International Journal of Plant & Soil Science
10(1): 1-12, 2016; Article no.IJPSS.23551
ISSN: 2320-7035

SCIENCEDOMAIN ***international***
www.sciencedomain.org

Influence of Fallow Ages on Soil Properties at the Forest-Savanna Boundary in South Western Nigeria

E. O. Onijigin[1], A. S. Fasina[2*], D. A. Oluwadare[2], U. O. Ogbonnaya[2], K. S. Ogunleye[2] and O. J. Omoju[2]

[1]Department of Guidance and Counseling, Ekiti State University, Ado-Ekiti, Nigeria.
[2]Department of Soil Science and Land Resources Management, Faculty of Agriculture, Federal University, Oye-Ekiti, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author EOO designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors ASF and DAO managed the literature searches, analyses of the study and performed the spectroscopy analysis. Authors UOO, KSO and OJO managed the experimental process and statistical analyses while author EOO identified the species of plant. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2016/23551
Editor(s):
(1) Marco Trevisan, Institute of Agricultural Chemistry and Environmental Research Centre BIOMASS, Faculty of Agriculture, Catholic University of the Sacred Heart, Italy.
Reviewers:
(1) Evans Ntim Amedor, Kumasi Institute of Tropical Agriculture, Ghana.
(2) Maria Jose Alves Bertalot and Eduardo Mendoza, Instituto Elo de Economia Associativa, Brazil.
Complete Peer review History: http://sciencedomain.org/review-history/13104

Original Research Article

Received 7th December 2015
Accepted 5th January 2016
Published 28th January 2016

ABSTRACT

Aims: This study examined changes in soil properties under different fallow ages within the forest-savanna boundary in southwest Nigeria.
Study Design: The study area was covered with grid lines of 2 km^2 with numbered quadrants. Ten quadrants were randomly selected as sampling sites, from each quadrant, six different fallow plots of varying ages were selected to make up 60 plots of 40 m by 25 m each.
Place and Duration of Study: The research was conducted at Ekiti North local government areas (LGA) of Ekiti State in 2014.
Methodology: Soil samples (0-15 cm) were collected from soils of different fallow ages (1, 2, 4, 5, 6, 8, 10, 15 and 20 years) and analysed for organic matter, pH, available P, exchangeable cations, nitrate-nitrogen, sand, silt, clay and soil moisture using standard methods.
Results: Most of the examined soil properties increased gradually with increase in fallow age. Significant correlation (r^2 = 0.25) was obtained between soil pH and age of fallow in the forest zone.

**Corresponding author: E-mail: sundayfash2012@yahoo.com;*

Significant correlation (r^2 = 0.01) was obtained between age of fallow and organic matter for both forest and savanna zones thus indicating increase in soil organic matter as fallow age increases. Soils of the forest fallows were more fertile than soils of the savanna. Forest sand decreased with fallow age while there was substantial degradation of clay particles in the savanna.

Conclusion: Late and unmonitored burning system in the savanna fallow should be discouraged. Following the rate of depletion of soil properties due to cultivation and shortening of fallow age, other sustainable options as suggested in this work would help maintain soil fertility.

Keywords: Fallow; regeneration; soil properties; forest; savanna.

1. INTRODUCTION

The continuous use of soils in the tropics without proper management led to decline in soil fertility over time [1]. Under the low input systems of agriculture in the tropics, the soil is traditionally regenerated by a fallow cycle in which natural vegetation is allowed to grow for several years before the land is cleared and cropped. However, fertile land is becoming scarce and fallow periods becoming reduced and not available because there is pressure on land for other uses [2]. So, the best way is to find a way to manage the available soil resources for continuous crop production and sustainable agriculture. Fallow is commonly referred to as a resting period for agricultural land between two cropping cycles during which soil fertility is restored. Rotation bush fallow system is still practiced almost everywhere in Nigeria and it is the system of cultivation mainly practiced in Ekiti North local government area (LGA) of Ekiti state, Nigeria especially for the cultivation of root crops (yam, cassava, cocoyam) and grain crops (rice, maize, guinea corn). This system involves the cultivation of a piece of land for over two or more years during which some of the soil essential nutrients are depleted. The plots are left for some years varying from two to twenty years, these periods are called fallow periods. [3] said that changes in soil properties during the fallow periods are essential for maintaining soil productivity. The author observed that the accumulation of organic matter in fallowed soils overtime is largely confined to top 10 cm of the topsoil and that organic matter exerts marked effects on the properties of fallow soil. Hence, as organic matter builds up in fallow soils overtime, soil nutrient status and some physical properties are also improved. This assertion is supported by [4], [5] and [2].

Vine [6] and [7] also noted that the three main functions of vegetative fallow are:

(i) to regenerate P, K, Mg, N and some other essential nutrients
(ii) to build up soil humus which stores up N, C and P
(iii) to suppress growth of weeds that are difficult to control during cultivation.

The amount of fresh organic materials depends on the type of vegetation established. It is expected that in the forest zone, fallow regenerates quickly from seedlings, stumps and roots that are left in the field. With sufficient rainfall, rapid re-establishment of soil nutrients and organic matter will take place within few years of fallow, whereas it achieves a much lower rate in the savanna with lower rainfall.

Fallow study in the rainforest region of eastern Madagascar by [8] showed what happens when fallow periods are significantly reduced. For the past thirty years, the length of fallow has declined from eight to fifteen years and currently to three years. These current fallow periods are too short to maintain soil and vegetation productivity as the fertility of soil systems is not retained [9]. In addition, natural fallows in eastern Madagascar showed rapid nutrient regeneration in the fallow vegetation [10]. At least 36-57% of previous phytomass pool was attained within one year, whereas topsoil nutrient concentration started to increase only after 3 to 5 years of fallow [10].

