ASSESSMENT OF SOIL FERTILITY INDICATORS UNDER FALLOW REGIMES IN KAFIN MADAKI AREA BAUCHI STATE

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ABSTRACT

The paper assessed soil fertility indicators in both short and long fallow regimes in Kafin Madaki area, Bauchi state. A reconnaissance survey was conducted to identify the farmlands that are placed under fallow management systems. A total of 229 questionnaire containing enquiries on total number of farm holdings to a farmer, duration of fallow, crops grown on the farmlands before fallow and land use practices during fallow were randomly administered to the targeted farmers. Surface soil samples were collected from farmland under long and short fallow and a total of six soil fertility indicators such as OM, TN, AP, Ca, Mg, and K were assessed with the use of international guidelines for rating tropical soils. A simple percentage was used to analyze the responses from questionnaire. The results shows that all soil fertility indicators in both short and long fallow field are rated as low while K is rated as very low in soil under one year fallow. The paper concludes that this level of fertility may be attributed to the nature of parent material in the area, high environmental temperature posed by tropicality, and land use practices during fallow. Therefore based on the results and conclusion, there is a need to further investigate the quantitative changes of soil fertility indicators over a specified period of fallow.

Keywords: soil fertility, indicators, fallow regimes, Kafin Madaki, Bauchi.

INTRODUCTION

Bush fallowing alongside crop rotation, intercropping, fertilizer and manure application as well as application of household waste are among the dominant systems used in soil fertility management practices in Kafin Madaki area. Although the practice of fallowing is gradually decreasing in many parts of West Africa as a result of rapid population explosion (Martin, 2017), in Kafin Madaki area the system is still considered as one of the best soil fertility replenishing technique. The evaluation of soil fertility under municipal waste, bio-test method, fertilization and farming technology were intensively investigated (Boochman, 2004; Olowolafe, 2004 and Yusuf, 2000). Ogban et al (2005) investigated the influence of fallow on the physical and chemical properties of acid sand soil in south eastern Nigeria while Jing-wei et al (2011) has explore the combine consequences of land use type and soil management on soil fertility quality in North china city urban fringe. However, little attention has been paid to assessment of soil fertility indicators using international ratings for tropical soil (ILACO, 1985 & London, 1991) in Kafin Madaki area Bauchi state. Therefore, this research is aimed to assess soil fertility indicators in Kafin Madaki area using guidelines based on international ratings for tropical soils (ILACO, 1985 and London, 1991). The purpose of the study were to examine the fallow durations in the area and to explore the influence of the fallow duration on soil fertility indicators. Result from this study could guide the decision of farmers in the area on the appropriateness of fallowing as a soil fertility management practice for increased crop productivity.

STUDY AREA

Location and land area: Kafin Madaki is a local government headquarters of Ganjuwa local government, Bauchi state. It is positioned some 45 kilometers north of Bauchi, the state capital. It is averagely located between latitude $9^0 45^1$ and $10^0 52^1$ N and longitude $9^0 53^1$ and $10^0 1^1$E. Based on 2006 population census, the total number of people living in the area is about 12,000 persons. Although no exact statistical figure on the number of farmer in the area is available, however agriculture is ranked as the dominant occupation of the people in the area (Faruk, 2010). The popular practice includes wet season cultivation with occasional scattered irrigation along fadama and flood plains. The chief crops grown in the area include sorghum, millet, maize, beans, groundnut, cassava, soya beans, sugar cane and vegetables. Soil fertility is managed through fertilization, cropping system, and fallowing / shifting cultivation. Soil fertility management remains one of the pressing issues militating against the quantity of harvest in the area (Faruk, 2010). The climate of the area is the tropical dry and wet type, coded as **Aw** by Koppen (1912).

Two main air masses namely tropical continental (**cT**) and tropical maritime (**mT**) control the climate of the area. The former originates from Sahara desert while the latter originates from Atlantic Ocean.

