PHYSICO-CHEMICAL PROPERTIES OF SOILS UNDER TREES SPECIES FARMLANDS AT GAFAN, BUNKURE L. G. A., KANO STATE, NIGERIA

Adamu, U. A., Yahaya, U., Hussaini Y., Sirajo, A., Z. L. Ashigar, D. Idris, and A. A. Maigatari
[1]Federal College of Forest Resources Management, Maiduguri, Borno State, Nigeria.
[2]Binyaminu Usman Polytechnic, Hadejia, JigawaState, Nigeria.
adamubnusmanu96@yahoo.com 08066597177

Abstract
Due to increase in population and farming activities most farmers remove trees from their farm lands for more farming spaces instead of maintaining them for improving fertility of the soils leading to soil degradation. Trees specie investigated were Azadirachta indica, Mangifera indica, Adansonia digitata, Parkia biglobosa, Eucalyptus camaldulensis, Moringa oleifera, Diospyros mesiliformis and Vitellaria paradoxa. Three line transects of 300m were laid at 100m interval on farmlands. Soil samples under the tree species and 50 m away from the trees canopies (open land) were collected at 0-30cm depth at tree cardinal points using soil auger and analyzed. Textural classes of the soils were found to be loamy sand under Azadirachta indica, Diospyros mesiliformis, Vitellaria paradoxa, Tamaridus indica, Mangifera indica, Adansonia digitata and sandy loam under Eucalyptus camaldulesis and Moringa oleifera. The pH values of the samples were 7.78 and 5.38 under Eucalyptus camaldulensis, and Diospyros mesiliformis, respectively. Organic carbon ranges from (0.20%) under open land to (1.14%) under Diospyros mesiliformis. Total nitrogen (%) was lower at open land (0.05) and higher under Eucalyptus camaldulensis (0.40). However, soils under Eucalyptus camaldulensis had the highest content of Calcium (4.31cmol/kg), Phosphorus (15.21cmol/kg) and CEC (6.35cmol/kg) compare to the soils under other plant species. Farmers in the area of study should be advised to plant and conserve trees especially Eucalyptus camaldulensis due to its highest value of CEC which is the most significant factor in improving fertility status of farmland soils.

Key words: *Tree diversity, Soil, Physico-chemical property, Farmland trees.*

Introduction

Trees have always existed on lands whether cultivated or not. In early days farmers in tropics use existing trees or plants trees for some purposes like shade fire wood and fruits. Over the years they come to realize that trees have certain desirable role that they play on the soils which they uses to cultivate agricultural crops, this was simply by noticing better performance of crops grown under trees than those grown beyond the canopies of trees. Soil is a vital resource for human survival; it is a mixture of organic and inorganic materials on the immediate surface of the earth that serves as a natural medium for the growth of plants. The organic component of soil is made up of micro-organisms (dead and alive), and plants in varying stages of decay called humus. It improves soil structures and allows soil to store moisture, providing energy for soil microorganisms to make soil tillable for farming and provides nutrition for plants. The nutrients required by plant in relatively large quantity are nitrogen (N), phosphorous (P) and potassium (K) commonly referred to as N P K, Efretuei (2016). It has been observed that as the fertility of soil declines, soil structure weakens and the soil becomes susceptible to erosion (Adetunji, 2004). Soil biodiversity and its physical properties that control water movement and retention in the soil are largely affected due to animal activities (Young, 1999). The important of tree based land use systems in restoring soil fertility and improving the economy of farmers having small land holdings has been realized during the last two decades (Long, 1999). Trees help to maintain soil organic matter and improve physical properties and supply nutrient in farmland. Thus, integration of trees into farming system could go a long way to help in crop growth and enhancing the recycling of materials to provide a more complete ground cover which help to protect the soil from erosion and moderate extreme temperature (Adedire, 2004).

