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Effect of Surface Soil Removal and Organic Amendment on Soil Properties Cultivating Sesame (*Sesamum indicum* L.)

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A B S T R A C T

An experiment was conducted to study the effect of surface soil removal and organic amendment on soil properties cultivating sesame (*Sesamum indicum* L.) during *Kharif* 2018. A split plot with three replications was designed. Surface soil removal of 0 (control), 5 and 10 cm designated as D_0, D_1 and D_2 were carried out, respectively. The addition of different organic amendments was adopted *vis*, O_0- control, O_1- vermicompost @ 3 tonnes ha^{-1}, O_2- poultry litter @ 3 tonnes ha^{-1} and O_3- pig manure @ 3 tonnes ha^{-1}. Soil properties showed a significant change due to surface soil removal of 5 cm and 10 cm depth. The addition of vermicompost as an amendment showed highest pH (5.28), organic carbon (2.21 %), water holding capacity (64.78 %), cation exchange capacity (11.23 cmol (p^+) kg^{-1}), Available N (425.10 kg ha^{-1}), Available P (28.29 kg ha^{-1}) Available K (156.94 kg ha^{-1}) and lowest bulk density (1.16 g cm^{-3}). The interaction between surface soil removal and addition of organic amendment on soil properties was found to be highest with D_0O_1 (0 cm surface soil removal + Vermicompost @3 tonnes ha^{-1}) and lowest with D_2O_0 (10 cm surface soil removal + control). Addition of organic amendments in areas where surface soil was removed helped to improve the soil properties under sesame cultivation.

Introduction

Sesamum indicum L. is native to India and has been cultivated since time immemorial. They are globally produced mainly for their oil content. Apart from that, many countries also use it in confectionaries and bakeries. Among all the oilseeds, the production of sesame comes in third position contributing 27 per cent of the total production in the world (Pusadkar *et al.,* 2015). Erosion is the process of detachment of soil particles due to external forces such as wind and water and transportation of these detached particles elsewhere. Water erosion accounts for 56 per cent out of the total area whereas by wind is 28 per cent (Oldeman, 1991). Erosion not only removes the soil particles but also the nutrients along with it leaving the soil deficient of the nutrients required for plants to grow. Thus, this decline in topsoil depth also indicates nutrient loss, reduction of rooting depth, reduction of water and nutrient storage capacity and, hence, plant productivity (Braimoh and Vlek, 2008).

Manures used as soil amendment are considered very important in crop production from the stand point of fertility. Organic manure is a key fertilizer in organic and sustainable soil management. Manures when used as amendments help improve the quality of the soil in terms of both physical as well as chemical properties. Soil chemical properties increases on addition of organic manure by improving the microbial population of soil reducing the nitrogen loses through slow nutrient release (Tadesse *et al.,* 2013). The soil physical properties are also improved through addition of organic fertilizers and helps in supplying essential plant nutrients as well as protect the soil against erosion by supplying the cementing substance for desirable aggregate formation (Yadav *et al.,* 2020). The effect of surface soil removal and organic amendment on important soil properties under sesame cultivation in Nagaland has not been studied. Therefore the present investigation was carried out to evaluate the effect of surface soil removal and organic amendment on important soil properties under sesame cultivation in Nagaland.

Materials and Methods

A field experiment was carried out in the experimental farm of the Department of Soil and Water Conservation, School of Agricultural Sciences and Rural Development, Medziphema Campus, Nagaland University during 2018. The location of this institute is at $20^0$45’43’’N latitude and $93^0$53’04’’E longitude. It is at an altitude of 310 m above mean sea level (MSL). The climate of Medziphema is classified as humid and sub tropical.

