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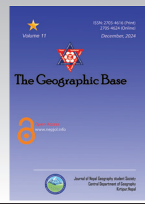

Relationship of Ph and Textural Class of Soil with Potato Production: A Case Study of Banepa Municipality, Nepal

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Abstract

Identification and classification of soil texture is one of the most important components of crop production, agricultural sustainability and land use management. Kavrepalanchok district plays an important role in potato production in Nepal. Therefore, this study was conducted to know the state of potato production, particularly, the relationship between soil pH, textural class, and soil productivity status with potato production in Ward No. 3 of Banepa Municipality of Kavrepalanchok District. Thirty-five sample plots were collected from the different locations in the study area. Questionnaire survey was conducted for the same households representing each sample plot and three key informant interviews with elderly farmers were undertaken for the information of history and types of potato used in farming. Soil samples were tested and analyzed at the soil laboratory of the Central Department of Geography, Tribhuvan University. The results show that the soil texture consisted of sandy *loam, sandy clay loam, loam, loamy sand, and silty loam. Soil pH ranged from strongly acidic to moderately alkaline, and the mean productivity of potato was found at 1.41 kg per m^2. For soil textural management, farmers used chemical fertilizers such as urea, DAP, and potash, while also employing animal manure, poultry manure, and green manure as organic fertilizers. The farmers used pesticides in the potato farms to control blight, apply micronutrients, and kill pests (insects, weeds). To treat other illnesses and weeds in potatoes, the majority of the farmers utilized herbicides in the highland or upper sloppy terrace fields (Baari land), but not in the lowland fields (Khet land). The improved variety of potato seeds available from government offices and cooperatives is found to be used by a few commercialized farmers.*

Introduction

Soil is described as the uppermost layer of the earth, where flora flourish, serving diverse purposes for various individuals and domains. It serves as a medium for vegetation growth for agriculturists and a base for construction for engineers. The productivity of crops is significantly impacted by soil texture, which encompasses sand, silt, and clay (Bhatia, 1967; Anaya, 1999; Oliver et al., 2013; Chakraborty & Mistri, 2015; Dogbe, 2015; Mushinskiy et al., 2016; Gnyawali et al., 2022). The potato (*Solanum Tuberosum L*), a globally significant crop, serves as a staple in the high-altitude region of Nepal, contributing to the alleviation of food insecurity with a yield of 3.52 million tons in 2023/24 (MoALD, 2025). Potatoes are recognized as a prominent crop in Nepal, making significant contribution to agricultural GDP of the country due to its adoptability, high potential yield, and high market demand (Khadka et.al., 2023). In recent years, Nepal has been importing more potatoes to meet demand (Gorakhapatra Corporation, 2022, Baral, 2024). Due to migration, a large part of agricultural land has been abandoned in the hills and mountains (Chidi et.al., 2024), which has led to labour shortage and imbalance between demand and supply. Likewise, potatoes farmers are faced with several challenges such as soil quality, access to varieties of improved seed, fertilizer, access to markets, and knowledge of soil conditions and their interactions with climate (Karanja et.al., 2014; Subedi et.al., 2019).

Soil texture and pH are important in potato cultivation, as it affects yield and susceptibility to pests and topographical challenges (Kehoe et.al., 2025). The variability in soil texture can help in the efficient utilization of resources. However, the studies investigating these soil properties in relation to potato production in Nepal are limited. Among the total districts of Nepal, Kabhrepalanchok district is one of the major areas of potato production district (MoALD, 2025). However, in the issues of potato production, there are limited academic researches which address soil quality and access to resource for increase production. Thus, this research into the interaction between soil characteristics, access to resources and farming knowledge to supports sustainable agricultural practices of potato cultivation in hilly like Kabhrepalanchok district of Nepal. Using labiratory-based findings can help the farmer make an informed decision, preventing poor fertilizer and pesticide applications from causing negative outcomes.

Methods and Materials

Study area

The study area is Ward 3 of Banepa Municipality, Kabhrepalanchok district, Bagmati province, Nepal (Figure 1), which extends from Latitude 27° 39' 41" North to Longitude 85° 31' 42" East and covers 10.35 square kilometers (MoFAGA, 2017) with a total population of 3378 (NSO, 2021). The elevation varies from 1145 meters to 1950 meters above sea level, with land slope ranging between less than 5° and 45°, and therefore, the soil type is diverse. The study area is located approximately 28 kilometers east of Kathmandu, the capital city, and about 115 kilometers from Hetauda, the provincial capital. The area is of significant cultural and religious importance due to the presence of religious tourist sites like the Basuki Nag Temple and Mahadev Kunda, which attracts tourists and pilgrims and hence impacts the social and economic development of the area.

According to LRMP (1986), the soils are classified into a predominance of *Alfisols*, *Entisols*, and *Inceptisols*, which have high clay content and moderate fertility (*Alfisols*), young and poorly developed soils (*Entisols*), and little soil development (*Inceptisols*). Agriculture is the main economic activity in the study area, the spatial distribution of soil texture, pH, and potato production practices must be understood in the context of the geography of the study area, since local geography, including elevation, climate, and soil types, influences local agricultural practices and land use.

