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Effect of Simulated Erosion and Nitrogen Levels on Physico-Chemical Properties and N, P and K Availability in Nagaland Soil

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Abstract

The effect of simulated erosion on physico-chemical properties of soil and combined effect of surface soil removal and fertilizer N addition on the fertility of soil under rapeseed cultivation was studied in field conditions. Simulated erosion caused a reduction in soil pH, field capacity, organic carbon content and available N, P and K levels in soil. The bulk density and clay content of the soil however, increased on removal of surface soil. Removal of 5, 10 and 15 cm of surface soil caused a loss of 75.3, 87.8 and 112.9 kg/ha in available N ; 2.0, 7.9 and 14.1 kg/ha in available P and 64.1, 121.1 and 134.3 kg/ha in available K, respectively. The average N, P and K fertility values of the soil left after the removal of 5, 10 and 15 cm of surface soil were found to be 82.2, 63.9 and 48.3% of the control (100%), respectively. In desurfaced soils, application of 40, 80 and 120 kg N/ha in rapeseed caused a significant increase in available N content. Available P and K also increased significantly on application of 80 and 120 kg N/ha. Addition of 40, 80 and 120 kg N/ha on croded soils caused an increase of 10.2, 11.0 and 21.9% in available N; 9.1, 20.8 and 30.5% in available P and 9.5, 18.6 and 29.1% in available K over control, respectively.
Key words : Simulated erosion, Eroded soils, Physico-chemical properties, Soil fertility, Available N, P and K.

Soil erosion brings about considerable changes in physical, chemical and biological properties of the soil by removing the most fertile surface soil. Soil erosion reduces the thickness of plough layer and thereby rooting volume. The on-site soil loss is accompanied by the loss of organic matter and plant nutrients with it. The combined effect of erosion induced on-site changes brings about a significant reduction in soil fertility and other soil conditions that affect plant growth. Cosequently, the production potential of the land and its quality are affected adversely. The impact of erosion is likely to be more pronounced in shallow hill soils. The loss of topsoil also occurs during land leveling and land clearing operations in hilly forested areas (1). Taking into account both onsite and major off-site effects linked to erosion such as sedimentation of reservoir, flood and its consequences, water pollution, wild life habitat destruction, biodiversity loss and degradation of environment, the consequences of soil erosion are agronomic, environmental and socio-economic. It is therefore imperative that the need based conservation efforts are introduced both on the farm and off the farm in the interest of mankind.

Removal of surface soil in erosion affects soil properties mainly through the loss of soil organic matter, plant nutrients and exposure of sub-soil material with low fertility and high acidity (2). The effect of the same dose of N, P and K fertilizers on the performance of the crops on non-eroded and eroded soil is expected to be different because of erosion-induced changes in soil properties of the later. Fertilizers are more effective on topsoil having adequate organic matter content than exposed sub-soil with depleted organic matter. Our knowledge on the effect of erosion and fertilizer N addition on soil properties and availability of N, P and K in eroded soils of hilly areas under cultivation of different crops is not adequate. An investigation was therefore, undertaken to evaluate the effect of simulated erosion on soil properties and combined effect of erosion and nitrogen levels on the availability of N, P and K levels in Nagaland soil under rapeseed cultivation.

Methods

A field experiment was conducted at the School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema during *rabi* season of 2005 on a loam soil. The experiment was laid in split plot design with three replications. Soil removal depths of 0, 0–5, 0–10 and 0–15 cm were used as main plots. Nitrogen doses of 0, 40, 80 and 120 kg N/ha were used as sub-plots. Nitrogen fertilizers as urea together with 60 kg P_2O_5 as single super phosphate and 50 kg K_2O as muriate of potash per hectare were applied as basal application. Rapeseed (*Brassica campestris* L. var *toria* Duth.) cultivar M-27 was used as test crop in 3 m × 2.7 m size plot with spacing of 30 cm between the rows using a seed a rate of 5.0 kg/ha. Necessary plant protection measures were taken to protect the crop from insect pests and diseases. Rapeseed crop was given two light irrigations one at pre-flowering and the other at pod formation critical stages of crop growth by watering only the crop line manually using water-sprinkler cane.

Soil samples from original (control) and desurfaced plots were collected before sowing and their physico-chemical properties determined. Silt (%) and clay (%) were determined by international pipette method (3) and sand (%) was estimated as 100- (% silt + % clay). Bulk density, field capacity and available N (alkaline permanganate method) content were determined using procedures outlined by Kanwar and Chopra (3). Soil pH was measured in 1 : 2.5 soil and water ratio using a glass electrode pH meter. Organic carbon content was determined by Walkley and Black method (4). The available P was extracted by Brays and Kurtz No. 1 extractant and P in the soil extract was measured colorimetrically using chlorostannous-reduced molybdophophoric blue color method, in hydrochloric acid (4). Available K was extracted with normal neutral ammonium acetate (4) and measured flamephotometrically. After the harvest of rapeseed crop, soil samples from all the sub-plots were also collected and assessed for available N, P and K content.

