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EFFECTS OF LAND USE ON THE NATURE AND POPULATION OF MICROORGANISMS IN THE SEMI-ARID REGION OF NORHT-EASTERN NIGERIA

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Abstract

This study was aim to investigate the effects of land use on the nature and population of microorganisms in soil from five different farms within University of Maiduguri, Borno State. A total of ten composite samples were obtained and analyzed in the laboratory. The total microbial population was consistently higher in the grazing reserved land with mean of $105x10^4$CFU/g than in cultivated farms with means of $84.5x10^4$CFU/g, $66x10^4$CFU/g and $66x10^4$CFU/g, for cereal (sorghum), beans and tomato farms respectively. The site with the least microbial population was gum-Arabic plantation with the mean of $29x10^4$CFU/g. Bacteria were the most dominant species at all sites regardless of depths.

Key words: Farming practices, biodiversity, Fungi, Bacteria and Population

Introduction

Soil support diverse microbial communities that play important roles in ecosystem level processes such decomposition of organic matter and nutrient cycling(Wright and Reddy, 2001).One gram of soil in good conditions can contain 600 million bacteria belonging to about 15,000 to 20,000 different species. These values decrease to one million bacteria encompassing from 5000 to 8000 species in desert soil (Informativocapebe, 2010).One cubic meter of soil may house many hundreds of species of bacteria, Actinomycetes, fungi, and algae. There may be 1.5 million species of fungi but only five percent have been described (Tilak, 2000).The richness, abundance and activity of the microbial community is vulnerable to influence by soil physical and chemical properties such as pH, moisture, organic matter content, and nutrient availability. Alterations in the physical and chemical nature of the soil may lead to shifts in microbial community, composition and changes in microbial function.

Agricultural practices such as fertilization and tillage influence soil chemical properties and nutrient dynamics throughout the soil profile (Gesch *et al.*, 2007; Wright *et al.*, 2007). Although several studies indicate that cultivation increases the population and diversity of soil biota, there has been few report of increased population under minimum tillage with residue incorporation as compared to conventional tillage (Linn and Doran, 1984).In general, cultivated soils have greater diversity than fallow lands (Kennedy and Smith, 1995). In a comprehensive study in Alfisols and Vertisols in Pennisular, India

(Venkateswarlu, 2000) observed a considerable decline in population and diversity as a result of top soil erosion. Application of nitrogen fertilizers like ammonium sulfate increases the fungal population whereas FYM and NPK application increased the population of fungi, bacteria and Actinomycetes (Sharma *et al.,* 1983). Certain species of microorganisms like Azobacter are very sensitive to soil acidity while others like Nitrosomonas and Nitrobacter are more sensitive to erosion of top soil (Venkateswarlu, 2000). Chemical fertilizers in particular are sometimes responsible for soil acidity (Barak *et al.,* 1998) and a decrease of microbiological activities in fertilized soils compared to those in natural habitat (Monkiedje *et al.,* 2006). It is known that addition of charred plant materials to soil accelerates breakdown of simple carbohydrates (Hamer *et al.,* 2004), and that microbial community activity and metabolic efficiency increases linearly with the addition of charcoal to soils(Steiner *et al.,* 2008).The application of animal manures, sewage sludge and compost have the potential not only to increase soil organic matter stock, but also to increase the size(Anderson and Domsch, 1989; Guerrero *et al.* ,2007), activity (Bolton *et al.,* 1987) and diversity (Hassink *et al.,* 1991) of the soil microbial community. The abundances of biomarkers from Gram-negative bacteria are normally increased in soil receiving application of farmyard manures (PeaCock *et al.,* 2001; Bohme *et al.,* 2005; Bossio *et al.,* 1998). Application of inorganic nitrogen (PeaCock *et al.,* 2001)or compost (Bossio *et al.,* 1998), are however associated with increased abundance of Gram positive biomarkers. Without changes to upstream animal husbandry and waste management, greater use of manures and allied materials within a more sustainable form of conventional agriculture has the potential to produce substantial, long live-changes to soil microbial community composition through the introduction of metals and antibiotics/other veterinary medicines(Abaye *et al.,* 2005).In a dry hot climate, the humidity and soil salinity are the most stressful factors for the soil microbial flora and frequently occur simultaneously (Batra and Manna, 1997; Zahran, 1997; Rietz and Haynes, 2003; Sardinha *et al.,* 2003). The effect is always more pronounced in the rhizosphere according to the increase in water absorption by plants due to transpiration. Fungi have been reported to be more sensitive to osmotic stress than bacteria (Pankhurst *et al.,* 2001; Sardinha *et al.,* 2003; Wichern *et al.,* 2006).There is a significant reduction in the total fungal count in soil salinized with different concentrations of sodium chloride.