There is the need to study time dynamics of nutrient accumulation in soil fertility restoration using natural fallows in both forest and savanna agro-ecological zones of Nigeria. It was in view of this that the present study was designed. The objective of this study was to examine changes in soil properties under different fallow ages (periods) in soils under forest and savanna fallows in Southwestern Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study area was located at Ekiti North LGA of Ekiti State. The major towns or settlements selected for the study include the followings: Ikole, Ire, Ilupeju, Oye, Ayede, Ayedun, Ijesha – Isu, Itapaji, Oke – Ako, Irele, Ilasa, Omuo, Ijelu and Ayegbaju Ekiti. The area lies between latitudes 7° 40'N and 8° 5'N and longitudes 5° 18'E and 5° 44'E. It is bounded in the North by Kwara State, on the West by Ero LGA, on the South by Ekiti Central LGA and Ekiti East LGA. Ekiti North LGA covers a total area of about 1450 km^2. The study was carried out in 2014.

The monthly rainfall ranges from 1250 mm-1500 mm. There is variation in the amount of rainfall between the Southern forest areas and the Northern savanna of the study area. The length and intensity of rainfall varies from 7 months in the forest areas to about 5 months in the savanna areas with fluctuations from year to year. The temperature of the study area is moderately high, it ranges between 26℃ and 29℃ and it also shows a large amount of annual range of temperature between 3℃ and 9℃. This climatic condition has several implications on the natural processes which have resulted into both physical and chemical properties of the soil of the area.

The study area can be divided into two physiographic regions:

i) Relatively lowland areas (<500 m) in the northern part of the L.G.A
ii) The upland areas in the southern part (<500 m).

River Ele, which rises in the upload flows to the north as River Oye and form a major tributary to River Oyi in Kwara State. Under the high rainfall and temperature condition, the climatic climax vegetation over the study area is considered to be rainforest, but under the influence of intensive farming only little patches of forest remain in the southern part of the area. In the drier northern part, grassy vegetation has become established following clearing and cultivation. Subsequent bush fires in the dry season prevent the re-establishment of forest vegetation. The tree species found in the forest include *Chlorophora excels*; *Mahogany*; *Khaya ivorensis*; *Obeche*.

The area is underlain by crystalline pre-cambrian basement complex rocks which include quartzite, grass and schist. There is a close correlation between soil type and the geology [11]. The soil of the study area is mainly ferruginous and it falls under series belonging to Ondo and Iwo association according to [11].

2.2 Study Methods

Reconnaissance survey of the study area was first undertaken before the actual field survey was carried out. This was primarily aimed at identifying the sites which had been selected for investigation. It was equally aimed at identifying the adjacent villages and to seek the cooperation of the villages and farmers who at later dates took the investigator to the fallow lands and through their help ascertained the fallow ages of the plots.

During the actual field survey, information as regards the last cultivator of the plot (to ascertain the authenticity of age) and the crops last planted were gathered. It was discovered that most of the fallow re-growths consist of secondary forests except in few plots where dense forests occur such as Ijesha Isu (plot 3), Ikole (plots 8 and 9), Ayedun (Plots 15 and 17), Ilasa (plot 20), Omu-oke (Plot 46).

2.3 Sampling Technique

The sites and the adjacent villages from where the soil samples were taken were selected by a system of stratified random sampling. The study area was demarcated using the administrative map of Ekiti State for the boundaries on topographical maps of Ikole south west, Ikole N.W, Ado – Ekiti S.E, Ado – Ekiti N.W, Osi S.E and Isanlu S.W.

The whole study area was covered with grid lines of 2 km^2, the quadrants were numbered and by using a table of random numbers, ten quadrants were thus selected as the sampling sites. In each of these sites, six different fallow plots of different ages were selected from the particular or specific quadrant. Each fallow plot considered was 40 m by 25 m. In all, 60 fallow plots were considered. From each plot, 5 points were randomly selected from where the soil samples were taken. The plot was also covered by grid lines and divided up into 40 small quadrants of 5 m by 5 m each and by using random sampling tables, 5 different points were selected from where the actual soil samples were taken. Hence there were 300 sampling points from 60 sampling plots. Soil samples were collected on the surface (0–15 cm).

2.4 Laboratory Analysis

Sort samples collected were analyzed using the International Institute of Tropical Agriculture [12] analytical methods.

2.5 Statistical Analysis

Simple correlation analyses were employed to examine the nature and the strength of relationship between the age of fallows and the soil properties in the whole area. Regression analyses were also employed to examine the magnitude or the importance of the effects of fallow system on soil characteristics in the whole area. This model was used to determine whether the rates of changes in forest fallows are greater or smaller than those of savanna fallows. Comparison of means between the forest and savanna areas was done using the t – test to examine whether savanna fallow soils have suffered greater deterioration than forest fallow soils.

3. RESULTS

3.1 Influence of Fallow Age on Soil Properties of Forest and Savanna Soils in the Study Area

The influence of fallow age on some selected soil properties of forest and savanna soils in southwestern Nigeria are given in Tables 1 and 2. The age of fallow in the study area ranged from 1 to 20 years. It was observed within the study area that forest sand content decreased with age of fallow while the savanna sand content increased. The sand contents in the forest decreased inconsistently with increasing years of fallow, the highest and lowest values being 86.7% and 68.4% at 6 and 20 years respectively. There was inconsistent trend in silt fractions of forest soils throughout the fallow years. Clay content in the forest decreased consistently from 12.45% to 10.2% with exceptions of 2 and 8 years that had about 19% clay. The soil pH remained moderately acidic (5.6–5.9) except in 6 and 8 years where it significantly (*P* = *.05*) decreased to strongly acidic values of 5.4 and 5.2 respectively. The organic matter content followed an inconsistent trend but became highest in 10 years. Status of available phosphate and nitrate decreased inconsistently with fallow age, the highest values were gotten for 2nd and 1st year respectively. There was inconsistent increase in exchangeable cations concentration with the highest values recorded for 20 years (Table 1).

