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# Spatial Variation of Soil Physicochemical Properties with Respect to Some Selected Tree Species in the Nigerian Northern Guinea Savanna

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***Author's contribution***

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

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## ABSTRACT

**Aim:** This study was aimed to find the impact of *Parkia biglobosa* ( Jacq.) Benth., *Daniella oliveri* (Rolfe) Hutch. & Dalziel and *Vitellaria paradoxa* C. F. Gaertn. trees on some selected surface (0-15 cm depth) soil physicochemical properties in the Nigerian northern Guinea Savanna ecological zone.

**Methodology:** Soil samples were collected within the crown zones (CZs), outside CZs (2m away from the crown radii) and the open field which served as a control. The soil samples were analyzed for organic carbon (OC), total nitrogen (TN), available phosphorus (AP), exchangeable potassium (EP), pH and particle size distribution.

**Results:** The result indicated that these trees have significantly ($\alpha = 0.05$) affected some (but not all) soil physicochemical properties within and outside their CZs. Compared with the open field, alteration of soil physicochemical properties was found to be highest within CZs in general than outside CZs and the least was the opened field.

**Conclusion:** The patterns of impacts of *P. biglobosa, D. oliveri* and *V. paradoxa* on different soil physicochemical properties were not the same. Each of these three different tree species has affected the soil underneath in a different way. On average, *P. biglobosa* has the highest impact

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followed by *D. oliveri* and the least was *V. paradoxa*. The soil properties that are greatly affected by the trees are OC and AP; while the least affected are pH and clay content. Such information is required for better understanding of the ecosystem and conservation of soil in particular and biodiversity in general.

*Keywords: Bauchi; Daniella oliveri; Guinea Savanna; Nigeria; Parkia biglobosa; physicochemical properties; Vitellaria paradoxa.*

## ABBREVIATIONS

*AP = Available Phosphorus; CZ = Crown zone; EP = Exchangeable Potassium; OC = Organic Carbon; TN = Total Nitrogen.*

## 1. INTRODUCTION

The tropical savannas support huge agricultural activities which include both crop cultivation and animals grazing. Parklands are those parts of the savanna with scattered trees and that are used for agricultural production. The traditional farming systems in the tropics have been known to rely on such trees and shrubs for ecological services especially soil fertility maintenance and regeneration. Maintenance of soil fertility is critical for both crops yield and increased availability of high quality feeds for livestock production [1,2].

Trees are known to influence physicochemical properties of soil by improving the soil structure, aeration, infiltration rate and water holding capacity [3]. Also the yearly contribution of surface vegetation to soil, in the form of leaves, branches, twigs, etc, gradually decomposes and becomes a part of the soil. The decomposing plant tissues (above and below ground litter) are the main source of soil organic matter, which influences the physicochemical characteristics of soil such as, texture, water holding capacity, pH and nutrients availability [4]. It is widely reported that soils under tree canopy (i.e. within the crown zone) accumulate more organic carbon than the open field due to the direct influence of the tree canopy [5]. Trees also have positive effects on immediate environments by the modification of the microclimate under the canopy through shading, leading to decreased temperature, evaporation losses and maintenance of higher soil moisture content [4]. The beneficial aspects of soil and microclimatic modification by trees include protection of heat sensitive crops from high temperatures, slow down the wind speed, reduce evaporation to conserve soil moisture for ground flora, reduce soil temperature and increases the availability of mineral nutrient to crops and other understory herbaceous species [1].

The effects of trees on soil properties and microclimate are often species-specific. Hence soil properties would differ among different tree species. This is because different tree species and age groups can differ in the quantity and proportions of different chemical constituent of litter, crown geometry and size, growth performance and ultimately the type of microhabitat they create [1,6], Hence the impact of trees on agricultural output in savanna parklands can generally differ in magnitude and specifically with respect to different types crops [1].

