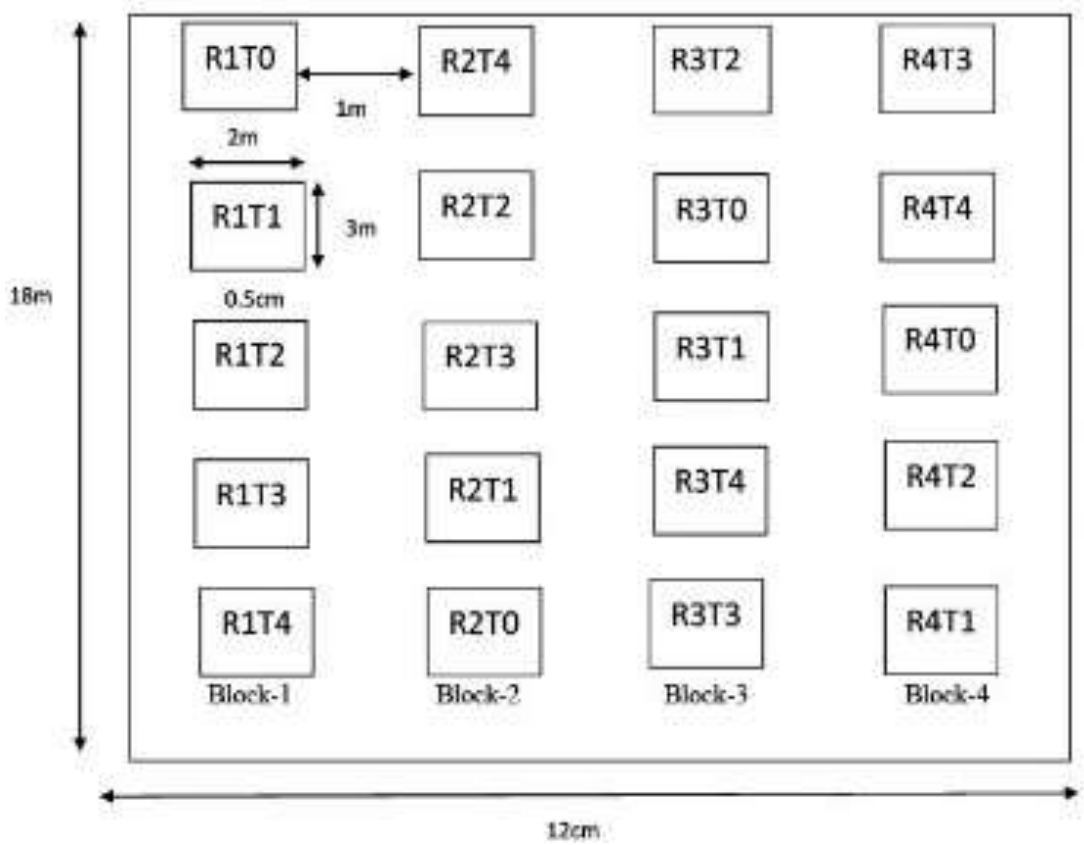

Fig. 1: Layout of RCBD of the experiment field

Results and Discussion

The outputs of the research conducted to study the effects of mulching on okra productivity are presented in this section. This includes the effect of mulching materials on growth parameters, yield, and yield parameters.

Effect Of Mulching Materials on Growth Parameters

Seed Germination:

Seed germination varied significantly based on the type of mulching material used (Table 2), consistent with the results reported by (Thakur *et al*., 2020). The highest seed germination rate was observed in plots with black plastic mulch (89.01), while the control plots had the lowest rate (68). Seed germination in black plastic mulch was followed by silver plastic mulch (83.26). Overall, plastic mulch generally resulted in higher seed germination compared to plant-based mulches like rice straw and sawdust, with control plots exhibiting the lowest germination rates.