Soil formation depends on the shape of the land surface, slope, and location (especially elevation); therefore, soils with the same parent materials and in similar climatic conditions may vary depending on their location in the landscape, determined primarily by drainage (for example, surface runoff and depth to the water table). The study area has elevations that range from 1145 meters to 1950 meters above sea level.

Slope is one of the most important factors to consider in land suitability for agriculture, from less than 5° for a gentle slope to greater than 45° for a very steep slope, where a steeper slope means lower suitability for agriculture in terms of the terrain gradient. The study area is located entirely within the Lesser Himalaya and is underlain by consolidated phyllite and metasandstone, whereas the valley in the area is filled with Quaternary sediments (gravel, sand, and carbonaceous clay).

The rivers in the study area, originating from elevations below 1500m, are the *Khothau Khola*, the *Sangla Khola,* and the *Kakara Khola*.

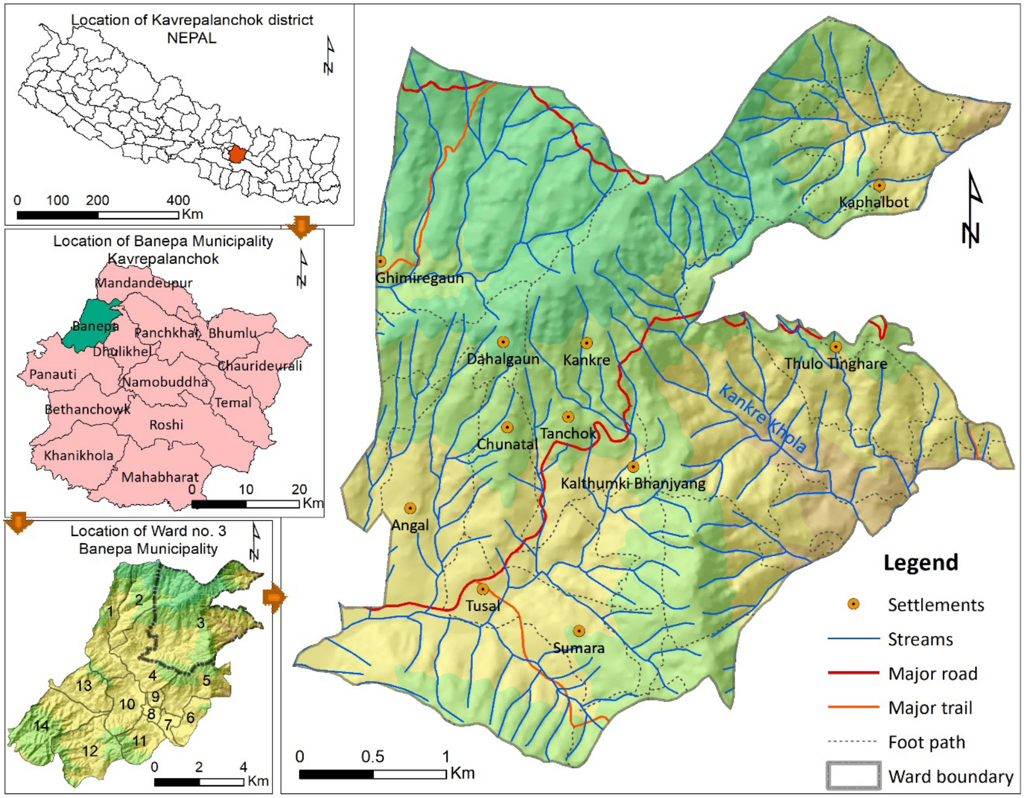

Figure 1. Location of the study area

Secondary data and household survey

Thirty-five sample farmers' households involved in potato farming were selected randomly, covering the entire study area, and a semi-structured, open-ended questionnaire survey was carried out with those farmers. Data acquired from them included the variety of potatoes, potato yield per square meter, application of fertilizers (both chemical and organic), and whether testing of soil texture and soil pH was conducted or not, among other factors. Additionally, three key informant interviews were conducted with elderly farmers (aged over 60 years) to acquire information on the history and types of potatoes used in farming.

Collection of soil samples

The locations were selected based on the types of land and the elevations of the land, which were identified from Google Earth, and then marked for future reference. The sampling areas were demarcated before soil sampling, based on different indicators such as visual appearance, slope, drainage patterns, soil type, productivity, and cropping patterns.

The study area was divided into lowland (1145 meters to 1620 meters), midland (1621 meters to 1780 meters), and highland (1781 meters to 1950 meters), and 35 soil samples were collected from the distinct soil sample pits (Figure 2) with diverse potato cultivation sites used throughout the year. Productivity was calculated for the plot area of land in the sample location. Out of 35 tested samples, the largest was sand, followed by silt and clay.

