GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL 10, NO. 2, 2011: 127-133
 ISSN 1596-2903
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EFFECTS OF *TECTONA GRANDIS* (TEAK) PLANTATION ON SOIL MICROORGANISMS IN A FERRUGINOUS SOIL OF NORTH CENTRAL NIGERIA.

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(Received 15, July 2011; Revision Accepted 21, September 2011)

ABSTRACT

Effects of *Tectona grandis* age series plantation on soil microorganisms were investigated. Using completely randomised block design (CRBD) soil samples were collected from the rhizosphere, non-rhizosphere and the natural forest for December, 2003, February, 2004, April, 2004, and June, 2004. The collected samples were treated and later plated using different media. Nutrient agar (N/A, oxoid) was used for bacteria isolation while potato dextrose agar (PDA, oxoid) was used for fungi isolation. Colonies of the microorganisms were examined, counted and identified with microscopes and biochemical tests. Results showed significant differences of micro-organisms counts (bacteria, P=0.01) between *Tectona grandis* plantation and natural forest while no significant difference was observed between the months of sampling for non-rhizosphere soil. There existed no significant difference in the bacteria count between blocks (P=0.006) in the rhizoshere soil while significant count in bacteria was observed (P=0.04) between the treatments. Fungi population did not show any significant difference in the rhizospre for both the blocks and the treatments (P=0.0001; (P=0.0002) respectively while significant differences exited between the treatments (P=0.66; P=0.42) respectively. The distribution of both the gram positive and gram negative microorganisms was not significantly different between the plantation and the natural forest. It was concluded that *T. grandis* plantation has significant effects on the microbial populations only during early years of establishment. It was found that *T. grandis* should be used as an agroforestry species to boost micro-organisms populations.

KEY WORDS: Rhizosphere, Non- Rhizosphere, Natural Forest, Micro-organisms.

INTRODUCTION

The ability of trees to promote the population of microorganisms ensures diversity and productivity of the ecosystem upon which man depends. To the farmer, the ecosystem is important because of the biochemical reactions that take place in the soils as a result of microbial populations under them. Hamilton (1965) and Chijioke (1978) found that growing monocultures of tree species is not only detrimental to the micro organisms but also creates imbalances in the ecosystem. Our ecosystems are greatly being disturbed through deforestation (Dagba *et al.* 2005). In recent years, emphasis is being placed on plantation development for wood requirements as well as environmental conservation.

Ralston, (1964) recognized *Tectona grandis* as a suitable species for rapid production of large volumes of timber, fuel wood, and poles of uniform and desirable quality as a result of which the species is being used for large scale plantations. Since the decline in the Tropical Shelter Wood System (TSS), artificial regeneration has been preferred over natural regeneration whenever conditions are suitable for it (Dagba, 1986). Therefore, the increasing emphasis on plantation forestry is reflected in the areas planted to date. The species have occupied unique position in forest policy in that since then, large scale plantations of the species are now being created with the view to meeting the industrial wood requirements of Nigeria (Nigeria Forest Policy, 2006).

Several areas in Nigeria have been planted with *Tectona grandis* as monocultures. These single tree species plantations if not properly managed may turn to have devastating effects on the soils on which they are grown (Nwoboshi, 1978). Reporting on his studies on the variation of natural forest site productivity and sites of single tree plantations, Nwoboshi, (1978) indicated variations in the site qualities to be quite significant. Chijioke and Mayer (1980) stated that for a forest soil to maintain a flourishing tree and agricultural crop, all the necessary qualities of a good soil namely; physical, chemical and biotic factors must be at an acceptable level of equilibrium.

One of the most obvious effects of vegetation on the soil is the deposition of dead parts like leaves and other plant materials. The rate of litter breakdown and humus incorporation in tropical soils characterised by

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broad-leaved trees is dependent on the number, species and the activities of micro-organisms (Nwoboshi 1978). According to him, maintenance of forest productivity is dependent in part on the efficient break-down of litter.

Theodorou (1984) opined that high microbial numbers in many soils may be due to root biomass of the different vegetation types. Roots of some trees have been reported to produce some toxic chemicals that tend to inhibit activities of soil micro organisms thereby reducing site qualities. The need for more research even in our local plantations to decide on the suitability or otherwise of single tree species becomes imperative. Therefore, the objective of the study was to investigate the presence, type and number of micro-organisms available in monocultures of *Tectona grandis* and those of the natural vegetation as a basis for recommending or discouraging the use of the species for plantation forestry in the area as well as other parts of Nigeria.

