Research Article

MULCHING MATERIALS AFFECTS GROWTH AND YIELD CHARACTERS OF CUCUMBER (*Cucumis sativus* cv. Malini) UNDER DRIP IRRIGATION CONDITION IN CHITWAN, NEPAL

A. Karki*, B. Sapkota, P. Bist, K. Bista, J. P Dutta, S. Marahatta, and B. Shrestha
Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal

*Corresponding author: ashmita.karki012@gmail.com

ABSTRACT

An experiment was done to evaluate the effect of mulching materials on growth and yield characters of cucumber (var: Malini) under drip irrigation condition during February to May 2018 in Chitwan district, Nepal. The experiment was done by using Randomized Complete Block Design (RCBD). Accordingly, four different mulching materials, viz. silver on black polyethylene mulch, black polyethylene mulch, rice straw mulch, and rice husk mulch were used as treatments. Each treatment was replicated four times. Un-mulched plot served as control. Mulching improved growth and yield characters of cucumber. Plant height and number of leaves were significantly higher ($p<0.05$) if silver on black polyethylene mulch was used. Similarly, highest number of male (69.50) and female (33.50) flowers per plant were recorded in silver on black polyethylene mulch used. Male flowers were minimum (29.80) in rice husk mulch used treatment whereas female flowers were minimum (10.30) in the control treatment. Sex ratio was the highest (3.43) in control and it was lowest (1.81) for rice husk mulch used treatment. Number of fruit per plant was significantly higher ($p<0.05$) (15.85) in silver on black polyethylene mulch treatment. Likewise, longest fruit length (18.42 cm) was measured in silver on black polyethylene mulch treatment whereas shortest (15.24 cm) length was measured in control. Yield of silver on black polyethylene mulch and black polyethylene mulch was almost three-folds and two-folds to that of the control, respectively. B: C ratio shows the use of silver on black polyethylene mulch and black polyethylene mulch economically more beneficial in cucumber production with highest benefit. Findings of this experiment thus clearly suggest the benefit of using silver on black polyethylene mulch, as well as black polyethylene mulch in cucumber cultivation compared to the other common mulching materials.

Key words: Growth, fruit yield, mulch

INTRODUCTION

Cucumber (*Cucumis sativus* L.), is one of the most popular members of the Cucurbitaceae family due to its excellent flavor, varied usefulness, texture and medicinal value (Shrivastava & Roy, 2013; Keerthika et al., 2016). The area under cucumber cultivation in Nepal is 10,812 ha producing 172,566 t of cucumber with the productivity of 15.96 t ha^{-1} (MOALD, 2020). Cucumber production faces several constraints, among them, competition for space, light, water, and nutrients; weakening crop stand, and reducing harvest efficiency mainly due to weed are the important (Osundare et al., 2019). Removal of weeds by manually, mechanically, or chemically, accounts major portion of pre-harvest cost. Effective method of weed control is manual weeding, but it is tedious and uneconomical due to labor scarcity and high wages in these days (Rao & Nagamani, 2010). Unfavorable climatic conditions lead to reduction of female flowers, delay in fruit growth, and mineral disorders. Deleterious effects on growth and yield are observed by water stress (Arshad, 2017).

The main objectives of mulching are weed control, conservation of soil moisture and modification of soil temperature (Olsen & Gounder, 2001). Mulching is a non-chemical weed control crop production technique which is effective alternatives to herbicides (Awodoyin et al., 2007). Mulch decrease irrigation requirements of cucumber plants compared to without plastic mulch (Abdrabbo, Farag, & Hassanein, 2009). High yield can be achieved altering micro climatic conditions, such as by using black polyethylene mulch in early season production as it increases surface soil temperature whereas silver black mulch is more appropriate for hot weather planting and production as it lowers surface soil temperature (Jabran, 2019).

Use of different mulching materials, mostly polyethylene mulches with or without drip irrigation in vegetable production seems increasing these days in Nepal (Sapkota et al., 2015; Jha et al., 2018; Bharati et al., 2020). Locally available materials in the vicinity of farm such as rice straw, rice husk, saw dust, dried leaves can also be used scientifically to conserve moisture, to suppress weed, and to increase yield (Shrestha et al., 2008). To meet the increasing demand of cucumber all the year round with the use of low-cost technology and practices, use of mulching with drip irrigation can be more appropriate approach to increase the cucumber yield. Under this context, an experiment was done to evaluate the performance of different mulching materials on growth, phenology, yield and profitability of Malini variety of cucumber.

