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Full Length Research Paper

Effect of long-term organic fertilizer application on soil microbial dynamics

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We assessed the effects of long-term organic fertilizer application on the culturable resident bacterial and fungal communities of a typical tropical soil of the Niger delta. The total viable bacterial counts ranged from 5.8 × 10^5 cfu/g to 1.6 ×10^6 cfu/g, while the fungal density varied from 3.5 × 10^5 cfu/g to 5.5 × 10^5 cfu/g. The highest bacterial and fungal counts were recorded during 21 – 52 weeks (S2) of fertilizer application, while the lowest counts were recorded during the 0 – 4 and 104 – 260 weeks of fertilizer application. Several bacteria isolated belonging to six genera including *Bacillus*, *Erwinia, Pseudomonas*, *Micrococcus*, *Proteus,* and *Klebsiella* were observed in this study, while the fungal isolates included members of the genera *Aspergillus*, *Penicillium*, *Rhizopus* and *Fusarium*. *Bacillus*, *Proteus* and *Aspergillus* and were observed to have increased in number within the period of the different treatments, in comparison with *Erwinia*, *Klebsiella*, *Micrococcus* and *Fusarium* genera which decreased in population. We conclude that the organic fertilizer used in the present study was well tolerated by the native soil micro flora since there were no discernable changes in the overall population of the resident soil bacteria and fungi. Besides their value in restoring soil nutrient and structure, incorporation of organic fertilizer could lead to the control of some soil borne bacterial and fungal pathogens.

Key words: Organic fertilizer, soil microbial dynamics, bacteria and fungi.

INTRODUCTION

Intensive cultivation, which leads to depletion of soil nutrients, is a major constraint on food production. To overcome the rapid decline in soil fertility, inputs of organic materials such as manure, compost and animal dung that contain nutrients are applied to the soil to improve and maintain crop yield.

vanCotthem (2007) defines fertilizer as any organic or inorganic material of natural or synthetic origin which is added to a soil to augment the level of or supply certain element essential for plant growth. Any amendment to the soil to enhance soil fertility is therefore a fertilizer. Organic fertilizer is derived from materials that are essentially carbon in nature. These materials of organic fertilizers can either be plant or animal or their by-products. One distinct merit of organic fertilizers is that they naturally contain organic matter that is beneficial to plants and the soil. Organic matter in organic fertilizers helps to improve the water-holding capacity of soil and also augments its structure, thus increasing its nutrient-holding capacity as well. Another benefit of organic matter in organic fertilizers is that it encourages microbial activity which plays a crucial part in the breakdown of nutrients so that plants can use them (Nester et al., 1998). There is less danger of over-fertilization by adding decomposed organic material to a garden. According to Paul and Clark (1996), it provides a slow release of nutrients as micro-organisms in the soil break down the organic material into an inorganic and water soluble form which the plants can use. The ultimate goal of fertilizer application is to maximize productivity and economic returns.

Several studies have shown that application of organic fertilizers reduces the incidence of soil-borne diseases

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and pathogens (Faqir et al., 1995; Vanlauwe et al., 1996; Sarathchandra et al., 2001; Graham and Haynes, 2005). In a similar study, Mobambo et al. (1994) conducted surveys of field and compound plantain plantings in Nigeria to determine effects of application of organic fertilizer on the severity of black leaf streak (black sigatoka) disease caused by *Mycosphaerella fijiensis*. They noted that the disease was reduced in compound gardens where organic fertilizers were regularly applied in the form of household refuse and animal waste. Vanlauwe et al. (1996) studying the effects of residue quality and decomposition of plant material, observed an increase in soil biomass when readily decomposable organic matter was added to native soil.

The effect of long-term application of organic fertilizers on soil microbial populations can be measured either as changes in the population of a particular organism, organism groups or methodologically defined pools such as the microbial biomass or as changes in biological activity, for example, soil respiration and enzyme activeties. Variable effects of a given amendment on different organisms may change the composition of the microbial community without changing total populations or activities (vanZwieten, 2006). The purpose of this study was to assess the population dynamics of resident soil bacteria and fungi in relation to the period of organic fertilizer application.

MATERIALS AND METHODS

Media

Nutrient agar and potato dextrose agar were the culture media employed in the study. The media were constituted according to manufacturer's specification. This involved weighing the appropriate quantities of each medium and dissolving in required amount of distilled water in conical flask with the aid of heat. The media were distributed in Bijou bottles according to required volumes and sterilized by autoclaving at 121°C for 15 min and maintained in molten form until ready for use.