The problem under the study area is that most of the farmers remove trees from their farm land for more farming space, charcoal production and to reduce shading effect on crops instead of maintaining them for improving fertility of soils. Thus, this research can be fundamental to providing crucial information on soil protection and fertility improvements by trees, there by subsequently enhance farmers to protect and plant trees on their farm land, as in a greater part of Africa and indeed Nigeria, trees are a common feature in many farms particularly in subsistence agriculture. Therefore, this study was designed to investigate physico-chemical properties of soils under some selected tree species on farmlands in Gafan village, Bunkure local government, Kano state.

Materials and methods

Study Area.

Bunkure local government is located between Latitude 110 34` 02”N to 110 46′ 05”N of the Equator and Longitude 80 26′ 36”E to 80 46′ 43”E of the prime meridian (Figure 2). The research was conducted at Gafan Village in Bunkure local government area of Kano state and is located between latitude 110 40’09”N of equator and Longitude 80 27’8”E.

Sample Collections

Eighteen (50m x 50m) plots were used for this study. Three lines transects of 300 m long were laid at 100 m intervals. On each transect, six plots of size 50 m × 50 m (0.25 ha) were alternately laid at 50m intervals including an open land 50 m x 50 m away from the trees canopies. Eight (8) tree species were found in the farmland which were as follows; *Azadirachta indica, Eucalyptus camaldulensis, Adansonia digitata, Moringa oleifera, Mangifera indica, Tamarindus indica, Diospyros mesiliforms and Vitellaria paradoxa.* Soil samples were collected from under the identified trees species on the farmlands at depth of 0 - 30cm at four cardinal points, using soil auger**.** The samples were air-dried, sieved with a 2 mm sieve, and put in plastic bags and properly tagged according to Marditech (2011), which later were taken to Soil Science Laboratory of Bayero, University Kano for physico-chemical analysis.

Soil analysis

The samples collected were analyzed for physico-chemical properties. The particle size was determined by Bouyocous hydrometer method (Bouyocous, 1951) and the textural class by soil texture triangle (USDA, 1960), soil pH by the used of pH meter as described by Blackman (1965); organic carbon content was determined by dichromate wet oxidation method as described by Wolf (1982); N content by Micro-Kjedhal method as described by Bremmer (1965); available phosphorus (P) was extracted using the Bray 1 method (Bray and Kurtz, 1945); exchangeable bases (Ca, Mg, K and Na) using 1M ammonium acetate solution (Anderson and Ingram, 1993) and CEC was estimated by summation of exchangeable bases.

Data Analysis

The data collected on the physico-chemical properties of the different soil samples were subjected to analysis of variance using "F" TEST as described by Snedecor and Cochran (1967) where significance was showed by "F" test. Genstat (17th Edition) was used for ANOVA and significant different means were separated using Duncan`s multiples range test.

Results

Diversity and Frequencies of Tree Species Found on the Study Area

Tree species found on the farmlands of the study were presented on Table 1. The result indicated that *Azadirachta indica* had the highest frequency of 15 stands, followed by *Adansonia digitata* with total frequency of 12 stands then *Moringa oleifera* 8 stands, *Eucalyptus camaldulensis* 6 stands, *Vitellaria paradoxa* 5 stands and *Mangifera indica* 5 stands, while trees specie with lowest stands were obtained to be *Tamarindus indica* 4 stands and *Diospyros mesiliformis* 2 stands.

Table 1: Tree species in the study area

SN	TREES SPECIES	LOCAL NAMES	FREQUENCIES
1	*Eucalyptus camaldulensis*	Turare	6
2	*Azadirachta indica*	Darbejiya	15
3	*Diospyros mesiliformis*	Kanya	2
4	*Vitellaria paradoxa*	Kadanya	5
5	*Moringa oleifera*	Zogale	8
6	*Tamarindus indica*	Tsamiya	4
7	*Mangifera indica*	Mangwaro	5
8	*Adansonia digitata*	Kuka	12

