SOIL MICROBIAL PROPERTIES AS AFFECTED BY FOREST CONVERSION TO AGRICULTURAL LAND IN THE DERIVED SAVANNA.

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ABSTRACT

Over the last few decades, attention has focused on the impacts that agricultural land uses have on biological and biochemical properties of soils. A research trial was carried out on the microbial properties of forest and arable farm land of Crescent University, Abeokuta located at Lanlate, 7.6°N and 3.45°E in Oyo State South West Nigeria, to investigate the microbial activities and properties of forest and agricultural farm land. Soils were taken from four locations of the two treatments (Forest and agricultural farm land) and a composite soil sample was obtained. The four points of collection represented four replications and data were then analyzed in a Randomized Complete Block Design. The results showed that more microbial activities were observed in the forest than in the agricultural farm land. This implies that cultivation of agricultural farm land reduces the activities of microbes.

Keywords: Land use, microbes, nematodes, forest and arable farm land.

INTRODUCTION

Forest clearing for agriculture is relatively common in Nigeria. Although shifting cultivation is no longer popular, the rate of agricultural development in the country has necessitated that some natural forest lands are cleared for the purpose of crop production. The conversion from forest to agricultural land use has tendency to cause a profound shift in edaphic factors which affect soil biological properties that are strongly influenced by the activities of the micro-organisms. Conrad et al. (1996) stated that shifts in microbial species composition and properties, may be associated with land use conversion and changes in vegetation. It has been stated that changes in microbial community composition or activity could have immediate or long term effect on ecosystem functioning (Perry et al 1989).

The most important components of soil microflora are bacteria and fungi (Jenkinson and Ladd 1981). These organisms play significant role in soil biotic processes which include the cycling of nutrients for plant growth. As bacteria and fungi are likely to have distinct functional roles in soil (Hendrix et al., 1986), a more robust understanding of the specific effects of land use and edaphic factors on these two microbial groups will improve our ability to predict the specific effects of land-use change on soil biotic processes. Over the last few decades, attention has focused on the impacts that agricultural land uses have on biological and biochemical properties of soils (Gregorich et al., 1997; Haynes and Beare, 1996). Soil organic C and N, as well as microbial biomass, have been proposed by some workers as indicators for assessing the effect of land use management (Janzen et al., 1992; Bremer et al., 1994; Alvarez and Alvarez, 2000).

Several studies have been conducted on physical, chemical and biological changes after deforestation and subsequent land cultivation in the tropics. (Ghuman and Lal, 1991; Joo et al, 1995; Sisti et al., 2004; Tchienkoua and Zech, 2004). However, there are few studies on the effect of conversion of natural forests in the Savanna into cultivated land systems on biological properties of soil. The objective of this study was to determine the microbial biomass C and N and population of bacteria, and fungi as affected by the conversion of forest to agricultural land.

MATERIALS AND METHODS

Study area
The study area was Crescent University Farm located at Lanlate, Oyo State, 7.6°N and 3.45°E in the derived Savanna region of Nigeria. The total farm size was about 100 ha of land with just about 5ha being cultivated. The dominant species of trees were *Bauhinia monandra* and neem. Cultivation on the agricultural plot started in 2009 when maize and cassava were planted. Marked areas of agricultural land (36 m × 50 m) and uncultivated forest land (40 m × 50 m) adjacent to each other were sampled. No crop was growing at the time of sampling and the dominant vegetation in the arable plot was elephant grass (*Pennisetum purpureum* and guinea grass (*Panicum maximum*).

**Soil Sampling**

Four transects were measured in each of the marked areas and eight points were sampled in each transect. The eight points sampled were bulked together to represent a replicate. Therefore, four replicates were taken from each of agricultural land and forest land. Sampling was done at a depth of 0 – 30 cm and samples were labelled and taken to laboratory.

