EFFECT OF DIFFERENT MULCHING MATERIALS ON GROWTH AND YIELD OF OKRA [*Abelmoschus esculentus* (L.)]

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ABSTRACT

A field experiment was conducted at Bhauratar in Bahudarmai Municipality of Parsa district of Nepal during spring-summer season started from February to May 2018 to assess the effectiveness of different organic and inorganic mulches in modulating the soil environment, growth, performance and yield of okra. The experiment was conducted in Randomized Complete Block Design (RCBD) with 5 treatments as follows: (1) Control, (2) Black plastic mulch, (3) Rice straw, (4) Saw dust and (5) Transparent White plastic mulch. Each treatment was replicated four times. Seed germination was significantly differed with the type of mulching material used. The highest seed germination percentage (82.00) was recorded from white plastic mulch plot and the lowest germination percentage (63.75) was recorded from control plot. The highest plant height was recorded from white plastic mulch at 30, 45, 60 and 75 DAS than that of other treatments. The highest number of picking (15.5) was recorded from black plastic mulch followed by white plastic mulch (14.25). The maximum fruit length (12.18 cm) was obtained from black plastic mulch and lowest (10.84 cm) was recorded from rice straw mulch. The highest productivity (29.86 Mt/ha) was recorded from black plastic mulch followed by white plastic mulch (25.03 Mt/ha). These findings suggest that plastic mulch causes positive effects on the growth and yield of Okra and maximum yield was obtained from black plastic mulch.

Keywords: *plastic mulch, organic mulches, seed germination, yield*

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] falls under Malvaceae Family and is also known as Lady's finger. It is one of the widely consumed and highly cultivated vegetable in South Asia and in the world. Okra being a dry season vegetable, it is a potential crop with opportunity to get high income by the small land holding farmers in Nepal. The market value of okra is high in the dry season but the market becomes already flooded with the vegetables coming from the neighboring country, India, due to open border. Nepalese farmers can only make the vegetables available later when the prices start going down due to late germination and harvest, ultimately compelling them to sell at lower prices. Moreover, due to climate change issues like lower water availability, the area and production of Okra is not increasing as that of other winter season vegetable crops. Farmers are also not getting access to irrigation from water resources such as irrigation canals due to the long distance coverage. Hence, there is a great scope of the utilization of the conservation agricultural practices such as mulching to not only make the vegetables available in the market at the right time i.e. when the price is higher but also to deal with the adaptive mechanism of climate change. So, mulching can be an important practical aid in preserving the soil moisture which eventually contributes in saving water and cost of frequent water application for the resource poor farmers. Many studies have stated that mulching aids in conservation of the soil moisture and reduction of water requirement at the limited period along with the improved crop yield (Singh & Gangwar, 1972, Singh et al., 1976). Mulching also controls the weed emergence reducing the cost of weeding. Mulching can be done by using varieties of locally available

materials like rice straw, saw dust, dries leaves, live mulches etc. These materials not only act as barrier to water loss but also add the organic component to the soil. But for commercial purpose nowadays plastic mulch with different thickness is available in the market. Different kinds of mulching materials can be used which are also documented by different authors for their beneficial impact in crop production. This study aims to assess the effects of different mulching materials on okra to select the better mulching material for that locality. In this experiment, an attempt has been made to analyze the change in okra yield due to mulching and non-mulching condition.

