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Effect of mulches and nutrient levels on growth, nutrient uptake and productivity of cauliflower in mid hills of Himachal Pradesh

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ABSTRACT

Field study on the effect of mulches and nutrient levels on weed infestation, growth, nutrient uptake and productivity of cauliflower (*Brassica oleracea* var. *botrytis* L.) was conducted during 2009-10 and 2010-11 in mid hills of Himachal Pradesh. Twelve treatment comprising combinations of four mulches, *viz*. black plastic mulch (BP), grass mulch (GM), pine needles mulch (PN), unmulched control (UM) and three levels of nutrients, *i.e.* F_1 (125% of recommended dose of NPK), F_2 (100% recommended dose of NPK) and F_3 (75% of recommended dose of NPK) were tried in factorial randomized block design. Results revealed that mulches effectively checked weed infestation, plant growth and cauliflower productivity were significantly influenced by mulches and nutrient levels. Black plastic mulch and 125% NPK together promoted plant and root growth, nutrient uptake, curd quality and yield of cauliflower. Treatment combination BPF_1 recorded 88.7% higher productivity (head yield 266.8 q ha^{-1}) closely followed by BPF_2 (83.6%, 259.6 q ha^{-1}) over unmulched control with 75% NPK (UMF_3).

Key words: Cauliflower, mulches, nutrient uptake, weed infestation.

INTRODUCTION

The climatic conditions in the mid hill region of Himachal Pradesh are quite congenial for the quality of off season cauliflower production (*Brassica oleracea* var. *botrytis* L.). However, productivity is low as greater percentage of the area under vegetable crops does not have assured irrigation facilities. Owing to this constraint, the crop faces severe moisture stress during active growth and development stages. The assured irrigation facilities are limited to 21% of total cultivated area. Under such situations, farmers have to depend largely upon rain and *in situ* moisture conservation through various kinds of mulches is indispensable. The region also experiences very low soil temperature during winter months, thus adversely affecting various growth and development processes. Moderation of soil hydrothermal regimes through the use of different kinds of mulches may enhance the yield and quality of vegetable production. Management practices are needed to increase moisture availabilities and control soil temperature so that these remain within optimum range during the growing season of the crop. Various mulch materials are known to conserve moisture during dry period in comparison to clean cultivation. Several workers tried to modify the hydro-physical and chemical properties of soil under cereal crops using different kinds of mulches like crop residues, pine needles and polythene sheets of different colours so as to provide more favorable conditions for crop growth.

Mulching and fertilizer application together promoted growth and development of crops (Liasu and Achakzai, 7). Increased soil water storage due to mulching increased the availability and uptake of nutrients by plants (Tan *et al.*, 14). The combination of mulch with NPK fertilizers provide additional nutrients and humic material through decaying of mulch and thus provide sustainable source of macro- and micro-nutrients to crops in addition to increasing the nutrient retention capacity of the soil (Atayese and Liasu, 3). However, much has not been documented on the effect of various mulch materials in combination with chemical fertilizers on the weed infestation, growth, nutrient uptake and productivity of vegetable crops especially the cauliflower in mid hills of Himachal Pradesh. Keeping above in view, the present study was undertaken.

MATERIALS AND METHODS

Field experiments were conducted during two crop years (2009-2011) at the experimental farm of Department of Soil Science and WM, Dr YS Parmar University of Horticulture and Forestry, Solan (HP). The soil (Typic Eutrochrept) was gravelly sandy loam in texture. Salient physical and chemical properties of the experimental soil of 0-15 cm depth were pH 6.88, bulk density 1.28 g cm^{-3}, organic carbon 7.9 g kg^{-1}, available N, P and K 339.8, 36.2 and 242.6 kg ha^{-1},

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respectively. Available Ca, Mg and SO_4^{2-}-S were 685.9, 422.8 and 51.1 kg ha^{-1}, respectively.

