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COMPARATIVE SOIL PROPERTIES OF MAJOR FALLOW SPECIES FOR ROOT AND TUBER CROPS PRODUCTION IN OLOKORO UMUAHIA, SOUTH EASTERN NIGERIA

Ekeledo, P.I[1] , Nwokocha, C.C[2] and Agoh ,E.C[3]
National Root Crop Research Institute, Umudike, P.M.B 7006, Umuahia, Abia State

Corresponding Author's E-mail: paulekeledo@gmail.com

ABSTRACT

A study was initiated in 2019 to examine the contributions of some selected indigenous multipurpose fallow species (MPTS): Monkey fruit (Dactyladenia barteri,), Velvet or black tamarind (Dialum guineense), and African rosewood (Anthonatha macarophylla) in selected four year fallow plots in Olokoro communities to soil chemical properties. A randomized complete block design was adopted for this study and replicated four times in four villages (Okwu, Amizi, Itu, and Agbama. Treatments consist of a collection of soil samples from 3 randomly selected four year fallow plots, each measuring 20m x 20m in the villages under study. A total of 12 fallow plots were sampled and later bulked to produce four (4) composite samples representing the four villages. The composite samples were presented for laboratory analysis. Data obtained were subjected to analysis of variance. Results show that nutrient distribution across different locations varied significantly at ($p < 0.01$), higher values of calcium (Ca) and exchangeable acidity (EA) (2.80 and 4.57 Cmol/kg, respectively) were recorded in Amizi soil. A Higher value of exchangeable potassium (K) obtained the from Itu location (0.608 Cmol/kg) differed significantly from values obtained from other locations. Fallow species at different levels of probability influenced soil chemical properties, Differences in nutrient distribution for fallow species were observed in this order: Dactyladenia barteri > Dialum guineense >Anthonatha macarophylla in their distribution for exchangeable bases, exchange acidity, ECEC, available P, and total N, indicating positive contributions of multipurpose trees and shrubs in soil nutrient dynamics also suggesting that these MPTS will play important roles in new agroforestry technologies designed to replace the traditional bush fallow system and improve soil nutrient stability for increased roots and tuber crops production

Keywords: Dactyladenia barteri, Anthonatha Macarophylla, Dialum guineense, Soil nutrients, multipurpose fallow species

INTRODUCTION

The bush fallow system constitutes ecological balance in our rather difficult environmental condition associated largely with heavy rains above 2000 mm per annum in most areas (Akobundu *et al.,* 2002). Erosion and flooding are made worse when bushes are cleared too frequently and the perennial root stocks of the fallow species are uprooted (Hauser, 1993, Owoeye, et al, 2022). The complex fallow ecosystem plays a very important role in the culture and feeding habit of the people (Okeke and Omaliko, 2002). Several plants and animal products of the fallow are used to supplement feeding for both man and domestic animals.(Meregini, 2000, Akobundu, 2002 and Dave, 2015).Earlier farming system survey of Olokoro community shows that the vegetation is mixed deciduous, with highly weathered fragile and acidic soil, having low fertility status. (Akabundu *et a*l., 2002). Okeke, (2003) and Eric *et al*, (2016) reported that in Umuahia South-East Nigeria, *Dactyladenia, barteri*, *Anthonatha macrophylla, and Dialum guineense* are selectively protected during land clearing and weeding. In this system as well as the more common brush fallow system, improvement in soil physical, chemical and biologic characteristics can be realized through the supply of adequate amount of organic matter (OM) in the surface of the soil as mulch (Martin, 2010, Tomas, 2017, Prance and White, 2022). Most farmers in Olokor Southeast Nigeria, rely on the brush fallow system for maintenance of soil fertility and productivity. It is considered an important management strategy for restoration of soil productivity through litter fall and decomposition and their deep root system binds the soil and prevents erosion, leaching and maintain better soil physical and biological conditions (Barrios and Cobo, 2004, Owoeye *et al*., 2022). The major indigenous fallow species in Olokoro south east Nigeria include: *Dactyladenia barteri, Dialum guineense and Anthonatha macrophylla.*