Table 2: Effect of mulching material on germination of okra at Jaleshwar, Mahottari, 2023

Treatments	Germination (%)
Black plastic mulch	89.01[a]
Silver Plastic mulch	83.26[b]
Rice straw mulch	79.49[bc]
Saw dust mulch	75.66[c]
Control	68.00[d]
LSD (0.05)	4.49
SEM (±)	0.65
F-probability	**
CV%	3.68
Grand mean	**79.09**

[Note: LSD = Least Significant Difference; CV (%) = Coefficient of Variation; DAS = Days after sowing; SEm = Standard Error of the mean; Means followed by the same letter(s) within each column are not significantly different at 5% level of significance by DMRT, ** indicate significance at <0.001.]

Various mulching materials, including sawdust, straw mulch, and polythene, have been shown to elevate soil temperature and conserve soil moisture in vegetable production (Patel, 2019). As a result, summer vegetable crops such as okra and squash displayed earlier seedling emergence in mulched conditions compared to non-mulched ones (Mahadeen, 2014). In arid and semiarid regions, a deficiency in soil moisture can hinder seed germination (Sharma, 1998). The highest germination rates observed under mulched conditions are likely due to adequate soil moisture and optimal temperature. Conversely, the lowest germination in the control plot can be attributed to limited available soil moisture resulting from excessive evaporation due to the absence of any mulching material.

Plant Height (cm):

The mulching materials had a significant impact on plant height at 20, 35, 50, and 65 days after sowing (DAS). At 20 DAS, the tallest plants were recorded in plots with black plastic mulch. However, at 35 DAS, 50 DAS, and 65 DAS there was no significant difference in the height of the Okra plant obtained from black and silver plastic mulches. At the beginning of the growing season, this difference in soil temperature may have influenced the growth rate of the okra plants, with those under black plastic mulch initially growing faster due to the warmer soil. However, as the season progresses, soil temperatures tend to stabilize and become more uniform across both black and silver mulched plots, which could result in similar plant heights. The tallest plants were observed from those plants with plastic mulches followed by the rice straw. There was a less significant difference in plant heights from control and saw dust plots. At 35, 50, and 65 DAS control plot was recorded to have slightly taller growth even than the mulched saw dust plot (Table 3). The results showed that various mulching materials significantly enhanced the plant height of okra compared to the control. Among the different treatments, T1 (black plastic mulch) produced the tallest plants, while the control plots exhibited the lowest growth.

Table 3. Effect of mulching material on plant height of okra at Jaleshwar, Mahottari, 2023

Treatments	Plant height on different stages (DAS)			
	20DAS	35 DAS	50 DAS	65 DAS (At final harvest)
Black Plastic	15.46[a]	19[a]	33.62[a]	62.27[a]
Silver plastic	10.98[b]	19[a]	33.80[a]	61.48[a]
Rice straw	10.25[b]	16.80[ab]	29.15[ab]	58.53[a]
Saw dust	10.88[b]	11.38[c]	24.87[b]	51.60[b]
Control	9.37b	13.70[bc]	29.50[ab]	51.62[b]
LSD (0.05)	1.922	4.265	6.424	5.129
Sem (±)	0.28	1.384	2.085	1.664
F- Probability	***	***	*	***
CV (%)	10.96	17.3	13.8	5.8
Grand Mean	**11.39**	**15.98**	**30.19**	**57.1**

[Note: LSD = Least Significant Difference; CV (%) = Coefficient of Variation; DAS = Days after sowing; SEm = Standard Error of the mean; Means followed by the same letter(s) within each column are not significantly different at 5% level of significance by DMRT, * and *** indicate significance at <0.05, and <0.001, respectively].

Table 4. Effect of mulching material on the number of leaves per plant of okra at Jaleshwar, Mahottari, 2023

	Leaf number on different stages			
Treatments	**20DAS**	**35 DAS**	**50 DAS**	**65DAS (At Final harvest)**
Black plastic	6.83[a]	12.25[a]	21.25[a]	32.97[a]
Silver plastic	6.00[b]	12.00[a]	21.50[a]	33.5[a]
Rice straw	5.83[b]	9.00[b]	16.75[b]	29[ab]
Saw dust	5.75[b]	8.00[b]	15.25[b]	25.75[b]
Control plot	5.89[b]	7.00[b]	18.75[ab]	27.75[ab]
LSD (0.05)	0.53	2.676	2.944	5.402
Sem (±)	0.08	0.868	1.243	1.753
F-probability	*	**	*	*
CV (%)	5.67	18.00	13.3	11.8
Grand Mean	**6.06**	**9.65**	**18.70**	**29.79**

[Note: LSD = Least Significant Difference; CV (%) = Coefficient of Variation; DAS = Days after sowing; SEm = Standard Error of the mean; Means followed by the same letter(s) within each column are not significantly different at 5% level of significance by DMRT, *and ** indicate the significance at <0.05, and <0.01, respectively].