MATERIALS AND METHOD

A field experiment was conducted at Bhauratar in Bahudarmai Municipality of Parsa district of Nepal during spring-summer season started from February to May 2018. The experiment site was situated at about $27^0$05' North latitude and $84^0$81' East longitudes at an elevation of 292 meter. The experiment was conducted in Randomized Complete Block Design (RCBD) with 5 treatments as follows: (1) Control, (2) Black plastic mulch, (3) Rice straw, (4) Saw dust and (5) Transparent White plastic mulch. Each treatment was replicated four times. The rice straw was used @ 6 Mt/ha^{-1} and so was the saw dust used. The thickness of black opaque plastic and white transparent plastic were 350 and 300 gauge respectively. Arka Anamika, variety of okra, was selected for the experiment purpose. Seeds were soaked in water for 24 hrs prior to sowing time. The seeds were sown at the rate of 40 kg/ha on 6th of February, 2018. Each plot measured 2.5 m in length and 2.4 m in breadth. The R-R distance between crops was 50 cm whereas P-P was 30 cm. The individual plot area was 6 m^2 with 5 rows and 8 plants per row giving a total of 40 plants in each plot. The distance between the blocks of replication was 1 m and distance between the plots within a single replication block i.e. between the treatments, was 50 cm. Out of total 5 rows, 2 rows were taken as border plants and the data were recorded from the 5 sample plants selected randomly within the remaining 3 rows. The NPK was applied at the rate of 80 kg, 60 kg and 60 kg per hectare as per the recommended dose.

Five plants were randomly selected excluding the border plants and were tagged accordingly for recording the observations on the following growth and yield parameters. Plant height was measured from the base of the plant to the tip of the apical or flower bud tip. Fully developed fresh leaves attached to the plants were counted and taken under measurements for number of leaves per plant. Total no. of pickings was recorded from the first to the last picking from the 5 randomly selected sample plants within the net plot area. Fruit length was measured at the time of harvest and average fruit length was recorded. Average fruit weight was obtained by dividing the total weight of fruits harvested from the 5 tagged plants by the number of fruits produced by the same 5 tagged plants. The net plot yield (yield obtained from plants leaving border plants) was converted to yield in Mt/ha to determine the productivity of the production.

RESULTS AND DISCUSSION

Effect of mulching material on seed germination of Okra

Seed germination significantly differed with the type of mulching material used (Table 1). The highest seed germination percentage (82.00) was recorded from white plastic mulch plot followed by the black mulched plot (76%) both being at par with each other and the lowest germination percentage (63.75) was recorded in control. In general, the seed

germination was recorded to be higher in plastic mulched plots which were followed by the plots with plant material viz. rice straw mulch and saw dust mulch. Early seed germination was observed in black plastic mulch followed by white plastic mulch and the germination was late in control plots.

The highest germination under plastic mulch condition might be due to the modification of seed environment. Lamont (1999) also indicated that use of plastic caused early and high seed germination by making the soil environment suitable for the seed germination. Black plastic mulching raises the soil temperature together with soil moisture conservation and reduction of soil nutrient loss while protecting soil structure and preventing soil erosion as reported by Otoo (1989) during a trial where he recorded rapid cassava stem production under black plastic mulch. Lower germination in black plastic mulch (76.00) than that in white plastic mulch (82.00) could be due to the higher soil temperature under black plastic mulch as compared to white plastic mulch. High soil temperature might have resulted in low soil water condition and caused less germination of seed under black plastic mulch which was also explained by Gunawardhana et.al., (2011). The lowest germination in control condition might be due to the less available soil moisture due to the lack of any mulching material there that could protect the soil moisture from evaporation.

Table 1. Effect of mulching material on germination of okra at Bhauratar, Parsa, Nepal

Treatments	Germination (%)
Control	63.75^{d}
Black Plastic Mulch	76.00^{ab}
Rice Straw Mulch	73.75^{bc}
Saw Dust Mulch	68.50^{cd}
White Plastic Mulch	82.00^{a}
LSD (0.05)	6.489**
SEM (±)	2.106
Grand Mean	72.8
CV (%)	5.8

***Significant at 0.01 level*

Means followed by the same letter in a column are not significantly different at 5% level of significance as determined by DMRT

Plant height was significantly affected by the mulching materials at 30, 45, 60, 75 DAS and at harvest stages. The highest plant height was recorded from white plastic mulch at each stage. Highest plant height (22.04 cm) was recorded from white plastic mulch and the smallest plant (11.32 cm) was recorded from saw dust mulch at 30 DAS (Table 2). Plant height was significantly higher in white plastic mulch at 30, 45, 60 and 75 DAS than that of other treatments. The tallest plant (49.67 cm) was observed from white plastic mulch and that of smallest (23.08 cm) was recorded from rice straw mulch at 45 DAS (Table 3). Similarly, the highest plant height was recorded from white plastic mulch at 60 DAS (92.17 cm) and 75 DAS (145.3 cm) and the lowest was recorded from rice straw mulch at 60 DAS (52.58 cm) and 75 DAS (90.0 cm) as presented in Table 2. The plant height was significantly different at harvest stage. The highest plant height (156.0 cm) was recorded in white plastic mulch and the lowest plant height (107.2 cm) was recorded from control plot at harvest stage (Table 2).