Dactyladenia barteri varies in habit from a climbing shrub to a small tree growing upto 12 m tall, with a dense spreading crown, the bole is crooked and fluted, often with multiple stems upto 20-40 cm in diameter. The shrub has an extensive deep root system that holds the soil and so can be used in schemes to prevent soil erosion (Owoeye *et al*., 2022). The tree produces large amount of litter and recycles appreciable quantities of nutrient through its deep root system, while its dense canopy aids in weed suppression (Prance and White, 2022). The stems provide good quality poles for yam staking and for construction (11T4, 1993, Okeke, 2002, Dave , 2015 and Eric *et al*,2016). *Dialum guineense* is a tree to 30 m high with densely leafy crown, but often shrubby. Bole is without buttresses, the bark is smooth, grey and the slash is reddish, yielding a little red gun. 11TA,1993 ,Okeke, 2002 and Orhue *et al*, 2007). It is a fruit bearing tree in the flowering plant family - *Fabaceae*. It has small tropical grape sized edible fruits with brown hard inedible shell. It plays an important role in the soil fertility restoration and selectively being protected during clearing and weeding of the farm (11TA, 1993 and Eric.2016)

Anthonatha macrophylla is a shrub to small understory tree within the *Fabaceae* family. It is endemic to the rain-forest region of West Africaand it is the most common of the species within the *Anthonatha* genus in Africa (Okeke and Omaliko 2002, Orhue *et al,* 2007). It is an evergreen shrub or tree with a wide spreading crown; it is multi-stemmed or branching from near the base (Etuk, et al, 2010). It is sometimes grown as a shade producing and soil improving tree (11TA, 1993, and Prance and White 2022). Farmers in Olokoro faced with the prospect of shorter fallow periods have for many years practiced traditional alley cropping system using *Dactyladenia barteri*

Anthonatha macrophylla and *Dialum guineense.* They selectively protect these indigenous fallow species during cleaning and weeding. The potential of some multipurpose trees and shrubs in soil chemical properties have been reported. Etuk*, et al*., (2010), reported the contribution of 1.61% N, 0.20% P and 0.90% K by *Anthonatha macrophyllia* in a 3 years old fallow, white for the same fallow length, *Dactyladenia barteri* yielded 1.47% N, 0.26% P and 0.08% K. Okeke and Omaliko, (2000) further reported a significant increase in soil exchangeable Ca^{2+} and Mg^{2+} levels of the soil as a result of the leaf litter mulch of *Dailum guineense* and *D barteri* and concluded that Ca^{2+} release rate was related to N release rate rather than to initial Ca^{2+} content.The study location lies in the rainforest zone and the vegetation is mixed deciduous with highly weathered fragile and acidic soil with low fertility status (Opara-Nadi, 2000; and Akobundu et al., 2002).The inherent low fertility status of the soil as a result of reduction in fallow length and continuous cropping by farmers in the area, has left the soil nutrient depleted and since chemical fertilizers re scarce and costly, must farmers in the study area rely on the bush fallow system for soil nutrient improvement. There is no detailed documentation of the resource profile of these indigenous multi-purpose fallow species, nor the extent of their contribution to soil improvement and processes involved in their regeneration of soil nutrient.

The objectives of this study were to determine the contribution of the indigenous multi-purpose trees and shrubs species to soil physical and chemical property and to compare their nutrient contribution across selected four year fallow farms in Olokoro-Umuahia, Abia State Nigeria.