Although the influence of trees in general on soils properties is well documented, the knowledge of the specific effects of different tree species on soil characteristics is still meager. The present study focused on the different physicochemical properties of soil, mainly the macronutrients and texture, with respect to different tree species that mostly dominated cultivated parklands of the Nigerian northern guinea savanna. The trees are *Parkia biglobosa* (Jacq.) Benth. (Mimosoideae), also known as locust bean, *Vitellaria paradoxa* C. F. Gaertn. (Sapotaceae), also known as the shea butter tree and *Daniela oliveri* (Rolfe) Hutch. & Dalziel [7]. The aim of this study is to identify the variation of different soil properties such as total nitrogen, available phusphorus, exchangeable potassium, organic carbon, soil pH and particles size ratios with respect to these tree species. An understanding of the specific influence of different tree species on soils is required for better land management, agricultural production and conservation of soil and biodiversity. Therefore, soil scientists, foresters, agriculturalists and conservationists will find this work to be of interest.

## 2. METHODOLOGY

The study area was the Yelwa campus of Abubakar Tafawa Balewa University, Bauchi, in Bauchi metropolis. It is located between latitude 100 17$^{I}$ north, longitude 80 49$^{I}$ east and at an altitude of 690.2m above sea level in the northern guinea savanna ecological zone of Nigeria [8]. The soils in this area are generally classified as Alfisols. These are type of soil that are well-developed with contrasting soil horizons (layers) depleted in calcium carbonate but enriched in aluminum- and iron-bearing minerals. Below the surface horizon is a region that has a relatively high concentration of available calcium, magnesium, potassium, and sodium ions [9]. The climate is characterized by rainy season that starts in April and ends in October, with the amount of rainfall of 1300 mm per annum [10].

The tree species used in this study was *Parkia biglobosa* (Jacq.) Benth*., Daniella oliveri* (Rolfe) Hutch. & Dalziel and *Vitellaria paradoxa* C.F. Gaertn. The study area was used for cultivation and animal grazing. The individual trees used in this study were all selected from the grazing areas that were not cultivated for at least five years. To collect the soil samples, the crown zone was divided into three roughly equal sectors. Since wind direction can affect direction of leaf fall, which in turn affects soil composition, one of the dividing lines of the sector always points toward the east so as to obtain uniformity in the sampling protocol (Fig. 1). By so doing the cardinal effect was at least minimized.

Along each of the three lines that divide the sectors, one sample was collected within the canopy radii, i.e. crown zone (CZ) at a standard distance of one meter (1m) from the stem. These three soil samples were pooled together to form one sample that represent soil of within the CZ. Three other samples were also collected at the distance of two meters (2 m) outside the CZ, but still on the line of division. These samples were also pooled to form one sample, representing soil sample outside the CZ. So for each of the ten individual trees of all the three species there were two soil samples, one from within the CZ and the other outside the CZ. Soil samples were also collected from ten different places in the open field (at a distance of about 20 m from the nearest tree). The opened field served as a control. All samples were collected at the depth of 0-15 cm, after clearing the surface litter, using sampling core. This depth was chosen because impact of tree on soil is highest in the topsoil [11]. The weight of single soil sample taken in the field was about 200 g.

