ASSESSMENT OF THE RELATIONSHIP BETWEEN SOIL PH AND MACRONUTRIENTS AT BASESHWOR, SINDHULI

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ABSTRACT

Macronutrients are the nutrients required by plants in relatively large amount. Nutrients availability is dependent on soil reaction, which is one of the most important chemical parameters. This study was carried out in Baseshwor area of Sindhuli District to determine the relationship between soil pH and soil macronutrients: total Nitrogen, available Phosphorus, exchangeable Potassium, extractable Calcium, and extractable Magnesium. A total of 30 representative soil samples was collected from the Baseshwor area and were analyzed following the standard procedures. A simple linear correlation and regression were performed by using MS EXCEL to compute the relationship between soil pH and the macronutrients. The result showed that there was a significant positive correlation between soil pH and total N (r=0.7310*), available phosphorus(r=0.6466*), extractable potassium (r=0.5569*), extractable Ca (r=0.6088*) and extractable Mg (r=0.5945*). Similarly, with the increase by one unit in soil pH; total N, available Phosphorus, exchangeable potassium, calcium, and magnesium increased by 0.3123, 72.29, 528.32, 906.37, and 108.42 units, respectively. It was also found that pH accounted for the change in about 53.4%, 41.8%, 31.0%, 37.1%, and 36.4% N, P, K, Ca, and Mg, respectively. Since most of the nutrients are available in the optimum pH range (6.5-7.5), maintenance of optimum soil pH is necessary for tackling the problems of unavailability of macronutrient from the soil in Baseshwor area, Sindhuli.

Keywords: *chemical parameters, correlation, exchangeable potassium, regression*

INTRODUCTION

Soil is a natural dynamic body formed and developed by natural forces acting on natural materials. It is usually differentiated into horizons from mineral and organic constituents of variable depth which differ from the parent material below in morphology, physical properties and constituent, chemical properties, composition, and biological characteristics (Davidson, 1992). The information on soil characteristics, classification, location, and distribution, is required for the soil based development planning in a particular area. Soil is the most important resource required for agriculture development, and is the most valuable natural resource too (Kanwar, 2000). Soils are an integral part of the landscape and their characteristics are largely governed by landscape in which they are developed. The systematic study of chemical properties and taxonomy of soil provides information on the nature and type of soil and their opportunities and constraints. Topographic maps, aerial photographs, and remote sensing data serve as important tools for geomorphologic analysis of the area and are useful in soil survey and mapping. The evaluation of soil fertility is perhaps the most basic decision-making tool for balanced and efficient nutrient management (Iftikar et al., 2009). It consists of estimating the available nutrients in the soil required for crop production. There are various techniques for soil fertility evaluation, among them soil testing is the most widely used tool for making balanced and profit-maximizing fertilizer recommendations, particularly for field crops. Chemical properties of soil are of paramount importance while considering the nutrient supplying capacity of soil to plant. It is therefore, an assessment of soil chemical properties should be carried out in order to make the best use of soil for crop production Soil tests need to be done at least once in three years (DOA, 1999); and it is also necessary to manage the soil by knowing the present soil fertility status and adopting the required management practices. This study might help for appropriate land use planning and also for crop zonation.

Nitrogen, phosphorus, potassium (primary elements), calcium, and magnesium (secondary elements) are important elements for plant growth, which are required in larger amounts and are called as macronutrients. Most of the soils supply enough calcium and magnesium whereas the other three elements nitrogen, phosphorous, and potassium are not usually available in large amounts for best crop growth and therefore, are added through fertilizers. The availability of macronutrients is highly dependent on soil pH as is the survival and activity of the microbes. Therefore, this study was conducted to determine the relationship between soil pH and macronutrients in Baseshwor, Sindhuli.

