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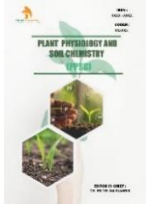

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RESEARCH ARTICLE

SOIL FERTILITY EVALUATION OF AN INSTITUTIONAL COMMERCIAL FARM PLOT IN THE SOUTH-WEST ZONE OF NIGERIA

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ABSTRACT

Soil fertility evaluation is very important as a decision-making tool for the management of soil nutrients sustainably. The study was conducted to evaluate the soil fertility status of the farm plot around the Sport Complex area of the University of Ibadan, Ibadan, Nigeria using fertility rating and fertility capability classification. Based on an existing soil map of the site, composite samples were collected from ten sampling points at 0-15 cm, 15-30 cm and 30-45 cm depth across three mapping units (Iregun, Effon and Mamu Series). The soil samples were collected to analyze the chemical properties, particle size distribution, soil texture, bulk density, porosity, moisture content, Soil pH, Organic carbon, total nitrogen, available phosphorus, exchangeable bases (Ca, Mg, K, Na), exchangeable acidity (H^+, Al^{3+}), exchangeable cation exchange capacity (ECEC) and base saturation of the study area. Data generated were subjected to statistical analysis using Analysis of Variance (ANOVA) and treatment means separated using Least Significant Difference (LSD) at 0.05% probability. Result shows the soils of the three mapping units were generally slightly acidic are predominantly loamy sand in texture. Major limitations observed in the study area are low CEC (e) and low nutrient reserves (k). The Fertility Capability Classification identified the Iregun and Mamu series as Sek (sandy, low CEC, low nutrient reserves) and Effon series as SLek (sandy with loamy substrata, low CEC, low nutrient reserves). The study highlights the need for improved soil management practices, such as incorporating organic manure and minimizing tillage, to enhance soil fertility and productivity.

KEYWORDS

Soil, Fertility, Evaluation, Nutrients, Ibadan.

1. INTRODUCTION

Soil is a naturally occurring ecosystem consisting of a mixture of minerals and organic matter with a definite form, structure and composition (Oklo et al., 2021). Soil is a dynamic, living matrix that is an essential part of the terrestrial ecosystem (Abiala et al., 2013). Soils are exposed to one form of disturbance or the other. Investigations have shown that soil infertility due to land degradation has been a major constraint to food production (Agbede and Adekiya, 2012). Which can disrupt the condition of ecosystem stability, and as a result, biomass productivity will decrease (Aji et al., 2020).

Soil fertility is a relatively complex concept (Augusto et al., 2002) that can be defined as the potential of soil to generate or produce a substantial yield (Akintola et al., 2023). Also, researchers noted in their study that soil fertility is a subject of soil characteristics especially biological, chemical and physical, all of which affect the availability of nutrients directly or indirectly (Magdoff and Van, 2009; Chikere, 2019).

Soil fertility is a major area of concern which is a factor that determines soil productivity and crop performance. Some problems of poor soil fertility include; land use, poor management, lack of inputs, soil erosion and salinization have led to a decline in productivity and loss of vegetation (Mayer, 2021). Soil fertility is governed by soil chemical and physical properties which can be improved for increased production. They include pH, organic matter, CEC, available N, P and K, Ca, Mg, and S (Ayodele et al., 2019) as well as Fe, Mn, Cu, and Zn.

Evaluation of soil fertility is the most critical point for long-term planning in a specific area. Evaluation of soil fertility status and soil productivity is important to help monitor both soil fertility and yield sustainability over time and specific soil conditions (Adesemuyi and Nwagbara, 2017). The evaluation of soil fertility includes the measurement of available plant essential nutrients and the estimation of the capacity of soil to maintain a continuous supply of plant nutrients for a crop (Bijay and Singh, 2015).

The University of Ibadan, Ibadan, Nigeria is characterized with Institutional farmlands for research and commercial production. The Sport Complex area farmlands are one of the major farms for commercial production within the institution. The farm area is known for the production of arable crops such as maize and cassava, leaf vegetables, fruit vegetables and non-woody fruits such as banana and pawpaw.