During the field visit, the equipment for soil sampling, including plastic bags for soil samples, each labeled with a unique tag number, measuring tape, scale meter, standard soil description form, marker pen, knife, proper digging implements, and a pH field kits etc. were also taken. In this study, surface soil samples were taken from the soil stratum from 0 to 20 cm and sampling occurred between 10 and 15 December 2021. An abbreviated visit to the sampling site (plot) was performed during the potato harvest to confirm production volume and area using a structured questionnaire.

Technique of soil sample collection

Soil samples were crushed using a mortar and pestle and then sieved through a two mm sieve. The material was sent to the soil laboratory at the Central Department of Geography, Tribhuvan University, for detailed analysis. Coarse fragments greater than two mm were separated from the soil and the finer soil was retained for laboratory analysis. The tactile method was used to describe the texture of the soil in the field; initially, the soil was dampened with water and then manipulated between the thumb and fingers. Soil high in clay gives a good texture, whereas silt gives a smoother (but less fine) texture, and sand gives a distinctly coarser texture.

Soil particle size analysis

In the laboratory, the Bouyoucos Hydrometer method (Bouyoucos, 1962) was used to estimate the particle size in this study. A 50-gram air-dried sample of fine-textured soil was taken for textural analysis. The soil sample was placed in a baffled cup, then the cup was filled to a half-full with distilled water and 10 ml of a sodium hexametaphosphate solution was added. The mixture was stirred for five minutes with a stirrer, then it was transferred into a 1-L settling cylinder and filled with distilled water for this process. The cylinder was shaken in a fourth manner to avoid circular currents in the liquid. The hydrometer was inserted into the cylinder 20 sec after it was set on a firm, stable table and the initial hydrometer reading was taken after 40 sec. To figure out the difference between the first and second readings, the same procedure was repeated after 40 seconds. If the difference amounts to 0.5 grams, the hydrometer was considered calibrated to display the grams of soil material in suspension. The temperature was measured, and an adjustment of 0.36 was added to the hydrometer reading for each degree above 20°C and subtracted 0.36 for each degree below 20°C to achieve the correct hydrometer reading. The suspension was re-shaken it and then placed on a table free from external disturbances. The hydrometer reading was taken after two hours, and the correct hydrometer reading was obtained.

Soil pH analysis

The pH of the soil was measured using a digital pH meter by preparing a 1:1 solution of 10 grams of soil and 10 milliliters of ultra-pure water and agitating the mixture with a mechanical device for 30 minutes. Subsequently, the pH meter was calibrated with neutral (pH 7) and acidic (pH 4) buffer solutions. Then the pH mode was selected and the temperature control was set to stabilize. After this, the electrode was rinsed with ultra-pure water and dried with tissue paper.

The electrode was first submerged in a neutral buffer solution and the calibration was adjusted to 7, then removed from the buffer, rinsed with ultra-pure water and dried with tissue paper, submerged in an acidic buffer solution and adjusted to 4, removed from the buffer, rinsed with ultra-pure water and dried with tissue paper, and then placed in the prepared soil sample solution for testing. The pH of the tested soil solution, as measured by the pH meter, was recorded.

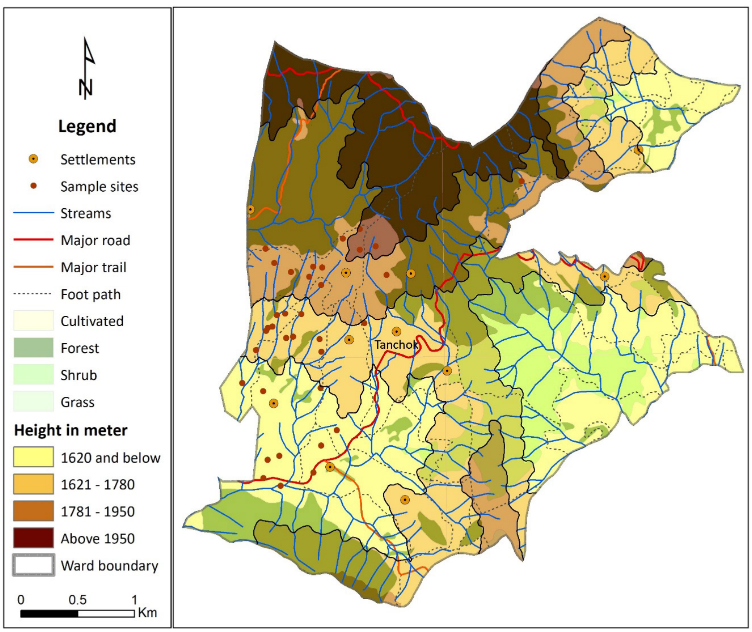

Figure 2. Soil sample point distribution along with elevation and land use

Soil classification technique

Upon completing laboratory analysis of the collected soil samples, classification of soil texture classes was performed, and the percentages of sand, silt, and clay were quantified for each specimen. These values were employed to find the textural class of each sample following the USDA (1998) soil texture triangle (Figure 3). The percentages of sand, silt, and clay were calculated on the data sheet, which helped the determination of the textural class using the textural triangle. Thus, the soil classification was typically derived based on texture by plotting the percentages of sand, silt, and clay on a soil texture calculator triangle or a soil texture triangle.

