Nigerian Journal of Soil Science 24 (2014) 108 – 116

Nigerian Journal of Soil Science

Journal homepage:www.soilsjournalnigeria.com

ASSESSMENT OF DEGRADATION IN SOILS OF TRANSPLANTED SHEA TREE (Vitellaria paradoxa Gartn C. F.) UNDER TWO LAND USE TYPES AT BIDA, NIGER STATE

***OSAYANDE P.E., OVIASOGIE P.O., EKEBAFE,M.O. AND MAIDOH F.U.**

Chemistry Division, Nigerian Institute for Oil Palm Research (NIFOR), P.M.B. 1030, Benin City, Edo State, Nigeria

**Corresponding author: pvefosa2001@yahoo.co.uk*

ABSTRACT:

Land use affects the fertility and management of soils. The influence of contrary land use types imposed on a Shea field was studied at NIFOR Substation, Bida, Niger state. The field, a sparse grass fallow measuring a 100m X 100m was demarcated into two equal halves. A portion of it was cleared and planted to melon while the sparse grass fallow was retained in the other portion. Composite surface soil samples were collected at 0-15cm in three replicates from each land use type and analyzed for physico-chemical properties in the laboratory. Degradation was assessed using FAO and Snakin *et al*. indicators and criteria for physical, chemical and biological degradation of soils. The estimation of the degree of degradation was based on physical, chemical and biological parameters of land use types. Except Ca, soil chemical properties differed significantly under the land use types though land use had no effect on texture of the soils. The soils under Shea cultivation at NIFOR Substation had a score of 4 each under the two land use types and were therefore very highly degraded with respect to nitrogen. Soils under grass fallow had a score of 3 and was highly degraded with respect to phosphorus while soils under melon had a score of 1 indicating none to slight degradation with respect to phosphorus. Soils under grass fallow had a score of 3 with respect to potassium and was therefore highly degraded while soils under melon had a score of 4 and was very highly degraded with respect to potassium. Chemical and biological degradation were as a result of soil fertility depletion and organic matter decline. The use of integrated fertility management system is suggested as a possible means of improving the soils for Shea tree cultivation in the area.

Key words: Bida, NIFOR, Shea tree, Soil degradation, Land use

INTRODUCTION

The distribution of Shea trees in the Shea belt of Nigeria is affected by the nature of soils. Soil characteristics and rainfall pattern combine to influence vegetation cover and land use pattern over time (Abubakari, *et al*., 2012). Land use in itself entails the arrangement, activities and the actions land users undertake in a certain land cover type to produce change or maintain it (FAO, 1997a). It establishes a direct link between land cover and the input of land user in their environment (Oviasogie *et al*., 2011). Under similar agro-ecological environments, land use and cultural practices are the dominant factors affecting soil properties and crop production (Nnaji *et al*., 2002). Crop production practices influence course of the formation and the physico-chemical status of the soil at any given time (Asadu and Enete, 1997). Land use ultimately affects the nutrient status of soils. Proper planning and adoption of sustainable management techniques are needed to maintain physical and chemical properties of soils. Senjobi, *et al*., (2010) reported that land use type is one of the critical factors affecting land degradation and soil productivity. They reported that physical and biological degradation were more severe than chemical degradation in all the land use types they studied. Amana *et al*., (2012) also reported that bulk density, mean weight diameter (MWD), water stable aggregates (WSA), soil organic matter (SOM), total nitrogen (TN), total porosity (TP), pH and available phosphorus (P) were significantly affected by land use types in their study of effects of land use types on soil quality in a Southern Guinea Savannah of Nasarawa State. Soil degradation means a reduction of the biological and economic productivity potentials of rain-fed cropland, irrigated cropland or range, pasture and forested land by one or a combination of processes (Amalu, 1998). Such processes include, among others, displacement of soil materials by wind and water erosion, deterioration of soil physical and chemical properties and long-term loss of natural vegetation (Adaikwu *et al*, 2012) The principal types of soil degradation are physical, chemical and biological degradation (Adaikwu *et al*, 2012; FAO 1994). Physical degradation refers to the deterioration of the physical properties of the soils. It includes soil compaction and hard setting, soil erosion and sedimentation and laterization. Biological degradation of the soil includes a reduction in soil organic matter (OM) content, decline in biomass carbon and decrease in activity of soil flora and fauna, high soil and air temperature due in part, to the use of chemicals and soil pollutants. Chemical degradation is caused majorly by nutrient depletion and excessive leaching of cation in soils with low activity clay. The buildup of some toxic chemicals and elemental imbalance that are injurious to plant growth also constitute chemical degradation of the soil (Adaikwu *et al*, 2012).

