International Journal of Horticultural Science and Technology
Journal homepage: http://ijhst.ut.ac.ir

Yield and Economic Analyses of Different Mulching Materials for Potato Production

Namrata Ghimire[1*], Arvind Srivastava[1], Deepak Poudel[2] and Kamal Raj Gaire[2]

1. Agriculture and Forestry University,Bharatpur, Nepal
2. Senior Agricultutre Officer, Prime Minister Agriculture Modernization Project, Government of Nepal

ARTICLE INFO

Article history:

Received: 2 December2020
Received in revised form: 22 February 2021
Accepted: 7March2021

Article type:

Research article

Keywords:

Canopy,
Mulch,
Plastic,
Potato,
Tuber.

ABSTRACT

To determine the suitability of different mulching materials for improving the yield of potato,a field experiment was conducted from January 2020 to May 2020 at Kavrepalanchowk, Nepal. The experiment was carried out in Randomized Complete Block Design (RCBD) with five treatments including: T1: silver plastic mulch, T2: black plastic mulch, T3: perforated black plastic mulch, T4: straw mulch, and T5: Control, with four replications. The experiment revealed that the highest tuber yield was obtained in silver plastic mulch (42.29tonne/ha) followed by perforated black plastic (41.04tonne/ha), black plastic (39.17tonne/ha), and straw (28.54tonne/ha) mulches, and the lowest yield was obtained in the Control treatment (21.46tonne/ha). Soil temperature was found to be influenced by the use of mulching materials with the highest soil temperature recorded under black plastic mulch, whereas the lowest soil temperature was detected under the Control treatment. The economic analysis of using different mulching materials showed the highest benefit/cost ratio by silver plastic mulch (3.63); followed by perforated black plastic mulch (3.53) and the lowest benefit/cost ratio was calculated for the Control (2.60). The present study, therefore, depicted silver plastic mulch followed by perforated black plastic mulch as the most effective mulching material for improving production of potato.

Abbreviations

%: Percentage, °C: Degree Celsius, CBS: Central Bureau of Statistics, CV: Coefficient of Variation, BC Ratio: Benefit- Cost Ratio, FAO: Food and Agriculture Organization, GDP: Gross Domestic Product, LSD: Least Significant Difference, Mt/ha: Metric ton per hectare, q/ha: Quintal per hectare, RCBD: Randomized Complete Block Design, DAP: Days After Planting, FYM: Farm-Yard Manure, MOP: Muriate of Potash.

Introduction

Potato (*Solanum tuberosum* L.) is an annual plant in the family Solanaceae that is widely grown for its starchy edible tubers and is also known as the King of vegetables (Potatopro, 2019). Potato is native to the Peruvian-Bolivian Andes and is one of the world's main food crops. It is world's number one non-cereal

* Corresponding Author's Email: namrataghimire11@gmail.com

crop feeding more than a billion people daily (FAO, 2013). It is the third most important food crop in the world after rice and wheat in terms of consumption (FAO, 2011). China is the largest potato producer in the world and Nepal ranks ninth in the major potato-producing countries in Asia (Potatopro, 2019). Moreover,it is a highly nutritious, easily digestible, wholesome food containing carbohydrates, proteins, minerals, vitamins, and high-quality dietary fiber. The tuber contains 70-80% water, 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fiber, and 0.9% ash (Gemmechu, 2017).

Mulching materials (either organic or inorganic) are the protective covering materials, which are placed on the ground around the plants to suppress weed growth, retain soil moisture or prevent freezing of roots. Mulching has gained popularity nowadays as a good means of soil conservation for cultivation. In research conducted at the University of Nebraska- Lincoln, corn-residue cover on the soil surface after planting proved to be a good approach for soil conservation (Shelton, 1995).Another experiment conducted in Japan in 2003 that examined the effects of plastic film mulching on the leaching rate of nitrate-nitrogen (NO^3-N) supported the conclusion that the nitrogen losses were reduced by the immobilization process with the increased nutrient availability, thereby improving the soil quality (Haraguchi, 2004).Hence, the plastic film reduces water loss, conserve moisture, control the weed population, improve the soil physicochemical and biological conditions in the dry season as well as decrease the nitrate leaching. These findings are also supported by Romic et al. (2003) and Li et al. (2013)

Mulching materials are found to have positive impacts on growth parameters and yield of crops. According to Singh and Ahmed (2008), black plastic mulch had a significant influence on the yield and growth of potatoes with the increase in emergence, plant height, and the number of stems. Among different types of mulches (white polythene sheet, black polythene sheet, perforated black polythene sheet, grass mulch), all the studied parameters such as emergence, germination, yield, and the number of tubers were recorded significantly higher in white polythene sheet than the other treatments (Mahmood et al., 2002). Research conducted in mid-hill conditions of Uttaranchal, India, during summer 1998, 1999, and 2000 using five locally available mulching materials (wheat straw, green twigs, farmyard manure (FYM), piltu (dry leaves of *Pinusroxburgh*, and forest litter) on potato cv.'KufriJyoti' showed a significant influence of such materials on soil moisture, soil temperature, plant height, fresh weight of shoot, the weight of tuber, number of tubers per plant, and tuber yield. The plants that are grown under black plastic mulch caused the highest soil temperature as well as showed a marginal difference in yield than that of the control plots (Ibarra-Jiménez et al., 2011).Generally, the polyethylene film mulches increased total tuber yield by 16 and 8% and average tuber weight by 14 and 12%, respectively, as compared to that of without mulch (Kang et al., 2003). Similarly, in one of the experiments conducted in India, the tuber yield was found significantly higher in polythene mulch (182.2 q ha^{-1}) than that of straw mulch (166.5 q ha^{-1}) and no mulch (142.9 q ha^{-1}) (Khalak and Kumar, 1992).