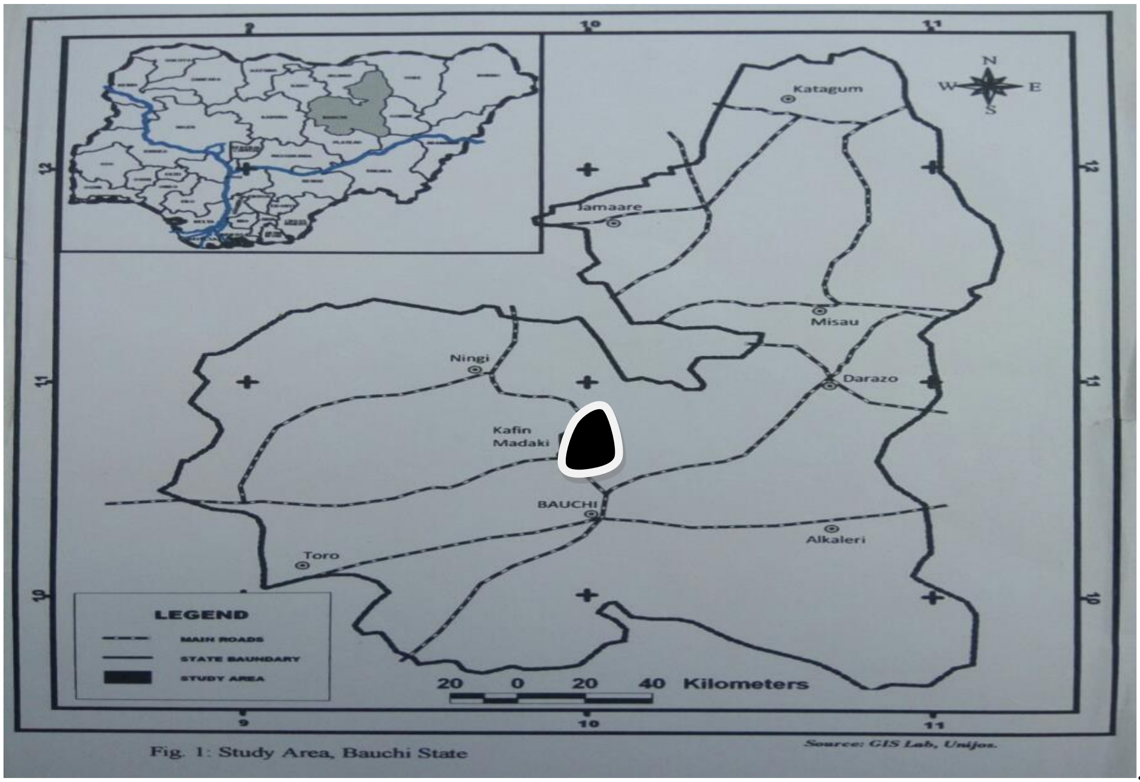

Fig. 1: Study Area, Bauchi State

The mean annual rainfall in the region is 1031mm although no two consecutive years records the same amount (BSADP, 1983). The time for rainfall onset and cessation is highly variable. The temperature in the area is warm to hot throughout the year. The mean monthly temperature records ranges from 20^0c – 22^0c in the coldest months to 28^0c – 32^0c in hottest months. The geology of the area is mainly pre – Cambrian basement complex which is made up of igneous, gneisses, and granites. The rocks are palaezoic to pre Cambrian while the older granites are palaezoic and consist of coarse foliated granite (Bauchi state hydrgeological sheet, 1968). The relief is made up of gently undulating terrain, river valleys, and elevated rock outcrops. The elevation of the area ranges from 400 meters to 520 meters. The soil of the area is weakly developed and poorly leached ferruginous tropical soil of alluvial and colluvial origin. They are mostly Alfisol or Ultisol (USDA soil survey staff, 1999). It has sand and sandy loam surface characterized by increase in clay with depth. The vegetation of the area is mainly a Sudan savannah type though with little Sahel formation. The Sudan savannah type of vegetation covers the area. The vegetation is luxuriant along river and stream courses, though recent deforestation activities and wood burning for charcoal has greatly changed the status quo. The grasses are generally short and maximum surface cover occur during peak of rainy season in August.

Research objectives

The objective of the study is mainly to assessed soil fertility indicators in both short and long fallow plots in Kafin Madaki area by using ILACO, 1985 and London, 1991. Specifically, the paper examined the kind of fallow practices in the area as well as identified the land use practice during resting period.

Research questions

1. What are the different kind of fallow practices in the area?
2. What is the land use practice during resting period?
3. What are the quantitative magnitudes of soil fertility indicators?