The clay content in savanna remained consistent between 10% and 15% during the aging period but the highest values were between 6 and 8 years of fallow. In contrast, sand content decreased from 85% to 76% within the 6 to 8 year window of fallow period. However, there was inconsistency in the trend of silt content in the soils in savanna. Interestingly, the pH significantly (*P* = *.05*) increased remarkably from very acidic (3.3) condition to moderately acidic (5.9) condition after 20 years fallow in the savanna. The organic matter content remained similar but showed increase in quantity with increasing fallow period and was highest at 2 years fallow. The available phosphate and nitrate concentrations increased remarkably during the fallow aging period, where the highest concentrations were found between 6 and 8 years of aging period (Table 1). This period (6-8 years) also showed consistent increase in the concentration of exchangeable cations as shown in Table 1.

3.2 Relationship between Fallow Age and Soil Properties of Forest and Savanna Soils in the Study Area

The relationships between fallow age and forest soil properties are presented in Fig. 1 while those of savanna are as presented in Fig. 2. The sand content of the soil ranged from 68.4% to 86.7% for forest soils while for savanna soils, the values ranged from 76.4% to 86.4%. In forest fallow, the relationship between sand and fallow age was weak, negative and insignificant with coefficient of determination (r^2) being 0.10. However, the relationship was observed to show stronger correlation than that of the savanna (r^2 = 0.06). This is to show that sand responds more to age of fallow in the forest area than in the savanna.

The silt content values ranged from 3.1% to 7.2% for forest soils while they ranged from 3.4% to 9.8% for savanna soils. The relationships between age of fallow and silt contents in forest and savanna zones were both weak and negative with corresponding r^2 values of 0.04 and 0.03 respectively. In the forest and savanna zones, the relationship between age of fallow and clay content were indicated by r^2 values of 0.19 and 0.07 respectively.

A significant (*P* = *.05*) correlation (r^2 = 0.25) was obtained between soil pH and age of fallow in the forest. There was an indication of strong tendency for the soil pH to increase as the soil regenerated under fallow. This increase was towards the neutral value of 7.0 (Tables 1 and 2). It was however observed that with r^2 being 0.25 in the forest and 0.35 in the savanna, there was a stronger relationship between age of fallow and soil pH in savanna than in forest fallows.