Physical Properties and Particles Size of Soils of the Study Area

Table 2, shows the Result of physical properties and particles size of the soil samples. The result indicated that sand particles ranged between (76.00 - 86.00%). Soils under *Vitellaria paradoxa, Tamarindus indica and Adansonia digitata* recorded the highest sand particles size (86.00 - 84.00) and there textural class was loamy sand, while soils under *Mangifera indica, Diospyros mesiliformis* and *Azadirachta indica* sand particles size was between (80.00 - 82.00). The result also indicated that sand particle size of the soil samples obtained under *Moringa oleifera and Eucalyptus camaldulensis* was between (78.00 and 76.00%) which was obtained to be the lowest particle size of sand and its textural class was sandy loam. This indicated there was a difference between the soils under the different trees species. The sand fraction in the soil falls in to the categories of sand textural class (Brady, 1999). Percentage silt ranges from (15.00 -17.00%). The highest value of silt was observed with soil samples under *Diospyros mesiliformis* (17%) followed by *Eucalyptus camaldulensis* (15.00%), *Tamarindus indica* (13.00%), *Mangifera indica* (11.00%), *Azadirachta indica* (11.00%), and *Adansoia digitata* (9.00%), while The lowest value of silt particles size was obtained with soil samples around *Vitellaria paradoxa and Moringa oleifera* (5%) each. This shows that there was a difference in silt level between the tree species which indicates low silt level in the soil samples. Percentage of clay particles size was presented in (Table 2). It shows that clay particles size ranged from (12 - 2%). The higher value of clay was observed with soil samples under *Moringa oleifera* (12%) followed by *Vitellaria paradoxa, Azadirachta indica*, open land of 50 m away from trees canopies and *Eucalyptus camaldulanesis* (10%), each, *Mangifera indica* and *Adansonia digitata* (8%) each, respectively, while the lowest value of clay particles size were recorded with soil samples under *Tamarindus indica (*4) and *Diospyros mesiliformis* (2). There was difference in pH between the

soils under the tree species. Result of the analysis revealed that the pH of the soils was found to be higher under *Eucalyptus camaldulensis* (7.78) followed by *Diospyros mesiliformis* (7.16), open land (6.54), *Adansoia digitata* (6.05), *Azadirachta indica* (6.01), *Moringa oleifera* (5.97) *Mangifera indica* (5.94), *Vitellaria paradoxa* (5.59), and was lower under *Tamarindus indica* (5.38).

Table 2: Physical Properties of the Soil Sample under Different Tree Species at Gafan Village

	PHYSICAL PROPERTIES				
TREE SPP	Sand (%)	Silt(%)	Clay (%)	Textural class	pH (H_2O)
Ec	76	15	10	Sandy loamy	7.78
Ai	80	11	10	Loamy sand	6.01
Dm	82	17	2	Loamy sand	7.16
Vp	86	5	10	Loamy sand	5.59
Mo	78	5	12	Sandy loam	5.97
Ti	84	13	4	Loamy sand	5.38
Mi	82	11	8	Loamy sand	5.94
Ad	84	9	8	Loamy sand	6.05
OL	80	12	10	Loamy sand	6.54

Trees specie Ec= *Eucalyptus camaldulensis,* Ai= *Azadirachta indica*, *Mo= Moringa oleifera,* Dm= *Diospyros mesiliformis,* Mi= *Mangifera indica*, *Vi= Vitellaria paradoxa,* Ti= *Tamarindus indica,* Ad= *Adansonia digitata,* OL= Open Land