Even though potato ranks as the fourth most important staple crop in Nepal, the national productivity (16.04 MT/ ha) is significantly lower than that of global productivity (52.4 MT/ ha) (AITC, 2020). There are numerous problems like maximum weed infestation, over-irrigation, increased disease problems, and leaching of nutrients resulting in lower productivity of potatoes in different parts of this country as well as in many other developing countries. Using feasible technologies such as mulching can be one of the major contributing factors for yield

improvement in potatoes. Therefore, this experiment was carried out to examine the influence of different types of mulching materials on the growth and yield of potato.

Materials and Methods

Experimental site

This study was carried out at Nala, Kavrepalanchowk district, Nepal located at 85º22"E to 85º49"E latitude and 27º20"N to 27º45"N longitude in the humid subtropical zone with an elevation of 280m from the sea level. The climatic condition of the experimental site showed the average maximum temperature of 21.40 ˚C, average minimum temperature of 11.60 ˚C, and maximum rainfall of 16.83 mm during the study period (Fig. 1).

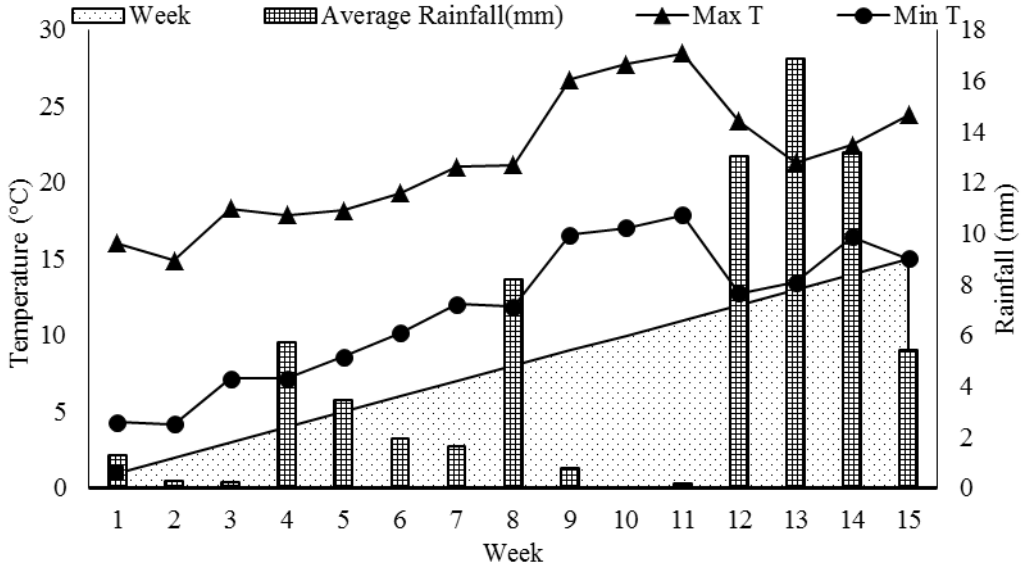

Fig. 1. Meteorological data at different weeks after sowing of potato at the at Nala, Kavrepalanchowk district, Nepal

Experimental design and treatments

The experiment was laid out in Randomized Complete Block Design (RCBD) with five treatments and four replications on a land area of 105 m^2 ($14m^2 \times 7.5m^2$) at Nala village of Kavrepalanchowk district, Nepal.

Treatments including:

T1 = Silver plastic mulching

T2 = Black plastic mulching

T3 = Perforated black plastic mulching

T4 = Straw mulching

T5 = Control plot

There were twenty total plots with the size of 3 m^2 (3m × 1m), where 5 rows with 5 plants per row were planted. The Cardinal variety of potato was sown where crop geometry was maintained at 60cm × 20cm. Plastic mulches (including: silver, black, and perforated black) were laid on the raised beds and sides were covered with soil and U-shaped pins. In the treatments with straw mulch, the 10-inch thick straw was placed whereas the plots were left uncovered in control treatments.

Cultural practices

The recommended dose of N, P, K fertilizers 100:100:60 kg/ha and FYM 1500kg/ha were applied (AITC, 2020). A full dose of FYM, Di-Ammonium Phosphate, MOP, and half dose of urea was applied as basal dose and the remaining half dose of urea was applied after earthing up at 45 DAP. Irrigation was done twice at 25 and 46 DAP along with one hand weeding at 45 DAP (AITC, 2020).

Data collection

Five plants were randomly selected from each experimental plot for recording the number of leaves, plant height, number of the aerial stem, canopy diameter, tuber number, and weight per plant as well as yield. Total germination percentage at 30DAP was recorded from every plot. A soil temperature of all the plots at 10 cm depth was recorded by a soil thermometer (Model: BJ-S300; Brand: BONAJAY) at four different times (30DAP, 45DAP, 60DAP, and 75DAP). After harvesting of potatoes, grading of their tubers were estimated based on three categories (large-sized, medium-sized, and small-sized). Furthermore, the tuber diameters were measured to classify them into marketable and non-marketable tubers with the help of Vernier caliper (Luis JJ, 2011). The data on the cost of cultivation, gross return, net return, and benefit/cost ratio were calculated on current input and output prices.