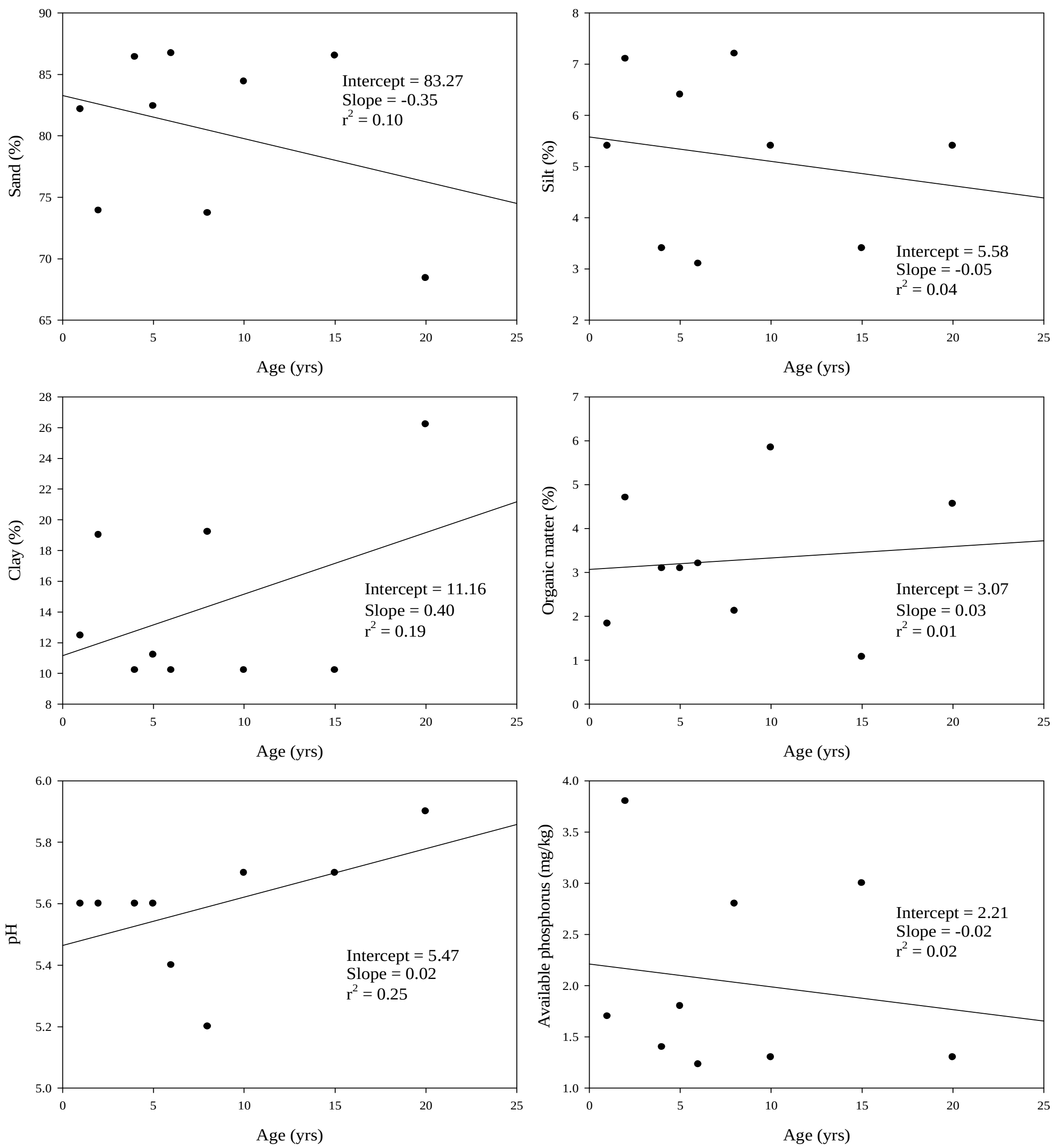

Fig. 1. Correlation between soil properties and age of forest fallow in years

The available phosphorous content of soils in the whole study area varies from 0.5 ppm to 5.0 ppm (Table 1). The relationship between fallow age and soil available phosphorus status was weak and negative in both forest and savanna zones with a stronger correlation (r^2 = 0.04) observed in the savanna.

The organic matter content of soils in the study area ranged from 0.07% to 5.84% with mean values of 3.27% and 2.39% for forest and savanna zones respectively. A significant (*P* = *.05*) and positive correlation (r^2 = 0.01) was obtained between age of fallow and organic matter for both zones. This shows that soil organic matter increases as fallow age increases. Significant correlation was not obtained between age of fallow and Nitrate – Nitrogen, age of fallow and exchangeable cations as well as age of fallow and soil moisture content.

Table 1. Influence of fallow age on some physical and chemical properties of savanna and forest soils in south western Nigeria

Fallow age (years)	Agro-ecological zone	% Sand	% Silt	% Clay	Soil pH ($CaCl_2$)	Avail P (mg/kg)	Organic matter %	Nitrate Nitrogen (g/kg)	Exchangeable cation (cmol(+)/kg) Ca	Na	K	Soil moisture %
1	Forest	82.15	5.40	12.45	5.6	1.70	1.83	7.65	510	20.25	106.9	11.39
	Savanna	85.4	4.4	10.20	3.3	1.60	2.18	0.70	320	31.3	102.5	10.1
2	Forest	73.9	7.1	19	5.6	3.8	4.70	0.95	1000	29.3	181.5	12.83
	Savanna	83.9	5.9	10.2	5.4	2.80	3.56	1.10	700	26.0	148	8.70
4	Forest	86.4	3.4	10.2	5.6	1.4	3.09	2.8	473	19	85	11.3
	Savanna	76.4	9.8	13.8	5.2	3.1	2.08	0.8	832	39	138.5	13.04
5	Forest	82.4	6.4	11.2	5.6	1.8	3.09	2.4	480	20	135	11.22
	Savanna	82.7	5.2	12.2	5.6	1.5	1.51	0.70	550	27.8	98.8	11.41
6	Forest	86.7	3.1	10.2	5.4	1.23	3.2	1.94	333	16	88.3	10
	Savanna	78.3	6.9	14.9	5.6	3.4	2.08	0.44	593.3	32.5	135.8	11.8
8	Forest	73.7	7.20	19.2	5.2	2.8	2.12	2.0	526.7	25.8	205.8	12.8
	Savanna	76.7	8.4	14.9	5.3	2.8	2.24	2.4	660	141.2	122.5	13.8
10	Forest	84.4	5.4	10.2	5.7	1.3	5.84	4.0	400	20	85	10.4
	Savanna	81.9	7.9	10.2	5.8	1.70	2.40	0.9	513.3	30	97.8	10.3
15	Forest	86.5	3.4	10.2	5.7	3.0	1.07	3.7	400	22	77.5	10.6
	Savanna	81.9	7.9	10.2	5.7	3.0	3.1	1.1	720	40	40	11.34
20	Forest	68.4	5.4	26.2	5.9	1.3	4.56	3.4	1340	30	225	12.64
	Savanna	86.4	3.4	10.2	5.9	1.4	2.35	1.9	520	25	132.5	9.14

Table 2. Influence of fallow age on some physical and chemical properties of savanna and forest soils in south western Nigeria