Thus, the objective of this study is:

- To assess the fertility status of the University of Ibadan Sport Complex area farm plot
- To determine the status of available nutrients in the farm area.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is located adjacent to the Sport Complex, close to Awolowo Hall of Residence, University of Ibadan, Oyo State. The area lies between Latitudes 07.26132° N - 07.26110° N and Longitudes 03.53182° E - 03.53090° E as shown in Figure 1. The size of the study area is 7.17 hectares.

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The climate of the area is designated as moderately humid with mean annual rainfall between 1467mm. There are two distinct seasons in the study area which are: the dry season occurs between October/ November and March/ April and the rainy season occurs between March/ April to October/ November. The mean annual temperature ranges from 24.4 °C to 32.6 °C.

2.2 Vegetation and Land Use

Fallow and arable farming are the main land use/land cover features of the study area. There are forest trees and shrubs on a part of the plot. A mixed cropping plot that comprised maize, cassava and melon. Some areas of this land have been left for fallow over the years which has brought about a formation of heavy forest at the opposite end of the study area. The vegetation is characterized by thick bushes and secondary forests. The observed land use types of the study area include arable cropping in which cassava, vegetables, corn, and melon were planted and fallow land.

2.3 Soil Sampling

The mapping units were identified based on an existing soil survey report and soil map of the area showing the three-soil series. A rigid grid method of soil survey was used where transects were laid 150 m apart. Examination points were predetermined in a Global Positioning System (GPS) device. The random sampling technique was used to collect soil samples from ten (10) different sampling points in each mapping unit. Soil auger was used for collection of the soil samples across the arable and fallow land within each of the three soil types.

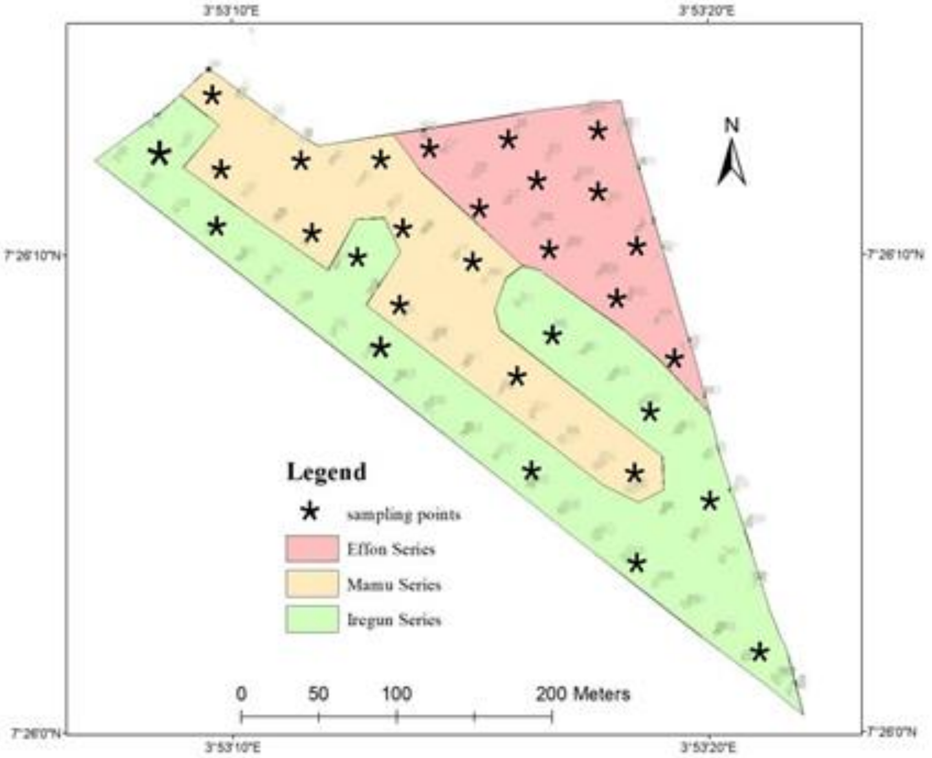

Figure 1: Soil map of the study area showing the soil series

The 10 sample points were located on each of the 3 mapping areas as shown in Fig.1 for soil sample collection. Soil samples were collected at 3 different depth of 0-15 cm, 15-30 cm and 30-45 cm at each of the sampling points on each mapped area (3 soil series). The samples were bulked accordingly and 3 representative samples were collected per depth in each of the mapped area (soil series). A total of 27 soil samples from the three mapping units were collected, bagged and labelled for laboratory analysis. The samples were sieved using 2 mm and 0.5 mm mesh sizes, and taken to the laboratory for routine chemical analysis.