Chemical Properties of the Soil Samples

Table 3 presents the chemical properties of soil under different trees species in the area of study. The result obtained from the soil samples analysis indicated that soil around *Eucalyptus camaldulensis* and *Moringa oleifera* were statistically at par in CEC content but significantly higher than the soils around the remaining tree species which were obtained to be statistically the same but in turn higher than the open land soil. The result also showed that Calcium (Ca) content of the soils around *Eucalyptus camaldulensis* and *Diospyros mesiliformis* statistically at par were significantly higher in Ca than soils around *Moringa oleifera* which was also significantly higher than soils around the remaining tree species including soil of open land statistically at par also. Soils under *Tamarindus indica* and *Mangifera indica* had the same amount of Potassium (K) concentration but significantly than soils around *Eucalyptus camaldulensis*, *Vitellaria paradoxa* and *Azadirachta indica* which were statistically similar also but significantly higher in K than *Adansonia digitata* that was obtained to be higher than the soils around *Diospyros mesiliformis* and *Moringa oleifera* statistically the same but in turn significantly higher than soil of open land. Magnesium (Mg) content, result obtained shows that soil of open land was significantly higher in Mg than *Eucalyptus camaldulensis* and *Mangifera indica* which were statistically similar but significantly higher in Mg than *Adansonia digitata* and *Vitellaria paradoxa* also statistically at par but higher than soils around *Azadirachta indica* and *Tamarindus indica* which were also the same but significantly higher than soils around *Moringa oleifera* which was in turn significantly higher than soil around *Diospyros mesiliformis.* Nitrogen (N) content, the result showed that there was no significant difference among the different soils around the trees specie of the study area but higher N was obtained with soil around *Eucalyptus camaldulensis* while lower was recorded with soil of open land. Sodium (Na) content, result recorded revealed that Na content of the soils around *Vitellaria paradoxa* was significantly higher than that of soils around *Diospyros mesiliformis, Eucalyptus camaldulensis, Adansonia digitata, Mangifera indica*, *Moringa oleifera* and *Azadirachta indica* statistically the same but significantly higher than soils around *Tamarindus indica* and open land. Organic Carbon (O.G) content the result obtained showed that O.G content of the soils indicated that soil around *Diospyros mesiliformis* was significantly higher in O.G than soil around *Eucalyptus camaldulensis* and *Mangifera indica* statistically at par but significantly higher than soils around *Moringa oleifera, Vitellaria paradoxa, Adansonia digitata, Azadirachta indica* and *Tamarindus indica* all statistically at par with one another but significantly higher than the soil of the open land that recorded the lowest O.G content. Phosphorus (P) content, the result indicated that soil around *Eucalyptus camaldulensis* was significantly higher in P than soils around *Mangifera indica* and *Azadirachta indica* which were statistically similar but significantly higher in P than soil around *Vitellaria paradoxa* and *Adansonia digitata* that was obtained to be at par but in turn significantly higher than the soils around *Diospyros mesiliformis, Tamarindus indica* and open land soil statistically the same. Trees specie percentage (TSP), result obtained indicated that there was no significant difference among the trees specie.

Table 3: Chemical properties of soil under different trees species at Gafan, Bunkure L. G. A

		CHEMICAL PROPERTIES							
TREE SPECIES	TSP	CEC (cmo/kg)	Ca (mg/100g)	K(mg/100g)	Mg (mg/100g)	N (mg/100g)	Na (mg/100g)	O.G (%)	P (mg/100g)
Ec	2.67	6.35^{a}	4.31^{a}	0.28^{b}	1.35^{b}	0.40	0.23^{b}	0.21^{d}	15.21^{a}
Mo	2.67	5.07^{ab}	2.94^{b}	0.19^{d}	0.74^{d}	0.10	0.24^{b}	0.46^{c}	10.42^{d}
Vp	2.00	4.32^{b}	2.68^{c}	0.24^{b}	0.96^{c}	0.14	0.46^{a}	0.57^{c}	11.76^{c}
Ad	4.33	4.62^{b}	2.44^{c}	0.21^{c}	0.99^{c}	0.17	0.23^{b}	0.56^{c}	11.33^{c}
Dm	1.33	4.56^{b}	4.10^{a}	0.19^{d}	0.48^{e}	0.24	0.20^{b}	1.14^{a}	8.89^{e}
Mi	2.00	4.40^{b}	1.96^{c}	0.44^{a}	1.19^{b}	0.21	0.25^{b}	0.86^{b}	13.03^{b}
Ai	5.00	4.27^{b}	2.17^{c}	0.30^{b}	0.76^{d}	0.14	0.26^{b}	0.55^{c}	11.39^{b}
Ti	4.00	3.89^{b}	1.80^{c}	0.52^{a}	0.87^{cd}	0.07	0.01^{c}	0.45^{c}	9.66^{e}
OL	0.00	1.45^{c}	2.17^{c}	0.18^{e}	1.67^{a}	0.05	0.11^{c}	0.20^{d}	9.27^{e}
SE+	1.395	0.476	0.405	0.011	0.046	0.103	0.037	0.069	0.285
P-value	0.570	<.001	0.002	<.001	<.001	0.468	<.001	<.001	<.001

