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ASSESSMENT OF PHYSICOCHEMICAL PROPERTIES AND MINERAL COMPOSITIONS OF FOREST NURSERY SOILS AT FEDERAL UNIVERSITY OF AGRICULTURE ABEOKUTA, NIGERIA

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ABSTRACT

Forest nursery soils at two different depths were investigated at Federal University of Agriculture Abeokuta (FUNAAB) for their physicochemical properties and mineral compositions as soil quality indicator. Soil samples were collected randomly from twenty (20) different points in two sites (site 1 and 2) within the same location at different depths (0-15cm and 15-30cm) with soil auger, air dried and taken to the laboratory for further analysis. Data obtained were subjected to descriptive statistics as well as analysis of variance (ANOVA). Level of soil pH was significantly ($p < 0.05$) higher in site 1 at both depths. Similarly, the level of soil pH was significantly higher at 15 – 30 cm depth when compared within each site. At 0 – 15 cm soil depth, all physicochemical properties except Total Nitrogen, Bulk Density and sand were significantly different ($p > 0.05$) between sites 1 and 2. Level of Potassium was higher than other macronutrients (K>Mg>Na>Ca) at both 0 – 15 cm and 15 – 30 cm soil depths when compared between sites. Trace micronutrients were significantly higher in site 2 than site 1 at 0 – 15 cm soil depth and the trend is as follows Fe>Zn>Mn>Cu. At soil depth 15 – 30 cm, levels of copper, zinc and manganese were significantly higher ($p < 0.05$) in site 1 than site 2 and the order of concentration include Cu>Fe>Zn>Mn. The study showed that forest nursery soils varied in their mineral composition and physicochemical properties in the studied sites.

Keywords: Forest nursery soil; soil properties; nutrients; soil depth

INTRODUCTION

Forests are significant to life on earth. They purify the air we breathe, filter the water we drink, prevent erosion, and act as an important buffer against climate change. Cultural and spiritual values, biodiversity conservation, nutrient recycling and carbon dioxide sequestration are among other services functions of the forest (Ajewole and Popoola, 2001). Despite the key roles forest play in the world´s environmental and economic health, we continue to lose forests, along with the endangered animals that live in them (Oliveira and Lacerola, 1993; Epstein *et al*., 1998).

A forest soil is a natural or only slightly distributed materials that took centuries to develop under permanent forest cover. Forest soils are influenced by forest vegetation. A succession of genetic soils layers is present, ranging from the very important surface organic layers down to the mineral parent materials. The persistent depositing of tree litter upon the ground for many years has developed the features surface layers of organic matter found in forest areas. When forests are removed and the land is used for agriculture, the soil structure generally deteriorates and this is evident by reduced pore space, increased bulk density, increased compaction, reduced content of water stable aggregates, and reduced rates of infiltration, has marked effects on surface water runoff, stream flow and sedimentation. Forest soils are important globally for many reasons which includes the relatively large amount of carbon stored in forest soil organic matter (Lowe *et. al*., 2016)

The structure of the forest soil directly influences the growth of the forest trees. Organic matter in the forest soil helps improve and maintain soil structure. In addition to microorganisms of a forest soil has a relatively high population of macro-organisms that favours soil structure and produces many large burrows and channels. Soil structure is defined as the manner in which the primary soil particles (sand, silt and clay) are combined and arranged with other solid soil components to form clumps or aggregates. It is also the arrangement and organization of the particles and substances that constitute soil. The quality of soil structure is measured by the capacity of the soil particles to clump together or aggregate (Lutz and Chandler, 1947).

Most forest soils have acidic soil reaction, with pH values lying between 3.0-7.0, though some forest soils have pH values greater than 7.0. The forest soils are generally more acidic (have less pH) than grassland and agricultural soils due to the continuous production of organic acids and $C0_2$ from decomposing litter. Chemical properties of soils include Cation exchange capacity which is the maximum quantity of total cation that a soil is capable of holding. Soil pH, soil nutrients, soil organic carbon, soil salinity among others (Wilson and Sellers, 1985). The aim of this study is to assess the structural characteristics and chemical properties of forest nursery soil in Federal University of Agriculture Abeokuta (FUNAAB) for optimum productivity at the nursery stage.