2.4 Laboratory Analysis

Soil samples collected from the survey site were brought to the laboratory for physical and chemical analyses. The soil was air-dried, crushed and sieved using 2.0 mm and 0.5 mm sieves to remove materials greater than 2 mm in diameter. The gravel and fine earth content of the samples were weighed to determine their ratio in each of the samples.

Particle size distribution was determined using the Bouyoucos hydrometer method (1962). The soil pH was determined in water using a pH meter in a 1:1 soil-solution mixture (Udo et al., 2009). Available phosphorus was determined using the Bray Test established by (Bray and Kurtz, 1945). Organic carbon was analyzed by the Dichromate oxidation method and described by (Udo et al., 2009; Walkley and Black, 1934). Total Nitrogen was done by the Kjedahl analytical method. The concentration of the micronutrients (Fe, Mn, Cu and Zn) was determined using the Atomic Absorption Spectrophotometer (Udo et al., 2009). Exchangeable Acidity was determined by (Black, 1965). Exchangeable cations (Ca, Mg, K and Na) were extracted with a neutral, normal ammonium acetate solution. Calcium (Ca) and Mg were determined by atomic absorption spectrophotometry while K and Na were determined by flame emission photometry. Effective Cation Exchange Capacity (ECEC) was calculated by the summation of the values of exchangeable cations and exchangeable acidity (Onwudike et al., 2016). Base saturation percentages for the soils were determined by dividing the summation of total exchangeable bases (Ca, Mg, K, and Na) of the soils by the Effective Cation Exchange Capacity (ECEC) of the soil (cmol/kg) and multiplying the results by 100 (Onwudike et al., 2016). The soils were grouped based on their fertility capability using the guidelines provided by (Sanchez et al., 2003).

2.5 Statistical Analysis

The Data generated were subjected to analysis of variance (ANOVA) using Genstat 17th Edition. Treatment means were separated using the Least Significant Difference (LSD) at 0.05% probability.

3. Result

The particle size distribution and textural class of the soils in the various series are shown in Table 1. On the surface soils (0-15 cm depths), the range of sand for the series was 814 - 868 g/kg with a mean value of 833 g/kg. The highest surface soil values for sand, silt and clay were recorded in Mamu (868 g/kg), Effon (107 g/kg) and Iregun (92 g/kg) respectively while the lowest values were recorded for sand, silt and clay in Effon (814 g/kg), Mamu (83 g/kg) and Effon (79 g/kg) respectively. Texturally, the 0-15cm soil depth for the 3 series is Loamy Sand.

In the subsoil (15-30 cm), the highest values for sand and clay were recorded in Mamu (828 g/kg) and Effon series (87 g/kg). Lowest values for sand, silt and clay were recorded in Iregun, Effon and Mamu which recorded values of 813 g/kg, 94 g/kg and 77 g/kg respectively (Table 1). Texturally, the 15-30cm soil depths for the 3 series are also Loamy Sand. At the lower depth of 30-45 cm, the Iregun and Effon series had an appreciable increase in clay content with 136 g/kg and 109 g/kg clay. The soils of the Mamu series decreased in clay content down the depth but had the highest amount of sand.

Table 1: Physical properties of soil in the study area.				
Sample	**Sand**	**Silt**	**Clay**	**Textural class**
		g/kg		
Iregun Series				
IS (0-15 cm)	817	90	92	LS
IS (15-30 cm)	813	106	81	LS
IS (30-45 cm)	744	120	136	LS
Effon Series				
ES (0-15 cm)	814	107	79	LS
ES (15-30 cm)	819	94	87	LS
ES(30-45 cm)	773	118	109	SL
Mamu Series				
MS (0-15 cm)	868	83	83	LS
MS (15-30 cm)	828	95	77	LS
MS (30-45 cm)	826	105	69	LS