Removal of the surface soil was done at depths of 0 cm, 5 cm and 10 cm whereas the application of organic amendment was done through addition of Vermicompost, Poultry litter and Pig manure all at the rate of 3 t ha^{-1}. The spacing of the crop was kept at 30 cm × 15 cm. A total of 12 treatments were laid in a split plot design with three removal depths as main plots and three organic amendments and a control as sub plots. The surface soil was removed by measuring the desired depth with a scale and scrapping the soil in a uniform manner with the help of a spade. Application of nitrogen as urea, P_2O_5 as single super phosphate and K_2O as murate of potash was done at the time of the final field preparation at the rate of 30:20:20 kg ha^{-1}. The organic amendments were incorporated to the plots according to the treatments two weeks before sowing. After harvest of the sesame crop, soil samples from individual plots were collected and processed for analysis. The various properties of the soils were estimated following standard procedures (Table 1). The initial soil properties of the experimental site are presented in Table 2.

Results and Discussion

Soil pH

The soil pH decreased with increase in surface soil removal depth. The highest soil pH was in control and the lowest was with 10 cm removal of soil (Table 3). Significant decrease of 1.0 and 2.3 % pH was recorded on removal of 5 cm and 10 cm, respectively as compared to control. The result is supportive of the findings reported by Larney *et al.,* (2000). Application of organic amendment had a significant effect on soil pH. Application of vermicompost resulted in the highest increase of soil pH compared to poultry litter and pig manure. The application of vermicompost, poultry litter and pig manure amounted to an increase of 2.7, 1.0 and 0.4% pH, respectively as compared to control. The rise in pH could be the result of liming effect of the added amendments. These findings are in accordance with the findings of Wong *et al.,* (1998).

Organic carbon

The study showed that soil organic carbon decreased with increase depth of soil removal. The highest organic carbon was observed in control and the lowest was recorded in 10 cm removal of surface soil (Table 3). A decrease of 9.0 and 15.0 % organic carbon was observed on removal of 5 and 10 cm of surface soil, respectively as compared to control. Organic carbon significantly increased with the application of organic amendment. The maximum organic carbon was observed with the application of vermicompost and the minimum organic carbon was observed in control. Application of vermicompost caused an increase of 10.5% in organic carbon as compared to control. The findings are in conformity with reports by Bakayoko *et al.,* (2009). The interaction between surface soil removal and organic amendments had no significant effect on organic carbon of the soil.

Cation exchange capacity

Surface soil removal had a significant effect on the cation exchange capacity (CEC) of soil. The cation exchange capacity was highest in 0 cm and lowest in 10 cm surface soil removal. It ranged from 11.78 to 10.03 cmol (p^+) kg^{-1} (Table 3). A decrease of 9.1 and 14.9% CEC was observed on the removal of 5 cm and 10 cm, respectively as compared to control. On addition of organic amendments, the cation exchange capacity of the soil increased. The highest and lowestcation exchange capacity was observed with the application of vermicompost and control, respectively. Addition of vermicompost, poultry manure and pig manure resulted an increase of 10.7, 10.4 and 7.5% increase in CEC as compared to control, respectively. The results are accordance with the findings of Xu and Mau (2016). The interaction between the surface soil removal and organic amendments had no significant effect on the cation exchange capacity of soil.

Water holding capacity

The maximum and minimum water holding capacity was observed in 0 cm and 10 cm removal of surface soil, respectively. It ranged from 65.57 to 63.20 % (Table 3). Significant decrease of 1.74 and 2.37 % in water holding capacity was recorded on the removal of 5 cm and 10 cm surface soil, respectively as compared to control. The results are supportive of the findings reported by Amegashie *et al.,* (2012). Addition of organic amendments increased the water holding capacity of the soil. The water holding capacity of soil ranged from 64.78% to 62.90%.

The highest water holding capacity was observed with the application of vermicompost and the lowest was observed in control. The increase in water holding capacity might be due to improvement in physical properties of the soil on addition of organic amendments. These findings are in accordance with the findings of Vengadaramana *et al.,* (2012).

Bulk density

The highest bulk density was observed on removal of 10 cm of surface soil and the lowest was with control. It varied from 1.19to 1.16 g cm^{-3}, respectively (Table 3). An increase of 1.7 and 2.6 % in bulk density was observed on removal of 5 and 10 cm surface soil, respectively as compared to control. These are in line with the findings reported by Oyedele and Aina (2006). Application of organic amendments decreased the bulk density of soil. The highest bulk density was observed in control and lowest was with addition vermicompost. Addition of vermicompost significantly decreased the bulk density of soil compared to poultry litter and pig manure. The application of vermicompost caused a decrease of 2.5 % bulk density as compared to control. The results are in accordance with the findings reported by Kumar *et al.,* (2017) and Laharia *et al.,* (2013).