MATERIALS AND METHODS

Study Area

The forest plantation under investigation is the *Tectona grandis* plantation situated at Akanga 32 kilometers on Lafia-Makurdi road. The plantation lies between Latitudes 8^0 0' and 8^0 20' North, and longitude 7^0 5' East. According to Agricultural Development Project (ADP) (2003), rainfall varies from 1.143mm-1.397mm with the peak occurring in August. Details are contained in Table 1. The vegetation is of Southern Guinea Savannah. It consists of open savannah woodland. The commonest tree species include *Lophira lanciolata, Terminalia glaucescens, T. macroptera, Danielia oliverii, Vitex doniana, Hymenocardia acida and Afzelia africana.* Interspaced with these are the tall tussoky grasses and herbs which include *Andropogon, Hyparrhena, Pennisetum and Chromolaena species.*
Two major formations are said to occur within the area. These are the cretaceous sandstones and the alluvium deposits giving rise to different soil types (SCOUP & CO Ltd 1979).

Site selection

Tectona grandis plantations established in 1969, 1970 and 1971 were purposively selected. Each plantation was divided into plots of 10m x10m with the use of grid lines. The selection of plots and trees were based on systematic random sampling. In each age series, the complete sampling plots were numbered. Using random number table, six plots were selected from each age series.

Soil Sampling Technique

Six augur samples of the top soil (0-15cm) beneath the litter layer were taken randomly from each plot (Non-Rhizosphere). The soils were placed in polythene bags with correct labels. Similarly, six other points were taken near the roots (Rhizosphere) and kept in the same way. Six other augur soil samples were likewise taken in the adjacent natural vegetation and treated in the same way. The process was repeated in the remaining two age series without the natural forest. The samples were taken in December 2003, February 2004, April 2004 and June, 2004. The samples were prepared following methods outlined by Griffiths and Brechi (1961). The prepared soil samples were air-dried and sieved ready for analysis.

Experimental Procedures

Following the procedures of Clark (1965), dilution series and poured plates were carried out on nutrient agar (N/A, oxoid) for bacteria. The medium was sterilised by autoclaving at 15 lb. pressure for 1hr.and counts made after six days of incubation. Potato dextrose agar (PDA, oxoid) was used for fungi count. Before pouring the plates, the medium was also autoclaved for 1hr and made acidic by adding 5ml of 0.1N H_2SO in order to inhibit bacteria growth of most actinomycetes. Counts were made after 4 days. Using microscopes, the gram stain, litmus milk test, Gallatin liquefaction/hydrolysis test and indole production test, the bacteria fungi were identified.

Statistical analysis

Two- way analysis of variance (ANOVA) was used to analyze the data using Microsoft Excel Analysis tool package add-in version 2007. Least significant difference (LSD) was calculated manually, the level of significance was $p<0.05$.

RESULTS

Bacteria population count for *Tectona grandi* in the non-rhizosphere soils.

The results of the counts are presented in Table 2. Bacteria counts ranged from (74.6 -120) × 10^6. Statistical analysis showed that bacteria counts differed significantly ($p = 0.01$) between the plantation and the natural forest. However there was no significant difference ($p< 0.05$) between the treatments (Sampled months) of 2003-2004 ($p = 0.55$).

Table 1: Mean monthly rainfall (mm) at Lafia.

Month	Mean Rainfall (mm)
January	0.00
February	28.30
March	2.70
April	21.65
May	36.66
June	18.05
July	25.77
August	38.04
September	28.04
October	8.94
November	5.37
December	0.00

Source: Nasarawa Agricultural Development Project, Lafia, Nigeria.

Table2: Mean bacteria population count for *Tecona grandis* in the non rhizosphere soils.

Age of plantation (Years)	bacteria count x 10^6/g of soil with time					
	Dec. 2003	Feb. 2004	Apr. 2004	Jun.2004	Block mean	LSD 0.05
35	101.3	102.6	114.3	95.0	103.3[a]	15.85
34	96.6	91.3	90.0	120.0	99.33a	15.85
33	87.3	77.0	74.6	78.6	79.30b	15.85
Natural forest	115.3	102.0	97.6	114.0	107.23[a]	15.85
Treatment mean	99.9	93.33	94.13	101.90		

Legend:
ANOVA: F = 6.27, P = 0,001 (between blocks), F = 0.74, P = 0.55 (between statements), mean with the same letter are not significantly different.

Bacteria population count for *Tectona grandis:* Rhizosphere soils.

Compared to the non-rhizosphere soils, bacteria counts in the rhizosphere soils were smaller for each corresponding age of the plantation established between 1969 to 1971, and were statistically significant (p = 0.006, Table 3). A similar trend was observed among the months of study between December 2003 – June 2004, but was not statistically significant (p = 0.41).