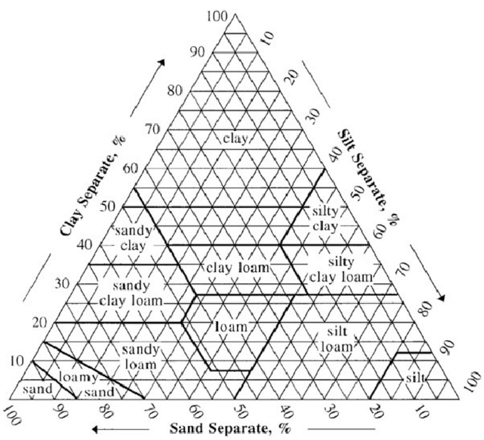

Figure 3. Soil textural triangle

Source: USDA, 1998

Secondary data, data processing, and analysis

The secondary data and maps were gathered from diverse sources, such as reports, books, articles, journals, online resources, dissertations, satellite imagery, Google Earth Pro, and LRMP. The ArcGIS software available at the Central Department of Geography, Tribhuvan University, was used for analyzing spatial and attribute data. The soil texture and pH data derived from the collected soil samples were digitized into a tabular format and integrated with the spatial locations of the soil pits. Using ArcGIS, various thematic maps were prepared to visualize the spatial variations of soil texture and pH within the study area.

Data on potato production for the last five years were analyzed using statistics to understand the variations in potato production using a Chi-square test. It is synthesizing the data in the variations in potato productivity based on soil textural classes in the study area. The soil samples were grouped in standard soil textural classes, and the acidity levels of the soil were categorized into similar groups. The productivity of samples was categorized into four groups. The Chi-square test was used to confirm the overall scenario of average productivity values of soil texture classes and soil pH values, at a 5% significance level (Singhal and Rana, 2015). The purpose of this analysis is to identify between texture and pH of soil and potato production in the study area.

For the Chi-square test (Pearson, 1900), the following formula has been used:

$$\chi^2 = \sum[\frac{(O_i - E_i)^2}{E_i}]$$

Where:

χ^2- represents the test statistic of chi-squared value,

Σ - represents the sum of the categories in the tables,

O_i - represents the observed frequency in the *i*,

E_i - represents the expected frequency in the *i*.

Results and Discussion

Soil textural status

Soil texture is the relative amounts of sand, silt, and clay in a soil layer or horizon. The proportion of soil texture determines the characteristics of the soil that affect crop production and help to decide how to manage the field (Wimalasekera 2015; Goueguel et al. 2019). It also plays a significant role in determining soil fertility and nutrient movement from the soil to the plant (AI-Hamed et al. 2017). Thus, soil texture effects on nutrient uptake, microbial activity, water infiltration and retention, and soil aeration (Gupta 2004; Bjorneberg 2013; Chauhan & Gill 2014). The USDA (1998) classification divides the soil into 12 different classes based on the particle size distribution in the soil (for example, loam soil contains about 40% sand, 40% silt, and 20% clay, while clay-rich soil contains about 25% sand, 30% silt, and 45% clay; sandy soil is composed of approximately 90% sand, 2% clay, and 8% silt) (Moritsuka et al., 2015). The percent of sand, silt, and clay for each soil sample is summarized in the Table 1. The proportion of these component of soil shows the texture varies across the study area. High sand content generally allows water to drain quickly, which reduce to hold water and nutrients of soil. Silt content varies widely, which reflecting variability in depositional and erosional processes in the area. Soils with moderate silt content are often more fertile and retain moisture better, although they are prone to compaction. Clay content is relatively low and consistent among the samples in the study area, which indicates low plasticity and low shrink–swell potential, but still important for water retention and soil structure.

Table 1. The soil texture of the study area

Texture (%)	Minimum	Maximum	Std deviation	Mean	Variance
Sand	43	80.5	10.66	61.40	113.75
Silt	9	51.5	11.46	25.37	131.47
Clay	3	20.5	4.80	12.64	23.12

Source: Laboratory of the Central Department of Geography, TU, 2021.

Status of soil pH

Soil pH is the major variable that influences numerous chemical processes (Havlin et al. 2010) measured on a scale that indicates the acidity or alkalinity of soil, which directly and indirectly affects plant growth (Pagani, 2011; Vista & Ghimire, 2018). However, individual plants may have more specific soil pH preferences that are outside of this general range. For example, soil pH affects nutrient availability and can impact crop health and yield, with potatoes preferring slightly acidic to slightly alkaline soil with a pH range of 5.5 to 7.5. The soil pH also significantly influences the solubility of nutrients and the activity of microbes. It also involves in decomposing organic matter, as well as facilitating various chemical reactions within the soil (Shafeeva et al., 2021). Generally, the soil pH values between 6 to 7 is considered optimal for plant growth and development, as it facilitates the adequate availability of most required nutrients. Nonetheless, specific plants may exhibit unique soil pH that extend beyond this typical range. Potatoes, or Solanum tuberosum, prefer soils a pH values from 5.5 to 7.0 and low salinity (Waterer, 2002). However, they are usually grown in pH values between 4.5 and 8.5, which affects the availability of different nutrients. It prefers slightly acidic to slightly alkaline ranging from 5.5 to 7.5 (The Nutrition of Potatoes, 2022).