At the laboratory, each replicate was divided into three sub-samples for the determination of microbial biomass C and N; bacterial and fungal population; and other routine soil analysis. Determination of microbial biomass Carbon and Nitrogen ratio was immediately commenced in the laboratory. The samples for bacterial and fungal counts were stored at a temperature of 4 C before analysis.

**Determination of microbial biomass C, N and P**

The microbial biomass C and N were determined by the fumigation-extraction method according to Vance et al. (1987) and Brookes et al. (1985) respectively. Each soil sample was divided into two parts with one part fumigated with chloroform. Both fumigated and non-fumigated soils were extracted with K$_2$SO$_4$. Organic C in fumigated and non-fumigated soil was determined as proposed by Vance et al. (1987) and total N in fumigated and non-fumigated soil as proposed by Brookes et al (1985). A correction factors (kc) of 0.33 (Sparling and Williams, 1986) and 0.54 (Brookes et al 1985) were used for the determination of biomass C and N respectively.

The microbial biomass P (MBP) was also determined by fumigation-extraction according to method of Brookes et al. 1982. Phosphorus was extracted from fumigated and unfumigated soils in 0.5 M NaHCO$_3$ (adjusted to pH 8.5 with NaOH) for 30 min on an end-over-end shaker. Phosphorus in fumigated and non-fumigated soil was analysed and used to determine microbial biomass P with a conversion factor 0.40 (Brookes et al. 1982).

**Calculations**

Biomass C (mg kg$^{-1}$ soil) = [C in fumigated soil – C in unfumigated soil]/Kec (0.33)

Biomass N (mg kg$^{-1}$ soil) = [N in fumigated soil – N in unfumigated soil]/Kec (0.54)

Biomass P (mg kg$^{-1}$ soil) = [P in fumigated soil – P in unfumigated soil]/Kec (0.40)

**Bacterial and fungal cultures**

Serial dilution of the soil samples collected was carried out using dilution factor of ×10$^2$ and ×10$^4$ for the culturing of fungi and bacteria respectively. The growth medium used for bacteria was nutrient agar while Potato Dextrose Agar (PDA) was used for fungi. The pour plate method as described by Fawole and Oso (1988) was used. After plating, the petri dishes were placed in incubator at a temperature of 28 °C for 72 hours. Colonies of bacterial formed on nutrient agar were counted using colony counter. The fungi species growing on the PDA media were also counted.

**Statistical Analysis**

Data were subjected to analysis of variance (ANOVA) using GENSTAT Release 10.3DE. Significant means were separated using Least Significant difference at probability level of $P < 0.05$.

**RESULTS AND DISCUSSION**

The soil analysis revealed that the pH (H$_2$O and KCl), organic C, available P, and total N reduced as a result of the cropping of land. The reduction in organic carbon content was more than 50% and that of available P was more than 40% (Table 1). Decomposition of organic matter was likely more rapid in cultivated fields where organic matter were buried due tillage unlike the forest where the litter accumulated on the soil surface. Land use change alters the below-ground ecosystem, often leading to loss of biodiversity and depletion of soil carbon (Doran and Zeiss, 2006). Studies by Tchienkoua and Zech (2004) revealed that soil organic carbon stocks increased significantly from cultivated food crop fields to tree based land use types. Crop removal of N, P and other nutrients in the cultivated land could be responsible for the lower amount of these nutrients in agricultural land compared to the forest. Since the agricultural plots at experimental site were cultivated with cassava and maize, removal of maize grains and cassava tuber would have taken much of these nutrients.

The microbial biomass C, N and P in the forest soil were significantly higher ($P<0.05$) than those of the agricultural soil (Figs. 1, 2, and 3). There was about two-fold increase in the microbial biomass N of the forest soil (80.89 mg/kg) compared to that of agricultural soil (38.76 mg/kg). These values were within the ranges observed in other tropical environments (Balota et al., 2003; Duda et al., 2003). The
microbial biomass P of 9 mg/kg and 5 mg/kg that was observed for forest and agricultural soils respectively, were within the range although relatively low when compared with the results of Balota and Auler (2011) who observed a range of 4.6 – 19.8 mg/kg under tree canopy and legume cropping.

