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TEMPORAL ASSESSMENT OF SOIL FERTILITY FOR CROP CULTIVATION IN NORTHERN, KATSINA STATE, NIGERIA

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ABSTRACT

***Purpose**: Soil is natural body in which almost all the needs of man are derived from. Temporal assessment from 2011 to 2024 was conducted on soil fertility for crop cultivation in Northern Katsina State, Nigeria. The aim of the study is to assess soil physical and chemical properties.*
***Design/methodology/approach**: Composite soil sampling methods for the collection of soil samples between the depths of 0-15cm was adopted. The soil samples were collected from sampled farmlands under crop cultivation and in the area as control and tested for some physical and chemical properties.*
***Findings**: The result revealed the soil properties including average clay 13.85%, pH 7.10, Oc 1.90% total N 0.90%, P 2.19ppm, K 0.77cmol/kg, Ca 8.01cmol/kg, Mg 3.57cmol/kg and CEC 2.89cmol/kg in the area. Analysis of variance (ANOVA) showed that calculated value F (0.012) is less than Table value (2.69), that there is no variation among the soil samples. The study shows that values of sample D with regards to clay 16.04% and Mg 4.02cmol/kg are higher compared to other areas.*
***Research limitation/implication**: Therefore, the findings of this study indicate that, the soil fertility is at low level and it has clearly shown the influence of man activities. The results of this study are greater compared to average clay 1.34%, Oc 0.90%, total N 0.006%, K 0.92cmol/kg, Ca 3.68cmol/kg and Mg 3.16cmol/kg of the year 2011. This clearly showed the influence of man activities which resulted increase in the soil values.*
***Practical implication**: Therefore, the area is recommended for millet cultivation and some crops on other part of the area. These include tomato, sorghum and vegetables, integration of organic and inorganic fertilizers and improvement in traditional fertility management should be maintained.*
Key Words: Soil, Fertility, Crop, Shinkafi village and Katsina.

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1.0 INTRODUCTION

There are various types of soil in Nigeria, each one existing in its own unique ecosystem and possessing unique fertility status (Muhammad, Buhari & Mohammed, 2023). It is common knowledge that soils with a high fertility level also have a high concentration of nutrients. As far as the nation is concerned, the requirement for food security has brought with it a commensurate need to harness the fertility of the soil as it has demonstrated the ability to be used throughout the entire year (Reijneveld *et al.*, 2019). Due to crop cultivation year after year, soils are depleted of their fertility status, therefore for a succeeding crop to survive successfully in the same environment, depleted nutrients must be supplemented (Dewangana *et al*., 2023). Fertile soils can provide enough nutrients to the crop throughout the growing season. As a result, higher yields per unit area are easier to achieve in fertile soils than in low-fertility soils.

Despite the limited ability of smallholder farmers to manage most of these factors (Ogbena *et al*., 2016). The extensive expertise they have acquired in the cultivation of land, it is evident that farmers should assume a crucial role in the stabilization of agricultural land management. There also appears to be a potential prejudice among soil scientists and other experts towards the knowledge possessed by farmers regarding soil fertility. Nevertheless, it has been observed that small-scale farmers possess a considerable aptitude for discerning variations in fertility levels among different types of agricultural areas (Domchang *et al*., 2014). According to Nesme *et al*. (2011), there exists a potential prejudice among soil scientists and other experts towards the knowledge of soil fertility possessed by farmers. Nevertheless, there is a significant lack of knowledge regarding farmers' perspectives on, fertilization recommendations, soil function, soil health, and soil fertility in general (Abdulkadir & Nuhu, 2020).

Researches on the fertility of the soil had been conducted in Nigeria and other African countries by the use of scientific methods for evaluating soil. These studies have produced a variety of findings (Fanuel *et al*., 2017). However, the scientific methods are not always consistent with how farmers perceived the fertility of the soil. Petrescu-Mag (2020) also asserted that a comprehensive examination of soil functions necessitates the inclusion of farmers. It’s against this background that this study analysed the perception of cereals farmers on soil fertility management practices. This is imperative to comprehend the level of information possessed by farmers regarding soil quality and health to facilitate the effective dissemination of suitable technology for on-farm evaluations.

The research of soil fertility status of Northern Katsina State (Shinkafi village) in the year 2011, revealed the soil properties including average clay of 1.34%, pH of 7.09, Oc of 0.94%, N of 0.006%, P 0f 13.15ppm, Ca of 3.68cmol/kg, K of 0.92cmol/kg, Mg of 3.16cmol/kg, and CEC of 10.70cmol/kg were found to be at lower level compared to fertility requirements for crop cultivation (Ahmed, 2011). This study investigated the temporal analysis of soil fertility status of the area in the year 2024 to ascertain the changes occurred within the period of time for measures to be for sustainable crop production or seek other alternative for economic development.