Experimental sites/design

The study was carried out within Uyo Metropolis, in Akwa Ibom State, south-south Nigeria. The experimental fields were divided into three sites with control, each for different treatments and levels of fertilizer. The optimum fertilizer dosage was applied to the field following the experimental methods adapted from Albiach et al. (2000) and Saggar et al. (2000). According to the period of fertilizer treatments, each of the experimental sites was designated as S1, S2 and S, respectively. The fields were properly ploughed before adding fertilizer.

Soil sampling and processing

Composite soil samples (0 to 30 cm depth) were collected randomly and aseptically from the various sites (S1, S2 and S3) with varying periods of organic fertilizer application. After sieving, approximately 300 g of each sample was pooled into sterile polyethylene bags, labeled and taken to the laboratory for analysis.

Isolation and counting of most platable microorganisms

The dilution plate technique was employed to enumerate the most important groups of soil bacteria and fungi. This involved weighing ten grams (10 g) of each soil samples and dissolving in one hundred milliliters (100 ml) of sterile water in conical flask. After which ten-fold serial dilution was carried out for each of the samples. One milliliter (1 ml) of the dilution(s) were inoculated into the molten agar pour (in Bijou bottles) and mixed gently. Subsequently, the contents of each of the Bijou bottles were poured into the corresponding Petri dish and allowed to set on the bench. Nutrient agar medium was used for the isolation of bacteria and potato dextrose agar was used for fungi. Petri dishes were incubated in an inverted position at 37°C for 24 h and at 25°C for 5 days for bacteria and fungi, respectively. Small inoculums from an isolated colony of each type of organism in the mixture were picked and transferred to an agar slant and preserved for further analysis.

Characterization and identification of microbial isolates

The characterization and identification of the microbial isolates were based on cell morphology, biochemical test and their ability to hydrolyze cellulose. The fungal isolates were identified by microscopic and macroscopic techniques described by Barrow and Feltham (2003).

RESULTS AND DISCUSSION

The bacterial and fungal counts of soil samples from the various sites with varying periods of organic fertilizer application are presented in Figures 1 and 2. From the results obtained, the total bacterial counts ranged from 5.8×10^5 to 1.6×10^6 cfu/g and fungal counts ranged from 3.5×10^5 to 5.5×10^5 cfu/g. The results showed that the highest counts were obtained within 21 – 52 weeks (S2) of organic fertilizer application, while the lowest counts were recorded during the 0 – 4 and 104 – 260 weeks for bacteria and fungi, respectively. According to Nester et al. (1998), microbial population is limited by the organic matter available in the soil. This implies that the addition of organic material into site S1, S2 and S3 dramatically increased the number of bacteria and fungi recorded in this study. This agrees with the findings of Albiach et al. (2000) that long-term application of organic fertilizers positively influences the soil available nutrients and results in increased microbial proliferation. Rangaraj et al. (2007) also found that incorporation of organic fertilizer increases the available phosphorus (P) status at maxi-mum level. The reason might be the slow releasing nature of the organic fertilizers.

The results of the bacterial and fungal enumeration at the different periods (0 - 4, 21 - 52 and 104 - 260 weeks) suggests that the applied dose were well tolerated by the resident micro flora. Evidently, none of the application rate resulted in any discernable change in the overall population of soil bacteria and fungi. Also, the frequency of occurrence of bacterial and fungal species presented in Table 1 indicates a change in the relative abundance of the different species after organic fertilizer treatment.

The study revealed the presence of the following

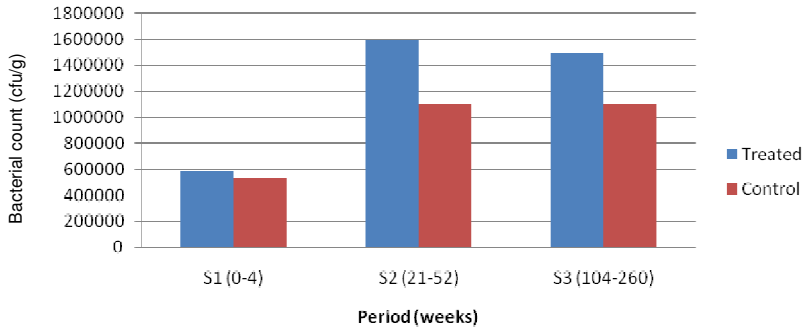

Figure 1. Bacterial counts against period of organic fertilizer application.

