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GROWTH YIELDS AND NUTRIENT STATUS UNDER *Pinus carribaea* AND *Nauclea diderrichii* PLANTATION IN OGUN STATE FORESTRY PLANTATION PROJECT AREA J4, IJEBU-ODE, OGUN STATE, NIGERIA

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Abstract

This study examined the growth yield and the nutrient status of two prominent tree species in Ogun State Forestry Plantation Project Area, Pinus carribaea stands established in 1991, 1992 and 1996 and Nauclea diderrichii in 1974, 1975, and 1976. Growth data and composite soil samples from 2 depths (0-15 and 15-30cm) were collected from five plots (20m x 20m^2) randomly located in the plantation of the two species and the adjacent natural forest for comparison. Growth tree variables measured includes number stem, diameter at breast height, basal area, tree height and volume and were subjected to two-way analysis of variance (ANOVA), Pearson Correlation Coefficient, Duncan Multiple Range Test (DMRT) statistical tools. The results show there was significant difference in number of tree per hectare, dominant diameter, volume/ha and mean diameter at dbh for the Pinus stands. A total of 4032 trees/ha, 752 trees/ha, 1744 trees/ha for the 1996, 1992 and 1991 years' Pinus stand respectively, with highest in years 1996 (4032/ha) while 816 tree/ha, 928 trees/ha, 704 trees/ha for the 1976, 1975, 1974 years' Nauclea stand respectively, Year 1996 (3210.26 m^3) has the highest in terms of volume and the least recorded in year 1992(1078.45 m^3) in Pinus, and highest in 1974(2362.89 m^3) and lowest in 1976 (1761.69m^3/ha) in Nauclea. There was high correlation between percentage sand and most of the tree growth variables for both species. Comparison of soil nutrients in the plantations with the nutrients in the natural forest revealed ability of the plantation establishment to replenish soil nutrient status.

Key Words: *Soil Depth, Plantations, Stand Age, Growth Variables, Correlation*

Introduction

Forests and trees provide vital resources and ecosystem services for all of humanity and majority of people deriving direct and indirect benefits from forests and trees in the form of employment, forest products, and contributions to livelihoods and incomes is estimated at 1.3 billion (FAO, 2014). Some 300 million to 350 million people, about half of whom are indigenous, live within or close to dense forests and depend almost entirely on forests for subsistence (Chao, 2012).

Today, several afforestation and reforestation projects are ongoing across the country, from northern part of Nigeria to the south to encourage afforestation, reforestation and climate change being an initiative of both Nigerian government and international communities (FGN, 2012). Among the established are both exotic and indigenous species plantations. Few among the indigenous species planted includes: *Parkia biglobasa, Terminalia superba, Terminalia ivorensis, and Nauclea didderichii* while exotic ones include *Tectona grandis, Gmelina arborea, Pinus spp, Cinderella odorata* (Adekunle *et al.,* 2011).

Complexity degree of variability exhibited in both time and space has been described as panacea for soil properties. The variability in soil properties according to Obasi *et al.* (2011) is defined as a function of prevailing soil forming factors and vegetation of the biotic components of soil formation. Majorly, variations in leaf type, root type, canopy size, decomposition rate of plant debris, as well as presence of decomposers, topography, slope orientation, land use and stand age has been identified as contributing factors in differences exhibited in soil properties in a particular vegetation.

Plantation trees grow rapidly and therefore nutrients demand is high especially at the early stage of development. Mutsaers *et al*. (1997) reported dominance of Alfisols in the forest savannah transition zone of Southwestern Nigeria. Farley and Kelly (2004) reported that the nutrient demand also varies with the age of the stand. The most significant changes in the nutrient status of the soil are likely to occur in plantations that 10-20years old (Turner and Kelly, 1985).

Plantations can have three main impacts on soils: nutrient removal from the soil as tree grows and are then harvested, changes in the chemistry of soil surface as the litter layer and organic matter are dominated by one species and hence uniform composition and decay characteristics and site preparation practices which directly affects soil physical parameters and in turn nutrient and moisture availability (Evans, 1999). Changes in soil properties in turn affect the productivity and sustainability of plantations. In addition, the comparisons of stands of various ages to adjacent natural forest are very useful for understanding how nutrient status changes as plantation matures (Farley and Kelly, 2004). Hence the objectives of this study are to assess the yield of the *Pinus caribaea* and *Nauclea diderichii* plantation, assess the nutrient status of the soils under *P. carribaea* and *N. diderichii* plantation and the effect of ages of these plantation on the yield and soil nutrient status.