MATERIALS AND METHODS

Primary data was used in this research. This includes laboratory analysis of soil samples and administration of questionnaire to farmers whose farmlands were chosen for sampling. Before the commencement of field work, a reconnaissance survey was conducted to identify the farmers who will be interviewed as well as to identify the farmlands placed under fallow regimes.

A total of 229 well-structured questionnaires concerning enquiries on the number of farm holdings for a farmer, fallow period practiced, crop grown, other soil fertility management practices and land use during fallowing were randomly administered to the farmers who were targeted in their farmlands and during association's meetings and workshops. The questions contained in the questionnaire were read verbally by the trained field assistant to the farmer and all appropriate responses were recorded accordingly by the same field assistant. The sample size of farmers were based on Krejcie, R.V. and Morgan, D. W. (1970).

Surface soil sampling

Farmlands that are managed under 1 year and 4 years fallow were identified since the farmers considered former as short and later as long fallow. Each of the farmland selected for the survey was divided in to ten (10) grids. In each grid, three sampling sites was chosen randomly by throwing up a coin three times. Surface samples was taken using Auger at a point where the coin landed. The three samples taken from one grid (0-10cm) was thoroughly mixed to form composite sample out of which sizeable portion was taken. The sample was air dried, crushed, package, label and taken to laboratory for routine analysis. The same procedure was done in the nine grids of the same farmland. This means that in each farmland (under 1 & 4 years fallow) a total of ten (10) composite samples were taken. Laboratory analysis of the following fertility variables soil reaction, organic matter content, total nitrogen, available phosphorus, exchangeable cations (Mg, K and Ca) were conducted. K was read with the aid of flame photometer while Ca and Mg were determined using AAS. Organic matter content was determined using Black (1965) and Kjdeldahl method (Jackson, 1962) was used in total nitrogen determination. The available phosphorus was determined based on Bray and Kurtz (1945) method.

The data obtained from field was organized in tables. Descriptive statistics and guidelines for rating soil fertility indicators which is based on international ratings for tropical soils (ILACO, 1985 and London 1991) was used in data analysis.

RESULTS AND DISCUSSION

The table containing number of farm holding per farmer is presented in table 1 while the mean values of soil fertility indicators are contained in table 2. Table 3 contains guidelines for rating soil fertility indicators which is based on international ratings for tropical soils (ILACO, 1985 and London 1991). The resultant ratings of soil fertility indicators in both short and long fallow regimes are contained in table 4. The number of farm holdings owned by farmers in the area significantly varies. Majority of the farmlands were owned through inheritance while others were acquired through rentals and personal purchase. The sizes of farm holdings varies from less than a hectare to a maximum of 10 hectares. Results of the number of farm holdings ownership from (table 1) shows that about 60.7% of the farmers in the area possessed one farm holding. Those with 2-3, 4 and above holdings represents 31.4% and 7.8% respectively. Dominance of 1 farm holding per head may be attributed to pressure on land posed by rapid population explosion been experienced in the area and in sub Saharan Africa in general. Similar observation was made by Salmanulfarisi (2013). Among the population with single farm holding, the result of the findings shows that about 76.4% are engaged in practicing short fallow while 23.6% are engaged in long fallow respectively. The results of the land use practice for those with 2-3 farm holdings indicated that short fallow and long fallow is represented by 43.4% and 56.6%, while the distribution order of short fallow (32.7%), long fallow (67.3%) were observed among population with ownership of 4 and above farmlands. This is an indication that the fallow duration is gradually shrinking perhaps due to population pressure and that the number of farm holding to a farmer determines the duration of fallow practiced. The lower the farm holding to a farmer, the shorter the duration of fallow engaged. In general, about 62.4% of the population engaged in short fallow practice while 37.6% take part in long fallow management practice. Ogban et al (2005) observed reduction of fallow duration in south eastern Nigeria. A survey of land use practice during fallow indicates that during rainy season, grasses and herbaceous vegetation emerge and cover the surface of the farm plots that are under fallow and dry up during dry season when moisture supply seizes. Highest surface cover is observed during the peak of rainy season (August). During the resting period, the plots are used for uncontrolled grazing of ruminant animals. The population of such animals sometimes is higher during rainy months (May – October) when Fulani herdsmen arrived in the area. Other activities on the farm plots during fallow period include cutting and removal of grasses by local population for domestic use. Other plants residues left are burnt by perennial fires which leaves only fire resistance species. The crops that are rotationally grown on the plots during rainy season includes beans, groundnut, maize and millets. Household waste, garbage and mineral fertilizer are occasionally used during growing seasons.