In this study, the pH measurements of the soil samples ranged from strongly acidic to moderately alkaline, as shown in Table 2. Of the total 35 polygons sampled, only two polygons were classified as strongly acidic, and an additional two were moderately alkaline, both accounting for 11.44 percent of the study area. In contrast, 19 samples were categorized as slightly acidic, constituting 54.28% of the study area, while 12 samples were characterized by a neutral pH, representing 34.28%. The majority of the samples had a slightly acidic pH range, followed by the neutral range. Nevertheless, polygons exhibiting strongly acidic and moderately alkaline characteristics were comparatively scarce. Neutral to moderately acidic soils are suitable for potato production. But in practice, potato is produced in a very strongly acidic to strongly alkaline environment (Tafesse, 2021). Thus, potato production is under the general practice.

Productivity of land

Soil productivity denotes the ability of soil to effectively maintain crop cultivation. The productivity of potatoes in the study area ranged from a minimum of 0.87 kg/m^2 to a maximum of 2.23 kg/m^2, with a mean productivity of 1.41 kg/m^2 and a standard deviation in productivity of 0.40 kg/m^2 (Table 2).

Relationship between soil textural classes and productivity

Of the five distinct textural classes, namely sandy loam, loamy sand, loam, sandy clay loam, and silty loam, 22 out of the total samples were classified as sandy loam, followed by loam, loamy sand, sandy clay loam, and silty loam (Table 2). Sandy loam notably exhibited the highest average potato yield at 1.556 kg per square meter, followed by loamy sand, sandy clay loam, and silty loam. Furthermore, the Chi-square test result revealed a significant difference in potato productivity across the various soil textural classes at a 5% significance level. Consequently, it can be concluded that potato productivity is significantly influenced by soil texture within the study area (Table 2).

Table 2. Soil textural and pH classes, percentage, and productivity of the study area

Unit of analysis	Number of Samples	Sample %	Production (kg/m^2)
Textural Classes			
Sandy clay loam	3	8.58	0.912
Sandy loam	22	62.86	1.556
Loam	5	14.28	1.068
Loamy sand	4	11.42	1.542
Silty loam	1	2.86	0.889
pH Classes			
Strongly acidic	2	5.72	1.315
Slightly acidic	19	54.28	1.296
Neutral	12	34.28	1.577
Moderately alkaline	2	5.72	1.601

Source: Laboratory of the Central Department of Geography, TU, 2021

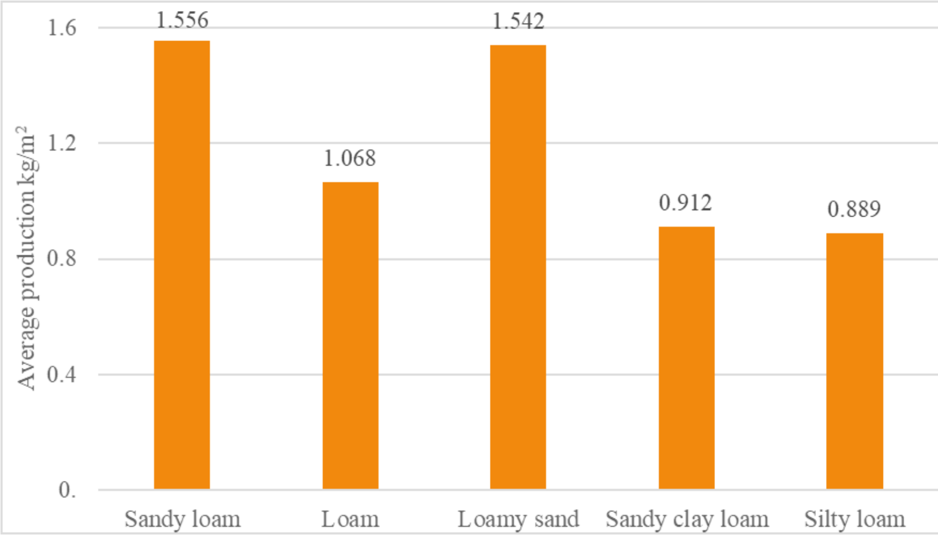

Figure 4. Soil textural classes and productivity of potatoes

Source: Laboratory of Central Department of Geography, T.U., and field visit, 2021.

Relationship between soil pH and productivity

The soil was classified into four pH classes: strongly acidic, slightly acidic, neutral, and moderately alkaline. The mean potato yield for each pH class is plotted in Figure 5, showing that the average yield was greatest in the moderately alkaline pH class (1.601 kg/m²) and least in the slightly acidic class (0.935 kg/m²).

