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Correlations of Available Phosphorus and Potassium with Soil pH and Organic Matter Content at Different Soil Reactions Categories in Soils of Western Development Region, Nepal

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Abstract: In the year, 2011-2012 altogether 695 soil samples were taken from western development region of Nepal to analyze phosphorus, potassium, organic matter content and soil pH. From those samples, randomly 100 samples were selected in such a way that 25 samples were taken from each soil reaction classes (strongly acidic, slightly acidic, neutral and alkaline soils). For each soil reaction class, the mean of available phosphorus, available potassium, organic matter content and pH were calculated. In addition, the simple linear correlations between available phosphorus- organic matter, available potassium - organic matter, available phosphorus- pH, available potassium- pH and organic matter- pH were calculated for all the soil classes. The significance of the simple linear correlation was tested under 0.05 and 0.01 level of significance. The study revealed that the correlation of the available phosphorus to the organic matter content of the soil decreased in the order of neutral to slightly acidic to strongly acidic to alkaline soils. It is highly significant in neutral soils, while it is significant in slightly and strongly acidic soils. However, it is non- significant in alkaline soils. The correlation of available potassium to the organic matter content of the soil decreased in the order of neutral to slightly acidic to alkaline to strongly acidic soil. It is highly significant for neutral and significant for slightly acidic soils. However, it is non-significant for alkaline and strongly acidic soils. There is not any significant correlation of soil pH with available phosphorus and available potassium.

Key words: Soil, phosphorus, potassium, organic matter, pH, available

INTRODUCTION

Soil pH is one of the determining factors in the plant nutrient availability in the soil. The pH of cultivable soils varies from 4 to 8 in different soils[1]. The necessary range of soil pH is 5.5 to 7.0 for the proper growth and development of most of the plants[2]. Most of the plant nutrients are available at slightly acidic to slightly alkaline soil (pH 6.5 to 7.5). Several plant nutrients are unavailable at very strongly acidic or very strongly alkaline soil. This is due to the various reactions in the soil that fix the nutrients and convert them to the form that is unavailable to the plants[3].

Organic matter is one of the major components of the agricultural soil. In the agricultural soil, the organic matter content varies from 0.1 to 30 percent. In a mineral soil, its content is up to 5 percent, while in the organic soil it may be up to 30 percent[4].

Soil organic matter plays key role to maintain soil fertility and productivity. The effect of the organic matter may be either direct or indirect. Organic matter acts directly as a source of plant nutrients and indirectly influences the physical and chemical properties. Increasing the organic matter content in the soil enhances the plant nutrients availability and helps to improve its physical and chemical properties. The aim of this study is to study the correlations of the soil pH and organic matter content to the phosphorus and potassium availability in the soil at different soil reactions.

METHODS

Location: The study site is the western development region of Nepal. It lies between 82.71˚E to 85.13˚E longitude and 27.34˚N to 29.98˚N latitude and occupies the area about 29465 sq km. It is about 20% of the total area of the country. The area divided into three physiographic regions, such as plains (15 %), mid hills (80%) and high hills (5%). The plains are hot with little rainfall, while the mid hills are warm with heavy rainfall and the high hills are cool with very little rainfall.

Soil Sampling: The soil sampling done by taking the soil from the top soil to the depth of 20cm throughout the year (July 2011 to July 2012). A total of 695 soil samples were collected from three different physiographic regions of Western Development Regions of Nepal and were analyzed in the soil testing laboratory. From these samples, 100 samples randomly selected for the study. Among them 5, 85 and 10 samples were collected from high hills, mid hills and plains respectively. The category of different soil reactions selected and number of samples under each category shown in **Table-1** and the range of the soil parameters under study shown in **Table-2.**

Table-1: The selected category of soil reactions

S.No.	Categories of soil reaction (pH)	Number of samples taken
1	Strongly acidic (<5.6)	25
2	Medium to slightly acidic (5.6-6.4)	25
3	Slightly acidic to slightly alkaline/Neutral (6.5-7.5)	25
4	Alkaline(> 7.5)	25
Total no. of soil samples taken		100

Table- 2: Range of the soil parameters under study

Soil parameters	Strongly acidic	Slightly acidic	Neutral	alkaline
pH	4.30-5.50	5.60-6.40	6.50-7.50	7.60-8.80
OM (%)	2.90-6.60	1.20-7.10	0.90-7.10	0.37-0.57
P_2O_5 (kg ha^{-1})	3.00-2748.00	3.00-3503.00	1.00-3052.00	1.00-132.00
K_2O (kg ha^{-1})	10.00-408.00	7.00-552.00	24.00-1128.00	24.00-504.00

Soil analysis: The soil analysis was done using the following methods as mentioned by Pradhan[5].

