Variability of Soil Properties in Agroecological Sites of Green Karnali Project Areas, Nepal

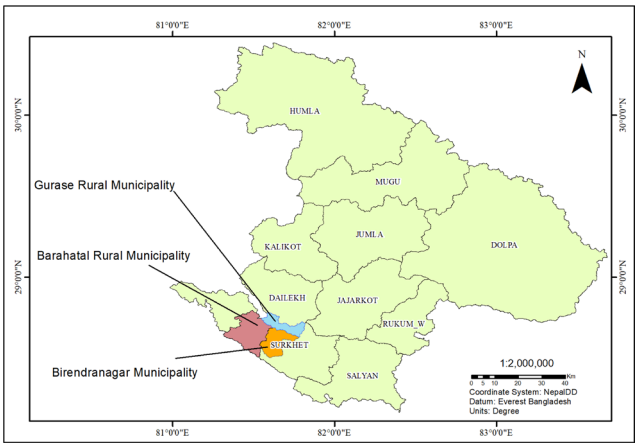
Authors:
Sambat Ranabhat, Dipesh Neupane, Buddha B.K, Laxman Khatri, and Santosh Shrestha

Introduction

The Karnali Province has set its mission to transform its production system through agroecological production systems. It aims to establish the province as a hub of sustainable organic agriculture, enhancing farmers' livelihoods and ensuring food security. Promoting organic farming practices, the mission improves healthy soil, for long-term agricultural productivity and environmental sustainability. However, Karnali province is highly vulnerable to soil erosion with an average soil loss of 9.85 tons/hectare/year [1] and land degradation [2]. Also, poor farmyard manure (FYM), and insufficient and improper fertilizer application including intensive cropping are declining soil fertility and productivity, especially in Nepal's hilly and mountain regions [3]. This has contributed to poor soil quality resulting in poor yields and production. Therefore, the study was conducted with the objectives i) to understand the status of major soil chemical properties (N, P, K, and pH) in the ecological model village of Surkhet and Dailekh, Nepal, and ii) to sensitize and aware farmers with soil test provisions and recommend soil health management practices based on a soil test campaign.

Methodology

» **Study Site-** The study was conducted in Barahatal and Birendranagar Municipality of Surkhet and Gurans Rural Municipality (RM) of Dailekh to assess soil variability mainly focusing on the major soil chemical properties i.e. pH, nitrogen (N), phosphorus (P), and potassium (K). During the soil testing campaigns, a total of 310 soil samples were tested i.e., Birendranagar (145), Barahataal (80), and Gurans (85).



Map : Karnali province depicting project implementation sites

» **Soil sampling-** Farmers were demonstrated to collect soil samples from a 10-15 cm depth, making a V-shaped trench. The outermost soil layer of 2.5 cm was scraped along with the sideways of the V-shaped trench [4]. Four sub-samples were collected using the "S" "Z" or "M" pattern in the field to prepare a composite sample of 2-3 kg from the field area of 1-2 ropani representing the farmer field. This composite sample was separated from stone, pebbles, crop stubble, and other foreign materials, which were subjected to an alternate quadrant removal procedure to obtain the final laboratory sample of 500 gm [4].

» **Soil analysis for NPK-** Soil analysis was performed through the soil kit box (pH soil test kit box with NPK testers) in the field to determine the qualitative level of nitrogen, phosphorus, and potassium in soil samples. It was determined in three levels i.e. low, medium, and high.

» **Soil pH-** It was measured using a digital pen pH meter (Model-5305, Peak Tech) at a dilution ratio of 1:2 (Soil Sample: Distilled water) [4].