Materials and Methods

Study Area

The study was carried out on different age series of *Nauclea didderichii* and *Pinus carribaea* plantations at Area J4, Ijebu- Ode, Ogun State located between latitudes 6°35' to 7°05' N and longitudes 4°19' to 4°40' E in the South-west of Nigeria, and covers an area of about 130,500 hectares (Ojo, 2004). It is about 135 km North-East of Lagos, about 120 km East of Abeokuta and about 80 km East of Ijebu-Ode (Ola-Adams, 1999). The mean annual rainfall ranges from about 1600 to 2000 mm with two annual peaks in June and September, with November and February being the driest months (Isichei, 1995, Chima *et al.,* 2014).

The *N. diderrichii* plantation is located at 6º50'16.11" N and 4º22'05.56" E. The plantations were established in 1975, 1974, and 1971 and have not been logged. The *P. caribaea* plantation is located at 6º50'03.54" N and 4º22'00.65" E near Mile 1 camp. The plantations were established in 1990, 1992, and 1996. These *N. diderrichii* and *P. caribaea* plantations covered land area of about 10 hectares and 2.4 hectares respectively. These plantations were chosen for the assessment of the yield and soil nutrient status under the influence of these tree species.

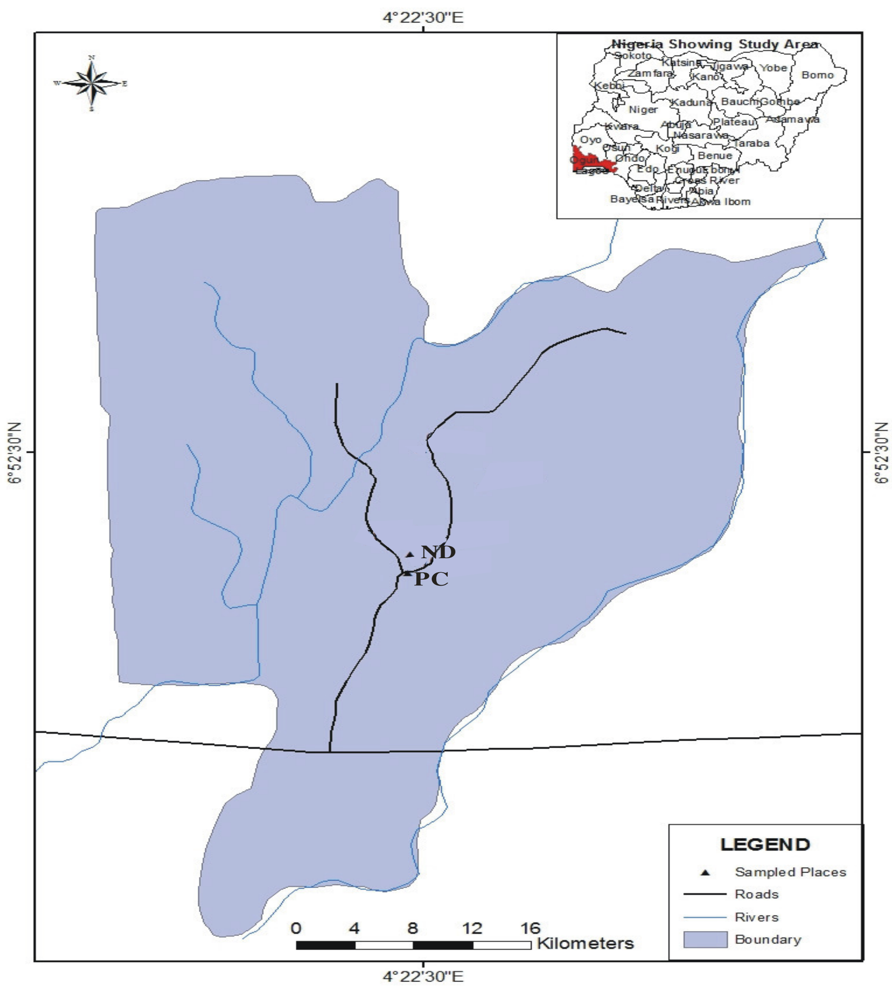

Fig. 1: Map of Omo Forest Reserve showing the study sites (Inset: Map of Nigeria showing study area)
Source: Adopted from Chima *et al.* (2014)

Data Collection

This study was carried out under age series plantations of *Pinus caribaea* established in and *Nauclea diderichiii* established in 1996, 1992, 1990 and 1975, 1974, 1971 respectively. Five equal size plots (25 m x 25 m) were randomly located in each of the selected age series. All measurement and soil sample collection was done in the plots. On each tree, the following variables were measured: Total height, Diameter at breast height (Dbh) (m), Diameters over bark at the base, middle and merchantable top.