Effect of mulching material on plant height of okra

Mulching plays vital role for root penetration making suitable environment for it by increasing soil moisture and soil organic matter content. High temperature induces rapid growth of plants (Ravinder et al., 1997) and therefore, the highest plant height was recorded from white plastic mulch compared to other mulches. At the same time, temperature higher than the optimum level threatens the growth and development of plants by reducing the soil moisture status. Optimum soil temperature and soil moisture are essential for better crop growth and establishment. Light and heat absorption capacity of black plastic is more than that of white plastic. Higher soil temperature might have resulted in lower soil moisture condition causing less suitable environment for plant height in black plastic mulch plot as compared to white plastic mulch (Gunawardhana et al., 2011). The dark color plastic mulch generates more soil temperature than that of light color. Gough (2001) and Decoteau et al. (1989) also recorded warmer soil temperatures with darker colored mulches compared to lighter colored mulches.

Table 2. Effect of mulching material on plant height of okra at Bhauratar, Parsa, Nepal

Treatments	Plant height (cm)				
	30 DAS	45 DAS	60 DAS	75 DAS	At final harvest
Control	12.29^{c}	30.46^{c}	69.00^{b}	101.7^{cd}	107.2^{e}
Black Plastic Mulch	16.21^{b}	39.67^{b}	76.5^{b}	126.4^{b}	131.5^{b}
Rice Straw Mulch	12.92^{c}	23.08^{d}	52.58^{c}	90.5^{d}	114.7^{d}
Saw Dust Mulch	11.32^{c}	29.33^{cd}	65.08^{b}	116.2^{bc}	121.1^{c}
White Plastic Mulch	22.04^{a}	49.67^{a}	92.17^{a}	145.3^{a}	156.0^{a}
LSD (0.05)	2.445**	6.404**	11.77**	18.57**	5.683**
SEM (±)	0.793	2.078	3.82	6.03	1.844
Grand Mean	14.96	34.44	71.1	116	126.09
CV (%)	10.6	12.1	10.8	10.4	2.9

***Significant at 0.01 level*

Effect of mulching materials on Number of leaves per plant in Okra

Number of leaves per plant was significantly affected by the mulching materials used at 30, 45, 75 DAS and at harvest but it was not significant at 60 DAS (Table 3). The highest number of leaves per plant was observed in black plastic mulch at 30 DAS (5.00), 45 DAS (9.00), 75 DAS (42.75) and at harvest (43.75) as in Table 3. The lowest number of leaves per plant was recorded from saw dust mulch at 30 DAS (3.75) and at 60 DAS (14.67). The number of leaves per plant was significantly lowest (5.833) in rice straw mulch at 45 DAS. Similarly, the lowest number of leaves per plant was recorded from control plot at 75 DAS (29.67) and at harvest stage (31.58).

Table 3. Effect of mulching material on number of leaves per plant in okra at Bhauratar, Parsa, Nepal

Treatments	Number of leaves per plant				
	30 DAS	45 DAS	60 DAS	75 DAS	At final harvest
Control	4.583^{ab}	7.167^{ab}	17.17	29.67^{b}	31.58^{b}
Black Plastic Mulch	5.00^{a}	9.00^{a}	19.17	42.75^{a}	43.75^{a}
Rice Straw Mulch	4.25^{bc}	5.833^{b}	16.08	34.08^{b}	35.58^{b}
Saw Dust Mulch	3.75^{c}	6.917^{ab}	14.67	33.17^{b}	32.83^{b}
White Plastic Mulch	4.667^{ab}	8.667^{a}	16.17	30.58^{b}	32.33^{b}
LSD (0.05)	0.5567**	2.066*	NS	7.55*	4.827**
SEM (±)	0.1807	0.67	0.945	2.45	1.567
Grand Mean	4.45	7.53	16.65	34	35.21
CV (%)	8.1	17.8	11.4	14.4	8.9