The populations and biomass levels of major groups of organisms in a typical soil profile (0-25cm) has already been described by Miller (1990). In terms of biomass, fungi dominate in the soil followed by bacteria and Actinomycetes. The total populations and live biomass are only reflections of the status of the soil at a given point of time, but do not give a clear picture of the living diversity as influenced by different land use practices over time. This research work aims to determine the effects of different farming practices and its functional significance on the soil biota with reference to University of Maiduguri farms.

Materials and Method

Study Area

The research was conducted at University of Maiduguri, Borno State, Nigeria. Maiduguri is located in the semi-arid region of Northeastern Nigeria, It is known for its dryness with semi-arid climate, savannah or tropical grasslands vegetation, light annual rainfall of above 300 to 500mm and the average daily temperature ranging from 22 to 35 degree centigrade, with mean of the daily maximum temperature exceeding 40 degree centigrade between March and June. It has mainly sandy loam soils (Arku *et al.*, 2011).The University of Maiduguri farms were divided into five namely; cereal vegetable, and legume farms, grazing land, and gum-Arabic plantation.

Collection of soil samples

The soil samples were collected at two depths: 0-15cm and 15-30cm, using screw-auger. Five samples were taken randomly from each site and mixed thoroughly to form composite samples. The soils were put into plastic bags, labeled and immediately transported to the laboratory for analysis (Subra, 2001; Okonkwo, 2010). A total of 10 composite samples were used in the study.

Soil analysis

The soil samples were sieved through a 2mm sieve. One gram of each sample was mixed with 10ml of deionized water in a screw-capped bottle. The soil solutions were then serially diluted down to five steps. One ml of each sample was pipetted into a petri dish in 3 replications, and was then mixed with nutrient agar (Subra, 2001; Jackie, 2013).The mixtures in the petri dishes were allowed to solidify and were incubated at 28˚C for 48 hours. The petri dishes were then removed from the incubator and the colonies enumerated using the plate count method (Julia *et al.*, 2005; Jackie, 2013)

Results

Table 1: Numbers and distribution of microorganisms present in the soils of different land use system

Sites	Soil depths	Bacterial counts CFU/g	Fungal counts CFU/g	Total microbial counts CFU/g
Cereal (sorghum) farm	0-15cm	$80.5x10^4$	$4.0x10^4$	$84.5x10^4$
	15-30cm	$74x10^4$	$5.5x10^4$	$79.5x10^4$
Grass (reserved) land	0-15cm	$95x10^4$	$10x10^4$	$105x10^4$
	15-30cm	$82x10^4$	$6x10^4$	$88x10^4$
Gum-Arabic plantation	0-15cm	$28x10^4$	$1x10^4$	$29x10^4$
	15-30cm	$64x10^4$	$5.5x10^4$	$50.5x10^4$
Harvested beans farm	0-15cm	$64x10^4$	$2x10x^4$	$66x10^4$
	15-30cm	$64x10^4$	$2.5x10^4$	$66.5x10^4$
Tomato farm	0-15cm	$57x10^4$	$9x10^{4s}$	$66x10^4$
	15-30cm	$46x10^4$	$3.5x10^4$	$49.5x10^4$

Table 1 above shows the numbers and distribution of microorganisms present in the soil samples of different land use system. The result indicated that the numbers of microorganisms were influenced by soil depths. As shown in the table, grass land has the highest microbial diversity of $105x10^4$CFU/g at the depth of 0-15cm while, Gum-Arabic plantation has the lowest microbial counts of $50.5x10^5$CFU/g. At the soil depth of 15-30cm, grass reserved land has the highest microbial counts of $88x10^4$CFU/g, while tomato farm has the lowest. Fungal populations increased in the grass reserved land and cereal farm and were more at the top (0-15cm). Regardless of depth, bacteria tend to outnumber the fungi.

