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Effect of seasonal variation on soil enzymes activity and fertility of soil in paddy fields of North Vanlaiphai, Mizoram, India

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For sustainability in agricultural productions, familiarity of soil quality and manual improvement to create the best possible growing environment for plants are extremely important. In this study the quality of soil of a paddy field in North Vanlaiphai was investigated with respect to the change in seasons throughout the year. A total of five (5) soil samples were selected from various places of the paddy field, and soil fertility indicators such as pH, total soil nitrogen (N), available phosphorus (Pav), exchangeable potassium (Kex), soil organic carbon (SOC), soil organic matter (SOM) and soil enzymes *viz.* dehydrogenase, phosphatase and urease were analyzed using standard protocols. All the parameters except available phosphorus and exchangeable potassium were found to be highest during rainy season whereas lowest in summer.

Key words: Soil enzymes, physico-chemical properties, soil fertility.

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Introduction

In context of sustainable agricultural production, soil testing is very important as it provides the conditions of available nutrients which indicates the fertility and productivity of the soils.[1] Nitrogen, phosphorus, potassium are important elements that dictate its fertility and yields of the crops.[2] Agricultural lands are multifunctional, providing a range of regulating, supporting and cultural ecosystem services in addition to food, fodder, fuel and fibre. This 'underscores the need to manage agricultural areas as multifunctional systems... not as ecological sacrifice zones'.[3]

Soil fertility is the capacity of a soil to supply essential plant nutrients in adequate amounts to facilitate optimum growth and production of a crop. Typically, inorganic nutrients such as N, P and C are usually found at high concentration due to the anthropogenic influence (e.g. fertilization, wastewater, agricultural procedures).[4] It was observed that the nutrient concentration changes along the crop cycle, very much related to the agricultural techniques used in the rice-fields as well as with the sediment status. Soil fertility and quality play a pivotal role in achieving the promising yield of the crops. However, unless properly managed, soil fertility as well as quality decline drastically with intensive farming. Maintenance of soil fertility is therefore very important for sustaining high yields of vegetation. In this line, a soil test can be an important management tool in developing an efficient soil fertility program and monitoring a field for potential soil and water management problems. A soil test provides basic information on the nutrient supplying capacity of the soil. The objective of this paper was to analyze the trend in fertility status of a paddy field of North Vanlaiphai, Mizoram with respect to seasonal variations.

Soil enzymes increase the reaction rate at which plant residues decompose and release plant available nutrients. The enzymatic reaction releases a product, which can be a nutrient contained in the substrate. Sources of soil enzymes include living and dead microbes, plant roots and residues, and soil animals. Enzymes stabilized in the soil matrix accumulate or form complexes with organic matter (humus), clay, and humus-clay complexes, but are no longer associated with viable cells. Enzymes respond to soil management changes long before other soil quality indicator changes are detectable. Soil enzymes play an important role inorganic matter decomposition and nutrient cycling. Some enzymes only facilitate the breakdown of organic matter (e.g., hydrolase, glucosidase), while others are involved in nutrient mineralization (e.g., amidase, urease, phosphatase, sulfates). The relationship may be indirect considering nutrient mineralization to plant available forms is accomplished with the contribution of enzyme activity.

Methodology

Analysis of soil physico-chemical parameters

Soil pH, bulk density, water holding capacity and soil moisture content was determined by using the method of Bashour and Sayegh[5]. Soil organic carbon, total soil nitrogen, available phosphorus was estimated by the method described by Walkley and Black[6], Jackson *et al.*[7] and Olsen *et al.*[8] respectively. Soil enzymes, dehydrogenase, Phosphatase and urease were determined by using the method of Casida *et al.*[9] Tabatabai *et al.*[10] and Mc Garity *et al.*[11], respectively.

Statistical analysis

All data are presented as means of three replicates with standard error. Differences between variables were tested with standard one-way analysis of variance (ANOVA), significant differences existed in all the parameters except parameter 3 that is Bulk density (**Table 4**). Differences were considered as significant at $P < 0.05$ levels. The statistical analyses were performed using SPSS software (Standard release version 16 for windows, SPSS Inc., IL, USA).