Statistical analysis

All the recorded data were entered into MS Excel and further subjected to analysis of variance (ANOVA). R- Studio was used for analyzing data. Duncan's multiple range test (DMRT) was conducted for mean separations by selecting a 5% level of significance.

Results

Effect of mulchingtreatments on growth parameters

The results of germination percentage, number of leaves, plant height, and number of aerial stems per plant and canopy diameter are presented in Table 1. All the parameters except the number of aerial stems per plant were significantly influenced by mulching treatments.

The parameters like emergence, germination, yield, and number of tubers were found significantly higher in mulching treatments than in the control.

Table 1. Effect of different mulching treatments on germination percentage, number of leaves per plant, plant height, number of aerial stems per plant, and canopy diameter of potato at Nala, Kavrepalanchowk district, Nepal

Mulching treatments	Germination percentage (%)	Number of leaves per plant		Plant height (cm)		Number of aerial stems per plant		Canopy diameter (cm)	
		60DAP	75DAP	60DAP	75DAP	60DAP	75DAP	60DAP	75DAP
Silver Plastic	98.75^{a}	38.70^{ab}	41.00^{b}	18.90^{ab}	19.67^{ab}	4.95	5.20	25.98^{a}	26.18^{a}
Black Plastic	98.75^{a}	51.20^{a}	55.45^{a}	19.57^{a}	21.57^{a}	6.60	6.87	24.51^{a}	25.32^{ab}
Perforated Black Plastic	96.25^{a}	37.70^{b}	41.35^{b}	20.02^{a}	22.54^{a}	6.55	6.80	25.72^{a}	26.47^{a}
Straw	87.50^{a}	23.95^{c}	27.55^{b}	13.80^{c}	16.12^{b}	4.90	4.90	21.06^{b}	22.08^{c}
Control	72.50^{b}	29.00^{bc}	32.52^{b}	14.72^{bc}	16.80^{b}	4.80	4.80	23.33^{ab}	23.82^{bc}
LSD (0.05)	10.82	12.65	13.24	4.44	4.45	NS	NS	2.69	1.81
SEm (±)	3.51	4.10	4.29	1.44	1.44	0.72	0.71	0.87	0.58
CV (%)	7.74	22.75	21.72	16.58	14.96	25.92	24.99	7.25	4.75
Grand mean	90.75	36.11	39.57	17.40	19.34	5.56	5.71	24.12	24.77

Means with the same letters do not differ significantly at p = 0.05 by DMRT. CV = Coefficient of variation. LSD = least significant difference, SEM = Standard error of the mean. DAP = Days after planting

Germination Percentage

The germination percentage at 30 DAP was significantly higher in mulching treatments than in the control. The highest germination percentage was observed in silver plastic (98.75%) which was statistically similar with black plastic (98.75%), perforated-black plastic (96.25%) and straw (87.50%) while the germination percentage in control (72.50%) was significantly lower than the other treatments (Table 1).

Number of leaves per plant

The number of leaves per plantat both 60 and 75 DAP was significantly higher in different

types of mulching materials except for the straw mulching. At 60 DAP; black plastic had the highest (51.20) and the straw had the lowest (23.95) number of leaves per plant. Moreover, the number of leaves in black plastic (55.45) observed at 75 DAP was significantly higher than that of the remaining treatments (Table 1).

There was a positive relationship between the number of leaves and yield of potato plants, in a way that more leaves corresponds to higher yield in potato (Fig. 2).

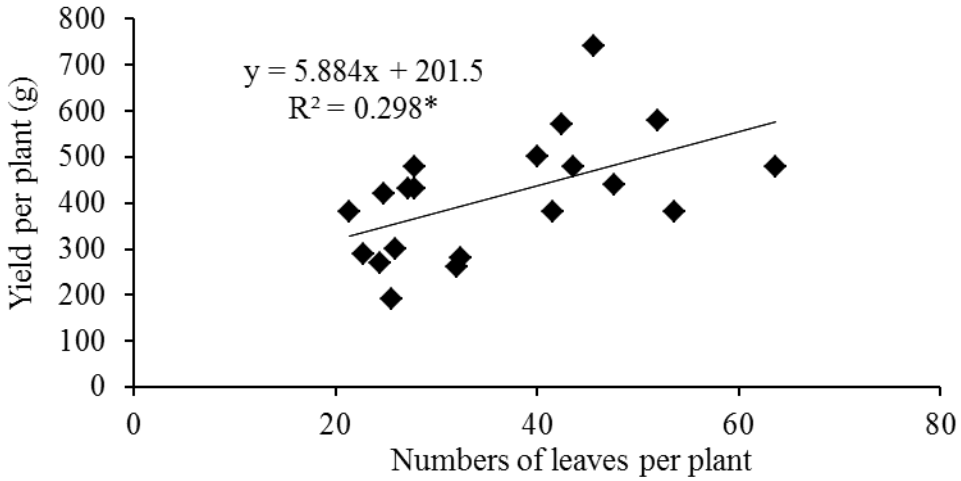

Fig. 2. Relationship between numbers of leaves per plant at 60 days after planting and yields per plant (g) at Nala, Kavrepalanchowk district, Nepal.R^2 means the coefficient of correlation.

Plant height

The result of statistical analysis showed that there was a significant effect of mulching materials on plant height. On appraising the plant height at different DAPs, tallest plant height was exhibited in plastic mulches as compared to the rest of the treatments (Table 1).

