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Evaluation of soil fertility status at the Agricultural Service Training Center (ASTC) Research Farm, Kuru, Jos South LGA, Plateau State, Nigeria

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A B S T R A C T

This study evaluated the soil fertility status of the Agricultural Service Training Centre (ASTC) Research Farm in Kuru, Jos South LGA, Plateau State, Nigeria. Specifically, the study assessed the soil fertility status and identified nutrient deficiencies in the area. Soil samples were collected at various depths (0-20 cm and 20-50 cm) from seven augering points and analysed for physical and chemical properties, including pH, electrical conductivity, organic matter, organic carbon, total nitrogen, exchangeable cations, extractable phosphorus, and sulphur. The results revealed that the soil has a slightly acidic to neutral pH, low organic matter and organic carbon content, moderate to high cation exchange capacity, and varying levels of extractable phosphorus and sulphur. These findings suggest potential limitations in soil fertility and ecosystem services that may affect crop growth and productivity. Based on the study's findings, recommendations are made for farmers and land managers to improve soil health and productivity, including adding organic matter, applying phosphorus fertilizers as needed, using conservation practices, conducting regular soil testing, selecting suitable crops, and planning rotations. Furthermore, land managers are advised to develop tailored nutrient management strategies, promote sustainable agricultural practices, and provide farmers with training and resources on soil testing, fertilizer application, and crop selection.

Keywords: Soil fertility, Nutrient deficiencies, Soil health, Sustainable agriculture, Nutrient management

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Introduction

The Agricultural Service Training Center (ASTC) Research Farm in Jos South, Nigeria, is a vital institution for agricultural research and development (Momoh *et al.*, 2018). The farm is a hub for innovation and knowledge sharing, promoting sustainable agriculture and enhancing crop yields (Agada, 2021). However, like many farmlands in Nigeria, the farm's soil fertility status is likely influenced by various factors, including management practices, fertilizer application, and soil degradation (Hjelm and Dasori, 2012). The ASTC Research Farm serves as a critical testing ground for new agricultural techniques aimed at addressing the challenges posed by soil degradation and nutrient depletion (Momoh *et al.*, 2018; Agada, 2021).

Through rigorous experimentation and field trials, researchers at the farm assess the effectiveness of various fertilization strategies and crop rotation systems for restoring and maintaining soil health (Srivastava *et al.*, 2024). According to Țopa *et al.* (2025), sustainable practices such as crop rotation, conservation agriculture, and the use of organic amendments can restore soil structure, increase organic matter, and promote biodiversity, ultimately enhancing soil health. Emphasizing sustainable practices, the farm integrates organic amendments and conservation tillage methods to reduce erosion and improve soil structure (Seitz *et al.*, 2019). Moreover, extension services provided by ASTC facilitate the transfer of innovative technologies to local farmers, empowering them to optimize input use and increase productivity while safeguarding the environment (Raji *et al.*, 2024). In this way, the farm contributes to advancing scientific knowledge and plays a transformative role in promoting food security and rural livelihoods in Jos South and beyond (Guluwa and Jimmy, 2018).

Soil is a multifaceted system of minerals, soil organic matter (SOM), water, and air. Soil quality, encompassing interactive physical, chemical, and biological properties, determines its suitability for agriculture and other uses. Soil fertility encompasses both the chemical and physical properties of soil (Loss *et al.*, 2014). Soil fertility assessment estimates the availability of native and residual nutrients for crop growth and determines fertilizer requirements for profitable yields (Nafiu *et al.*, 2012). Soil texture, structure, and colour are essential physical parameters of soil. Similarly, soil reaction (pH), organic matter, and macro and micronutrients are important soil chemical parameters. These properties play significant roles in soil fertility and testing.

Assessing soil fertility is vital for informed fertilizer application and soil management (Singh *et al.*, 2024). By analyzing nutrient content, pH, and other physical and chemical properties, farmers and researchers can detect deficiencies, optimize fertilizer use, and promote sustainable practices (Nakachew *et al.*, 2024). This approach not only enhances crop productivity but also reduces the environmental impact of agricultural activities (Srivastava *et al.*, 2024). Moreover, regular soil fertility assessments provide a dynamic understanding of soil health over time, enabling timely adjustments to cultivation practices (Țopa *et al.*, 2025). This proactive approach is essential in adapting to changing climatic conditions and mitigating the risks of soil degradation (Al-Shammary *et al.*, 2024). By integrating soil testing data with site-specific crop requirements, farmers can tailor nutrient applications, avoid over-fertilization, and minimize runoff that contributes to water pollution (Srivastava *et al.*, 2024). Furthermore, advancements in soil analysis techniques, including precision agriculture tools and remote sensing, have enhanced the accuracy and accessibility of fertility assessments (Al-Shammary *et al.*, 2024).

