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Effect of Simulated Erosion and Nitrogen Levels on the Performance of Rapeseed (*Brassica campestris* L. Var Toria, Duth.) under Nagaland Agro-Climatic Conditions

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Abstract

Performance of rapeseed on soil subjected to various rates of simulated erosion and fertilizer N application was evaluated under field conditions. Plant height, stover and grain yield decreased with increase in simulated erosion rates. On removal of 5, 10 and 15 cm of surface soil, plant height decreased by 30.2, 55.3 and 64.6%; grain yield by 45.0, 77.5 and 80.0% and stover yield by 33.6, 67.2 and 70.1% as compared to control, respectively. Surface soil and sub-soil contributed 80.6 and 19.4% towards grain yield and 70.1 and 29.9% towards stover yield, respectively. Maximum plant height, stover and grain yield was recorded with application of 120 kg N/ha. Nitrogen addition compensated relatively more towards the stover yield than that of grain. Simulated erosion significantly decreased N, P and K uptake in rapeseed. Removal of 5, 10 and 15 cm surface soil resulted in a decrease of 41.2, 75.0 and 79.6% in N uptake; 41.0, 77.0 and 82.1% in P uptake and 43.7, 75.1 and 80.8% in K uptake, respectively over control. Conversely, addition of fertilizer N on eroded soil caused an increase in N, P and K uptake by the crop. Addition of 40, 80 and 120 kg N/ha caused an increase of 45.8, 79.4 and 100.9% in N uptake; 33.3, 91.7 and 116.7% in P uptake and 55.6, 100.0 and 126.4% in K uptake, respectively over control. The contribution of surface soil towards the N, P and K uptake in rapeseed was more (79.6, 82.1 and 80.8%, respectively) than the sub-soil (20.4, 17.9 and 19.2%, respectively).
Key words : N, P and K uptake, Simulated erosion, Desurfaced soil, Eroded soil.

Water erosion is one of the main processes of land degradation in North Eastern region of India. The loss of surface soil in erosion causes considerable changes in physical, chemical and biological properties of the soil. Erosion adversely affects soil conditions that influence plant growth. 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 impact of erosion is likely to be more pronounced in shallow hill soils. The combined effect of erosion induced on-site changes brings about a significant reduction in the crop production and land quality. The surface feeding crops are likely to be affected the most in eroded soils. The major off-site effects with which erosion is linked include 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 thus agronomic, environmental and socio-economic. It is therefore imperative that need based soil and water conservation efforts are introduced in time both on the farm and off the farm in the interest of mankind.

On progressive erosion, sub-soil becomes a part of plough layer together with remaining surface soil and eventually may replace surface soil under severe erosion conditions. The removal of 15 cm of surface soil caused a reduction of 71.4% in soybean yield (grain + dry matter yield) (1) and 30.5% in yield of upland paddy (2). This suggested that the affect of erosion on crop performance is substantial and varied with the crop. The erosion induced crop production losses may or may not be compensated through additional input of fertilizers and manures. The effectiveness of nitrogen fertilizers on residual surface soil may be lower as compared to uneroded soils. The effect of simulated erosion and N levels on the performance of rapeseed (*Brassica campestris* L. *var Toria*, Duth.) which is a surface feeder is not avail-

Table 1. Effect of simulated erosion and nitrogen levels on plant, stover and grain yield.

Simulated erosion rates (cm of soil depth removal)	Doses of N (kg/ha) 0	40	80	120	Mean
Plant Height (cm)					
0	27.0	28.1	30.1	30.7	29.1
5	13.1	17.8	23.5	26.9	20.3
10	5.8	14.4	14.8	16.8	13.0
15	4.5	7.9	12.8	15.7	10.3
Mean	12.7	17.1	20.3	22.5	18.2
CD (P=0.05)	E=4.2		N=3.5		
Stover Yield (q/ha)					
0	11.9	14.1	14.3	14.5	13.7
5	5.3	8.4	10.7	12.0	9.1
10	2.9	4.1	4.9	5.7	4.5
15	2.6	3.6	4.7	5.3	4.1
Mean	5.7	7.6	8.6	9.4	7.8
CD (P=0.05)	E=2.2			N=2.4	
Grain Yield (q/ha)					
0	3.2	4.2	4.3	4.4	4.0
5	1.2	1.9	2.5	2.9	2.2
10	0.6	0.8	1.1	1.3	0.9
15	0.4	0.6	0.8	1.2	0.8
Mean	1.4	1.9	2.2	2.4	2.0
CD (P=0.05)	E=0.7			N=0.6	

able for Nagaland soils. Such information is necessary for developing crop production strategy on eroded soils.