MATERIALS AND METHODS

Site description

The study was conducted at Baseshwor village located in Sindhuli District, Bagmati Province. Sindhuli is one of the major areas where Junar (Sweet Orange i.e *Citrus sinensis var. junar*) is produced on a large scale and is one of the major areas of the current Junar Super Zone of Nepal under the newly launched Prime Minister Agriculture Modernization Project (PMAMP). Sindhuli District is situated between 26° 55' to 27° 22' North Latitude and 85° 15' to 86° 25' East Longitude. This district is elevated from 168-2785 meters above the mean sea level whereas the elevation of Baseshwor ranges from 391-1702 meters. According to the district profile of Sindhuli, the climate of the study area is predominantly subtropical and suitable for growing a wide range of crop and fruit species. The geology of the study area is strongly reflected in its physiographic and the formation of rock strongly comprises the East-West along the length of the district. The soil is formed from acidic parent materials. The cropping system of irrigated land is rice-wheat-maize, rice-lentil-rice, rice-mustard-rice, rice-wheat, etc. whereas the cropping system of unirrigated upland is maize-millet, maize-soybean, maize-mustard, maize-buckwheat, etc.

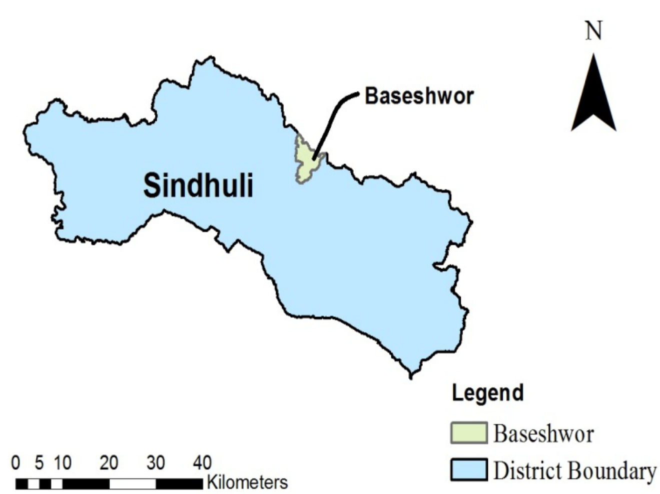

Fig 1: Sindhuli District showing Study area (Baseshwor)

Soil sampling

Preliminary work on the study of the map regarding road, river, land system, land cover was done before the filed visit. Google Earth was used to separate 30 different polygons in the base map of Baseshwor. These polygons were cut by analyzing different land systems, cropping patterns, land cover by using Google Earth. A total of 30 soil samples were collected using a soil auger from 0-15 cm depth from the cultivated land of respective polygons of the village. Garmin GPSMAP 62 series was used to record the co-ordinate of the sampled spot. Dead plants, furrow, old manures, wet spots, and the areas near compost pit were excluded during soil sampling. This was done to minimize the differences, which may arise because of the dilution of soil organic matter due to mixing through cultivation and other factors. The composite soil samples collected from representative fields were then put in polythene bags and numbered with distinct markings.

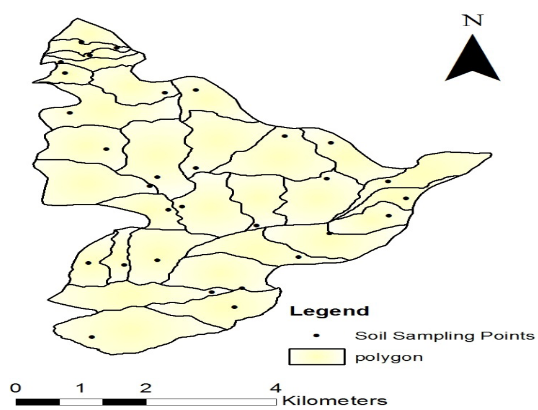

Fig 2: Map showing soil sampling points

Laboratory Analysis

The collected soil sample was then brought to Agriculture Technology Center (ATC) for chemical analysis. ATC is a private soil lab situated at Kupondol, Lalitpur. Standard laboratory procedures were followed in the analysis of the selected physicochemical properties in the study. The soil samples were air-dried and passed through a 2mm sieve for the analysis. The physical and chemical properties of the soil and the methods adopted for analysis are presented in Table 1.