At both 60 and 75 DAP, the plant height observed in perforated-black plastic (20.02 and 22.54 cm, respectively) was significantly higher than that of straw (13.80 and 16.12 cm, respectively) and was statistically similar to the remaining plastic mulches (Silver and Black).

There was a positive relationship between plant height and yield of potato plants, in a way that taller plants corresponds to higher yield in potato (Fig. 3).

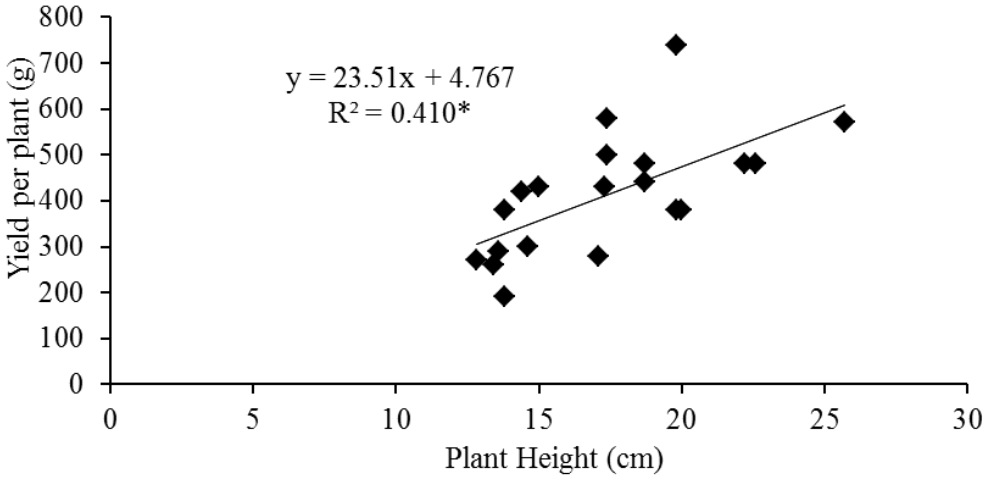

Fig. 3. Relationship between plant heights at 60 days after planting and yield per plant (g) at Nala, Kavrepalanchowk district, Nepal.R^2 means the coefficient of correlation.

Number of aerial stems per plant

The result of statistical analysis recorded no significant effect of mulching materials on the number of aerial stems per plant at both 60 and 75DAP.

Canopy diameter

Significant differences were observed in the canopy diameter among different mulching materials. Comparatively, the canopy diameter was recorded highest in plastic mulches to that of straw and control. At 60 DAP, the highest canopy diameter was observed in Silver plastic (25.98 cm) which was statistically similar to that of the other two plastic mulches and significantly different from that of straw (21.06 cm) and control condition (23.22 cm). Similarly, the canopy diameter was significantly higher in perforated black plastic (26.47 cm), while the least canopy diameter was observed in plants grown in straw (22.08 cm) at 75DAP.

There was a positive relationship between canopy diameter and yield of potato plants; in a way that wider canopy corresponds to higher yield in potato (Fig. 4).

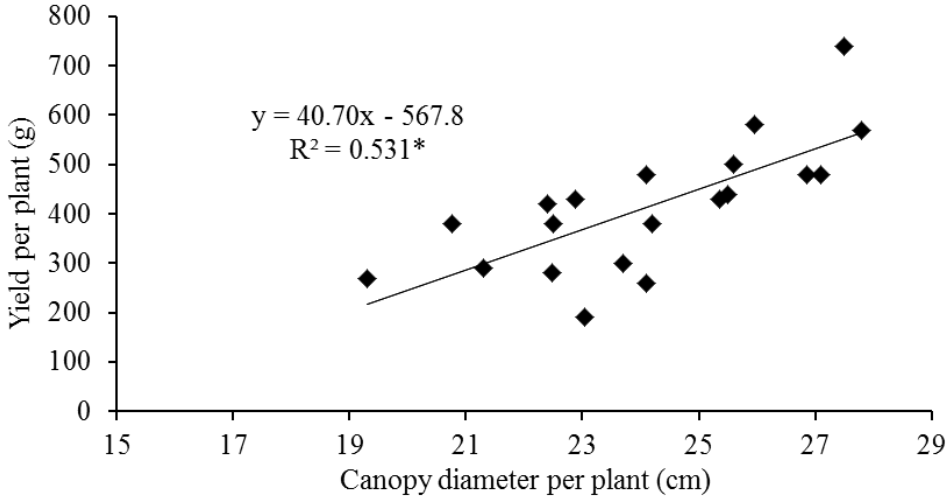

Fig. 4. Relationship between canopy diameter and yields per plant at 60 days after planting at Nala, Kavrepalanchowk district, Nepal.R^2 means the coefficient of correlation.

Effect of mulching treatments on yield parameters

The data representing the yield parameters such as the number of tubers per plant and yield per plant are presented in Table 2. When both the parameters were appraised together, significantly higher results were recorded in mulching treatments than in the control (Table 2).

Number of tubers per plant

The number of tubers per plant was statistically higher in mulching treatments than that of control. The highest number of tubers per plant was observed in silver plastic (14.15) and the least was recorded in the control treatment (5.20).Furthermore, the second-highest number of tubers was observed in perforated black plastic (9.33), which was higher than the number of tubers in plant grown in black plastic (8.28) and straw (7.75) (Table 2).

Yield per plant and tuber yield

The statistically highest yield per plant was observed in silver plastic (507.5g/plant); whereas the lowest in control (257.5g/plant). Similarly, yield (t/ha) was also significantly affected by mulching materials where the highest yield was exhibited by Silver plastic (42.29t/ha) and the lowest by control (21.46t/ha) (Table 2).

