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Effects of Rainfall Seasonal Dynamics on the Chemical Properties of the Soil of a Tropical Southern Humid Rainforest Ecosystem in Nigeria

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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Short Research Article

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ABSTRACT

Rainfall season changes in Nigeria affect soil chemical properties in tropical rain forest, the effect of rainfall variation on soil chemical properties depend on its intensity, duration and time. However, the report on the seasonal variation/changes in rainfall remained sketchy especially for the rainforest zone in Nigeria. Due to this, in the Southern humid rainforest in southwestern, Nigeria, assessment of seasonal changes on soil chemical properties was done. The study was done in Ala Forest Reserve in Ondo State of Nigeria in 2010, 2011 and 2012. Twenty randomly selected sampling plots were chosen at different seasons viz: January (considered as dry season), March (onset of rainy season), June-July and September (peak of rainy season) and November (waning of rainy season). At five selected locations, random sampling was done at the depth of: 0 – 5 cm, 5 – 10 cm, 10 – 15 cm and 15 – 20 cm. Soil organic matter, soil pH, available phosphorus, total nitrogen and exchangeable cations (Ca, Mg and K), increased during the peak of rainy season. Soil nitrogen, organic matter and cation exchange capacity (CEC) decreased down the profile depths. Dry season (January) and peak of rainy season (June/July and September) showed greater influence on soil chemical properties. Phosphorus content was maximum in dry season (January) and at the onset of rainy season (March). However, it remained lower at the peak of the rainy season (June-July and September). On the other hand, soil organic matter and total nitrogen were found to be low in dry season (January) as result of burning of the vegetation. At the peak of rainy

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season (July and September), nitrogen content increased as a result of nitrogen fixation activities. Also, the decrease in the total exchangeable bases (TEB) at the depths (10-20 cm) might be attributed to their involvement in the tissue synthesis and stem elongation at this active growth period.

Keywords: Soil chemical properties; rainfall seasons; humid rain forest; sampling depths.

1. INTRODUCTION

Ala Forest covers 401km ^{2} between latitudes 5^0 12^1 and longitudes 6^0 05^1 in the lowland forest zone in Ondo State. It is contiguous with Akure-Ofosu, Owo and Idanre forest reserves [1].

Dense vegetation and closure of tree canopy afford the soil adequate cover, thereby reducing the loss in nutrients that are essential for the growth plants. At different level, vegetation also covers helps in protecting the soil from harsh climate, mostly rainfall and sunlight [2].

Available nutrients estimation in soil has genesis of soil as well as ecological importance which is partially controlled by forest and vegetation [2]. Soil nutrients may differ among similar geographical area due to natural and/or man-made interferences. Therefore, a complete knowledge of spatial changes of soil nutrients is necessary. A combination of factors such as topography, rainfall, parent material and soil management practices control the distribution of nutrients in soils. Similar to this, land use patterns and vegetation types play important role in soil nutrient mineralization, transformation and fertility potential. Changes as a result human influence alter several processes in soil; physical properties such as porosity, soil structure, aggregate stability, soil depth, consistency and water percolation, soil chemical properties such as soil organic matter, nutrient content, total exchangeable bases, availability and cycling, pH and C: N) and biological soil properties such as soil microbial population, soil faunal, biomass productivity and carbon mitigation [2].

There are several reports present about the effect of soil parameters in the composition and distribution of in Nigerian savanna vegetation [3], [4]. Soil texture, structure and mineral content influenced vegetation associations within the rainforest and tree species [2,5]. Phosphorus mineralization–immobilization of organic Phosphorus, are strongly influenced by seasonal changes in rainfall, temperature, moisture, plant growth, and by organic matter accumulation from litter fall [6,7,8] and [9]. Soil properties and biogeochemical processes are affected by land cover [10,11]. In the tropical ecosystem, rainy and dry seasons are characterized by a few ecological conditions. This conditions set up some series of processes which influence the biotic and soil components of the ecosystem [9]. In the course of literature review, information of seasonal variability on the soil chemical properties in Nigerian tropical rainforest was sketchy. Only limited information on the effects of forest fire in the dry season is available [12]. Therefore, the present work focuses on to document the seasonal dynamics on the chemical properties in Nigerian tropical rainforest ecosystem. This paper is therefore to bridge the gap in this respect.

2. MATERIALS AND METHODS

2.1 Site Description

Ala Forest covers 401km ^{2}. It is contiguous with Akure-Ofosu, Owo and Idanre forest reserves [1].

2.2 Relief and Drainage

Most of the land of Ala forest reserve falls within altitude of 250 meters above sea level. It is composed of lowlands and rugged hills with granitic outcrops [1].

2.3 Geology

The main geological formation of the reserve is the pre-Cambrian Basement complex, sedimentary and igneous rocks. This basement complex includes the oldest rocks known in Nigeria [1].

2.4 Rainfall and Temperature

Rainfall in this area is usually above 1500 mm annually, distributed over ten months from February to November. The rainfall expressed two peaks viz ; June-July and September. The rainfall within a year shows two maxima, the first one of 1883.3 mm occurring in June -July, while the second one with 2000 mm is in September. The temperature was fairly constant for the years and ranged between 17.4^0C and 17.3^0C for the minimums, while the mean monthly maximum temperature ranged between 27.5^0C and 27.6^0C.