The experiment was laid out with 12 treatments replicated thrice in randomized block design. The treatments comprised combinations of four types of mulches, *viz*. black plastic mulch (BP), grass mulch (GM), pine needles mulch (PN), unmulched control (UM) and three levels of nutrients, *i.e.* F_1 (125% of recommended dose of NPK), F_2 (100% recommended dose of NPK) and F_3 (75% of recommended dose of NPK). Three-week-old seedlings of Sweta cultivar were transplanted in plots of dimension of 3.0 m × 2.5 m at spacing of 60 cm × 45 cm on 18th Dec. 2009 and 30th Oct. 2010. Recommended doses (100%) of FYM, N, P_2O_5 and K_2O is 25 t ha^{-1}, 125, 75 and 65 kg ha^{-1}, respectively, and were applied as per the treatments of the experiment in the form of calcium ammonium nitrate, single super-phosphate and muriate of potash. Entire dose of P and K fertilizers was applied at the time of field preparation. The N fertilizer was applied in two split doses, first dose at the time of transplanting and second dose one month after transplanting.

The UV resistant black plastic sheets were cut in rectangular shape, slightly larger than the dimension of plots and holes were made by scissors to fit the plants in the holes. Mulch sheet was laid in the plots before the transplanting of seedlings. The air-dried grass and pine needles mulch materials were spread evenly in the plots to have uniform mulch @ 10 t ha^{-1} just after the establishment of the seedlings. The plastic mulch was removed after the completion of experiment. The partially decomposed grass mulch was allowed to remain in the plot, which was later on mixed with soil. However, undecomposed pine needles mulch was removed and applied afresh during the second year. Three representative soil samples from 15 cm depth were collected before transplanting and analyzed for physical and chemical properties following standard procedures. The weed biomass was estimated twice at one month interval after the application mulches. Three quadrants of 0.3 m × 0.3 m were laid randomly in each plot. The samples taken were dried in oven at 60 ± 5°C for 48 h and their weight was taken to determine the weed dry mass.

Root growth parameters, *viz*. dry weight (DW) of root and root volume (RV) were determined at the time of crop harvest. Root volume (RV) was determined by water displacement method. The roots were then dried in oven at 60 ± 5°C till a constant weight attained and expressed as g $plant^{-1}$. Leaf and curd samples were collected and processed according to the method suggested by Chapman (4). The nutrient contents were determined following standard methods for the analysis. The uptake of nutrients was calculated from data on contents (%) of the given nutrient in leaf and cauliflower head multiplied by the corresponding dry matter yield. Curd weight (g $plant^{-1}$) including the stalk at marketable maturity was recorded to compute curd yield (q ha^{-1}). Only pooled data of each parameter for two crop seasons (2009-10 and 2010-11) have been presented.

RESULTS AND DISCUSSION

Application of mulches significantly reduced the weed infestation compared to unmulched control (Table 1). There was no weed growth under black

Table 1. Effect of mulches and nutrient levels on weed biomass and root growth in cauliflower.

Treatment (M/F)	Weed biomass (kg ha^{-1})				Dry weight of roots (g $plant^{-1}$)				Root volume (cm^{-3})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
BP	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	9.5	9.3	5.0	7.9	4.9	4.8	2.6	4.1
GM	89.5 (102.5)	88.1 (98.6)	87.1 (96.0)	88.2 (99.2)	8.0	7.7	4.3	6.7	4.2	4.0	2.2	3.5
PN	68.0 (82.6)	66.7 (79.3)	65.2 (75.9)	66.6 (79.3)	9.4	9.0	4.8	7.7	4.9	4.7	2.5	4.0
UM	152.6 (241.0)	146.1 (240.1)	144.0 (230.3)	147.6 (237.2)	7.4	7.2	3.7	6.1	3.8	3.7	1.9	3.2
Mean	77.5 (106.5)	75.2 (104.5)	74.0 (100.7)		8.6	8.3	4.4		4.5	4.3	2.3	
$CD_{(0.05)}$												
M	8.6 (6.8)				0.3				0.4			
F	NS				0.2				0.3			
M × F	NS				0.5				0.7			

