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EFFECTS OF 27-YEAR OLD DIFFERENT FALLOW SYSTEMS ON PROFILE PROPERTIES OF AN ALFISOL IN SOUTHERN GUINEA SAVANNA

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Abstract

A profile pit each was dug in two fallow lands under Gmelina arborea and natural bush fallow at the University of Ilorin, Teaching and Research farm in the southern guinea savannah to evaluate the effects of different fallow systems on the physical, chemical and morphological properties of the soils. Samples were collected from the pedogenic horizons of each profile at different depths and later condensed to form surface and subsurface soil samples. The result of the analysis shows that though the soil characteristics seemed to be better under Gmelina fallow, the differences in the physical and morphological properties were not statistically different under the two land use systems. Also, the Ca, K, Mg, Na, total acidity and base saturation (BS) were not significantly affected by the profile depth (surface and subsurface). However the soil reaction (pH) and effective cation exchange capacity were significantly affected by soil depths.

Introduction

Land degradation is a major problem in many parts of the tropics (Hartman 1981). This has been recognized as a major factor contributing to low agricultural productivity in sub-sahara Africa (Sanchez, 2002; Vanlauwe and Giller, 2006). This is due to over exploration of vegetation and adoption of inappropriate methods of farming. Therefore, there is a need to increase the sustainable agricultural productivity of land with acceptable inputs to meet increasing human needs while maintaining the soil resource base and minimizing environmental degradation. Agboola and Ayodele (1985) have shown that the soil degradation under some traditional farming systems is on the increase in the tropics and to reclaim the degraded soil through traditional fallow technique has not been easy because of the high demand for land and the relatively long fallow periods required. Woody trees play an important role in increasing fertility status of soils under its stand by providing adequate litter falls and decomposition by soil biota to return nutrients back to the soil for use (Diack *et al.* 2000). *Gmelina arborea* is a short live woody tree that has been found to improve physical, chemical and biological properties of soil and can regulate the flow of soil nutrient (Kang *et al.*, 1990). The soil fertility status depends on the amount and availability of essential nutrient elements for plant growth and development (Lombin, 1999). The study aimed at evaluating the physical, chemical and morphological properties of soil under *Gmelina arborea* fallow and compares it with those under natural fallow with a view to understanding the potential of *G. arborea* in ameliorating soil fertility status

Materials and Methods

Description of the Experimental Sites

The study was carried out Agro- forestry Establishment of the University of Ilorin Teaching and Research farm located on Latitude 8^o 29’ N, Longitude 4^o 35’ E and on an elevation of 310 m above sea level. The study area falls within the southern Guinea savannah zone of Nigeria.

Soil Sampling and Analysis

A parcel of land on an Alfisol mapping unit was used for this experiment. A portion of the land was planted to *G. arborea* while the other portion was left under natural fallow since 1986. A soil profile pit was dug on sites representing each of the two identified fallow systems (*Gmelina arboria* and Natural fallow land). The profile pits were described following FAO 1980 guideline and soil samples were taken from each pedogenic horizon for laboratory analyses as follow;

- Particle size distribution was analysed using hydrometer method and textural class was determined by the soil textural triangle.
- Soil pH was determined in water by using a soil solution ratio of 1:2 by means of a Philip analogue pH meter.
- Available phosphorus was determined by Trough method. The extracted phosphorus was determined by the molybdate blue colour method (Bremner, 1996).
- The exchangeable bases, calcium (Ca), magnesium (Mg), potassium (K) and Sodium (Na) were extracted using IN Ammonium acetate (pH 7.0).
- Percentage organic carbon (OC) was determined using Walkley - Black method (IITA, 1979). Percent organic matter (OM), was determined by multiplying product of organic carbon with 1.724,
- Effective cation exchange capacity (ECEC) was determined by summation of basic cations and exchangeable acidity.

The horizons from each profile were condensed into surface and subsurface soils for statistical analysis. All data collected were subjected to analysis of variance (ANOVA) and significant means were separated using $LSD_{(0.05)}$

Results and Discussion

Table 1 shows the results of physical, chemical and morphological properties of the two sites studied. The result reveals that clay movement under gmelina was more than under natural fallow hence, the argillic horizon was more pronounced under Gmelina. This may be as a result of the effect of the rooting system of the Gmelina plants that promotes better soil aggregation leading to better porosity. However, it was statistically shown that these variations in the textural classes of the two sites (*Gmelina* and natural bush fallow) were not significant and this confirms that texture is not a property that can easily change under soil management unlike soil structure (Olaniyan, 2001). The two sites were dominated by sandy loam texture though these also varied with depth in the two sites. The surface layers contained more sand than the subsurface layers in the two sites. Similarly, the soil colour both under *Gmelina arborea* and natural bush fallow had the same hue in the 10YR region the *Gmelina* site possess colour ranging from dark brown at the surface and brownish yellow at the subsurface layers while the natural bush fallow possess pale brown at surface to very pale brown at the subsurface layers. The dark brown colour of the surface layer in the *Gmelina* site can the attributed to the higher percentage of organic matter obtained from the leaf litter as shown in Table 2. In another vein, the soil reactions in the two sites generally ranged between slightly acidic to moderately alkaline. The pH under *Gmelina* ranges from 4.9 to 8.1 while under the natural bush fallows it ranged from 6.4 to 7.7.