Note: IS= Iregun Series; ES= Effon Series; Ms= Mamu Series; cm= Centimeter

The pH of the soils ranged from slightly acidic (6.4) for the soils formed on the Iregun and Effon series to moderately acidic (6.0) in the Mamu series as shown in Table 2. Organic carbon was high in soils of the Iregun and Effon series with respective mean values of 16 g kg^{-1} and 15.4 g kg^{-1} respectively as presented in Table 2. The soils formed on the Mamu series had low amounts of organic carbon with a mean of 9.2 g kg^{-1}. The surface 0 - 15cm soils contained more organic carbon (17.2 g/kg) than the lower 15 - 30cm (13.1g/kg) and 30-45 cm (10.3 g/kg). Soils formed on Iregun and Mamu series had medium amounts of total nitrogen with means of 1.8 g kg^{-1} and 1.9 g kg^{-1} respectively while soils of Effon series had higher amounts of total nitrogen (2.1g kg^{1}). This indicates that all the soils in the three series have medium to high nitrogen content. The available phosphorus was low for all the soil series with mean values of 3.4 mg kg^{1}, 4.3 mg kg^{1} and 6.1 mg kg^{1} for soils formed on the Iregun, Mamu and Effon series respectively.

Calcium had the highest mean concentrations among the exchangeable cations in the studied soils (Table 2). The mean values of Ca were low in Iregun (3.8 cmol/kg,), Effon series (4.2 cmol/kg) and Mamu series (2.9 cmol/kg) soils. The soils formed on the Effon and Mamu series had medium amounts of Mg with means of 1.0 cmol/kg and 0.9 $cmolkg^{1}$ respectively while soils of the Iregun series had medium amounts of Mg (1.1 cmol/kg). The soils formed on the Effon and Mamu series had medium amounts of K with means of 0.2 cmol/kg, and 0.3 $cmolkg^{1}$ respectively while soils of the Iregun series had medium amounts of K (0.5 cmol/kg). Generally, the mean values of exchangeable cations were higher in the soils of the Iregun series than Effon and Mamu series.

The mean values of the micronutrients in the soils showed that Fe had the highest values in the studied soils. Extractable manganese ranged from 59.4 mg kg^{-1} to 82.2 mg kg^{-1} on soils of the series. The mean values obtained show that all the soil series had high amounts of extractable manganese. Extractable iron ranged from 90.5 mg kg^{-1} to 116.7 mg kg^{-1} on soils of the series. The mean values obtained show that all the soil series had high amounts of extractable iron (Table 2). Extractable copper ranged from 0.9 mg kg^{-1} to 1.4 mg kg^{-1} on soils of the series. The mean values obtained show that all the soil series had medium amounts of extractable copper. Extractable zinc ranged from 1.5 mg kg^{-1} to 1.9 mg kg^{-1} on soils of Effon, Iregun and Mamu series. The mean values show that all the soil series had medium amounts of extractable zinc.

Table 2: Chemical properties of soil series based on depth at the study area.														
Sample	**pH**	**O.C**	**T.N**	**Av. P**	**Ca**	**Mg**	**K**	**Na**	**EA**	**ECEC**	**BS**	**Mn**	**Fe**	**Cu**	**Zn**
		g/kg		mg/kg			cmol/kg				%		mg/kg		
Iregun Series															
IS(0-15cm)	6.6	19.7	2	4.7	5.9	1.2	0.9	1.8	1.3	11.1	88.3	94.4	137.1	1.7	2.1
IS(15-30cm)	6.4	17.3	1.7	3.6	3.3	1	0.2	0.3	0.4	5.2	92.3	81.3	110.4	1.4	1.9
IS(30-45cm)	6.3	11	1.1	2	3.4	1.1	0.6	1.3	0.9	6.9	92.8	71	102.6	1.1	1.8
Effon Series															
ES(0-15cm)	6.6	21.7	1.9	8	4.8	1	0.2	0.3	0.9	6.5	96.9	91.4	124.1	1	1.5
ES(15-30cm)	6.3	14.7	2.4	4.5	3.3	1	0.2	0.3	0.9	5.2	92.3	73.2	100.1	1.2	1.5
ES(15-30cm)	6.3	10	2.1	5.7	3.4	1	0.2	0.4	0.9	5.3	94.3	66.2	105.8	1.4	1.4
Mamu Series															
MS(0-15cm)	6.3	10.3	2	5.7	3.3	0.9	0.7	1.3	0.9	6.4	96.9	62.4	92.6	1	1.6
MS(15-30cm)	6.3	7.3	1.4	2.8	2.4	0.9	0.2	0.3	0.3	4.1	92.7	54.3	87.6	0.9	1.4
MS(15-30cm)	6	10	2.2	4.5	3.1	1.1	0.2	0.3	0.4	5.1	92.2	61.5	91.3	0.9	1.5