Table 2. Effect of different mulching treatments on the number of tubers per plant, yield per plant, and tuber yield (t/ha) at Nala, Kavrepalanchowk district, Nepal.

Treatments	Number of tubers per plant	Yield per plant (g/plant)	Tuber Yield (t/ha)
Silver Plastic	14.15[a]	507.5[a]	42.29[a]
Black Plastic	8.28[b]	470.0[a]	39.17[a]
Perforated Black Plastic	9.33[b]	492.5[a]	41.04[a]
Straw	7.75[b]	342.5[ab]	28.54[ab]
Control	5.20[c]	257.5[b]	21.46[b]
LSD (0.05)	1.60	156.7	13.04
SEm (±)	0.52	0.05	4.23
CV %	12.43	24.54	24.54
Grand Mean	8.39	414	34.50

Means with the same letter do not differ significantly at p = 0.05 by DMRT. CV = Coefficient of variation. LSD = least significant difference, SEM = Standard error of the mean. DAP = Days after planting

Effect of different treatments on Tuber Diameter and Grading of Tuber

The statistical analysis of the result showed a significant difference in tuber diameter and grading of the tuber into different categories (Table 3).

Tuber Diameter

The highest number of marketable tuber (1-2.5cm diameter) was recorded in silver plastic (10.14) that was significantly different from that of the lowest number recorded in control (3.25). Higher marketable tuber yield and total tuber were observed in silver plastic. Similarly, the highest non-marketable tubers (<1cm diameter) were again recorded in silver plastic (4.16) which was significantly different from that of the lowest number recorded in control (1.95).

Grading of Tuber

The highest large-sized (>50gm), medium-sized (25-50gm), and small-sized (<25gm) tubers were observed in silver plastic (3.25, 4.67, and 5.71); whereas the lowest large-sized, medium-sized, and small-sized tubers were observed in control (1.95, 1.37 and 1.47).

Table 3. Effect of different mulching treatments on tuber diameter and grading of tuber at Nala, Kavrepalanchowk district, Nepal.

Treatments	Tuber diameter		Grading of tuber		
	MTN (1-2.5cm)	UMTN(<1cm)	LST (>50g)/ plant	MST (25-50 g)/ plant	SST (<25g)/ plant
Silver Plastic	10.14[a]	4.16[a]	3.25[a]	4.67[a]	5.71[a]
Black Plastic	5.72[b]	1.56[b]	2.56[a]	1.96[bc]	3.75[bc]
Perforated Black Plastic	6.38[b]	1.43[b]	1.68[ab]	3.88[a]	4.50[b]
Straw	5.68[b]	1.34[b]	2.00[b]	2.56[b]	3.19[c]
Control	3.25[c]	1.95[b]	1.95[b]	1.37[c]	1.87[d]
LSD (0.05)	1.99	1.96	1.22	1.03	1.22
SEm (±)	0.63	0.64	0.39	0.33	0.36
CV %	20.77	61.02	38.04	27.07	19.14
Grand Mean	6.24	2.09	2.09	2.49	3.80

Means with the same letter do not differ significantly at p = 0.05 by DMRT. CV = Coefficient of variation. LSD = least significant difference, SEM = Standard error of the mean. DAP = Days after planting

(MTN indicates "marketable tuber number", UMTN indicates "Unmarketable tuber number").

(LST indicates "Large Sized Tuber", MST indicates "Medium Sized Tuber" and SST indicate "Small Sized Tuber")

Effect of different treatments on soil temperature

Average soil temperature at 10 cm depth during the experimental period (Fig.5) was affected by the mulching and materials applied. Results indicated that the type of mulch improved the soil temperature following the order of black plastic > perforated black plastic > silver plastic > straw > control.

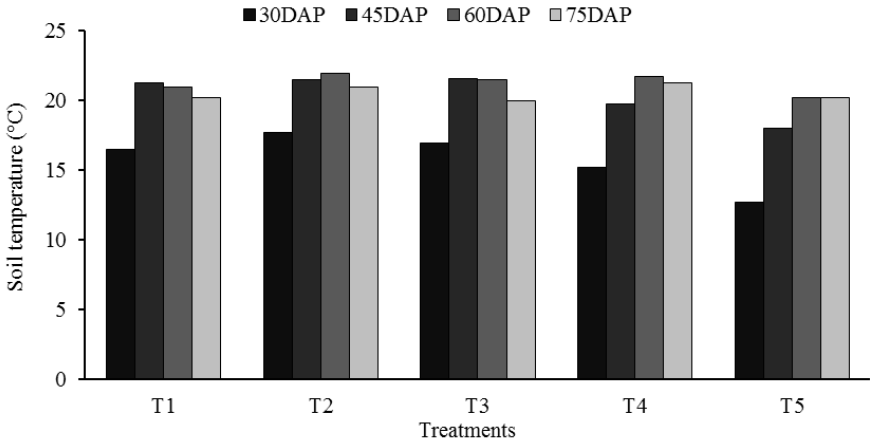

Fig. 5. Effect of different mulching treatments on soil temperature. Treatments including: T1 = Silver plastic mulching, T2 = Black plastic mulching, T3 = Perforated black plastic mulching, T4 = Straw mulching, T5 = Control plot.

Economic analysis

The economics was worked out taking into consideration the cost of production for eachtreatment, the corresponding marketable yield with prevalent prices per unit output.