Table 1. List of methods used in soil test for different soil parameters

SN	Parameters	Unit	Methods
1.	Soil texture		Hydrometer (Bouyoucos, 1962)
2.	Soil color		Munsell color chart
3.	Soil structure		Field feel
4.	Soil pH		Potentiometric 1:2 (Jackson, 1973)
5.	Organic Matter	%	Walkley and Black (Walkley and Black, 1934)
6.	Total N	%	Kjeldahl (Bremner and Mulvaney, 1982)
7.	Available Phosphorus	Kg/ha	Olsen's (Olsen et al., 1954)
8.	Exchangeable Potassium	Kg/ha	Ammonium acetate (Jackson, 1967)
9.	Available Ca and Mg	ppm	EDTA Titration (El Mahi et al., 1987)

Statistical analysis

Descriptive statistics (mean, range, standard deviation, standard error, coefficient of variation) of soil parameters were computed initially using STAR (Statistical Tool for Agriculture Research) developed by IRRI. Correlation and regression analysis were carried out to detect the functional relationship between soil pH and macronutrients. The data were analyzed using a statistical package STAR and Microsoft Office Excel 2013.

RESULTS AND DISCUSSION

Status of the macronutrients in the study area

The result of the analysis of soil samples taken from the study area showed that the pH ranged from 6.18 to 7.00. Similarly, the organic matter (%) ranged from 0.09 to 6.3 with an average of 2.59%. Average total Nitrogen (N) was found to be 0.16% whereas the mean value for available Phosphorus (P) and exchangeable Potassium (K) of were found to be 33.55kg/ha and 508.9 kg/ha, respectively. Similarly, the average extractable Calcium (Ca) and Magnesium (Mg) content of the studied samples were found to be 800.13 ppm and 85.4 ppm, respectively (table 2).

Table 2. Descriptive statistics of soil chemical properties

Variable	Mean	Max	Min	S.D	SEm	CV
pH	6.60	7.00	6.18	0.19	0.04	2.95
Organic matter (%)	2.59	6.3	0.09	1.44	0.26	55.55
Total N (%)	0.16	0.38	0.07	0.08	0.02	51.23
Available P (Kg/ha)	33.55	98.82	4.12	21.76	3.97	64.87
Exchangeable K (Kg/ha)	508.9	912.4	220.6	184.66	33.71	36.29
Extractable Ca (ppm)	880.13	1624	498	289.78	52.91	32.92
Extractable Mg (ppm)	85.4	162.0	42	35.50	6.48	41.56

SD- Standard Deviation, SEm- Standard Error of Mean, CV- Coefficient of Variation

Correlation coefficient (r) of macronutrients with soil pH

The correlation of total nitrogen, available phosphorus, exchangeable potassium, extractable calcium, and magnesium are established with soil pH (table 3). These elements are important for plant growth and required in a larger amount. The availability of macronutrients is highly dependent on soil pH. To understand plant nutrient availability, it is important to understand soil chemistry and interacting factors that affect soil pH (Brady & Weil, 2002).

Table 3. Correlation coefficient and P value of different macronutrients with soil pH.

Variable	r	P value
Total N%	0.7310*	0.0000
Available P_2O_5	0.6466*	0.0001
Exchangeable K_2O	0.5569*	0.0014
Extractable Ca	0.6088*	0.0004
Extractable Mg	0.5945*	0.0005

‘*’ indicates significant at 5% level of probability.

Relationship between pH and total nitrogen

The data on correlation revealed that total nitrogen (r=0.7310) was significant and positively correlated with soil pH. This showed accounted that pH accounted for about 53.4% of the total variability in total nitrogen as figure 3. By the increase in pH, total nitrogen increases progressively and vice versa. With the increase in soil pH by one unit, total nitrogen increases by 0.3123 unit and vice versa.

A significant and positive correlation was also found by Athokpam et al. (2013). Non-significant and positive results were obtained by Dhamak et al. (2014). Khadka et al. (2016) obtained significant negative correlation while studying soil in western Nepal. This contradiction might be due to the reason that the soil pH in the study area ranged from slightly acidic to neutral.