Results and Discussion

Effect of Simulated Erosion on Physico-Chemical Properties of the Soil

The data showed that the simulated erosion caused a drastic change in all the properties of the soil (Table 1). Removal of 0, 5, 10 and 15 cm surface soil caused a progressive decline in soil pH, field capacity, sand and organic carbon content. However, silt, clay and bulk density increased on removal of surface soil. The data further showed that available N, P and K content in desurfaced soils decreased with increase in simulated erosion rates. On removal of 5, 10 and 15 cm of surface soil, there occurred a loss of 75.3, 87.8 and 112.9 kg/ha in available N ; 2.0, 7.9 and 14.1 kg/ha in available P and 64.1, 121.1 and 134.3 kg/ha in available K contents, respectively. The data established that with the removal of each centimeter of surface soil, the loss (kg/ha per cm) of available N and K, decreased with increase in simulated erosion rates while that of available P increased. The loss was estimated to be 25.1, 8.8 and 7.5 kg/ha per cm in available N ; 0.4, 0.8 and 0.9 kg/ha per cm in available P and 12.8, 12.1 and 9.0 kg/ha per cm in available K contents, respectively. On removal of surface soil, available N, P and K contents decreased from 338.7 to 225.8 kg/ha, 17.6 to 3.5 kg/ha and 322.5 to 188.2 kg/ha, respectively. When compared on per cent basis, simulated erosion affected P availability the most followed by K and N. The data established that simulated erosion adversely affected physico-chemical properties and available N, P and K contents of soil. These results are similar to those observed by Lalmuanpuia (5) who reported a loss of 14.0, 33.0 and 86.0 kg/ha in available N ; 16.0, 16.7 and 17.6 kg/ha in available P and 103.4, 114.4 and 132.0 kg/ha in available K contents on removal of 5, 10 and 15 cm of surface soil, respectively.

Table 1. Effect of simulated erosion on physico-chemical properties of soil.

Soil properties	Original soil	Soil depth removed (cm)		
		0-5	0-10	0-15
Sand (%)	52.3	46.8	44.6	41.4
Silt (%)	23.2	24.6	26.3	27.4
Clay (%)	24.5	28.6	29.1	32.2
pH	5.9	4.6	4.4	4.4
Bulk density (g/cc)	1.19	1.23	1.24	1.25
Field capacity (%)	46.9	45.4	38.4	38.0
Organic carbon (%)	1.86	1.56	1.54	1.36
Available N (kg/ha)	338.7	263.4	250.9	225.8
Available P (kg/ha)	17.6	15.6	9.7	3.5
Available K (kg/ha)	322.5	258.4	201.4	188.2

On removal of 5, 10 and 15 cm of surface soil, N fertility status of original soil decreased to low from

Table 2. Effect of addition of different doses of N fertilizer on available N, P and K content (kg/ha) of eroded soils after crop harvest.

Simulated erosion rates (cm of soil depth removed)	Doses of N (kg/ha) 0	40	80	120	Mean
	Available N (kg/ha)				
0 (control)	347.1	367.9	397.2	430.6	385.7
5	284.3	321.9	355.4	393.0	338.6
10	263.4	292.7	321.9	365.8	310.9
15	242.5	269.7	301.1	337.6	287.7
Mean	284.3	313.1	343.9	381.8	330.7
CD (P = 0.05)		E =19.1		N = 25.1	
	Available P (kg/ha)				
0 (control)	27.2	29.5	29.8	30.6	29.3
5	19.7	20.2	22.0	23.4	21.3
10	10.8	12.6	15.3	17.9	14.2
15	3.7	5.2	7.5	8.6	6.3
Mean	15.4	16.8	18.6	20.1	17.7
CD (P = 0.05)		E = 2.0		N = 1.4	
	Available K (kg/ha)				
0 (control)	352.5	360.3	371.1	379.1	365.7
5	297.1	309.8	233.1	332.3	315.6
10	279.9	291.5	296.8	308.0	294.1
15	266.1	276.3	283.7	296.6	280.7
Mean	298.8	309.5	318.6	329.1	314.0
CD (P = 0.05)		E = 21.5		N = 18.9	