Okra plants often prefer warm soil conditions for optimal growth, and cooler soil temperatures under sawdust mulch may have slightly slowed down their growth, leading to shorter plants (Mamkagh, 2009). Sawdust mulch can also impact nutrient availability in the soil. As it decomposes, sawdust can tie up nitrogen and other nutrients during the decomposition process, potentially making these nutrients less available to the okra plants (Hooda *et al*., 1997). This could affect their growth and height compared to the control plots where nutrient availability may be relatively higher Plastic mulch establishes a salt-free environment around the plant roots, which promotes increased root growth. Mulching reduces soil compactness and favors proper root growth and distribution (Singh, 2020).

Number Of Leaves Per Plant:

The number of leaves per plant was significantly influenced by the type of mulching material used at 20, 35, 50, and 65 days after sowing (DAS). Black plastic mulch recorded the highest number of leaves per plant at 20 DAS (6.83), 35 DAS (12.25), 50 DAS (21.25), and 65 DAS (32.97), as shown in Table 4. There was only a minor difference in the number of leaves between the control and sawdust-mulched plots.

The increased number of leaves per plant observed with black plastic mulch at each stage of okra development can likely be attributed to the elevated soil temperatures that enhance leaf production. (Thakur *et al*., 2020). Plastic mulches capture incoming solar radiation and transfer a significant portion of it to the soil, raising soil temperatures and fostering greater leaf development. Additionally, the higher soil temperatures under plastic mulch are partly due to reduced evaporation and increased microbial activity (Bhutia *et al*., 2017).

Days to flowering:

Days to flowering were significantly affected by the mulching material (Table 5). The more days for flowering were recorded from the control plot and saw dust plot which were the same in number (44.75). The earliest flowering occurred in plots with black plastic mulch (38), followed by those with silver plastic mulch (37).

Table 5. Effect of mulching material on days to flowering of okra at Jaleshwar, Mahottari, 2023

Treatments	**Days to first flowering**
Black Plastic	38.00[b]
Silver Plastic	37.00[b]
Rice straw	40.75[ab]
Saw Dust	44.75[a]
Control	44.75[a]
LSD (0.05)	5.995
Sem (±)	1.946
F-probability	*
CV, (%)	9.5
Grand Mean	**41.05**

[Note: LSD = Least Significant Difference; CV (%) = Coefficient of Variation; DAS = Days after sowing; SEm = Standard Error of the mean; Means followed by the same letter(s) within each column are not significantly different at 5% level of significance by DMRT, * indicates the significance at <0.05].

Flowering was seen earlier in mulching conditions (Mhadeen, 2014). Using black plastic mulch with three times tillage took less time to emerge. About 50% flowering was seen earlier 3-6 days in a plot mulched with polythene in an experiment conducted by (Mamkagh, 2009).

Effect of Mulching Materials on Yield and Yield Parameters of Okra

Mulching materials significantly influenced the number of fruits per plant. The greatest number of fruits per plant was recorded with black plastic mulch (24.53), while sawdust mulch resulted in the fewest fruits per plant (19.79) (Table 6). (Olabode, 2006) also found that plastic mulch led to a higher fruit count per plant, whereas wood shaving mulch yielded the lowest fruit number.

Fruit length was significantly influenced by the treatments. The longest average fruit length (15.86) was observed with black plastic mulch, followed by silver plastic mulch with an average length of 12.56 cm. Sawdust mulch resulted in the shortest average fruit length at 10.48 cm (Table 6).

There were no significant statistical differences in average fruit weight among the treatments, indicating that the mulching material did not notably affect fruit weight. The highest fruit weight was recorded with black plastic mulch (18.9), while rice straw mulch resulted in the lowest fruit weight (14.2) (Table 6).