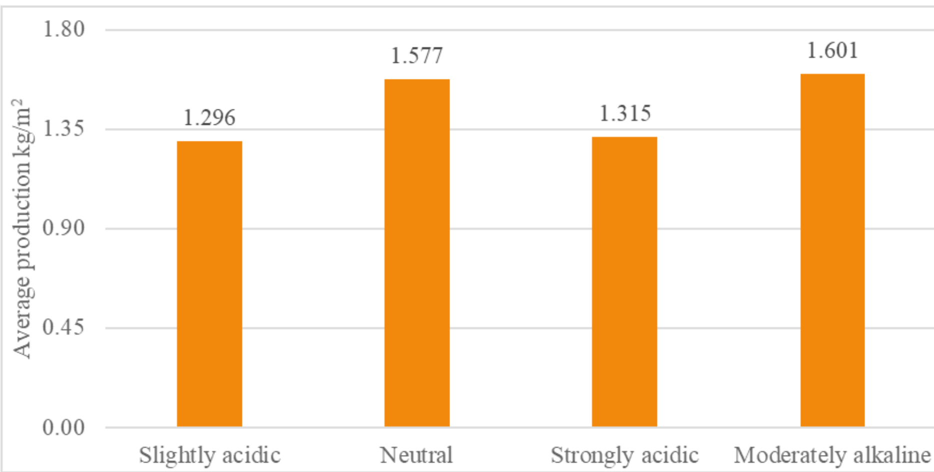

Figure 5. pH classes and the productivity of the potato

Source: Laboratory of Central Department of Geography, T.U., and field visit, 2021.

The overall picture suggests that as the soil became more acidic. The potato production changed at levels of soil acidity. However, the Chi-square test was not able to show that these differences were significant at the 5 percent significance level. They may therefore be due to chance or due to the small sample size, since the soil pH level is affected by other chemical factors such as chemical fertilizers, pesticides, and organic manure, which can affect productivity levels.

Management of potato farms

The soil pH values range from 5.4 to 7.9, with an average of 6.57. Approximately 54% of the tested soil samples are slightly acidic, 34.5% are neutral, and the remaining 11.5% are alkaline (variance = 0.17 and standard deviation = 0.41). Sand composition of the four classes of soil texture ranged from 43% to 80.5% (mean = 61.41%). Similarly, silt content varied from 9% to 51.5% (mean = 25.38%), and clay content ranged from 3% to 20.5% (mean = 12.65%). Farmers applied both organic and chemical fertilizers to improve the physical and chemical properties of the soil and potato yield. Urea, DAP, and potash were used as chemical fertilizers, and animal dung (cow dung, buffalo dung, and poultry manure) were used as organic manure. Of the 25 largest sample farmers, 25 applied herbicides to control invasive weeds, and 5 each practiced manual removal of weeds and a combination of both methods. During the winter dry season, farmers found it necessary to irrigate the potato cultivation from the local rivers in the lowland (Khet). In contrast, farmers cultivated potatoes particularly in the highland (Bari) during the rainy season, where irrigation from the rivers is difficult. A few midland (Bari) farmers employed sprinkler irrigation for potato cultivation. Out of the total farmers, 25 farmers used locally available potato seeds, while the remaining 10 used improved seeds available from public sources, as well as from commercial potato vendors.

In terms of potato productivity, sandy loam was found to yield the highest production at 1.556 kg/m2, followed by loamy sand at 1.542 kg/m2, loam at 1.068 kg/m2, sandy clay loam at 0.912 kg/m2, and silty loam at 0.889 kg/m2. For soil pH, moderately alkaline soils had the highest potato yield at 1.601 kg/m², followed by neutral soils at 1.577 kg/m², strongly acidic soils at 1.315 kg/m², and slightly acidic soils at 1.296 kg/m², which was the lowest. Although different pH levels influence productivity, the variations were not statistically significant at the 5% level. In the study area, due to the small sample size, there is no significant effect related to the use of chemical fertilizers. However, productivity varied significantly across different soil textural classes.

For agricultural land preparation in the study area, organic manure and small tractors were used for ploughing and tillage, but no specific practices were documented. Challenges to potato productivity included a lack of JTA services, insufficient knowledge among farmers, reliance on indigenous knowledge, absence of soil testing, potato diseases, and limited availability of fertilizers and seeds. Among the five main soil types, ranging from acidic to alkaline, better potato yields were obtained from sandy loam and loamy sand due to improved drainage and aeration, whereas clay was difficult to manage; marginally better potato production was observed in neutral and moderately alkaline soils. Though the farmers used both chemical and organic fertilizers to enhance soil fertility, organic manure was declining due to the decline of livestock farming and green manure.