The Diameter at Breast Height of all trees encountered in a sample plot was measured and their basal areas were calculated. Two mean trees (these were trees whose basal areas were the closest to the mean basal area) were selected per plot. Diameters over bark at the base, middle and merchantable top, as well as total height of these mean trees in each of the plots were measured.

A total of twenty-four (24) soil samples were collected at 0–15 cm and 15–30 cm depths from three different points within the sample plots and were mixed to obtained composite soil samples for each depth. Soil samples were also collected from the adjacent natural forest to the plantations. The samples were properly labeled, air-dried and sieved for laboratory analysis.

Soil physical properties (particle size analysis) were determined by using the hydrometer method of Bouyoucous (1951) with sodium hexamephosphate (calgon) as dispersing agent. For the soil chemical analysis, Walkley and Black (1934) dichromate oxidation method was adopted in the determination of organic matter content of the soil samples. The micro-kjeldah method was also employed in determining the total nitrogen (Jackson, 1958). The available soil phosphorus was determined with the aid of the spectrophotometer using molybdenum blue method of Murphy and Ricky (1962). Exchangeable potassium, calcium, and magnesium were extracted with ammonium acetate (Chapman, 1965). Flame photometer was used to determine the amount of potassium in the samples while Calcium and Magnesium was obtained by EDTA titration.

Data Analysis

Basal Area Calculation

The Basal Area of all trees in the sample plots was calculated using the Husch *et al.* (2003) formula:

$$B.A = \frac{\pi D^2}{4} \ldots\ldots\ldots \text{Husch } et\ al. (2003)$$

Where BA=basal (m^2), D= diameter at breast height (cm) and $\pi = p = pi(3.142)$

Volume Calculation

Volume of individual trees was calculated in every plot using the Newton's formula of Husch *et al.* (2003). This equation is expressed as follows:

$V= (h/6)\ (A_b + 4A_m + A_t)$

Where V= tree volume (m^3), A_b, A_m and A_t = tree cross sectional area at the base, middle and top at a merchantable height, respectively (m^2) and h (meters).

The experimental design adopted was the Completely Randomized Design. The one-way analysis of variance (ANOVA) was used to examine the presence of significant differences in tree growth variables and in the various soil properties obtained for the age series across the depths. Mean separation was carried out using the Duncan Multiple Range Test (DMRT). The Pearson Correlation Coefficient was used to obtain the relationships between tree growth variables and the soil properties. For tree growth variables and soil analyses, five replicates were involved per stand.

Result

Table 1 shows the summary of growth variables for *Pinus carribaea* plantations of 21, 25, and 26 years old (1996, 1992 and 1991) respectively. Number of stem per hectare are 4032/ha, 752/ha, 1744/ha for the 1996, 1992, 1991 years' stand respectively. The mean diameter at breast height was significantly high in year 1992 (88.76 cm) and least in year 1996 (69. 32 cm) and the dominant diameter at the breast height was high in year 1996 (104.53 cm), least in year 1992 (101.66 cm) and the mean height for year 1991 (30.00 m) was the highest while 1996 (24.11 m) was the lowest and there was no significant difference between year 1992 and 1991. In year 1991, dominant height was at the highest (35.17 m) compare to least recorded in year 1996 (29.70 m), where year 1992 was on the average and there was no significant difference. Basal area for 21, 25, 26 years are 328.53, 98.91, 192.33 respectively, was highest in year 1996 (328.53 m^2/ha) and least in year 1992 (98.91m^2/ha). Year 1996 (3210.26 m^3) has the highest in terms of volume and the least recorded in year 1992 (1078.45 m^3) and there was high significant in 21 years old.

