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COMPARATIVE EFFECT OF SELECTED TREE LEGUMES ON PHYSICO-CHEMICAL PROPERTIES OF AN ALFISOL IN EKITI STATE

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ABSRACT

Soils in the tropics commonly suffer from multiple nutrient deficiencies due to continuous cultivation. The negative impact of in organic fertilizer on soil and environment appears to have made its application on soil to be less effective. This study thus examined the effect of tree legumes on physio-chemical properties of an alfisol. Soil samples from three year fallows of *Senna siamea, Gliricidia sepium, Leucaena leucocephala* and natural fallow were collected at 0-15 cm and 15-30 cm depth. The samples were analyzed using standard laboratory procedures. The result revealed that leguminous species improved the textural class of the soil from loamy sand to sandy loam at 0-15 cm depth. Bulk density along the soil depth increases under agroforestry species fallows than the natural fallow. Chemical properties along the soil depths significantly ($p < 0.05$) improved under leguminous fallows with pH range (7.02-7.19), N (0.61% - 2.79%) and P (211.71ppm - 242.11ppm) when compared with the soil under natural fallow with pH (5.96 - 6.77), N (0.10% - 0.73%) and P (206.15ppm-224.88ppm) Also there is a significant reduction in values of Na (66.29ppm- 50.48ppm) and K (75.52ppm -52.22ppm) in soils under agroforestry species along the soil depth, when compared with natural fallow Na(74.21ppm - 67.83ppm) and K (90 .0ppm - 76.66 ppm).

Keywords: tree legumes, agroforestry, physico-chemical, alfisol, ekiti state.

INTRODUCTION

Soil fertility management on smallholder farms in the tropics has become a major issue as a result of degradation due to rapid population growth (Fitzparick, 1986). In Nigeria, particularly in the south western zone, continuous cropping with intercropping intensified has greatly reduce the fertility of agricultural lands, to the extent that it could no longer supply the nutrient required by crops for normal growth. Most of the soils in tropics are dominated by alfisols, utisols and oxisols with low activity clay. These soils have low buffering capacity, low water retention and are susceptible to soil erosion and compaction. Thus soils in this region suffer from multiple nutrient deficiencies, nutrient imbalances and degradation of vital chemical properties (Ogunkunle, 2009).

The destruction of vegetation through forest clearing for cropping purposes further reduces the vegetation cover thereby leading to erosion, especially in the sloppy area. Leaching of nutrients below the rooting zone of crops as a result of water logging, and the volatilization of nitrogen (N) and deficiency of phosphorus are common. Although high crop yield can be obtained with application of inorganic fertilizer, agriculture with such high input is no more popular because of its high cost and negative impact on soil and environment. Also continuous intensive cultivation with application of urea fertilizer to supply nitrogen could alter the soil physical and chemical properties by decreasing the pH and reducing the exchangeable base contents which leads to soil degradation (Odunze *et al.*, 2012; Eche *et al.*, 2013). Consequently, research efforts have been geared towards organic farming with the use of trees on farmland intensified.

Agroforestry, a land management system which involves the incorporation of leguminous woody species into crop production and /or animal production, is one option that has received significant attention in the recent years among agriculturists and foresters. Agroforestry offers a potential solution to the problem of land degradation and declining agricultural production in the tropics (Olujobi and Oke, 2005). The distinctive contributions of agroforestry tree species include improve infiltration, fixation of atmospheric nitrogen and recycling of nutrient from lower soil horizons through nutrient pump. There is no doubt that trees have plaid important role in soil conservation and management throughout the tropics. However, the choice of tree species for use in agroforestry is very important and to a large extent determines the success or failure of the system (Atta-Krah and Sumberg, 1998).

According to Rachie (1983), selection of trees for agroforestry is based on general criteria of climate and soil. Another important criterion to be considered in choosing tree species for agroforestry is the characteristics of the tree, such as high biomass production and fast or moderate rate of litter decay (Vergara, 1984). The potentials of leguminous plants as a source of nutrient for agricultural crops are being exploited in tree fallow and alley cropping system. The aim of this study therefore, is to evaluate the comparative effect of improved tree legume fallow and natural fallow on the physico-chemical properties of an alfisol.