2.0 LITERATUREREVIEW

Soil fertility in Northern Nigeria has progressively declined due to increased pressure on land resources arising from rapid population expansion, which is forcing farmers to adopt continuous cropping coupled with the use of an inadequate amount of fertilizer or other soil amendments (Kamai *et al*., 2020). Fertilizer availability has been a pressing issue for a long time, most especially in Nigeria where the price keeps on skyrocketing despite government intervention (Mohammed *et al*., 2019). Akinbile *et al*., (2018) reported that high cost of inputs (96.0 %) and lack of availability of fertilizer (76.0 %) were considered as severe production constraints militating against rice enterprise. Several studies have shown that the soils in Northern Nigeria are deficient in nutrients, being far below critical levels for the production of most crops, including rice (Kamai *et al*., 2020). Farmers are mindful of the significance of fertilizers that is both organic and inorganic in farming activity (Ezui *et al*., 2021).

Soil fertility indices are the elements that are basic building block of soil chemistry and biology. Thus, of over 100 indices which have been identified, about 80 occur in nature, and only 16 nutrients/elements are required for plants to complete their life cycle (Yusuf, 2016a). Three of the 16 (carbon, hydrogen and oxygen) are provided to plants through photosynthesis. The others must be provided by, or through the soil. According to Yusuf (2015), these 13 elements are usually present as part of larger chemical compounds, but are generally able to provide into charged particles called irons which are used by growing plants. These irons are present in the soil solution (water between solid soil particles) and the roots of the plant from the water and move up through the plant in xylem tissue.

The essential elements as soil fertility indices for crop and their chemical symbols are nitrogen (N), phosphorus (P), potassium (K), organic matter (OM), pH and cation exchange capacity (CEC) (Ufot, 2012; Yusuf, 2016b). In addition, micronutrients and soil particles (clay fraction) also are of paramount important. These soil properties determine the capacity of soil supply nutrients to plants. This capacity

to provide nutrients to crop plants is in part influenced by the physical properties of soils and is one component of soil fertility. Desirable soil physical properties and the capacity of the soil to provide nutrients for growing crops are both soil quality indicators. Soil fertility, plant health and the resistances are resilience of crop plants to pest and pathos. Soil fertility requires a balance of critical plant nutrients and either deficiency or excess of nutrients can adversely affect plant growth, susceptibility to pests, and post-harvest quality.

It can be understood that soil indices for rice cultivation were clearly stated without identifying the matching requirements and possibly farmers' problems. Therefore, this study identified soils to understand soil limiting factors and farmers' problem to improve production. The elements and soil properties specifically for crop include PSD, AWHC, pH, Oc, N, P, K, Ca, Mg, Na, CEC and micro nutrients (Cu, Fe, Mn and Zn).

3.0 STUDY AREA

Northern Katsina State (Shinkafi village) is located in Katsina local government area at the north end of Katsina State along Kaita Road, between latitude 12º55'N – 13º08'N and longitude 7º32'E – 7º42'E (Katsina State Ministry of Lands, Survey and Environment, 2018).