Table 2 shows the summary of growth variables for *Nauclea diderrichii* plantations of 41, 42, and 43 years old (1976, 1975 and 1974) respectively. Number of stem per hectare are 816/ha, 928/ha, 704/ha for the 1976, 1975, 1974 years' stand respectively, with highest in year 1975 (928/ha) and least in year 1974 (704/ha), mean diameter at breast height was significantly high in year 1974 (125.28 cm) and least significant in year 1976 (79.9 cm). The dominant diameter at the breast height for 41, 42, and 43 years are 96.66 cm, 127.88 cm, 145.82 cm respectively. Mean height for 41, 42, and 43 years are 23.55, 24.55, 32.89 respectively, with highest in year 1974 (32.89 m) and least in year 1976 (23.55 m). Dominant height was highest in year 1974 (34.19 m) and least in year 1975 (26.38 m) and year 1974 (189.13 m^2) has the highest in basal area compare to the least recorded in 1976 (127.89 m^2) and 1975 close to 1974 and there was no significant difference. The volume/ha was significantly high in 1974 (2362.898 m^3/ha) and least significant in 1976 (1761.69 m^3/ha).

There was high correlation coefficient value obtained between most of the tree growth variable and soil physical properties in the *Pinus* stands. Mean diameter at breast height and mean height were positively correlated (0.528). Mean diameter at breast height and basal area (-0.787). Mean diameter at breast height and volume (-0.715) were significantly negatively correlated. Potassium and sodium are positively correlated (0.985), mean dbh and mean height negatively correlated with potassium, magnesium and calcium but positively correlated with nitrogen and percentage organic matter. Volume and basal area are significantly positively correlated (0.949) (Table 3).

Positive and significant correlation coefficients were evident between the tree growth variable and soil chemical properties in the *Nauclea* stands. Mean diameter at breast height and mean height (0.72). Mean diameter at breast height and basal area (0.70) were significantly correlated, Mean diameter at breast height and volume (-0.7) were significantly negatively correlated. Potassium and sodium are significantly positively correlated (0.985). Mean dbh, mean height and basal area were significantly positively correlated with magnesium. Mean dbh and mean height was significantly positively correlated with calcium, nitrogen and percentage organic matter was negatively significantly correlated with magnesium, calcium, and nitrogen. Volume and basal area significantly positively correlated (0.8). Table 5 shows the summary of chemical properties of *Pinus carribaea* stands. This study was carried out on adjacent natural forest, 25, and 26 years old (1992 and 1991) respectively at 0-15 cm and 15-30 cm depth. It was observed that the pH are: 5.83; 7.225; 6.46;6.23; 7.25 and 6.12 for the adjacent natural forest, 1992, 1991 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in year 1992 at 15-30 cm and least in adjacent natural forest (5.83) at 0-15 cm and there was significant difference at 0-15 cm. Available sodium was higher in year 1991 (44.35) at 0-15 cm though not significantly different from other element and lowest in adjacent natural forest (5.44) at 0-15 cm. Available potassium was high in year 1991 (21.67) at 0-15 cm and least in year 1992 (7.31) at 15-30 cm and there was no significant difference. The available magnesium are 1.21, 0.79, 0.88, 0.46, 0.67, 0.46 for the adjacent natural forest, 1992, 1991 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in adjacent natural forest (1.21) at 0-15 cm and least in adjacent natural forest (0.46) at 15-30 cm and there was no significant difference. In 1991 (0.73) at 15-30 cm has the highest in terms of available calcium compare to the least recorded in adjacent natural forest (0.23) at 15-30 cm and there was no significant difference at 0-15 cm. The available phosphorus are 17.21, 1.46, 3.89, 3.74, 1.20, 2.58 for the adjacent natural forest, 1992, 1991 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in adjacent natural forest (17.21) at 0-15cm compare to the least recorded in year 1992 (1.20) at 15-30 cm and there was no significant difference at 0-15cm. The total nitrogen are 1.05, 1.4, 0.91, 0.88, 0.56, 0.42 for the adjacent natural forest, 1992, 1991 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in year 1992 (1.4) at 0-15 cm and least in year 1991 (0.42) at 15-30 cm and there was no significant difference at 0-15 cm. The percentage organic matter are 2.24, 1.67, 2.02, 2.71, 0.75, 0.78 for the adjacent natural forest, 1992, 1991 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in adjacent natural forest (2.71) at 15-30 cm and least in year 1992 (0.75) at 15-30 cm and there was no significant difference at 0-15 cm.