MATERIALS AND METHODS

Description of the Study Area

The study was carried out at the nursery site of the Department of Forestry and Wildlife Management, Federal University of Agriculture Abeokuta (FUNAAB), Ogun State. This area falls within Latitudes 7°N and 7°58 and Longitudes 3°20'E and 3°37'E. The area has a tropical climate with a bimodal distribution of rainfall; it lies within the humid lowland tropical rainfall with two distinct seasons (the wet season from March to October and the dry season from November to February). The mean annual rainfall is about 1113 mm which peaks in July and September. The relative humidity of the area is 82.4% and the average monthly temperature of 35.8°C (Aiboni, 2001). The forest nursery is divided into two main parts on the basis of planting stocks (bare-root & container nursery) as well as seedling size (transplant & seedling nursery). The bare root plant section is the study area for this research. This site is divided into two; site 1: plants grow directly in the nursery soil and the roots are separated from the soil at the time of lifting such as tomatoes. The lifted planting stock is further handled and planted without soil surrounding the roots. Also, it has only seedling beds in which seedlings are raised, no transplanting is done. We use this bed for some agroforestry practical for growing crops e.g Solanum spp., amaranthus, and celosia; and site 2: planting activities are not carried out here; the land is untilled.

Soil Sample Collection and Laboratory Analysis

Soil samples were collected randomly from ten points at two different depths 0-15 cm and 15-30 cm in each site (site 1 and site 2) at the FUNAAB forest Nursery with soil auger. Site 1 and site 2 represent frequently cultivated for agroforestry bare-root seedling and intermittently used parts respectively. The samples were poured into individual sample bags, appropriately labelled and taken to the laboratory for analysis.

The collected samples were air dried, crushed and sieved through a 0.5 m mesh size sieve and analyzed. Soil particle size was determined by the pipet method (Gee and Bauder, 1986), soil pH was determined in 0.01M $CaCl_2$ by using a soil collection solution ratio for 1:2.5 by means of a Phillip analogue pH meter. The soil was determined using the pH meter (Black, 1965). The organic carbon content of the soil was determined by the wet oxidation method of Walkley-Black as described by Allison (1965). The total nitrogen content of the soil was determined by Micro Kjeldahl procedure Bremner (1965). C:N was computed as ratio of N:C. Available phosphorus (P) was extracted by the Bray 1 method. The P concentration in the extract was determined colorimetrically by using the Spetronic 20 and absorption was read-off as described by Bray and Kurts (1945) and modified Murphy and Riley (1962). Exchangeable K, Ca and Mg were extracted using ammonium acetate, K was determined on flame photometer and Ca and Mg by Atomic Absorption Spectrophotometer (AAS). The trace nutrients are copper (cu), iron (Fe), manganese (Mn) and Zinc (Zn).

The Soil textural class was identified following the ISSS soil texture classification system. The proportion of clay, silt and sand were used to characterize particles size distribution while the soil physiochemical properties such as bulk density, porosity, soil organic matter, pH, CEC, moisture content, and soil organic carbon (SOC) which were considered as indicators of soil quality were determined.

Statistical Analysis

The data obtained were analysed using analysis of variance (ANOVA) with the Statistical Analysis System (SAS, 2015) computer package at 5% level of significance to determine difference in the treatments effect, while the means of differences among the treatments were separated using Fisher's Least Significant Difference (F-LSD; $P < 0.05$).

RESULTS

pH Levels

The pH levels measured were significantly ($p<0.05$) higher in site 1 at both depths (0-15 cm and 15-30 cm) as presented in Figure 1.