MATERIAL AND METHODOLOGY

This experiment was done in the Bharatpur Metropolitan City-16, Mangalpur, Chitwan, Nepal during February to May 2018. The experiment was done by using Randomized Complete Block Design (RCBD); each

treatment was replicated four times. Four different mulching materials- silver on black polyethylene mulch, black polyethylene mulch, rice straw mulch, rice husk mulch, and un-mulched (control) were used as treatments. Malini variety of cucumber was used and plants were maintained under drip irrigation condition. There were a total of 20 plots. Individual net experimental plot area compromised of 4 m × 3.9 m (15.6 m^2). Each plot contained 4 rows of plants and; each row with 6 plants. Thus, each plot contained 24 plants whereas 5 plants were taken as sample from middle area. Row to row spacing was kept one meter and plant to plant spacing was maintained as 0.65 m. Distance between two plots was maintained as one meter.

Different mulching materials as treatments were laid on specific plots after drip lines were fixed, before transplantation. Both plastic mulches (20 m in each plot) were placed tightly on soil surface surrounded with mud in all sides. Rice straw (22.43 t ha^{-1}) was placed in two layers, and rice husk (38.46 t ha^{-1}) was spread evenly on the soil surface. Recommended dose of FYM (30 t ha^{-1}) and N: P: K @ 7:2:5 kg per Ropani (equivalent to 140:40:100 kg ha^{-1}) was used. Recommended full dose of FYM, phosphorous as DAP, potassium as MOP and recommended half dose of nitrogen through urea were applied as basal dose. Remaining half dose of nitrogen was supplied through fertigation at two split doses at 30 DAT and 45 DAT respectively. A correlation and regression analysis was done among the selected parameters to understand whether relationship exists between the selected variables and also to know about degree of their association (Gomez & Gomez, 1984). Statistical tools such as Genstat and MS Excel were used for the analysis of variance and other data analysis procedures.

RESULTS AND DISCUSSION

Plant height

Mulching didn't have significant effect ($p>0.05$) on plant height at 15 DAT and 45 DAT, but had significant effect on plant height ($p<0.05$) at 30 DAT and 60 DAT (Table 1). The maximum final plant height at 60 DAT was for treatment with silver on black polyethylene mulch but it was statistically similar to the treatment- black polyethylene mulch (177.00 cm) and rice straw mulch. The minimum plant height was measured in control which was statistically similar ($p>0.05$) with rice husk mulch, black polyethylene mulch and rice straw mulch treatments (Table 1).

Enough soil moisture near root zone, extended retention of moisture due to minimized evaporation, availability of moisture could have lead to higher uptake of nutrients resulting in proper growth and development of the plant (Simunek & Hopmans, 2009). The nature of silver on black plastic mulch to accumulate heat during day and loss during night can be a possible reason for increased vine length compared to control (Parmar et al., 2013), and it was related to the plant growth and performance. Similar findings were also reported in cucumber, by Hallidri (2001); in watermelons, by Ansary & Roy (2005); in tomato, by Sharma & Agrawal (2004), and in strawberry by, Ali & Gaur (2007). Lighter color mulches reflects more light with increased light intensity that could affect plant development and yield through greater photosynthetic rates. Ratio of FR:R is important in phytochrome regulation of plant physiological processes, and can affect internode length and stem elongation, chloroplast ultrastructure, photosynthetic efficiency, and photosynthate partitioning among leaves, stems and roots (Decotcau, 2008).

Table 1. Effect of mulching materials on plant height (cm) of cucumber at different days after transplanting (DAT) in Chitwan, Nepal, 2018

Treatments	Plant height (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT
Control	56.99	91.20^{c}	140.00	143.80^{b}
Silver on black polyethylene mulch	64.31	136.60^{a}	186.00	196.60^{a}
Black polyethylene mulch	62.08	122.40^{ab}	170.00	177.00^{ab}
Rice straw mulch	54.73	110.00^{bc}	144.20	168.60^{ab}
Rice husk mulch	58.67	109.30^{bc}	153.90	154.40^{b}
LSD (=0.05)	NS	21.67	NS	32.76
SEm (±)	3.58	7.03	18.44	10.63
CV%	12.10	12.30	23.00	12.60
Grand mean	59.40	113.90	160.40	168.10