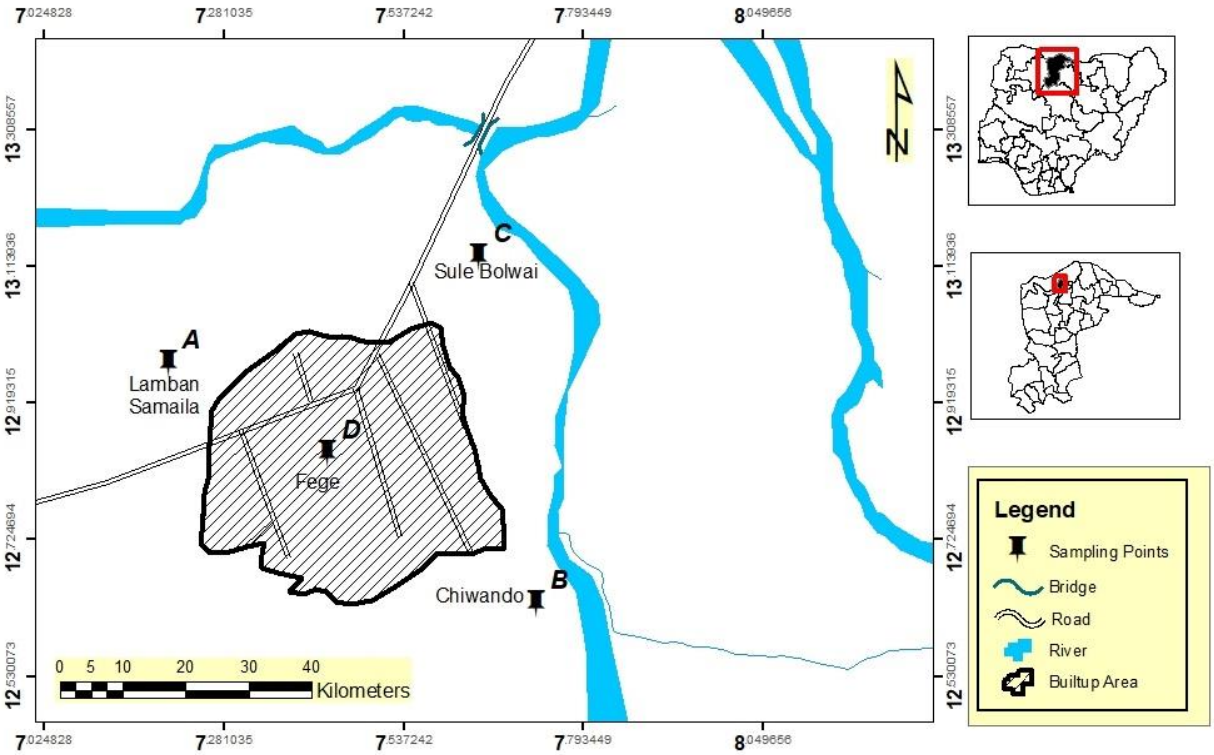

Figure 3.1: Map of Northern Katsina State (Shinkafi Village) showing Sampling Points
Sources: GIS Lab, Geography Department, BUK (2025)

The rainy season of area is between the month of May to September and it has its peak in the month of August. The rainfall ranges from 4 to 5months and recorded 550mm – 800mm annually, based on average of 10years from 2000 to 2009. It is characterized by conventional rainfall (dry and wet climate) followed by long dry season of 6 – 7months (Meteorological Unit, Umaru Musa Yar'adua International Airport Katsina, 2020). The mean maximum temperature of the area is 40^{o}C in the month of April and May. At the peak of rainy season, average maximum temperature is 42^{o}C and in December average temperature is 19^{o}C (Meteorological Unit, Umaru Musa Yar'adua International Airport Katsina, 2020).

Relative humidity denotes the amount of water vapour in the atmosphere (air) compared to what the air can hold when fully saturated. The minimum relative humidity of the area is 15% in December to January and maximum as 90% around July to September, (Meteorological Unit, Umaru Musa Yar'adua International Airport Katsina, 2020). Soils are the mixture of rock particles loosened by weathering, mineral salts and dead vegetation matter. In the northern part of Katsina State, the soils are largely sandy in nature and are fine in texture. The soils of the area are sandy in nature (Chude, 2012). Figure 1 showing map of the study area.

The most cultivated food crops are sorghum, maize, millet, white beans, rice and vegetables. The domesticated animals including goat, sheep and cow use to feed on the leaves and cane of the crops after harvest (Chude, 2012; Ahmed, 2014; 2019).

4.0 MATERIALS AND METHOD

4.1 Field Work

Fieldwork (survey) was carried out on the study area to identify farmlands that cultivate crop including millet, tomato, beans and others. It also involved physical characteristics of the study area. These include soil and land use types, soil management, vegetation etc. Composite samples were drawn from quadrant of 12m^2 in which five samples at the depth of 0 to 15cm were collected randomly within the quadrant and bulked as one composite sample. In this regard, according to Yusuf (2017) five samples were collected within the 12m^2 and bulked as composite representative of the area. The Composite

samples collected were air dried, put in cotton yard bags, labelled A, B, C and D appropriately and stored.

The soil samples were collected on 19th May, 2024 after harvest. They were taken to the soil laboratory of Umaru Musa Yar'adua University, Katsina for further analyses of soil physical and chemical properties. Geographic Positioning System (GPS) was used to locate the sampled location.

4.2 Laboratory Analysis

The samples were analysed for fertility indicators for the following; clay, EC, soil pH, total nitrogen, exchangeable bases (Na^+, Ca^{++} and Mg^{++}), available phosphorus, potassium and nitrogen (Lamofor *et al.*, 1990; Ibitoye, 2008; Eno *et al.*, 2009; Estefan, Sommer and Ryan, 2013; Garba, 2014). Statistical analysis for coefficient of variation and Analysis of variance (ANOVA) were used. The procedures for the analysis are stated in Table 4.1.

