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Soil Quality Assessment of Different Land Use in Kabba Southern Guinea Savannah of Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author TSB designed the study and wrote the first draft of the manuscript. Author MY performed the statistical analysis and contribute to the discussion of results. Both authors read and approved the final manuscript.

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ABSTRACT

The study assessed the soil qualities of five land use types; Oil palm plantation, Nursery site, Forest (Teak), Citrus orchard and Arable Crop land in Kabba College of Agriculture using selected biological indicators which include, Organic Carbon (OC), Total Nitrogen (TN), Microbial Biomass Carbon (MBC) and Microbial Biomass Nitrogen (MBN). An area of 40 m x 30 m that is representative of each land use was selected, sampled and analyzed following standard procedures for laboratory analysis. The highest values of OC (18.41 g/kg) and TN (7.95 g/kg) were obtained at the nursery site followed by Oil Palm (OC - 14.12 g/kg; TN - 6.56 g/kg), the lowest values were obtained at the Arable Crops site (OC - 10.53 g/kg; TN - 5.20 g/kg). The MBC values ranged from 307 – 498 mg/kg across the land use studied. The MBN values obtained in this study ranged between 16.93 - 34.41 mg/kg. The MBC/MBN ratios obtained in this study were relatively high and in the following order Forest land (26.5 mg/kg) > Oil Palm Plantation (21.3 mg/kg) > Citrus orchard (19.5 mg/kg) > Nursery site (15.9 mg/kg) > Arable Crops land (12.2 mg/kg) respectively indicating the predominance of fungi in these soils. It is recommended that sustainable practices that will encourage replenishment of C and N into the soil should be adopted in the study area.

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Keywords: Soil quality; land use; organic carbon; total nitrogen; microbial biomass.

1. INTRODUCTION

Soil quality according to Karlen et al. [1] can be defined as the capacity of soil to function within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality and support human health and habitation. The call for sustainable agricultural production to meet food and industrial demand of fast increasing population as well as ensure the safety of soil and environment has made the study of soil quality to be imperative. Several workers had laid emphasis on the importance of soil in solving recent global issues such as poverty alleviation and food security, demands for energy and water and climate change [2,3,4,5].

The assessment of the quality of the soil is important in monitoring soil productivity and meeting the global demand on soils. Several indicators had been used to express the quality of soils which include; bulk density, porosity, soil organic matter, total nitrogen and microbial properties [6,7] or simulation modeling [8].

According to Babalola and Fasina [9] different agricultural land use can bring out variation in soil properties, therefore soils of the same nature can end up having different soil conditions as a result of the use to which they are put into. This view was supported by [10,11,12]. An assessment of the soil functional capacities on the bases of land utilization types is important in other to have information on current condition of soils and for the development of soil management system that will guarantee soil sustainability. Kabba College of Agriculture is situated on 346 hectares of land, about 250 hectares have been classified as agricultural land by Higgins [13] and there was no report on assessment of soil functionality of the area. The need for this study is therefore imperative. The objectives of this study were:

1. To determine the soil quality of the study area.
2. To compare the soil quality of the different land use in the study area.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study area is located in Kabba, Southern Guinea Savanna Ecological Zone of Nigeria (latitude 07˚53′N and 07 ˚5′N and Longitude 6˚8′E and 6 ˚3′E). The rainfall spans from April to November with the peak in June to September while the dry season extends from December to March. The mean annual rainfall is 1,570 mm per annum with an annual temperature range of 18˚C - 32˚C and the Mean Relative Humidity is 59% [14].

The main vegetation of the area is; tall grasses, shrubs, some trees, plantains, oil palm, etc. Some parts of the area, however, had been put to cultivation of arable crops like maize and tubers such as yam and cassava while a part of the site is used for field experiments with experimental crops such as cowpea, cassava, maize tomato being planted. On the whole, human activities (cultivation) influenced the vegetation. The major soil orders within the experimental sites are Gleysol and Alfisol [15]. The land uses under consideration include: Oil Palm Plantation, Nursery Site, Arable Crops Land, Citrus Orchard and Forest Land.

2.1.1 Soil sampling and laboratory analysis

An area of 40 m x 30 m, that is representative of each of the land use was selected for soil sampling. The area selected was demarcated to four and composite soil samples were collected at each of the demarcated area at soil depth 30 cm. Part of the sample was stored in plastic bags at 4°C for soil microbial biomass (SMB) determinations i.e. Microbial Biomass Carbon (MBC) and Microbial Biomass Nitrogen (MBN). The remaining soil was air-dried, passed through a 2 mm sieve and stored at ambient temperature for analysis of other soil properties.

Total Nitrogen (TN) was determined by the Kjeldahl digestion procedure [16]. Organic Carbon (OC) was determined by digesting the soil at 130^0C for 30 min with concentrated H_2SO_4 and $K_2Cr_2O_7$, after which OC was, determined calorimetrically [17]. Soil Microbial Biomass Carbon (MBC) and Soil Microbial Biomass Nitrogen (MBN) were determined by the chloroform fumigation–extraction method [17] in closed desiccators for 24 hrs at 25^0C. MBC/MBN ratio, MBC/OC ratio and MBN/TN ratio (%) were calculated from the results of the analysis. The levels of parameters studied were expressed for each land use with bar chart and shown in Figs. 1, 2 and 3.