Note: DAT=Days after transplanting

Number of leaves per plant

Effect of different mulching materials on number of photo-synthetically active leaves was significant for all measured parameters (Table 2). Highest number of leaves at 60 DAT was counted in silver on black polyethylene mulch treatment, but it was statistically similar ($p>0.05$) to the treatment black polyethylene mulch and rice straw mulch used. The treatment control had the lowest number of leaves per plant. The decrease in leaf number at 60 DAT was perhaps due to the removal of diseased, insect damaged and old leaves to protect plant from further infestation, thus only photo synthetically active leaves were counted.

Rajablariani (2012) reported the maximum number of leaves per plant in the plots with mulched with silver/black plastic. The author had concluded that microclimatic condition improved by mulching, that might have provided a suitable condition for producing higher number of leaves in the plants. Alteration of the light microenvironment as upwardly reflected light from silver mulches- decreases the ratio of red to far-red light compared to black mulches, and it was thought to lead to develop greater leaf areas in plants grown on reflective silver mulches compared to black plastic (Decotcau, 2007). Favorable root-zone temperature using plastic mulch promotes uptake of water and mineral nutrients which in turn promotes better foliage and growth of plant(Tindall et al., 1990). The reason is also supported by Bosland & Votava (2000) as the authors reported about higher soil temperatures (up to 23^0C) and its link to promote leaf growth.

Table 2. Effect of mulching materials on number of photo-synthetically active leaves of cucumber at different days after transplanting (DAT) in Chitwan, Nepal, 2018

Treatments	Number of leaves per plant			
	15 DAT	30 DAT	45 DAT	60 DAT
Control	5.90^{b}	15.10^{c}	26.80^{c}	21.50^{c}
Silver on black polyethylene mulch	8.75^{a}	42.70^{a}	55.30^{a}	39.00^{a}
Black polyethylene mulch	8.30^{a}	30.00^{b}	47.70^{ab}	33.80^{ab}
Rice straw mulch	5.90^{b}	26.90^{b}	39.10^{bc}	29.10^{abc}
Rice husk mulch	6.90^{ab}	24.70^{b}	29.30^{c}	25.20^{bc}
LSD (=0.05)	2.03	9.16	13.06	11.48
SEm (±)	0.66	2.97	4.24	3.73
CV%	18.50	21.40	21.40	25.10
Grand mean	7.15	27.80	39.60	29.70

Note: DAT=Days after transplanting

Total male, female flowers and sex ratio

Total number of female flowers was significantly different among the treatments. The highest number of male flowers per plant was counted in silver on black polyethylene mulch (69.50) and black polyethylene mulch treatments (Table 3). The lowest number of male flowers was counted in rice husk but it was statistically similar to the rice straw mulch and control treatments. The treatment with silver on black polyethylene mulch produced highest number of female flowers per plant whereas it was lowest for control. Male female ratio was significantly higher ($p<0.05$) for control compared to other mulched treatments. Bhujbal et al. (2015) also had reported maximum number of flowers per plant (39.86) in the treatment with black color on silver polyethylene mulch.

Table 3. Effect of mulching materials on total male, female flowers and sex ratio of cucumber in Chitwan, Nepal, 2018

Treatments	Total male and female flowers per plant and sex ratio		
	Male flower	Female flower	Sex ratio (m:f)
Control	32.60^{c}	10.30^{c}	3.43^{a}
Silver on black polyethylene mulch	69.50^{a}	33.50^{a}	2.05^{b}
Black polyethylene mulch	54.40^{ab}	23.50^{b}	2.30^{b}
Rice straw mulch	38.00^{bc}	19.60^{b}	2.11^{b}
Rice husk mulch	29.80^{c}	16.60^{bc}	1.81^{b}
LSD (=0.05)	19.00	7.30	0.80
SEm (±)	6.17	2.37	0.26
CV%	27.50	22.80	22.40
Grand mean	44.90	20.70	2.34

