Estimation of nitrogen and phosphorus in fertilizers found in Nepalese market and some soil samples

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Abstract: Soil fertility is the basis for agriculture, soil acts as a crucial reservoir of plant micronutrients including the major elements such as nitrogen and phosphorus which largely determine plant health and crop productivity. The availability of nutrient absorption largely depends on the soil pH and soil moisture content as it affects the soil's chemical, physical, and biological properties and plays a key role in agricultural productivity.

In this study, 15 soil samples were collected from Thecho, Gokarna and Pathivara Yangwarak to measure moisture content, soil pH, nitrogen and phosphorus content and 6 samples of fertilizers from the Nepalese market were selected for their nitrogen and phosphorus content. Soil moisture was found in the range of 16.57 – 28.40 % and soil pH was found in a slightly acidic to nearly neutral with pH value in the range of 6.5 – 7.0. Nitrogen content was estimated by the Kjeldahl method and phosphorus content was estimated by Olsen's method. Among 15 soil samples, phosphorus in 11 soil samples were found high value, 3 soil samples were found medium value and 1 soil sample were found low value and nitrogen in 5 soil sample were found high, 5 soil samples were found medium and 5 soil samples were found low value. In most of the fertilizers, nitrogen and phosphorus content were found much lower than labeled in the packet.

Keywords: Fertilizer; Nitrogen; Phosphorus; Soil fertility; Soil pH.

Introduction

The increasing demand for crops in the agricultural market and people's living, impel the farmers towards scientific farming. Proper use of land improves the structure of the soil, increasing soil resistance to the change in environment and improving the quality of soil[1].

Soil contains essential nutrients and is the basis of crop cultivation and agricultural production. All the required elements present in the soil are always in a dynamic balance. The soluble phosphate present in soil solution is available as phosphorus, used to increase the plant productivity and is considered as the main index of soil fertility[2]. The optimum solubility of phosphorus lies in the pH range 6.2 – 7.0. At low pH, phosphorus is tied up with Al and Fe and is not available to plants to improve the soil fertility[3].

The current status of soil fertility is declining; most of the agricultural soil has low content of nitrogen, phosphorus and potassium. There is always a shortage of chemical fertilizers in the country and are not available at the time of cultivation due to the procurement and distribution system. There is a vast difference in the demand and supply of fertilizers, illegal trading of inorganic fertilizer occurs with the low quality of fertilizers suffering the farmers and resulting in poor national income. The import of fertilizer (Ammonium sulfate) had been started in 1953 from India[4]. The estimated requirement for fertilizer is more than 800,000 metric tons of Urea and more than 400,000 metric tons of Diammonium phosphate[5]. The trend of fertilizers by sales of the public sector had been increasing from 81845 metric tons in the fiscal year 2009/10 to 394595 metric tons in the fiscal year 2019/20[6]. The demand for quality fertilizer requires establishing chemical fertilizer plants in the country[4].

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Materials and Methods

Collection of samples

Soil samples were collected from Thecho, Lalitpur (27° 36′ 55″ N, 85° 19′ 40″ E), Gokarna, Kathmandu (27° 44′ 13″ N, 85° 22′ 42″ E), and Pathivara Yangwarak, Taplejung (27° 18′ 30″ N, 87° 45′ 10″ E) at the end of the day time on 15th April 2023, by using Zigzag method at a depth of 15 cm from top surface with the help of spade[6,7]. The temperature of Pathivara Yangwarak was found of about 16.2 °C, and the temperature of Thecho and Gokarna were found of about 21.2 °C. Five different samples were collected separately from each site. Each soil sample was collected by mixing an equal proportion of five nearby locations of the specified area. It was then placed in airtight plastic bags to preserve their composition and prevent contamination. Commercial inorganic and organic fertilizers FI-1, FI-2, FI-3 FI-4, FO-1 and FO-2 were collected from the market of Kathmandu for the analysis of nitrogen and phosphorus content.