Results and Discussion

Soil parameters were studied in different seasons of the year *viz*. rainy season, winter and summer. Results showed that all the soil parameters varied under the influence of seasonal variations (**Table 1 & 2**). The pH of the soil found to be lowest in rainy season (4.7), followed by winter and highest in summer (5.29). Decreased pH during rainy season may be due to decomposition of organic matter which releases organic acids leading to leaching of bases under prevailing high rainfall.[12-13] Soil organic carbon; soil organic matter and total soil nitrogen were highest during rainy season. During this study period, amount of nitrogen in kg ha^{-1} followed the order rainy season (0.27)>winter (0.17)>summer (0.14). When soil is warm and moist, decomposition proceeds rapidly and nitrogen released from

Table 1 | Soil physical properties.

Soil properties	Rainy season	Winter	Summer
Temperature (˚C)	25.27 ± 0.08	19.33 ± 0.23	25.97 ± 0.22
Moisture Content (%)	77.8 ± 2.90	46.65 ± 1.81	8.03 ± 0.11
Bulk Density (gm/cm^3)	0.91 ± 0.02	1.05 ± 0.02	1.03 ± 0.03

Table 2 | Soil chemical properties.

Soil properties	Rainy season	Winter	Summer
Soil pH	4.7 ± 0.01	4.87 ± 0.07	5.29 ± 0.00
Soil organic carbon (%)	2.86 ± 0.04	1.34 ± 0.00	1.02 ± 0.03
Soil organic matter (%)	4.93 ± 0.08	2.31 ± 0.00	1.76 ± 0.06
Total soil nitrogen (%)	0.27 ± 0.00	0.17 ± 0.00	0.14 ± 0.00
Available phosphorus (kg/ha)	3.96 ± 0.04	4.23 ± 0.02	3.64 ± 0.05
Exchangeable potassium (kg/ha)	136.38 ± 3.05	135.43 ± 1.24	151.3 ± 1.11

Table 3 | Soil enzyme activity.

Enzymes	Rainy season	Winter	Summer
Dehydrogenase (µg TPF/gm dry soil/24hrs)	0.81 ± 0.06	0.13 ± 0.00	0.09 ± 0.00
Phosphatase (µg p-NPP/gm dry soil/hr)	89.86 ± 1.70	49.36 ± 1.34	48.73 ± 0.78
Urease ($NH4^{+}$-N/ml/3hrs)	1.10 ± 0.01	0.84 ± 0.00	0.56 ± 0.00

Table 4 | One-way analysis of variance (ANOVA).

Sl. No.	Parameters	Source of variance	f-value	p-value
1	Soil temperature	Rainy season X Winter X Summer	178.4229*	.000005*
2	Soil moisture content	-do-	156.0891*	.000007*
3	Bulk density	-do-	3.5191	.097453
4	Soil pH	-do-	21.9284*	.001743*
5	Soil organic carbon	-do-	382.6270*	.000000*
6	Soil organic matter	-do-	388.1868*	.000000*
7	Total soil nitrogen	-do-	259.4000*	.000001*
8	Available phosphorus	-do-	27.4648*	.000955*
9	Exchangeable Potassium	-do-	9.7898*	.012905*
10	Dehydrogenase	-do-	125.4613*	.000013*
11	Phosphatase	-do-	227.8959*	.000002*
12	Urease	-do-	533.4444*	.000000*

crop residues may be significant, but when soil is cold or very dry, nitrogen released may be lesser.[14]

Percentage of soil organic carbon and soil organic matter followed the order rainy season (2.86 and 4.93)>winter (1.34 and 2.31)>(1.02 and 1.76), respectively. Soil carbon content is positively correlated with soil organic matter.[15] Low level of phosphorus and potassium may be attributed to removal of crop residues and grazing of livestock,[16] leaching from poor sandy soil,[17] and due to high rainfall.[18]

Soil enzymes showed the same trend in our data (**Table 3**), highest in rainy season and lowest during summer. Soil enzymes have varying optimum pH and temperature at which they function most efficiently. Their structure and substrate binding ability can be altered by heat and extreme cold temperature. The activity of many soil enzymes often correlates with soil moisture content, drought may suppress enzyme activity. Chhonkar *et al.*[19] described positive correlation of phosphates activity with soil organic carbon and negative correlation with soil pH. Soil enzymes activity can be related to soil organic matter and total soil nitrogen.[20-21] All these features could be attributed to the increased amount of enzyme activity during rainy season and decreased rate during summer.

Conclusion

The comparative study of biochemical and physico-chemical properties of N. Vanlaiphai paddy field soil during the three seasons' *viz.* rainy, winter and summer, showed significance ($p<0.05$) variation among all the parameters except bulk density. It t is assumed that different seasonal pattern has effect on biochemical and physico-chemical properties of the soil.

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