Values in parentheses are for second interval plastic mulch (BP). Mulching with grass (GM) and pine needles (PN) also found effective for controlling weeds but not as good as BP. The control of weed infestation, *i.e.* weeds dry weight at first and second intervals under BP, PN and GM was to the tune of 100-100, 54.8-66.5 and 40.2-58.2%, respectively, over UM. Nutrient levels as well as their interaction with mulches gave non-significant effect on weed growth. Mulching has smothering effect on weed population by putting a physical barrier to imparting photosynthetic activity and inhibiting the top growth of weeds. Mulching reduces competition occurring between main crop and weeds and thus creates favorable conditions for crop growth. The reduction in incidence of weeds under plastic mulch (BP) might be due to suppression of weed growth due to lack of sun light, their delayed emergence and reduced population.

Mulches significantly influenced the root growth parameters, *i.e.* dry weight (DW) and volume of root (RV) in 0-15 cm depth (Table 1). Dry weight of roots increased by 29.5, 26.2 and 9.8% and RV by 28.1, 25.0 and 9.4% under BP, PN, GM, respectively, over unmulched control (UM). Higher root growth under mulches is primarily due to moderation of hydrothermal regimes leading to favorable soil-air-water relations which encourages proliferation and elongation of roots. Adequate moisture under mulches reduces the soil strength for root penetration and proliferation. Several earlier reports have also highlighted the beneficial effect of straw mulch on root growth (Acharya and Sharma, 1; Moreno *et al.*, 8). Among nutrient levels, F_1 registered highest DW of roots (8.6 g plant^{-1}) and RV (4.5 cm^3 plant^{-1}), which were at par with F_2 and increased significantly over F_3 (Table 1). The beneficial interaction effect of mulches and nutrient levels on root growth parameters was found to be significant and irrespective of mulches, both DW and RV increased with increasing nutrients levels. Maximum growth of roots (DW and RV) was recorded with BPF_1 treatment combination being 156.7 and 157.9% higher over unmulched control and 75% nutrient level (UMF_3), which might be due to the increased availability of nutrients

Black plastic mulch (BP) exhibited significantly higher contents of leaf N and K, *i.e.* 2.62 and 2.18%, respectively, which were at par with contents under PN (2.59%) and GM (2.14%) over unmulched crop (2.43 and 2.06%). Under nutrient levels, F_1 appreciably increased the leaf N and K contents, *i.e.* 2.63 and 2.23%, respectively, which were found to be at par with F_2 and significantly increased over F_3. Interactive effect of mulches and nutrient levels recorded maximum leaf N and K (2.69 and 2.28%) under BPF_1 and minimum (2.32 and 1.87%) under UMF_3 (unmulched control and 75% nutrient level). Efficient utilization of applied nutrients under mulching treatments could be expected because of an enlarged, more fibrous and active surface feeder roots, conditioned by favorable hydrothermal regimes resulting in higher uptake of nutrients. Panwar *et al*. (11) also recorded increased leaf N under mulch in mango and attributed such effects to better soil hydrothermal regimes.

A comparison of data among nutrient levels indicated that leaf N contents increased consistently with nutrient levels (Table 2). These observations are in close agreement with the finding of Neilsen *et al*. (10) who also observed a positive relationship between N content in soil and apple leaves. Increased N contents in leaves may also be due to the positive role of K that causes more absorption and efficient translocation of N in the plant system (Stojkovska *et al*., 13). There was no significant effect of mulches and nutrient levels on leaf P contents. According to Tisdale *et al*. (15), phosphorus availability decreased with an increase in N level in the soil. Leaf K contents of cauliflower increased with increasing nutrient

Table 2. Effect of mulches and nutrient levels on leaf NPK contents (%) in cauliflower.