Location	Fallow age (years)	Agro- ecological zone	% Sand	% Silt	% Clay	Soil pH ($CaCl_2$)	Avail P (mg/kg)	Organic matter %	Nitrate Nitrogen (g/kg)	Exchangeable Cation (cmol(+)/kg) Ca	Na	K	Soil moisture %
Ijesha Isu	1	Forest	86.4	3.4	10.2	5.4	1.3	2.50	14	380	12.5	62.5	10.15
$\bar{X}$			86.4	3.4	10.2	5.5	1.4	1.88	12	400	17.5	100	10.1
Ayedun	1	Forest	81.4	7.4	11.2	5.5	1.0	2.08	1.2	500	23	107.5	12
Ayegbaju	1	Forest	74.4	7.4	18.2	5.9	3.0	0.87	3.4	760	28	157.5	13.3
$\bar{X}$			82.15	5.40	12.45	5.6	1.7	1.83	7.65	510	20.25	106.9	11.39
Omu-odo	1	Savanna	84.4	5.4	10.2	1.2	1.80	1.74	0.7	280	32.5	75.0	10.4
Oke-ako	1	Savanna	86.4	3.4	10.2	5.3	1.35	2.62	0.7	360	30	130	9.7
$\bar{X}$			85.4	4.4	10.2	3.3	1.60	2.18	0.7	320	31.3	102.5	10.1
Ikole	2	Forest	84.4	2.4	13.2	5.7	2.5	5.6	0.9	960	26	162.5	11.65
Ayegbaju	2	Forest	63.4	11.8	24.8	5.5	5.0	3.69	1.0	1040	32.5	200	14.0
$\bar{X}$			73.9	7.1	19.0	5.6	3.8	4.7	0.95	1000	29.3	181.5	12.83
Oke-Ako	2	Savanna	82.4	7.4	10.2	5.4	2.5	3.09	1.4	1040	30	170	8.8
	2	Savanna	85.4	4.4	10.2	5.4	3.0	4.03	0.8	360	22	125	8.5
$\bar{X}$			83.9	5.9	10.2	5.4	2.80	3.56	1.10	700	26	148	8.7
Ijesha Isu	4	Forest	84.4	5.4	10.2	5.6	1.6	3.62	2.3	380	14	65	11.57
Aiyedun	4	Forest	85.4	4.4	10.2	5.6	1.3	3.20	2.3	560	21	112.5	11.4
	4	Forest	89.4	0.4	10.2	5.6	1.4	2.42	3.7	480	22	77.5	11.0
$\bar{X}$			86.4	3.4	10.2	5.6	1.4	3.09	2.8	473	19	85	11.3
Ijelu	4	Savanna	86.4	3.4	10.2	5.0	2.5	0.34	0.6	300	17.5	87.5	9.4
Omu-oke	4	Savanna	61.4	20.4	18.2	5.6	4.5	2.68	0.8	1300	48	205	18
$\bar{X}$			66.4	15.4	18.2	5.2	1.3	3.15	1.0	860	47.5	117.5	13.2
Omu-odo	4	Savanna	85.4	4.4	10.2	4.7	3.0	0.07	1.1	1000	40	112.5	12.1
Itapaji	4	Savanna	82.4	5.4	12.2	5.7	4.0	4.16	0.3	700	41	170	12.5
$\bar{X}$			76.4	9.8	13.8	5.2	3.1	2.08	0.8	832	39	138.5	13.04
Ijesha Isu	5	Forest	82.4	6.4	11.2	5.6	1.8	3.09	2.4	480	20	135	11.22
$\bar{X}$			82.4	6.4	11.2	5.6	1.8	3.09	2.4	480	20	135	11.22
Ilasa	5	Savanna	88.4	1.4	10.2	5.6	1.25	1.14	0.8	360	20	107.5	10.13
Ijelu	5	Savanna	86.4	3.4	10.2	5.5	1.6	0.20	0.7	280	17	97.5	9.5
Omu-oke	5	Savanna	71.4	10.4	18.2	5.5	1.8	3.22	0.5	1140	39	85	16
Omu-odo	5	Savanna	84.4	5.4	10.2	5.8	1.3	1.48	0.6	420	35	105	10
$\bar{X}$			82.7	5.2	12.2	5.6	1.5	1.51	0.70	550	27.8	98.8	11.41
Ijesha Isu	6	Forest	84.4	5.4	10.2	5.6	1.35	3.56	0.8	260	14	90	10.1
Ikole	6	Forest	86.4	3.4	10.2	5.5	1.35	4.63	4.1	460	19	112.5	10

Aiyedun	6	Forest	89.4	0.4	10.2	5.1	1.0	1.41	0.9	280	15	62.5	10
$\bar{X}$			86.7	3.1	10.2	5.4	1.23	3.2	1.94	333	16	88.3	10
Ijelu	6	Savanna	86.0	3.8	10.2	5.6	1.3	0.27	0.4	200	12.5	82.5	10.6
Omu-oke	6	Savanna	66.4	11.4	22.2	5.5	5.0	2.61	0.6	920	45	162.5	14.5
Itapaji	6	Savanna	82.4	5.4	12.2	5.7	3.75	3.35	0.2	660	40	162.5	10.4
$\bar{X}$			78.3	6.9	14.9	5.6	3.4	2.08	0.4	593.3	32.5	135.8	11.8
Ikole	8	Forest	84.4	5.4	10.2	5.5	1.25	2.75	1.0	480	21.5	117.5	10.15
$\bar{X}$			74.4	8.4	17.2	5.3	2.5	0.13	3.2	700	26	125	13.11
Ayegbaju	8	Forest	62.4	7.4	30.2	4.9	4.5	3.62	1.7	400	30	375	15
$\bar{X}$			73.7	7.16	19.2	5.2	2.8	2.12	2.0	526.7	25.8	205.8	12.8
Ilasa	8	Savanna	87.4	2.4	10.2	5.5	1.3	0.07	5.0	400	21.0	87.5	9.6
Omu-oke	8	Savanna	65.4	12.4	22.2	5.6	3.5	2.88	0.7	860	27.5	135	17.8
Omu-odo	8	Savanna	77.4	10.4	12.2	4.8	3.5	3.76	1.6	720	37.5	145	13.87
$\bar{X}$			76.7	8.4	14.9	5.3	2.8	2.24	2.4	660	28.7	122.5	13.8
Ikole	10	Forest	84.4	5.4	10.2	5.7	1.3	5.84	4	400	20	85	10.4
$\bar{X}$			84.4	5.4	10.2	5.7	1.3	5.84	4	400	20	85	10.4
Ijelu	10	Savanna	82.8	7.0	10.2	5.8	0.5	1.14	0.8	380	20	90	11
Itapaji	10	Savanna	80.4	9.4	10.2	5.7	3.25	2.55	0.4	500	30	11	8.8
Oke-ako	10	Savanna	82.4	7.4	10.2	5.8	1.25	3.50	1.5	660	40	192.5	11
$\bar{X}$			81.9	7.9	10.2	5..8	1.67	2.40	0.9	513.3	30	97.8	10.27
Aiyedun	15	Forest	86.5	3.4	10.2	5.7	3.0	1.07	3.7	400	22	77.5	10.6
$\bar{X}$			86.5	3.4	10.2	5.7	3.0	1.07	3.7	400	22	77.5	10.6
Itapaji	15	Savanna	78.4	11.4	10.2	5.6	3.5	3.62	1.1	500	37.5	130	11.55
Oke-ako	15	Savanna	85.4	4.4	10.2	5.8	2.5	2.55	1.0	940	42.5	150	11.12
$\bar{X}$			81.9	7.9	10.2	5.7	3.0	3.09	1.1	720	40	140	11.34
Ikole	20	Forest	68.4	5.4	26.2	5.9	1.3	4.56	3.4	1340	30	225	12.64
$\bar{X}$			68.4	5.4	26.2	5.9	1.3	4.56	3.4	1340	30	225	12.64
Ilasa	20	Savanna	86.4	3.4	10.2	5.9	1.35	2.35	1.9	520	25	132.5	9.14
$\bar{X}$			86.4	3.4	10.2	5.9	1.35	2.35	1.9	520	25	132.5	9.14