***Significant at 0.01 level; *Significance at 0.05 level*

Means followed by the same letter in a column are not significantly different at 5% level of significance of DMRT

The highest number of leaves per plant in black plastic mulch at every stages of okra development could be due to the higher soil temperature required for leaf formation. Plastic mulches absorb incoming solar radiation and transmit a considerable part of it to the soil increasing soil temperature suitable for more leaf formation. The optical properties of the plastic used as mulching material determines the surface energy balance of plastic mulch and its influence on the crop environment (Ham et al., 1993). Higher soil temperature under plastic mulch condition is also due to the reduction of evaporation and higher microbial activity under plastic mulch (Abdel-Hafeez & Abu-Goukh, 1984; Tarara, 2000; Sanders, 2002).

Effect of mulching material on yield and yield parameters of okra

Number of picking was significantly affected by the mulching material. Number of picking from black plastic mulch, white plastic mulch and from control plots were not statistically different. The highest number of picking (15.5) was recorded from black plastic mulch followed by white plastic mulch (14.25). The lowest number of picking (8.5) was recorded from saw dust mulch (Table 4). The picking was started with the readiness of okra fruit for marketing. The picking was initiated from the plot with black plastic mulch due to early fruit set in okra plants. Early seed germination was related to early flowering and fruiting of okra plants in black plastic mulching plot. Number of pickings is directly associated with number of fruits per plant and also with the productivity of the crop. Duzyaman (1997) reported increment in okra production due to fruit removal at early stage suitable for marketing. Early fruit removal also enhanced the activity of leaves and apical growth that is related to the fruit production. Duzyaman (2006) reported higher number of okra fruits with lower fruit weight. The satisfactory yield of okra is directly associated with frequent and complete harvest of the fruits. Okra yield was also recorded to be early in plastic mulch than that in no mulch control (Simone et al., 2002; Incalcaterra &Vetrano, 2000).

Table 4. Effect of mulching material on yield parameters and yield of okra at Bhauratar, Parsa, Nepal

Treatments	Number of picking	Number of fruits per plant	Average fruit length (cm)	Average fruit weight (g)	Yield per plant (g)	Productivity (Mt/ha)
Control	13.5^{a}	26.67^{bc}	11.32^{b}	11.47	306.4^{b}	20.43^{b}
Black Plastic Mulch	15.5^{a}	36.83^{a}	12.18^{a}	12.24	447.8^{a}	29.86^{a}
Rice Straw Mulch	10.75^{b}	20.88^{c}	10.84^{b}	14.12	298.2^{b}	19.88^{b}
Saw Dust Mulch	8.5^{c}	25.25^{c}	11.25^{b}	11.20	282.5^{b}	18.83^{b}
White Plastic Mulch	14.25^{a}	32.35^{ab}	11.50^{ab}	11.62	375.4^{ab}	25.03^{ab}
LSD (0.05)	1.964**	6.413**	0.747*	NS	113.8*	7.59*
SEM (±)	0.637	2.081	0.242	1.16	36.9	2.46
Grand Mean	12.5	28.4	11.42	12.13	342	22.8
CV (%)	10.2	14.7	4.2	19.1	21.6	21.6

***Significant at 0.01 level; *Significance at 0.05 level*

Number of fruits per plant was significantly affected by the mulching materials. The highest number of fruits per plant (36.83) was observed in black plastic mulch and the lowest number of fruits per plant (20.88) was recorded from rice straw mulch (Table 4). Higher number of pickings from the black plastic mulch could be the reason for maximum number of fruits per plant which was also reported by Duzyaman (1997). He reported higher okra yield with early and frequent fruit removal.