Soil properties exhibit geographic and chronological variability influenced by inherent factors such as soil formation, management practices, fertilization, and crop rotation (Sharma *et al.*, 2011). The high degree of variability in soil features due to anthropogenic activities requires monitoring key indicators and their critical limits to assess changes in soil quality for different agro-ecological zones at local, national, and global levels (Yakubu and Mallo, 2019). Many soil indicators interact with each other; thus, the value of one is affected by one or more of the other parameters (Arshad and Martin, 2002). Soil is a crucial natural resource, and its nutrients play a vital role in ensuring food security, promoting human health, and fostering sustainable development. Soil fertility and nutrient management are essential in modern agriculture and play a crucial role in sustainable development and the management of fertilizers at specific crop production sites (Harishma *et al.*, 2025). Therefore, assessment of soil fertility is imperative as a decision-making tool for the sustainable management of soil nutrients. Fertility management based on soil testing is an effective tool for increasing agricultural soil production. Analysing soil nutrient content, spatial distribution, and the classification of soil nutrient levels are essential for developing scientifically and economically sound fertilization recommendations, thereby reducing excessive fertilizer application.

Ultimately, these practices contribute to the resilience and sustainability of agricultural systems, promoting long-term food security while preserving ecosystem balance (FAO, 2017). However, in Nigeria, the indiscriminate application of fertilizers by farmers, without considering the specific nutrient needs of the soil and crops, has led to inefficient use, resulting in low soil fertility and reduced crop productivity. Similarly, at the Agricultural Service Training Center (ASTC) Research Farm, there is a significant lack of comprehensive data regarding the soil fertility status. This data deficiency poses a challenge to informed decision-making regarding fertilizer application and soil management practices, potentially leading to inefficient resource use, reduced crop yields, and environmental degradation. Accurate soil fertility data is essential for developing tailored fertilization strategies that optimize agricultural productivity while minimizing adverse environmental impacts. Without this information, there is a risk of over-application or under-application of fertilizers, leading to nutrient imbalances and diminished soil health. Addressing this knowledge gap is crucial for ensuring effective fertilizer use and sustainable soil management, supporting both agricultural output and environmental stewardship.

This study aims to address this knowledge gap by evaluating the soil fertility status of the ASTC Research Farm, providing essential data to inform sustainable soil management practices and optimize crop productivity. By assessing the soil's physical and chemical properties, identifying nutrient deficiencies and limitations, and providing recommendations for sustainable soil management practices, this study will contribute to improved agricultural productivity and sustainability. Addressing this knowledge gap is paramount for ensuring the effective use of fertilizers and the sustainable management of soil resources, thereby supporting both agricultural output and environmental stewardship.

The specific objectives of this study are to:

i. assess the soil fertility status of the Agricultural Service Training Center (ASTC) Research Farm in Jos South Local Government Area.
ii. identify the nutrient deficiencies and limitations in the soil within the study area.

Materials and Methods

The study was carried out at the Agricultural Service Training Centre (ASTC) Research Farm, Kuru, Jos South Local Government Area, Plateau State, Nigeria. The farm is located at Latitude 9°44'N, Longitude 8°51'E, at an elevation of 1,240 m above sea level [m.a.s.l.]. Jos South LGA has an area of approximately 510 km². The region's climate is largely controlled by its high altitude, with mean annual temperatures ranging between 18°C and 22°C. The soils are ferruginous and loamy, characteristic of the Jos Plateau.

Materials used

(i) Munsell soil color chart, (ii) Soil auger, (iii) Sampling bags, (iv) Permanent marker, (v) Weighing balance, (vi) pH meter, (vii) EC meter, (viii) Cylinder, (ix) Beaker, (x) Mortar and pestle, (xi) Stirrer, (xii) Hydrometer, (xiii) Sieve (2mm), (xiv) Stopwatch

A random survey was conducted within the study area to determine the soil color, texture, and consistency using a soil auger. To assess the fertility status of the study area, soil samples were collected using an auger from the soil surface at various depths (0-20 cm and 20-50 cm). The samples were analyzed for physical and chemical properties at the Soil Science Laboratory of FECOLART Kuru-Jos.

The soil samples were analyzed for:

- Electrical Conductivity (EC): Measured using an Electrical Conductivity meter in a soil-water suspension (1:2.5) (Jaiswal, 2003).
- Organic Matter (%): Calculated by multiplying the organic carbon content by a factor of 1.724 (Walkley and Black, 1934).
- Total Nitrogen: Determined using the Micro Kjeldahl method (Bremner and Mulvaney, 1982).
- Exchangeable Cations: Extracted using neutral ammonium acetate (NH_4OAc) and determined by flame photometry for calcium and magnesium (Black, 1965).
- Soil pH: Measured potentiometrically in a 1:2.5 soil-water ratio (Moberg, 2000; McLean, 1982).
- Organic Carbon: Determined by the wet digestion method of Walkley-Black (Nelson and Sommer, 1982; Moberg, 2000).