1. Soil Reaction was recorded using electrode pH meter.
2. Organic matter was analyzed using Black and Waley's method.
3. Phosphorus determined by Modified Olsen's bicarbonate method.
4. Potassium reading done by using flame photometer after the nutrient extracted from the soil using ammonium acetate.

After the soil analysis, the mean values on organic matter content, available phosphorus content and the available potassium content were classified into low, medium and high as the classification given in **Table 3.**

Table-3: Classification of OM, phosphorus and potassium content in the soil[5]

Soil parameters	Low	Medium	High
OM (%)	< 2.5	2.5-5.0	> 5.0
P_2O_5 (kg ha^{-1})	< 31	31-55	>55
K_2O (kg ha^{-1})	< 110	110-280	>280

Statistical analysis: The linear correlation of the nutrients (phosphorus and potassium) with organic matter content and pH of the soil were calculated within four different soil reactions categories separately using excel worksheet and their significance were tested at 0.05 and 0.01 level of probability at n-2 degree of freedom as in Gomez and Gomez[6].

The mean for the pH, organic matter content and available nutrients (phosphorus and potassium) contents of the different categories of the soil under the study were also calculated and compared.

RESULTS AND DISCUSSIONS

Organic matter content in the soil: The range of organic matter content is medium to high in strongly acidic soils but it is low to high in rest of the soil reactions (**Table- 2).** The mean organic matter content is highest (4.390 ± 0.234) in strongly acidic soil and it decreases as the soil pH increases and become lowest (2.040 ± 0.196) in alkaline soil (**Table- 4**). It is medium in all the soil reactions except the alkaline soils that is low in organic matter content.

Table-4: Means of different parameters of four different soil reaction class

Soil parameters	Strongly acidic	Slightly acidic	Neutral	alkaline
pH	5.132 ± 0.072	5.992 ± 0.047	6.944 ± 0.067	7.892 ± 0.700
OM (%)	4.390 ± 0.234	3.750 ± 0.371	3.380 ± 0.341	2.040 ± 0.196
P_2O_5 (kg ha^{-1})	401.000 ± 114.257	346.000 ± 161.183	357.000 ± 155.762	23.000 ± 5.079
K_2O (kg ha^{-1})	107.000 ± 19.959	191.000 ± 29.953	243.000 ± 60.737	79.000 ± 18.771

Available phosphorus content in the soil: The range of the available phosphorus is low to high in all the soil reactions **(Table- 2**). The mean available phosphorus is highest (401.000 ± 114.257) in strongly acidic soil while it is lowest (2.040 ± 0.196) in the alkaline soil (**Table - 4).** The phosphorus availability is higher in neutral soil than in the slightly alkaline soil. The available phosphorus in high in all the soil reactions but in the alkaline soil it is low.

Lower the pH, more available are the metallic ions, especially Mn, Fe and Al. These elements then combine with soluble P and form insoluble compounds[7]. But in this experiment the phosphorus availability is increased from slightly acidic to strongly acidic soil due to the increase in organic matter content of the soil, which on decomposition produces various organic acids, which solubilize phosphates and phosphate bearing minerals[8].In the alkaline soil the availability is low as the available phosphorus reacts with calcium to form calcium phosphate and also the organic matter content in the soil is low due to the lower microbiological activities in the alkaline soil[9].

Available potassium content in the soil: The range of available potassium is low to high in rating in all the soil reactions **(Table - 2).** The mean value on potassium availability is the highest (243.000 ± 60.737) in the neutral soil and is the lowest (79.000 ± 18.771) in alkaline soil **(Table - 4).** It is lower in strongly acidic soil than in the slightly acidic soil. The available potassium is medium in neutral and slightly acidic soil whereas it is low in strongly acidic and alkaline soils.

The potassium content decreases with the decrease in soil pH from neutral to slightly acidic and strongly acidic in reaction. It also decreases as soil pH increases from neutral and becomes alkaline.