Moisture content

2 g of soil samples were dried in an oven at 105 °C for 24 hours followed by cooling in desiccators and the weight of dried soil was measured, the process was repeated till the weight remained constant[7].

pH of the soil samples

50 mL of distilled water was added to 5 g of air-dry soil sample and was stirred for an hour; the suspension was then left for sedimentation and filtered. The pH of the filtrate was then measured using a pH meter (Mettler Toledo, LE438) calibrated by using a buffer solution having pH 4.0, 7.0 and 9.2 at 20 °C.

Determination of nitrogen in soil and fertilizer

Total nitrogen in the samples was estimated using the Kjeldahl method. 1 g soil sample and 2 g digestion mixture (1:10 mixture of $CuSO_4$ and Na_2SO_4) were mixed and 10 mL of concentrated H_2SO_4 was added followed by heating at 410 °C for 1 hour. 20 mL of distilled water and 40 percent NaOH were then added, the color of the mixture turned dark brown. It was then heated and distillate was collected in a conical flask containing 10 mL of 2 % H_3BO_3 acid. Finally, the whole content was titrated with standard H_2SO_4 solution[8].

Determination of phosphorus in soil and fertilizer

Phosphorus in the samples was estimated using Olsen's method. 100 mL of 0.5 M $NaHCO_3$ solution was added to a flask containing 5 g air-dry soil and 1 g activated charcoal and was shaken for 30 minutes at a speed of 180 rpm. It was then filtered using filter paper (Whatman no. 42). 5 mL reagent (H_2SO_4, ammonium molybdate and antimony tartrate) was added to 5 mL of filtrate and placed in dark for 1 hour to develop a blue coloration and absorbance of the solution was measured with a spectrophotometer (PerkinElmer, UV/VIS Lambda 365) at a wavelength of 882 nm[9,10].

Results and Discussion

Moisture content in soil

Soil moisture depends on the soil types, climate, topography, vegetation and temperature. Soil moisture is a key factor in agricultural productivity. It affects the soil's chemical, physical, and biological properties. The moisture content of soil at different locations is shown are the following Figure 1:

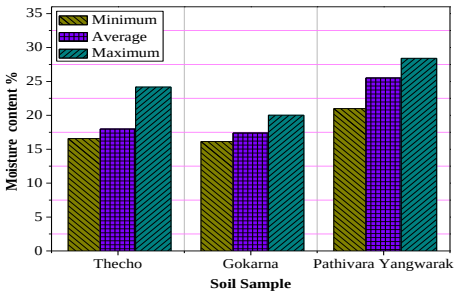

Figure 1: Moisture content in the soil sample.

The high moisture content value of the soil at Pathivara Yangwarak may be due to the lower temperature of about 16.2 °C compared to Thecho and Gokarna both have a temperature of about 21.2 °C. The lower temperature reduces the evaporation rates and increases the moisture retention of the soil. Other important factors such as

geographical location, climatic conditions and frequent rains are also expected to the increased moisture content of the soil.

Soil pH

The pH of soil samples at different locations are shown in the following Figure 2:

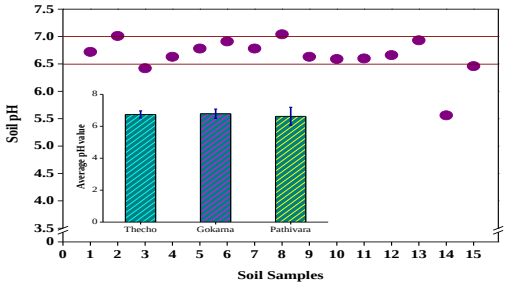

Figure 2: pH of soil samples.

The pH values range from 5.56 to 7.04. Out of 15 samples, 2 of them were found in the nearly neutral range and the remaining 13 samples lie in the slightly acidic range. Most of the soil samples have pH values in the range of 6.6 – 7.0. pH can strongly control the absorption performance of the available nutrients to the plant. The absorption of available phosphorus occurs at a pH range of 6.5-7.0[11].