2.5 Plot Description and Samples Collection

The study site was located in the North-Eastern of the reserve in 2010, 2011 and 2012. In the location of the forest, one hectare (100m x 100m) was separated and divided into 100 plots of 10m x 10m.

Twenty plots were randomly selected at each location for soil sampling at four different sampling periods viz: January (dry season), March (Beginning of rains), June/July and September (peak of rains) and November (end of rains). Soil samples were collected at four different top soil depths; 0 – 5cm, 6 – 10cm, 11 – 15cm and 16 – 20cm at five randomly selected locations of each plot for one mean sample.

2.6 Methods of Samples Collection and Analysis

A Dutch auger was used to collect soil sample which were carefully kept in well labeled plastic bags and sent immediately to laboratory for analysis.

(a) Particle size analysis

This was done by hydrometer method [13] using sodium haxametaphosphate (calgon) as dispensing agent.

(b) Chemical analysis

The soil samples were dried for few days sieved to pass through 2mm mesh and chemically analyzed. The pH (in water) was determined in a 1: 2.5 solution (soil: distilled water) and was measured with a standard glass electrode. The organic carbon content of the soil was determined according to [14] dichromate oxidation method. The percentage organic matter content in the samples was calculated by multiplying the values of organic carbon by the conventional Van Bammeller factor of 1.724. Total soil nitrogen was determined by Macro Kjeldahl methods [15]. Available phosphorus was extracted using Bray II method [16] and determined by spectrophotometer.

Exchangeable Na, K, Ca and Mg were extracted with $Bacl_2$ 0.1m [17] and analyzed by atomic absorption. Exchangeable acidity was determined from 0.1 NaCl extracts and titrated with 1.0N HCl.

Cation exchange capacity (CEC) was determined by summing up total exchangeable bases (TEBS) and total exchangeable acidity (TEA), which the base saturation = TEB/CEC X 100.

Where TEB = Total exchangeable bases
CEC = Cations Exchangeable capacity

2.7 Statistical Analysis

The data were subjected to two-way analysis of variance (ANOVA) and means were separated by Duncan New Multiple Range Test at 5% level [18].

3. RESULTS

3.1 Effect of Dry Season (December – February) on Soil pH, C, N and Available Phosphorus

The effect of dry season on soil chemical properties is shown in Table 1, also, Fig. 1, shows the fluctuation of rainfall in the study area, the driest months were December, January and February. The mean value of rainfall recorded during the study was 66.67mm. Dry season significantly affect soil pH, soil carbon, total nitrogen and available phosphorus within the sampling depths, at $p < 0.05$ (Table 1). The values of soil carbon, total nitrogen and available phosphorus were higher at 0-5cm and 5-10cm. However lower values of soil carbon; total nitrogen and available phosphorus were recorded at the lower depths. Soil pH was also higher at upper depths compared to lower depths.

In the same vein, significant differences were observed for soil pH, soil organic carbon, total nitrogen and available phosphorus throughout the seasons. Dry season and at the beginning of rains recorded higher values of available phosphorous (Table 5).

3.2 Effect of Dry Season (December – February) on Total Exchangeable Bases Calcium, Magnesium, Potassium, Sodium and (TEB, Ca, Mg, K and Na)

Also, significant differences was observed for calcium (Ca), magnesium (Mg), and potassium (K) among the sampling depths ($P < 0.05$) in dry season as well as sodium (Na) and total exchangeable bases (TEB) (Table 1). Higher values of all calcium, magnesium, potassium, total exchangeable bases and sodium were recorded at 0-5 cm and 5-10 cm. While lower values of calcium, magnesium, potassium, total exchangeable bases and sodium were sampled at the depths of 10-15 cm and 15-20 cm.

Significant differences were noticed for the exchangeable acidity (EA) and cation exchange capacity (CEC) (sampling depths P< (0.05)) (Table 1) during dry season [19]. The recorded highest values was 0.19 cmol/kg soil in 0-5cm depth for pH, while the highest value of 5.52 cm/kg of soil was recorded from 5 -10cm depth (Table 1).

Across the seasons, there were significant differences in both exchangeable acidity (EA) and CEC. Dry season and the onset of rainy season as well as peak of raining season and end of rains did not affect exchangeable acidity (EA) cation exchange capacity (CEC) significantly (Table 5).

3.3 Effect of Beginning of Rainy Season (March) on Soil pH, C, N and Available Phosphorus

Table 2 shows the effect of beginning of rainy season on soil chemical properties; also, Fig. 1 shows the fluctuation of rainfall in the study area, with March as the beginning of rainy season. The mean value of rainfall recorded during the study was 416.7mm. Beginning of the rainy season, (March-October) influenced soil pH, soil carbon, total nitrogen and available phosphorus significantly in the sampling at $p < 0.05$ (Table 2). Also significant differences were also observed among the sampling depths for the properties considered during the beginning of rainy season. Values of soil carbon, total nitrogen and available phosphorus increased at 0-5 cm and 5-10 cm.

Across the seasons, soil pH, soil organic carbon, total nitrogen and available phosphorus show significant differences.

3.4 Effect of Beginning of Rainy Season (March-October) on Total Exchange Bases, Calcium, Magnesium, Potassium, Sodium and (TEB and Ca, Mg, K, Na)

Significant differences were observed for calcium (Ca), magnesium (Mg), total exchangeable bases (TEB) and potassium (K) among the sampling depths in dry season. However, in rainy season did not have significant effect on sodium (Na) (Table 2).