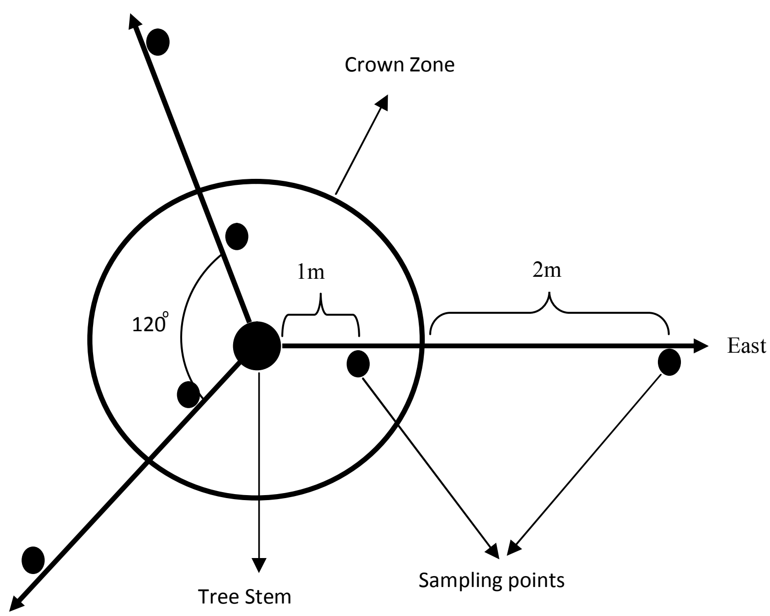


**Fig. 1. Diagram of the sampling design**

All samples were air-dried and transported to soil laboratory of Abubakar Tafawa Balewa University for analyses following a standard procedure described by Page, [12]. The samples were analyzed for TN (%); AP in milligrams per kilogram (mg/ $kg^{-1}$); EP (cmol (+)/ $kg^{-1}$); OC (%); pH and percentages of sand, clay and silt. These are some of the most important indicators of soil characteristics [3,5].

Total nitrogen in all samples was determined by the Kjeldahl method. Available phosphorus was extracted with 0.5 M NaHCO3 (pH 8.5) and determined spectrophotometrically as blue molybdate-phosphate complexes under partial reduction with ascorbic acid. Soil pH and electrical conductivity (EC) were measured in a 1:2 soil: water extract after shaking for 30 min. Organic carbon (OC) was analyzed by dichromate oxidation and titration. Organic Carbon was heated with an excess volume of standard $K_2Cr_2O_7$ in Con. $H_2SO_4$. Followed by digestion at the low temperature by the heat of dilution of $H_2SO_4$ and the organic carbon in the soil is thus oxidized to $CO_2$.

The data was analyzed for significant differences between soils from within CZs, outside CZs and the open field using Analysis of Variance (ANOVA) and followed by Tukey Multiple Comparisons of Means. All statistical analyses were carried out using the statistical software: MINITAB® For Windows 11.12 version, 1996 Minitab Inc.

## 3. RESULTS

The result of this study indicated that the trees have some significant ($P$=0.05) effects on soil physicochemical properties compared to the opened field.

### 3.1 Organic Carbon (%)

The mean value of OC inside CZ of *Parkia biglobosa* was 2.98 (Table 2). This mean value is at least twice greater than the mean values of almost all the other variables and is significantly greater than all. The differences of the mean values of the OC among all the rest of the variables were statistically insignificant, but they are slightly higher inside CZs (with the range of 1.46-2.98) than outside CZs (range: 1.12-1.46) while it was 1.20 in the opened field.

### 3.2 Total Nitrogen (%)

The mean value of TN was found to be higher within the crown zones (CZs) than outside CZs (i.e. at a distance 2 meters outside the CZ) of the trees (Table 1). The mean value in the open field was the least (0.10). The mean values found inside and outside CZs respectively was highest in *Parkia biglobosa* (0.22 and 0.16), followed *Daniella oliveri* (0.16 and 0.26) and the least was in *Vitellaria paradoxa* (0.14 and 0.11). However, Tukey's pairwise comparisons show that significant differences was only between inside CZ of *P. biglobosa* with outside CZs of *D. oliveri* and *V. paradoxa,* and also with the open field (Table 3).