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MATERIALS AND METHOD

The Study Area

This study was carried out at the Teaching and Research Farm, Ekiti State University Ado-Ekiti, in South West Nigeria. Ado Ekiti is located between Latitude7^0 6' and 7^0 7' North and Longitude 5^0 24' and 5^0 29' East in the rainforest belt at an elevation of 25 m above sea level. The annual rainfall ranged from 1, 200 mm to 1, 500 mm. Day temperature fluctuates between minimum of 24^oC and maximum of 35^oC with little variation throughout the year. The annual relative humidity ranged between 65% and 90% during the raining season. The soil is an alfisol (Oxic-Tropudalf - USDA soil taxonomy or Ferruvic - FAO/UNESCO). The soil is well drained with moderate fertility.

Soil sample collection and preparation

Soil samples were collected from three years fallow of each of the three selected multipurpose tree species (*Senna siamea, Gliricidia sepium* and *Leucaena leucocephala*) at the depth of 0-15 cm and 15-30 cm using soil auger. Soil samples were also collected from land under natural fallow (control). Sample collection at each level were replicated three times at different spots. Samples were air dried, crushed and sieved through 2 mm sieve mesh for laboratory analysis.

Laboratory analysis

Soil samples were analyzed using standard laboratory procedures. The particle size distribution was determined using Bouyoucos hydrometer method as modified by Gee and Bauder (1986). The textural classes were subsequently obtained using the soil textural triangle. Bulk density was determined by the gravimetric method using undisturbed soil cores (Blake and Hartge, 1986). Soil pH was determined with a pH meter (Maclean, 1982). Cation exchange capacity was determined using the neutral normal ammonium acetate (NH_4OAC) method (Devis and Freitas, 1970). Organic carbon was determined using dichromate wet oxidation method (Nelson and Sommers, 1982). Exhangeable Ca and Mg were determined from the extracts by EDTA titration method (Devis and Freitas, 1970). The elements Na and K were determined using flame photometer (Rich, 1965) Total nitrogen was determined by micro-Kjedahl method (Jackson 1962). Available phosphorus was determined using Bray no. 1 method (Bray and Kurtz, 1945).

Stastical analysis

Data collected were subjected to one way Analysis of Variance (ANOVA) using Statistical Analysis System (SAS) (2000) package at 5% level of significant to determine differences in the treatment effect. Where significant differences occur, the means were separated using Duncan's New Multiple Range Test (DMRT).

RESULTS AND DISCUSSIONS

Effect of agroforestry tree species on soil physical properties

The result in Table-1 revealed that textural class of the soil under agroforestry tree fallows improved from loamy sand to sandy loam at the surface layer of the soil when compared with that of natural fallow. The observed improvement in texture from loamy sand to sandy loam, could be attributed to the increase in silt level (Tables-1 and 2) which probably results from the formation and addition of humus from the decomposed high quality litters from the agroforestry species. This observation is in agreement with the submission of Ogunwole (2005), who reported that improvement in soil physical property depends on the quality of residue cover. Similarly the observed improvement in texture due to higher values of silt and clay at the sub-surface level in all the treatments is in consonance with the results obtained by Audu *et al.,* (2009). The least bulk density value obtained under natural fallow at the soil surface level (Table-1) compared to the values obtained under agroforestry species treatments could be as a result of mart layer formed by low quality litters which does not decompose easily, thereby lowering soil compaction by rain drops. The implication is that soils under agroforestry tree species are more compacted, thereby increasing the water holding capacity of the soil than the soil under natural forest which drain and dry fast due to high porosity. The higher bulk density value obtained at sub-surface level (Table-2) in all the treatments could be due to the weight of the upper soil layers (Odunze *et al.*, 2009). Generally, the observed mean range of bulk density in the study (1.21 g/cm^3-1.35 g/cm^3) is ideal for optimum root growth since it is less than 1.40 g/cm^3 (Eche *et al.,* 2013).

Table-1. Particle size distribution and bulk density of the sampled soil (0-15 cm).

Species	**Sand** (%)	**Silt** (%)	**Clay** (%)	**Bulk density** (g/cm^3)	**Textural class**
Senna siamea	70.31	22.20	8.48	1.23	Sandy loam
Gliricidia sepium	70.43	20.88	8.68	1.25	Sandy loam
Leucaena leucocephala	70.33	21.09	10.57	1.29	Sandy loam
Natural fallow	73.78	19.00	7.21	1.21	Loamy sand

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Table-2. Particle size distribution and bulk density of the sampled soil (15-30 cm).