At the beginning of rains (May) (Table 2), sodium did not show any significant differences in the sampling depths. Calcium, magnesium, potassium and total exchangeable bases were statistically different in the sampling depths. Different seasons also influenced calcium, magnesium, potassium and total exchangeable bases statistically. The value of calcium was high at the peak and waning of rainfall while potassium and total exchangeable bases were higher at the onset of rainy season.

Significant differences were observed for exchangeable acidity (EA) and cation exchange capacity (CEC) (Table 2) in the sampling depths.

Across the seasons, there were significant differences in exchangeable acidity (EA) and cation exchange capacity (CEC).

3.5 Effect of Peak of Rainy Season (June/July to September) on Soil pH, C, N and Available Phosphorus

Tables 3 and 4 show the effect of the peak of rainy season on soil chemical properties, also, Fig. 1, shows the fluctuation of rainfall in the study area, with June/July as the peak (1) and September as peak (2) of rainy season. The mean values of rainfall recorded during the study were 1883.3mm and 2000mm respectively. Peak of rainy season (June-September) influenced soil pH, soil carbon, total nitrogen and available phosphorus in the sampling depths, at $p < 0.05$ (Tables 3 and 4). Values of soil carbon, total nitrogen and available phosphorus were higher at 0-5 cm and 5-10 cm as opposed to lower values recorded at 10-15 cm and 15-20 cm depths. In comparison between the two peaks of the rains, values recorded in June/July were higher than what were recorded in September.

In the same vein, peak of rainy season show on soil pH, soil organic carbon, total nitrogen and available phosphorus across the seasons except between June/July and September (C and D).

3.6 Effect of Peak of Rainy Season (June/July to September) on Total Exchangeable Bases, Calcium, Magnesium, Potassium, Sodium (TEB, Ca, Mg, K and Na)

At peak of the rainy seasons (June-September), significant differences was observed for calcium (Ca), magnesium (Mg), total exchangeable bases (TEB) and potassium (K) among the sampling depths ($P < 0.05$) . However, there was insignificant effect of peak of rainy season on sodium (Na).

During this season, (September C) (Tables 3 and 4), there were significant differences among the sampling depths for calcium, magnesium, potassium, and total exchangeable bases. While values of sodium remained constant down the sampling depths. Calcium, magnesium, potassium and total exchangeable bases were higher at 0-5 cm and 5-10 cm, they were however lower at 10-15 cm and 15-20 cm.

There were significant differences in the values of calcium, magnesium, potassium and total exchangeable bases across the seasons. In contrast, no significant differences were recorded between June/July and September.

Significant differences were observed for exchangeable acidity (EA) and cation exchange capacity (CEC) in the sampling depths ($P < 0.05$) (Tables 3 and 4).

The exchangeable acidity (EA) value showed significant differences in the sampling depths (0-5cm) with the maximum value of 0.29 cmol/kg of soil. Also CEC values were high during this period, with the highest value recorded at 0-5cm depth (Tables 3 and 4).

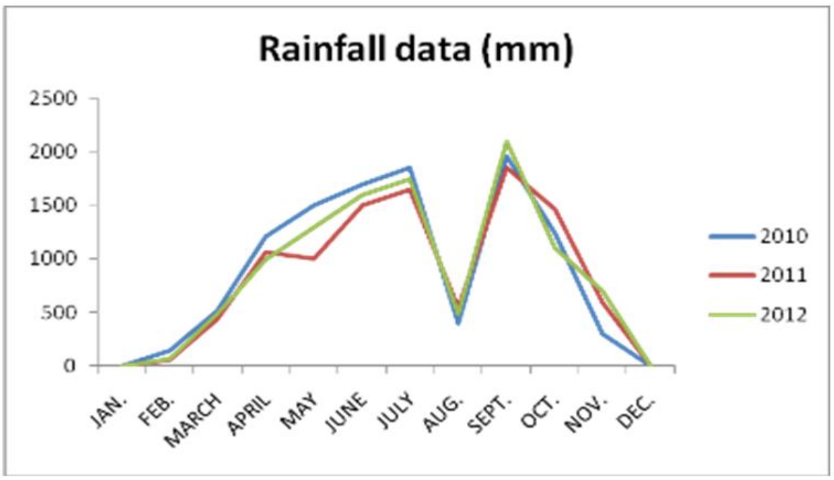

Fig. 1. Rainfall data (mm) for 2010, 2011 and 2012

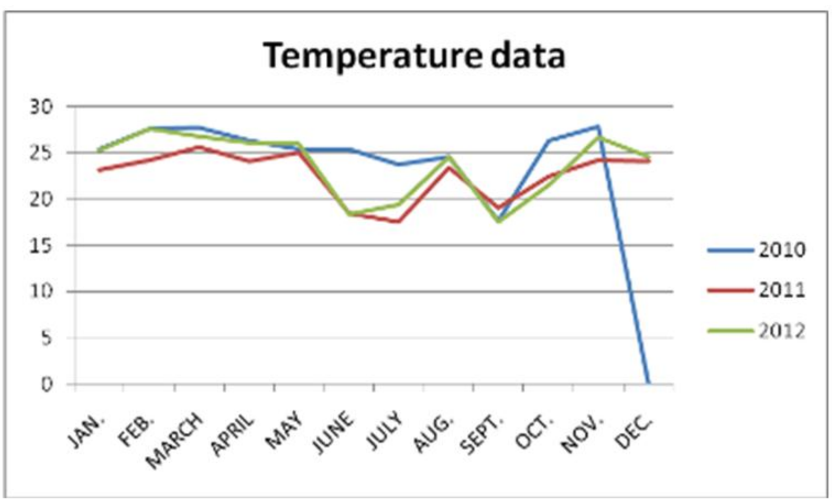

Fig. 2. Temperature in degree

Across the seasons, both exchangeable acidity (EA) and CEC were significantly affected except between dry season and beginning of rains as well as between the peak of rains and end of rains (Table 6).