Conclusion

Soil texture and pH levels are significantly influenced in potato productivity. As soil texture, loam is favorable for potato cultivation. The soil texture includes the proportions of sand, silt, and clay, which affects critical factors such as nutrient absorption, water retention, and microbial activity. Likewise, soil pH represents the level of acidity and alkalinity and they affects nutrient solubility and microbial processes. Thus, the range of pH influence on the plant growth. Generally, various plants favor an optimal pH ranges from 6 to 7, whereas potatoes thrive within a pH range of 5.5 to 7.5. Due to the favorable drainage systems and aeration properties, the highest potato yields are found in sandy loam whereas clay soils show limitations. Despite the general suitability of the soils for potato cultivation in the study area, highly acidic or moderately alkaline conditions pose specific challenges. The study revealed substantial productivity differences associated with the soil texture rather than pH, possibly attributed to limited sample sizes or extraneous factors. Soil fertility can be enhanced by the farmers through the application of lime to mitigate acidity and organic amendments, which improve soil structure. It also provided that there is a comprehensive soil testing and analysis being conducted to ascertain optimal conditions for potato growth. Soil choice significantly affects potato quality and yield, highlighting the need for solutions to improve farmland production. Accurate soil texture classification is crucial in potato farming. Further experiments are necessary to deepen the understanding of optimizing potato cultivation.

The identified challenges are inadequate soil testing, a lack of official agricultural guidance, and a lack of fertilizer resources. Thus, the results highlight that the soil plays important role in agriculture and food security, which need for more research and advanced soil management techniques, agricultural guidance by authorities and sufficient fertilizer resources to improve potato production.

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References

Al-Hamed, S. A., Wahby, M. F., Aboukarima, A. M., & Marazky, M. S. E. (2017). Effect of soil and water characteristics on yield and properties of 'Spunta potatoes'. *Chilean Journal of Agricultural Research*, *77*(3), 250–256. https://doi:10.4067/s071858392017000 300250

Anaya, A. L. (1999). Allelopathy as a tool in the management of biotic resources in agroecosystems. *Critical Reviews in Plant Sciences*, *18*(6), 697-739. https://doi:10.1080/07352689991309450

Baral, B. (2024, March 13). The tales of Nepali Potato. *The Annapurna express*. https://theannapurnaexpress.com/story/47907/

Bhatia, S. S. (1967). A new measure of agricultural efficiency in Uttar Pradesh, India. *Economic Geography, 43*(3), 224–260. https://doi.org/10.2307/143292

Bjorneberg, D. L. (2013). Irrigation | Methods. In *Reference module in earth systems and environmental sciences, pp. 1–9.* Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.05195-2

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analyses of soils. *Agronomy Journal*, *54*(5), 464–465. https://doi:10.2134/agronj1962.00021962005400050028x

Chakraborty, K. & Mistri, B. (2015). Soil fertility and its' impact on agricultural productivity: A study in Sapar Mouza, Burdwan-1 C.D. Block, West Bengal. *International Journal of Humanities & Social Science Studies (IJHSSS), 2*(3), 196-206

Chauhan, B. S. & Gill, G. S. (2014). Ecologically based weed management strategies. In B. S. Chauhan & G. Mahajan (Eds.), *Recent advances in weed management* (pp. 1–12). Springer. https://doi.org/10.1007/978-1-4939-1019-9

Chidi, C. L., Shrestha, U. S., Sharma, P., Shrestha, P., & Shrestha, S. (2024). Dynamics of population, agricultural land, and vegetated areas in the central to eastern mountain and hill districts of Nepal. *The Third Pole: Journal of Geography Education, 24*(1), 46–63. https://doi.org/10.3126/ttp.v24i1.73364

Dahal, J., Chidi, C. L., Mandal, U. K., Karki, J., Khanal, N. R., & Pantha, R. H. (2018). Physio-chemical properties of soil in Jita and Taksar area of Lamjung district, Nepal. *The Geographical Journal of Nepal*, *11*, 45–62.

https://doi.10.3126/gjn.v11i0.19548

Dogbe, W., Dzomeku, I. K., Yahaya, B. S., Siise, A., Krofa, E. O., & Awuakye, S. A. (2015). Influence of seed quality and soil fertility management on the productivity of rice (Oryza sativa L) in the guinea savanna of Ghana. *International Journal of Development, 2*(2). http://www.udsijd.org.

Gnyawali, B., Aryal, I., & Mandal., U. K. (2022). Land suitability assessment for cereal crops in Sainamaina municipality, Nepal. *The Geographic Base, 9*, 141–154. https://doi.org/10.3126/tgb.v9i1.55449

Gorakhapatra Coorporation. (2022, August 02). Potato, onion worth above Rs. 14 billion imported. *The Rising Nepal*. https://risingnepaldaily.com/news/14814

Goueguel, C. L., Soumare, A., Nault, C., & Nault, J. (2019). Direct determination of soil texture using laser-injured breakdown spectroscopy and multivariate linear regressions. *Journal of Analytical Atomic Spectrometry, 34*(8), 1588–1596. https://doi:10.1039/C9JA00090A

Gupta, P. K. (2004). *Soil, plant, water, and fertilizer analysis*. Agrobios, India.

Havlin, J. L., Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (2010). *Soil fertility and fertilizers: An introduction to nutrient management.* India: Pearson India Education Services Pvt. Ltd.