### 3.3 Available Phosphorus (mg/ $kg^{-1}$)

The mean values of AP were also higher inside CZs than outside CZs of the trees and the open field. Pair wise comparisons show that the mean value inside CZ of *P. biglobosa* (24.88) is significantly higher than all other variables. Mean values of all other variables were not significantly different among themselves except between inside CZ of *D. oliveri* (17.85) with outside CZs of and *V. paradoxa* (9.60). The mean value of the open field (11.34) was higher than that of the outside CZs of *P. biglobosa* (11.11) and *V. paradoxa.*

### 3.4 Exchangeable Potassium (cmol (+)/ $kg^{-1}$)

EP was not significantly affected by the trees. However, the mean values inside and outside CZ of *D. oliveri* and the open field (0.234, 0.213 and 0.220 respectively) were slightly higher than the mean values inside and outside CZs of both *P. biglobosa* (0.156 and 0.171 respectively) and *V. paradoxa* (0.178 and 0.171 respectively).

### 3.5 pH

The differences between mean pH values were insignificant among all the variables. The difference between the highest and the lowest mean values (6.46 and 6.22 respectively) was only 0.24.

### 3.6 Particle Size Distribution (%)

The mean percentages of sand were slightly higher inside CZs than outside CZs of *V. paradoxa* and *P. biglobosa*, while the reverse was obtained in *D. oliveri*. However these differences were all statistically insignificant in the same tree species (Table 2). Across different tree species, inside CZ of *P. biglobosa* (81.65) is significantly higher than inside and outside CZ of *D. oliveri* (70.82 and 72.92 respectively) and outside CZ of *V. paradoxa* (74.52). Inside CZ of *V. paradoxa* (78.12) is also significantly higher than inside CZ of *D. oliveri.*

The mean percentage of silt inside CZ of *D. oliveri* (19.25) was significantly higher than inside CZ of *V. paradoxa* (13.56) and inside and outside CZ *P biglobosa* (10.52 and 12.32 respectively). The mean percentages of clay were insignificant among all variables, but they were higher outside CZs than inside CZs of *V. paradoxa* (8.32 and 10.12 respectively) and *P. biglobosa* (7.83 and 9.76 respectively), while the reverse was the case in *D. oliveri* (9.93 and 9.74 respectively).

## 4. DISCUSSION

In this study *Parkia biglobosa, Daniella oliveri* and *Vitellaria paradoxa* were found to have significant positive impact on some (but not all) soil physicochemical properties as compared with the opened field. There was greater impact within the trees' crown zones (CZ) than outside CZ (i.e. a radial distance of at least two meters outside the CZ). The impact of trees in general on soil characteristics have been well documented [13-15], It was also found that the impact of trees on soil decreases as distance increases from the trunk [16].

**Table 1. One-way analysis of variance for organic carbon and physical properties of soils with respect to different tree species and the open field**

| Soil properties | Factor | Mean | St. Dev. | F- value | p-value |
|---|---|---|---|---|---|
| **Organic carbon (%)** | A | 1.46 | 0.5929 | 13.48* | 0.000 |
| | B | 1.12 | 0.5763 | | |
| | C | 1.86 | 0.7601 | | |
| | D | 1.34 | 0.6433 | | |
| | E | 2.98 | 0.5016 | | |
| | F | 1.46 | 0.3646 | | |
| | G | 1.20 | 0.2359 | | |
| **Sand (%)** | A | 78.12 | 7.008 | 5.11* | 0.000 |
| | B | 74.52 | 5.082 | | |
| | C | 70.82 | 5.174 | | |
| | D | 72.92 | 4.091 | | |
| | E | 81.65 | 2.702 | | |
| | F | 77.92 | 5.181 | | |
| | G | 75.52 | 5.232 | | |
| **Silt (%)** | A | 13.56 | 5.747 | 5.37* | 0.000 |
| | B | 15.36 | 3.968 | | |
| | C | 19.25 | 3.843 | | |
| | D | 17.41 | 2.755 | | |
| | E | 10.52 | 1.942 | | |
| | F | 12.32 | 1.807 | | |
| | G | 14.29 | 6.098 | | |
| **Clay (%)** | A | 8.32 | 1.641 | 2.21 | 0.054 |
| | B | 10.12 | 1.589 | | |
| | C | 9.93 | 1.585 | | |
| | D | 9.74 | 1.569 | | |
| | E | 7.83 | 0.990 | | |
| | F | 9.76 | 3.694 | | |
| | G | 10.19 | 1.775 | | |