Table 6 shows the summary of chemical properties of *Nauclea didderichii* stands. pH values are 6.55, 6.75, 5.85, 6.7, 6.8, 6.9 for the adjacent natural forest, 1975, 1974 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in year 1974 (6.9) at 15-30 cm and least in year 1974 (5.85) at 0-15 cm and there was significant difference at 0-15cm. The available sodium are 5.65, 6.31, 6.31, 5.87, 6.09, 6.09 for the adjacent natural forest, 1975, 1974 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in year 1974 and 1974 (6.31) at 0-15 cm and least in adjacent natural forest (5.65) at 0-15 cm and there was no significant difference at 0-15 cm. The available potassium was significantly high in year 1975 (10.65) at 0-15 cm while least in adjacent natural forest (9.23) at 15-30 cm. Available magnesium was significantly high in adjacent natural forest (1.17) at 0-15 cm and least in year 1975 (0.66) at 15-30 cm. The adjacent natural forest (0.95) at 15-30 cm has the highest in terms of available calcium compare to the least recorded in adjacent natural forest (0.23) at 0-15 cm Available phosphorus are 5.05, 6.40, 8.31, 2.96, 3.97, 4.22 for the adjacent natural forest, 1975, 1974 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in year 1974 (8.31) at 0-15cm and least in adjacent natural forest (2.96) at 15-30 cm. Total nitrogen are 2.14, 0.98, 1.44, 2.21, 0.81, 1.44 for the adjacent natural forest, 1975, 1974 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in year 1974 (2.21) at 0-15 cm and least in year 1975 (0.805) at 15-30 cm and there was significant difference. The percentage organic matter are 0.52, 5.12, 5.31, 1.48, 1.13, 5.01 for the adjacent natural forest, 1975, 1974 years' stand at 0-15 cm and 15-30 cm depth respectively, with highest in year 1974 (5.31) at 0-15 cm and least in adjacent natural forest (0.52) at 0-15 cm.

Table 7 shows the summary of soil physical properties of *N. didderichii* and *P. carribaea* stands. This study was carried out on 42, and 43 years old (1975 and 1974) *N. didderichii* plantations and 25, and 26 years old (1992 and 1991) plantations respectively at 0-15 cm and 15-30 cm depth. Result for soil particle shows that there was significant difference in the sand particle of ND 1975 and ND 1974 at both depth, while there was a significant difference in the sand particle of PC 1991, PC 1992 at both depths in *P. carribaea*. However, PC 1991 (0-15 cm) had the highest sand particle of 95.33, followed by PC 1991(15-30 cm), with least sand particle in ND 1975 at both depths (0.00). Result for percentage silt (Table 3) shows that there was significant difference in the silt particles of ND 1974, PC 1991and PC1992 at both depths and ND 1975(0-15 and 15-30) and significant difference in the percentage clay particles of PC 1991and PC1992 between depths.

Discussion

The number of stem per hectare are 4032/ha, 752/ha, 1744/ha for the 1996, 1992, 1991 years' plantations respectively (Table 1). Variation was observed in the number of stem per hectare in the *P. carribaea* plantation. Consequently, anthropogenic factors such as: human activities in the forest plantation project e.g. farming, firewood collection, debarking, poaching, leave collection among other have been attributed to this variation. The same trend was also observed with number of stem per hectare (816/ha, 928/ha, 704/ha) for the 1976, 1975, 1974 years' *N. didderichii* plantation respectively. This ascertained the report of FAO (2010) that between 1990 and 2010, 8,193,000 ha accounted for 47.5% of Nigerian forest cover was lost due to deforestation. In another perspective, natural death as a result of environmental factors and inconsistence in the number of stem per hectare could have been the cause of the variation. (Oladoye *et al.,* 2014).