MATERIALS AND METHODS

This study was carried out in Olokoro community in Umuvhia-South, Abia State South-East Nigeria (Lat. 5º 25′ and 5º 39′ N and Long. 7º 24′ E and 7º 33′ E). Rainfall within this area is over 2000 mm annually. Three indigenous fallow species (*Dactyladenia barteri, Dialum guineense* and *Anthonatha macrophyllia*), and their Soil chemical properties were studied in a four year fallow farms in Olokoro community in 2019. A randomized complete block design was used and replicated four times in four villages (Okwu, Amizi, Itu and Agbama). Test consists of collection of soil samples from randomly selected four year fallow plots. Three (3) fallow plots measuring 20 m x 20 m were selected from each village, giving a total of 12 fallow plots. Soil samples were collected (0.30 cm depth) from the base of the selected fallow species using a soil auger in a 1 m x 1 m quadrat established around the base of the trees/shrubs species. A total of 12 samples were collected from the four villages and taken to the National Root Crops Research Institute, Umudike Soil Laboratory for physico-chemical analysis. Soil particle size distribution was determined using hydrometer method by Gee and Bauder (1986) after dispersing the soil with sodium hydroxide (0.1 N NaOH). Soil pH was determined in distilled water at the ratio of 1:2.5 (soil: liquid) using a pH meter according to McClean (1982). Organic carbon was analyzed following Walkley and Black dichromate (wet) oxidation method (Nelson and Sommers, 1982). Total nitrogen was determined by the micro kjeldahl digestion method as described by Bremner and Mulvaney (1982). The exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) were extracted using ammonium acetate solution (Thomas, 1982). Exchangeable acidity was determined according to the method of Mclean (1982). Available P was analyzed using Bray II method as described by Olsen and Sommers (1982). All soil data obtained were subjected to analysis of variance (ANOVA) using GenStat Discovery Edition 4. Significant treatment means separated using least significant difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

The mean soil physico-chemical properties of the various villages outside the base of the various fallow species are presented in Table 1. The soils across all location are generally acidic, sandy loam textured and the Ca+ and Mg+ dominated the exchange complex of the soil and is of the low to medium class..

Table I. Mean Soil Physico-Chemical Properties of the Study Sites (50 m away from the fallow spp)

Parameters	Amizi	Itu	Agbama	Okwu
Sand (g/kg)	7.76	8.23	8.32	7.96
Silt (g/kg)	1.17	0.98	0.92	1.13
Clay (g/kg)	1.07	0.79	0.76	0.91
PH (I:I H20)	4.2	5.02	5.46	5.29
Texture	SL	SL	SL	SL
Organic Carbon (g/kg)	0.99	0.82	0.84	0.89
Organic Matter (g/kg)	1.71	1.41	1.45	1.53
Total Nitrogen (g/kg)	0.27	0.22	0.23	0.19
Available P (mg/Kg)	21.11	19.00	19.33	19.41
Exchangeable Cation (Cmol/kg)				
Ca^{2+}	1.95	2.72	2.01	1.71
Mg^{2+}	1.86	1.20	1.60	1.62
K^{+}	0.11	0.20	0.27`	0.19
Na^{+}	0.08	0.40	0.24	0.09
ECEC (Cmol/Kg)	4.76	5.64	5.48	4.90
Exchange Acidity (Cmol/Kg)	0.76	1.12	1.27	1.29
Base saturation (%)	84.03	77.40	75.18	73.67

Effect of location on selected chemical properties of a 4 year multipurpose fallow spp of Olokoro soils are as presented in Table 2.

Table 2. Effects of location on selected chemical properties of four year multipurpose fallow spp farms in Olokoro, southeastern Nigeria.

Treatment	Ca Cmol/kg	Mg	K	Na	EA	ECEC	P (mg/kg)	TN (g/kg)	OM (g/kg)	BS (%)
Location										
Agbama	2.53	**2.12**	0.252	**0.108**	3.95	8.96b	18.63	**2.25a**	4.31	**56.33**
Amizi	**2.80**	**2.13**	0.270	**0.107**	**4.57**	**9.88**	**20.18**	**1.98**	3.72	53.25
Itu	2.32	**2.15**	**0.608**	0.085	4.12	9.28	**19.51**	**2.33**	4.32	**55.48**
Okwu	1.73	1.73	0.153	0.087	3.85	7.56	19.17	2.16	**4.42**	49.50
$LSD_{(0.05)}$	**0.11****	**0.24****	**0.261****	**0.010****	**0.29****	**0.41****	**0.96***	**0.14****	**0.08****	**2.75****

*, ** = Significant at 5 and 1% probability levels, respectively.