Discussion

The main aim of the study was to determine the effects of land use on the nature and population of microorganisms in University of Maiduguri farms. Soil microbial communities are susceptible to changes with different agricultural practices and land use management. In this study, soil dilution and plates counts method was used for the enumeration and isolation of the biota in soil samples from land under grazing, plantation and cultivation. The results from the table above shows that all cultivated lands and the grass land soils show consistently higher microbial populations than soil samples from land planted with gum-Arabic trees. The number of microorganisms was influenced by soil depths. In all the soil samples tested, the distribution of microbes was higher at the soil depth of 0-15cm, with the exception of soil samples from gum- Arabic plantation which shows higher microbial counts at the depth of 15-30cm,and the harvested beans farm which shows relatively higher microbial populations also at same depth of 15-30cm. However, the higher diversity of microbes may be influenced by the abundance of leaves and grass residue that are dropped on the soil surface, which soil biota used as food source. Amendment of soil surface with manure, sewage sludges, compost, and other chemical fertilizers may increases organic matter contents which may increases the size of the soil microbial community. The result of this study is contrary to the work of Ekelund *et al.* (2001) who reported that, a bacterial peak has been observed at a 42.5cm depth in the peat profile of a spruce (Piceaabies) and birch (Betula pubescens) forest in Denmark, caused by partial anaerobic conditions, higher water contents, and higher organic matter content deeper in the soil. It also contrary to the result of Wuczkowski *et al.* (2003) who reported that in agricultural soils with conventional farming the higher diversity was recorded at a depth of 30-35cm caused by agricultural practices.

The bacterial counts of soil samples studied were generally higher than the fungal counts. Fungi populations increased in the grass land and tomato farm and were even more in the top soil (0-15cm).The abundance of fungi in the two land use systems may be attributed to their ability to proliferate at acidic soil. This corresponds with the work of Okonkwo (2010) who reported that the abundance of fungi on the top soil (0-15cm) may be attributed to the fact that fungi are strict aerobes and exhibit selection preference for various depths of the soil. It also agreed with the report of Wuczkowski *et al.* (2003) that the highest diversity of cultivable microfungi and yeasts in Autsria was found in the top layer of the forest soil (0-15cm) without temporal flooding.

The total microbial counts varied with the different farming systems, with sample from grass land generally having the highest counts ranged from 105×10^4CFU/g to 88×10^4 CFU/g. Gum-arabic plantation was the least, ranged from 29×10^4 CFU/g to 50.5×10^4 CFU/g. The variations in the distribution of microorganisms may be influenced by plant residues that covers the soil surface, also protect the soil from sealing and crusting by raindrop impact, thereby enhancing the proliferation and activity of microorganisms. Also, heavy application of organic materials in the soil surface, such as human waste, and animal dropping during grazing may provide carbon to the soil organisms, and also helps to balance the micronutrients contents of the soil, hence increases their population and diversity. The lower microbial counts at the soil surface of gum-Arabic trees may be resulted from the lack of leaf litter which may expose the soil to erosion. This study corresponds with the work of Vertakeswarlu (2000), who observed a considerable declined in populations and diversity of as a result of top soil erosion. An even distribution of microorganisms without a decrease in their number with depth was found in a cryogenic weakly solidized loamy-sandy pale soil of Yakutia (Inovano, *et al.*, 2008).This finding was similar or slightly similar with our result on the total microbial counts of harvested beans farm, which equal distributions of microbes at both depths, with ranged from 66 x 10^4CFU/g to 66.5 x 10^4CFU/g.

It could be concluded that increase in microbial activity and diversity is influenced by soil depths. Also, grass land and cultivated lands support the growth and survival of soil biota.

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