Table 4.1: Methods of Determining Physical and chemical Properties of Soil Samples

Physicochemical Parameters	MethodsAdopted
PSD& AWHC (%)	1:25 water ratio Hydrometer
Soil pH	pH meter (1:25 water ratio)
Total nitrogen (%)	Micro kjeldahl
Phosphorus(ppm)	Spectrophotometry (centrifuge) and calculation
Organic carbon (%)	Walkley black (dichromate solution), leaching, titration and calculation
Exchangeable bases(cmol/kg)	Bray 1 (NH_4OAC, Na^+& K^+ by flame photometer and Ca^{++}& Mg^{++} by atomic absorption, AAS)
CEC(cmol/kg)	Calculated by the sum of exchangeable bases
Electrical Conductivity (%)	Leaching and Electrical Conductivity Meter

Source: Adapted from Eno *et al.* (2009); Ahmed (2019)

5.0 PRESENTATION AND DISCUSSION OF RESULTS

The results of soil physical and chemical properties in the study area are presented in Table 5.1

Table 5.1: Soil Properties in Northern Katsina State (Shinkafi Village) at the Year 2024

Sample ID	pH	OC %	N %	P ppm	Ex. Bases (Cmol/kg)				CEC Cmol/kg	PSD (%)			EC %
					Na	K	Ca	Mg		Clay	Silt	Sand	
A	6.80	1.63	0.81	1.85	5.22	0.26	8,11	3.44	2.16	12.64	3.28	82.08	1.23
B	6,90	1.81	0.72	2.15	5.13	0.28	7.32	3.15	3.04	12.64	3.28	84.08	1.21

C	7.02	2.01	1.05	2.31	4.78	1.24	8.44	3.66	3.31	14.08	3.28	82.64	1.67
D	7;40	2.16	1.02	2.45	5.36	1.30	8.16	4.02	3.06	16.04	3.28	80’64	1.53
Average	**7.03**	**1.90**	**0.90**	**2.19**	**5.12**	**0.77**	**8.01**	**3.57**	**2.90**	**13.85**	**3.28**	**82.36**	**1.41**
SD	**0.14**	**0.23**	**0.12**	**1.02**	**1.65**	**0.13**	**2.34**	**0.98**	**0.86**	**3.72**	**0.76**	**3.67**	**0.08**
CV %	**1.99**	**12.11**	**13.33**	**46.58**	**32.23**	**16.88**	**29.21**	**27.45**	**29.65**	**26.86**	**23.17**	**4.45**	**5.67**

Key: A-Lambun Sama’ila, B-Chiwando, C-Sule Balwai, D-Fagge (Inside Shinkafi)

Source: Field Work and Laboratory Analysis (2024)

From Table 5.1, the high value of clay fraction of 16.04% is recorded at Fagge (inside Shinkafi village and the lowest of 12.64% at Lambun Sama’ila and Chiwando area. The lowest pH level of 6.80 and higher pH of 7.40, were found to be at Lambun Sama’ila and Fagge areas and are almost neutral in nature. This corresponds with the findings of Chude, Jayeoba and Berding (2012), which shows soil pH values below 4.5 are strongly acidic and values of average pH of 7.03, the soil is at very low in fertility levels. They added that soil pH levels of 6.1-6.5 are slightly acidic and soils are very fertile. Therefore, the pH levels in thestudy area in this regard are classified as very low fertile.

The result shows average Oc of 1.9%, N of 0.90%, P of 2.15ppm, K of 0.77cmol/kg and Ca of 8.01cmol/kg at the study area. The values are very low compared to result of soils at Musawa area (Ahmed, 2014). Thus, Esu *et al* (2014) suggested that higher micronutrients influence low values in exchangeable bases in the soils. Therefore, macronutrient values in this regard are below the plants requirement as pointed by Yusuf (2015).

The values of soil have increased compared to the values of soil in the year 2011. This could as a result of human activities in the area. This include settlement by building houses and developmental project. This can led to the changes in soil properties as indicated by Yusuf (2017) that soil change in addition to other soil from different location with different parent materials. The values of coefficient of variation are found to be below 50% which shows there is no variation among the soil samples. Analysis of variation (ANOVA) recorded F of 0.12 and table value of 2.32 which indicated there is no variation.