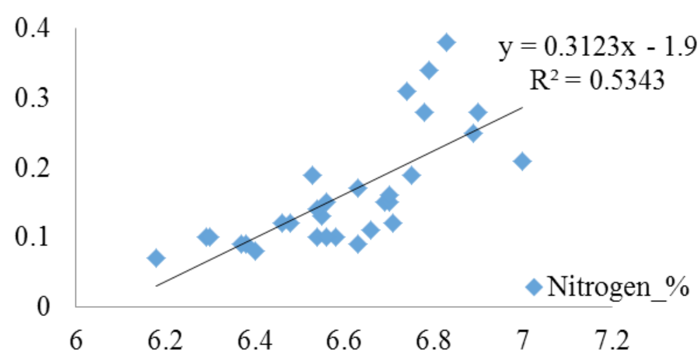

Figure 3. Relationship between pH and total nitrogen

Relationship between soil pH and available Phosphorus

Correlation analysis revealed that available phosphorus (r=0.6466) was significant and positively correlated with soil pH. This also showed that pH accounted for about 41.81% of the total variability in available phosphorus as shown in figure 4. By the increase in pH, available Phosphorus increases progressively and vice versa. With the increase in soil pH by one unit, available phosphorus increases by 72.29 units and vice versa.

Similar results were also obtained by Athokpam et al. (2013). In contrast, a significant and negative correlation was obtained by Khadka et al. (2016) while studying soils of western Nepal. Which may be due to the soil pH in the study area ranged from slightly acidic to neutral

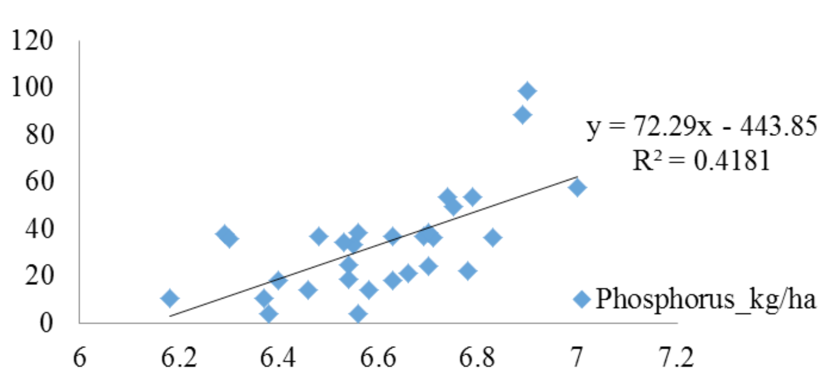

Figure 4. Relationship between soil pH and available Phosphorus

Relationship between pH and exchangeable Potassium

Correlation analysis of soil pH and potsssium revealed that exchangeable potassium (r=0.5569) was significant and positively correlated with soil pH. This showed that pH accounted for about 31.01% of the total variability in exchangeable potassium as figure 5t. By the increase in pH, potassium increases progressively and vice versa. With the increase in soil pH by one unit, potassium increases by 528.32 units and vice versa.

A significant and positive correlation was obtained by Athokpam et al. (2013). Singh et al. (2012) showed that the relationship between potassium content was a significant and positive correlation with soil pH. Khadka et al. (2016) found extractable potassium significantly and negatively correlated with soil pH while studying the soils in the western Nepal. Non-significant and positive correlations were obtained by Dhamak et al. (2014).

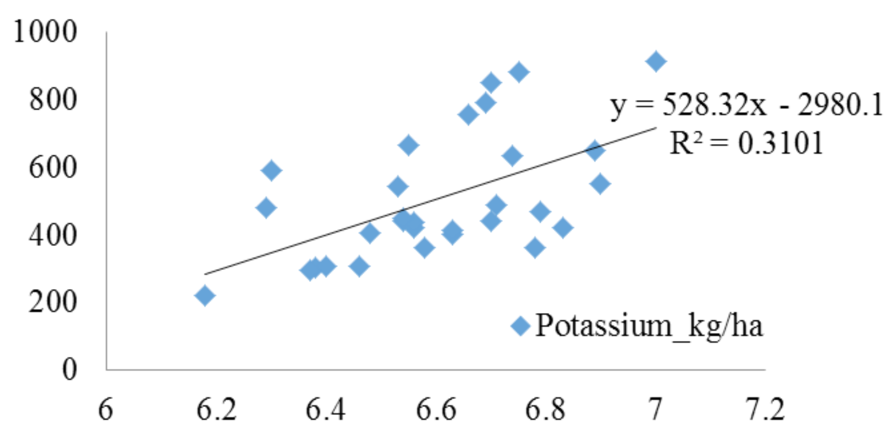

Figure 5. Relationship between pH and Extractable Potassium

Relationship between pH and Extractable Calcium

The result of correlation analysis between pH and Calcium revealed that extractable Calcium (r=0.6088) was significant and positively correlated with soil pH. This showed that pH accounted for about 37.07% of the total variability in extractable calcium as figure 6 . By the increase in pH, extractable calcium increases progressively and vice versa.