Results and Discussion

Soil pH

All three locations were dominated by neutral soil pH (ranges between 35% and 60%) [Fig 1]. 61.3% of the total soil samples tested from Barahtaal showed a significantly higher proportion of alkaline soils whereas Gurans had a greater proportion of acidic soils (44.7% of the total soil sample) [Fig 1]. The Gurans RM receives comparatively higher precipitation which could be a possible reason for the acidic soil there [5]. Higher precipitation contributes to soil acidity due to the leaching of basic cations [6]. The majority of farmers of the Gurans region cultivate crops such as potato, maize, and wheat which are suitable for acidic to neutral soil. In addition to these, acid soil-tolerant crops such as broccoli (ब्रोकाउली), onions (प्याज), sweet corn (मकै), asparagus (कुरिलो), citrus (सुन्तला जात), coffee (कफि), cucumbers (काक्रो), beans (सिमि), turnips (सलगम), etc. can be potential crops in Gurans. In the case of the Karekhola site in the Indrapur community, the average soil pH was 6.2 with Sandy loam soil texture so the application of soil lime at the rate of 43 kg/ropani will help to improve soil pH (माटोको अम्लियपना र सुधारका उपायहरू). In the case of Barahataal, higher soil alkalinity could be attributed to the region's colluvial and calcareous parent materials [7]. It is suggested to grow green manure crops such as sesbania (धैचा), cowpea (बोडी), buckwheat (फापर), mustard (रायो), etc. that have potential in the Barahatal region which can adapt in alkaline soil.

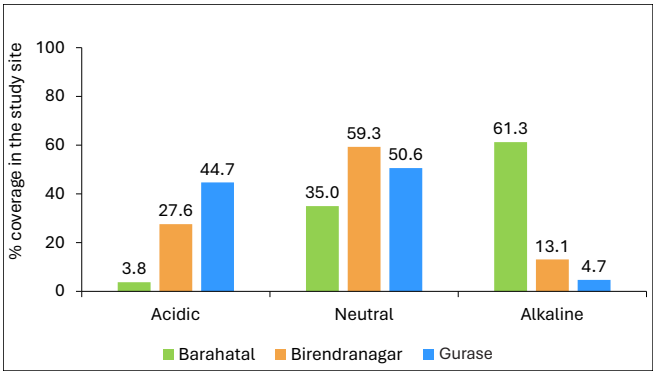


Fig 1: Variability of Soil pH in Green Karnali Project Site

Soil Nitrogen

Soil samples from Gurans, Birendranagar, and Barahataal were recorded with low nitrogen with 44.71%, 60 %, and 78.7% of total samples, respectively [Fig 2]. The potential cause for the low soil N could be the application of the sub-optimal amount of low-quality FYM from actions such as FYM exposure to intense sunlight and monsoonal rains, the nitrogen content of compost tends to deplete [8]. It is suggested to apply 1000-1200 kg or 40-50 Doko/Ropani of well-decomposed FYM before crop planting for instant improvement [9].

Up to 97% of the nitrogen (N) assimilated by cattle through feed is excreted in urine and feces in the form of urea and organic N [10] these nitrogen are particularly prone to volatilization loss. N retention in urine and farmyard manure (FYM) can be optimized through an Improved FYM management system i.e., careful collection, layering, and moistening of raw materials, and shading of the manure heap. FYM should not be left in the field and let dry before application, a common practice in the Karnali and Nepalese farming systems. Immediate mixing into the soil is required, If immediate mixing into the soil is not possible, the manure should be well covered with leaf litter or mulch and then incorporated into the soil within 3-4 days. Additionally, practices promoted by the Green Karnalai project such as cattle sheds with the provision of collecting cattle urine and utilizing them as liquid fertilizer (Jhol Mal-1) to supply nitrogen to the crops and insect/pest control (Jhol Mal 2 and 3).

Continuous monocropping and cultivation of heavy nutrient feeder crops such as maize, potato, etc. can lead to the depletion of soil nitrogen levels [11]. Therefore, it is advisable to follow intercropping and crop rotation strategies integrating legumes such as beans (सिमि), peas (केराउ), and pulses (दलहन बालि) with other crops. It facilitates atmospheric nitrogen fixation thereby enhancing soil N [12]. Green manure such as sesbania (धैचा), clover (तीनपाते), vetch (भेच), or alfalfa (अल्फा अल्फा) can be grown during fallow period i.e., Baishak to Jestha (April - May) before rice plantation that can further enrich the soil, as these crops contribute organic matter that improves soil structure and nutrient availability when incorporated before planting.