Table 3: Mean bacteria population count for *Tectona grandis* in the rhizosphere soil

Age of plantation (Years)	Bacteria Count x 10^6/g of soil with time June.2004					
	Dec. 2003	Feb. 2004	Apr. 2004	Jun.2004	Block mean	LSD 0.05
35	78.6	74.6	85.0	71.0	77.30[a]	10.18
34	80.6	77.6	83.3	87.3	82.20[a]	10.18
33	63.3	55.3	60.6	71.0	62.55[b]	10.18
Treatment mean	74.17	69.19	76.3	76.43		

Fungi population count from *Tectona grandis* in the Non-Rhizosphere Soils

The mean fungi population count in the rhizosphere soils generally increased with increased age of the plantation. Differences were statistically significant between the blocks ($p < 0.0001$) while it was observed that no significant difference existed between the treatments ($p = 0.66$) as presented in Table 4. The natural forest had the least count of fungi microorganisms relative to older established plantations.

Table 4: Mean fungi population count for *Tecona grandis* in the non- rhizosphere soils.

Age of plantation (Years)	fungi count x 10^4/g of soil with time					
	Dec. 2003	Feb. 2004	Apr. 2004	Jun.2004	Block mean	LSD 0.05
35	100.3	101.0	98.3	106.0	104.40[a]	6.35
34	81.6	80.3	77.6	82.3	80.45[cd]	6.35
33	74.3	79.3	82.6	74.3	77.63[c]	6.35
Natural forest	35.0	36.0	41.3	40.6	38.23[b]	6.35
Treatment mean	72.80	74.15	74.95	75.80		

Legend:
ANOVA: F = 236.85, P = 0, 0001 (between blocks), F = 0.55, P = 0.66 (between statements), mean with the same letter are not significantly different.

Fungi population count from *Tectona grandis* in the Rhizosphere Soils

Similarly, the mean fungi population count in the rhizosphere soil also generally increased with the age of the established plantation. The older plantation established 35years had higher count of fungi microorganisms across the sampled months compared to younger plantations established 34 and 33 years (Table 5). The differences in fungi population counts for the different ages of the plantations were statistically significant ($p = 0.0002$) while there was no significant difference between the months of sampling ($p = 0.42$).

Table 5: Mean Fungi population count for *Tectona grandis* in the rhizospher soil

Age of plantation (Years)	Fungi count x 10^4/g of soil with time					
	Dec. 2003	Feb. 2004	Apr. 2004	Jun.2004	Block mean	LSD 0.05
35	86.3	97.6	93.3	94.3	92.88[a]	6.45
34	74.6	79.3	75.0	78.3	76.80[b]	6.45
33	67.0	62.0	67.6	71.3	76.80[b]	6.45
Treatment mean	75.97	79.63	78.63	81.30		

Legend:
ANOVA: F = 47.68, P = 0.0002 (between blocks), F = 1.09, P = 0.42 (between treatments), mean with the same letter are not significantly different.

Azotobacter population count from *Tectona grandis* in the Non-Rhizosphere Soils

The result of Azotobacter population count from the non-rhizosphere soils is presented in Table 6. The population counts for these microorganisms were also generally higher in the older established plantations, while the natural vegetation had relatively lower counts for each of the sampled months. Significant differences in population counts were observed between the plantation and the natural forest (p = 0.0002) and for the sampled months (p = 0.05.

Table 6: Mean population count for *Tectona grandis* in the rhizosphere soils.

Age of plantation (Years)	Fungi count x 10^4/g of soil with time					
	Dec. 2003	Feb. 2004	Apr. 2004	Jun.2004	Block mean	LSD
35	23.6	17.0	17.6	22.0	20.05^{ab}	23.73
34	81.0	21.6	15.6	21.0	34.8^{a}	23.73
33	15.6	13.3	12.3	14.3	13.86^{ab}	23.73
Natural forest	11.3	10.6	8.6	12.6	10.78^{b}	23.75
Treatments mean	32.86	15.63	13.53	17.48		

Legend:
ANOVA: F = 22. 06, P = 0.0002 (between blocks), F = 3.80, P = 0.05 (between treatments), mean with the same letter are not significantly different.

Azotobacter population count from *Tectona grandis* in the Rhizosphere Soils

The result is presented in Table 7. A similar trend was observed in both the rhizosphere and the non rhizosphere soils, with lower Azotobacter count in the younger plantation blocks compared to the older ones. The mean number of counts were also statistically significant for the sampled months (P = 0.001) as well as the age of the plantations (P = 0.003). In contrast, Azotobacter counts were apparently higher in the non-rhizosphere soils than in the rhizosphere soils (Tables 7).

