EFFECT OF AGROFORESTRY TREES ON CHEMICAL PROPERTIES OF VERTISOLS OF THE SAHEL REGION OF BORNO STATE, NIGERIA.

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ABSTRACT

Agroforestry practices involving the planting or retention of trees on croplands have been proposed as a simple solution to the restoration of soil fertility, especially in the semi arid regions. To test the validity of this proposal, a study to evaluate the contribution of 15 years old plantations of Acacia nilotica, Acacia senegal, Balanites aegyptiaca trees to soil fertility was undertaken on Borno vertisols. Soil samples were taken from the treated and control plots, these were analysed for soil pH, Organic matter, Nitrogen, phosphorus and Effective cation exchange capacity. The experimental design adopted was a Randomised Complete Block Design replicated four times. The result indicated a lowering of the soil pH under the tree covers while there was an increase in organic matter content in soils under Acacia senegal, increased total Nitrogen under Acacia nilotica and Acacia senegal. Changes in Phosphorus and effective cation exchange capacity did not show any specific pattern.

Key Words: Vertisol, Agroforestry tree species, Chemical properties.

INTRODUCTION

The Sahel region of Nigeria occupies the extreme northern portion extending from latitude 12^0N to the internal boundary with Republic of Niger on latitude 13^0N. The climate is characterized by high diurnal temperature fluctuations and low relative humidity. Rainfall distribution patterns are highly irregular in time and space. The zone has a fragile ecosystem characterized by sparse vegetation, which in its natural state is very heterogenous, consisting of trees with small to medium sized leaves and grasses of only 1-1.5m high (Hopkins, 1974). Human activities combined with long drought effect have deteriorated the zone, creating seasonal desert-like conditions (Arnborg, 1983).

The soils of the region are the brown and reddish brown groups- Entisols, Alfisols and Vertisols. Vertisols are dark montmorrilonite rich swelling and cracking soils. They have very little profile morphology, poorly structured and are generally described texturally as clayey. The soils are generally characterized by low organic matter and total N contents because of low biomass production and higher rate of decomposition. P availability is also low (Mokwunye, *et al*. 1996).

One of the major impediments to land use in the region is the nature of the soil especially the hard, caked surface, cracking vertisols which are poorly structured combined with low fertility status. So far, apart from few restricted studies of the soils (Siewierski, *et al.*, 1982, Esu, 1983), little is known about their properties and peculiar problems of management. Large vertisols areas are still inactivated, although some are fairly intensively grazed.

Justification

The rapid rates of forest loss and degradation across have continued to increase both the fragmentation of many populations and the risk of species' extinction. With the dependence on the scanty trees for food, fodder and fuel wood, there is need for the provision of economic trees to meet up the demand and also improve soil for agricultural use. This leads to the study aimed at evaluating the effects of some tree species on the chemical properties of the vertisols.

Materials and Methods

Study Area

The study was carried out at the New-Marte Overseas Development Administration (ODA) sponsored Agroforestry Experimental site ($12^{0}5^{1}$N, $13^{0}52^{1}$E) within a gazetted forest reserve.

Experimental Design and Treatments

The design adopted was the Randomized Complete Block Design (RCBD) with four replications. Plots were chosen from the original ODA layouts of 1987. The treatments were control (no tree planted), *Acacia nilotica*, *Acacia senegal* and *Balanites aegyptiaca*. The total experimental area is 30 hectares with each plot size measuring 25m x 25m with a total number of 25 trees per plot.

Soil sampling

Bulked composite soil sample collected before the planting of trees in 1987 was used as a basis for comparing subsequent soil results. Soil samples were collected from the top soil (0-15cm) using an auger. Collection was carried out before the establishment of rainfall (May-June) at a distance of 1m from the tree stand. Soil samples were collected from each of the plots 10 years (1997) and 15 years (2002) after the trees were planted. Samples were then air-dried, ground, sieved and packed in wooden crates and kept in laboratory.

Soil Analysis

Soil samples were subjected to chemical analysis. pH was determine in water (1:1) and KCl (1:2.5) using a pH meter, Organic Carbon by Walkey Black wet oxidation method (Black 1965), Phosphorus extraction by Bray No 1 method (Bray, 1954) and Exchangeable cations (Ca, Mg, K and Na) through leaching with neutral normal ammonia acetate solution.

Statistical Analysis

Treatments and interaction effects were determined by carrying out analysis of variance (ANOVA) using GENSTAT (Genstat 5 release 3.2 statistical packages PC/Windows, 1995). The least significant differences (LSD) were calculated to compare the means where significant differences were found.

Results and Discussion

Table 1: Soil pH under the different tree species and time (0, 10, and 15 years).