Shea is a dominant member of the canopy vegetation of Niger State. It is common practice for farmers to cultivate food crops such as guinea corn, millet, maize, melon and groundnuts within Shea tree parklands. This practice ensures that the land is put to maximum use. There is however need to study the effects of this land use type on the soil's physical and chemical properties with a view to proffering solutions to problems arising from excessive and intensive use of the land.The general objective of this study therefore was to determine the influence of contrary land use types imposed on a Shea field at NIFOR substation, Bida, Niger State while the specific objective was to assess the extent of soil degradation in portions of the field under the two land use types.

MATERIALS AND METHODS:

Study area

This study was conducted at the Nigerian Institute for Oil Palm Research Substation, Bida, Niger State. The area falls within the Southern Guinea Savannah zone of Nigeria and is located on Latitude 08^0 05.278'N and Longitude 006^0 47.789'E with annual rainfall ranges between 500mm to 1200mm per annum. Minimum and maximum temperature ranges between 24^0C and 33^0C respectively. The site is generally flat with the presence of a few ant hills. The major land use types in the area are arable crop production intercropped in Shea tree parklands.

Field studies

Shea seeds which were depulped, washed and dried were first sprouted in raised beds and subsequently sown in poly bags. The seedlings were transplanted when they were one year old in a 9m X 9m X 9m triangular spacing,giving a total of 150 trees/ha. The field was a sparsely populated grass fallow measuring 100m X 100m which was demarcated, cleared and a portion of it planted to melon. Thus the field was measured into 2 equal halves of 50m X 100m each with each of the 50m X100m under grass fallow and melon (*Collocynthis citrullus*) cultivation respectively obtained locally from the market in Bida. Two melon seeds were planted per hole at a spacing of 2.5cm in March/April of 2013. The Shea trees were watered regularly from an adjacent well at the Substation. Composite soil samples were collected in three replicates at 0-15cm to determine the influence of the sparsely populated grassland and melon plant on soils of the Shea field after four months of cultivation in July of 2013. The collected soil samples were bagged in polyethylene bags for physical and chemical analysis in the laboratory.

Laboratory studies

Physical properties: Particle size distribution was determined by the hydrometer method Boyoucous (Gee and Bauder, 1986).

Chemical properties: Soil organic carbon was determined by the Walkley-Black method (Nelson and Sommer, 1996). Total nitrogen (TN) was determined by Kjeldahl (Bremner, 1996) method. Soil pH was determined in a 1:2 soil to water suspension using a pH meter (Maclean, 1982). Available phosphorus was extracted by the Bray-1 extractant (Bray and Kurtz, 1945). Soil exchangeable bases were extracted by the ammonium acetate method buffered at pH 7 (Thomas, 1982). Calcium and magnesium were read with the aid of a UV2100 Spectrophotometer while potassium and sodium were read with a flame photometer. Cation exchange capacity (CEC) was by the summation of exchangeable bases. Total exchangeable acidity, hydrogen and aluminium ($H^+ + Al^{3+}$) was by titration method (Anderson and Ingram, 1993)while effective cation exchange capacity (ECEC) was determined by summation of exchangeable cations and exchangeable acidity ((Kamprath,1970; Mylavarapu and Kennelley, 2002). The base saturation was calculated as the ratio of exchangeable bases to the effective cation exchange capacity (ECEC) expressed in percentage while the exchangeable sodium percentage (ESP) was computed as the ratio of Na to CEC expressed in percentage (Brady and Weil, 1999).