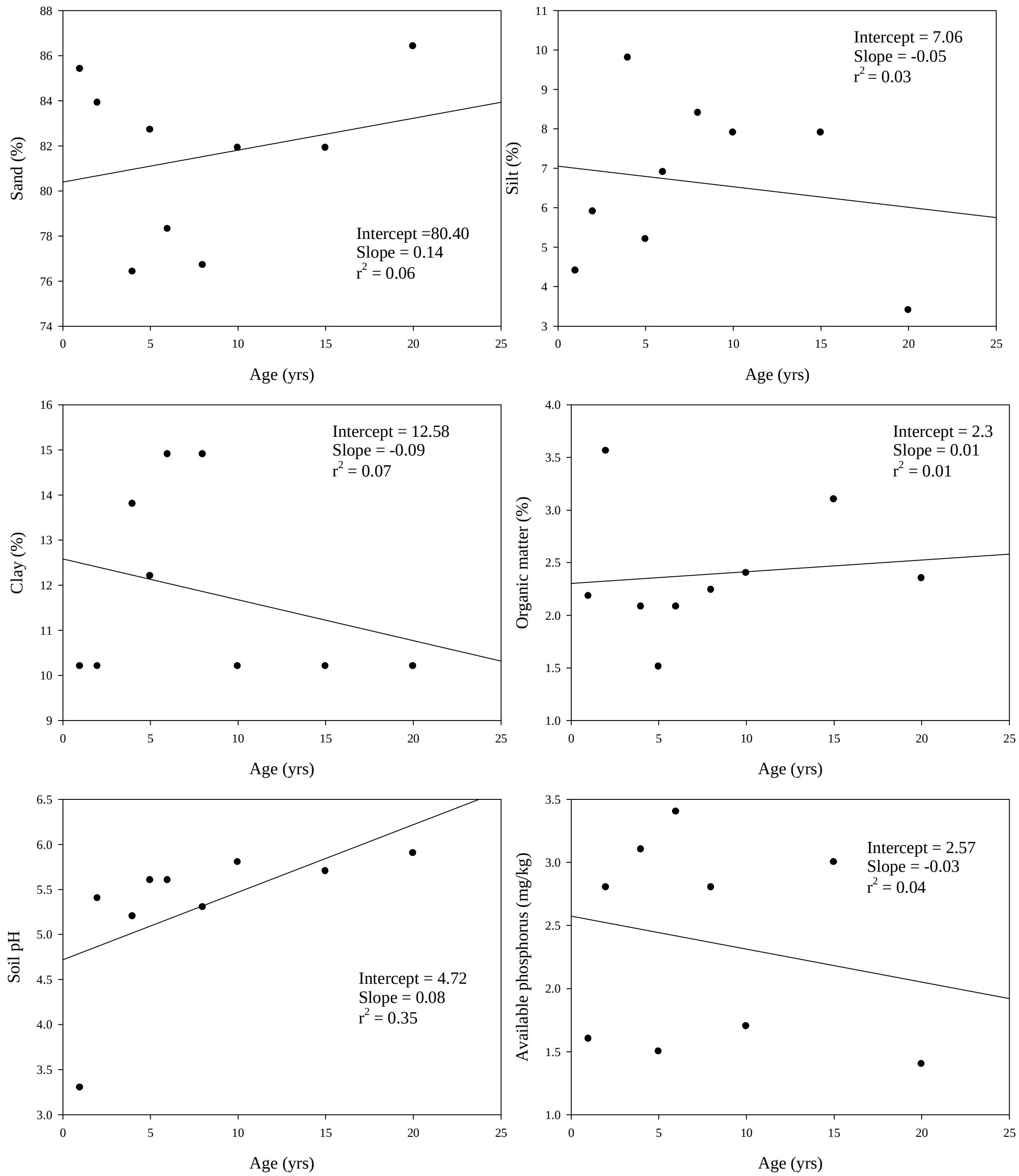

Fig. 2. Correlation between soil properties and age of savanna fallow in years

4. DISCUSSION

The observed decrease in forest sand content with fallow age could be attributed to increase in the rate of organic matter production resulting from litter and leaf fall addition to the soil as fallow advanced in age, this agrees with the findings of [13] and [14].