Average fruit length, diameter and individual fruit weight

Significant differences among different mulching materials used were found on fruit length, but not to the fruit diameter and individual fruit weight (Table 4). Fruit length was longest in silver on black polyethylene mulch, but it was statistically similar ($p>0.05$) with black polyethylene mulch. Control had shortest fruit length. Parmar et al. (2013) in the case of watermelon had reported maximum fruit size and average fruit weight with the treatment-silver on black plastic mulch, whereas it was minimum in the case of control. The authors further explained about the attainment of larger fruit size and weight under silver on black mulch, which was due to congenial soil moisture, resulting in higher uptake of nutrition for better growth of fruit, the reduction in evaporation losses of soil moisture caused by mulches covering the soil surface in row of watermelon. These explanations are also in consonance with those reports of Hallidri (2001) in cucumber; Ansary & Roy (2005) in watermelon; Sharma & Agrawal (2004); Aruna et al. (2007) in tomato, and Suresh & Kumar (2006) in pointed gourd.

Table 4. Effect of mulching materials on average fruit length (cm), diameter (cm) and individual fruit weight (g) of cucumber in Chitwan, Nepal, 2018

Treatments	Average fruit length, diameter and individual fruit weight		
	Fruit length (cm)	Fruit diameter (cm)	Individual fruit weight(g)
Control	15.24^{d}	5.082	227.9
Silver on black polyethylene mulch	18.42^{a}	5.227	280.9
Black polyethylene mulch	17.43^{ab}	5.456	260.2
Rice straw mulch	16.92^{bc}	5.234	250.0
Rice husk mulch	15.72^{cd}	5.204	245.7
LSD (=0.05)	1.407	NS	NS
SEm (±)	0.457	0.0979	13.74
CV%	5.5	3.7	10.9
Grand mean	16.75	5.241	252.9

Average fruit number per plant and yield

Highest number of fruit per plant was counter in silver on black polyethylene mulch (Figure 1). Control had the lowest number of fruit per plant which was at par with rice straw mulch and rice husk mulch treatments. Black polyethylene mulch had average fruit number per plant, being at par with rice straw mulch and rice husk mulch. Favorable soil temperature, moisture conditions and pest-disease control consistently increased higher fruit set than other mulch and no mulch in silver on black polyethylene mulch in watermelon (Parmar et al., 2013). Mutetwa & Tuarira (2014) also reported that silvery grey colored mulch would perform significantly better results on the extent of fruit set in cucumber. These findings are in accordance with the reports of Hanna (2000) in cucumber and Andino & Motsenbocker (2004); Ansary & Roy (2005), in watermelon.

Yield obtained was significantly different for different mulches (Figure 1). Highest yield was obtained in silver on black polyethylene mulch which was at par with black polyethylene mulch. It was followed by rice straw mulch being at par with rice husk mulch and control (20.8 t ha^{-1}) (Figure 1) where control had the lowest yield. Higher increased yield under drip irrigation and polythene mulch resulted due to better water utilization, higher uptake of nutrients and excellent soil-water-air relationship with higher oxygen concentration in root zone (Bhujbal et al., 2015). These findings agree with those of Singh & Kamal (2012). As mulch films are nearly impervious to carbon dioxide which is necessary for photosynthesis, 'Chimney effect' might have been created, resulting in abundant CO_2 for the plants which might have added higher plant growth and fruit yield grown under different plastic mulches (Diaz-Perez, 2010). The authors further stated that- more number of leaves as a result of more branches would result due to the extra length (more number of internodes) in the main stem that could positively influenced to the yield. The color of plastic mulch affects the upper soil profile temperature and the soil heat accumulation, measured as soil degree-day (DDsoil). Soil degree-day (DDsoil) and plant photosynthesis were positively correlated with yiled, suggesting that increases in cucumber yield are due in part to an increase in soil temperature and plant photosynthesis (Ibarra-Jimenez et al., 2008).