Available Nitrogen in soil

The study revealed that available nitrogen content in soil decreased with increasing soil removal depth. The highest and lowest available N was observed with 0 cm and 10 cm removal of surface soil. It ranged from 392 to 339.73 kg ha^{-1} (Table 3). Significant decrease in the available nitrogen was found on removal of 10 cm compared to 5 cm. Similar findings are also reported by Barrows and Kilmer (1963).

Table.1 Soil properties and methods followed for determination

Soil parameters	**Methods employed**	**Reference**
Soil pH	Glass electrode pH meter (1:2.5 soil and water ratio)	Jackson, 1973
Organic carbon	Walkey and Black rapid titration	Jackson, 1973
Cation exchange capacity	NH_3 distillation method	Baruah and Barthakur, 1997
Water holding capacity	Keen Rackzowaski boxes	Piper, 1966
Bulk density	Pycnometer method	Majumdar and Singh, 2000
Available Nitrogen	Alkaline potassium permanganate method	Subbiah and Asijia, 1956
Available Phosphorus	Bray's No. 1 method	Bray and Kurtz, 1945
Available Potassium	Neutral ammonium acetate	Hanway and Heidal, 1952

Table.2 Initial soil properties of the experimental site

Soil parameters	**Value**
Soil pH	4.8
Organic carbon (%)	1.9
Cation exchange capacity [c mol (p^{+}) kg^{-1}]	9.8
Water holding capacity (%)	62.4
Bulk density (g cm^{-3})	1.10
Available Nitrogen (kg ha^{-1})	376.3
Available Phosphorus (kg ha^{-1})	21.7
Available Potassium (kg ha^{-1})	134.4

Table.3 Effect of surface soil removal and organic amendments on soil properties

Parameters	Soil depth removal (cm)	Control	Vermicompost	Poultry litter	Pig manure	Mean
Soil pH	0	5.23	5.37	5.23	5.17	5.25
	5	5.17	5.27	5.20	5.17	5.20
	10	5.03	5.20	5.13	5.13	5.13
	Mean	5.14	5.28	5.19	5.16	5.19
	SEm±(D)	0.013		**CD at 5% (D)**	0.065	
	SEm±(O)	0.79		**CD at 5% (O)**	0.274	
Organic Carbon (%)	0	2.13	2.40	2.43	2.37	2.33
	5	2.00	2.17	2.20	2.07	2.11
	10	1.87	2.07	1.93	2.03	1.98
	Mean	2.00	2.21	2.19	2.16	2.14
	SEm±(D)	0.028		**CD at 5% (D)**	0.185	
	SEm±(O)	0.139		**CD at 5% (O)**	0.638	
CEC [c mol (p+) kg^{-1}]	0	10.83	12.13	12.27	11.87	11.78
	5	10.17	11.07	11.17	10.43	10.71
	10	9.43	10.50	9.83	10.33	10.03
	Mean	10.14	11.23	11.09	10.88	10.84
	SEm±(D)	0.112		**CD at 5% (D)**	0.807	
	SEm±(O)	0.552		**CD at 5% (O)**	2.788	
WHC (%)	0	63.80	66.86	65.77	65.87	65.57
	5	62.65	64.60	64.27	63.81	63.83
	10	62.25	62.88	63.93	63.75	63.20
	Mean	62.90	64.66	64.66	64.48	64.20
	SEm±(D)	0.157		**CD at 5% (D)**	1.674	
	SEm±(O)	0.778		**CD at 5% (O)**	5.788	
Bulk density (g cm^{-3})	0	1.17	1.13	1.17	1.17	1.16
	5	1.17	1.17	1.20	1.17	1.18
	10	1.23	1.17	1.17	1.20	1.19
	Mean	1.19	1.16	1.18	1.18	1.18
	SEm±(D)	0.019		**CD at 5% (D)**	0.092	
	SEm±(O)	0.065		**CD at 5% (O)**	0.226	
Available nitrogen (kg ha^{-1})	0	334.51	459.95	418.13	355.41	392.00
	5	271.79	418.13	397.23	334.51	355.41
	10	250.88	397.23	376.32	334.51	339.73
	Mean	285.72	425.10	397.23	341.48	362.38
	SEm±(D)	9.543		**CD at 5% (D)**	47.171	
	SEm±(O)	45.963		**CD at 5% (O)**	158.020	
Available phosphorus (kg ha^{-1})	0	22.62	28.87	27.60	26.06	26.29
	5	21.96	28.17	26.42	24.48	25.26
	10	21.59	27.84	27.06	23.63	25.03
	Mean	22.06	28.29	27.02	24.73	25.53
	SEm±(D)	0.071		**CD at 5% (D)**	0.350	
	SEm±(O)	0.412		**CD at 5% (O)**	1.420	
Available potassium (kg ha^{-1})	0	125.7	169.9	158.3	149.3	150.8
	5	124.1	161.7	155.5	147.4	147.2
	10	115.9	139.2	143.9	144.3	135.8
	Mean	121.9	156.9	152.6	147.0	144.6
	SEm±(D)	0.946		**CD at 5% (D)**	6.566	
	SEm±(O)	4.675		**CD at 5% (O)**	22.703	