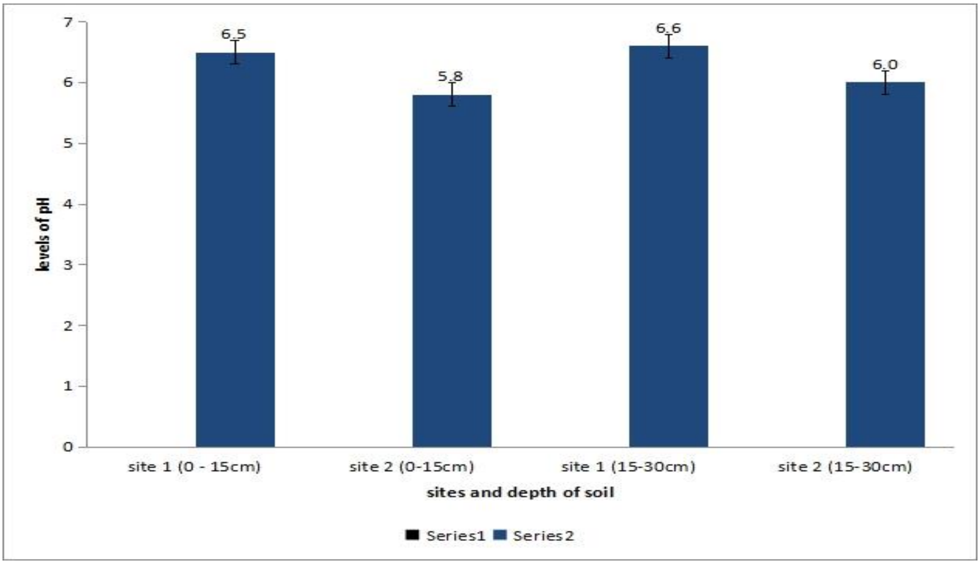

Figure 1: Levels of pH of the study sites

Physicochemical Properties of the Two Sites

Results of the chemical analysis of sites 1 and 2 at two different depths are presented in Table 1. At 0 – 15 cm soil depth, there was no significant ($p > 0.05$) difference in total nitrogen (0.18 %; 0.15 %), Bulk Density (2.07 g/cm^3; 1.99 g/cm^3), sand (76.60; 75.8) between site 1 and site 2. On the other hand, Available Phosphorus, Organic Carbon, Organic matter, clay and sand were significantly higher in site 1 (Table 1).

Table 1: Chemical properties of the study sites

Chemical properties	0 – 15 cm		15 – 30 cm	
	Site 1	Site 2	Site 1	Site 2
Total Nitrogen (%)	0.18±0.01	0.18±0.01	0.15±0.00	0.21±0.02
Available P. (mg/kg)	8.92±0.06^c	9.98±0.33^b	12.23±0.16^a	11.42±0.53^a
Organic carbon (%)	1.50±0.56^b	2.38±0.39^a	1.50±0.27^b	1.54±0.13^b
Organic matter (%)	2.59±0.97^b	4.31±0.75^a	2.59±0.46^b	2.72±0.14^b
Bulk Density (g/cm^3)	2.07±0.05	2.00±0.16	1.99±0.13	1.91±0.12
Porosity	0.22±0.02^b	0.19±0.06^b	0.25±0.05^a	0.28±0.05^a
Sand (%)	76.60±1.48^a	68.80±2.63^b	75.70±0.89^a	75.88±1.73^a
Clay (%)	7.66±0.88^c	13.35±1.51^a	8.86±0.88^b	9.66±0.91^b
Silt (%)	15.72±1.79^b	17.12±0.87^a	15.42±1.58^b	14.73±1.10^b

Means in the same row having similar superscripts are not significantly different ($p < 0.05$)

Composition of Essential Minerals at the Two Sites

Figure 2 presents the composition of some mineral elements in site 1 and site 2 at different depths. At 0 – 15 cm and 15 – 30 cm soil depths, the level of Potassium was higher in site 2 than other essential minerals (Sodium, Calcium and Magnesium) when compared between sites.