In both *P. carribaea* and *N. didderichii* species, volume per hectare, basal area, dominant Dbh, mean height, dominant height increases significantly. This is a reflection of the fact that, plantations tree growth variables increase with age. This is similar to the study Adekunle *et al.,* (2011) who observed an increase in stand growth with different age series in Teak plantation in Omo Biosphere forest reserve. This process has been described inevitable especially where there are favourable environmental conditions and all other factors that support tree growth. There was higher record of Basal area per hectare in *P. carribaea* of 1996 plantation than year 1991 and 1992. This may be due to human activities and lack of adequate maintenance occurrence over a long period of time in both (1991 and 1992) plantation. According to Adekunle *et al.* (2011), it was observed that both thinning and clearing have not been carried out in the stands, consequently, competition between undergrowth and trees for nutrients, space, light and water was at its climax. Plantations receiving various silvicultural treatments of pruning, irrigation, fertilization and inter-cultivation have better growth and timber productivity than sole trees or poorly managed plantations (de Avila *et al.,* 2015). From *et al.* (2015) inferred that fertilizer application increases tree height by more than 20 percent, productivity enhancement, high foliage yield, early growth and good quality of plant species through good botanical formation.

There was general increase in most soil chemical properties with age in both *P. carribaea* and *N. didderichii* plantations in the study area (Table 5 and 6). This indicates the soil replenishment ability of both species as their age increases and there was higher soil nutrient in both species than the adjacent natural forest. Increase in available nutrients maybe ascribed to mineralization of nutrients from litterfall, fine roots and release of nutrients in residual from soil reservoir (Singh and Sharma, 2007). Also, there was geometric increase in percentage organic matter, available nitrogen, phosphorus, calcium, sodium with age. This situation cannot be over-emphasized in tropical rainforest soils which are characterized with poor nutrient availability, consequently, larger percentages of nutrients in the soils are held in the living organisms, in particular, above ground components. According to Onyekwelu *et al.* (2006), due to the fact that nutrient are quickly leached away by heavy rainfall, tropical rainforests have developed very efficient nutrient cycling system, aided by the warm and moist conditions in the forest, which are adequate for breaking down organic materials.

In general, decreasing trend of nutrient concentration observed in this study as the soil is been dig deeper suggest that the upper or uttermost layer (upper) 0-15 cm of soil is richer in the nutrient than the lower depth layer (15-30 cm) as shown in Table 5 and Table 6. This can be attributed to the fact that upper layer is an abode for both accumulation and decomposition of mineral and organic matter. This incorporates the study of Nwoboshi (2000) as horizon A is discovered to be a place of incorporation of decomposed organic and mineral matter into the soil. These accounted for the reason while there the soil nutrient decreases with depth. Van Straaten *et al.* (2015) reported that the higher the initial Soil Organic Content (SOC), the higher the loss. The soil texture did not vary widely in the entire study site where most soil were relatively sandy, are from sandy loam. Decreases in SOC stocks were most pronounced in the topsoil, although older plantations showed considerable SOC losses below 1 m depth than younger plantation of Palm (*Elaeis guineensis*), Rubber (*Hevea brasiliensis*), and Cacao (*Theobroma cacao*) in Peru, Cameroon and Indonesia respectively. During the first few years of plantation establishment, very little recycling of nutrients usually occurs due to crown formation, shaded leaves, and dead hanged which causes little return of nutrients into the soil (Evans, 1999). Compare to natural forest with constant nutrient uptake, variation exist in different ages stands in man-made plantation. To buttress the point, Singh and Sharma (2007), attributed lower litter inputs and higher nutrient demands as an additional factor responsible for the low nutrient status in younger stands.

Soil pH was also found to be at increased trend (i.e. increase in acidity) with increase in soil depth, contrary to result observed by Chima *et al.* (2014) in Omo Biosphere Forest Reserve. Due to soil disturbance through anthropogenic activities, this trend could be as a result of exchangeable base occurred in some selected elements, especially Ca and Na, as suggested by Chima *et al*. (2014). Exchangeable (potassium, magnesium and calcium) bases generally decreased with increase in soil depth, K was generally high at both plantations and depths. This observation is attributed to the leaching of the cations down the soil depth by rainfall (Conradie *et al.,* 2017).

Conclusion

The study of yields and nutrient status in soils under *P. carribaea* and *N. didderichii* plantation in Ogun state forestry plantation project area J4, Ijebu-Ode, Ogun State, Nigeria was carried out in relation to some soil physical and chemical properties has been examined. The tree growth variables were discovered to increase withstand age in both *P. carribaea* and *N. didderichii* plantations.

The relative distribution of soil particles (% silt, % clay and % sand) supported the growth and development of the species. Nutrient elements essential for effective tree performance were in both sites, but in different proportion. The soil pH was within the range required for mineralization of nutrients for plant use. There was high correlation between the tree growth variables and most of the physical and chemical properties of the soils. Plantation development of these species should be encouraged by the Government through provision of incentives, planting materials and technical-know how for those willing to plant trees.