3.7 Effect of End of Rainy Season (November) on Soil pH, C, N and Available Phosphorus

Table 5 shows the effect of end of rainy season on soil chemical properties, also, Fig. 1, shows the fluctuation of rainfall in the study area, the November as end of rainy season. The mean value of rainfall recorded during the study was 300mm. End of rainy season (November) showed profound influence on soil pH, soil carbon, total nitrogen and available phosphorus in the sampling depths , at $p < 0.05$ (Table 5). f Soil carbon, total nitrogen and available phosphorus were found to be higher at 0-5 cm and 5-10 cm in contrast to low quantity recorded from 10 -15 cm and 15-20 cm.

In the likely manner, dry and beginning of rainy seasons affect soil pH, soil organic carbon, total nitrogen and available phosphorus significantly, however, peak and end of rainy seasons did not affect pH, N and C/N significantly.

3.8 Effect of Rainy Season Waning (November-February) on Calcium, Magnesium, Potassium, Sodium and Total Exchange Bases (Ca, Mg, K, Na TEB)

Among the sampling depths ($P \leq 0.05$) and total exchangeable bases (TEB), significant differences were recorded for calcium (Ca), magnesium (Mg), and potassium (K). However, sodium showed no significant difference between 5-10 cm and 10-15 cm during this season (Table 5). Higher values of these parameters were recorded at 0-5 cm and 5-10 cm during this period.

Calcium, magnesium, potassium and total exchangeable bases were affected significantly by the dry and the beginning of rainy seasons, in contrast, no significant differences were found among the peak and end of rainy seasons (Table 6).

Significant differences in the sampling depth of 0-5cm (P < (0.05) was recorded for the exchangeable acidity (EA) and cation exchange capacity (CEC) (Table 5) with the maximum value of 0.29 cmol/kg soil, for CEC. A maximum value of 8.06 cmol/kg of soil was recorded from 0-5cm depth (Table 5).

Across the seasons, both exchangeable acidity (EA) and CEC were significantly affected. However, peak of rainy season and end of rains did not affect both exchangeable acidity (EA) cation exchange capacity (CEC) significantly (Table 6).

4. DISCUSSION

4.1 Seasonal Patterns and Sampling Depths on, Organic Carbon, soil pH, Total Nitrogen and Available Phosphorus

Findings showed that rainfall dynamics affect the distributions of soil pH, carbon, soil organic, exchangeable cations, total nitrogen and available phosphorus in all the seasons and soil depths.

4.2 Soil Reactions (pH)

High rainfall is related to acid dilution, thus lowering the soil acidity down the profile recorded at the beginning and peak of rains [20]. This is in line with the results of this study showing that soil pH becomes less acidic down the depths. Lack or little in dry season (November-February) and in the beginning of rainy season might be accounted for the distribution of soil pH down the soil depth. This had lead to the little or no movement of cations down the soil depths at these periods. In contrast, soil pH tends to decrease down the sampling depths peak of rainfall (June-September) and end of rains (November) , due to vertical movement of dissolved cations as a result, soil acidity increased down the depths. The annual occurrence of forest fire in the area might have caused the soil pH changes over the seasons, the ash released from the accumulated litter following forest fire in January, could have caused a slight increase in the soil pH [21].

4.3 Organic Matter

The patterns of total carbon and soil organic matter varied between seasons show a decreasing pattern in depths and across the seasons. At the peak of the rains, decomposition was encouraged thereby releasing more organic matter. A favorable environment for microbial activity was created resulting in rapid decomposition which further changes the total carbon in the soils [22]. Low rains as well as frequent fire in the area could have caused the low percentage of soil organic carbon in the dry season of the year (November-February). The decrease in soil organic carbon down the profile might be due to little or absence of soil microorganisms that are responsible for the decomposition (Tables 1, 2, 3 and 4). Very high rainfall observed at the peak of rains (June-July to September), enhanced better decomposition and accumulation of soil organic carbon, which might be a reason of the distribution of organic carbon across the seasons [21].

4.4 Total Nitrogen

Variable results were reported by many workers in relation to seasonal and fire effects on the nitrogen content of soil [23]. In this study, the different amount and patterns of rainfall had resulted in different pattern of total N content. This variation might be due to fluctuations in water table leading to differential in litter decomposition and subsequently nitrogen mineralization [2]. Intensive fire leads to volatilization of nitrogen which is easily lost from system as low as 200^0C [24]. This accounted for low nitrogen content in January (dry season) (Table 1). The actual nitrogen loss occurred due to volatilization was estimated to range from 75 kg/ha [25] to 907 kg/ha [26]. The decreased in soil nitrogen in March (beginning of rains) (Table 2), might be due to increased in the leaching of Nitrates during this period as a result of absence of vegetation and organic matter layer which led to increased infiltration rates [2]. While the At the onset of rains (June-July to September) (Tables 3 and 4) and at the waning of rains in November (Table 4), nitrogen contents were increased, which could be as a result of increased activity of nitrogen fixing microbes. Low rainfall which reduced mineralization as well as the distribution of soil organic matter in the area might have accounted for low total nitrogen distribution during the dry season and at the beginning of rains. However, the moderate total nitrogen recorded during the peak of rainfall (June/July and September) (Tables 3 and 4) might be interlinked with the high rate of mineralization due to high rainfall [27].