Species	**Sand** (%)	**Silt** (%)	**Clay** (%)	**Bulk density** (g/cm^3)	**Textural class**
Senna siamea	58.82	27.81	13.35	1.25	Sandy loam
Gliricidia sepium	68.76	21.14	10.10	1.28	Sandy loam
Leucaena leucocephala	60.53	24.66	14.80	1.35	Sandy loam
Natural fallow	69.68	21.22	9.10	1.23	Sandy loam

Effect of agroforestry species on soil chemical properties

The significant ($p < 0.05$) higher values of pH and exchangeable hydrogen (H^+) obtained in soils under agroforestry species treatments, when compared with the soil under natural fallow (Tables 3 and 4), may largely be due to addition of high organic matter content from rapid decomposition and mineralization of high quality litters from these tree species. Similar observation has been reported by Madukwe, *et al* (2008) that organic residue neutralizes acidity of farm land by increasing the soil pH and exchangeable hydrogen (H^+) of soil. Also the observed increase in Calcium (Ca) level of the soil under agroforestry species over that of natural fallow at both soil depth is a proof that these species of trees ameliorate soil acidity. This assertion agrees with Drechsel *et al* (1991) who earlier reported that leguminous trees species (*Senna siamea* and *Albizia lebbeck)* significantly ameliorate soil acidity by increasing top soil pH and Ca level.

Significant ($p < 0.05$) reduction in the sodium (Na) ion (a major cause of soil sodicity) under agroforestry species treatments compared to that of natural fallow in the result, could also be attributed to significant ($p < 0.05$) higher organic carbon in soils under agroforestry species treatments over that of natural forest. The reduction in Na ion would definitely increase the productive capacity of the soil under the selected agroforestry species. This assertion is in consonance with the report of Singh *et.al* (1988) that the growth of leguminous agroforestry species (*Prosopis juliflora*) restored alkaline soil of 90% exchangeable Na in central Togo. Significant ($p < 0.05$) higher nitrogen (N) values obtained under fallows of the selected agroforestry species compare to the value obtaned for soil under natural fallow may have resulted from the combine effect of rapid decomposition and mineralization of the high quality litters of agroforestry trees to release nutrients and biological nitrogen fixation (BFN) through mycorrhizal association in the root nodules of the species (Olujobi *et al*., 2013).

The positive correlation relationship observed between organic carbon and other soil mineral nutrients in this study (Tables-5 and 6) is an indication that these species improved soil fertility, thus can be used to correct deficiency of soil nutrient especially N and P, which are the most defficient in tropical soil and the most limiting in plant growth (Saika and Jain, 2007, Eche, *et al* 2009). The general decline observed in OC, N, P, Ca CEC and other plant nutrients at the sub-surface soil level in all the treatments, may be due to leaching, runoff and plant uptake (Eche *et al*., 2013).

Table-3. Chemical properties of the sampled soil (0-15 cm).

Variables	**Treatments**			
	S S	**G S**	**L L**	**N F**
pH of H_2O	7.19a	7.02c	7.11b	6.77d
Org. C (%)	2.99a	2.84b	2.63c	1.42d
N (%)	2.67a	2.73a	2.02b	0.73c
Exch. bases (ppm)				
Na	57.14c	55.36d	66.29b	74.21a
K	73.40c	75.53b	63.64d	90.07a
Ca	67.08b	74.20a	66.13c	63.63d
Mg	86.30c	86.48c	87.77b	89.53a
CEC	2.77a	2.87a	2.79a	3.28a
Base sat. (%)	10.25a	10.16a	10.17a	9.68a
P (ppm)	231.49bc	242.11a	235.57ab	224.88c
Al^{3+}	0.53c	0.82ab	0.74b	0.89a
H^+	0.71b	0.81b	1.14a	0.46c

Mean with thesame letter in the row are not significantly different at ($p < 0.05$)
SS– *Senna siamea,* GS– *Gliricidia sepium,* LL– *Leucaena leucocephala*, NF– Natural forest

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Table-4. Chemical properties of the sampled soil (15-30 cm).