Treatment (M/F)	Nitrogen				Phosphorus				Potassium			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
BP	2.69	2.67	2.49	2.62	0.36	0.33	0.29	0.33	2.28	2.27	1.98	2.18
GM	2.66	2.65	2.41	2.57	0.34	0.32	0.26	0.31	2.24	2.23	1.94	2.14
PN	2.68	2.66	2.44	2.59	0.35	0.31	0.27	0.31	2.26	2.25	1.96	2.16
UM	2.49	2.48	2.32	2.43	0.28	0.25	0.24	0.26	2.16	2.14	1.87	2.06
Mean	2.63	2.61	2.41		0.33	0.30	0.26		2.23	2.22	1.94	
$CD_{(0.05)}$												
M	0.03				NS				0.02			
F	0.03				NS				0.01			
M × F	0.05				NS				0.03			

levels. Similar findings were also earlier made by Albregts and Chandler (2) who reported that leaf K concentrations were positively correlated with soil applied potassium.

Application of mulches and nutrients significantly enhanced the uptake of nutrients (Table 3). The uptake of N, P and K under black plastic mulch (BP) and pine needles mulch (PN) was at par with each other, but was significantly higher over unmulched control (UM) to the tune of 15.3-22.1, 14.3-22.1 and 15.4-22.3%, respectively. This may be due to higher biomass yield, more fibrous and active root system (Table 1). Mulching enriched the soil nutrients status, which were available to the crop (Nedunchezhiyan, 9). Higher nutrient uptake under black plastic and pine needles mulches over grass mulch and unmulched control has also been reported by Gupta and Acharya (5) in strawberries. Among nutrient levels, uptake of N, P and K increased under F_1 which was at par with F_2 and increased significantly over F_3 and increased to the tune of 41.5-44.4, 41.8-44.8 and 41.4-44.1% under F_1 and F_2 over F_3, respectively. Higher availabilities of NPK as well as higher foliage weight and curd yield can be attributed for the higher uptake of nutrients (Table 4). Interactive effects of mulches and nutrient levels on nutrient uptake were found significant and at all nutrient levels uptake was higher with mulches than unmulched control (Table 3). Significantly higher N, P and K uptake was found with BPF_1 and BPF_2 when compared with corresponding level of nutrient without mulching. The uptake of N, P and K under BPF_1 increased to the tune of 81.3, 79.3 and 81.4%, respectively over UMF_3. Mulching with higher levels of nutrients application resulted in higher availability of nutrients, which were efficiently utilized by the crop and produced higher yield that led to higher nutrient uptake. The higher uptake of N in organic mulches with higher rates of N application might have been due to favorable moisture regimes, which in turn allowed greater proliferation of roots, thereby facilitating higher absorption of nutrients and water from the soil.

Mulching in cauliflower with BP, PN and GM exhibited significantly higher foliage weight (air dry basis) over UM being 23.4, 22.1, 20.6 and 19.2 q ha^{-1}, respectively (Table 4). These mulches registered about 7.3-21.9% higher foliage weight over UM which may be attributed to improved soil hydrothermal regimes, nutrient availability and lesser weed population. Growth of apple and vines was better under mulch compared to unmulched crop owing to improved soil quality, increased availability of nitrogen and soil moisture, increased microbial activity in the rhizosphere and weed control (Neilsen *et al.*, 10; Kurafuji *et al.*, 6). A comparison among nutrient levels revealed foliage weight to the tune of 44.3 and 41.9% higher under F_1 and F_2, respectively over F_3. These results are in consonance with the findings of Liasu and Achakzai (7), who reported that in tomato plant, application of NPK fertilizer supplemented the nutrient contents of soil required for improved nutrition and growth of the plant. The favourable interactive effect of mulches and nutrient levels also increased foliage weight and treatment combination BPF_1 led to an increase of 81.2% foliage weight over UMF_3, which might be due to effective utilization of applied nutrients under adequate moisture availability.

Curd weight and curd yield of cauliflower were significantly affected by mulches, nutrients and their interaction (Table 4). Application of mulches, *viz.* BP, PN and GM registered 34.6, 21.4 and 16.0% higher curd weight and curd yield over UM control. The effective weed control, favourable hydrothermal regimes, better root growth and increased nutrient uptake under mulches might have led to higher curd

Table 3. Effect of mulches and nutrient levels on NPK uptake (kg ha^{-1}) by cauliflower.