Production cost

The cost of production was calculated for one hectare from the cost involved in the experimental plots. Production cost included general cost and treatment-wise variable cost. The average cost was about 406740NRs. Among all the treatments, the highest production cost was incurred in silver plastic (406740NRs.) followed by black plastic (406740NRs.), perforated black (406740NRs.), straw (385490NRs.), and control (36299NRs.).

Gross return

Gross return was influenced by different mulching materials. The average gross return in the experiment was 1207500NRs./ha. Among all the treatments highest gross return was found in silver plastic (1480208NRs.) followed by perforated black (1436458NRs.), black plastic (1370833NRs.), straw (998958.3NRs.), and the lowest in control (751041.7NRs.).

Benefit: Cost ratio

The Benefit: Cost ratio was calculated to be highest in silver plastic (3.63) followed by perforated black (3.53), black (3.37), straw (2.59), and the least were calculated in control (2.06).

Table 4. Effect of different mulching treatments on the economics of potato

Treatments	The total cost of production (NRs./ha)	Gross return (NRs./ha)	Net return (NRs./ha)	Benefit: Cost ratio
Silver plastic	406.74	1480.208	1073.468	3.63
Black plastic	406.74	1370.833	9640.933	3.37
Perforatedblack plastic	406.74	1436.458	1029.718	3.53
Straw	385.49	9989.58	6134.683	2.59
Control	362.99	7510.41	3880.517	2.06

Discussion

Effect of different mulching treatments on potato growth parameters

Mulching has a positive effect on emergence at 30 DAP than the control condition (Mahmood et al., 2002).In the current study, a higher germination percentage was also seen in mulching treatments. The higher germination in mulch conditions is due to an increase in soil temperature. Black plastic mulches maintain the optimum temperature in the root zone and hence accelerate the growth and development of the plants. Similarly, the thermal conduction of the radiation by mulching materials to the soil increases the soil temperature (Ping et al., 1994).

In an experiment conducted at Nepal Agriculture and Research Council (NARC), Islamabad, growth rate and growth attributes were higher in mulching treatments compared to the controls without mulches at both 45and 60DAP (Mahmood et al., 2002). Furthermore, Mahmood et al. (2002) showed that the plant height of potatoes increased as a result of using plastic mulches. While calculating the data regarding the number of aerial stems per plant, insignificant results were exhibited in all five treatments. This finding is in contradiction with Singh and Ahmed (2008) and Samy and EI-Zohiri (2013) who reported that there was a significant difference in the number of main stems per plant in potato due to mulching and black plastic mulch gave the highest number of stems due to favorable temperature. This contradiction might be due to variation of soil, experimental setup, environmental conditions, and variety used. Likewise, the canopy diameter was significantly higher in perforated black plastic mulches. It was because the moisture extraction ratio of perforated plastic is higher in deep soil layers and thus increases total readily available soil moisture for plant growth. Also, perforated pores over plastic films provide aeration in the root zone of the plant and hence contribute to better growth and development of the plant. These results are also in accordance with the findings of Hong et al. (2012) who reported that the higher soil temperature under plastic mulches leads to an active metabolism in the plants with increment in the amount of nutrients absorption and enhancement of growth parameters such as canopy diameter.

Effect of mulching treatments on yield parameters

In this study, the number of tubers per plant was highest in silver plastic mulch. Plots covered with silver plastic mulch had significantly higher average number of tubers per plant and statistically superior to control and other mulching treatments (Jalil MA, 2004).Among different mulching materials, silver plastic mulches affect the plant microclimate sufficiently which improves the yield by changing the amount and spectral distribution of radiation reflected in the leaves (Decoteau et al., 1989).These results aligned with the findings of (Ruiz et al., 1999) who noted that silver plastic promotes optimum root temperature for plant growth with the greatest efficiency of nitrogen utilization and the greatest tuber yield; whereas black plastic depresses nitrogen metabolism as well as the yield. Similarly, Matheny (1992) reported that light is reflected from silver mulch results in the deposition of more photosynthates into the tubers of potato plants, and hence produces a higher yield and larger-sized marketable tubers. Manganelli (2017) reported that white and silver plastic mulches reflect higher light radiation and prevents higher temperature buildup under plastic and in the root zone of the plant, which contributing to higher yield. He also concluded that the higher yield was the result of an increase in photosynthetic area by the use of colored plastic mulch that affects photosynthate partitioning in harvestable organs. Plastic mulches improve potato yield on an average by 24.3% and straw mulch increases by 16% (Monirovic et.al, 1996). These results regarding yield/ha are also supported by the findings of Mahmood et al.

(2002) and Singh et al. (2021) who stated that where mulching is done with a plastic sheet (black or white), the yield increases by more than 17 t/ha. Similar results were extracted from this study as well.

Effect of mulching treatments on tuber diameter and grading of tuber

The current study revealed that the highest number of marketable and non-marketable tubers were obtained in silver plastic; whereas their lowest number were recorded in the control condition. A higher number of medium-sized and large-sized tubers in perforated black mulch as observed in this study were due to better moisture availability, proper aeration along optimal temperature in the root zone of the plant (Kadar et al., 2017).Mulching increases the percentages of large-sized, medium-sized, and small-sized tubers (Goling, 1997).In mulching, there is an increase in temperature which fastens root growth consuming maximum available phosphorus in the soil leading to an increase in the yield of small-sized tubers (Goldy and Smiller, 2011). Similar results were obtained in the present study as well.