*A= inside CZ of V. paradoxa; B= outside CZ of V. paradoxa; C= inside CZ of D. oliveri; D= outside CZ of D. oliveri; E= inside CZ of P. biglobosa; F= outside CZ of P. biglobosa; G= open field; CZ = Crown Zone* $F_{0.05\,(1)\,2,\,27}$ *= 3.35; Note: calculated F-values with asterisk (*) are significant at α = 0.05*

**Table 2. One-way analysis of variance for chemical properties of soils with respect to different tree species and the open field**

| Soil properties | Factor | Mean | St. Dev. | F- value | p-value |
|---|---|---|---|---|---|
| **Total nitrogen (%)** | A | 0.14 | 0.06204 | 5.51* | 0.000 |
| | B | 0.11 | 0.05277 | | |
| | C | 0.16 | 0.05685 | | |
| | D | 0.12 | 0.05175 | | |
| | E | 0.22 | 0.06096 | | |
| | F | 0.16 | 0.06816 | | |
| | G | 0.10 | 0.01767 | | |
| **Available P (mg/ kg$^{-1}$)** | A | 12.22 | 5.391 | 10.82* | 0.000 |
| | B | 9.60 | 5.255 | | |
| | C | 17.85 | 6.676 | | |
| | D | 13.71 | 7.658 | | |
| | E | 24.88 | 2.413 | | |
| | F | 11.11 | 3.013 | | |
| | G | 11.34 | 2.973 | | |
| **Ex. potassium (cmol (+)/ kg$^{-1}$)** | A | 0.178 | 0.02860 | 2.71 | 0.021 |
| | B | 0.171 | 0.03725 | | |
| | C | 0.234 | 0.08316 | | |
| | D | 0.213 | 0.08460 | | |
| | E | 0.156 | 0.04169 | | |
| | F | 0.171 | 0.04533 | | |
| | G | 0.220 | 0.05457 | | |
| **pH** | A | 6.31 | 0.7478 | 0.44 | 0.848 |
| | B | 6.25 | 0.5560 | | |
| | C | 6.35 | 0.1592 | | |
| | D | 6.46 | 0.1443 | | |
| | E | 6.22 | 0.2727 | | |
| | F | 6.35 | 0.1771 | | |
| | G | 6.39 | 0.2291 | | |

A= inside CZ of *V. paradoxa;* B= outside CZ of *V. paradoxa;* C= inside *CZ of D. oliveri; D= outside CZ of D. oliveri; E= inside CZ of P. biglobosa; F= outside CZ of P. biglobosa; G= open field; CZ = Crown Zone;* $F_{0.05\,(1)\,2,\,27}$ *= 3.35; Note: calculated F-values with asterisk (*) are significant at P = 0.05*

**Table 3. Tukey's pairwise comparisons for soils physicochemical properties with regard to different tree species and the open field**

| Soil properties | Overall conclusion |
|---|---|
| Organic matter (%) | B = G = D = A = F = C ≠ E |
| Total nitrogen (%) | G = B = D ≠ E = A = C = F |
| Available P (mg/ kg$^{-1}$) | F = G = A = D = B ≠ C ≠ E |
| Ex. potassium (cmol (+) / kg$^{-1}$) | E = B = F = A = D = G = C |
| pH | A = B = C = D = E = F = G |
| Sand (%) | C = D = B ≠ E = G = F =A |
| Silt (%) | E = F = A ≠ C = G = B = D |
| Clay (%) | E = A = D = F = C = B = G |

*A= inside CZ of V. paradoxa; B= outside CZ of V. paradoxa; C= inside CZ of D. oliveri; D= outside CZ of D. oliveri; E= inside CZ of P. biglobosa; F= outside CZ of P. biglobosa; G= open field; CZ = Crown Zone*

