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INFLUENCE OF TEAK, (Tectona grandis) ON MICROBIAL POPULATIONS IN AKANGA FOREST RESERVE OF NASARAWA STATE NIGERIA

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ABSTRACT

Laboratory and field experiments were carried out during the dry and wet seasons of 2010 and 2011 at the Akanga Forest planted with Teak (Tectona grandis) for the production of timber and poles. The area prior to use was an undisturbed forest and planting was carried out from 1966 at an annual interval to the year 1982.The intent of these experiments was to compare the changes in microbial composition and population as well as the influence of seasons on the microbial populations. Soil samples were collected from three plantation age series 1979, 1980, 1981 and control. The samples were analyzed using standard procedures. Litter accumulation was found to be highest in the 1981 plantation with a value of 545.18kg/ha in the dry season. Microbial composition was determined to be predominantly bacteria and fungi. Bacteria population was found to be highest in the wet season (99.84 Cfu/g). Fungi population was also found to be 98.10Cfu/g in the wet season. There were significant relationships between the microbial population and diversity and other edaphic factors. This study showed that rainfall seasons have great effect on the parameters studied. It was concluded that protection of the litter layer is necessary in order to ameliorate soil degradation and nutrient limitation in the study area, since litter layer was not only the main source of soil organic matter and available nutrients, but also the regulator of soil microbial activity.

Keywords: Forest, Soils, Microbial, Composition, Population, Akanga

1. INTRODUCTION

A large area of land that is thickly covered by trees is known as a forest. This area usually forms an ecosystem. Components of this ecosystem include soil, plants, air, water, sunlight and several other organisms which could be either micro or macroscopic. These organisms are interdependent or depend on each other.

There has been a vigorous attempt to introduce exotic species of teak, *Tectona grandis* in Nigeria as viable alternatives to the indigenous sources of poles and timber for industrial uses. However, the effects of these exotic species on the soils and the ecosystem in general have not been well understood.

Soil microbe populations play fundamental role in ecosystem functioning, as they decompose organic matter, determining the release of mineral nutrients in the soil and influencing primary

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productivity and nutrient cycling. It is an indication of soil biological productivity and measurable changes in microbial biomass and may reflect changes in soil fertility (Brookes 2001). The passage of seasons may influence microbe populations and microbial biomass directly, through changes in microclimate, or indirectly, by influencing plant metabolism that feeds back to the soil ecosystem (Behera and Sahani, 2003; Verburg *et al.*, 1999).

Soil microorganisms are an integral part of forest ecosystems as they play central roles in most nutrient transformations in forest soils. The stability and sustainable development of forest ecosystems rely on these nutrient transformations and the interactions between above- and below-ground components drives forest ecosystem processes (You *et al.*, 2014). For the below ground processes, soil microbial communities are important in mediating soil organic matter decomposition, and nutrient cycling in these ecosystems (van der Heijden *et al.*, 2008). Studies have reported that soil microbial composition and or community structure can be altered by plant species, plant diversity, vegetation or forest type through modifying the site microclimate and litter chemistry (De Deyn *et al.*, 2008; Wardle *et al.*, 2012; Jassey *et al.*, 2013).

Akanga Forest (Kurmin Akanga) was first established in 1966 with plantation number FP- PL-01-66 in Obi Local Government Area of Nasarawa state .Teak (*Tectona grandis)* was planted for the production of timber and poles. The area prior to use was an undisturbed forest and planting was carried out at an annual interval to the year 1982.
Since the establishment of this plantation, no effort has been made to consider the effect of the plantation on the physical, chemical and microbial properties and composition of the soils. This research was therefore carried out to compare the changes in microbial composition and population under teak at the different age series and to determine the influence of seasons on microbe populations.

2. MATERIALS AND METHODS

The site for the study is an already established plantation of *Tectona grandis* located in Akanga on Longitude 8^0 34'E and Latitude 8^0 18'N within the Guinea Savanna of Nigeria which lies in the central location of the country. The plantation is situated at Akanga in Obi Local Government Area of Nassarawa state.The area fall within the Southern guinea vegetation zone (Keay, 1953). Annual rainfall varies from 1143 mm – 1397 mm with the peak occurring in August to September. The area is about 185m above sea level.