Note: Note: IS= Iregun Series; ES= Effon Series; MS= Mamu Series; cm= Centimeter; O.C= Organic Carbon; T.N= Total Nitrogen; Av.P= Available Phosphorous; Ca= Calcium; Mg= Magnesium; K= Potassium; Na= Sodium; EA= Exchangeable Acidity; ECEC= Exchangeable Cation; BS= Basic Saturation; Mn= Manganese; Fe= Iron; Cu= Copper; Zinc= Zinc.

Results of the soil series and soil depth as factors on the chemical composition of the study area are shown in Table 3. Though generally slightly acidic, the pH values varied significantly ($p< 0.05$) among the soil series and soil depth. The depths 0 -15cm acidic (pH 6.5), 15- 30cm (pH 6.2) and 30-45 (6.1) were all slightly acidic. However, the degree of acidity varied significantly with 0-15cm being the most acidic. Iregun series and Effon series had the same acidity of 6.4 which was significantly higher than the Mamu series with 6.0 soil p.H. Effon series had a statistically higher Avail. P (6.1 mg/kg) than the Iregun and Mamu series while soil depth of 0-15 had the highest (6.1 mg/kg). Iregun series and Effon series had the highest O.C and T.N of 16.0 g/kg and 2.1 mg/kg respectively while the soil depth of 15-30cm (13.1 g/kg) and 0-15cm (1.9 mg/kg) had the highest O.C and T.N respectively. T.N among the soil depths was statistically the same. Iregun series (0.5 cmol/kg) had a statistically higher K than Mamu (0.3 cmol/kg) and Effon (0.2 cmol/kg) series while soil depth of 0-15 cm (0.6 cmol/kg) had the highest level of K followed by 30-45cm (0.3 cmol/kg) and 15-30cm (0.2 cmol/kg). Effon series had the highest and the most significantly different ECEC of 7.8 cmol/kg followed by the Iregun series (5.6 cmol/kg) and Mamu series (5.2 cmol/kg) while the soil depth 0-15cm had the highest ECEC of 8.0 cmol/kg followed by 30-45cm (5.7 cmol/kg) and 15-30cm (4.8 cmol/kg). Effon series had the highest BS% of 94.10 % while soil depth of 30-45 cm had the highest with 96.9%.

The result of the Fertility Capability Classification of the soils of the study area is shown in Table 4. Iregun series and Mamu were classified as Sek which implies that the soils are sandy in texture (S), low in CEC (e) and have a low nutrient reserve (k) while the Effon series was classified as SLek which implies that the soil s sandy in texture (S), loamy substrata texture (L), low in CEC (e) and has low nutrient reserve (k).

Table 3: Effects of the soil series and soil depth as factors on the chemical composition of the study area.

Factors	pH	Avail. P	O.C	T.N	K	ECEC	BS
		mg kg^{-1}	g kg^{-1}	mg/kg	cmol/kg		%
Soil series (S)							
Iregun series	6.4a	3.4b	16.0a	1.8b	0.5a	5.6b	91.24b
Effon series	6.4a	6.1a	15.4a	2.1a	0.2c	7.8a	94.10a
Mamu series	6.0b	4.3b	9.2b	1.9ab	0.3b	5.2c	93.23ab
L.S.D @ 0.05%	*0.03*	*1.0*	*4.1*	*0.3*	*0.02*	*0.1*	*1.38*
Soil depth (D)							
0-15	6.5a	6.1a	17.2a	1.9a	0.6a	8.0a	92.3b
15-30	6.2b	3.7b	13.1ab	1.8a	0.2c	4.8c	94.3ab
30-45	6.1c	4.0b	10.3b	1.8a	0.3b	5.7b	96.9a
L.S.D @ 0.05%	*0.03*	*1.0*	*4.1*	*ns*	*0.02*	*0.1*	*2.7*

Note: O.C= Organic Carbon; T.N= Total Nitrogen; Av.P.= Available Phosphorous; K= Potassium; ECEC= Exchangeable Cation; BS= Basic Saturation.