Table 7: Mean azotobacter population count for *Tectona grandis* in the rhizosphere soils.

Age of plantation	Azotobacter Count x 10^4/g of soil with time					
	Dec. 2003	Feb. 2004	Apr. 2004	Jun.2004		LSD 0.05
35	15.3	15.3	14.6	20.0	16.3^{a}	1.50
34	13.6	13.6	13.3	17.0	14.38^{b}	1.50
33	10.0	13.3	11.3	16.0	12.65^{c}	1.50
Treatment mean	12.9^{b}	14.7^{b}	13.07^{b}	17.67^{a}		
LSD (0.05)	1.73	1.73	1.73	1.73		

Legend:
ANOVA: F = 17. 08, P = 0.0003 (between blocks), F = 19.49, P = 0.001 (between treatments), mean with the same letter are not significantly different

Biochemical Test

Results obtained from biochemical test show that there were more gram-positive organisms than gram-negative organisms for older plantations than the natural forest, except the plantation established 33years that had equal number of gram-positive and gram-negative organisms (Table 8).

Table 8: Distribution of Gram-Positive and Gram-Negative micro-organisms in *Tectona grandis* soil

Types of micro-Organism	Tectona grandis year of establishment				
	35	34	33	Natural forest	Block mean
Gram Positive	5	4	5	6	5.0
Gram Negative	3	4	3	2	3.0
Treatment mean	4	4	4	4	

Legend:
ANOVA: F = 6.0, P (between blocks), F = 0.0, P 1.00 (between treatments)
However, there were no significant differences between the number of gram-positive and gram-negative organisms.

DISCUSSION

Soil micro-organism population and activities have been reported to be affected by factors such as fire, PH, organic matter, moisture, temperature and nutrients (Ogabor 1986, Ikojo 1982, Campbell *et al* 1982).

In the present study, it was observed that the population count of micro-organism differed between the plantation and the natural forest, between the age series and to some extent between the periods of sampling. Of particular note was that such differences were more pronounced during the month of June which marks the period of stable raining season in the area. This period alters factors that influence microbial activities. According to Clark (1977), activities of bacteria are usually greatest during the raining season with declines during hot dry seasons and cold periods. In his study, Campbell *et al* (1982) found that with seasonal changes in temperature and moisture, the population of some organisms fluctuated. He further explained that dew formations on very dry soil enhance microbial growth through releases of labile organic materials. Ikojo (1982) also observed significant differences in microbial populations between ages of trees and time of sampling.

It was also observed that the oldest plots had significantly higher microorganisms than the younger ones. This could be explained probably that as the trees get older, there is accumulation of litter with a corresponding increase in decomposition and this probably encourages multiplication of microbes in the soil environment. According to Campbell *et al* (1982), as the trees grow, they get into a state of dynamic equilibrium with soil nutrients on one hand, and microorganisms on the other thereby encouraging litter decomposition and a release of nutrients for plants

Findings also showed more bacteria, fungi and *azotobacter* microorganisms in the non-rhizosphere soils than the rhizosphere soils. The reasons might be that some substances secreted by the roots of *T. grandis* are inhibitory to microbial growth and activity. This observation agrees with those of Campbell *et al* (1982), where they found low population counts around the roots. As the trees get older, there are more populations, suggesting that the amount of these secretions become less as the trees grow older. Apart from this, there are some plants that favour high bacteria populations. Theodorou (1984) found that the microbial numbers, microbial biomass, nitrogen and nitrogen transformations were all dependent upon the type of vegetation that produced the root regions. It is therefore, possible to say, that the non-rhizosphere regions encourage the growth of a variety of shrubs and grasses with greater and denser rooting system with less inhibitory substances that might have encouraged more microbial growth, and more uniform distribution as the trees grow older. The ability of the natural forest to produce more micro-organisms than the monocultures of *T. grandis*, could be due to the fact that there are a variety of trees, herbs and shrubs that produce favourable chemicals for microbial activities.

CONCLUSION AND RECOMMENDATION

T. grandis growing as monocultures do have adverse effects on the population, type and activities of micro-organisms through secretion of inhibitory substances within the roots region in the early stages of planting. However, the effect of *T.grandis* on the microbial population and their activities are momentary hence do not render soils on which they grow infertile.

It is recommended that *T. grandis* can be used as a plantation species. However, for the early years of plantation development, some suitable agroforestry practices should be adopted to encourage

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