Statistical analysis: Data obtained from the laboratory was subjected to One- way analysis of variance (ANOVA) and the Least Significance Difference (LSD) procedure at 5% level of probability was used to compare the effects of the two land use types on soil properties. Data were also compared with (FAO 1979) and Snakin *et al*. (1996) outlined indicators and criteria for chemical and biological degradation of soil to ascertain the extent of soil degradation with respect to the two land use.

RESULTS AND DISCUSSION:

Influence of land use on physical properties of the soils

The physical properties of the two land use types are shown in Table 1. The particle size distribution of top (0-15cm) of the soils shows that there is no difference in the textural class of the soils under the two land use types. This means that short term land use did not alter the physical properties of the soils. Texture is largely determined by parent material (Obi, 1999). The fact that there was no difference in the texture of the two land use types agrees with the findings of Amana *et al*., (2012) who studied five land use types (cassava, corn, legume, oil palm and forest) and observed that land use had no effect on the texture of the soils.

Table 1: Effects of two Land use types on soil physical properties of top (0-15cm) soils at NIFOR Substation, BIDA.

S/no	Land use type	Sand	Silt g/kg	Clay	Textural Class
Mean	Grass Fallow		**230**	**260**	Sand
Mean	Melon	**953.33**	**243.33**	**234.33**	Sand
LSD (5%)		NS	NS	NS	

LSD: Least Significant Difference, NS: Non significant.

Table 2: Chemical Properties of the top soil (0-15cm) at NIFOR Substation, Bida.

S/No	Land Use Type	pH	O.C	TN g/kg	Avail. P Mg/kg	Ca	Mg	Na Cnik/lg	K	H^+	ECEC	Base Sat	ESP (%)	SO_4 mg/kg
Mean	Grass Fallow	5.50	3.0	0.12	6.08	1.05	0.87	0.32	0.12	0.41	2.65	88.29	12.82	5.25
Mean	Melon	5.30	3.6	0.20	11.15	1.06	0.49	0.49	0.10	0.5	2.43	81.20	16.22	7.96
LSD (5%)		0.2	0.2	0.02	0.02	NS	0.10	0.02	0.02	0.02	0.02	5.61	0.29	0.05

O.C. = Organic carbon, TN = Total nitrogen, Avail P = Available phosphorus, Ca = Calcium, Mg = Magnesium, K = Potassium, H^+ = Hydrogen ion, ECEC = Effective cation exchange capacity, Base sat % = Base saturation percent, ESP = Exchangeable sodium percentage.

Influence of land use on chemical properties of the soils

All the soil chemical properties except calcium were significantly different as a result of the two land use types (Table 2). This is probably due to the fact that the melon plant provided a better vegetative cover after four months of cultivation than the sparsely populated grass fallow. The better vegetative cover provided by the melon plant may have influenced the accumulation of organic matter in the portion of the field cultivated to melon. This is buttressed by the higher organic carbon content in the portion of the field cultivated to melon (Table 2). The amount of organic material in a soil is often expressed as the amount of organic carbon (Bridges 1978 cited by Ogeh and Osiomwan, 2012). The accumulation of organic matter may have influenced the content of total nitrogen and available phosphorus as these values were significantly higher in the portion of the field cultivated to melon than the values in the sparsely populated grass fallow (Table 2). According to Agboola *et al*., (1998), soil organic matter had been found to be related to all soil nutrients and its activity accounts for 95% of crop yield in the tropics. Vagen *et al*., (2006) support the dependency of soil physical, chemical and biological attributes to soil organic matter. According to them, increased soil organic matter improves aggregation, nutrient-retention capacity, colloidal characteristics and biodiversity in soil. Calcium was also higher in the portion of the field cultivated to melon though the values were not significantly different. There was a significant ($P< 0.05$) decrease between the two land use types with respect to soil pH, magnesium, potassium and effective cation exchange capacity (ECEC). These values were lower in the portion of the field cultivated to melon than the sparsely populated grass fallow(Table 2). This is consistent with the findings of Ogunkunle and Eghaghara (1992) who reported significant differences between land use types in soil pH, extractable P, K, Ca, Mg total N, organic matter and bulk density. This may be as a result of uptake of some of these nutrients by the cultivated melon plant. This is also consistent with the findings of Osundare (2012) who attributed decreases in virtually all the nutrients after cropping in plots where N-fertilizers were not applied to uptake by melon. He also attributed the decrease in soil pH to decreases in the exchangeable bases; which he noted was due perhaps, to leaching and /or melon uptake. Melon has been reported to be a heavy miner of plant nutrients especially nitrogen (Constellanos *et al*., 2011) and the exchangeable bases (Osundare 2012). According to Constellanos *et al*., (2011) dry matter production of leaves and stems of melon (Cucumis *melo*) increased as the N amount increased. The dry matter of the whole plant was affected similarly, while the fruit dry matter decreased as the N amount was increased above 112kg/ha, 93kg/ha and 95kg/ha.