Table 4: Fertility Capability Classification of soils of the study area

Soil series	Type	Substrata	Modifiers	FCC Classes
Iregun	S	-	ek	Sek
Effon	S	L	ek	SLek
Mamu	S	-	ek	Sek

Note: L-Loamy textured; S- Sandy textured; e= low CEC with high leaching potential (<10cmol/kg soil by sum of EB+EA); k=low nutrient reserves- K deficiencies.

4. Discussion

The high sand fraction in the study locations could be attributed to the parent material dominant in the area which is coastal plain sand since the texture of the soil is highly influenced by the parent material over time. Therefore, good management practices such as the incorporation of organic manure into the soil (especially, farmyard manure) will help bind the soil particles together and thus, improve the aggregate stability of the soil. Moreover, the cultivation of cover crops and minimum tillage will reduce the effects of splash erosion and leaching in the area (Adesumuyi and Nwagbara, 2017).

Soil pH is the major driver of soil fertility. It is a vital fertility parameter as it governs the availability of nutrients in the soil The pH (6.0-6.4) of the series is slightly acidic to neutral, where the topsoil (0-15 cm) has the highest value and it reduces down the depth for all the soils series. According to researchers, the acidic nature of the soil could be attributed mostly to excessive leaching and erosion due to the high amount of rainfall in the area (Ekong and Uduak, 2013). The low pH could be due to the continuous removal of basic cations by harvested crops. There is a need to reduce this level of acidity to improve soil fertility for sustainable crop production (Ekong and Uduak, 2013). The result also revealed the decrease in pH from 0-15 to 30-45 and it was significantly influenced by soil depth.

Soil organic carbon is rated high with mean values of 15.4 g/kg and 16 g/kg in soils of Iregun and Effon while organic carbon in the Mamu series was low. The low value of organic carbon contents in the Mamu series could be attributed to the high rate of decomposition and mineralization of organic matter consequent upon the prevalent high temperature, low vegetal cover, and poor soil management sometimes by burning of crop residues, intense cultivation and seasonal bush burning. Therefore, there is a need for the farmers in the area to adopt cultural practices such as minimum tillage operation, mulching, organic manuring, etc. that will encourage the return and incorporation of plant/crop residues into the soil to increase the level of soil organic matter.

The low amount of ECEC in the land types could be attributed to low organic matter and high weathering. The low fraction of clay and organic matter in the soils is responsible for the low cations retaining ability and hence it's low capacity to hold nutrients against leaching, hence the necessity for adequate soil management. (Yakubu et al., 2019). They have low amounts of nitrogen and phosphorus content. Lower nitrogen levels may be due to low pH levels, coarse texture, and a high temperature that facilitates faster degradation, well-aerated conditions and crop removal, as well as leaching of nitrates due to excessive rainfall and plant removal (Ekong and Uduak, 2013). The low level of available P in the soil was suspected to be due to the slightly acidic nature (Ande et al., 2017; Ekong and Uduak, 2013) of the soil which invariably renders P unavailable and unconducive for the release of P.

5. Conclusion

The study conducted on the University of Ibadan's Sport Complex farm plot area reveals a predominantly loamy sand texture across three soil series: Iregun, Effon, and Mamu. The soils are slightly acidic, with pH values ranging from 6.0 to 6.6. Organic carbon levels are highest in the surface soils, especially in the Iregun and Effon series, while the Mamu series exhibits lower organic carbon content. Nitrogen content is medium to high across all series, but available phosphorus is low. Calcium is the dominant exchangeable cation, with other cations like magnesium, potassium, and sodium present in varying but generally moderate amounts. Micronutrient analysis shows high levels of extractable iron and manganese, with medium levels of copper and zinc. The fertility capability classification indicates low nutrient reserves and low cation exchange capacity, suggesting the need for improved soil management practices. Incorporating organic manure and minimizing tillage could enhance soil structure and fertility, mitigating issues such as erosion and nutrient leaching in the study area. This evaluation underscores the critical need for ongoing soil fertility management to sustain agricultural productivity in the area.

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