It could also be attributed to weathering processes which became pronounced as age of fallow increased under favourable physical and climatic conditions hence the disintegration of sand particles leads to increase in both silt and clay contents. The increased sand content with fallow age in the savanna zone is attributable to the fact that savanna vegetation is burnt yearly during dry seasons thereby leaving the soils bare with the first rains washing away the finer clay and silt particles. Additionally, the sandy nature of the soils recorded for both agro- ecological zones is probably due to the nature of the parent materials of both study sites which is basically basement complex granites and gneisses.

Of all the textural compositions, the substantial degradation of clay particles poses a greater threat to soil fertility in the savanna area. This is because during fallow, the clay particles which form basis for soil-plant ionic (nutrient) exchange are exposed to various degree of erosion thus making the soil structure and water holding capacity to degenerate; with limited available soil cover. The decrease in sand fraction with proportional increase in clay fraction in the forest ecology might also be due to the cementing actions of humic and fulvic substances of organic matter with soil particles thus implying less removal and retention of soils' finer particles (organic colloidal fractions) which are agents of soil aggregate formation as reported by [15]. [16] demonstrated that detrimental effects of exposure of savanna could be associated with decrease in clay content. Hence, constant exposure of savanna fallows during dry season to fire, will affect the clay content condition in the savanna than in the forest ecology. The implication of this is that while the forest fallows have ability to produce greater yield due to greater organic matter, organic carbon and moisture content, the savanna fallows suffer deterioration which may result in poor yield.

In both agro-ecological zones, a rise in the level of soil pH was observed during the fallow period as a result of the building up of exchangeable nutrient bases on the top soil as shown in Tables 1 and 2. The observed increment in soil pH value and its stronger correlation with increasing fallow age in the savanna is an indication that age is more important for soil pH development in savanna fallows than in the forest. The lower pH of the forest top soil could be due to leaching during which exchangeable base cations are washed down the soil profile by the typical incessant rainfall of the forest zone thereby causing the surface soil to become more acidic. [17] reported that at the peak of rainfall, soil pH tends to increase down the sampling depths due to vertical translocation of dissolved cations. Also, fluctuation in soil pH values as fallow age increased might be due to natural differences among the study sites with respect to hydrogen ion concentration. Older fallows produce more litter than younger ones, organic and inorganic acids which are potential donors of hydrogen ions and are produced as a result of decomposition of organic material [18]. Thus it is likely that more acids are liberated in the older fallows as a result of litter decomposition. In this study, forest fallow soils had lower pH than savanna fallow soils and this may be due to the effect of forest vegetation constant rainfall. It is thus an indication that the forest fallows are more acidic than savanna fallows.

The build-up of available phosphorus in the soil during the fallow periods is of considerable importance since its deficiency in fallow soil is a factor that frequently limits crop yield [18]. Generally, there was inconsistent increase in the level of available phosphorus in the top soil with increase in the length of fallow period especially in the savanna. It is an indication that age is more important for phosphorus determination in savanna fallows than in the forest. The lower level of available phosphorus in the savanna fallow could be attributed to the fact that faster rate of phosphorus uptake by rapidly growing forb vegetation is not matched by the slower rate of its returns through leaf fall and mineralization of litter. It is also found that there is no appreciable difference between forest and savanna fallows in available phosphorus. This may be due to the fact that tropical soils are said to be generally low in available phosphorus [18]. The observed overall reduction in phosphorus bioavailability in the top soils might be due to its reaction with calcium to form insoluble compounds because most soils in the tropics contain large amounts of iron- and aluminium-oxides or amorphous alumino-silicate clays which absorb P firmly and ensure P is virtually unavailable for plant uptake [19].

Lower levels of organic matter content were obtained in the soil of younger fallows. This may be attributed to the regrowth comprising of *Eupatorium odoratum* which generally dominates about 70% of all the younger plots studied. The litter production of this weed seems inadequate to balance the rate of organic matter content loss in the soil. The relatively higher level of organic matter content in the soil of older fallows is not unconnected with the presence of woody perennials in the vegetation cover. The trees with their distinct canopies cover the ground surfaces more than the forb vegetation. Tree canopy protects the soil surfaces from the direct impact of solar radiation, precipitation and wind. In other words, soils protected this way will certainly retain more nutrients than the exposed soils. The tree canopy also induces a situation whereby surface run-off and direct evaporation from soils are less than from the soils covered by weeds or grass. The increase in the leaf and litter fall gives rise to litter accumulation and as litter accumulation increases, there is tendency for the nutrient to increase. The result obtained for the correlation between organic matter and fallow age in this study agreed with findings of [20] and [21].

An appreciable difference was obtained in organic matter contents between savanna and forest soils. This is due to the greater litter production in the forest fallow than savanna fallow because the forest woody vegetation increases every year while savanna grasses return very little to the soil. This implies that soils of the forest fallows will be more fertile than soils of the savanna fallows. Additionally, increasing clay contents in forest over the sandy savanna soils could have also led to the increased organic matter contents in forest soils attributable to restricted aeration in finer-textured soils, reduced rate of organic matter oxidation and the binding of humus to clay particles [22].

5. CONCLUSION

The study examined changes in some soil properties under traditional fallow systems in both savanna and forest agro-ecological systems. It attempted to compare the fertility of soils within savanna and forest fallow. The result indicated that for most soil properties, there was gradual increase in value as age of fallow increased. This implies poorer fallow lands for younger fallows and richer soil for older fallows. The trend obtained for the influence of age of fallow on soil properties in forest and savanna soils may be attributed to several factors in the study area as follows:

1. The dominance of forb vegetation especially *Eupatorium odoratum* in abandoned farmlands during the first few years.
2. The effect of burning which retards the growth of vegetation to produce canopy for ground cover especially in the savanna fallows where the spear grass *Imperata cylindrical* takes over after burning.
3. The sandy nature of the soil and consequently inherent low natural soil fertility.
4. The removal of felled trees in fallow vegetation for use as fuel which is still the major source of fuel wood, results in a gradual depletion of soil nutrients.
5. Only clay pH, organic matter, calcium, nitrogen and potassium showed significant increase as the age of fallow increases in both savanna and forest soils.