ASSESSMENT OF BIOLOGICAL AND CHEMICAL DEGRADATION:

Assessment of Chemical and Biological degradation as a result of the two land use types

Table 5 shows scores for chemical and biological degradation of the soils as result of the two land use types. This was done by comparing some of the values of the chemical properties obtained with FAO 1979; Snakin *et al*., (1996) and Senjobi *et al*., 2010 guidelines and criteria for assessing chemical and biological degradation in soils (Tables 3 and 4).Soils under Grass fallow and Melon Land use types had scores of 4 each and was therefore very highly degraded with respect to nitrogen (Table 5). Soils under GrassFallow had a score of 3 (highly degraded soils) with respect to phosphorus. The score was 1 in Melon land use type indicating none to slightly degraded soils with respect to phosphorus. Soils under Grass fallow had a score of 3 with respect to potassium and was therefore highly degraded while soils under Melon cultivation had a score of 4 and was very highly degraded.

Soils under Grass fallow and Melon cultivation had scores of 2 each indicating moderately degraded soils while both land use types had scores of 1 each with respect to base saturation indicating none to slightly degraded soils with respect to base saturation (Table 5). This buttresses the fact that the soil exchange complex of the two land use types are saturated with exchangeable bases with base saturation percent values of 89 and 88 respectively (Table 2).

Table 3: Indicators and Criteria for Chemical Degradation of Soils

	* Degree of degradation (%)			
Indicator	**1**	**2**	**3**	**4**
Content of Nitrogen Element (Multiple decrease) N (%)	> 0.13	0.10 - 0.13	0.08-0.10	< 0.08
Content of phosphorus Element (mg/kg)	> 8	7 – 8	6 – 7	< 6
Content of Potassium Element (cmol/kg)	> 0.16	0.14 – 0.16	0.12 – 0.14	< 0.12
Content of Readily Soluble Salts (Increase by %)	< 0.20	0.20 – 0.40	0.40 – 0.80	> 0.8
Content of ESP (Increase by % of CEC)	< 10	10 – 25	25 – 50	> 50
Content of Base Saturation (Decrease of Saturation if more than 50%)	< 2.5 %	2.5 – 5%	5 – 10%	> 10%
Excess Salts (Salinization) (Increase in conductivity) mmho/cm/yr	< 2	2 – 3	3 – 5	> 5

*** Source:** FAO (1979); Snakin *et al*., (1996); Senjobi *et al*., 2010.

** Where 1 = None to slightly degraded soils
2 = Moderately degraded soils
3 = Highly degraded soils
4 = Very highly degraded soils

Table 4: Indicators and Criteria for Biological Degradation of Soils

Indicator	**1**	**2**	**3**	**4**
Content of organic matter in soil (%)	> 2.5	2 – 2.5	1.0 – 2	< 1.0

Source: FAO (1979); Snakin *et al*., (1996) Senjobi *et al*., (2010).

** Where 1 = None to slightly degraded soils
2 = Moderately degraded soils
3 = Highly degraded soils
4 = Very highly degraded soils

Table 5: Scores for Chemical and Biological degradation of the two land use types at NIFOR Substation, BIDA.