Fruit length was significantly ($p<0.05$) affected by the treatments. The highest average fruit length (12.18 cm) was recorded from black plastic mulch followed by that in white plastic mulch (11.50 cm). The lowest average fruit length (10.84 cm) was recorded from rice straw mulch. Harvesting time from flowering to fruit maturity determines the fruit length. Fruit harvesting in short interval could be the reason for shorter fruit length. Rapid fruit development and elongation in black plastic mulch and white plastic mulch due to the favorable soil environment from optimum soil moisture, soil temperature and available plant nutrients could be the reason for comparatively lengthy fruits in plots mulched with plastics as shown in Table 4.

Average fruit weight was not statically different among the treatments. The fruit weight was not significantly affected by the mulching material. The highest fruit weight (14.12 g) was recorded from rice straw mulch and the lowest fruit weight (11.20 g) was recorded from saw dust mulch (Table 4.). There was significant difference in yield per plant among the treatments. The highest yield per plant (447.8 g) was recorded from black plastic mulch followed by white plastic mulch (375.4 g). The lowest yield per plant (282.5 g) was recorded from saw dust mulch which was statically similar to that from rice straw mulch (298.2 g) (Table 4.).

The higher yield in plastic mulch plots could be due to the higher nutrient concentration and nutrient uptake by the plants as reported by Hundal et al. (2000) in tomato. The nutrient and moisture loss is relatively less in plastic mulch than in plant residue mulch and control plots. The maximum yield per plant in okra under plastic mulch was also recorded by Ham et al. (1993), Khambal et al. (2009), Lourduraj et al. (1997), Sanders et al. (2002) and Sannigrahi et al. (2002).

Okra productivity was significantly affected by the mulching materials used. The highest productivity (29.86 Mt/ha) was recorded from black plastic mulch followed by white plastic mulch (25.03 Mt/ha). The lowest okra productivity (18.83 Mt/ha) was recorded from saw dust mulch. Statistically there was no significance different between the productivity from rice straw mulch (19.88 Mt/ha), saw dust mulch (18.83 Mt/ha) and control plot (20.43 Mt/ha).

The highest productivity from black plastic mulch could be explained as a close relation on number of pickings (15.5), number of fruits per plant (36.83) and yield per plant (447.8 g). The productivity of the okra is directly related to the number of picking, number of fruits per plant and weight of the fruits. Batra et al. (1985) found higher yield of okra with polyethylene mulch compared to bare soil. Vethamoni and Balakrishnan (1990) and Brown and Lewis (1986) recorded higher yield of okra from black mulch instead of bare soil due to ability of plastic mulch to reduce weeds and fertilizers leaching. Simone et al. (2002) also reported significantly higher yield of different varieties of okra from plastic mulch than that in control in an experiment conducted in Florida. Higher yield of okra was recorded from plastic mulch due to improved soil moisture retention (Lourduraj et al., 1997; Tiwari et al., 1998; Saikia et al., 1997). The ambient temperature provided by the plastic mulch might have also caused significantly higher yield and productivity from plastic mulching plot (Khan et al., 1990a; Khan et al., 1990b; Lamont, 1999; Incalcaterra & Vetrano, 2000; Brown & Channell-Butcher, 1999b). Lal (1975) also reported high okra productivity from mulching. Rapid growth and higher yield of tomato and sweet pepper was also reported by Geneve (1981). It is possible to double and triple crop production with maximum efficiency by early crop production and higher yield per unit area with cleaner and quality produce only with plastic mulch technology (Lamont, 1999).

CONCLUSION

Okra yield and yield parameters were significantly affected by different mulching material. Highest okra productivity was obtained from plot with black plastic mulch. Vegetable production using plastic mulch was better than no mulch traditional system. The black plastic mulch was found to be more beneficial for the growth and yield of okra. Due to maximum no. of pickings and maximum number of fruits per plant in the plot with black plastic mulch, the yield might have been highest in black plastic mulch plot among all the treatments. However the environment damage due to microplastice has to be considered in waste management.

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