Table 1: Number of farm holding for the respondents

Number of Holdings	Number of respondents	Percent (%)	1 year fallow (%)	4 years fallow (%)
1	139	60.70	76.4	23.6
2-3	72	31.44	43.4	56.6
4>	18	7.86	32.7	67.3

Source: field survey, 2018

Concerning the ratings of soil fertility indicators, the value quoted as ‘’very low’’ signifies a critical level below which plants grown in the area are expected to show severe deficiency symptoms (Olowolafe, 2008). The organic matter content in both long and short fallow field is rated as low. However, a slight increase in the property was noticed in soil under long fallow regime. The overall low level of organic matter in the soils may be linked to vegetal burning commonly practiced during dry season, other forms of vegetation removal for domestic uses, as well as high tropical temperature condition. Olowolafe (2008) noted that the great temperature of the tropical region may be regarded as a leading factor for rapid decomposition, mineralization and disappearance of organic matter and organic material in the climatic region.

The total nitrogen in both fields is also rated low, even though a slight mean increase in the element is noticed in low fallow soils. The rainfall in the area may have an impact on its status in the area considering the dynamic nature of the element and its susceptibility to leaching. The low levels of TN in the area may also be informed by annual vegetal burning since the area is known for dry season bush burning. Similar observation showed that the nitrogen level of the soil is affected by vegetation burning, leaching and high temperature posed by tropicality (Olowolafe, 2008). The deficiency of nitrogen element is considered as a probable reason why sustainable crop production in Sudano-sahelian regions of West Africa is constrained.

Similarly, the available phosphorus is also rated low in all fallow fields. The mean value of the element in short fallow field seemed to be higher than in long fallow field probably due to inorganic fertilizer (NPK 10-15-15) supplement recently used and which contain phosphorus component. The general low status of AP in the soils may be ascribed to the type of parent material (laterite) in the area. The tropical lateritic soils are mostly acidic and contains active Fe and Al oxides that are responsible for high phosphate sorption which leads to deficiency of the element in the soils (Uehera and Gilman, 1981 in Olowolafe, 2008).

The amount of Calcium, Magnesium and Potassium kept at exchange site to a large extent determines the soil reaction and their accessibility to plants. Usually the quantities of these cations are considered as yardstick for understanding the actual soil fertility (ILACO, 1985). Based on the results of basic cations computed, the mean value of exchangeable Mg and K are lower than that of exchangeable Ca. this is because, Ca produces great physical force to the exchange site than K and Mg. However, both of the basic cations measured are rated as low, with K rated as very low