4.5 Exchangeable Cations

In this study, the concentration of Ca, Mg, K, Na and TEB decreased, indicating that the exchange site was dominated by H+ and Al3+. There is possibility that these basic cations were being eroded and leached since high rainfall occurred during these periods. This findings were in agreement with NurQursyna et al. [28], they were of the opinion that high precipitation might lead to decrease in exchangeable bases. The decrease in the total exchangeable bases (TEB) during the peak of rainy season at the depths of 10-20 cm could be attributed to the use of these elements for tissue synthesis during this period. There were decline in the soil nutrients (exception: soil nitrogen) at the peak of rainy season, which coincided with the active growth and usage of mineral elements of forest trees [29]. Conservation of the organic matter layer is recommended to reduce soil degradation and nutrient depletion in the study area, since the organic matter layer was not only the main source of soil nitrogen and available nutrient elements, but also enhanced the activity soil microbial [29].

4.6 Available Phosphorus

In most forest ecosystems, a considerable amount of the nutrients remain reserved in the organic material on the forest floor [30]. Forest fire might be responsible for the slight increase in phosphorus in dry season (January) (Table 1) and in March (beginning of rains) (Table 2), as reported by De Ronde, [31] who found that a high intensity wild fire resulted in an immediate increase in phosphorus level in the southern Cape Forestry Region of South Africa [32]. Available phosphorus level was fairly constant in dry season (January) and at the beginning of raining season (March) (Table 2) and decreased sharply during the peak of rainfall (September) (Tables 3 and 4) as a result of growth of plants and accumulation of biomass during growing season [33].

Cation exchange capacity (CEC) was low in the entire area which might be due to the soil organic carbon distribution as well as low activity clays [23]. Excessive amount rainfall between June and September may be a reason for this. This study took place in a humid forest, where, organic input from the litter was identified as a major factor to the increased available P which was low, this was consistent with the previous submissions [30] at the peak of raining season. As reported by Olojugba [24], due to the change in the clay type and the nature of parent material, the low CEC might have resulted.

Table 1. Effect of rainfall seasonal dynamics on some soil chemical properties during Dry season (December-February)

Depth	Properties												
	PH in (H_20)	OC %	OM %	N %	C/N	Cal	Mag	K	Na	TEB	av P	EA	CEC
						cmol/Kg of Soil							
0-5 cm	6.7^{a}	2.73^{a}	4.69^{a}	0.26^{a}	10.5^{a}	6.15^{a}	1.01^{a}	0.54^{a}	0.05^{ab}	7.75^{a}	2.8^{a}	0.19^{a}	7.94^{a}
5-10 cm	6.3^{b}	1.56^{b}	2.68^{b}	0.2^{b}	7.9^{b}	4.13^{a}	0.87^{b}	0.32^{b}	0.05^{ab}	5.37^{ab}	2.3^{b}	0.17^{b}	5.54^{b}
10-15 cm	6.3^{b}	1.44^{c}	2.3^{c}	0.2^{b}	7.2^{b}	2.90^{c}	0.85^{b}	0.28^{c}	0.06^{a}	4.09^{bc}	1.8^{c}	0.15^{c}	4.24^{c}
15-20 cm	6.2^{b}	1.33^{d}	2.23^{c}	0.19^{bc}	7.0^{c}	3.00^{b}	0.75^{c}	0.33^{b}	0.04^{b}	4.12^{b}	1.4^{a}	0.14^{c}	4.26^{c}

Means on the same column with the same letter are not significantly different at P < 0.05; OC = Organic carbon, OM = Organic matter, N = Total nitrogen, C/N = carbon: nitrogen ratio, Ca = calcium, K = potassium, Na = sodium; TEB = Total exchange bases, av. P = Average phosphorus, EA = exchange acidity and CEC = cations exchange capacity

Table 2. Effect of rainfall seasonal dynamics on some soil chemical properties at the beginning of rainy season (March)

Depth	Properties												
	PH in (H_20)	OC %	OM %	N %	C/N	Cal	Mag	K	Na	TEB	av. P	EA	CEC
						cmol/Kg of Soil							
0-5 cm	6.6^{b}	2.72^{a}	4.69^{a}	0.27^{a}	10.07^{a}	2.41^{ab}	0.86^{a}	0.53^{a}	0.04^{ns}	3.84^{c}	2.8^{a}	0.19^{a}	4.03^{b}
5-10 cm	6.7^{ab}	2.57^{b}	4.42^{b}	0.26^{ab}	9.88^{ab}	3.17^{a}	0.82^{c}	0.34^{b}	0.04^{ns}	5.37^{a}	2.3^{b}	0.17^{b}	5.52^{a}
10-15 cm	6.7^{ab}	1.59^{b}	2.73^{c}	0.25^{ab}	6.36^{c}	2.66^{b}	0.84^{b}	0.27^{c}	0.04^{ns}	4.09^{bc}	1.8^{c}	0.15^{c}	4.22^{d}
15-20 cm	6.8^{a}	1.42^{c}	2.44^{d}	0.24^{bc}	5.9^{d}	2.20^{b}	0.84^{b}	0.25^{d}	0.04^{ns}	4.12^{b}	1.4^{d}	0.14^{d}	4.50^{c}

