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Research Article

Effect of mulch materials on potato production and soil properties in high hill of Parbat, Gandaki Province, Nepal

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ABSTRACT

An experiment for two consecutive years (2017 and 2018) was conducted to evaluate the use of mulching materials in increasing productivity and profitability of potato production. The experiment was conducted in Randomized Complete Block Design (RCBD) with five different mulching materials including control replicated for four times namely, banmara (*Agertina adenophora*) weed (T1), black polythene sheet (T2), white polythene sheet (T3), commercially used mulch paper having black color outside and silver color inside (T4) and farmers practice (T5) as a control with no mulch. The research result revealed that all the mulching materials significantly (p value $\leq$ 0.05) increased tuber yield and yield attributing characters of potato as compared with control (no mulch). The highest tuber yield was obtained from mulching with commercial mulch paper followed by mulching with black polythene sheet in both years. Mulching with banmara also produced significantly (p value $\leq$ 0.01) higher tuber yield than no mulch plot in the year 2017 and 2018. Mulching practices significantly (p value $\leq$ 0.05) improved the soil available phosphorus. The incremental benefit cost ratio was highest (2.97) in the mulched with banmara followed by commercial mulch paper (2.12). The banmara mulch was also profitable with comparatively higher tuber yield.

Keywords: Mulch materials, potato, soil properties, tuber yield

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INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops in Nepal and plays a vital role in ensuring national food security (Lama *et al.*, 2016). It occupies 6th position in terms of area coverage and 2nd place in production as well as 1st position in productivity (MoALD, 2020). The area coverage under potato in Nepal is 193997 hectares with production of 3112947 metric ton and productivity of 16.04 mt/ha. While, it is only 1271 ha, 20270 mt and 15.9 mt/ha in Parbat district which is lower than national average in terms of area production and productivity respectively (MoALD, 2020). Considering the trend of population growth

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and consequently the increase demand for food in country and dwindling cultivable land area, the potato is likely to play very important role in future for food and nutritional security. Potato productivity is declining in high hills and mountains of Nepal (Subedi, 2010). The reasons of decline production could be several such as, lack of improved cultivation practices, weed infestation, (Ghimire & Chaudhari, 2010), inadequate supply of quality seed, occurrence of pest and disease and poor soil and nutrient management practices etc. The soil fertility and management situation may also causing low yield. The sustainable soil and crop management practices are usually not practiced in high hill potato production areas. Thus, farmers, in general, may not be aware for improved practices in potato production.

For soil fertility management, mulching is one of the most cost-effective means, because of a range of positive effects can be obtained for soil fertility and other factors important for plant production (Shelton *et al.*, 1995). Soil mulching which covers the soil at the base of cultivated plants with a layer of protective material (Bégin *et al.*, 2001) has been widely used in the world for growing crops like potatoes. The benefits of mulching potatoes include saving irrigation water (Singh *et al*., 2015), reducing soil erosion (Edwards *et al.*, 2000) and leaching of fertilizer (Bégin *et al*., 2001), controlling weeds or reducing the dose of herbicide, enhancing early growth, harvest (Zhao *et al.*, 2014) and increasing tuber yields (Singh *et al.*, 2015; Zhao *et al.*, 2014).

Nepalese farmers are using different mulch materials, but they have little guideline what mulch material would be beneficial for them. Thus, the objective of this experiment was to evaluate the effect of different mulch materials on the yield and yield attributing characteristics of potato as well as soil properties for high hill agro-ecological domain in Gandaki Province of Nepal.

MATERIALS AND METHODS

Field experiment was conducted at Jaljala Rural Municipality 06, Saliza of Parbat district, Gandaki province at 28.34^0 North latitude, 83.63^0 East longitude and 2190 meter above sea from January to May, 2017 and 2018. The soil was sandy loam with pH 5.16, organic matter 3.87%, total nitrogen of 0.34 %, available P_2O_5 of 60 mg/kg and ammonium acetate extractable K_2O of 208 mg/kg. The experiment was conducted in Randomized Complete Block Design (RCBD) with four replications and five treatments consisting of different mulch materials and farmers practice with no mulch. Treatments comprised of mulching with banmara (*Agertina adenophora*) weed (T1), black polythene sheet (T2), white polythene sheet (T3), commercially used mulch paper (T4) and farmers practice (T5) as a control treatment with no mulch. The amount of banmara used as mulch materials in the experiment was 10 t/ha and the thickness of black polythene, white polythene and commercial mulch sheet were 300 gauze, 300 gauze and 25 micron, respectively. The plot size was 7.2 m^2 (3 m×2.4 m) with the spacing of 60 cm between rows and 25 cm within row. Khumal seto-1 variety of potato tuber during 1^{st} year (2017) and Janakdev variety for 2^{nd} year (2018) were planted at January for experimentation, and harvesting was done at June of each year. In polythene and commercial mulches, holes were punched for planting tubers and sides were sealed with earth. The crop was grown under rainfed conditions. Full dose of N, P_2O_5 and K_2O as per the recommended dose i.e. 100:100:60 N, P_2O_5 and K_2O kg/ha were applied through urea, di-ammonium phosphate (DAP) and muriate of potash (MOP), respectively. On addition, 20 ton/ha farm yard manure (FYM) were applied uniformly before planting in all