Methods

A field experiment was conducted during *rabi* season of 2005 on loam soil at the School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema. The experiment was laid in split-plot design with three replications. Soil removal depth of 0, 0—5, 0—10 and 0—15 cm were used as main plots and nitrogen doses of 0.40, 80 and 120 kg N/ha were used as sub-plots. The texture of the surface soil of the experimental field was loam. The physico-chemical properties of original soil and resultant surface soil after removal of 5, 10 and 15 cm of surface soil of experimental site in detail have been reported else where (3). After desurfacing the soils to various depths manually, the sand, pH, organic C, available N, P and K levels in the resultant surface soils decreased whereas the silt and clay contents increased as compared to uneroded soils. Nitrogen was applied as urea together with 60 kg P_2O_5, as single super phosphate and 50 kg K_2O as muriate of potash per hectare at the time of sowing. Rapeseed variety M-27 was sown in 3.0 m × 2.7 m size plot with spacing of 30 cm between the rows using a seed rate of 5.0 kg/ha. Necessary plant protection measures were taken to protect the crop from insect pests and disease. 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.

Plant height was recorded at 30 days after sowing. At maturity stage, the stover and grain yield (g) of the sub-plot was recorded after oven drying the same to a constant weight and the data was used to estimate the stover and grain yield (q/ha), respectively. Plant and grain samples collected were analyzed for nitrogen, phosphorus and potassium content using standard procedures (4). Total N in grain and stover was estimated colorimetrically using Nessler's reagent (4) in H_2SO_4 and H_2O_2 digested plant materials. Both total P and K were determined in tri-acid digested grain and stover samples. The P was estimated colorimetrically and K was measured flamephotometrically (4). The yield (q/ha) and N, P and K content (%) of grain and stover was used to compute the uptake of these nutrients (kg/ha) by the crop. The N, P and K uptake data were used to evaluate the effect of surface soil removal and nitrogen levels on the uptake of these nutrients by rapeseed and also the contribution of surface soil (plough layer 0—15 cm) and sub-soil (soil below surface soil) towards the nutrients uptake. The uptake of any nutrient in control (uneroded) was considered a contribution of both surface soil and subsoil and was taken as 100%. The uptake of that nutrient after removal of top 0—15 cm of surface soil was taken as contribution of sub-soil. The difference between the uptake in control (100%) and sub-soil was taken as the contribution of surface soil towards the uptake of that nutrient. The difference between observed yield and expected yield on eroded soil when expressed as per cent yield of uneroded soil for nay dose of N was

Table 2. Effect of simulated erosion and nitrogen levels on the uptake of N, P and K (kg/ha).

Simulated erosion rates (cm of soil depth removed)	Doses of N (kg/ha) 0	40	80	120	Mean
N Uptake (kg/ha)					
0	25.2	32.6	35.8	37.6	32.8
5	9.3	17.2	23.7	27.0	19.3
10	4.9	6.9	9.4	11.4	8.2
15	3.5	5.6	7.8	10.4	6.7
Mean	10.7	15.6	19.2	21.5	16.7
CD (*P*=0.05)	E=5.4		N=5.1		
P Uptake (kg/ha)					
0	3.0	3.4	4.5	4.8	3.9
5	1.1	1.9	2.8	3.2	2.3
10	0.5	0.8	1.1	1.4	0.9
15	0.3	0.5	0.8	1.2	0.7
Mean	1.2	1.6	2.3	2.6	1.9
CD (*P*=0.05)	E=0.5		N=0.6		
K Uptake (kg/ha)					
0	16.8	23.9	27.5	29.6	24.5
5	6.5	11.8	17.5	19.6	13.8
10	3.4	5.3	6.7	8.9	6.1
15	2.2	3.7	5.8	7.1	4.7
Mean	7.2	11.2	14.4	16.3	12.3
CD (*P*=0.05)	E=3.2		N=3.6		

taken as per cent compensation of yield due to addition of that dose of N.