Tree species	Plantation age (years)		
	0	**10**	**15**
An	6.60	6.30	6.53
As	6.75	6.48	6.90*
Ba	6.80	6.43	6.78*
Co	6.57	6.40	6.65

LSD 0.2502 *significant at 5%

An- Acacia nilotica
As- Acacia Senegal
Ba- Balanites aegyptiaca
Co- control (no trees)

Table 1 show the active soil pH under the different tree plantations and control for the 0, 10 and 15 years. When the trees were 10 years of age, the active soil pH under all the tree species dropped significantly. This could be attributable to the period of active growth of trees thereby resulting in high uptake of soil cations and accumulation/ decomposition of the plantation litter. The plantation at 15 years old showed pH that is statistically significant ($P<0.05$) under *Acacia senegal* and *Balanites aegyptiaca*. The soil pH has influence on nutrient absorption and plant growth, as essential elements tend to be less available when the pH is raised from 5.0 to 7.5 or 8.0.

Table 2: Organic matter content (%) under the different tree species and time (0, 10, and 15 years).

Tree species	Plantation age (years)		
	0	**10**	**15**
An	0.549	0.484	0.623
As	0.622	0.674	0.752
Ba	0.553	0.545	0.726*
Co	0.570	0.670	0.627

LSD 0.1665 *significant at 5%

Gradual build up of organic matter was observed under the tree covers. Under *Acacia nilotica*, there was a decline in the first 10 years which could probably be due to plant utilization in the growth and development processes, there was an increase in the 15TH year, though not statistically significant. Under *Acacia senegal*, there was an increase in OM content though not statistically significant . *Balanites aegyptiaca* showed a statistically significant difference in organic matter content at the end of the 15years.

This could be as a result of increase in size and age of tree as reported by Bernhard-Reversat, 1982.

Table 3: Total Nitrogen content (%) of soil under the different tree species and time (0, 10, and 15 years).

Tree species	Plantation age (years)		
	0	**10**	**15**
An	0.036	0.045	0.048*
As	0.041	0.034	0.047*
Ba	0.041	0.039	0.040
Co	0.040	0.033	0.038

LSD 0.01152 ***significant at 5%**

Total Nitrogen content (%) under *Acacia senegal* and *Acacia nilotica* at the 15th year showed a statistically significant difference, this could be due to their ability to fix atmospheric nitrogen as both are leguminous tree species while *Balanites aegyptiaca* showed a slight increase which was not statistically significant (p>0.05), this could be as a result of utilization by plant. This result therefore, confirmed the ability of leguminous trees to increase N availability.

Table 4: Soil Phosphorus content (ppm) under the different tree species and time (0, 10, and 15 years).

Tree species	Plantation age (years)		
	0	**10**	**15**
An	17.00	18.50	17.00
As	18.25	18.00	9.50
Ba	17.75	12.50	7.50
Co	16.44	17.50	17.00

LSD 3.125 ***significant at 5%**

Through all the stages of the experiment, soil P availability was very unstable, which shows that it is not readily available for crop use.

Table 5: The Effective CEC (meq/100g) of soil under the different Tree Species and time (0, 10, and 15 years).

Tree species	Plantation age (years)		
	0	**10**	**15**
An	39.20	37.79	37.90
As	38.96	39.04	36.68
Ba	39.09	38.44	40.29
Co	37.12	37.38	37.34

LSD 2.288

The value of cation exchange capacity of a clay soil is partly pH dependent. The CEC gives the total number of cations it can retain on its absorbent complex.Under *Acacia nilotica* and *Balanites aegyptiaca* the ECEC value dropped marginally at 10years and increases slightly later (15years) while *Acacia senegal* has a significant difference at 10years which later dropped.

CONCLUSION AND RECOMMENDATIONS

Improved soil chemical conditions under agroforestry are a consequence of the favourable effects of tree on soil process. The practice of agroforestry will be of great benefit in improving the surface soil and root penetration on the vertisols. Some of the favourable effects of trees on soil chemical properties are shown in table 2 and 3, where increase in soil organic matter content and soil nitrogen have been recorded. Increase in the content of soil organic matter usually enhance the availability of divalent micro-nutrients such as cu^{2+} , Zn^{2+} and Mn^{2+} that have affinity for exchange sites on soil organic matter due to chelation with organic anions.

The study showed that under the different tree species, there was an improvement in soil nutrients status as compared with the control plots (no trees were planted).

It is therefore recommended that *Acacia nilotica, Acacia senegal* and *Balanites aegyptiaca* can be intercropped favourably on vertisols in the sahel as they tend to improve soil organic matter. The planting of these tree species will help in improving and sustaining the fragile soil chemical properties of the area.

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