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the treatments and control. The experiments received uniform plant protection and cultural management practices throughout the period of crop growth. The necessary data for growth, yield and yield parameter were recorded. For analysis of variance, Statistical tool for agricultural research (STAR) version: 2.0.1 were used, and the significance was determined using Fisher's least significant difference at $p<0.05$. Benchmark and post-harvest soil samples were collected and analyzed for soil reaction, total N, available phosphorus, exchangeable potassium and organic matter using standard lab method at soil laboratory of Directorate of Agricultural Research, Lumle, Kaski, Nepal. Economic analysis for each treatment was worked out using incremental benefit cost ratio (IBCR) on prevailing market prices using following formula. IBCR = Additional return over control/Additional cost over control

RESULTS AND DISCUSSION

All mulching treatments showed a significantly (p value ≤ 0.05) higher emergence percentage, number of tubers per plot, weight of tuber per plot and yield of potato tuber during the 1st year of experiment (2017). Cent percent emergence was recorded from the mulched plot with black polythene sheet and commercial mulch paper whereas 86% emergence was recorded from the plot without mulching (Table 1). There is not any significant (p value > 0.05) difference in number of under sized tuber among the treatments but the weight of under sized tuber, number and weight of medium and oversized tuber were significantly higher in mulched treatment as compared to without mulched treatment. Total number of tubers per plot was recorded highest from the plot mulched with black polythene sheet (285) which was statistically similar among other mulching materials but significantly higher than non-mulched plot (210). The highest tuber yield of potato was obtained from commercial mulch paper (17.19 mt/ha) followed by mulched with black polythene (16.67 mt/ha) and lowest from without mulch (9.95 mt/ha).

Table 1: Effects of different mulching materials on tuber yield and yield attributing characters of Khumal Seto-1 variety of potato at Jaljala, Parbat (2190 masl), 2017

Treatments	Emergence (%)	Under size Tuber/Plot (<25g)		Medium size Tuber/Plot (25-50 g)		Over size Tuber/Plot (>50 g)		Total Tuber/Plot		Yield (mt /ha)
		No	Wt (kg)	No	Wt (kg)	No	Wt (kg)	No	Wt (kg)	
Mulching with *Banmara*	95.5	117.75	1.72	111.25	4.26	56.75	4.14	285.75	10.12	14.06
Mulching with black polythene sheet	100	121	1.74	109.5	3.9	80.5	6.36	303	12	16.67
Mulching with white polythene sheet	97.75	109.25	1.51	100.25	3.75	64.25	5.17	273.75	10.44	14.51
Mulching with commercial mulch paper	100	113.25	1.74	109.5	4.19	69.50	6.44	292.25	12.38	17.19
No mulching	86.5	92	1.16	73.5	2.66	44.50	3.34	210	7.16	9.95
Mean	96	110.65	1.58	99.2	3.75	63.10	5.09	272.95	10.42	14.5
P Value	0.01	0.4	0.11	0.07	0.02	0.01	0.01	0.01	0.001	0.001
$LSD_{0.05}$	4.29	ns	ns	ns	0.97	10.20	1.75	44.03	1.73	2.41
CV, %	2.9	20.58	20.03	18.07	16.8	10.5	22.42	10.47	10.81	10.81

Wt: weight, ns: non significant, CV: Coefficient of variation

During the second year of experiment (2018), all mulched treatments again significantly