Results and Discussion

Effect on Plant Growth Parameters

Plant Height. Simulated erosion caused a significant reduction in plant height at all levels (Table 1). Maximum plant height (29.1 cm) was observed in control. Minimum plant height (10.3 cm) was however, recorded in treatment where 15 cm of surface soil was removed. The plant height decreased by 8.8, 16.1 and 18.8 cm as compared to control on removal of 5, 10 and 15 cm surface soil. This amounted to a decrease of 30.2, 55.3 and 64.6% in plant height, respectively. Plant height increased with the increase in N dose. The increase in plant height was computed to be 34.6, 59.8 and 77.2% on application of 40, 80 and 120 kg N/ha, respectively. These results are in agreement with those observed by Hussian et al. (2) in upland paddy. They reported that higher doses of N had a tendency to cause an increase in the height paddy plant. The interaction between erosion rates and N levels on the height of plant was not significant.

Stover Yield. The stover yield decreased significantly at all levels of simulated erosion when compared with control (Table 1). The stover yield decreased by 33.6, 67.2 and 70.1% (4.6, 9.2 and 9.6 q/ha, respectively) on the removal of 5, 10 and 15 cm of suface soil, respectively. Maximum stover yield (13.7 q/ha) was observed in control and minimum (4.1 q/ha) with simulated erosion rates of 15 cm. The addition of N caused a significant increase in stover yield at all levels except with 40 kg N/ha when compared with control. Addition of 80 kg N/ha did not cause a significant increase in stover yield as compared to 40 kg/ha. Application of 120 kg N/ha also did not cause significant increase in stover yield over 80 kg N/ha. Addition of 40, 80 and 120 kg N/ha caused an increased of 33.8, 52.1 and 66.2% in stover yield, respectively. Data analysis showed that addition of 40, 80 and 120 kg N/ha on an average could compensate 8.5, 16.7 and 22.0% towards the stover yield loss due to erosion. The interaction of simulated erosion rates and levels of N on stover yield was non-significant. Nitrogen being the essential nutrient for vegetative growth, its addition is expected to cause an increase in plant growth thereby producing more stover yield. Similar results have been observed earlier in upland paddy (2).

Grain Yield. The grain yield of rapeseed decreased significantly at all the levels of simulated erosion (Table 1). The maximum grain yield (4.0 q/ha) was recorded in control and minimum (0.8 q/ha) was observed on removal of 15 cm surface soil. The grain yield decreased by 45.0, 77.5 and 80.0% (1.8, 3.1 and 3.2 q/ha, respectively) on removal of 5, 10 and 15 cm of soil, respectively. Comparison of stover and grain yield showed that the per cent decreased in stover yield was less than the grain yields at all the levels of erosion. The decrease in grain yield due to erosion seems to be related to the the changes in soil fertility levels and other soil properties affecting plant growth. Similar findings have been reported by other investigators (2). Zhiete et al. (1) also showed that simulated erosion rates of 5, 10 and 15 cm caused a reduction of 18.2, 47.7 and 68.2%, respectively in grain yield of soybean. Addition of N caused a significant increase in rapeseed grain yield when applied at the rate of 80 and 120 kg N/ha. Addition of 40 kg N/ha did result an increase in yield but the effect was not significant. The data established that the grain yield increased by 35.7, 57.1 and 71.4% on addition of 40, 80 and 120 kg N/ha, respectively over control. The increase in yield on addition of 80 and 120 kg N/ha was 15.7 and 28.4%, respectively as compared to 40 kg N/ha. The yield increase was 10.9% on application of 120 kg N/ha over 80 kg N/ha. The data further established that addition of 40, 80 and 120 kg N/ha on an average could compensate 4.7, 11.2 and 17.2% towards grain yield, respectively. Interaction of simulated erosion rates and levels of N on grain yield did not cause significant effect. These findings are in accordance with the observations made earlier in upland paddy (2) and soybean (1). The increase in yield due to application of N might be due to favorable effect of N on growth and yield attributing components of the plant as N is a major structural constituent of the cell which plays an important role in grain formation and development and thus yield. None of the fertilizer N dose applied could compensate for the loss of grain yield due to removal of surface soil.