Table 5.2: Soil Properties in Northern Katsina State (Shinkafi Village) in the Year 2011

Sample ID	pH	OC %	N %	P ppm	Ex. Bases (Cmol/kg)				CEC Cmol/kg	PSD (%)			EC uc/cm
					Na	K	Ca	Mg		Clay	Silt	Sand	
A	6.96	0.44	0.004	10.50	2.10	1.10	2.70	2.94	8.30	2.76	4.00	93.24	365
B	7.24	0.70	0.005	11.70	2.20	0.78	3.10	2.40	9.10	0.50	6.26	93.24	237
C	7.08	0.78	0.006	13.20	2.40	0.40	3.20	2.30	11.20	0.35	5.41	94.24	381
D	7;08	i.82	0.010	17.20	3.20	1.38	5.70	5.00	14.35	1.76	6.00	92.24	203
Average	**7.09**	**0.94 0.53**	**0.006**	**13.15**	**2.48 0.43**	**0.92 0.37**	**3.68 1.18**	**3.16 1.09**	**10.70 2.34**	**1.34 0.98**	**5.42 0.89**	**93.24**	**296.5 77.65**
SD	**0.10**		**0.002**	**2.50**								**0.71**	
CV %	**1.41**	**56.33**	**33.33**	**19.01**	**17.34**	**40.21**	**32.07**	**34.43**	**21.87**	**73.13**	**16.42**	**0.76**	**26.14**

Key: A-Lambun Sama'ila, B-Chiwando, C-Sule Balwai, D-Fagge (Inside Shinkafi)

Source: Field Work and Laboratory Analysis (2011)

From Table 5.2, the average clay fraction recorded 1.34%, which is very low compared to plant requirements. According Ahmed (2019), clay fraction is one of the yard sticks of measuring soil fertility and should be about 30% and above. The macronutrients are at very low level and below the requirements for rice cultivation. These include average soil Oc of 0.94%, N of 0.006%, K of 0.92cmol/kg and P of 13,15ppm. It has been observed that soil pH has impact on soil macronutrients. The result shows pH of 6.96, pH of 7.24 and pH of 7.08 at Lambun Sama'ila, Chiwando and Sule Balwai areas (Table 4.2). Soil pH is like the temperature of an element and thus could be used to diagnose what is likely to be disease problem of the soil or plant growth. A good and overall nutrients (availability) are found at mean pH of 6.5 and field crop prefer a pH of 6 or higher (Yusf and Tukur, 2012; Yusuf, 2017). According to Ahmed (2019) the pH scale ranges from 0 to 14, a neutral state is indicated at pH 7.0, values below 7.0 are acidic and above 7.0 are basic.

6.1 CONCLUSION AND RECOMMENDATIONS

The high value of clay fraction of 16.04% was recorded at Fagge (inside Shinkafi village and the lowest of 12.64% at Lambun Sama'ila and Chiwando area. The lowest pH level of 6.80 and higher pH of 7.40, were found to be at Lambun Sama'ila and Fagge areas and are almost neutral in nature. The result shows average Oc of 1.9%, N of 0.90%, P of 2.15ppm, K of 0.77cmol/kg and Ca of 8.01cmol/kg at the study area. The values of soil have increased compared to the values of soil in the year 2011. This could be as a result of human activities in the area. This includes settlement by building houses and developmental project. Considering the above findings, it can be concluded that the soil values of 2024 are higher compared to the soil values of 2011 and the soil is at low level in fertility for crop cultivation. Therefore, measures should be taken in order to improve soil fertility for crop cultivation.

1. The soil pH level is found to be almost neutral. The use of chemical fertilizer is recommended to stabilise the levels of pH.
2. The major soil properties including P and K are found to be at very low levels compared to the crop requirements. The use of chemical fertilizer is recommended to normalise their level in the soil for intensive crop production in the area.
3. The soil nutrients including P and K were found to be at lower level. The use of chemical fertilizer is recommended to balance the issue.
4. The areas including Lambun Sama'ila Chiwando are recommended for other land uses. This is because the areas are almost occupied by building houses and other developmental project. The Sule Balwai area is recommended to cultivate cropd including millet, sorghum and beans.
5. The major soil properties including Oc, N, P and K are found to be at very low levels compared to the crop requirements. Integration of organic and inorganic fertilizer is recommended. Thus, plants need these soil properties in large quantity to meet the requirements for growth and development.

7.0 LIMITATION OF THE STUDY

The study is limited to assess soil biological properties. The soil fertility is at low level and it has clearly shown the influence of man activities.

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