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increased emergence percentage, weight of tubers per plot and yield of potato tuber as compared with no mulch. Emergence percentage of potato was recorded significantly (p value ≤ 0.01) higher in mulched practices in comparison with without mulch practices. More than 99 % emergence was recorded from plot mulched with black polythene sheet and commercial mulch paper, whereas 84 % emergence was recorded from the plot without mulching. There was not any significant (p value > 0.05) difference in number and weight of under sized tuber (<25 g), number of medium sized (25-50 g) and oversized tuber (>50 g) among the treatments but the weight of medium and oversized tuber is significantly higher in mulched treatment as compared with without mulched treatment (Table 2). Total number of tuber per plot was recorded the highest from the plot mulched with banmara (312) which was statistically similar with other treatments but total weight of tuber per plot was significantly higher in mulched with banmara, black polythene and mulch paper as compared to mulch with white polythene and no mulch. The highest yield of potato tuber was obtained from mulch with commercial mulch paper (24.31 mt/ha) followed by mulch with black polythene (23.38 mt/ha), mulched with banmara (22.77 mt/ha) and the lowest from no mulching (15.76 mt/ha).

Table 2: Effects of different mulching materials on yield and yield attributing characters of Janakdev variety of potato at Jaljala, Parbat (2190 masl), 2018

Treatments	Emergence (%)	Under size Tuber/Plot (<25g)		Medium size Tuber/Plot (25-50g)		Over size Tuber/Plot (>50g)		Total Tuber/Plot		Yield (mt/ha)
		No	Wt (kg)	No	Wt (kg)	No	Wt (kg)	No	Wt (kg)	
Mulching with *Banmara*	95.5	175	4.50	72	4.82	65	7.08	312	16.39	22.77
Mulching with black polythene sheet	99	162	4.32	71	4.89	65	7.61	298	16.83	23.38
Mulching with white polythene sheet	97.5	115	2.77	56	3.42	54	5.14	231	11.34	16.05
Mulching with commercial mulch paper	99	157	4.65	79	6.15	56	6.70	290	17.50	24.31
No mulching	84	136	3.74	77	3.27	49	4.55	269	11.55	15.76
Mean	95.15	149.20	4.0	73.20	4.51	58	6.22	280.4	14.72	20.45
P Value	0.001	0.65	0.46	0.65	0.03	0.69	0.04	0.39	0.01	0.01
$LSD_{0.05}$	2.7	ns	ns	ns	1.89	ns	2.22	ns	4.02	5.58
CV %	2.85	39.6	39.2	18.86	27.2	31.16	23.2	21.33	17.73	17.74

Wt.: weight, ns: non significant, CV: Coefficient of variation

The mean soil data of two years revealed that available phosphorus content in soil differed significantly among the treatments but there was not significant effect on soil reaction, total soil nitrogen, exchangeable potassium and organic matter among the treatments (Table 3). The available P_2O_5 in soil was significantly higher in all mulch treatments as compared with no mulch treatment. Total soil nitrogen (0.41%) was recorded highest from the treatment mulch with banmara and lowest form control treatment (0.33%). The highest soil organic matter (4.10%) was recorded from the mulched treatment with banmara and it seems to be in

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the increasing trend over the time but statistically similar with other treatments.

Table 3: Effects of different mulching practices in soil properties during potato production in Jaljala, Parbat (2190 masl), 2018

Treatments	Soil pH	Total soil N (%)	Available soil P_2O_5 (mg/kg)	Exchangeable soil K_2O (mg/kg)	Soil OM (%)
Mulching with *Banmara*	5.75	0.41	66	224	4.10
Mulching with black polythene sheet	5.77	0.39	67	217	3.94
Mulching with white polythene sheet	5.83	0.35	65.75	213	3.96
Mulching with Commercial Mulch paper	5.75	0.38	66.75	229	3.95
No mulching	5.73	0.33	64.70	194	3.96
Mean	5.77	0.37	66.05	215.65	3.98
P Value	0.52	0.31	0.02	0.31	0.32
$LSD_{0.05}$	ns	ns	1.29	ns	ns
CV,%	2.31	14.0	5.3	10.6	2.78

ns: non significant, CV: Coefficient of variation

Incremental benefit cost ratio was highest (2.97) in banmara mulching followed by mulching with commercial mulch paper (2.12) and the lowest from white polythene sheet mulching (0.33).