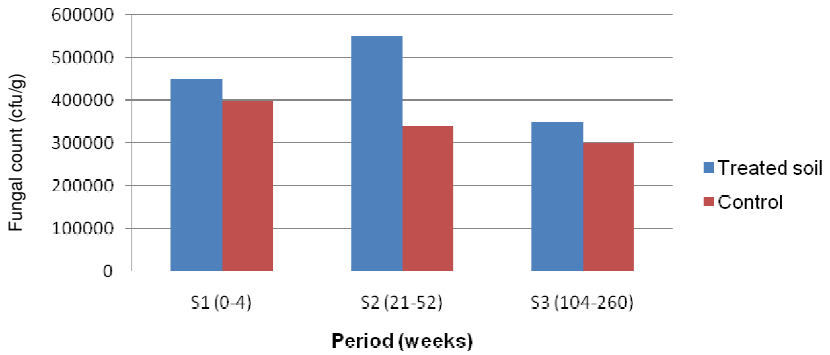

Figure 2. Fungal counts against period of organic fertilizer application.

Table 1. Percentage frequency of occurrence of isolates from soil with organic fertilizer application.

Probable organism	Period of fertilizer application (weeks)					
	0 - 4		21 - 52		104 – 260	
	Treated soil (S1)	Control	Treated soil (S2)	Control	Treated soil (S3)	Control
Bacteria						
Bacillus sp.	15.0*	19.0	20.0	15.0	21.0	18.0
Erwinia sp.	-	5.00	7.00	9.00	-	6.00
Pseudomonas sp.	-	14.0	-	3.00	13.0	11.0
Micrococcus sp.	15.0	5.00	12.0	5.00	-	6.00
Proteus sp.	25.0	19.0	17.0	31.0	21.0	23.0
Klebsiella sp.	15.0	5.00	-	5.00	-	6.00
Fungi						
Aspergillus sp.	30.0	14.0	17.0	16.0	18.0	6.00
Penicillium sp.	-	5.00	12.0	8.00	13.0	12.0
Rhizopus sp.	-	9.00	-	5.00	14.0	6.00
Fusarium sp.	-	5.00	15.0	3.00	-	6.00

*Frequency of occurrence of isolates (%).

bacterial isolates of the genera: *Bacillus*, *Erwinia*, *Pseudomonas*, *Micrococcus*, *Proteus* and *Klebsiella*, whereas the fungal isolates were *Aspergillus*, *Penicillium*, *Rhizopus* and *Fusarium*. The initial distribution of soil bacteria and fungi before the organic treatment indicated that *Bacillus*, *Proteus*, *Aspergillus* and *Penicillium* species

were most abundant. *Bacillus*, *Proteus* and *Aspergillus* species were seen to have increased in number within the period of the different treatments. On the contrary, *Erwinia* spp., *Klebsiella* spp., *Micrococcus* spp. and *Fusarium* spp. decreased in number, being the least detected after organic fertilizer application at the different periods. The reduction in the frequency of isolated *Erwinia, Klebsiella* and *Fusarium* suggested the potential attribute of the fertilizer treatment in biological control of soil borne *Erwinia, Klebsiella, Micrococcus* and *Fusarium* species. This agrees with Mobambo et al. (1994) survey of field and compound plantain plantings to determine effects of application of organic fertilizer on the severity of black leaf streak disease caused by *Mycosphaerella fyiensis*. They noted that the disease was reducing in compound gardens where organic fertilizers were regularly applied in form of household refuse. The reduction in the population of *Erwinia, Klebsiella, Micrococcus* and *Fusarium* species further suggests that these soil borne bacteria and fungi may not have competitive saprophytic ability comparable to *Bacillus, Proteus* and *Aspergillus* species. Usually, the most competitive population will sustain the highest growth rate under the prevailing soil conditions, while the least competitive would be eliminated or inhibited. These explanations suffice for varying responses of the different resident bacterial and fungal species.

Conclusion

The results of the present study indicate that long term organic fertilizer application was well tolerated by the native soil microflora since there were no discernable changes in the overall population of the resident soil bacteria and fungi. The soil fertility status (macro and micronutrients) was enhanced. Besides their value in restoring soil nutrient and structure, incorporation of organic fertilizer could lead to the control of some soil borne bacterial and fungal pathogens.

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