3. RESULTS AND DISCUSSION

3.1 Organic Carbon and Total Nitrogen

Results on Organic Carbon (OC) and Total Nitrogen (TN) are presented in Fig. 1. The highest values of OC (18.41 g/kg) and TN (7.95 g/kg) were obtained at the Nursery site followed by Oil Palm OC (14.12 g/kg) and TN (6.56 g/kg), the lowest values were obtained at the Arable Crops site (OC - 10.53 g/kg; TN - 5.20 g/kg). The OC and TN values recorded in this study are generally low by in agreement with values reported for Nigeria soils [7,18,15].

The high results obtained at the nursery and Oil palm site could be attributed to all year round cultivation, adequate nutrient input from fertilizer and manure, returns of decay organic materials to the soil in the form of decaying roots, litter and crop residues [7].

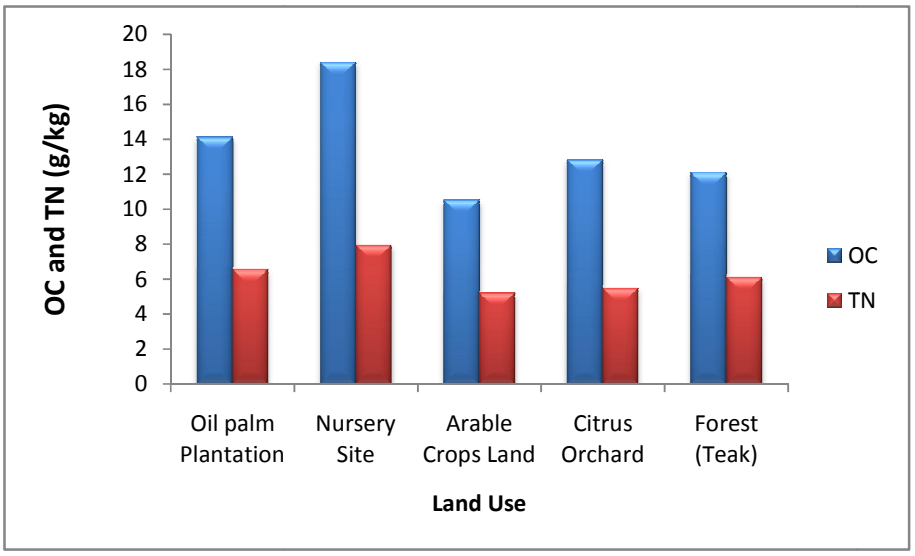

Fig. 1. Effect of land use on organic carbon and total nitrogen

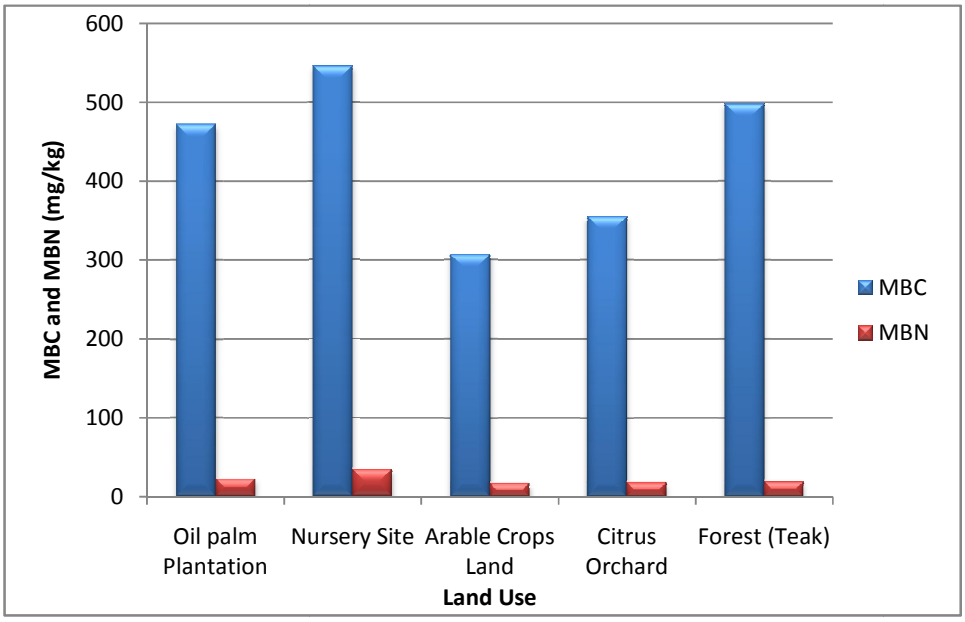

Fig. 2. Effect of land use on microbial biomass carbon (MBC) and microbial biomass nitrogen