Significant differences in yield per plant were observed among the treatments. Black plastic mulch produced the highest yield per plant (463.91), followed by silver plastic mulch (405.00). The lowest yield was recorded with sawdust mulch (300.00), which was statistically similar to yields from rice straw and control plots (Table 6). The increased yield in plots with plastic mulch may be attributed to higher nutrient concentrations and improved nutrient uptake by the plants, a trend previously observed in tomato studies by (Hooda *et al*., 1997). The higher yield for okra under plastic mulch has been consistently documented by various researchers, including (Snyder, 2015); (Thakur *et al.*, 2020).

Okra productivity was significantly influenced by the type of mulching materials used. Black plastic mulch achieved the highest productivity at 30.00 Mt/ha, followed by silver plastic mulch at 27.00 Mt/ha. Sawdust mulch resulted in the lowest productivity at 20.00 Mt/ha. There were no significant differences in productivity among rice straw mulch (21.06 Mt/ha), sawdust mulch (20.00 Mt/ha), and the control plot (21.06 Mt/ha) (Table 6).

Insects Observed During Field:

The insect populations were significantly influenced by the type of mulching materials used (Table 7). However, at 18 days after sowing (DAS), there was no significant variation in the number of insects per plant. But at 25DAS, the highest number was recorded on the control plot whereas the lowest was found on the sawdust mulched plot. Similarly, the sawdust mulched plot continued to have the lowest number of insects at 32DAS and 39DAS too. There was also a smaller number of insects observed in plastic mulching on different days of sowing. The physical barrier of the plastic might deter crawling insects from reaching the plants or laying eggs in the soil near the plants (Bhutia *et al*., 2017). Sawdust might possess certain chemical or physical properties that repel insects or hinder their development compared to other mulches (Gordon *et al*., 2010).

Table 6: Effect of mulching material on yield parameters and productivity of okra at Jaleshwar, Mahottari, Nepal, 2023

Treatments	Number of fruits per plant	Average fruit length (cm)	Average fruit weight (g)	Yield per plant (g)	Productivity (Mt/ha)
Black plastic mulch	24.53^{a}	15.86^{a}	18.90	463.91^{a}	30.00^{a}
Silver plastic mulch	21.63^{ab}	12.56^{ab}	16.92	405.00^{ab}	27.00^{ab}
Rice straw mulch	22.01^{ab}	12.14^{b}	14.20	315.83^{b}	21.06^{b}
Sawdust mulch	19.79^{b}	10.48^{b}	15.10	300.00^{b}	20.00^{b}
Control	20.82^{b}	11.54^{b}	15.17	315.83^{b}	21.06^{b}
LSD (0.05)	2.56	3.42	1.07	60.00	4.00
SEM (±)	0.37	0.16	0.62	15.00	1.00
F-probability	*	*	NS	*	*
CV %	7.62	17.75	4.33	10.99	20.02
Grand mean	**21.76**	**12.52**	**16.06**	**359.53**	**23.97**

[Note: LSD = Least Significant Difference; CV (%) = Coefficient of Variation; DAS = Days after sowing; SEm = Standard Error of the mean; Means followed by the same letter(s) within each column are not significantly different at 5% level of significance by DMRT, * and NS indicate the significance at <0.05 and non-significant at <0.05 level]

Table 7: No. of insects per plant in different mulching materials used in Jaleshwar, Mahottari, 2023

Treatments	18DAS	25DAS	32DAS	39DAS
Black Plastic	4.825^{a}	4.125 ^{b}	3.2275^{bc}	1.785^{b}
Silver plastic	4.830^{a}	4.275^{b}	3.1500^{cd}	1.875^{b}
Rice straw	5.225^{a}	4.775^{a}	3.4750^{ab}	2.675^{a}
Saw dust	5.100^{a}	3.575^{c}	2.9000^{d}	1.665^{b}
Control plot	4.975^{a}	4.700^{a}	3.7250^{a}	2.650^{a}
LSD (0.05)	0.895	0.4046	0.3021	0.2965
SEM (±)	0.2906	0.131339	0.09806	0.0962
F-probability	NS	**	**	**
CV%	11.64749	6.123	5.951	9.038
Grand Mean	**4.991**	**4.29**	**3.2955**	**2.13**