Means on the same column with the same letter are not significantly different at P < 0.05; OC = Organic carbon, OM = Organic matter, N = Total nitrogen, C/N = carbon: nitrogen ratio, Ca = calcium, K = potassium, Na = sodium; TEB = Total exchange bases, av. P = Average phosphorus, EA = exchange acidity and CEC = cations exchange capacity

Table 3. Effect of rainfall seasonal dynamics on some soil chemical properties at the peak of rainy season (June/July)

Depth	Properties												
	pH (H_20)	OC %	OM %	N %	C/N	Cal	Mag	K	Na	TEB	av. P	EA	CEC
						cmol/Kg of Soil							
0-5 cm	6.4^{b}	2.94^{a}	5.1^{a}	0.31^{a}	9.5^{a}	4.2^{a}	1.14^{a}	0.38^{a}	0.05^{a}	5.77^{a}	2.4^{a}	0.29^{a}	6.06^{a}
5-10 cm	6. 5^{a}	2.69^{b}	4.63^{b}	0.29^{a}	9.1^{b}	3.78^{b}	0.96^{b}	0.27^{b}	0.04^{b}	5.05^{b}	1.8^{b}	0.07^{b}	5.12^{b}
10-15 cm	6.5^{a}	2.43^{c}	4.2^{b}	0.27^{b}	9.0^{b}	2.76^{b}	0.92^{c}	0.27^{b}	0.04^{b}	3.99^{c}	1.5^{c}	0.14^{c}	4.13^{c}
15-20 cm	6.4^{b}	2.31^{d}	4.0^{c}	0.26^{c}	8.1^{c}	2.18^{d}	0.81^{d}	0.22^{c}	0.03^{c}	3.24^{d}	1.2^{d}	0.13^{d}	3.42^{d}

Means on the same column with the same letter are not significantly different at P < 0.05; OC = Organic carbon, OM = Organic matter, N = Total nitrogen, C/N = carbon: nitrogen ratio, Ca = calcium, K = potassium, Na = sodium; TEB = Total exchange bases, av. P = Average phosphorus, EA = exchange acidity and CEC = cations exchange capacity

Table 4. Effect of rainfall seasonal dynamics on some soil chemical properties at the peak of rainy season (September)

Depth	Properties												
	pH in (H_20)	OC %	OM %	N %	C/N	Cal	Mag	K	Na	TEB	av. P	E.A	CEC
						cmol/Kg of Soil							
0-5 cm	6.3^{b}	2.84^{a}	4.89^{a}	0.30^{a}	9.4^{a}	4.19^{a}	1.12^{a}	0.37^{a}	0.04^{a}	5.72^{a}	2.3^{a}	0.29^{a}	6.01^{a}
5-10 cm	6. 4^{a}	2.59^{b}	4.46^{b}	0.30^{a}	8.6^{c}	3.77^{b}	0.93^{b}	0.26^{b}	0.05^{a}	5.01^{b}	1.7^{b}	0.08^{d}	5.09^{b}
10-15 cm	6.3^{b}	2.33^{c}	4.01^{b}	0.26^{b}	9.0^{b}	2.76^{c}	0.93^{b}	0.25^{b}	0.04^{a}	3.98^{c}	1.4^{c}	0.15^{b}	4.13^{c}
15-20 cm	6.4^{a}	2.31^{c}	4.0^{b}	0.26^{b}	8.9^{bc}	2.18^{d}	0.85^{c}	0.21^{c}	0.02^{b}	3.26^{d}	1.2^{d}	0.13^{c}	3.39^{d}

Means on the same column with the same letter are not significantly different at $P < 0.05$; OC = Organic carbon, OM = Organic matter, N = Total nitrogen, C/N = carbon: nitrogen ratio, Ca = calcium, K = potassium, Na = sodium; TEB = Total exchange bases, av. P = Average phosphorus, EA = exchange acidity and CEC = cations exchange capacity

Table 5. Effect of rainfall seasonal dynamics on the soil chemical properties at the of End rain (November)

Depth	Properties												
	PH in (H_20)	OC %	OM %	N %	C/N	Cal	Mag	K	Na	TEB	Av. P	E.A	CEC
						cmol/Kg of Soil							
0-5 cm	6.4^{a}	2.7^{a}	4.6^{a}	0.3^{a}	9.0^{a}	6.2^{a}	1.14^{a}	0.38^{a}	0.05^{a}	7.77^{a}	2.4^{a}	0.29^{a}	8.06^{a}
5-10 cm	6.1^{c}	2.44^{b}	4.2^{b}	0.28^{b}	8.7^{b}	3.92^{b}	0.96^{b}	0.27^{b}	0.04^{b}	5.19^{b}	1.8^{b}	0.07^{d}	5.26^{b}
10-15 cm	6.2^{b}	2.37^{c}	4.1^{b}	0.27^{b}	8.6^{c}	3.26^{d}	0.92^{c}	0.27^{b}	0.04^{b}	4.49^{c}	1.5^{c}	0.14^{b}	4.63^{d}
15-20 cm	6.1^{c}	2.33^{c}	2.8^{c}	0.26^{bc}	8.4^{d}	3.57^{c}	0.81^{d}	0.22^{c}	0.03^{c}	4.63^{d}	1.2^{d}	0.13^{c}	4.76^{c}