Location significantly ($P < 0.01$) affected all the chemical properties studied. Higher values of calcium (Ca) and exchangeable acidity (EA) (2.80 and 4.57 Cmol/kg, respectively) were recorded in Amizi soil. Okwu soil recorded the least value of Ca (1.73 Cmol/kg). Lesser values of EA occurred in Okwu, Agbama and Itu locations (3.85, 3.95 and 4.12 Cmol/kg, respectively) which did not differ significantly with each other. Higher values of magnesium (Mg) were obtained from Itu, Amizi and Agbama locations (2.15, 2.13 and 2.12 Cmol/kg, respectively) which differed significantly with value (1.73 Cmol/kg) obtained from Okwu location. Higher value of exchangeable potassium (K) obtained from Itu location (0.608 Cmol/kg) differed significantly with values obtained from other locations. Agbama and Amizi locations recorded higher sodium (Na) content (0.108 and 0.107 Cmol/kg, respectively). Lesser values of Na were obtained from Okwu and Itu soils (0.087 and 0.085 Cmol/kg, respectively). Highest significant value of effective cation exchange capacity (ECEC) was obtained from Amizi soil, while lowest values were recorded from Okwu and Agbama locations (7.56 and 8.96 Cmol/kg, respectively). Amizi and Itu locations recorded significantly ($P < 0.01$) higher amount of available phosphorus (P) (20.18 and 19.51 mg/kg, respectively). However, available P in Itu did not differ significantly with available P in Agbama and Okwu locations (18.63 and 19.17 mg/kg, respectively). Location had varied effect on total nitrogen (N) and organic matter (OM). Whereas, higher values of total N were obtained in Itu and Agbama soils (2.33 and 2.25 g/kg, respectively), highest value of OM (4.42 g/kg) was recorded from Okwu soil which hitherto recorded least values of measured parameters. Agbama and Itu locations recorded highest values of percentade base saturation (%BS) (56.33 and 55.48%, respectively.There was no consistency on the effect of multipurpose trees/shrubs specie on chemical properties (Table 3). However, fallow spp at different levels of probability influenced soil chemical properties studied. *D. guineense* fallow sp yielded higher Ca (2.44 Cmol/kg) which differed significantly ($P < 0.01$) with values obtained from soils of *D. barteri* (2.31 Cmol/kg) and *A. mycrophylla* (2.29 Cmol/kg) fallow spp. *D. guineense* and *D. barteri* fallow spp recorded higher Mg contents (2.24 and 2.03 Cmol/kg, respectively) than *A. mycrophylla* fallow sp that recorded 1.84 Cmol Mg/kg soil. Similar results were obtained for ECEC, *D. barteri* (9.14 Cmol/kg) and *D. guineense* (9.06 Cmol/kg) which differed significantly with value obtained from

A. mycrophylla soils (8.57 Cmol/kg). *A. mycrophylla* fallow sp yielded higher amount of exchangeable K (0.511 Cmol/kg). Significantly ($P < 0.01$) lowest level of exchangeable acidity (3.82 Cmol/kg) was obtained from *A. mycrophylla* fallow sp. This was followed by 4.14 Cmol/kg recorded by *D guineense* fallow sp. Low levels of EA obtained from these fallow spp contributed to the higher levels of %BS obtained from *A. mycrophylla and D. guineense* Fallow spp (55.32 and 53.66 Cmol/kg, respectively). Higher values of TN and OM (2.35 and 4.21 g/kg, respectively) were recorded from *D. barteri* soils which did not differ in OM content with value obtained from *A. mycrophylla* (4.24 g/kg) fallow sp. This confirms the work of Meregini, (2000),Okeke and Omaliko,(2000) and Owoeye et al, (2022) who stated that Anthonatha macrophylla has higher capacity to increase soil organic matter because of its fast decomposition rate and low carbon/nitrogen ratio and lignin content.