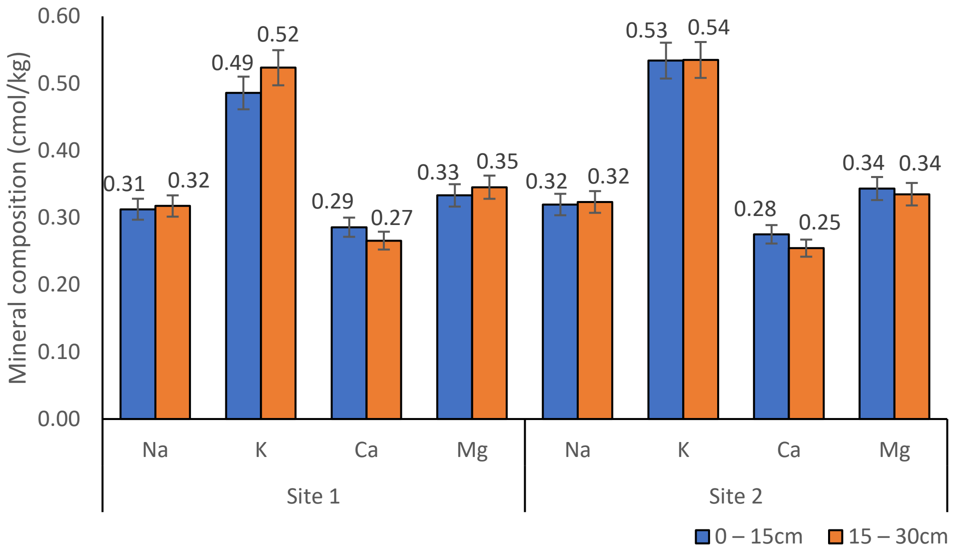

Figure 2: Mineral composition of the studied sites

Sites and Depths

Levels of Trace Elements at the Two Sites

The levels of some trace minerals recorded in the soils of the two sites are shown in Table 2. At 0 – 15 cm soil depth, results showed significantly higher ($p < 0.05$) levels of copper, iron and zinc in the site 2 than the site 1. On the other hand, manganese level was significantly higher ($p < 0.05$) in site 1 than site 2 (Table 2). At soil depth 15 – 30 cm, levels of copper, zinc and manganese were significantly higher ($p < 0.05$) in site 1 than site 2. However, level of iron was significantly higher ($p < 0.05$) in the site 1 than site 2 (Table 2).

Table 2: Levels of trace elements in the two soil

Trace element	0 – 15 cm		15 – 30 cm	
	Site 1	Site 2	Site 1	Site 2
Cu	0.10±0.00b	0.10±0.00b	0.11±0.01a	0.09±0.00c
Fe	6.21±0.01b	6.02±0.03d	6.48±0.09a	6.09±0.02c
Zn	0.21±0.01b	0.20±0.01c	0.22±0.01a	0.19±0.00d
Mn	1.25±0.01b	1.35±0.31a	1.20±0.01c	1.15±0.02d

Means in the same row having similar superscripts are not significantly different ($p < 0.05$)