Effect of mulching treatments on soil temperature

In a study carried out on mulching in Northern China, there was a 2–9 °C increase in daily mean soil temperatures, especially during the early growing period of the crop. As the plant canopy enlarged, more soil surface was shaded reducing the soil temperature difference between mulching and control without mulching (Wang, 2009). Moreover, another research conducted in China found that conventional tillage techniques coupled with green manuring and plastic mulching model and simply plastic mulching model (PM) increased soil temperature (0-20 cm layer) by 3.6°C and2.9°C per day, respectively than the control (ShiJie, 2011). The results of this study regarding soil temperature are based on the conclusions drawn by earlier researchers. Practical benefits from straw mulch are expected in regions where the optimum temperature for the growth of the potato is higher and moisture is deficient because the straw mulch reduces the soil temperature, conserves the moisture content, and depresses the nitrates (Bushnell and Welton, 1931). Applying the black plastic mulch increased soil temperature by 1.5 - 2.47 °C as compared to the other mulching materials and bare soils. These findings are in agreement with many other field studies (El-Nemr, 2006; Singh., 2012; Moursy, 2015). The warmer soil temperatures can quicken seedling emergence and growth to achieve the desired population structure at an earlier growth stage (Zhou, 2009)which maximizes the absorption of solar radiation and enhance the yield (Li, 2013). Furthermore, elevated soil temperature can be lethal for nematode and soil-borne pathogens as well as many weed seeds before its germination through solarization (Singh and Kamal, 2012)

Effect of mulching treatments on economic analysis of potato

In this study, the highest cost of cultivation was calculated from plastic mulches while the lowest from the control. Similarly, the highest return was obtained from plastic mulches in comparison to the straw and control treatments resulting in the highest B: C ratio in silver plastic mulch and the lowest in the control. In a study carried out at Sabarkantha district, Gujarat, India, the average cost of cultivation for potato crop was 95594.24 Rs./ha. Among total expenses, seeds contributed to about 40.36% of the total cost (Chaudhary et al., 2017). Similarly, the study conducted at Sindh province of Pakistan showed an average per acre gross income of Rs. 140390.00 and total expenditure of Rs. 76917.00 with an input-output ratio of 1:0.82. (Noonari et al., 2016). In the study area of Baglung, Nepal, total income from potato per ha was found 268,047 NRs. with a B:C ratio of 1.44 (Bajracharya and Sapkota, 2017). One of the findings from Achham district showed the total average cost, gross revenue, and gross margin per hectare as 256,285.293NRs. 373384.449 NRs. and 117099.156 NRs.

respectively. Furthermore, in a study done at Taplejung district, the cost of production per Kg potato was 7.3NRs.and the B:C ratio was 2.9 (Timsina, Kafle, & Sapkota, 2011).

Conclusion

Silver plastic mulch and perforated black plastic were found to be more suitable mulching materials compared to the other mulches in terms of yield and economic analysis. The soil temperature was depicted maximum in black plastic followed by perforated black plastic, white plastic, straw, and control. Hence, it can be suggested that the production of potato with the use of silver plastic followed by perforated black plastic is comparatively higher and economical in the study area of Kavrepalanchowk, Nepal when compared to the no-mulching condition. Future researches can be conducted with the use of other mulching materials along with more than one variety of potato. Also, more investigations are needed for different agro-ecological zones and different climatic conditions to identify the actual efficacy.

Acknowledgment

The authors are obliged to the help from Agriculture and Forestry University (AFU) and Prime Minister Agriculture Modernization Project (Potato Superzone) for providing the opportunity to conduct the research. Also, we are grateful to Mr. Binod Rayemajhi and Mr. Gaurav Adhikari for their inputs and technical assistance.

Conflict of interest

The authors indicate no conflict of interest for this work.

References

AITC. 2020. Agriculture and livestock diary,2020. Retrieved from Agriculture information and training center: https://aitc.gov.np/

Bajracharya, M., & Sapkota, M.2017. Proftability and productivity of potato. Agriculture & Food Security.

BushnellJ, Welton F.A. 1931.Some effect of straw mulch on yield of potatoes. Journal of Agricultural Research.43 (9), 837-46.

Chaudhary, D. D., Ghaghod, J. P., Thakar, K. P., & Patel, D. G. 2017. Cost of Cultivation of Potato in Sabarkantha District of Gujarat. *AGRES – An International e. Journal (2017) Vol. 6, Issue 4:689-695*.

Decoteau, D., Kasperbauer, M., & Hunt, P. 1989. Mulch surface affects yield of fresh market tomatoes. *Journal of the American Society for Horticultural Science, 114*, 216-224.

El-Nemr M. 2006. Effect of mulch types on soil environmental conditions and their effect on the growth and yield of cucumber plants. Journal of Applied Sciences 2(2), 67-73.

FAO. 2011. FAO Statistical Yearbook. 2011. Food and Agriculture Organization of the United Nation.

FAO. 2013. FAOSTAT. FAOSTAT retrieved from https://www.potatopro.com/nepal/potato-statistics.

Gemmechu G.E. 2017. Review on Compost and Mineral NP-fertilizer Application Rate Effects on the Yield and Yield Components of Potato (*Solanumtuberosum* L.). Science, Technology & Public Policy. Vol. 1, No. 1, pp. 7-11.

Goldy R, Smiller E. 2011. Are phosphorus applications under plastic mulch really necessary? Michigan State University Extension.

Goling C. 1997. Effect of plastic film mulching on increasing potato yield. Acta Agriculturae Zhejiangensis 83-86.