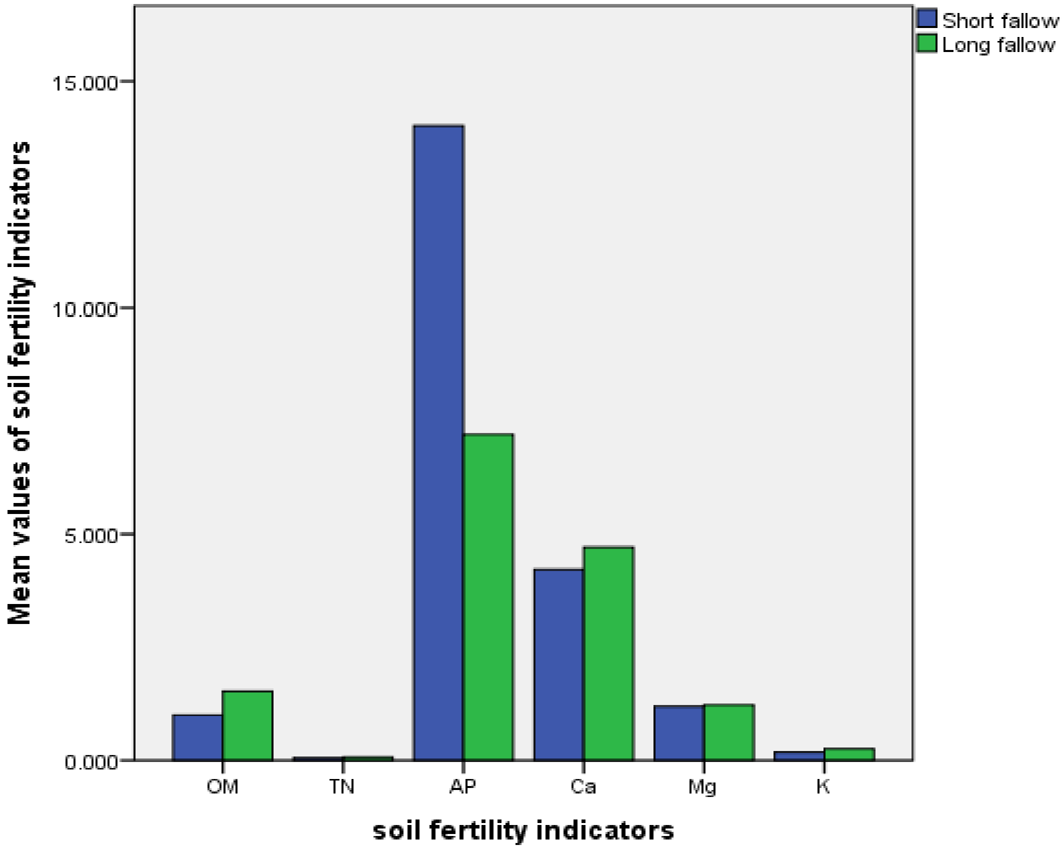

Figure 2: Mean values of soil fertility indicators under different fallow regimes

in soil under one year fallow regime. The resultant status of these cations in both fallow regimes may be associated to the lateritic composition of the soil in the area. Olowolafe (2002) observed that the amount of nutrient content of the soil is influenced by the nature of parent material in the area. The very low status of exchangeable K in soil under one year fallow perhaps indicates higher

Proportion of laterites in the field than the corresponding fallow fields observed.

This therefore showed that reliance on fallowing as a soil fertility management system is counterproductive to the viable agricultural production in the area. Yusuf (2000) noted that fallowing is one of the unsustainable soil management system been practiced in many parts of West Africa

Table 2: Mean values of soil fertility indicators

Nutrient elements	Short fallow	Long fallow
Organic matter content (OM)	1.006	1.533
Total Nitrogen (TN)	0.052	0.076
Available Phosphorus (AP)	14.019	7.200
Calcium (Ca)	4.220	4.714
Magnesium (Mg)	1.194	1.230
Potassium (K)	0.179	0.260

Table 3: Guidelines for rating soil fertility indicators

	OM (%)	**TN** (%)	**AP** (ppm)	**Ca** (cmol(-)/100g)	**Mg** (cmol(-)/100g)	**K** (cmol(-)/100g)
Very High	>6.0	>0.300	-	>20	>8	>1.2
High	4.3-6.0	0.226-3.000	>50	10-20	3.0-8.0	0.6-1.2
Medium	2.1-4.2	0.126-0.225	15-50	5-10	1.5-3.0	0.3-0.6
Low	1.0-2.0	0.050-0.125	<50	2-5	0.5-1.5	0.2-0.3
Very low	<1.0	<0.050	-	<2	<0.5	<0.2

Source: (ILACO, 1985 and London, 1991

Table 4: Soil fertility ratings

Nutrient elements	Short fallow	Long fallow
Organic matter content	Low	Low
Total Nitrogen	Low	Low
Available Phosphorus	Low	Low
Calcium	Low	Low
Magnesium	Low	Low
Potassium	Very low	Low

CONCLUSION

The following soil fertility indicators such as organic matter, total nitrogen, available phosphorus and exchangeable calcium, magnesium and potassium were assessed. The result of soil fertility rating in both short and long fallow management system showed that the status of all soil fertility indicators are low though potassium was rated very low in soil under short fallow. A slight quantitative increase in the fertility indicators with increase in fallow duration was observed, however in the case of phosphorus element, the increase in magnitude occurred in reverse order. The nature of the parent material in the area, the climate most especially rainfall and temperature and land use practices during resting period may be considered as the prime causes for the status of the indicators. Hence the need to further investigate the pattern of changes that is taking place during fallow with specific interest in predicting quantitative changes over a defined period of time.

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