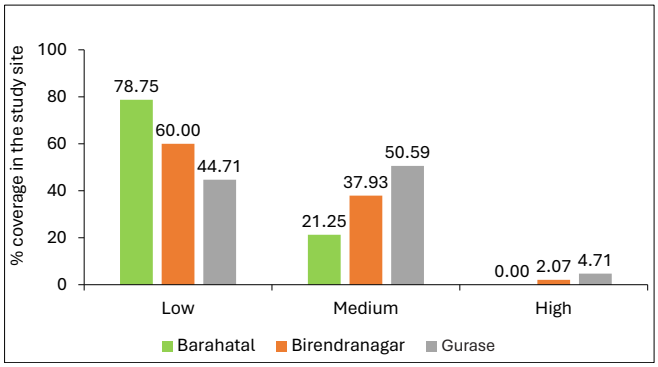


Fig 2: Variability of Soil Nitrogen in Green Karnali Project Site

Soil Potassium

The majority of the soil samples of Birendranagar (55.17%), Barahtaal (48.75%), and Gurans (40.00%) had medium levels of potassium [Fig 3]. In Nepal, medium to high levels of soil potassium are recorded within the medium range (110–280 kg K2O/ha) [6]. Based on the soil potassium contents as depicted by the result, it is suggested to use organic potassium sources such as wood ash (काठको खरानी), blood meal (हड्डिको धुलो), or rock powders (ढुंगाको धुलो), e.g., granite dust (ग्रेनाइटको धुलो) that naturally contains potassium in Gurans site to increase soil K. Similarly, in Barahatal, it is suggested to grow to cover crops i.e., spinach (पालुंगको साग), chickpea (चना), rajma bean (राज्मा), clover (तीनपाते), and alfalfa (अल्फा) during fallow periods, to scavenge and accumulate potassium from deeper soil layers. Organic mulch such as straw (पराल), leaves (पात पतिंगर), or grass clippings can be applied to the soil surface, which holds potassium ions in an exchangeable or available form.

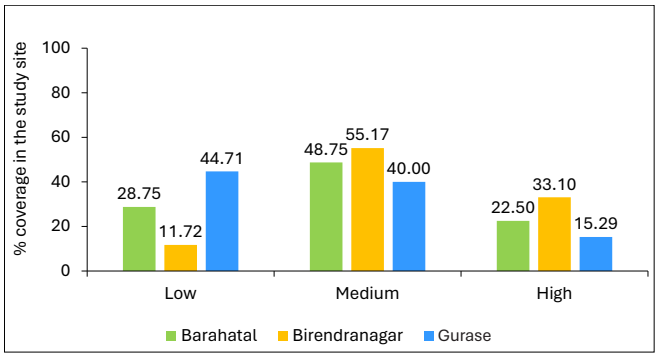


Fig 3: Variability of Soil Potassium in Green Karnali Project Site

Soil Phosphorus

The majority of soil samples tested had high phosphorus levels in all three sites with Barahataal (97.50%) followed by Gurans (88.24%) and Birendranagar (84.14%) [Fig 4]. Studies conducted by the Nepal Agricultural Research

Council (NARC) suggest that the soil phosphorus level is increasing in Nepal due to the use of Diammonium Phosphate fertilizer in the field by farmers [6]. Although, soil phosphorus shows an increasing trend its availability to plants could be critical due to higher fixation properties with soil [13]. Hence, It is suggested that the farmers adopt crop rotation and intercropping along with the application of well-decomposed compost manure or FYM before planting to maintain the plant's available phosphorus in the soil.

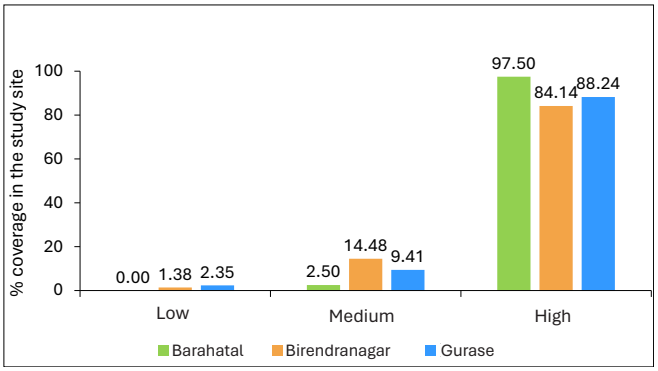


Fig 4: Variability of Soil Phosphorous in Green Karnali Project Site

Farmer Sensitization: Soil Analysis and Health Management

The soil test campaign sensitized 310 farmers from 17 groups from the Surkhet and Dailekh districts on the importance of managing soil health required for enhancing crop productivity. Farmers participation in the soil samples collection, analysis and further discussion on implications of the soil test results were reflected through commitments to adopting soil health-friendly farming practices such as preparation and use of well-decomposed FYM, intercropping with leguminous crops and mulching to maintain and improve soil quality.