Table 3. Effects of multipurpose fallow spp on selected chemical properties of four year fallow spp farms in Olokoro, southeastern Nigeria.

Treatment	Ca	Mg	K	Na	EA	ECEC	P	TN	OM	BS
	Cmol/kg						(mg/kg)	(g/kg)	(g/kg)	(%)
A. mycrophylla	2.29	1.84	**0.511**	**0.111**	3.82	8.57	19.02	2.10	**4.24**	**55.32**
D. guineense	**2.4a**	**2.24**	0.174	0.065	4.14	**9.06**	18.96	2.08	4.12	**53.66**
D. barter	2.31	**2.03**	0.278	**0.115**	**4.41**	**9.14**	**20.40**	**2.35**	**4.21**	51.61
$LSD_{(0.05)}$	**0.10****	**0.21****	**0.226***	**0.009***	**0.25****	**0.36**	**0.83***	**0.12****	**0.07****	**2.38***

*, ** = Significant at 5 and 1% probability levels, respectively

Table 4. Interaction effect of location and multipurpose fall0.00spp on selected chemical properties of four year fallow spp farms in Olokoro, southeastern Nigeria.

Location X fallow spp	Ca	Mg	K	Na	EA	ECEC	P	TN	OM	BS
	Cmol/kg						(mg/kg)	(g/kg)	(g/kg)	(%)
Agbama X *A.mycrophylla*	2.80	2.32	0.275	0.087	**3.40**	8.88	18.00	**2.51**	4.82	**61.71**
Agbama X *D. guineense*	2.40	2.05	0.159	0.081	3.58	8.27	18.50	1.84	3.85	56.71
Agbama X *D. barter*	2.40	2.00	0.323	0.571	4.86	9.74	19.40	**2.40**	4.26	50.07
Amizi X *A.mycrophylla*	2.00	1.60	0.354	0.122	4.60	8.68	20.00	1.96	3.68	46.96
Amizi X *D. guineense*	**3.60**	**2.80**	0.077	**0.060**	4.48	**11.02**	19.50	1.68	2.84	**59.34**
Amizi X *D. barter*	2.80b	2.00	0.379b	0.139	4.63	9.95b	21.00	2.29	4.63	53.45
Itu X *A. mycrophylla*	2.35	1.85	**1.246**	0.130	3.86	9.44b	19.53	1.97	4.05	**58.82**
Itu X *D. guineense*	2.15	**2.50**	0.319	**0.050**	4.35	**9.37**	18.85	**2.41**	4.68	53.56
Itu X *D. barter*	2.45	2.10	0.260	0.075	4.15	9.04	20.15	2.60	4.24	54.06
OkwuX *A. mycrophylla*	2.00	1.60	0.170	0.103	**3.40**	7.27	18.50	1.96	4.41	53.26
Okwu X *D. guineense*	1.60	1.60	0.140	0.070	4.16	7.57	19.00	2.41	**5.12**	45.05
Okwu X *D. barter*	1.60	2.00d	0.150	0.087	4.00	7.84	20.00	2.11	3.72	46.85
Interaction $LSD_{(0.05)}$	**0.19****	**0.41****	**0.453***	**0.018****	**0.50****	**0.71****	**NS**	**0.24****	**0.14****	**4.76****

, ** = Significant at 1% probability level; NS = Not significant at 5% probability level.