Variables	15-30 cm			
	S S	**G S**	**L L**	**N F**
pH of H_2O	7.10a	6.15c	7.07b	5.96d
Org. C (%)	1.86a	1.34a	1.71a	1.11a
N (%)	0.61b	1.12a	1.14a	0.10c
Exch. bases (ppm)				
Na	52.81c	50.48d	58.57b	67.83a
K	52.22a	56.34a	52.72a	76.66a
Ca	65.26b	69.69a	63.91c	53.61d
Mg	84.79a	86.25a	85.17a	78.52a
CEC	2.60b	2.73b	2.70b	4.74a
Base sat. (%)	9.81a	9.62a	9.64a	7.25a
P (ppm)	211.71a	230.57a	231.68a	206.15b
Al^{3+}	0.52d	0.88b	0.73c	0.87a
H^+	0.69c	0.74b	0.92a	0.41d

Mean with thesame letter in the row are not significantly different at ($p < 0.05$)
SS-*Senna siamea,* GS- *Gliricidia sepium,* LL- *Leucaena leucocephala*, NF- Natural forest

Table-5. Correlation matrix showing relationship between the chemical properties of the soil at 0-15 cm depth.

	pH	**OC**	**N**	**Na**	**K**	**Ca**	**Mg**	**CEC**	**B**	**P**	**Al+**	**H+**
pH	1.00											
OC	0.35	1.00										
N	0.42	0.17	1.00									
Na	0.05	-0.40	-0.94	1.00								
K	0.46	0.58	-0.63	0.47	1.00							
Ca	0.82	0.31	0.72	-0.81	-0.26	1.00						
Mg	0.20	-0.30	-0.95	0.98	0.58	-0.71	1.00					
CEC	0.21	0.18	0.19	-0.27	0.03	0.47	-0.20	1.00				
BS	-0.76	0.05	0.12	0.06	-0.04	-0.36	-0.03	-0.00	1.00			
P	-0.53	0.07	0.69	-0.70	-0.56	0.83	-0.07	0.35	-0.25	1.00		
Al+	-0.05	-0.14	-0.59	0.53	0.48	0.00	0.65	0.19	-0.43	-0.12	1.00	
H+	-0.83	-0.74	0.34	-0.18	-0.90	0.07	-0.29	0.02	-0.95	0.41	-0.23	1.00

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Table-6. Correlation matrix showing relationship between the chemical properties of the soil at 15-30 cm depth.

	pH	OC	N	Na	K	Ca	Mg	CEC	B	P	Al+	H+
pH	1.00											
OC	0.55	1.00										
N	0.32	0.40	1.00									
Na	0.07	-0.23	-0.69	1.00								
K	0.64	-0.48	-0.11	-0.20	1.00							
Ca	0.82	0.33	0.81	-0.96	0.09	1.00						
Mg	0.18	-0.14	0.08	-0.31	-0.09	0.35	1.00					
CEC	0.21	0.48	-0.79	0.88	-0.16	-0.91	-0.17	1.00				
BS	-0.64	-0.12	0.28	0.09	-0.08	-0.03	-0.08	-0.10	1.00			
P	-0.32	0.13	0.10	-0.32	-0.09	0.37	0.99	-0.18	-0.08	1.00		
Al+	-0.45	-0.34	-0.07	0.45	-0.48	-0.33	0.20	0.58	0.01	0.19	1.00	
H+	-0.90	0.55	0.87	-0.59	-0.00	0.72	0.07	-0.86	0.28	0.09	-0.30	1.00

CONCLUSIONS

Results from this study revealed that the use of multipurpose tree species (S*enna siamea, Gliricidia sepium and Leucaena leucocephala*) in fallow system significantly improve physical and chemical properties of soil when compered with natural fallow. Results obtained from this study has established that the selected multipurpose tree species greatly affects the dynamic relationship between different soil parameters i.e. (soil pH, H^+, organic carbon, N, P, K and CEC of the soil). Also the result has revealed that *Gliricidia sepium* significantly performed better in improving soil nurients (N, P, K, Ca and CEC) than *Senna siamea* and *Leucaena leucocephala*. Since there are variations in the impact of the different tree species on soil fertility improvement, this could form the basis for thier selection as fallow tree in the study area. It is however recommended that Farmers should be educated more on how to improve their traditional agroforestry practices using improved fallow system. Also for easy adoption, farmers should be educated more on the services and environmental functions of trees on crop land.

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