DISCUSSION

There were variations in the physicochemical parameters of the forest nursery soils assessed at the two different sites and depths. The particle size distribution (proportion of clay, silt and sand) also varied among soil depths. Generally, the soils in both sites and depths have a good balance of particle sizes which will have the best stability of pore space size and thus the best soil properties for maximum plant growth and productivity. Muoghalu and Awokunle (1994) reported a similar trend in the particle size distribution in the Nigerian rainforest region, Omo Biosphere Reserve, Nigeria. While the texture is a basic soil property, vegetation disparity could have contributed to the variations in particle size distribution. The pH of the soils was slightly acidic. Consequently, availability of nutrients such as Nitrogen and Phosphorus needed by plants will be supported within these soils. This is corroborated by Alloway and Aryes (1997) who stated that high value of pH is predictable as most soils in the tropics range from acidic to slightly neutral. The value may also be as a result of buffering effect of soil organic matter against pH change in addition to the release of basic cations during organic matter decomposition. The percentage of organic matter in the two sites varied but was higher at 0-15 cm depth in site 1. The substantial difference is probably due to the accumulation and decay of leaf litter and root in the soil. Thus, improves soil physical properties by providing organic binding agents, increasing water holding capacity of soils, provides better aeration, lowering soil bulk density, and improving the elasticity and resilience of the whole soil. The decrease in organic matter with depth could be due to the decrease in the abundance of the fine roots with depth; at greater depth, larger diameter roots predominate, and this agrees with the work of Oyedele *et al.* (2008) who stated that organic matter plays a significant role in adsorption reaction in the soil. It is widely known that 90% of soil nitrogen is in organic combination. High total nitrogen value observed in site 1 could be ascribed to the dominance of nitrogen fixing tree species composition such as *Leucaena leucocephala*, *Albizia lebbeck* and *Gliricidia sepium* around the forest nursery and their rate of decomposition. This is in consonance with the report of Vanlauwe *et al.* (1997) and Deng (2020) that species with high nitrogen content decompose more rapidly. Available phosphorus levels were higher at 15-30 cm depth in both sites. Higher phosphorus content in the soil may be an indication of excessive use of inorganic fertilizer or routine application of compost manure high in phosphorus in the area. According to Etabo *et al.* (2018) and Fageria (2002) phosphorus availability or unavailability in the soil to plants critically affect the uptake of nitrogen and other nutrients. In addition, variation in essential mineral composition between and within sites were observed. In site 1 and 2, the trend of micronutrients includes K>Mg>Na>Ca at both 0 – 15 cm and 15-30 cm soil depths. Level of Potassium was higher than other essential elements Sodium, Calcium and Magnesium in site 2 at both 0 – 15 cm and 15 – 30 cm soil depths when compared between sites. The result of Oladoye (2021) in a related study agrees with this study, where Calcium and Magnesium decreased significantly with soil depth in all the study site with 0 - 15cm depth varying significantly from 15- 30cm depth. Higher level of trace mineral was recorded in site 2 at 0 – 15 and the trend is as follows; Fe>Zn>Mn>Cu. At soil depth 15 – 30 cm, the order of concentration includes Cu>Fe>Zn>Mn. As reported by Kirchmamm (2011) and Combatt *et al.* (2021), trace minerals which are required for the normal growth of plants vary in their composition in the soil. All the macronutrients assessed in this study varied with depth in each site.

CONCLUSION

The study on the assessment of physicochemical properties and mineral compositions of forest nursery soils indicated variations in these parameters at different depths and sites within the same locations. Physiochemical properties such as Bulk Density, Porosity, and

Soil Organic Carbon are considered as indicators of soil quality which ensures optimum productivity at forest nursery stage. The proportion of Clay, Silt and sand were used to characterize particle size distribution also varied. There were disparities in mineral composition both micro and macro minerals between the two sites. Site 2 had better physicochemical properties and higher level of some essential minerals needed for good performance of seedling growth at nursery stage. Future studies should investigate other likely factors which can affect the productivity of soils at nursery stage.

REFERENCES

Aiboni, V.U. (2001). Characteristics and classification of soils of a representative topographic location in the University of Agriculture, Abeokuta (UNAAB), Nigeria. *ASSEST Series A*, 1(1): 35-50.

Ajewole, O.I. and Popoola, L. (2001). Monetization of forest services functions for sustainable management. *Journal of Environmental Extension*, 1(1): 117-125.

Allison. L.E. (1965). Organic Carbon. *In*: Black, C.A. (Ed.) *Methods of Soil Analysis Part 2 Chemical and Microbiological Properties*. American Society Agronomy, 1376-1378pp Madison, Wisconson.

Alloway, B.J, Ayres, D.C. (1997). *Chemical Principles of Environmental Pollution*. Blackie Academic and Professional. 53-359pp.

Black, C.A. (1965). Methods of soil analysis II. chemical and microbiological properties. Madiso, Wisconsion, *American Society of Agronomy*, 9 (2): 1572.

Bray, R.H. and Kurtz, L.T. (1945). Determination of total organic and available form of P in soil. *Soil Science*, 59: 39-45.