Determination of nitrogen in soil

Nitrogen content in the soil samples at different sites of Thecho, Gokarna and Pathivara Yangwarak are shown in the following Figure 3:

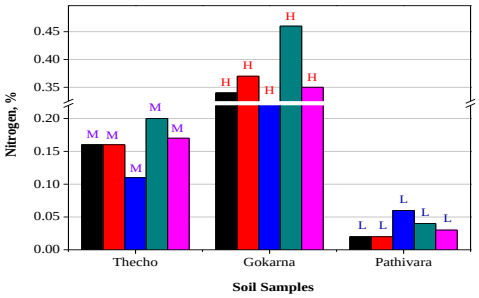

Figure 3: Nitrogen content in soil samples.

For mountains and hilly region presence of nitrogen, less than 0.1 % is classified as low, between 0.1 – 0.3 % as medium and more than 0.3 % as high[8]. Nitrogen content in soil samples of Thecho was found medium ranges from 0.11% to 0.20% and at Gokarna, it was found high ranges from 0.29% to 0.46%. It may be due to the use of nitrogen-containing inorganic fertilizers. However, Nitrogen content in soil samples of Pathivara Yangwarak was found low, which may be due to the unavailability of inorganic fertilizer and the use of organic fertilizers which contain less amount of nitrogen. Similar results were also reported by Devkota et al., 2019. They found low to medium range (0.031 - 0.121 %) of nitrogen in the soil samples of Bagarkot, Amargadhi and Alital areas of Nepal[12].

Determination of phosphorus in soil

The absorbance of the standard phosphate (KH_2PO_4) solution in the range of 0.0 - 2.4 ppm were measured and are plotted against concentration as shown in the following Figure 4:

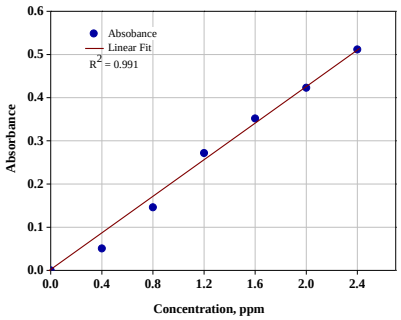

Figure 4: Calibration plot for phosphorus determination.

Phosphorus content in the soil samples at different sites of Thecho, Gokarna and Pathivara Yangwarak are shown in the following Figure 5:

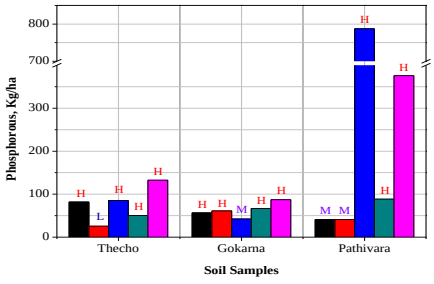

Figure 5: Phosphorus content in soil samples.

The presence of phosphorus less than 26 kg/ha is classified as low, between 26 – 55 kg/ha as medium and more than 55 kg/ha as high[8]. The phosphorus content in soil samples of Thecho was found in the range of 25.63 - 132.35 kg/ha one low and four high. In Gokarna, it was found in the

range of 42.19 - 87.17 kg/ha one medium and four high and in Pathivara Yangwarak, it was found in the range of 25.62 to 787.27 kg/ha two medium and three high. The notably high phosphorus in the soil sample of Pathivara Yangwarak may be due to the presence of soap and detergent residues located near the water source used for human utility. Devkota et al., 2019 reported a low to high range (10.3 - 715.2 kg/ha) of phosphorus content in the soil sample of Bagarkot, Amargadhi and Alital areas of Nepal[12].

Determination of nitrogen and phosphorus in fertilizer samples

Nitrogen and phosphorus content in the commercial fertilizer available in the Nepalese market were measured and are shown in the following Table 1:

Table 1: Nitrogen and phosphorus in fertilizer samples.