initial medium. While simulated erosion rates of 10 and 15 cm reduced the P fertility status to low from initial medium, the removal of 5 cm of surface soil did not cause any reduction in fertility status of P. The fertility status of K of the eroded soils also reduced to medium from initial high. The data also revealed that on removal of 5 cm of surface soil, available N, P and K levels of the resultant surface soil decreased and were found to be 77.8, 88.6 and 80.1% of the levels present in control (100%), respectively. Similarly, on removal of 10 and 15 cm of surface soil, the available N, P and K levels also decreased and were estimated to be 74.1, 55.1 and 62.4% and 66.7, 19.9 and 58.4% of the levels observed in control, respectively. These figures relative to control denote the remaining value of desurfaced soils in respect of N, P and K fertility. The average N, P and K fertility values of the soil left after removal of 5, 10 and 15 cm of surface soil were worked out to be 82.2, 63.9 and 48.3% of the control (100%), respectively. These values are comparable with the soil fertility values of 80, 60 and 30% of the control reported by Stefanovits (6) for weekly croded, moderately croded and strongly croded soils, respectively.

Effect of Simulated Erosion and N Levels on N, P and K Availability

Table 2 revealed that available N content in soil decreased significantly at all levels of simulated erosion as compared to control (0 cm of surface soil removed) after harvest of rapeseed. The highest available N (385.7 kg/ha) was found in control and lowest (287.7 kg/ha) was recorded where 15 cm of surface soil was removed. The N fertility values of the soil subjected to simulated erosion of 5, 10 and 15 cm were found to be 87.8, 80.6 and 74.6% of control, respectively. The decrease in available N content thus worked out to be 12.2, 19.4 and 25.4% in desurfaced soils as compared to control, respectively. This amounted to a loss of 47.1, 74.8 and 98.0 kg N/ha of available N. The available N contents were reduced by 8.2 and 15.0% on removal of 10 and 15 cm of soil depth, respectively as compared to 5 cm of soil removal. When compared with 10 cm of soil depth removal, the available N content was reduced by 7.5% on removal of 15 cm surface soil. The decrease in available N due to simulated erosion appears to be related to the loss of topsoil rich in organic matter and other soil constituents. Lalmuanpuia (5) also reported that on removal of 5, 10 and 15 cm of surface soil, available N decreased by 63.2, 74.7 and 106.0 kg/ha, respectively (11.9, 14.0 and 19.9%, respectively) after the harvest of maize crop. The data further showed that application of fertilizer N significantly increased the available N content in the soil at all the levels of addition (Table 2).Maximum available N (381.8 kg/ha) was recorded on application of 120 kg N/ha and minimum (284.3 kg/ha) was recorded in control. Available N increased by 10.2, 21.0 and 34.3% (47.0, 59.6 and 97.5 kg N/ha, respectively) on addition of 40, 80 and 120 kg N/ha, respectively over control. Similarly, available N increased by 11.0 and 21.9% on addition of 80 and 120 kg N/ha, respectively over 40 kg/ha and 11.0% on addition of 120 kg N/ha when compared with 80 kg N/ha. Lalmuanpuia (5) also reported that in eroded soils addition of 60, 120 and 180 kg N/ha caused an increase of 6.5, 16.6 and 21.3% (27.5, 70.2 and 90.9 kg N/ha) in available N after the harvest of maize crop, respectively. The increase in available N on application of fertilizer N could be due to combined effect of mineralization of organic N, contribution of added fertilizer N towards available N pool, and N lost from the soil including plant uptake. Only one third to half of fertilizer N added to the soil is utilized by the crop and remaining may either get lost or accumulate in soil (7). The interaction effect of simulated erosion rates and N levels was not significant.