Combatt, C.E., Jarma, O.A., Hernandez, B. Jaraba, N.J. and Rodriquez, P.L. (2021). Macroelements and microelements in soil and their relationship with the content of Steviol Glucosides in *Stevia rebaudiana* Bert from five regions of Colombia. *Horticulture* 7: 547. https://doi.org/10.3390/horticulturae7120547.

Deng, L., Huang, C., Kim, D.G., Shangguan, Z., Wang, K., Song, X. & Peng, C. (2020). Soil GHG fluxes are altered by N deposition: New data indicate lower N stimulation of the N2O flux and greater stimulation of the calculated C pools. *Global Change Biology*, 26(4):2613-2629.

Epstein, H.E., W.K. Lauenroth, I.C. Burke and D.P. Coffin, (1998). Regional productivities of plant species in the Great Plain of the United States. *Plant Ecol*ogy, 134: 173-195.

Etabo, E. M., Wekha, W. N., Korir, N. K and Gweyi-Onyango, J. P. (2018). Effect of Phosphorus Levels on Soil Properties and Plant Tissues of Two Nerica Varieties. *Asian Soil Research Journal*, (3): 1-9.

Fageria, N.K., Baligar, C. and Clark, R. B., (2002). Micronutrients in crop production, *Advances in Agronomy*, 77: 186 – 268.

Gee, G.W. and Bauder, J.W. (1986). Particle-Size Analysis. *In*: Klute, A., Ed., Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods, Agronomy Monograph No. 9, 2nd Edition, *American Society of Agronomy/Soil Science Society of America,* Madison, WI, 383-411pp.

Kirchmann, H., Eriksson, J. (2011). Trace Elements in Crops: Effects of Soil Physical and Chemical Properties. *In*: Glinski, J., Horabik, J., Lipiec, J. (Eds). *Encyclopaedia of Agrophysics. Encyclopaedia of Earth Sciences Series.* Springer, Dordrecht. https://doi.org/10.1007/978-90-481-3585-1_175.

Lowe, K. M., Shulmeister, J., Feinberg, J. M., Manne, T., Wallis, L. A. and Welsh, K. (2016). Using soil magnetic properties to determine the onset of Pleistocene human settlement at Gledswood Shelter 1, northern Australia. *Geoarchaeology,* 31(3): 211-228.

Muoghalu, J.I. and Awokunle, H.O. (1994). Spatial patterns of soil properties under tree canopy in Nigerian rainforest region. *Tropical Ecology*, 35(2): 219-228.

Murphy, J. and Riley, J.P. (1962). A modified single solution method for determination of phosphate in natural waters. *Analytica Chimica Acta*, 27: 31-36.

Oladoye, A.O. (2021). Physiochemical properties of soil under two different depths in a tropical forest of International Institute of Tropical Agriculture, Ibadan. *Journal Of Research in Forestry, Wildlife and Environmental*, 7 (1): 41 – 52.

Oliveira, R and Lacerola L.D (1993). Produ e compsiqu. Ca da serappilheira na Floresta da Tijula (Rz) *Revit Brasil Bot*. 16: 93-99.

Oyedele, D. J. Gasu, M. B and Awotoye, O.O. (2008). Changes in soil properties and plant uptake of heavy metals on selected municipal solid waste dump sites in Ile-Ife, Nigeria. *African Journal of Environmental Science* and *Technology*, 3 (5): 107-115.

SAS (2015). SAS Institute Inc. SAS/STAT® 14.1 User's Guide. Cary, NC: SAS Institute Inc.

Vanlauwe B. Diels J., Songinga N. and Merckx, R. (1997). Residue quality and decomposition: An unsteady relationship? *In*: Cadisch, G. and Galler, K.E. (Eds.) *Driven by Native Plant Litter Quality and Decomposition*. 157-166pp.

Wilson, M.F. and A.H. Sellers, (1985). A global archive of land cover and soils data for use in general circulation models. *Journal of Climatology*, 2: 119-143.