Correlations of organic matter content with phosphorus and potassium availability in soil at different soil reactions: The correlation coefficient for organic matter content and phosphorus is highly significant (r = 0.619**) for neutral soil. It is significant for slightly acidic (r = 0.474*) and strongly acidic (r = 0.443*) soil. But it is non-significant (r = - 0.012) for alkaline soil (**Table-5**). It is highest at neutral soil and it decreases as soil become slightly acidic and become even less in strongly acidic soil. It also decreases as soil pH increases and soil becomes alkaline. The correlation coefficient is lowest and negative in the alkaline soil.

The correlation coefficient for organic matter content and potassium is highly significant (r = 0.725**) for neutral soil. It is significant (r = 0.397*) for slightly acidic soil. But it is non-significant for strongly acidic (r = - 0.386) and alkaline (r = 0.229) soil **(Table-5).** It is highest at neutral soil and it decreases as soil become slightly acidic and become even less in strongly acidic soil. It also decreases as soil pH increases and soil becomes alkaline. At strongly acidic soil, the correlation coefficient is negative and at alkaline soil it is positive but the value is higher for strongly acidic than alkaline soil. The correlation of organic matter to available phosphorus and available potassium were similar to the results of Singh and Misra[10] & Kapkiyai *et al.*[11].

Table- 5: Simple linear correlations among different soil parameter within different soil reaction classes

Soil parameters	Strongly acidic	Slightly acidic	Neutral	alkaline
P_2O_5-OM	0.443*	0.474*	0.619**	-0.012
K_2O-OM	-0.386	0.397*	0.725**	0.229
P_2O_5-pH	0.250	-0.099	-0.310	-0.222
K_2O-pH	0.002	0.072	-0.350	-0.180
OM- pH	-0.182	-0.173	-0.363	-0.010

Note: ** means significant at 0.01 level of probability and * means significant at 0.05 level of probability at n-2 d.f. where n is the sample size

Correlations of soil pH with phosphorus and potassium availability in soil at different soil reactions: The correlation of soil pH with available phosphorus is non-significant at all the soil reactions (**Table - 5**). It is negative in all the classes except at strongly acidic soil. The value is the highest(r = - 0.310) in neutral while it is the lowest (r = - 0.099) in slightly acidic soil. The value is higher in strongly acidic than in the alkaline soil.

The correlation of soil pH with available potassium is also non-significant at all the soil pH (**Table-5).** It is positive in strongly acidic and slightly acidic soil. But it is negative in neutral and alkaline soil. The value is the highest (r = -350) in neutral soil and the lowest (r = 0.002) in the strongly acidic soil. But the correlation is higher in alkaline soil than in the slightly acidic soil. As the correlations remain non-significant then no specific relationship is existed between them. The finding is similar to the works of Chaudhari *et al*.,[12].

Correlations of organic matter content with soil pH at different soil reactions: The correlation coefficient of the organic matter with the soil pH is negative and non-significant at all the soil reaction classes (**Table-5).** It is the highest (r = - 0.363) in neutral soil while it is the lowest (r = - 0.010) in alkaline soil. The correlation coefficient is higher in strongly acidic soil than in slightly acidic soil. The finding is similar to the results of Jilkova and Frouz [13].

CONCLUSIONS

The following conclusions were derived from the study of selected soil samples from Western Development Regions, Nepal.

1. The soil organic matter increased with the decrease in soil pH.
2. The available phosphorus content of the soil is the highest in strongly acidic soil while it is lowest in the alkaline soil.
3. The available potassium content of the soil is highest in the neutral soil while it is lowest in the alkaline soil.
4. The correlation of the available phosphorus to the organic matter content of the soil decrease in the order of neutral to slightly acidic to strongly acidic to alkaline soils. It is highly significant in neutral soils, while it is significant in slightly and strongly acidic soils. But it is no significant in alkaline soils.
5. The correlation of available potassium to the organic matter of the soil decrease in the order of neutral to slightly acidic to alkaline to strongly acidic condition. It is highly significant for

neutral and significant for slightly acidic soils. But it is non significant for alkaline and strongly acidic soils.

6. There is not any significant correlation of soil pH with available phosphorus and available potassium. But the correlation is positive between soil pH and available phosphorus in case of strongly acidic soil while it is negative in rest of the soil reactions. The correlation is positive between soil pH and available potassium in strongly acidic and slightly acidic soils but it is negative in neutral and alkaline soils.
7. The correlation coefficient between soil pH and organic matter is non significant and negative in all the soil reactions. But the value is highest in neutral soil and lowest in alkaline soils.

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