[Note: LSD = Least Significant Difference; CV (%) = Coefficient of Variation; DAS = Days after sowing; SEm = Standard Error of the mean; Means followed by the same letter(s) within each column are not significantly different at 5% level of significance by DMRT, the star ** and NS indicate significant at <0.01 and non-significant at <0.05 level]

Table 8: Economic analysis of okra cultivation employing various mulching materials in Jaleshwar, Mahottari, 2023

Treatments	Total cost of cultivation (NRs 000 /ha)	Gross return (NRs 000 /ha)	Net return (NRs 000 /ha)	B: C ratio
Black plastic	287.55	927.90	640.45	3.23
Silver plastic	287.55	800.00	512.45	2.79
Rice straw mulch	185.55	416.20	230.65	2.25
Saw dust mulch	180.85	350.00	169.45	1.94
Control	175.55	315.90	140.35	1.80

Economics of Different Mulching Materials

The economic analysis of okra production involved combining the general cultivation costs with the additional expenses for the treatment (mulching materials). The benefit-cost ratio was then calculated using the available parameters.

The cost of cultivation of black and silver plastic was same (NRs. 287,550) in a one-hectare area. This was the highest cost of cultivation and lowest was expended in control plot (NRs. 180,850). The highest net return (NRs. 640,350) was achieved with black plastic mulch, followed by silver plastic mulch. The highest benefit-cost ratio (3.23) was recorded with black plastic mulch, while the control plot had the lowest ratio (1.8). Plastic mulch is also recognized for its effectiveness in suppressing weed growth. Weed management is a significant cost factor in agriculture. By reducing the need for extensive weed control, the treatment saves on labour and herbicides, contributing to a more favourable B:C ratio (Maurya, 2013). Plastic mulch can also reduce the leaching of fertilizers, which means that the nutrients applied to the soil are more efficiently utilized by the plants, leading to better yields and, consequently, higher gross returns. The Benefit cost ratios for both the Black Plastic Mulch and Silver Plastic Mulch treatments are close, highlighting their comparable economic efficiency. Their similarities in terms of cost-effectiveness and benefits highlight the versatility and adaptability of plastic mulching techniques for different agricultural contexts. However, among them, okra cultivation using black plastic mulch is the most profitable one having highest B:C ratio at Jaleshwar, Mahottari.

Conclusion

Okra growth and yield factors experienced notable variations due to various mulching materials. Among these materials, black plastic mulch emerged as particularly advantageous for okra cultivation. It effectively improved the soil conditions, leading to better crop establishment and increased production. The highest okra productivity, accompanied by the highest net return and benefit-cost ratio, was achieved with the application of black plastic mulch. It's worth noting that although the production costs were relatively higher with black plastic mulch, the overall economic benefits were substantial. Similar to black plastic mulch, silver plastic mulch also demonstrated positive outcomes concerning growth and yield parameters. Using plastic mulch for vegetable production surpasses traditional non-mulch methods in terms of crop performance and economic returns. Exploring other factors that could enhance the yield and quality of okra crops would need further research.

Conflict of Interest

The author declares that there is no conflict of interest with the present publication.

Authors' Contribution

S. Chaulagain designed the research plan; S. Chaulagain, S. Poudel, S. Adhikari and D. Rajbahak performed the experimental works and collected the required data. S. Chaulagain, S. Shrestha and B. Chaudhary analyzed the data; S. Chaulagain and S. Shrestha prepared the manuscript. S. Shrestha and A.S. Rajput finalized the manuscript. All authors reviewed and approved the final version of the manuscript.

Acknowledgments

I would like to acknowledge Agriculture and Forestry University, Rampur, Chitwan, Nepal, and Prime Minister Agriculture Modernization Project (PMAMP), Vegetable Zone, Mahottari for facilitating this research. I am deeply grateful to Associate Prof. Sundar Tiwari, PhD for his supervision and guidance throughout the research.

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