Note; Means followed by the same letter(s) are not significantly different at 5% level of significance using Duncan`s Multiples Range test.
Trees specie Ec= *Eucalyptus camaldulensis,* Ai= *Azadirachta indica, Mo= Moringa oleifera,* Dm= *Diospyros mesiliformis,* Mi= *Mangifera indica, Vi= Vitellaria paradoxa,* Ti= *Tamarindus indica,* Ad= *Adansonia digitata,* OL= Open Land
O.G= Organic carbon, TSP= Trees species percentage, CEC= Cation Exchange Charge

Discussion

Particles Size Analysis

The result indicated that sand quantity was between (80-76%). The sand, silt and clay fractions in the soil therefore, fall in to the categories of sand textural class (Brady, 1999 and U.S.D.A, 1960).

The result of the study showed that organic carbon levels ranges 0.20 to 1.14. The highest value was observed with soil under *Diospyros mesiliformis* (1.14%) while the lowest value of organic carbon was obtained with soil of open land (0.20%). These pointed out that there was significance difference among the tree species in organic carbon. The result also revealed very low organic carbon content of the soils (Chude *et al,* 2012). Total nitrogen the result shows N content ranges between (0.05 to 0.40%). However, the result indicated that total nitrogen was found to be higher under *Eucalyptus camaldulensis* the lowest was observed around open land. However, the result indicated that there was no significance difference among the soils around trees specie in Nitrogen levels; it also revealed very low N content of the soils of the study area (Chude *et al.,* 2012). Though findings of Radwanski and Wickens (1981) reported there was higher level of total nitrogen under trees than away from its canopy. The low Nitrogen probably could be due to the maturity of the trees and land uses. Result of available phosphorus shows that there was significance difference in the available P between the trees specie values ranged from (8.89 - 15.21mg/kg), indicating moderate level of available P in the soils (Chude *et al.,* 2012). *Eucalyptus camaldulensis* has highest value of the amount of (15.21cmol/kg). However, *Diospyros mesiliformis* was found to be the lowest in P level 8.89 cmol/kg.

The result of exchangeable bases (Ca, M, K, and Na) shows that there was significance difference between the soil under the tree species in available calcium which ranged from (1.80 - 4.31 cmol/kg) with a mean of (0.405cmol/kg). Chude *et al.* (2012) reported that tropical soils with calcium level as low as 0.2cmol/kg is good for agricultural crops. The higher calcium level was recorded around *Eucalyptus camaldulensis* (4.31cmol/kg) the lowest value was recorded around *Tamarindus indica* (1.80cmol/kg). Magnesium level in the soils ranges from (0.48 - 1.67cmol/kg). Chimdi *et al.* (2012) reported that magnesium level of 0.5cmol/kg is considered deficient treasured in the tropics. Magnesium values obtained in this study was higher under *Eucalyptus camaldulesis* (1.35cmol/kg), while the lowest value of magnesium was obtained from soil under *Diospyros mesiliformis* (0.48cmol/kg). Potassium level in the soil ranged from (0.18 - 0.44cmol/kg). The value obtained in this study pointed out that there was significance difference in potassium level between the soils under the trees specie were by high K level was observed around *Mangifera*. indica with (0.44cmol/kg) while the lowest value was under open land (0.18cmol/kg). Sodium level in the soil ranged from (0.46 - 0.01cmol/kg) with a mean value of indicating a significant difference among the soils under the trees specie in sodium level. Chimdi *et al*. (2012) reported that soil with exchangeable sodium level > 1cmol/kg are considered as potentially Sodic. Sodium value obtained in this study was high around *Vitellaria paradoxa* (0.46cmol/kg) while the lowest was observed under *Tamarindus indica* (0.01cmol/kg).