Chemical properties of soils of the two land use types	Land use type	Score
Nitrogen	Grass fallow	4
	Melon	4
Phosphorus	Grass fallow	3
	Melon	1
Potassium	Grass fallow	3
	Melon	4
Exchangeable Sodium Percentage (ESP)	Grass fallow	2
	Melon	2
Base Saturation (%)	Grass fallow	1
	Melon	1
Organic matter	Grass fallow	2
	Melon	1

1 = None to slightly degraded soils
2 = Moderately degraded soils
3 = Highly degraded soils
4 = Very highly degraded soils

CONCLUSION

The type and degree of degradation found on the two land use types are major factors to be considered in determining the appropriate approach to soil rehabilitation or improvement for Shea tree cultivation at NIFOR substation, Bida. Chemical and biological degradation were as a result of soil fertility depletion and organic matter decline. Bio-reclamation of Degraded Lands (BDL) system which enhances the conversion of degraded crusted soils into productive lands is suggested. This can be achieved by combining water harvesting technologies (micro-catchments, planting pits and trenches), application of animal and plant residues and planting of high-value nitrogen-fixing trees and cover crops. Further studies are needed to ascertain the extent of physical, chemical and biological degradation in Shea parklands that are currently being used by the local farmers for guinea corn, millet and maize cultivation. Findings from such studies will help improve the management of soils of the Shea tree parklands for improved seed production for export purposes and meet farmers return on investment.

ACKNOWLEDGEMENT:

The corresponding author is grateful to the Executive Director of the Nigerian Institute for Oil Palm Research (NIFOR) and the Director, Date Palm & Shea Tree Development Department for funding. Sincere thanks are also due to Dr. Mrs. Esohe G. Ilori for providing a comfortable means of transportation to both substations. Worthy of mention here is the Officer in charge of NIFOR Substation, Bida for his wonderful hospitality during the period of our stay at the station.

REFERENCES:

Abubakari A H., Nyarko G., Yidana J.A., Mahunu G.K., Abagale F.K., Quainoo A., Chimsah F. and Avornyo V (2012). Comparative Studies of Soil Characteristics in Shea parklands of Ghana. *Journal of Soil Science and Environmental Management.* Vol 3 (4), pp 84-90

Adaikwu A.O., Obi M.E. and Ali A. (2012). Assessment of degradation status of soil in selected areas of Benue state, Southern Guinea Savanna of Nigeria. *Nigerian Journal of Soil Science* 22 (1) PP 171-180

Agboola, A.A., Ndaeyo N.U., and Kalu O.I. (1998). Soil fertility management alternatives to Inorganic Fertilizer use. In O. Babalola; G.A. Babajide and S. Mustapha (Eds.), Soil management for sustanaible Agriculture and environmental harmony, *Proc.*24th Annual Conference of Soil Science Society of Nigeria. (pp. 1-9). Bauchi. 7th -11th December, 1998.

Amalu, U.C. (1998). Issues on agricultural and environmental sustainability chapter 7, in Agricultural Research and Extension Delivery System in Sub Sahara Africa. University of Calabar Press, Calabar, Nigeria.

Amana, S.M., Jayeoba, O.J. and Agbede O.O. (2012). Effects of land use types on soil quality in a Southern Guinea Savanna, Nasarawa State of Nigeria. *Nigerian Journal of Soil Science*, Volume 22 (1). PP 181-185.

Asadu, C.L.A. and Enete A.A. (1997). Food crop yields and soil properties under population pressure in sub-Saharan Africa: The case of cassava in Southeast Nigeria. Outlook on Agriculture, 26: 29-34

Anderson, J.M. and Ingram, J.S.L. (1993). Tropical Soil Biology and Fertility; A Handbook of Method of Analysis *International Wallingford*, UK, 38-39

Brady, W.C. and Weil, R.R. (1999). The nature and properties of soil. 12th Edition, Prentice Hall, New Jersey

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

Bremner, J.M: Methods of Soil Analysis, Part 3. Chemical Methods, Soil Science of America and American Society of Agronomy, SSSA Book Series No. 5, Madison-USA (1996).

Bridges, E.M. (1978). *World Soils*. 2nd edition. University Press, Cambridge. ISBN 0-521-29339-1.

Constellanos M.T., Cabello M.J., Cartagena M.C., Tarquis A.M., Arce A. and Ribas F (2011). Growth dynamics and yield of melon as influenced by nitrogen fertilizer. *Sci. Agric* (Piracicaba, Braz.) vol 68, Number 2, P 191-199.