Site selection and demarcation Three age series were considered for sampling based on location and less interference by extraneous factors. Trees planted in the years 1979, 1980 and 1981 with a total hecterage of 78, 28 and 40 respectively were taken. Plots of 200m x 200m ware demarcated for sample collection, in each plot 10 soil samples were randomly collected and bulked. Total numbers of plots for the year 1979 were 1,950; 700 plots for 1980 and 1000 plots for 1981. 300 plots were selected for 1979, 110 plots for 1980 and 160 plots for 1981. Soil samples adjacent to the plantation were also collected as control plots. Soils were collected at the

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depth of 0-20cm using an auger. The sampling was restricted to this zone because it provides the bulk of plant nutrients (Russell, 1974).

Laboratory Analysis

The soil samples were air-dried, crushed and sieved through a 2 mm sieve for laboratory analysis. The following determinations were carried out using standard procedures: Particle size distribution was estimated by hydrometer method of Bouyoucos 1951. Core samplers were used in taking samples and bulk density was determined and expressed as a weight of dry soil per unit volume of moist soil (Campbell and Henshall, 1991). Total porosity (%)was computed from those of bulk density value of 2.65gcm-3 (Vomocil, 1965). The soil pH was measured with a glass electrode in a 1:1 soil-water suspension (Hendershot *et al.*, 1993). Organic Carbon was determined using the wet acid oxidation procedure. (Walkley and Black, 1934). Total Nitrogen was determined by microkjeldahl method as reported by Page *et al.*, 1982. Available Phosphorus was extracted with Bray-1 extractant and the Concentration of P in the extract was determined colorimetrically (Bray and Kurtz, 1945). Exchangeable bases were extracted using the Melich 3 extractant. Ca and Mg were determined by Atomic Absorption Spectrophotometer while Na and K were determined using a flame photometer. Litter traps of 1m x 1m were constructed using 2 mm mesh nylon fabric attached to a wooden frame and were elevated off the ground to avoid soil and water contamination. Litter accumulated in each collector was retrieved forth nightly and separated into leaves, twigs, and reproductive (flowers and fruits) parts. The forth night collections were then summed up for each month. Litter samples collected were then air dried and weighed. Assessment of biological properties was limited to fungi and bacteria because they have the highest values of biomass and respiratory metabolism and have greater participation in organic matter decomposition processes (Persson *et al.*, 1980). Standard procedures for determining the total number of soil microbes was adopted for culturing of bacteria and fungi (Alexander, 1982). Fungal growths were observed macroscopically for colour, texture, diffusible pigments and colonal topography. The observation of these features supplemented with growth and microscopic appearance helped in the identification of fungi. Data collected was subjected to correlation analysis to determine the relationship between the edaphic factors and microbial populations.

3. RESULTS AND DISCUSSION

Litter accumulation of the experimental sites for the dry season of the 2010 study period is shown in Table 1. The litter is composed of the leaves, twigs, fruits and flowers. The leaf content was found to be highest value of 502.41kg/ha in the 1981 plantation, this was followed by 448.87 k/ha in the 1979 plantation and the least value of 362.89kg/ha was found in the 1980 plantation. Twig composition was found to be highest in 1979 with a value of 6.67kg/ha, followed by 6.41kg/ha in the 1981 plantation, while the least value was recorded in the1980 plantation with a value 5.45kg/ha. Fruit litter was found to be highest in the 1981 plantation, the 1980 plantation recorded 32.45kg/ha and 32.01kg/ha was found for the 1979 plantation. There was no flower litter recorded during the dry season. The 1981 plantation was found to be highest

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with a value of 545.18kg/ha, this was followed by the 1979 plantation which recorded 487.55kg/ha and 400.79kg/ha was recorded for the 1980 plantation. Choubey *et al.*, (1988) found that litter production was 1.5-2.0 times greater in the teak plantations (20-23 year) than in adjoining forest. Greater contents of nitrogen, phosphorus, potassium and calcium were noticed in plantations than in forest litter, indicating a greater nutrient return in the plantations. Singh *et a1.*, 1990 also reported that annnual leaf litterfall was higher in teak than in eucalypt. It was also observed that decay rate of the litter varied significantly both in the field and in the laboratory.