The top soil under Gmelina had extremely low pH (4.9) this is acidic. The low pH under *Gmelina* can be attributed to the presence of microorganisms on the surface that acts on leaf litter, while the higher pH of the natural bush fallow can also be attributed to the increase in bases such as Ca, K and Mg. There were no significant differences among the surface and subsurface soils of the two pits in the quantities of organic matter content (OM%), calcium (Ca), potassium (K), magnesium (Mg), sodium(Na), total acidity (TA), percentage basic cation saturation (BCS%) and total available phosphorus(P). However, *Gmelina* pit had higher percentage of organic matter (1.3500), calcium (2.14 cmol/kg)), potassium ((0.910 cmol/kg) and Magnessium (2.97 cmol/kg) at the surface when compared with natural bush fallow as shown in (Table 2). This shows that *Gmelina arborea* is superior to other plants contained in the natural fallow in drawing nutrients from strata inaccessible to most plants and gradually supply them to the top soil through leaf fall which decomposed rapidly. The effective cation exchange capacity (ECEC) in all depths was higher than the critical value of 4 cmol/kg of soil for the tropical soils. This high value of ECEC can be attributed to the degree of weathering and leaching processes as described by (Kang *et al*., 1991). The ECEC under *Gmelina arborea* was significantly higher than the ECEC under the natural bush fallow at the surface while the reverse was the case at the sub surface soil as shown in Table 2. This confirms that fallow (whether natural or specific) is a sure way of improving soil condition, however the use of *Gmelina arborea* as a fallow crop is superior to natural fallow in this ecological zone.

Conclusion and Recommendation

The results of the experiment shows that the use of *Gmelina arborea as a fallow crop* is superior to leaving the land under natural fallow. The Gmelina plot was higher in percentage organic matter and basic exchangeable cations as well as other nutrient elements that are organic matter-bound when compared with natural bush fallow, as a result of the accumulated leaf litters deposition on the soil surface. However, it acidulates hence; care must be taken in the choice of soil and crop to be planted along with or after it. It can also be that *Gmelina arborea* should be used either as fallow crop or other agro-forest systems involving production of arable crops in areas where there are salinity problems.

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Table 1: Physical, Chemical and Morphological Properties of Different Fallow in Alfisol

	Depth	Particle size			Textural Class	Colour	pH $(1:1H_2O)$	OM %	Ca	K	Mg	Na	Total acidity	ECEC cmo/ kg	Ava. P Mg/kg	BCS %
		Sand%	Silt%	Clay%					cmol/kg of soil							
Profile Pit 1	0-20	75.36	16.00	8.64	Sandy Loam	10YR4/3 DB	4.9	1.71	3.15	2.66	1.26	0.43	0.35	7.85	19.81	95.5
	20-35	89.36	18.00	10.64	Loamy sand	10YR 5/8 YB	5.9	0.99	1.12	3.28	0.56	0.61	0.50	16.10	9.18	95.8
	35-60	67.36	16.00	16.64	Sandy Loam	7.5YR 6/8SB	7.1	0.61	1.26	2.46	0.42	0.43	0.75	5.32	14.14	85.9
	60-90	61.36	20.00	18.64	Sandy Loam	10YR 6/8 BY	8.1	0.38	1.33	1.23	0.28	0.43	0.85	4.12	10.01	85.9
Profile 2	0-25	77.36	12.00	10.64	Sandy loam	10YR 6/3 PB	6.7	1.24	1.33	2.87	0.70	0.52	1.55	6.97	17.22	77.8
	25-55	77.36	12.00	10.6	Sandy Loam	10YR 5/8 YB	7.1	0.89	0.84	2.97	0.63	0.52	0.70	5.66	15.16	87.6
	55-90	75.36	12.00	10.64	Sandy loam	7.5YR 5/6 W	6.4	0.88	0.63	2.97	0.63	0.52	1.80	6.55	12.22	72.5
	90-120	61.30	30.00	8.64	Sandy loam	10YR 8/2 W	7.1	0.60	1.05	2.87	0.35	0.35	0.25	4.87	7.77	94.9
	120-150	89.36	18.00	10.64	Loamy sand	10YR 8/4VPB	7.7	0.36	1.40	2.46	0.70	0.43	2.95	7.94	2.24	82.8

D=Dark; B=Brown; Y=Yellow; S= Strong; P=Pale; W=White: V=Very

Table 2: Physico-chemical properties of surface and subsurface soils of the two pits

		G. arborea	Natural Bush Fallow	SE±	LSD
pH	Surface	5.40b	6.90a	0.23	0.456
	Subsurface	7.10b	7.75a	0.32	0.642
OM%	Surface	1.35	1.07	0.18	Ns
	Subsurface	0.49	0.74	0.24	Ns
K Cmol/kg	Surface	0.91	0.67	0.223	Ns
	Subsurface	0.35	0.49	0.117	Ns
Ca Cmol/kg	Surface	2.14	1.09	0.85	Ns
	Subsurface	1.30	0.84	1.22	Ns
Mg Cmol/kg	Surface	2.97	2.92b	0.62	Ns
	Subsurface	1.85	2.92	0.88	Ns
Total acidity%	Surface	0.43	1.12	0.64	Ns
	Subsurface	0.80	1.03	0.92	Ns
ECEC Cmol/kg	Surface	6.96a	6.32b	0.224	0.447
	Subsurface	4.72b	5.71a	0.32	0.632
BCS%	Surface	93.7	82.7	10.5	Ns
	Subsurface	82.7	83.7	14.99	Ns
Available P Mg/kg	Surface	17.95	16.19	8.51	Ns
	Subsurface	12.08	10.01	1.204	Ns