FAO (1979). A provisional methodology for soil degradation assessment. FAO Rome, 84 pp.

FAO (1997a). *Africover land cover classification*. Remote Sensing Centre Series 70. FAO, Rome.

FAO (1994). Mangrove Forest Management Guidelines. FAO Forestry Paper 117, 319pp.

Gee, G.W. and Bauder J.W. (1986). Particle size analysis, In: Wute A (ed) Methods of Soil Analysis. Part 1 physical and mineralogical methods. 2nd edition. Madison, WI. USA: ASA-SSA, Pp. 383-411

Kamprath, E.J., (1970). Soil acidity and liming. In: P.A. Sanchez (Ed.), A review of soil research in tropical Latin America. N.C. Exp. Station Technical Bulletin No. 219.

MaClean, E.O (1982). Aluminium in C.A. Black (ed). Methods of Soil Analysis. Part 2, Agro Monograph 9, Second edition, ASA and SSA, Madison, Wisconsin. PP 539-579

Mylavarapu, R.S. and D.E. Kennelley (2002). UF/IFAS extension soil testing laboratory (ESTL): Analytical Procedures and training manual. Institute of Food and Agricultural Sciences, University of Florida, Gainesville, USA, pp 28.

Nelson, D.W. and L.E. Sommer (1996).Total carbon, Organic Carbon and Organic Matter. In: Sparks, D.L. (Ed), Methods of Soil Analysis. Part 3. SSSA Book Series No. 5 SSSA Madison, WI,PP: 960-1010.

Nnaji, G.U., Asadu C.L.A. and Mbagwu J.S.C. (2002). Evaluation of physico-chemical properties of soils under selected agricultural land utilization types. *Agro Science,* 3: 27-33.

Ogeh J.S. and Osiomwan G.E. (2012). Evaluation of the effects of oil palm on some physical and chemical properties of Rhodic Paleudults. *Nigerian Journal of Basic and Applied Sciencces* 20(1) 78-82.

Obi, M.E. (1999). Physical and Chemical responses of a degraded sandy clay loam soil to cover crops in Southern Nigeria. *Pland* and *Soil* 211: 165-172.

Ogunkunle A.O. and Eghaghara, O.O. (1992). Influence of land use on soil properties in a forest region of Southern Nigeria. *Soil Use and Management.* 8(3): 121-125.

Osundare B. (2012). Responses of Melon (*Collocynthis citrullus*) and Soil chemical properties to different N-sources in Ado-Ekiti, Southwestern Nigeria. *Nigerian Journal of Soil Science* 22 (1).

Oviasogie, P.O., Aisueni N.O., Oko-Oboh E., and Stephen O. (2011). Land use and biophysical properties in relation to Elaeis *guineensis* and Hevea *brasiliensis* estabilishment. *Nigerian Journal of Life Science* 1(2) PP 135-140.

Senjobi B.A., Ande O.T. and Ogunkunle A.O. (2010). Land degradation assessment under different uses. In: Taiwo L.B., Oluwatosin G.A., Adediran J.A., Are K.S., Oke A.O. and Ojeniyi S.O. (Eds), Emerging Challenges to Soil Resources in Times of Global Climate Change and Food Crisis. Proceedings of the 34th Annual Conference of the Soil Science Society of Nigeria, March 22nd to 26th, 2010.

Snakin, V.V., Krechetor, P.P., Uzovnikova, T.A., Alyabina I.O., Gurov A.F., Stepichev A.V. (1996). The System of assessment of soil degradation. *Soil Technology*. **8**: 331-343.

Thomas, G.W. (1982). Exchangeable cations. In: Page A.L. *et al* (eds). Methods of Soil Analysis part 2. *Agron. Monigr* 9. Wisconsin 3rd edition. *ASA* and *SSSA* Madison, pp 159-165.

Vagen T.G., Andrianorofanomezana M.A.A. and Andrianorofanomezana S. (2006). Deforestation and Cultivation effects on Characteristics of Oxisols in the highlands of Madagascar. *Geoderma* **131**: 190-200.