Table 1: Soil Properties for Agricultural land and Forest area soils of Crescent University farm.

<table>
<thead>
<tr>
<th>Soil properties</th>
<th>Agricultural land (AC)</th>
<th>Forest area (FA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (H₂O)</td>
<td>6.2</td>
<td>6.8</td>
</tr>
<tr>
<td>pH (KCl)</td>
<td>4.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Organic C (%)</td>
<td>1.24</td>
<td>2.79</td>
</tr>
<tr>
<td>Available P (mg/kg)</td>
<td>12.19</td>
<td>21.63</td>
</tr>
<tr>
<td>Total N (g/kg)</td>
<td>0.086</td>
<td>0.106</td>
</tr>
<tr>
<td>K (cmol/kg)</td>
<td>3.39</td>
<td>4.49</td>
</tr>
<tr>
<td>Ca (cmol/kg)</td>
<td>5.54</td>
<td>10.25</td>
</tr>
<tr>
<td>Mg (cmol/kg)</td>
<td>2.74</td>
<td>2.87</td>
</tr>
<tr>
<td>Na (cmol/kg)</td>
<td>4.42</td>
<td>4.64</td>
</tr>
<tr>
<td>Sand (g/kg)</td>
<td>804.0</td>
<td>854.0</td>
</tr>
<tr>
<td>Clay (g/kg)</td>
<td>146.0</td>
<td>126.0</td>
</tr>
<tr>
<td>Silt (g/kg)</td>
<td>50.0</td>
<td>20.0</td>
</tr>
</tbody>
</table>

The significant change in microbial biomass C could be as a result of changes in the level of organic matter which is a function of soil C. Since plants provide most of the soil C in terrestrial ecosystem through litter production which most soil heterotrophic organisms depend on (Raynaud et al., 2006), microbial biomass C was higher in forested area than the cultivated areas because there was more litter production in the forested areas. Microbial biomass is just about 5% of the SOM, but it is the most labile fraction and plays an important role in nutrient cycling which makes them a good index of soil fertility (Balota and Auler 2011). The farming activities in the cultivated area probably responsible for the lower microbial C, N and P in the cultivated field since there were limited organic materials that were returned to the soil. The nutrients from the microbial cells are released five times faster than from decomposing soil plant cover residues (Paul and Clark, 1996).
The fungal count observed under forest soil was significantly higher (P<0.05) than that of agricultural soil (Figure 4). About 200% increase was observed. Similar trend was observed for bacterial count (Figure 5) when forest soil was compared with agricultural soil (Figure 5). Land use conversion and changes in cultivation can exert significant impacts on soil microbial communities and cause a shift in species composition and properties (Conrad, 1996). Khan (1999) stated that the microbial diversity is less in the agricultural lands due to increased use of pesticides and fungicides which is not common in the forest region. Several studies have shown that changes in microbial community structure may be associated with numerous alterations in soil properties caused by the land-use change, including pH, C and N content, organic matter, P concentration and exudates released by plants (Berg and Smalla, 2009; Lauber et al., 2008; Jesus et al., 2009; Carson et al., 2010; Osborne et al., 2011).

As land use intensification increases and soil quality is degraded, it has been hypothesized that the diversity of soil organisms will decrease (Swift et al., 1996), and the resistance and resilience of a community to disturbance decreased because fewer organisms can adapt to the disturbance. In agricultural soils, the microbial community has typically been exposed to long-term and frequent soil disturbance in comparison to forest soils.

CONCLUSION

Conversion of Savanna forest land to agricultural land lowered the microbial biomass of the Crescent University farm soil. Also, organic C of the agricultural land was significantly reduced. Cropping activities (Intercropping, mixed cropping and alley farming) that can increase the organic matter of the agricultural land are suggested as this can increase the microbial biomass and improve the soil quality for sustainable crop production.

References