Conclusion

The soil variability assessment across three different locations revealed that neutral soil pH dominated across all sites. However, Barahataal has a significantly higher proportion of alkaline and Gurans with a greater proportion of acidic soils. Low nitrogen levels were prevalent across all sites and prompt action was required to improve the soil N. Conversely, phosphorus levels were higher across all sites, and Potassium levels showed medium levels. These findings provide valuable insights into the soil properties of the Green Karnali project areas, crucial for informing sustainable agricultural practices and land management strategies in the region.

Acknowledgement

We gratefully acknowledge the Green Kanali project supported by DANIDA through DanChurchAid (DCA) for funding the study. Special thanks to LI-BIRD, SOSEC, and Integrated Agriculture Laboratory, Karnali province, for their technical support during the soil test campaign.

Reference

[1] Aryal, K. R., Panthi, S., Basukala, R. K., Kharel, R., Gautam, A., Poudel, B., Sharma, S., Adhikari, B., Budha, R. K., & Khadka, S. (2023). Soil loss estimation of Karnali river basin, Nepal. Journal of Sedimentary Environments.

[2] Pokhrel, K. P., Chidi, C., Timilsena, N. P., & Mahat, D. K. (2021). Flood Hazards and Livelihood Challenges in Lower Karnali River Basin: A Case from Sudur Paschim. 6(5).

[3] Shrestha, R. K. (2009). Soil fertility under improved and conventional management practices in Sanga, Kavrepalanchowk district, Nepal. Nepal Agriculture Research Journal, 9, 27-39.

[4] SMD. (2017). Manual for soil and fertilizer analysis. 5–6.

[5] Bhandari, G. (2013). Trends in seasonal precipitation and temperature–A review In Doti and Surkhet Districts of Nepal. International Journal of Environment, 2(1), 269–279.

[6] Soils, W., & Series, B. (2021). The Soils of Nepal.

[7] National Soil Science Research Center (NSSRC), USAID's Nepal Seed and Fertilizer (NSAF). (n.d.). Digital Soil Map of Nepal. Retrieved May 10, 2024, from https://soil.narc.gov.np/

[8] Brown, S., Chaney, R. & Angle, J. S. Subsurface Liming and Metal Movement in Soils Amended with Lime stabilized Biosolids. (1997).

[9] AITC. (2080). Krishi Diary 2080.

[10] McCrory, D. F. & Hobbs, P. J. Additives to reduce ammonia and odor emissions from livestock wastes: a review. J. Environ. Qual. 30, 345–355 (2001).

[11] Pervaiz, Z. H., Iqbal, J., Zhang, Q., Chen, D., Wei, H., & Saleem, M. (2020). Continuous cropping alters multiple biotic and abiotic indicators of soil health. Soil Systems, 4(4), 59.

[12] Jensen, E. S., Carlsson, G., & Hauggaard-Nielsen, H. (2020). Intercropping of grain legumes and cereals improves the use of soil N resources and reduces the requirement for synthetic fertilizer N: A global-scale analysis. Agronomy for Sustainable Development, 40(1), 5.

[13] Richardson, A. E., Hocking, P. J., Simpson, R. J., & George, T. S. (2009). Plant mechanisms to optimize access to soil phosphorus. Crop and Pasture Science, 60(2), 124-143.

Some photographs during the soil campaign

Citation

Ranabhat, S., Neupane, D., BK, B., Khatri, L., & Shrestha, S. (2024). *Variability of Soil Properties in Agroecological Sites of Green Karnali Project Areas, Nepal*. LI-BIRD.

Project Partners