- Available Sulphur: Extracted with 0.15% $CaCl_2$ solution (1:5 ratio), shaken for 30 min, filtered, and determined turbidimetrically with $BaCl_2$ (Tabatabai and Bremner, 1970).
- Extractable Phosphorus: Determined using the Bray-1 method (Bray and Kurtz, 1945; Moberg, 2000) followed by color development with ascorbic acid (Murphy and Riley, 1962).
- Determination of Exchangeable Bases and Cation Exchange Capacity: Cation exchange capacity was determined by the ammonium acetate saturation method (Chapman, 1965).

Results and Discussion

Table 1. Textural properties of the seven (7) mapping units.

Sample No	Soil color		Sand	Silt	Clay	Textural class
	Dry	Moist				
			0-20 cm			
C1a	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	41.4	16.28	42.32	Clay
C2a	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	44.4	16.28	39.32	Clay loam
C3a	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	43.4	18.28	38.32	Clay loam
C4a	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	54.4	19.60	26.00	Sandy clay loam
C5a	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	47.4	19.28	33.32	Sandy clay loam
C6a	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	45.4	21.28	33.32	Sandy clay loam
C7a	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	41.4	23.28	33.32	Clay loam
			20-50 cm			
C1b	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	47.4	16.28	36.32	Sandy clay
C2b	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	47.4	17.28	35.32	Sandy clay
C3b	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	46.4	16.28	37.32	Sandy clay
C4b	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	45.4	12.28	42.32	Sandy clay
C5b	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	42.4	15.28	42.32	Clay
C6b	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	43.4	21.28	35.32	Clay loam
C7b	10YR 6/8 Brown yellow	10YR 5/8 Yellowish brown	40.4	21.28	38.32	Clay loam

Source: Field Survey, 2025

The laboratory analysis revealed that the soil samples exhibited textural classes of clay, sandy clay, clay loam, and sandy clay loam at both the surface (0-20 cm) and sub-surface (20-50 cm) depths. These findings are consistent with those of Yusuf *et al.* (2015), who observed similar soil textures across different land-use types. The implications of these findings are significant, as understanding soil texture is crucial for informed decisions about crop selection, soil management, and land-use planning. Specifically, the presence of clay, sandy clay, clay loam, and sandy clay loam soils necessitates tailored strategies for water and nutrient management. Effective soil structure management and nutrient application can optimize crop productivity while minimizing environmental impact. Moreover, these insights can inform land suitability assessments and soil conservation efforts, ultimately contributing to more sustainable agricultural practices.

As noted by Brady and Weil (2002), soils with predominantly large particles tend to drain quickly and have lower fertility, whereas very fine-textured soils may be poorly drained and prone to waterlogging, rendering them less suitable for agriculture.

Differences in texture can significantly affect the soil's physical and chemical properties. Given the composition of sand, clay, and silt in the soil within the project area, along with other parameters such as organic matter content, moisture content, and pH, the soil is versatile, productive, and capable of supporting microbial growth and plant life. The relatively permanent nature of these characteristics makes them useful for comparing the abilities of different soils and evaluating their suitability for specific uses.

Table 2. Chemical properties of the seven (7) mapping units.

Sample No	pH h2o	pH cacl2	EC ppm	OM (%)	K+ ppm	Mineral N (mg kg⁻¹)	Phosphorus ppm	Sulphur Ppm	Organic carbon
0-20 cm									
C1a	6.58	5.95	49	0.29	0.0026	17.85	0.14	1.48	0.12
C2a	6.64	5.33	47	0.29	0.0025	16.05	0.08	1.18	0.16
C3a	6.70	5.11	64	0.28	0.0044	18.98	0.00	1.56	0.11
C4a	6.71	5.32	73	0.28	0.0049	17.85	0.08	1.32	0.09
C5a	6.56	5.16	60	0.29	0.0039	18.53	0.10	0.90	0.10
C6a	6.38	4.98	89	0.28	0.0043	17.18	0.05	1.24	0.11
C7a	6.45	4.03	158	0.29	0.0057	27.12	0.00	1.11	0.18
Mean	6.57	5.13	77.14	0.29	0.0040	19.08	0.06	1.26	0.12
20-50 cm									
C1b	6.80	5.44	82	0.27	0.0050	19.44	0.17	1.65	0.19
C2b	6.71	5.21	49	0.27	0.0038	15.82	0.12	1.33	0.10
C3b	6.83	5.29	45	0.28	0.0032	16.95	0.20	1.51	0.19
C4b	6.79	5.15	34	0.27	0.0043	16.49	0.00	0.89	0.14
C5b	6.88	5.73	53	0.29	0.0029	15.37	0.09	1.03	0.21
C6b	6.75	4.17	25	0.28	0.0027	17.85	0.08	1.02	0.11
C7b	6.91	4.26	48	0.28	0.0039	19.89	0.06	1.06	0.15
Mean	6.81	5.04	48	0.28	0.0033	17.40	0.09	1.36	0.16