Long term fallow periods are increasingly becoming difficult to be maintained by farmers due to pressure on land for other uses and land tenure problems. Consequently, shortening of fallow age to less than ten years with intensive cultivation is fast depleting soil properties. These have now called for need to consider other sustainable options for sustainable food production such as replenishment of soils with organic and inorganic amendments (fertilizers), crop rotation, incorporation of plant residues and green manures, composting, use of cover crops, surface mulching (especially in the savanna), alley cropping, management of nitrogen fixing trees and inter-planting of food crops such as cereals with nitrogen fixing legumes to reduce the problem of nitrogen deficiency thus helping to maintain soil fertility. The late and unmonitored burning system in the savanna fallow should also be discouraged to give way to early and monitored burning so as to allow some of the trees and shrubs to survive and still provide canopy for the soil thus reducing direct impact of sun during dry season. These would probably conserve soil nutrients and water.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Ayeni LS, Akinbani AS. Assessment of soil fertility management among the arable crop farmers in Ondo Southwestern Nigeria. Am J Research Communication. 2015;3(2):25-34.
2. Oluwadare DA, Voncir N, Mustapha S, Agele SO. Effects of organic and mineral fertilizers on soil chemical properties, growth and yield of pop corn (*Zea mays* everta) in a Northern Guinea Savanna Zone of Nigeria. J Sustainable Technology. 2013b;4(2):87–103.
3. Aweto AO. Organic matter build-up in fallow soil in a part of South-Western Nigeria and its effects on soil properties. J Biogeography. 1981;8(1):67-74.

4. Lal R. Forest soils and carbon sequestration. Forest Ecology and Management. 2005;220:242–258.
5. Offiong RA, Iwara AI. Effects of fallow genealogical cycles on the build-up of nutrients in soils of the Cross River rainforest, South-Southern Nigeria. Ethiopian J Environmental Studies and Management. 2011;4(4):84–95.
6. Vine RG. Heat transfer through bark and the resistance of trees to fire. Australian J Botany. 1968;16:499-514.
7. Food and Agriculture Organization. The importance of soil organic matter: Key to drought-resistant soil and sustained food production. FAO Soils Bulletin. 2005;80.
8. Styger E, Fernandes ECM, Rakotondramasy HM, Rajaobelinirina E. Degrading uplands in the rainforest region of Madagascar: Fallow biomass, nutrient stocks, and soil nutrient availability. Agroforest Syst; 2009. DOI: 10.1007/s10457-009-9225-y
9. Styger E. Fire-less alternatives to slash-and-burn agriculture (tavy) in the rainforest region of Madagascar. PhD dissertation, Department of Crop and Soil Science, Cornell University, Ithaca, New York; 2004
10. Brand J, Pfund JL. Site-and watershed-level assessment of nutrient dynamics under shifting cultivation in eastern Madagascar. Agriculture, Ecosystems & Environment. 1998;71(1/3):169-183.
11. Smyth AJ, Montgomery RF. Soils and land use in Central Western Nigeria. Nigerian Govt. Press, Ibadan; 1962.
12. International Institute of Tropical Agriculture. Selected methods for soil and plant analysis. Laboratory Manual Series No. 1, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria; 1979.
13. Dhyani SK, Chauhan DS. Agroforestry practices of North-Eastern hill region of India. In: Agroforestry traditions and innovations (ed. Narain P, et al.) CSWCR&TI, Dehradun. 1994;19-23.
14. Leindah DN, Choudhury BU. Soil fertility status in relation to fallow cycles and landuse practices in shifting cultivated areas of Chandel District Manipur, India. IOSR J Agriculture and Veterinary Science. 2013;4(4):1-9.
15. Oluwadare DA, Osakwe UC. Effects of applied organic materials on physical properties of intensively cropped ultisol in North-Eastern Nigeria. J Recent Advances in Agriculture. 2014;2(3):199-207.
16. Cunningham RK. The effect of clearing a tropical forest soil. J Soil Science. 1963; 14:334-335.
17. Fatubarin A, Olojugba MR. Effect of rainfall season on the chemical properties of the soil of a Southern Guinea Savanna ecosystem in Nigeria. J Ecology and the Natural Environment. 2014;6(4):182-189.
18. Adepetu JA, Adetunji MT, Ige OU. Soil fertility and crop nutrition, 1st ed. Jumak Publishers; 2015.
19. Potash and Phosphate Institute. Effect of Foliar applied monopotassium phosphate on high yielding canola and wheat grown in Southern Manitoba; 2003. Available:http://www.ppi-far.org/far/farguide.nsf/
20. Chikere – Nkoju C, Okorie IK, Christo IE. Effect of fallow period on some physico-chemical properties of a sandy loam ultisol, South East Nigeria. Global Research J Science. 2011;1:28–32.
21. Areola O, Aweto AO, Gbadegesin AS. Organic matter and soil fertility restoration in forest and savanna fallows in southwestern Nigeria. Geo Journal. 1982; 6(2):183-192.
22. Ann M, Clain J, Jeff J. Soil pH and organic matter. Nutrient Management Module. 2003;8. Available:http://www.msuextension.org/publications.asp

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/13104