After crop harvest there was a significant reduction in available P content at all levels of simulated erosion (Table 2). The decrease in available P content increased with the increase in simulated erosion rates. Highest available P content (29.3 kg P/ha) was recorded in control and lowest (6.3 kg P/ha) was observed in treatment where 15 cm of soil was removed. After crop cultivation, the P fertility value of the soil subjected to simulated erosion of 5, 10 and 15 cm was found to be 72.7, 48.5 and 21.5% of control, respectively. The reduction in available P content was estimated to be 27.3, 51.5 and 78.5% in desurfaced soils, respectively as compared to control. This amounted to a loss of 8.0, 15.1 and 23.0 kg/ha in available P levels. The available P contents were reduced by 33.3 and 70.4% on removal of 10 and 15 cm of soil depth, respectively as compared to 5 cm of soil removal. When compared with 10 cm of soil depth removal, the available P content was reduced by 55.6% on removal of 15 cm surface soil. Comparatively, per cent decrease in available P content after cultivation on eroded soils was more than that observed in available N. Similar effect of simulated erosion on available P content in eroded soils was observed earlier by Chauhan et al. (1). These investigators reported that available P contents were reduced by 14.1, 32.9 and 50.6% (1.2, 2.8 and 4.3 kg P/ha, respectively) on removal of 5, 10 and 15 cm of soil, respectively as compared to control after the harvest of soybean crop. The decrease in available P content in soil may be attributed mainly to the loss of topsoil and the loss of organic matter and plant nutrients with it. The data also showed that addition of N caused significant increase in available P contents at all levels of addition except that of 40 kg N/ha which caused insignificant increase when compared with control. Addition of 80 and 120 kg N/ha also caused significant increase in available P content as compared to 40 kg N/ha. The available P content in soil on addition of 40, 80 and 120 kg N/ha caused an increased of 9.1, 20.8 and 30.5% (1.4, 3.2 and 4.7 kg P/ha, respectively) as compared to control. Similarly, addition of 80 and 120 kg N/ha caused an increase of 10.7 and 19.6%, respectively as compared to 40 kg N/ha and 8.1% on addition of 120 kg N/ha when compared with 80 kg N/ha. Other investigators (1) also reported that addition of 15, 30 and 45 kg N/ha in eroded soils caused an increase of 0.3, 0.7 and 1.1 kg/ha in available P (5.1, 11.9 and 18.6%, respectively) after the harvest of soybean crop, respectively. The increase in available P on addition of N could be either because of the more labile nature of inorganic P compounds synthesized during the transformation of added P in soil or due to release of more soluble P forms from soil constituents on weathering in the resultant surface soil after desurfacing (1) or both. The interaction between simulated erosion and N levels on the effect of available P content was not significant.

Simulated erosion caused a significant reduction in available K content in soil at all the levels as compared to control after the harvest of rapeseed. Highest avaialble K content (365.7 kg K/ha) was recorded in control and lowest (280.7 kg K/ha) where 15 cm of surface soil was removed. The effect of removal of 10 cm of surface soil on available K was recorded at par when compared with 5 cm. However, removal of 15 cm of surface soil caused a significant decrease in available K as compared to 5 cm. Simulated erosion rates of 15 cm did not cause significant decrease in available K as compared to 10 cm. After cultivation, the K fertility values of the soil subjected to simulated erosion of 5, 10 and 15 cm were found to be 86.3, 80.4 and 76.8% of control, respectively. The available K levels in these desurfaced soils decreased by 13.7, 19.6 and 23.3%, respectively when compared with control. This amounted to a loss of 50.1, 71.6 and 85.0 kg/ha available K. The data also revealed that on removal of 10 and 15 cm of surface soil the available K decreased by 6.8 and 11.1%, respectively as compared to 5 cm removal. On removal of 15 cm surface soil the available K content decreased by 4.6% when compared with the removal of 10 cm of surface soil. Similar observations were also made by Chauhan et al. (1). These investigators reported that removal of 5, 10 and 15 cm of surface soil caused a decrease in available K by 24.5, 33.9 and 42.3% (59.7, 82.5 and 103.1 kg K/ha, respectively) when compared with control, respectively. The decrease in available K may be attributed mainly to the loss of surface soil relatively rich in available K and other soil constituents. Table 2 also showed that the available K content increased with increase in the dose of fertilizer N. The increase in available K content of soil was not significant on addition of 40 kg N/ha as compared to control. However, addition of 80 and 120 kg N/ha caused a significant increase in available K content of soil over control. Similarly, significant increase in available K on addition of 120 kg N/ha was observed over 40 kg N/ha. Application of 40, 80 and 120 kg N/ha caused an increase of 3.5, 6.6 and 10.1% in available K (10.7, 19.8 and 30.3 kg K/ha, respectively), respectively as compared to control. Similarly, available K increased by 2.9 and 6.3% on addition of 80 and 120 kg N/ha when compared with 40 kg N/ha and 3.3% on addition of 120 kg N/ha when compared with 80 kg N/ha. Other investigators (1) also observed that in eroded soils, addition of 15, 30 and 45 kg N/ha caused an increase of 5.2, 8.2 and 11.2% (8.9, 14.0 and 19.2 kg K/ha, respectively) in available K content after the harvest of soybean crop, respectively. The increase in available K on addition of fertilizer N may be due to the combine effect of desurfacing induced release of available K from minerals on their exposure to weathering agents in the resultant surface soil and influence of ammonium ions on the release of potassium ions from soil constituents during transformation of added N source (1). Ammonium ions are almost of the same size as potassium ion, behave exactly in the same manner (7) and compete with each other for exchange sites on clay complex. The mechanism proposed for fixation of ammonium ion is similar to that for potassium. Hence presence of ammonium ion will alter both the fixation of added potassium and release of fixed potassium (8). The interaction between simulated erosion and N levels on the effect of available K was not significant.

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