In all cases, the interaction effect of surface soil removal depth (D) and applied organic amendment (O) was found to be non-significant i.e., D X O = NS

Addition of vermicompost significantly increased the available nitrogen in the soil compared to addition of poultry litter and pig manure. Application of vermicompost, poultry litter and pig manure resulted an increase of 48.8, 39.0 and 19.5 % in available N, respectively as compared to control. The increase in available nitrogen might be due to increase in nutrient content on added organic amendments. The results are in accordance with the findings reported by Savithri *et al.,* (1991).

Available phosphorus in soil

The highest available phosphorus was observed in control and the lowest available phosphorus was recorded in 10 cm removal of soil. It ranged from 26.29 to 25.03 kg ha^{-1} (Table 3). A reduction of 3.9 and 4.8 % on available phosphorus resulted from removal of 5 and 10 cm surface soil, respectively as compared to control. These findings are in accordance with reports made by Tuttle *et al.,* (1985). The study also revealed that the addition of organic amendments resulted in an increase of available phosphorus in soil. The highest available phosphorus was recorded with the addition of vermicompost. Addition of vermicompost, poultry litter and pig manure caused an increase of28.2, 22.5 and 12.1% available phosphorus, respectively as compared to control. The increase in available phosphorus might be because of increase solubility of phosphorus due to high phosphate activity. These findings are in accordance with the findings of Dutta and Chauhan (2011).

Available potassium in soil

The study showed that soil available potassium decreased with increase in depth of soil. The highest and lowest available potassium was observed with removal of 0 cm and 10 cm surface soil, respectively. It ranged from150.8 to 135.8 kg ha^{-1} (Table 3). A significant reduction in available phosphorus was recorded in 10 cm removal of surface soil as compared to 5 cm. A decrease of 2.4 and 9.9 % available potassium was observed on removal of 5 cm and 10 cm surface soil, respectively as compared to control. Significant increase in available potassium resulted from addition of organic amendments. The maximum available potassium was observed with the application of vermicompost and minimum was in control. Addition of vermicompost, poultry manure and pig manure caused an increase of 28.7, 25.2 and 20.6 % available potassium, respectively as compared to control. The addition of vermicompost caused a significant increase in the availability of potassium as compared to poultry litter and pig manure. Similar results are also reported by Han *et al.,* (2016).

In conclusion treatments with no removal of surface soil exhibited better soil characteristics compared to treatments with 5 cm and 10 cm soil removal. The application of vermicompost as an amendment improved the soil health significantly compared to control. Among the organic amendments, vermicompost showed better results than others.

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