### 4.1 Organic Matter (%)

Soil OC is an accumulation of dead plant materials, partially decayed and partially re-synthesised plant and animal residues. The result of this study indicated that mean values of soil OC were higher from within CZs than outside CZs, and the least was the opened field. Although such results were well documented, [7,17] only within *P. biglobosa* was found in this study to have statistically significant impact on soil OC. The range of the mean values was 1.46-

2.98 within CZs; 1.12-1.46 outside CZ and 1.20 in the opened field. *P. biglobosa* has the highest amount followed by *V. paradoxa* and *D. oliveri* having the least. Tarfa et al. [13] reported that the leaf of *P. biglobosa* was richer in OC and other mineral nutrients than leaves of some indigenous trees, and also soil amendment with leaf of *P. biglobosa* significantly increases soil OC, TN and AP. The cause of these effects was believed to be mainly due to decomposition of leaves [13,18] Soil organic matter is of critical importance in maintaining long-term soil fertility since it is the reservoir of metabolic energy, which drives soil biological processes involved in nutrient cycling and availability [19]. One of the general problems peculiar to the soils of the Nigerian savanna regions is a low soil organic matter content [10].

## 4.2 Total Nitrogen (%)

Nitrogen is one of the most limiting nutrients found in soils of Nigerian Guinea Savanna [13]. It is obtained predominantly through decomposition of organic matter by a process known as nitrogen mineralization [20]. It is well documented that application of tree foliage amplifies soil nitrogen by this process [13]. The result of this study indicated that *P. biglobosa* has the highest impact on amount of soil TN followed by *D. oliveri* and then *V. paradoxa.* The opened field has the least amount. However, only the mean value of within CZ of P*. biglobosa* was significantly higher than the opened field. The ranges of the mean values of soil TN were 0.14-0.22 within CZs; 0.11-0.16 outside CZs and 0.10 in the opened field. TN is considered to be low if it is less than 0.1% and high if it is more than 0.3% of the dry soil. High levels of nitrogen may indicate that little or no nitrogen need be applied [21]. Hence these trees increase soil TN beneath their crowns within the range that is considered optimal for most crops. Also, since the amount of fertilizer nitrogen needed equals the nitrogen requirement minus the available nitrogen from a soil test [22], presence of these trees in this region will reduce loss of resource due to the cost of inorganic fertilizer; i.e. the result of this study indicated a positive impact of these trees on arable land in regard to maintenance of soil TN.

## 4.3 Available Phosphorus (mg/ $kg^{-1}$)

In this study, the trees were also found to increase soil phosphorus. *P. biglobosa* has the highest impact on amount of soil AP followed by *D. oliveri* and then *V. paradoxa.* The opened field has the least amount. However, the opened field has a slightly higher AP than outside CZs *P. biglobosa* and *V. paradoxa.* The ranges of the mean values of soil AP were 12.22-24.88 within CZs; 9.60-13.71 outside CZs and 11.34 in the opened field. However, some studies reported that AP increases with increasing distance from tree bole [17]. There is already a widespread occurrence of phosphorus deficiency in most arable land in the savanna zones of Western Africa, particularly in Nigeria [23,24]. Phosphorus deficiency is considered to be one of the most important macronutrients limiting agricultural production in the tropics. In fact, it has been reported to be the single most limiting nutrient to crop production in northern Guinea Savanna of Nigeria [25,26]. The cost of fertilization due to phosphorus deficiency is a serious economic setback for farmers of this region [23].