HaraguchiT.M. 2004. Effects of plastic film mulching on leaching of nitrate-nitrogen in an upland field converted from paddy. Paddy and Water Environment 2(2), 67-72.

Hong, Z., You-Cai, X., Feng-Min, L., Run-Yuan, W., Sheng-Cai, Q., Tao-Feng, Y., et al. 2012. Plastic film mulch for half growing-season maximized WUE and yield of potato via moisture-temperature improvement in a semi-arid agroecosystem. *Agricultural Water Managment* , 68-78.

Ibarra-Jiménez L,Lira-Saldivar R.H, Valdez-Aguilar L.A, Lozano-Del Río J. 2011. Colored plastic mulches affect soil temperature and tuber production of potato. Acta Agriculturae Scandinavica 61(4), 365-371.

Jalil M.A, Azad M.A, Farooque A.M. 2004. Effect of different mulches on the growth and yield of two potato varieties. Journal of Biological Sciences 4(3), 331-3.

Kadar, M., Senge, M., Mojid, M., & Onishi, T. 2017. Effects of plastic-hole mulching on effective rainfall

and readily available soil moisture under soybean (Glycine max) cultivation. *Paddy and Water Environment*. doi:10.1007/s10333-017-0585-z

Kang BK, Kang YK, Kang SY. 2003. Influence of polyethylene film mulch and seedling types on growth and tuber yield of fall-grown potato. Korean Journal of Crop Science KR2004006005.

Khalak, A., & Kumar aswamy, A. S. 1992. Nutrient uptake and tuber yield of potato as influenced by irrigation and mulching under scarce water condition in Alfisols. *Indian Potato Association, 19*(1-2), 35-39.

Li S.X., Wang Zhaohui, Li S.Q., Gao Ya-Jun. 2013. Effect of plastic sheet mulch, wheat straw mulch and maize growth on water loss by evaporation in dry land areas of china. Agricultural Water Management 116, 39-49.

Luis JJ, H. L. 2011. Colored plastic mulches affect soil temperature and tuber production of potato. *Acta Agriculturae Scandinavica* , 365-371.

Mahmood M.M, Farooq K, Hussain A, Sher R. 2002. Effect of Mulching on growth and yield of the potato crop. Asian Journal of Plant Science 132-133.

Manganelli, C. C. 2017. Coloured Plastic Mulches Improve the Growth and Yield of the Tomato in High-Density Plantings.São Paulo State: College of Agricultural and Veterinary Sciences.

Matheny, T. H. 1992. Potato Tuber Production in Response to Reflected Light from Different Coloured Mulches. *Crop Science Society of America*.

Monirovic M.N, Misovic M.M, Brocic Z.A. 1996.Effect of organic mulch application on the yield of potato seed crop. International Society for Horticultural Science 462, 291-296.

Moursy S.A. 2015. Polyethylene and Rice Straw as Soil Mulching: Reflection of Soil Mulch Type on Soil Temperature, Soil Borne Diseases, Plant Growth and Yield of Tomato. Global Journal of Advanced Research 2(10), 1497-1519.

NPDP. 2007. National Potato Research Program. Khumaltar, Lalitpur: National Potato Research Program, National Agriculture Research Council.

Ping H.C. 1994. The physiological and ecological effects of covering plastic film on the potato.Acta Agriculture Zhejiangensis 6, 102-106.

PotatoPro. (2019). Retrieved from Potatopro web site: https://www.potatopro.com/

Romic, D., Romic, M., Borosic, J., & Poljak, M. 2003. Mulching decreases nitrate leaching in bell pepper (Capsicum annuum L.) cultivation. *Agricultureal Water Management* , 87-97.

Ruiz, J., Hernandez, J., Castilla, N., & Romero, L. 1999. Potato Performance in Response to Different Mulches. 1. Nitrogen Metabolism and Yield. *J. Agric. Food Chem* , 47.

Samy, M. M., & EI-Zohiri, S. 2013. Influence of Colored Plastic Mulches and Harvest Date on Tubers Yield and Quality of Potato.. *Journal of Applied Sciences, 28*(12B), 845-859.

Shelton D.P. 1995. Corn residue cover on the soil surface after planting for various tillage and planting systems. Journal of soil and water conservation50(4), 399-404.

ShiJie F.W.D. 2011. Effects of different cultivation techniques on soil temperature, moisture, and potato yield. Transactions of the Chinese Society of Agricultural Engineering 27(11), 216-221.

Singh S, Dhillon BS, Kaur M. 2021. Effect of mulching and irrigation levels on growth and productivity of barley (*Hordeumvulgare* L.). Journal of Pharmacognosy and Phytochemistry 10(1),1126-30.

Singh AK, Kamal S. 2012. Effect of black plastic mulch on soil temperature and tomato yield in mid hills of Garhwal Himalayas. Journal of Horticulture and Forestry 4(4), 77-79.

Singh N, Ahmed Z. 2008. Effect of mulching on potato production in high altitude cold arid zone of Ladakh. Potato Journal 35, 3-4.

Timsina, K. P., Kafle, K., & Sapkota, S.2011. Economics of potato (Solanum tuberosum L) production in Taplejung district of Nepal. *Agronomy Journal of Nepal (Agron JN) Vol. 2*.

Wang F. X. 2009. Potato growth with and without plastic mulch in two typical regions of Northern China. Fields Crops Research 110(2), 123-129.

Zhou L.F. 2009. How two ridges and the furrow mulched with plastic film affect soil water, soil temperature and yield of maize on the semiarid loess Plateau of China. Field crops Research 113, 41-47.