Means on the same column with the same letter are not significantly different at $P < 0.05$; OC = Organic carbon, OM = Organic matter, N = Total nitrogen, C/N = carbon: nitrogen ratio, Ca = calcium, K = potassium, Na = sodium; TEB = Total exchange bases, av. P = Average phosphorus, EA = exchange acidity and CEC = cations exchange capacity

Table 6. The mean (n=10) of some soil chemical properties across seasons (0 – 20 cm)

Seasons (mm)	Properties												
	pH in (H_20)	OC %	OM %	N %	C/N	Cal	Mag	K	Na	TEB	av. P	EA	CEC
						cmol/Kg of Soil							
A (66.7)	6.5^{a}	2.78^{a}	4.80^{a}	0.29^{a}	9.58^{a}	3.0^{d}	0.88^{b}	0.31^{b}	0.05^{a}	4.24^{d}	2.08^{a}	0.15^{b}	4.39^{c}
B (416.70)	6.4^{b}	2.34^{cb}	4.00^{b}	0.26^{b}	9.00^{b}	3.36^{c}	0.84^{c}	0.35^{a}	0.04^{b}	4.59^{c}	2.08^{a}	0.15^{b}	4.74^{bc}
C (1883,3)	6.4^{b}	2.00^{c}	3.40^{c}	0.25^{b}	8.00^{c}	3.48^{b}	0.96^{a}	0.29^{c}	0.04^{b}	4.77^{b}	1.73^{b}	0.16^{a}	4.93^{b}
D (2000)	6.4^{b}	2.00^{c}	3.40^{c}	0.25^{b}	8.00^{c}	3.48^{b}	0.96^{a}	0.23^{c}	0.04^{b}	4.71^{b}	1.73^{b}	0.16^{a}	4.87^{b}
E (300)	6.37^{bc}	1.80^{d}	3.01^{d}	0.24^{b}	7.50^{c}	4.24^{a}	0.96^{a}	0.29^{c}	0.04^{b}	5.53^{a}	1.73^{b}	0.16^{a}	5.69^{a}

Means on the same column with the same letter are not significantly different at $P < 0.05$; A = Dry Season (December-February); B = Beginning of Rains (March); C = Peak of Rains (June/July); D = Peak of Rains (September); E = End of Rains (November); OM = organic matter, OC = organic carbon N = total nitrogen, Na = sodium , Ca = calcium, K = potassium; TEB = total exchange bases, av. P = average phosphorus, C/N = carbon : nitrogen ratio, E.A = exchange acidity and CEC = cations exchange capacity

5. CONCLUSION

In southern humid rain forest of Nigeria, rainfall seasonal dynamics have great effects on soil chemical properties.

Litton CM [29] and Olojugba [34], reported that the sustainability of land use systems for long term period is achievable by adopting patterns of resource use in the natural systems. The most influenced soil chemical properties were total nitrogen, Soil organic matter, exchange cations (Ca, Mg & K), soil pH, available phosphorus, cation exchangeable capacity (CEC). Dry and peak of rainy seasons showed more influence on soil chemical properties in the study area. In dry season (January) and at the beginning of rainy season (May), soil pH and available phosphorus were higher. These were low at the peak of rains. Soil organic matter and total soil nitrogen were low in dry season (January) probably due to annual fire occurrence in the forest. However, nitrogen content increased at the peak of rainy season as a result of nitrogen fixation activities.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Ogunjemite BG, Oates JF. Assessment of the chimpanzee populations in Akure-Ofosu Forest Reseve, Southwestern, Nigeria. Jor. Res. Wildlife and Environ. 2011;3(2):32-38.
2. Available:http://www.academicjournals.org/article/article1393528636_Fatubarin%20and%20Olojugba.pdf
3. Abdulhameed A. Comparative effect of *Albizia lebbeck* and *Dalbergia sisso* trees on soils nutrients in semi- arid region of Northern Nigeria. Nig. J. Bot. 2005;18: 197-202.
4. Perrott KW, Sarathchandra SU, Waller JE. Seasonal storage and release of phosphorus and potassium by organic matter and the microbial biomass in a high-producing pastoral soil. Australian Journal of Soil Research. 1990;28:593–608.
5. Kodešová R, Kodeš V, Žigová A, Šimunek J. Impact of plant roots and soil organisms on soil micromorphology and hydraulic properties. Biologia. 2006;61:S339–S343.
6. McGrath DA, Comerford NB, Duryea ML. Litter dynamics and monthly fluctuations in soil phosphorus availability in an Amazonian Agroforest. Forest Ecology and Management. 2000;131:167–181.
7. Ross DJ, Tate KR, Scott NA, Felthman CW. Land-use change: Effects on soil carbon, nitrogen and phosphorus pools and fluxes in three adjacent ecosystems. Soil Biology & Biochemistry Jor. 1999;31: 803–813.
8. Zeng DH, Hu YL, Chang SX, Fan ZP. Land cover change effects on soil chemical and biological properties after planting Mongolian pine (*Pinus sylvestris* var. Mongolica) in sandy lands in Keerqin, northeastern China. Plant and Soil. 2009; 317:121–131.
9. Bodner G, Loiskandl W, Buchan G, Kaul HP. Natural and management-induced dynamics of Hydraulic conductivity along a cover-cropped field slope. Geoderma. 2008;146:317-325.
10. Kodešová R, Vignozzi N, Rohošková M, Hájková T, Kocárek M, Pagliai M, Kozák J, Šimunek J. Impact of varying soil structure on transport processes in different diagnostic horizons of three soil types, Journal of Contaminant Hydrology. 2007; 104:107-125.
11. Kodešová R, Kocárek M, Kodeš V, Šimunek J, Kozák J. Impact of soil micro morphological features on water flow and herbicide transport in soils. Vadose Zone Journal. 2008;7:798–809.
12. Suwardji P, Eberbach PL. Seasonal changes of physical properties of an Oxic Paleustalf Red Kandosol) after 16 years of direct drilling or conventional cultivation. Soil and Tillage Research. 1998;49:65-77.
13. Gee GW, Bauder JW. Particle-size Analysis. Pages. In Methods of Soil Analysis Part 1. A. Klute (edi.), Soil Science Society of America Book Series 5, Madison, Wisconsin, USA. 1986;383-411.
14. Walkley A, Black IA. Determination of organic carbon in soil. Soil Sci. Soc. Am. 1965;37:31-43.
15. Bremner JM. Nitrogen method of soil analysis, part one (ed) C.C. Black American Society of Agro forestry. Madison. Wisconsin, USA. 1965;1149-1178.
16. Bray RH, Kurtz LT. Determination of total organic carbon and available form of phosphorous in soil. Journal of Soil Sci. 1965;59:39-45.