## 4.4 Exchangeable Potassium (cmol (+) $kg^{-1}$)

A number of studies confirmed that soils from northern Guinea savanna are deficient in potassium [24]. In this study the three tree species were found to have little but negatively insignificant effect on EP compared to the opened field, except for *D. oliveri* which has almost the same concentration with the opened field. The highest concentration was associated with *D. oliveri* followed by *V. paradoxa* and the least was *P. biglobosa.* The concentrations were higher within CZs than outside CZs of *D. oliveri* and *V. paradoxa* while the reverse is the case in *P. biglobosa.* However, the result is encouraging for arable cultivation in the savanna parklands, considering that the critical level of EP for most crops here was suggested to be 0.16 cmol (+) $kg^{-1}$ [27,28] while the average mean value associated with these trees was at least above this critical value.

## 4.5 pH

Soil pH value is a measure of the hydrogen ion activity of the soil water system and expresses the acidity and alkanity of soil. Soil pH influences the solubility of nutrients and their uptake by plants, microbial activity and physical condition of the soil. The differences of soil pH values associated with all variables were insignificant as indicated by the result of this study. The range of these values was 6.22-6.46 and the difference between these extreme values is just 0.24.

However, slightly lower pH mean values were observed within CZs than outside CZs of *D. oliveri* and *P. biglobosa* while the reverse is the case in *V. paradoxa.* A study conducted in Mali indicated that soils under *P. biglobosa* trees were significantly lower in pH than soils in the open field [17]. Also, Tarfa et al. [13] found that changes in soil pH were far less than that of TN and AP after amendments of soil with *P. biglobosa* leaf. Alhaji, [22] mentioned that majority of plant nutrients (including nitrogen, phosphorus, potassium) are most available in mildly acidic soils ranging from 6.0 to 7.0 and that it is desirable to maintain the pH of mineral soils between 6.0 and 6.5. Amba et al. [9], who studied the soil properties in a nearby cultivated land in the present study area found the pH values ranging from 5.65 to 6.83. This suggests that these trees maintain the soil pH in the range (6.35 to 6.46) that is suitable for most crops.

## 4.6 Particle Size Distribution

All the particle size distributions with respect to the three tree species were found to be insignificantly different compared to the open field. The mean values for percentages of sand were higher inside CZs than outside CZs *P. biglobosa* and *V. paradoxa*, while the opposite was obtained in *D. oliveri*. According to the United State Department of Agricultuire (USDA) textural triangle (http://soils.usda.gov/technical/aids/investigations/texture/), soils from inside and outside CZs of *P. biglobosa* and *V. paradoxa* and the open field were Loamy Sand while soils from inside and outside CZ of *D. oliveri* was Sandy Loam. However, many studies revealed that soils of Bauchi state are mostly sandy loam [22]. Several studies reported higher clay and silt content near trunks of trees like *V. paradoxa* and *Faidherbia albida* than in the open field, and this was believed to be as a result of lower levels of soil erosion under tree cover; the preference of tree sites by termites which bring fine elements to the surface; or the fact that some trees regenerates more easily in areas affected by termites or clay-rich zones [17]. The reverse was observed in this study for *V. paradoxa* and *P. biglobosa,* but it is true for *D. oliveri* [4]. The result of this study and others suggest that the impact of trees on soil physical properties beneath their crowns depends on the tree species, their geographical locations and possibly micro-environment. However, information derived from the result of this study will be helpful in the management of agro forestry in the parklands of this region, where local farmers depends heavily on these tree species for soil improvement [29,30].

Based on the findings of this study and others, it can be said that concentrations of mineral nutrients and the input of OC are not consistent with respect to different tree species or individuals of the same tree species that grows in different geographical location. One possible explanation of this may be as follows: trees can affect soil physicochemical properties and the microclimatic conditions beneath and at the edge of their crowns [31]; the pattern of these variations are different with respect to different tree species [11]; these will in turn affect the composition and productivity of herbaceous layer beneath and at the edge of their crown [17,32] the species composition of the herbaceous layer depends on the geographic or climatic region [33]; the shade-lover and shade-tolerant herbaceous species may strongly compete among themselves for one particular mineral nutrient or the other beneath and at the edge of the tree crown [19,32] but such competition may be far less among the sun-lover herbaceous species that grow in the open field; the amplification of these high-demand mineral nutrients by the trees may not compensate for their rate of mining due to the degree of intense competition among the herbaceous species that grow beneath and around the tree crown; these will reveal a deficiency or an increasing concentration of such high-demand mineral nutrient with increasing distance from the tree crown, as in the case of EP found in this study. Therefore, the levels and patterns of concentrations of different mineral nutrients cannot be consistent among different tree species or even the individuals of the same tree species that grow in different localities.