Table 4: Incremental benefits cost ratio analysis of different mulching materials at Jaljala, Parbat (2190 masl) during 2017 and 2018

Treatments	Mean tuber Yield (mt/ha)	Additional tuber yield (mt/ha)	Value of additional tuber yield (NRs)	Quantity of mulch materials (kg ha^{-1})	Cost of Mulch materials (NRs)	Cost of additional Labour (NRs)	Additional cost of mulching (NRs)	Incremental benefits cost ratio (IBCR)
Mulching with *Banmara*	18.41	5.56	194600	10000	50000	15510	65510	2.97
Mulching with black polythene sheet	20.02	7.17	250950	1000	250000	5170	255170	0.98
Mulching with white polythene sheet	15.28	2.43	85050	1000	250000	5170	255170	0.33
Mulching with Commercial Mulch paper	20.75	7.9	276500	10000	125000	5170	130170	2.12
No mulching	12.85	0	0	0	0	0	0	0

Price of Potato NRs 35/kg, Labour charge NRs 517/8 hrs, Black polythene sheet (300 Gauze) NRs 250/kg, White polythene sheet (300 Gauze) NRs 250/kg, Commercial mulch sheet (25 micron) NRs 6000/480 m^2, Banmara NRs 5/kg.

All the mulching treatment significantly increased tuber yields of potato as compared to control (no mulching) (Table 1, 2). The highest tuber yields of potato were obtained from commercial mulch paper/sheet mulching followed by black polythene and banmara as shown

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in Table 1 and 2. The higher temperature and humidity under mulched during the early development period may have resulted in the higher emergence rate and strong seedling increased the stems and branches per plant and thus leading to greater number of tubers in tuber initiation. Furthermore, the extended period of tuber initiation could have also promoted the tuber bulking. Consequently, the number and weight of tuber in mulching were the highest. According to Li (2018) the use of mulch materials help in increased soil temperature that enhances the emergence and growth to obtain the maximum plant population which maximize more number of tuber formation and ultimately enhance the tuber yield. As it is known that the mulching materials affect crop growth and development in various ways such as that decreases the amount of water loss due to evaporation (Wang *et al.*, 2008; Li *et al.*, 2013), enhances soil water infiltration (Gan *et al.*, 2013), distributes soil moisture again; and therefore relieves water stress to some degree (Chakraborty *et al.*, 2008). High number of leaves in potato plant was found in mulching treatment as compared to no mulch, the high number of leaves probably supported to increase tuber yield.

Owing to many advantages, mulching improved crops yields both in quantity or quality along with increased in water and nutrient use efficiency (Wang *et al.*, 2008). The number of large sized tubers per plot was found significantly (p value ≥ 0.01) higher in mulched treatment as compared to the controlled condition. Zhao (2012) further explained that higher yield of large sized tubers with the use of mulch materials might have led to better development and growth of individual tuber and hence large sized potato and higher yield.

The results were more noticeable in case of commercial mulch paper, black polyethylene and banmara mulch compared to white polythene mulches and control condition. This result probably were associated with more soil moisture and nutrient to main targeted potato plants as these mulch materials reduced the competitions with lesser weed growth. The study conducted in Dadeldhura district of Nepal reported similar result with highest potato tuber yield from black polyethylene mulch compared to saw dust, rice straw and rice husk (Bharati *et al.*, 2020).

The use of organic materials as mulch materials probably helped to add organic matter in soil that resulted to increase the soil organic matter in the experimental plots. The treatment where banmara was used as the mulching material could be the most profitable because it is locally available resource (Table 4). However, commercial mulch paper could be the easier way to use, if there is shortage of organic materials like banmara or grass for mulch and labour. Bhattarai *et al.* (2009) also revealed that the uses of organic sources as a mulch material could be the profitable way of mulching for potato production and improving soil properties. The studies conducted in Dadeldhura district by Joshi *et al.*(2020) and Bharati *et al.*(2020) have reported black plastic mulching as the best mulching material for potato production

CONCLUSION

All the mulching materials used in the experiment increased the potato tuber yield as compared with no mulch. Mulching with the use of commercial mulch paper with black color outside and silver color inside produced the maximum potato tuber yield but the incremental benefit cost ratio was the highest with banmara as mulching materials. Therefore, mulching with locally available banmara weed could be the most profitable and sustainable practice for potato production if there is availability of source materials and labors otherwise mulching

with commercial mulch paper seems better option to enhance the productivity and profitability of potato in the hills.

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Authors' Contributions

S. Timilsina and A. Khanal prepared the research concept and design, analysis and interpretation of data, drafting of the manuscript. CK Timilsina contributed for field work, data recording and entry. TB Poon helped in critical revision of the manuscript.

Conflict of Interest

The authors of the paper declare that there is no conflict of interest for the publication of this manuscript.

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