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Table 1: Summary of the tree growth variables for *Pinus carribaea* stands in Omo Forest Reserve, Ogun State Nigeria

Year	Age	No of stem /ha	M.Dbh(cm)	D.Dbh(cm)	M.Ht(m)	D.Ht(m)	BA(m^2/ha)	VOL(m^3/ha)
1996	21	4032[a]	69.32[a]	104.53[a]	24.11[a]	29.70[a]	328.53[a]	3210.26[a]
1992	25	752[b]	88.76[b]	101.66[a]	27.38[ab]	30.06[a]	98.91[b]	1078.45[b]
1991	26	1744[c]	80.73[c]	102.50[a]	30.00[b]	35.17[a]	192.33[c]	2330.27[c]

M. dbh, mean diameter at the breast height; D. dbh, dominant diameter at the breast height; M. Ht, mean height; D. Ht, dominant height; BA, basal area; Vol, volume .

Table 2: Summary of the tree growth variables for *Nauclea didderichii* stands in Omo Forest Reserve, Ogun State Nigeria

Year	Age	No of stem /ha	M.Dbh(cm)	D.Dbh(cm)	M.Ht(m)	D.Ht(m)	BA(m^2/ha)	VOL(m^3/ha)
1976	41	816[a]	79.19[a]	96.66[a]	23.55[a]	27.27[a]	127.89[a]	1761.69[a]
1975	42	928[a]	105.02[b]	127.88[b]	24.55[a]	26.38[a]	182.19[a]	1812.09[a]
1974	43	704[a]	125.28[c]	145.82[b]	32.89[b]	34.19[b]	189.13[a]	2362.90[a]

M. dbh, mean diameter at the breast height; D. dbh, dominant diameter at the breast height; M. Ht, mean height; D. Ht, dominant height; BA, basal area; Vol, volume

Table 3: Correlation coefficient for Tree growth variables and Soil chemical properties for *Pinus carribaea* stands in Omo Forest Reserve, Ogun State Nigeria

	M.Dbh	M.Ht	BA/ha	VOL/ha	C.Na (mol/Kg)	C. K (mol/kg)	C.Mg (mol/Kg)	C.Ca (mol/kg)	P (mg/kg)	% N	% OM
M.Dbh(cm)	1										
M.Ht	0.528*	1									
BA (m^2/ha)	-0.787*	-0.429	1								
VOL/ha(m^3)	-0.715*	-0.211	0.949*	1							
C.Na(mol/Kg)	-0.535*	-0.319	0.210	0.101	1						
C. K(mol/kg)	-0.491	-0.303	0.118	0.018	0.985*	1					
C.Mg(mol/Kg)	-0.149	-0.265	-0.073	-0.033	0.066	0.136	1				
C.Ca(mol/kg)	-0.138	-0.185	0.418	0.427	-0.254	-0.270	-0.252	1			
P (mg/kg)	-0.079	0.218	0.013	0.135	-0.028	0.024	0.640*	0.018	1		
% N	0.303	-0.016	-0.479	-0.511	0.034	0.047	0.204	-0.318	0.130	1	
% OM	0.229	0.406	-0.165	-0.043	-0.132	-0.067	0.111	-0.398	0.216	0.430	1

* Correction is significant at the 0.05 level (2-tailed)

Table 4: Correlation coefficient for Tree growth variables and Soil chemical properties for *Nauclea didderichii* stands in Omo Forest Reserve, Ogun State Nigeria

	M.Dbh	M.Ht	BA/ha	VOL/ha	C.Na (mol/Kg)	C. K (mol/kg)	C.Mg (mol/Kg)	C.Ca (mol/kg)	P (mg/kg)	% N	% OM
M.Dbh(cm)	1										
M.Ht	0.72*	1									
BA(m^2/ha)	0.70*	0.45	1								
VOL/ha(m^3)	0.39	0.48	0.8*	1							
C.Na(mol/Kg)	-0.72*	-0.61*	-0.28	-0.19	1						
C. K(mol/kg)	0.417	0.36	0.25	0.44	-0.42	1					
C.Mg(mol/kg)	0.78*	0.58*	0.57*	0.44	-0.43	0.62*	1				
C.Ca(mol/kg)	0.42	0.45	0.14	0.06	-0.54*	0.10	0.19	1			
P (mg/kg)	-0.26	-0.31	0.11	0.21	0.48*	0.04	0.02	-0.49*	1		
% N	0.36	0.44	-0.00	0.03	-0.33	0.45	0.51*	0.36	-0.30	1	
% OM	-0.50	-0.46	-0.06	-0.05	0. 50*	-0.38	-0.61*	-0.54*	0.46	-0.72*	1