Fertilizer Samples	Nitrogen (%)		Phosphorus, P_2O_5 (%)	
	Leveled value	Measured value	Leveled value	Measured value
FI-1	46.00	42.13	-	-
FI-2	20.08	16.03	20	4.35
FI-3	15.00	13.37	15	3.25
FI-4	18.00	11.88	46	0.18
FO-1	2.00	1.63	2.0	0.21
FO-2	2.50	1.21	2.0	0.21

In most of the fertilizers, nitrogen content was found lower than labeled in the packet and phosphorus in all 5 fertilizers was found much lower than claimed in the packet. High demand for fertilizers and limited production appreciate illegal trading of low-quality fertilizers, decreasing soil fertility.

Conclusions

Soil moisture in Thecho, Gokarna and Pathivara Yangwarak was found in the range 16.57-24.16 %, 16.13-20.02 % and 21.00-28.40 % respectively. Out of 15 samples, 13 samples were found in the slightly acidic range and the remaining 2 of them were found in the nearly neutral range. 11 sites were found high, 3 sites were medium and 1 site was low content of phosphorus. Nitrogen content in all the soil samples in Thecho, Gokarna and Pathivara Yangwarak was found medium, high and low respectively. Nitrogen content in the fertilizer samples FI-4 and FO-2 were found much lower than leveled in the packet, however phosphorus in all soil samples were found much lower than leveled in the packet and therefore most of the fertilizers are of low quality that may not be able to increase soil productivity.

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References

1. Wang, R. 2016. Chemical Analysis of Available Nutrients (N,P,K) in Agricultural Soil. *4th International Conference on Mechanical Materials and Manufacturing Engineering*. 485-488.
   Doi: 10.2991/mmme-16.2016.94
2. Pan Guoqing. 2004. The Evolution Law of Soil Organic Matter Content in Cultivated Soil. *Jiangsu Journal of Agricultural Science*. **3**:21-25.
3. Schreier H., Shah, P.B. and Lavkulich, L.M. 1995. Soil acidification and its impact on nutrient deficiency with emphasis on red soils and pine litter additions. In: Challenges in Mountain Resource Management in Nepal: Process, Trends and Dynamics in Middle Mountain Watersheds. Workshop Proceedings. Kathmandu, Nepal April 10-12. *International Development Research Center*. Ottawa. 183-192.
4. NARC 2022. Fertilizers in Nepal, Government of Nepal, Nepal Agricultural Research Council. *Nation Agriculture Research Institute*. Khumaltar, Lalipur. 2022. 1-66.
5. MoALD 2020. Statistical information on Nepalese agriculture (2019/20). *Ministry of Agriculture and Livestock Development*. Singhadarbar, Kathmandu.
6. MoALD 2022. Statistical Information in Nepalese Agriculture. *Ministry of Agricultural and Livestock Development*. Singhadarbar, Kathmandu, Nepal.

7. Hooda, S. and Kaur S. 1999. *Laboratory Manual for Environmental Chemistry*. First edition. S. Chand & Company Ltd. New Delhi.
8. Standard operating procedure (SOP) for estimation of Total Nitrogen (N) in soil samples by Kjeldahl Method. 2022. *Forest Research and Training Centre (FRTC)*. Babarmahal, Kathmandu.
9. Food and Agriculture Organization of the United Nations (FAO). 2021. Standard operating procedure for soil available phosphorus - Olsen method. Rome.
10. Olsen, S.R., Cole, C.V., Watanabe, F.S. and Dean, L. A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. *United State Department of agriculture.* Washington D.C. https://books.google.com.np/books?id=d-oaM88x5agC&printsec=frontcover#v=onepage&q&f=false
11. Penn C. J. and Camberato, J. J. 2019. A Critical Review on Soil Chemical Processes that Control How Soil pH Affects Phosphorus Availability to Plants. *Agriculture*. **9**:1-18. Doi: 10.3390/agriculture9060120
12. Devkota, S., Sunar, B. and Pandey, A. 2019. Soil nutrient Analysis of Amargadhi, Bagarkot and Alital VDCs of Dadeldhura, Nepal. *The Journal of Agriculture and Environment*. **20**:199-204. Doi: 10.3126/aej.v20i0.25069