Table 1: Litter Accumulation at Akanga Forest Reserve for the Dry Season of 2010.

Location	Leaves (kg/ha)	Twigs (kg/ha)	Fruits (kg/ha)	Flowers (kg/ha)	Total (kg/ha)
1979	448.87	6.67	32.01	-	487.55
1980	362.89	5.45	32.45	-	400.79
1981	502.41	6.41	36.36	-	545.18

The morphological and biochemical characteristics of Bacteria isolates found in Akanga Forest Reserve are shown in Table 2. Characteristics such as colour of colony, texture, shape, gram reaction, catalase, coagulase, indole, citrate, lactose, and sucrose were used in identifying some of the suspected organisms in the study area.

The morphological characteristics of Fungal isolates found in Akanga Forest Reserve are shown in Table 3. Characteristics such as colour of colony, texture, hyphae, and reproductive structures were used in identifying some of the suspected organisms in the study area.

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Table 2: Morphological and Biochemical characteristics of Bacteria Isolates Found in

Colour of colony	**Texture**	**Shape**	**Gram reaction**	**Catalase**	**Coagulase**	**Indole**	**Citrate**	**Lactose**	**Sucrose**	**Organism identified**
Cream	Smooth	Cocci	+	+	+	_	+	AG	AG	*Staphylococcus aureus*
Dark blue	Smooth	Bacillus	+	+	_	_	+	A	A	*Bacillus cereus*
Green	Smooth	Bacillus	_	+	_	_	+	A	AG	*Pseudomonas spp*
Pale	Smooth	Cocci	+	+	_	_	+	A	AG	*Streptococcus spp*
Pink	Smooth	Bacillus	_	+	_	+	+	A	AG	*Escherichia coli*

KEY: + - Positive, -- - Negative, A- Acidic, AG – Acid and Gas produced.

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Bacteria populations (Cfu/g) at the experimental sites for dry and wet season are shown in Table 15. The population of bacteria was variable in the two seasons. The highest population of 84.26 x 10^6Cfu/g was found in the 1979 plantation during the dry season, this was followed by 81.68 x 10^6Cfu/g in the 1980 plantation and 81.02 x 10^6Cfu/g in the 1981 plantation. The least value of 60.80 x 10^6Cfu/g was recorded in the control. In the wet season, the highest value of 99.84 x 10^6Cfu/g was found in the 1981 plantation, followed by 99.56 x 10^6Cfu/g in the 1979 plantation and 96.66 x 10^6Cfu/g in the 1980 plantation. The least value 76.00 x 10^6Cfu/g was also recorded in the control.

Fungi populations (Cfu/g) at the experimental sites for dry and wet season are shown in Table 16. The population of fungi was variable in the two seasons. The highest population of 87.36 x 10^4Cfu/g was found in the 1980 plantation during the dry season, this was followed by 81.96 x 10^4Cfu/g in the 1979 plantation and 81.84 x 10^4Cfu/g in the 1981 plantation. The least value of 56.00 x 10^4Cfu/g was recorded in the control. In the wet season, the highest value of 98.10 x 10^4Cfu/g was found in the 1979 plantation, followed by 96.82 x 10^4Cfu/g in the 1980 plantation and 95.24 x 10^4Cfu/g in the 1981 plantation. The least value of 58.55 x 10^4Cfu/g was also recorded in the control.

Table 3: Bacteria Population (Cfu/g) at Akanga Forest Reserve in the Dry and Wet Season

Location	Colony Count on Nutrient Agar	
	Dry Season (x10^6)	Wet season (x10^6)
Control	60.80	76.00
1979	84.26	99.56
1980	81.68	96.66
1981	81.02	99.84

Table 4: Fungi Population (Cfu/g) at Akanga Forest Reserve in the Dry and Wet Season.