The interaction effects of location and multipurpose fallow species on soil chemical properties of Olokoro soils are as shown in Table 4. Results showed that *D. guineense* fallow sp in Amizi returned significantly ($P < 0.01$) highest amount of Ca (3.60 Cmol/kg) and Mg (2.80 Cmol/kg) which did not differ significantly with Mg content under the same fallow sp in Itu location (2.50 Cmol/kg). Exchangeable K significantly ($P < 0.05$) showed highest value of 1.246 Cmol/kg in Itu x *A. mycrophylla* interaction. Agbama x *A. mycrophylla* interaction recorded highest values of TN (2.51 g/kg) and %BS (61.71%) which did not differ significantly with values of TN in Agbama x *D. barteri* (2.40 g/kg) and in Amizi x *D. guineense* (59.34%) and in Itu x *D. guineense* (58.82%) interactions. Highest significant amount ($P < 0.01$) of OM (5.12 g/kg) was obtained from Okwu x *D. guineense* interaction plots. Location x fallow sp interaction had no significant treatments effect ($P < 0.05$) on available P content, However, values obtained ranged from 18.00 to 21.00 mg/kg .Amizi x *D. guineense* interaction recorded significantly ($P < 0.01$) highest amount of ECEC (11.02 Cmol/kg). Lowest values of ECEC were obtained in the 3 fallow spp in Okwu (7.27 – 7.84 Cmol/kg).

CONCLUSION AND RECOMMENDATIONS

The high nutrient contribution of the fallow species under study showed their potential to contribute to soil nutrient when used in an intercropping situation with arable crops. *Dactyladenia barteri*, tended to increase soil OC, Ca Mg and effective cation exchange capacity and EA up to 30 cm top soil layer It can also provide good mulch material because of its low decomposition rate (C/N 28:1-36:1, lignin 42.6%, polyphenol (4.1%), decomposition rate 100 days (as little as 20% may have decomposed after 6 months Higher levels of Ca, Mg, Na, EA, ECEC and available P were recorded in Amizi soils after a 4 year fallow period. This was followed by Itu fallow spp that recorded higher values of Mg, K, avail.P, TN and %BS. Agbama fallow spp recorded higher Mg, Na, TN and %BS.. The least improvement on soil chemical properties occurred in Okwu location, although Okwu recorded significantly highest amount of OM. Improvement in soil nutrients after a 4 years fallow period in 4 locations of Olokoro followed this trend: Amizi fallow spp > Itu fallow spp > Agbama fallow spp > Okwu fallow spp .*Dactiladenia barteri* across the 4 study locations, improved greater number of soil chemical properties like Mg, Na, EA, ECEC, avail. P, TN and OM; followed by *A. mycrophylla* because of its high exchangeable K, OM and %BS. Interaction effect of location and fallow spp masked the simple effect of *D. barteri* in improving soil fertility of Olokoro soils, but projected *D. guineense* which showed capacity to improve soil nutrient base in Amizi and in Itu following a 4 year fallow period with multipurpose fallow species.

. *Anthonatha macrophylla* has higher ability to increase soil organic matter and base saturation of the soil and *Dialum guineense* is effective in restoration of degraded soil, its deep root system enhances aggregate stability, prevents soil erosion and contributes to soil nutrient through litter fall and decomposition. Therefore, these multipurpose fallow species are recommended for more intensive agroforestry innovations like the alley system, Scatter tree or planted fallow systems and other productive agroforestry systems that are viable for climate smart agriculture

REFERENCES

Akobundu, I.O, Isichie,A.O, Ekeleme, F, Agyakwa ,G.W, Juckei,E.S and Malongoy,K,(2002); An analysis of vegetation as a resource in south –eastern Nigeria;ILCA ,Ibadan;46-52

Asoiro, F.U., Ezeoha, S.C., Ezenne, G.C and Ugwu, C.O, (2007). Chemical and Mechanical Properties of Dialium guineense Fruit in Nigerian ;Journal of Technology (NIJOTECH), Vol. 36. No 1 252-260.

Anderson, J.M., Ingram, J.S.I (1989). Tropical Soil Biology and Fertility Handbook of Materials.. CAB International. WallingFord. U.K,89-94

Bray, R.H. and Kutz, I.T. (1945). Determination of Total Organic and available Forms of P in Soil. Soil Sc. 11, 59: 39-45.