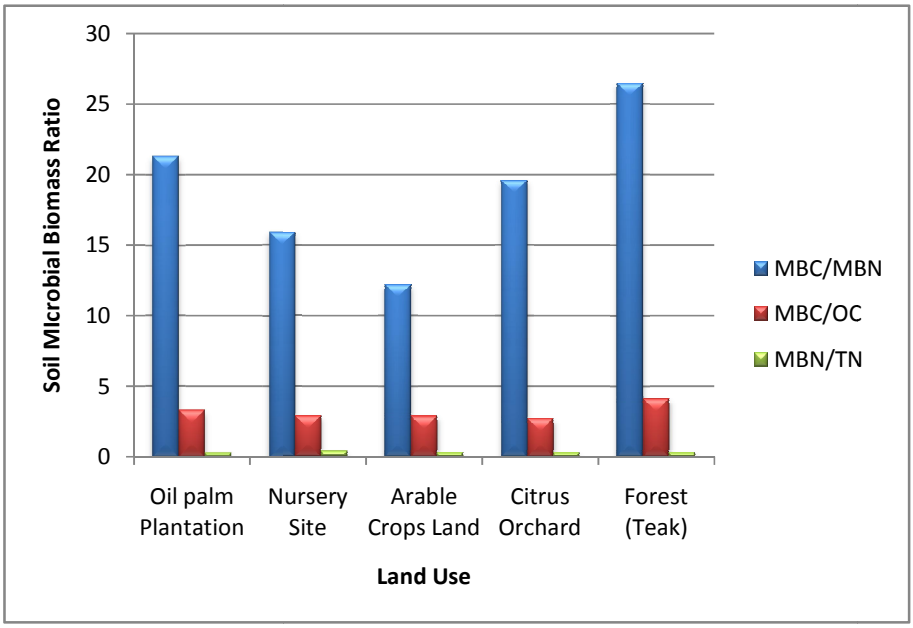

Fig. 3. Effect of land use on soil microbial biomass ratio

Organic C may serve as a suitable indicator of soil quality. Several studies reported that soil organic matter fractionation may offer information on soil fertility status and past management history of soils [19,20]. In this study, soils from land use studied contained different Organic Carbon levels that reflect the management practices on them. This observation agrees with [20] who compared C fraction changes in different soil management strategies after 18 years of continuous cultivation in a long-term, on-station experiment located on the Kikuyu Red Clay.

3.2 Microbial Properties

Results on microbial properties are presented in Figs. 2 and 3. The MBC values ranged from 307 to 498 mg/kg across the land use studied. These values are in agreement with of values of 115 to 1231 mg/kg reported by [21,22] and 61 to 1620 mg/kg reported by [23] in other land use types and terrestrial ecosystems. Also the values are in agreement with the findings of [7] - 182 to 766 mg/kg and [24] - 131 to 270 mg/kg for Nigerian Soils in other land use types and terrestrial ecosystems. However, it is lower than the values of 1000 to 2000 mg/kg recorded in humid tropical forest in Amazonia [25].

The lowest value of MBC (307 mg/kg) was recorded at the arable crops site. This is responsible for the lowest OC value (5.2 mg/kg) recorded at the site and can be attributed to tillage, poor return of plant residue as a result of harvesting [10]. Relationship between Microbial Biomass and OC has been established [7,26]. The MBN values obtained in this study ranged between 16.93 to 34.41 mg/kg, they are in agreement with reported values of 18.59 to 44.78 mg/kg by [7] and 25.6 to 42.2 mg/kg by [27]. The Nursery site has the highest OC, TN, MBC and MBN value and this has been attributed to round the year cultivation with application of inorganic and organic fertilizers [7,27].

The MBC/MBN ratio has been reported to be related to the soil microbial community [7]. A low MBC/MBN ratio indicates that the microbial biomass contains a higher proportion of bacteria whereas a high value suggests that fungi predominate in the microbial population [28,29]. The MBC/MBN ratios obtained in this study were relatively high, ranging from 15.9 to 26.5 mg/kg indicating the predominance of fungi in these soils. The MBC and MBN when expressed as percentages of OC and TN respectively give an estimation of the quantities of nutrients in the microbial biomass, organic matter dynamics and substrate availability in soils [30]. Reports in this study revealed that MBC accounted for between 2.7 to 4.1% of OC while MBN was 0.3 to 0.4% of STN. This result also agrees with the findings of [7]. However, the MBN as a percentage of TN obtained are lower than the ranges reported in

literature by other workers for arable, pasture and forest; and the low values indicate that the microbial biomass is not important as a sink for N in these areas [27]. Differences in biomass content are directly related to the primary factors affecting microbial ecology [31]. Climatic factors play significant role on biodegradable organic material and microbial growth [32]. The study area has a humid tropical climate which is characterized by high temperature, rainfall and humidity, these along with intensive tillage most especially in the arable land may limit microbial biomass.

4. CONCLUSION

Indicators studied in this research OC, TN, biomass C and N proved to be suitable biological indicators of soil quality in the study area and they all agree with findings of past research on the subject matter. Round the year cultivation practice in the Nursery site improves the quality of soil in the study area. Microbial activities are more active in the Nursery and Plantation areas than the Arable land due to high levels of C and N. It is therefore recommended that sustainable practices such as, the use of organic manure, green manure, planting of legumes as sole crop and intercrop that will encourage replenishment of C and N into the soil should be adopted in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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