The result of C.E.C was range (1.45 - 6.35cmol/kg) indicating a moderate C.E.C in the soil. The highest value of C.E.C was recorded with soil under *Eucalyptus camaldulensis* (6.35cmol/kg) while the lowest value was around open land (1.45). These show that there was significant difference in C.E.C level among the trees specie. This could be due to variation in tree maturity and litter fall contributed by the trees. The result of C.E.C the result confirmed the finding of Radwanski and Wickens (1981) that C.E.C value are found to be high or low depending on type of tree species and land uses.

Conclusion and recommendations

The study has shown that there were few trees species in the area. The dominant tree species was *Azadirachta indica*. Result from soil analysis showed poor soil in terms of organic carbon and total nitrogen, which are mainly the most important nutrients for plant growth and development and this could be attributed to continuous cropping taking place in the area. This may further worsen the problem of biodiversity loss in the area. Based on the findings of this research it could be recommended that Farmers in Gafan village can be advised to plant more trees especially *Eucalyptus camaldulensis* in their farmlands because it has the highest values in CEC and organic carbon for soil fertility enhancement of their farm land. It is also recommended that indiscriminate felling of trees for whatever purpose should be minimized because the litter from these trees is important in ameliorating the soil and protection of farmland.

Reference

Adedire, M. O. (2004). Environmental protection: The Agroforestry option. *Nigeria* Journals *of Forestry* 34(1):1-6.

Adetunji. M. T., (2004). Integrated soil nutrient management options for Nigerian Agriculture. In managing soil resources for food security and sustainable environment. Proceeding of the 29th*Annual Conference of the soil science society in Nigeria.* 6-10 December 2004, University of Agriculture Abeokuta, Nigeria. Soil Science Society of Nigeria, Abeokuta, Nigeria. Pp. 27-34.

Anderson, J. M. and Ingram, J. S. I. (1993). Tropical Soil Biology and Fertility, A *Handbook of Methods*, 2nd Edition. CAB International, Wallingford, U.K. 340PP

Blackman, V. H. C. (1965). The Compound Interest Law and Plant Growth. *Annals of Botany.* 33:333-360

Bouyoucous, G.H. (1951). A recalibration of the hydrometer for making mechanical analysis of soils. *Agro.Jour.*43, 434-438.

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

Bremmer, H. H. (1965). *Total Nitrogen*. In C. A. Black (ed). Methods of Soil Analysis Part 2

Chimdi, A., Gebrekidan, H., Kibert, K., Tadesse, A., (2012). Status of selected physio-chemical properties of soils under different land use systems of western Oromia, Ethiopia. *Journal of Biodiversity and Environmental Science* 2(3):57-71.

Chude, V.O., Oloyiwola, O. A., Osho, A. O. and Daudu C. K. (2012). Fertilizer Use and Management Practices for Crops in Nigeria (4th edition). Federal Department of Fertilizer, Federal Ministry of Agriculture Abuja Nigeria pp-42-45

Efretuei, A. (2016). Soil Nutrients. Retrieved from https://permaculturenews.org

Long, A. J., Nair, P.K.R. (1999).Trees outside forests: agro-, community and urban forestry. *New Forests,* 17: 1-3, 145-174.

Marditech (2011), Development of a GIS-Based Soil Suitability for Rice Production in Kano state, Nigeria. Unpublished Interim Report Submitted to Kano state.

Radwanski, S. A. and Wickens , G.E. (1981) Vegetative fallows and potential value of the neem tree (*A. indica). In the Tropics Econ. Bot*. 35, 398-414.c

Singh KP. Singh PK, Tripathi SK (1999). Litter fall, litter decomposition and nutrient release patterns in four native tree species raised on coal mine spoil at Sugrauli, India. *Biol. Fert. Soils* 29: 371-378.

Snedecor, G. W. and Cochran, W. G. (1967). Statistical Methos 6th Edition Iowa State University Press, Ames, Iowa, U.S.A. pp 456.

USDA (1960). Soil Classification; a Comprehensive System, 7th Approximation

Wolf, B. (1982). An improved universal extracting solution and its uses for diagnosing soil fertility. *Communication in soil Science and Plant Analysis* 13 (12): 1005-1033

Young, A. (1999) Change and constancy; Analysis publication in agro-forestry systems volume 1-10.