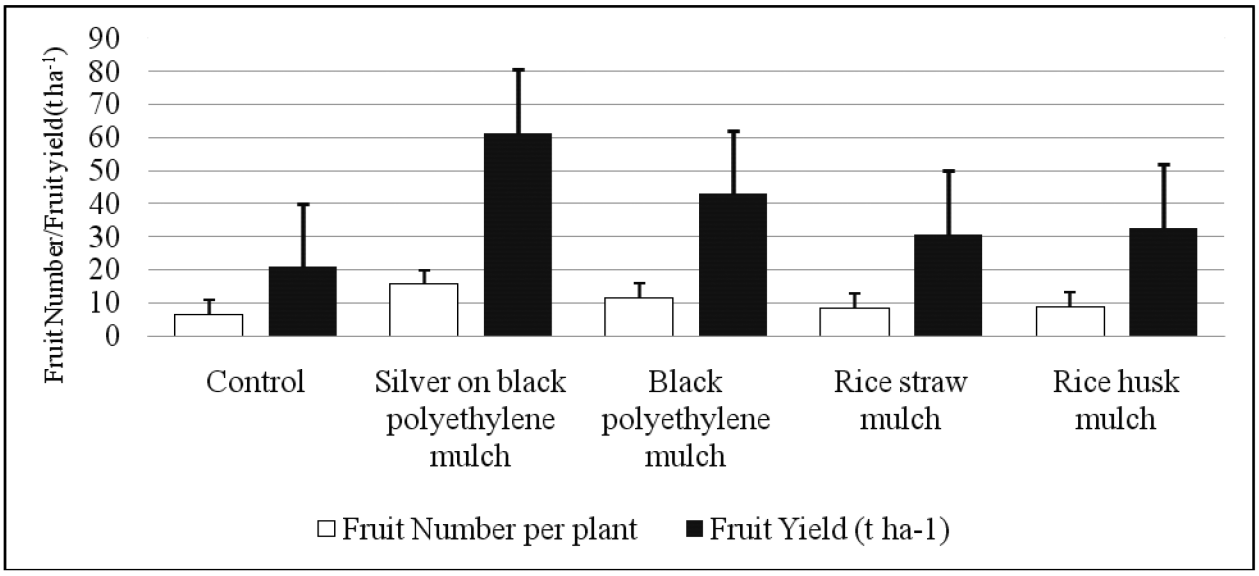

Figure 1. Effect of mulching materials on average number of fruit per plant, & yield (t ha^{-1}) of cucumber in Chitwan, Nepal, 2018

Total cost of cultivation, gross return, net return and B: C ratio

Significant difference among different mulches was observed regarding benefit to cost ratio (Table 5). Maximum benefit to cost ratio was found in silver on black polyethylene mulch, but it was statistically at par with black polyethylene mulch treatment. Rice straw mulch had the lowest benefit to cost ratio and was statistically similar to rice husk mulch (Table 5).

Table 5. Effect of mulching materials on total cost of cultivation (NRs. ha^{-1}), gross return (NRs. ha^{-1}), net return (NRs. ha^{-1}) and B: C ratio of cucumber in Chitwan, Nepal, 2018

Treatments	Total cost of cultivation (NRs. 000 ha^{-1})	Gross return (NRs. 000 ha^{-1})	Net return (NRs. 000 ha^{-1})	B: C ratio (NRs. 000 ha^{-1})
Control	354.22	519.20^{c}	165.00	1.47^{b}
Silver on black polyethylene mulch	495.18	1530.90^{a}	1035.80	3.09^{a}
Black polyethylene mulch	409.45	1072.90^{ab}	663.40	2.62^{a}
Rice straw mulch	1598.02	766.70^{bc}	-831.30	0.48^{c}
Rice husk mulch	726.58	814.80^{bc}	88.20	1.12^{bc}
Silver on black polyethylene mulch		481.10		0.91
LSD (=0.05)				
SEm (±)		156.10		0.29
CV,%		33.20		34.00
Grand mean	716.69	941.00	224.00	1.76

CONCLUSION

The mulching materials had influenced to the growth parameters, sex ratio, individual fruit size, total number of fruit per plant and yield. Use of silver on black polyethylene mulch and black polyethylene mulch were comparatively superior in terms of growth, fruit size, total numbers of fruit per plant and yield performance of cucumber. Yield of silver on black polyethylene mulch and black polyethylene mulch was almost three-folds and two-folds to that of the control, respectively. B: C ratio shows the use of silver on black polyethylene mulch and black polyethylene mulch economically more beneficial in cucumber production with highest benefit. All these facts and figures thus suggest the scope of use of silver on black polyethylene mulch and black polyethylene mulch in cucumber cultivation. However, the effect of different mulches on crops could also be affected by the material

used as mulches, color of plastic mulches, seasons, and locations. Therefore, it is recommended to conduct similar studies with further coverage in plastic materials use with multi-location and years to validate these preliminary findings before coming into a concrete conclusion.

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