Moreover, it can be clearly seen that there is a weaker relationship between soil physicochemical properties and *D. oliveri* and *V. paradoxa* as indicated by the result of this study. This is quite different from most of the studies found in the literature, which almost always record strong relationships between trees and the physicochemical properties of soil beneath them. But in the present study such relationship was only observed in *P. biglobosa*. Also, comparison between the result of the present study and other studies may not be valid as most studies were done in forests (either natural or man-made) where tree crowns are touching one another, forming a continues canopy. The effects of a particular tree species may not indentify. The reasons for the weak relationship between *D. oliveri* and *V. paradoxa* and physicochemical properties of soil beneath their crown zones may be interpreted as follows, based on the visual observation of the trees and the study area by the researcher:

1. Due to the geometry and larger size of their leave; their heights and crown geometry of these trees, the senesced leaves fall far from the tree base unlike the leaves of *P. biglobosa*.
2. Effect of wind on the falling leaves is much because the trees are isolated from one another and therefore receives direct and full impact of the wind, which carries the falling leaves far from the tree base.
3. Because of the removal of ground herbaceous plants due to grazing and frequent burning, the fallen leaves are not "trapped" but rather move horizontally away from the crown zone by the impact of atmospheric momentum.

Taking into consideration the above mentioned points, it can be said that:

1. Most of the decomposition and cycling of nutrient via leaves of *D. oliveri* and *V. paradoxa* take place outside and far from theirs crown zones (CZs), giving rise to weaker relationship between the tree and physicochemical properties of soil beneath their CZs. The leaves are laden with mineral nutrients and therefore play a very crucial role in soil nutrient input. On the other hand the leaf size and spreading geometry of crown of *P. biglobosa* limits the lateral movements of its falling leaves, hence most of them fall and decompose under the tree CZ.
2. Analyses of a tree leaf for quantity and quality of mineral nutrients contents cannot tell the true impact of that tree on soil because the decomposition and cycling of those mineral nutrients may be far from the proximity of the tree, as the falling leave may be carried far from the tree by the influence of atmospheric momentum
3. To know the true nature of the impact of trees on soil one should consider the parkland as a whole rather than the proximity of the trees.

Nevertheless, before we can fully arrest the knowledge of impact of trees on soil physicochemical properties, there is a need for a series of complex experiments both in time and space. Therefore, it can be said that now the generalized knowledge of the universal impact of trees on soil physicochemical properties is still far from conclusive.

## 5. CONCLUSION

The impact of *Parkia biglobosa, Daniella oliveri* and *Vitellaria paradoxa* trees on some selected surface (0-15 cm depth) physicochemical properties of soil was investigated in the Nigerian northern Guinea Savanna ecological zone. The result indicated that these trees have significant ($P$ = 0.05) effects on some (but not all) physicochemical properties of soils within and outside their crown zones. Compared with the open field, alteration of soil physicochemical properties was found to be highest within crown zones than outside crown zones and the least was the opened field. On the average, *P. biglobosa* has the highest impact followed by *D. oliveri* and the least was *V. paradoxa*. The soil properties that are greatly affected by the trees are OC and AP; while the least affected are pH and clay content. Analyses of the result and comparisons with other studies suggest that the pattern of impact of trees on different soil physicochemical properties is not consistent among different tree species or even the individuals of the same tree species that grow in different localities.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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