The data thus established that the reduction in plant height, stover and grain yield increased with the depth of soil removal. The reduction in stover and grain yield on removal of 10 cm and 15 cm of surface soil was not significant, however. This suggested that the effect of simulated erosion on these plant growth parameters reached its maximum at 10 cm of simulated erosion as further reduction in yield at 15 cm of erosion was marginal. This would be expected in a crop like rapeseed which is a surface feeder. The average reduction in stover and grain yield in rapeseed in desurfaced soils was estimated to be 67.5 and 57.0%, respectively. An in depth analysis of the yield data revealed that surface soil and sub-soil contributed 80.6 and 19.4% towards grain yield and 70.1 and 29.9% towards stover yield, respectively.

Effect of Erosion and N Levels on N, P and K Uptake

N Uptake. Table 2 showed that increase in the rates of simulated erosion caused a significant decrease in N uptake by rapeseed as compared to control. The highest N uptake (32.8 kg/ha) was recorded in control and lowest (6.7 kg/ha) was recorded where 15 cm of soil was removed. The data revealed that on removal of 5, 10 and 15 cm of surface soil, the N uptake in rapeseed was 58.8, 25.0 and 20.4% of control. The established that N uptake decreased by 41.2, 75.0 and 79.6% (13.5, 24.6 and 26.1 kg/ha, respectively) on removal of 5, 10 and 15 cm surface soil, respectively over control. Similarly, the N uptake decreased by 57.5 and 65.2% on removal of 10 and 15 cm, respectively over 5 cm surface soil removal. When compared with 10 cm simulated erosion, the N uptake decreased by 18.3% on removal of 15 cm surface soil. Addition of fertilizer N caused an increase in N uptake by plant (Table 2). The increase in N uptake however, was not significant at all levels of N application. Addition of 80 and 120 kg N/ha caused a significant increase (79.4 and 100.9%, respectively) in N uptake over control. Application of 40 kg N/ha did cause an increase (45.8%) in N uptake but the effect was not significant. Similarly addition of 80 kg N/ha did not cause a significant effect on N uptake when compared with 40 kg N/ha. However, application of 120 kg N/ha caused significant effect when compared with 40 kg N/ha. The interaction between simulated erosion and N levels did not cause significant effect on the uptake of N by the crop.

P Uptake. The data revealed that simulated erosion caused a significant reduction in P uptake by rapeseed at all the levels when compared with control (Table 2). Similarly, simulated erosion rates of 10 and 15 cm caused a significant decrease in P uptake when compared with 5 cm. However, 15 cm of surface soil removal did not cause any significant decrease in the uptake of P when compared with 10 cm. Highest P uptake (3.9 kg/ha) was recorded in control and lowest (0.7 kg/ha) where 15 cm of soil was removed. On removal of 5, 10 and 15 cm of surface soil, the p uptake was 59.0, 23.0 and 17.9% of control. The data thus established that these rates of simulated erosion caused a reduction of 41.0, 77.0 and 82.1% (1.6, 3.0 and 3.2 kg/ha, respectively) in P uptake, respectively as compared to control. Further, removal of 10 and 15 cm caused a decrease of 60.9 and 69.6%, respectively as compared to 5 cm of surface soil removal. When compared with 10 cm of soil removal, the P uptake decreased by 22.2% on removal of 15 cm surface soil.

The data also revealed that increase in levels of N addition did cause an increase in P uptake by the plants. However, the increase in P uptake was not significant at all levels of N application. Addition of 80 and 120 kg N/ha caused significant increase in P uptake as compared to both control and 40 kg N/ha. However, the application of 40 kg N/ha did not cause any significant increase in uptake of P when compared with control. Similarly, addition of 120 kg N/ha did not cause any significant increase in P uptake as compared to 80 kg N/ha. Application of 40, 80 and 120 kg N/ha caused an increase of 33.3, 91.7 and 116.7%, respectively in P uptake as compared to control. Similarly, addition of 80 and 120 kg N/ha caused an increase of 43.7 and 62.5% as compared to 40 kg N/ha. The interaction effect between simulated erosion and N levels did not cause significant effect on the uptake of P by rapeseed.