Source: Field Survey, 2025
Note: Mineral N refers to extractable NO_3^-*-N +* NH_4^+*-N.*

Table 2 presents the chemical properties of the seven mapping units, including pH, electrical conductivity (EC), organic matter (OM), potassium (K^+), mineral nitrogen (N), phosphorus (P), sulphur (S), and organic carbon (OC) content. These parameters are essential for understanding soil fertility and nutrient availability.

Soil pH

The soil pH ranged from 6.38 to 6.91, indicating slightly acidic to neutral conditions. This range is considered ideal for most crops, as it allows for optimal nutrient availability. According to Jackson *et al.* (2018), this pH range supports the availability of essential nutrients like N, P, K, S, Ca, Mg, B, Cu, Fe, and Zn. The finding implies that the soil is suitable for a wide range of crops, and the optimal pH range may reduce the need for lime or other pH-adjusting amendments.

Mineral nitrogen content

Mineral nitrogen ranged from 15.37 to 27.12 mg kg⁻¹ across depths, with a mean of 19.08 mg kg⁻¹ in the 0–20 cm layer and 17.40 mg kg⁻¹ in the 20–50 cm layer. These values are low for arable soils in the tropics, where >40 mg kg⁻¹ is often considered adequate for crop uptake during the growing season (Weil and Brady, 2016). The low mineral N likely reflects low organic matter content and limited organic inputs at the site. The slightly higher values in the topsoil compared to the subsoil are consistent with the expected pattern, driven by greater organic matter and microbial activity near the surface. This suggests that nitrogen fertilization or legume-based rotations will be necessary to meet crop demand and prevent yield limitations.

Organic matter and organic carbon content

Organic matter content ranged from 0.27% to 0.29%, and organic carbon from 0.12% to 0.16%. Both are considered very low (Brady and Weil, 2002), indicating potential limitations to soil fertility, structure, and water-holding capacity. Low organic matter can result from intensive tillage, inadequate crop rotation, or insufficient organic amendments (Wang *et al.*, 2020; Pittarello *et al.*, 2021). Strategies such as incorporating cover crops or organic amendments may be necessary to enhance soil health.

Exchangeable potassium content

Exchangeable K^+ ranged from 0.0025 to 0.0057 ppm, indicating very low levels. According to Landon (2014), values <0.2 cmolc kg^{-1} are considered low for most crops. This suggests a high likelihood of potassium deficiency and the need for K fertilization (Zhang *et al.*, 2013).

Extractable phosphorus and sulphur content

Extractable phosphorus ranged from 0.06 to 0.09 ppm, indicating low to moderate levels of available P, while sulphur ranged from 1.26 to 1.36 ppm, indicating moderate to adequate levels. The low to moderate phosphorus content may limit crop growth and productivity, while the moderate to adequate sulphur content suggests sulphur deficiency is unlikely to be a major concern. Knowledge of these parameters enables farmers and land managers to develop targeted plans to enhance soil fertility, structure, and ecosystem services, ultimately improving crop productivity and sustainability (Yusuf *et al.*, 2015).

Conclusion

This study assessed the soil fertility status of the Agricultural Service Training Center (ASTC) Research Farm in Jos South Local Government Area. The results revealed that the soil has a slightly acidic to neutral pH, low organic matter and organic carbon content, moderate to high cation exchange capacity, and varying levels of extractable phosphorus and sulphur. These findings suggest that the soil has potential limitations to soil fertility and ecosystem services, which may impact crop growth and productivity.

Recommendations

Based on the study's findings, the following recommendations are made:

- Farmers at ASTC Research Farm should apply organic amendments and phosphorus fertilizers where soil tests indicate deficiencies, adopt conservation practices such as reduced tillage and crop rotation, and match crop selection to current soil nutrient status to improve soil health and productivity.
- Extension personnel should provide on-farm support for regular soil testing, interpret results for farmers, and deliver practical training on balanced fertilization, crop rotation planning, and conservation practices tailored to local soil conditions.
- Land policy managers should develop nutrient management guidelines based on soil cation exchange capacity and nutrient levels, promote incentives for sustainable practices like cover cropping and reduced tillage, and strengthen farmer access to soil testing services and training programs.

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