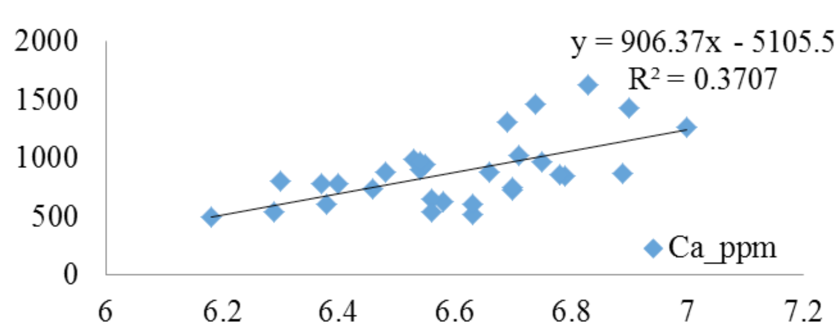

Figure 6. Relationship between pH and Extractable Calcium

With the increase in soil pH by one unit, extractable calcium increases by 906.37 units and vice versa. Similar results were obtained by Khadka et al. (2016) while studying the soils of the western Nepal. Similarly, Dhamak et al. (2014), Mahapatra et al. (1996) and Medhe et al. (2001) also obtained similar results.

Relationship between pH and Extractable Magnesium

The result of correlation between soil pH and magnesium revealed that extractable agnesium (r=0.5945) were significant and positively correlated with soil pH. This showed that pH accounted for about 35.35% of the total variability in extractable magnesium as figure 7. By the increase in pH, extractable magnesium increases progressively and vice versa. With the increase in soil pH by one unit, extractable magnesium increases by 108.42 units and vice versa. A significant and positive correlation between pH and extractable magnesium were obtained by Khadka et al. (2016) at western hills of Nepal. But Dhamak et al. (2014) and Madhe et al. (2001) obtained a non-significant correlation**.**

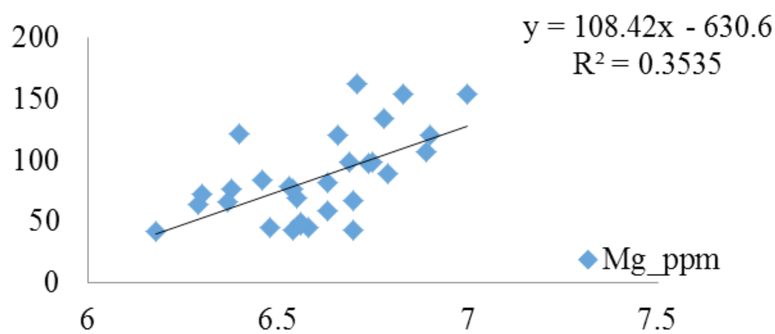

Figure 7. Relationship between pH and Extractable Magnesium

CONCLUSION

A significant and positive correlation was seen between soil pH and primary nutrients. Also, a significant and positive correlation was found with secondary nutrients. With the increase in soil pH, primary nutrients were increased gradually and vice-versa. At the same time, with the increase in soil pH, secondary nutrients were also increased consequently and vice-versa. Thus, soil pH can control the availability of macronutrients. The growth and development of plants are directly influenced by essential plants nutrients. The soil fertility status was observed to be low for available phosphorus, extractable calcium, and organic matter; medium for total nitrogen, and extractable magnesium, while it was found high regarding available potassium. Thus the balance of such essential plant nutrients is possible only through proper management of soil pH. Therefore, for availability of soil macronutrients, rational management of soil pH is must at Baseshwor, Sindhuli of Nepal.

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