Location	Colony Count on PDA	
	Dry Season ($x10^4$)	Wet Season ($x10^4$)
Control	56.00	58.55
1979	81.96	98.10
1980	87.36	96.82
1981	81.84	95.24
Key: PDA- Potato Dextrose Agar		

Relationships between soil properties and the studied parameters at the experimental site

Relationships between soil properties and the studied parameters in the dry season of is shown on Table 5. There was a positive and significant relationship between the fungal population and the bacteria population (r= 0.968). pH, organic carbon, percentage nitrogen and all the exchangeable bases showed negative relationships that were not significant with the fungal population. There was however a negative and highly significant relationship (r= -0.995) between the fungal population and the porosity of the soils while that with the bulk density was negative but not significant (r= -0.980). Bacteria population correlated significantly and positively with the total litter (r= 0.960). The relationship between the bacteria population was negative and significant (= -0.978). There was a highly significant and positive relationship (r= 1.000) between the organic carbon content of the soils and the cation exchange capacity of this forest soils. There was a positive and significant relationship between the fungal population and the bacteria population (r= 0.989). pH, organic carbon, percentage nitrogen available P and all the exchangeable bases showed negative relationships that were not significant with the fungal population. Total litter also correlated positively and significantly with the fungal population (r= 0.985). Bacteria population correlated highly significantly and positively with the total litter (r= 0.999). There was a highly significant and positive relationship (r= 1.000) between the organic carbon content of the soils and the cation exchange capacity of this forest soils.

It has been suggested that one of the main pathways by which vegetation can affect the structure and function of soil microbial communities is *via* altering physicochemical characteristics of the soil (Augusto *et al.*, 2002, Russell *et al.*, 2007, Williams and Rice, 2007, Angel *et al.*, 2010, Castro *et al.*, 2010, Mueller *et al.*,2012, You *et al.*, 2014) through species specific litter

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chemistry (Ushio *et al.,* 2008; Strickland *et al.,* 2009). Some studies have shown that some soil properties are highly correlated with soil microbial community composition (Ushio *et al.,* 2008; Strickland and Rousk, 2010). Contrastingly, in the present study, correlations of microbiological properties to edaphic characteristics were relatively weak.

The central question addressed by this study was how microbial communities respond to environmental perturbation in the form of an ecosystem conversion from a native forest to Teak monoculture, and involved two contrasting concepts in microbial ecology. One concept concerned the linkage of plant communities with those of soil microbes, such that characteristics of the former (composition and diversity) affect the latter (De Deyn *et al.,* 2008; Wardle *et al.*, 2012; Jassey *et al*., 2013).

The number of bacteria in soil is influenced primarily by the amount and quality of food available. Other factors affecting their numbers include physical factors (moisture and temperature), biotic factors (predation and competition), chemical characteristics of the soil (acidity, dissolved nutrients and salinity). A similar range of fixed factors (like climate, stoniness, mineralogy, texture, cultivation) has been identified controlling the maximum potential of soil organic matter content (Silwana and Lucas, 2002). The number of microbial organisms varies with the habitat in which they are found. Despite these variations, there are a few generalization that can be made, for example, cultivated fields are generally lower than undisturbed native lands in numbers of soil organisms (Zelles, 1996).
Microbial diversity and abundance is less when there is a few plant vegetation, frequent fire outbreak and coarse leaves that make decomposition very difficult. Litters with high content of more complex and slowly degradable phenolic compound and lignin often decompose very slowly (Nwoboshi, 2000). The population, diversity and the proportional amounts of nutrients to be released into the soil by the microbes during decomposition are direct function of litter quality.

4. CONCLUSION

Soil microbe populations play fundamental role in ecosystem functioning, as they decompose organic matter, determining the release of mineral nutrients in the soil and influencing primary productivity and nutrient cycling. It is an indication of soil biological productivity and measurable changes in microbial biomass and may reflect changes in soil fertility. The passage of seasons may influence microbe populations and microbial biomass directly, through changes in microclimate, or indirectly, by influencing plant metabolism that feeds back to the soil ecosystem.

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