Bremner, R (1965). Fabric and Mineral Analysis of Soil. John Willy and Sons Inc, New York. Pp 56-60 Wood Mulch Zmaz

Bremner, J. M. and Mulvaney, C. S. (1982). Total nitrogen. In: Page, *et al*. (eds). Methods of Soil Analysis, Part II. Am. Soc. Agron. 9, Madison, WI, USA.

Dave J and Eric, T (2015). Edible Forest Garden, Chelsea Green Pub Co. ISBN 9781890132606.

Eric Toensmerer (2016). The Carbon Farming Solution.A Global Toolkit of Perennial Crops and Regenerative Agricultural Practices for Climate Change Mutigationand Food Salenty.Chelsea Green Pub.co COISBN 978160358712.

Etuk, I.., Ndeeyo, N.U. and Olajide O, (2010). Variation in the qualities of three Macro-Nutrient (N.PLC) in the leaf Pruning of three Indigenous agroforestry Tree Species. In Journal of Native and Science 8 (11): 148-151, ISSN 1545-0740.

Gee, G.W. and Bauder, J.W. (1986). Particle size analysis. Methods of soil analysis. Ed. A. Klute. *American Society of Agronomy.* Madison, W.I. USA.

Martin Crawford, (2010). Creating a Forest Garden: Working with Nature to Grow Edible Crops UIT/Green Book, ISBN-10: 1900322125.

Mclean, E. O. (1982). Soil pH and lime requirements. In: Page *et al*. (eds). Methods of Soil Analysis, Part II. Am. Soc. Agron. 9, Madison, WI, USA.

Meregini, A.O. (2002)Establishment, growth and performance of browse spp im south-eastern Nigeria In: Leynolds and A, N.Atta-Krahh(eds); Browse use and small ruminant productivity in south –eastern Nigeria, ILCA, Humid zone programme,Ibadan,50-64

Nelson, D.W. and Sommers, L.E. (1982). Total carbon organic carbon and organic matter. In: A.Z. Page et al. (eds.). Methods of soil analysis. Part 2, 2nd ed. ASA, SSSA, pp 539-579.

Nwobosi, L.C., (2000). The Nutrient Factor in Sustainable Forestry. Ibadan University Press Pub. House, University of Ibadan Nigeria 19-47.

Owoeye, L.G, Ortiz,R,Gichuru,M.P and Vuylsteke,D (2022);Variations in soil nutrient levels under multi-purpose hedgerow cropping with plantation, In:ACTA Horticulturae No;540.301-308

Olsen, S. R. and Sommers, L. E. (1982). Phosphorus. In: Page, A. L., Miller, R. H. and Keeny, D. R. (Eds). Methods of Soil Analysis. Part II. 2nd ed. *Am. Soc. of Agron.* Inc., Madison W. I. pp. 15 – 72.

Opara- Nadi, O.A (2000). Soil Resources and Agricultural productivity in Nigeria. Food and Fibre Production in Nigeria in 21st Century.

Orhue R., Osaigboro, H.U., and Nosakhare, C. (2007. Growth of *Dialium guineense* Wild Seedlings and Changes in some Chemical roperties in the Soil amended with Brewery Effluent in Journal of Agronomy Vol. 6 (4) 548-553.

Okeke, A.I and Omaliko,C.P.E(2002);Litter decompositioin and carbon dioxide evolution of some Agroforestry fallow species in south-Eastern Nigeria; In forest Ecol.Manager,50:103-106

Prance and White. (In; F., Hook, F. Olive) (2022). Plants for a Future species Data Base Chelsea Green Pub Co. ISBN 9781890132007.

Tomas Remiarz, (2017). Forest Gardening in prelice. An Illustrated Practical Guide for Homes, Communities and Enterprises. Permanent Publication ISBN: 185623393X.

Thomas, G. W. (1982). Exchangeable cations. In: Page *et al.* (eds). Methods of Soil Analysis,Part II. *Am. Soc. Agron*. 9, Madison, WI, USA.