Treatment (M/F)	N uptake				P uptake				K uptake			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
BP	9.5	9.3	5.0	7.9	10.4	10.2	7.9	9.4	85.1	83.3	64.5	76.3
GM	8.0	7.7	4.3	6.7	9.5	9.3	6.2	8.2	77.3	75.6	50.4	67.2
PN	9.4	9.0	4.8	7.7	9.9	9.8	6.9	8.8	80.8	79.7	56.4	72.0
UM	7.4	7.2	3.7	6.1	8.8	8.6	5.8	7.7	71.6	70.1	46.9	62.4
Mean	8.6	8.3	4.4		9.7	9.5	6.7		78.7	77.2	54.6	
$CD_{(0.05)}$												
M	4.56				0.58				5.21			
F	3.95				0.50				4.51			
M × F	7.90				1.00				9.02			

Table 4. Effect of mulches and nutrient levels on curd weight and yield of cauliflower.

Treatment (M/F)	Curd weight (g $plant^{-1}$)				Curd yield (q ha^{-1})			
	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
BP	800.4	778.9	560.3	693.2	266.8	259.6	186.8	231.1
GM	683.3	667.2	474.1	597.3	227.8	222.4	158.0	199.1
PN	718.5	686.9	501.1	625.1	239.5	229.0	167.0	208.4
UM	580.6	568.4	424.1	514.9	193.5	189.5	141.4	171.6
Mean	695.7	675.4	489.9		231.9	225.1	163.3	
$CD_{(0.05)}$								
M	23.87				9.32			
F	20.67				7.99			
M × F	41.35				15.98			

weight and consequently the curd yield. Raina *et al.* (12) have also attributed such effects of mulch to higher rooting density in surface layers because of optimum soil moisture conditions resulting thereby in higher nutrient uptake and yield of pea and tomato. Curd weight and curd yield increased significantly with increasing nutrient levels (Table 4). The nutrient level F_1 (125% of recommended dose of nutrients) registered highest curd weight and curd yield (695.7 g $plant^{-1}$ and 231.9 q ha^{-1}), which were at par with F_2 (675.4 g $plant^{-1}$ and 225.1 q ha^{-1}) and increased over F_3 (489.9 g $plant^{-1}$ and 163.3 q ha^{-1}) to the tune of 37.8-42.0%. Application of NPK to the cauliflower supplemented the nutrient contents of the soil by making essential nutrient elements available required for improved nutrition and healthy growth of the plant (Liasu and Achakzai, 7). The interactive effect of mulches and nutrient levels was also found to be significant and the treatment combination BPF_1 recorded highest curd weight and yield, *i.e.* 800.4 g $plant^{-1}$ and 266.8 q ha^{-1}, respectively, thereby exhibiting 88.7% increase over UMF_3. This could be ascribed to the additive effect of all the inputs on the availability of essential nutrients. Mulch and nutrients had complementary effect on nutrient availability to plants because organic mulch when decomposes release nutrients and organic matter, which when added into the soil, increase the growth of plants.

The foregoing discussion lead to the conclusion that black plastic mulch (BP) is as good as grass (GM) and pine needle (PN) mulches for achieving higher cauliflower productivity in light texture soils under rainfed conditions in mid hill region of Himachal Pradesh. All mulches effectively checked weed growth and encouraged plant growth, but there was complete check under black plastic mulch. The decomposition GM and PN mulches, however, added organic matter and enriched the soil nutrients, which consequently increased soil fertility. Fertilizer application was more effective in mulched crop as evidenced by encouraged growth and development, nutrient uptake and increased productivity of cauliflower. Increased soil moisture conservation with the application of black plastic mulch and 125% recommended dose of NPK increased cauliflower productivity by 88.7% over unmulched control with 75% recommended dose of NPK.

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