K Uptake. The data showed that K uptake in rapeseed decreased with the increasing rates of simulated erosion and the effect was significant at all the levels when compared with control. Maximum K uptake (24.5 kg/ha) was recorded in control which was higher than the uptake (4.7 kg/ha) recorded in treatment where 15 cm of soil was removed. Similarly, simulated erosion rates of 10 and 15 cm caused a significant decrease in K uptake as compared to 5 cm. However, 15 cm of soil removal did not result any significant reduction in K uptake as compared with 10 cm of simulated erosion rate. Further, on removal of 5, 10 and 15 cm of surface soil, the K uptake was 56.3, 24.9 and 19.2% of control. The K uptake thus decreased by 43.7, 75.1 and 80.8% (10.7, 18.4 and 19.8 kg/ha, respectively) on removal of 5, 10 and 15 cm surface soil, respectively as compared to control. Similarly, on removal of 10 and 15 cm surface soil, K uptake decreased by 55.8 and 66.0%, respectively as compared with 5 cm surface soil removal. Removal of 15 cm surface soil resulted in a reduction of 23.0% in K uptake when compared with 10 cm surface soil removal. The data showed that the K uptake by the crop increased significantly with increase in N dose at all levels when compared with control. Addition of 120 kg N/ha caused a significant increase in K uptake as compared to 40 kg N/ha. However, addition of 80 kg N/ha did not cause any significant effect in K uptake as compared to 40 kg N/ha. Likewise, addition of 120 kg N/ha did not cause any significant effect on the uptake of K when compared with 80 kg N/ha. The K uptake on addition of 40, 80 and 120 kg N/ha increased by 55.6, 100.0 and 126.4%, respectively over control. The interaction between simulated erosion and N levels on K uptake by the crop was not significant.

The reduction in N, P and K uptake in rapeseed on the removal of surface soil might be related to the changes in physico-chemical properties, low nutrient availability and lack of proper plant growth conditions in resultant surface soil affecting plant growth adversely (1, 3). The combined effect of low infiltration, high bulk density, less pore space to hold water for plant use and low fertility and organic carbon content after the removal of surface soil are likely to affect crop performance and nutrient uptake adversely. Zhiete et al. (1) reported that erosion significantly decreased N, P and K uptake by soybean crop and addition of fertilizer N, on the contrary caused an increase in N, P and K uptake. Wessies et al. (5) showed that rooting zone nutrient and organic matter content and water holding capacity are greatly reduced due to erosion. Soil structure and clay content also changed. These effect are due to soil loss and reduction in the depth of topsoil. These erosion induced changes bring about significant reduction in soil fertility and other soil conditions that affect plant growth adversely. Consequently both the quality of soil and its production potential are reduced.

Addition of N in eroded soils caused an increase in N, P and K uptake by rapeseed at all levels (Table 1). The increase in uptake of these nutrients on addition of fertilizer N appears to be a combined effect of higher N, P and K availability and favorable increase in grain and stover yield resulting in higher utilization of N, P and K by the crop plants. The increase in N, P and K uptake due to N application has also been reported by Biswas et al. (6). The increase in vegetative growth on addition of fertilizer N might be expected due to its favorable effects. N is one of the most essential nutrients which enhances vegetative growth (7) and plays an important role in plant growth and grain formation and development. The increase in P uptake as influenced by N addition may be due to the ability of N to increase cation exchange capacity of roots and causing maximum proliferation of root mass in a specified area and thereby resulting relatively more efficient absorption of P. Such observations have been made earlier by Kanwar (8). The increase in K uptake may be due to increase in dry matter production by plants on addition of N influencing the availability and utilization of K and other nutrients considerably and thereby resulting higher nutrient uptake. Similar effect of the added fertilizer N in increasing available N, P and K levels in desurfaced soils has also been reported earlier (9).

Analysis of the data established that average reduction in N, P and K uptake in rapeseed in eroded soils was 65.3, 66.7 and 66.5%, respectively. On removal of 5, 10 and 15 cm of surface soil, N uptake decreased by 41.2, 75.0 and 79.6%; P uptake by 41.0, 77.0 and 82.1% and K uptake by 43.7, 75.1 and 80.8% as compared to control, respectively. The data led to conclude that N, P and K uptake in rapeseed in eroded soils was severely reduced when simulated erosion rates exceeded 5 cm. The implication of this is that the cultivation of rapeseed should be confined to least eroded soils. The data further revealed that the contribution of surface soil towards N, P and K uptake in rapeseed was more (79.6, 82.1 and 80.8%, respectively) than the sub-soil (20.4, 17.9 and 19.2%, respectively). The higher contribution of surface soil towards N, P and K uptake in rapeseed which is a shallow rooting crop and thereby a surface feeder, is expected. Thus apart from soil fertility and plant growth conditions, contribution of surface soil and sub-soil towards N, P and K uptake could also be influenced by crop characteristics.

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