Karanja, A., Shisanya, C. and Makokha, G. (2014) Analysis of the key challenges facing potato farmers in Oljoro-Orok Division, Kenya. *Agricultural Sciences, 5,* 834-838. https://doi.org/10.4236/as.2014.510088

Kehoe, M., Harding, A. Pagdilao, S. J. & Appels, W. M. (2025). Effect of topographical and soil complexity on potato yields in irrigated fields. *Agricultural Water Management, 307*, 109216. https://doi.org/10.1016/j.agwat.2024.109216

Khadka, T., Chauhan, D., Tiwari, A., Regmi, B., Dahal, S., & Manandhar, S. (2023). Value chain analysis of potato in Bajhang district, Nepal. *Archives of Agriculture and Environmental Science, 8*(4), 516–523. https://doi.org/10.26832/24566632.2023.080409

LRMP, (1986). *Land system report*. Land Resource Mapping Project (LRMP), Kenting Earth Sciences Limited, Government of Canada and Government of Nepal.

MoALD. (2025). Statistical information on Nepalese agriculture 2080/81 (2023/24).

Government of Nepal, Ministry of Agriculture and Livestock Development, Kathmandu, Nepal. https://moald.gov.np/content/307/statistics-information-on-nepalese-agriculture-2080-81/

MoFAGA. (2017). *Sthaniya taha* (Local Level in English). Ministry of Federal Affairs & General Administration, Government of Nepal, Singadarbar, Kathmandu. Website: www.sthaniya.gov.np/gis/

Moritsuka, N., Izawa G., Katsura, K. & Matsui, N. (2015). Simple method for measuring soil sand context by nylon mesh sieving. *Soil Science and Plant Nutrition, 61*(3), 501–505. https://doi:10.1080/00380768.2015.1016864

Mushinskiy A. A., Aminova, E. V., & Gerasimova, E. V. (2016). Selection of medium-early and medium-ripe potato varieties for the steppe zone of the southern Urals. *Samara State Agricultural Academy,1*(4), 18–21. https://doi:10.12737/21797

NSO. (2023). *National population and housing census 2021: National report*. National Statistical Office, Government of Nepal, Kathmandu, Nepal. https://censusnepal.cbs.gov.np/results/downloads/national?type=report

Oliver, D. P., Bramley, R. G. U., Riches. D., Porter, I., & Edward, J. (2013). Review: Soil physical and chemical properties as indicators of soil quality in Australian viticulture. *Australian Journal of Grape and Wine Research, 19*, 127–134. https://doi:10.1111/ajgw.1201

Pagani A. (2011). *Soil pH and lime management for corn and soybean*. (Publication No. 10374). [Doctoral dissertation, Iowa State University, Ames, Iowa]. https://doi:10.31274/ etd-180810-2005

Pearson, K. (1900). On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling. *Philosophical Magazine Series 5, 50*(302), 157-175.

Shafeeva, E., Komissarov, A., Ishbulatou, M., Mindibayev, R., & Lykasov, O. (2022). Utilization of poultry manure when cultivating potatoes in the southern steppe of the Republic of Bashkortostan. *Saudi Journal of Biological Sciences, 9*(3), 1501–1509. https://doi:10.1016/j.sjbs.2021.11.022

Singhal, R., & Rana, K. R. (2015). Chi-square test and its application in hypothesis testing. Journal of the Practice of Cardiovascular Sciences 1(1).

https://doi:10.4103/2395-5414.157577

Subedi, S., Ghimire, Y.N., Gautam, S., Poudel, H.K. & Shrestha, J. (2019). Economics of potato (Solanum tuberosum L.) production in Terai region of Nepal. *Archives of Agriculture and Environmental Science, 4*(1), 57-62.

https://dx.doi.org/10.26832/24566632.2019.040109

Tafesse, S., Braam, C., Van Mierlo, B., Lemaga, B. & Struik, P. (2021). Association between soil acidity and bacterial wilt occurrence in potato production in Ethiopia. *Agronomy, 11*(8), 1541. https://doi:10.3390/agronomy11081541.

The Nutrition of Potato Crops. (2022). https://www.yara.co.uk/siteassets/crop-nutrition/fertiliser-choices/yarabela/nutrition-of-potatoes.pdf/.

USDA. (1998). *Soil quality indicators: pH.* Soil quality information sheet. National Soil Survey Center, Soil Quality Institute, NRCS, USDA, and the National Soil Tilth Laboratory, Agricultural Research Service, USDA. https://www.thinktrees.org/wp-content/uploads/2019/03/Soil-Quality-Indicators-pH.pdf

Vista, S. P. & Ghimire, T. B. (2018). Assessment and mapping soil fertility status of potato super zone, Kavrepalanchowk. *International Journal of Agricultural Research, 3*(1), 132–136. https://doi:10.46492/IJAI/2018.3.2.1

Waterer, D. R. (2002). Impact of high soil pH on potato yields and grade losses to common scab. *Canadian Journal of Plant Science, 82*(3), 583–586.

https://doi:10.4141/P01-046

Wimalasekera, R. (2015). Role of seed quality in improving crop yields. In *Crop Production and Global Environmental Issues* (pp. 153–168). Springer International Publishing. http://doi:10.1007/978-3-319-23162-4_6