* Correction is significant at the 0.05 level (2-tailed)

Table 5: Soil Chemical properties of *Pinus carribaea* stands in the study area

Year	Age	Depth	pH	C.Na (mol/Kg)	C. K (mol/kg)	C.Mg (mol/Kg)	C.Ca (mol/kg)	P (mg/kg)	% N	% OM
	ADJ.NF	0-15	5.83^{a}	5.44^{a}	9.62^{a}	1.21^{a}	0.3^{b}	17.21^{a}	1.05^{a}	2.24^{a}
1992	25		7.23^{b}	6.10^{a}	9.1^{a}	0.79^{a}	0.33^{b}	1.46^{a}	1.4^{a}	1.67^{a}
1991	26		6.46^{c}	44.35^{a}	21.67^{a}	0.88^{a}	0.25^{b}	3.89^{a}	0.91^{a}	2.02^{a}
	ADJ.NF	15-30	6.23^{a}	5.66^{a}	9.49^{a}	0.46^{a}	0.23^{b}	3.74^{a}	0.88^{a}	2.710^{a}
1992	25		7.25^{a}	4.79^{a}	7.31^{a}	0.67^{a}	0.43^{b}	1.20^{b}	0.56^{ab}	0.750^{b}
1991	26		6.12^{a}	5.65^{a}	9.49^{a}	0.46^{a}	0.73^{a}	2.58^{ab}	0.42^{b}	0.775^{c}

Values with similar letters vertically are not significant at ($P \geq 0.05$)

Table 5: Soil Chemical properties of *Pinus carribaea* stands in the study area

Year	Age	Depth	pH	C.Na (mol/Kg)	C. K (mol/kg)	C.Mg (mol/Kg)	C.Ca (mol/kg)	P (mg/kg)	% N	% OM
	ADJ.NF	0-15	5.83^{a}	5.44^{a}	9.62^{a}	1.21^{a}	0.3^{b}	17.21^{a}	1.05^{a}	2.24^{a}
1992	25		7.23^{b}	6.10^{a}	9.1^{a}	0.79^{a}	0.33^{b}	1.46^{a}	1.4^{a}	1.67^{a}
1991	26		6.46^{c}	44.35^{a}	21.67^{a}	0.88^{a}	0.25^{b}	3.89^{a}	0.91^{a}	2.02^{a}
	ADJ.NF	15-30	6.23^{a}	5.66^{a}	9.49^{a}	0.46^{a}	0.23^{b}	3.74^{a}	0.88^{a}	2.710^{a}
1992	25		7.25^{a}	4.79^{a}	7.31^{a}	0.67^{a}	0.43^{b}	1.20^{b}	0.56^{ab}	0.750^{b}
1991	26		6.12^{a}	5.65^{a}	9.49^{a}	0.46^{a}	0.73^{a}	2.58^{ab}	0.42^{b}	0.775^{c}

Values with similar letters vertically are not significant at ($P \geq 0.05$)

Table 7: Soil Physical properties of *Nauclea didderichii* and *Pinus carribaea* stands in the study area

Year	Depth	Sand	Silt	Clay
ND 1974	0 - 15	0.00^{b}	0.00^{d}	0.00^{b}
	15 - 30	65.67^{ab}	1.00^{cd}	0.00^{b}
ND 1975	0 - 15	0.00^{b}	0.00^{d}	0.00^{b}
	15 - 30	0.00^{b}	0.00^{d}	0.00^{b}
PC 1991	0 - 15	95.33^{a}	4.67^{ab}	0.00^{b}
	15 - 30	90.67^{a}	6.00^{a}	3.33^{a}
PC 1992	0 - 15	64.33^{ab}	2.33b^{cd}	0.00^{b}
	15 - 30	92.33^{a}	5.67^{a}	2.00^{a}

ND = *Nauclea diderrichii* plantation, PC = *Pinus carribaea* plantation