17. Hendershort WH, Lalande H, Duquette M. Soil reaction and exchangeable acidity. In; Soil Sampling and Methods of Analysis (ed. M.R. Carter). Lewis Publishers, USA. 1993;141-q45.
18. SAS Institute. SAS/Start User's Guide, 2 Version 9.2. SAS Inst., Cary N.C, USA; 2005.
19. Olojugba MR, Fatubarin AR. Effect of seasonal dynamics on the chemical properties of the soil of a Northern Guinea savanna ecosystem in Nigeria. Journal of Soil Science and Environmental Management. 2015;6(5):100-107.
20. Bray NC, Weil RR. The nature and properties of soils 14th edition. 2008;504-517.
21. Fatubarin AR, Olojugba MR. The influences of forest fire on the vegetation and some soil properties of savanna ecosystem in Nigeria. JSSEM. 2014;6(32): 2400-2407.
22. Andriesse JP. Nature and management of tropical peat. In: FAO Soil Bulletin, FAO Rome. 1988;165.
23. White EW, Thompson WW, Gartner FR. Heat effects on nutrient release from soils under ponderosa Pine. Journal of Range Management. 1973;26:22-24.
24. NurQursyna Bt BC, Adzmi BY, Rashid BA. Mornitoring the effect of precipitation and pineapple cultivation on the dynamics of nutrient and chemical properties in peat in peat soils. Jor. Life Sci. and Tech. 2013; 1(4):238-245.
25. De Ronde C. Impact of prescribed fire on soil properties: comparison with wildfire effects. In: Goldammer JG & MJ Jenkins (eds) Fire in ecosystem dynamics: Mediterranean and northern perspectives. SPB Academic Publishing, The Hague, The Netherlands. 1990;127-136.
26. Olojugba MR. Characterization, classification and fertility evaluation of the Forest of the Basement Complex of South Western Nigeria: Evidence from the Forestry Plantations of Federal University of Technology, Akure, IJAFS. 2010;1:208-222.
27. Ahmed OH, Husni MM, Hanafi MM, Seyed Omar SR, Anur AR. Macronutrient distribution and cycling of Pineapple planted on tropical peat. Pertanika Jor. Trop. Agric. Sci. 2000;23(2):89-95.
28. Fatubarin A. Ecosystems studies in a Southern Guinea Savanna vegetation in Nigeria. PhD, Thesis, University of Ibadan. 1980;427.
29. Litton CM, Santelices, R. Early post-fire succession in a *Nothofagus glauca* forest in the Coastal Cordillera of south-central Chile. International Journal of Wild land Fire. 2002;11:115-125.
30. Wagner GH, Wolf DC. Carbon transformations and soil organic matter formation. In: Sylvia DM, JJ Fuhrmann, PG Hartel & DA Zuberer (eds) Principles and applications of soil microbiology. Prentice-Hall, Princeton, New Jersey, USA. 1998; 218-258.
31. De Ronde C. Impact of prescribed fire on soil properties: Comparison with wildfire effects. In: Goldammer JG & MJ Jenkins (eds) Fire in ecosystem dynamics: Mediterranean and northern perspectives. SPB Academic Publishing, The Hague, The Netherlands. 1990;127-136.
32. Ayo Fatubarin, Olojugba MR. Effect of Rainfa ll season on the chemical properties of the soil of a Southern Guinea Savanna ecosystem in Nigeria. Journal of Ecology and the Natural Environment. 2014;6(4): 182-189.
33. Styles D, Coxon C. Meteorological and management influences on seasonal variations in phosphorous fractions extracted from soils in western Ireland, Geoderma. 2007;142:52-164.
34. Olojugba MR. Characterization, classification and fertility evaluation of the forest of the basement complex of South Western Nigeria: Evidence from the Forestry Plantations of Federal University of Technology, Akure, IJAFS. 2010;1:208-222.

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