academicJournals

Vol. 12(13), pp. 1103-1111, 30 March, 2017
DOI: 10.5897/AJAR2017.12223
Article Number: B17A25A63459
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Influence of different soil management practices on soil organisms and maize (*Zea mays* L.) yield in South Eastern Nigeria

Benwari A. O., Uchunor S. I. and Omovbude S.*

Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, P. M. B. 5323, Choba, Port Harcourt, Rivers State, Nigeria.

Received 13 February, 2017; Accepted 2 March, 2017

The experiment was conducted at Teaching and Research Farm of University of Port Harcourt between May and August, 2016 to determine the influence of different soil management practices on soil organisms and maize yield (*Zea mays* L.) in South Eastern Nigeria. The experiment consisted of six treatments, namely: control (no application), cover crop (pumpkin cover), 10 t/ha dry guinea grass mulch (dead mulch), 10 t/ha poultry manure, 250 kg/ha N:P:K 15:15:15 and 10 t/ha dry guinea grass as bush burning material. These treatments were laid out in a Randomized Complete Block Design with four replicates. Results showed that the initial bacterial count was 2.0 × 10^6 CFU/g, fungal count (1.7 × 10^5 cfu/g), and earthworm casts (0). The soil was sandy loam and the pH was very strongly acid (4.80). At 11 weeks after application (WAA), NPK treated plots had the highest bacterial count (4.6 × 10^6 CFU/g), while cover crop and dead mulch plots had the highest fungal count (1.9 × 10^5 cfu/g). At the point of harvest, the highest earth worm casts (19.00) were in cover crop. The most predominant bacteria isolates across the various soil management practices were *Bacillus* and *Pseudomonas* species, while that of fungal were *Aspergillus niger* and *Candida* species. Maize yield differed significantly ($p<0.05$) among various soil management practices. In spite of the variation in the population of soil organisms, NPK plots produced the highest yield (170 kg/ha) and is therefore recommended.

Key words: Influence, maize yield, soil management practices, soil organisms, Southeastern Nigeria.

INTRODUCTION

The functions of soil organisms have direct and indirect effect on crop growth, soil quality and the sustainability of soil productivity. The organisms found in the soil encompassed of the micro and macro organisms. The activities of macro organisms, specifically earthworms are beneficial because they help to decompose organic matter and their burrowing habit incorporates the organic matter into the soil and also creates large pore spaces

*Corresponding author. E-mail: sundayomovbude@yahoo.com.

Table 1. Rainfall distribution and temperature of the study area in 2016 (Department of Geography, University of Port Harcourt, Port Harcourt, Rivers State, Nigeria).

Month	Rainfall (mm)	Temperature Range (ºC) Max. - Min.
January	0.00	37.00 – 11.00
February	0.00	38.83 –16.10
March	115.50	34.86 – 25.57
April	109.70	34.79 –24.46
May	341.50	32 .88– 23.42
June	217.50	30.83 –23.26
July	353.60	29.58 – 22.75
August	167.00	29.58 – 22.03
September	1087.10	34.88 –28.41
October	140.10	31.46 – 22.86
November	2.60	33.35 – 14.10
December	6.50	34.10 – 14.10
Total	2541.10	402.14–248.06
Mean	211.76	33.51 –20.67

that aerate the soil and allow faster water infiltration. The smaller organisms (microorganism), such as bacteria, fungi and algae, further decompose the organic matter, which releases nutrients in a form that 'higher' plants can use.

Soil management practices influence the physical and chemical properties of the soil, thereby bringing about changes in the biological community's structure, functions and various soil processes through changes in the quality and quantity or organic matter residues in the soil. The use of organic manure, inorganic fertilizers, mulching, cover cropping, bush burning, pesticide application, etc., influences soil biological, physical and chemical properties and have varying degree of impact on the productivity and sustainability of the soil. The application of inorganic fertilizers that contain nitrogen and other essential elements like phosphorus and potassium are important in the growth and development of maize. Most inorganic fertilizers increase soil microbiological activities, because they increase plant productivity, hence, leaving organic residues of high quality as food for soil biota.

Research has shown that the application of NPK compound fertilizers increased the population of bacteria, fungi, and actinomycetes. Organic manure such as poultry droppings, generally increase the biological activities and population of the macro and microorganism communities and biomass, through an increase in supply of energy (Enwall et al., 2007). Burning of crop residues increases the population of some soil microbes, through the increase in soil pH to a level that is optimal for microbial activities and population as well as crop productivity. However, the repeated burning of crop residues depletes the soil organic matter and biological activities fall as the food supply to soil biota is reduced. Mulching helps to supply organic matter and nutrients, not only to plants but also to soil organisms (Cherr et al., 2006). Mulching positively influences the population of soil fauna (Brevault et al., 2007) by creating food supply and an optimal environmental condition for their performance. The quantity and quality of crop residues used as mulch are properties that affect the biological activities and population in soil.

Over the years, farmers carry out various soil management practices to improve crop yield with little or no knowledge on how it affects the organisms present in the soil. Such practices could lead to changes in the population and biological processes carried out by these organisms. Maize popularly called corn of the family of Poaceae was chosen for this study because it is the most completely domesticated of all the arable crops and it constitutes the basic food for the people in South Eastern Nigeria. Hence, the objective this study was to determine the influence of different soil management practices on soil organisms and maize yield in South Eastern Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was conducted at Teaching and Research Farm, University of Port Harcourt (04°15′N and 7°15′E) between the month of May and August in Rivers State, Southeastern, Nigeria. Rivers State is within the humid tropics ecological zone of South Eastern, Nigeria. Rainfall distribution and temperature of the study area in 2016 are shown in Table 1. The total rainfall for the year was 2541.1 mm with a mean of 211.76 mm. The total temperature for the year was 402.14 to 248.06°C with a mean of 33.51 to 20.67°C. The total amount of rainfall during experimental period from May to August 2016 was 1079.6 0 mm with an average of 269.9 mm per month. Rainfall value during the cropping season of maize (May to August) ranged between 167.00 and 353.60 mm

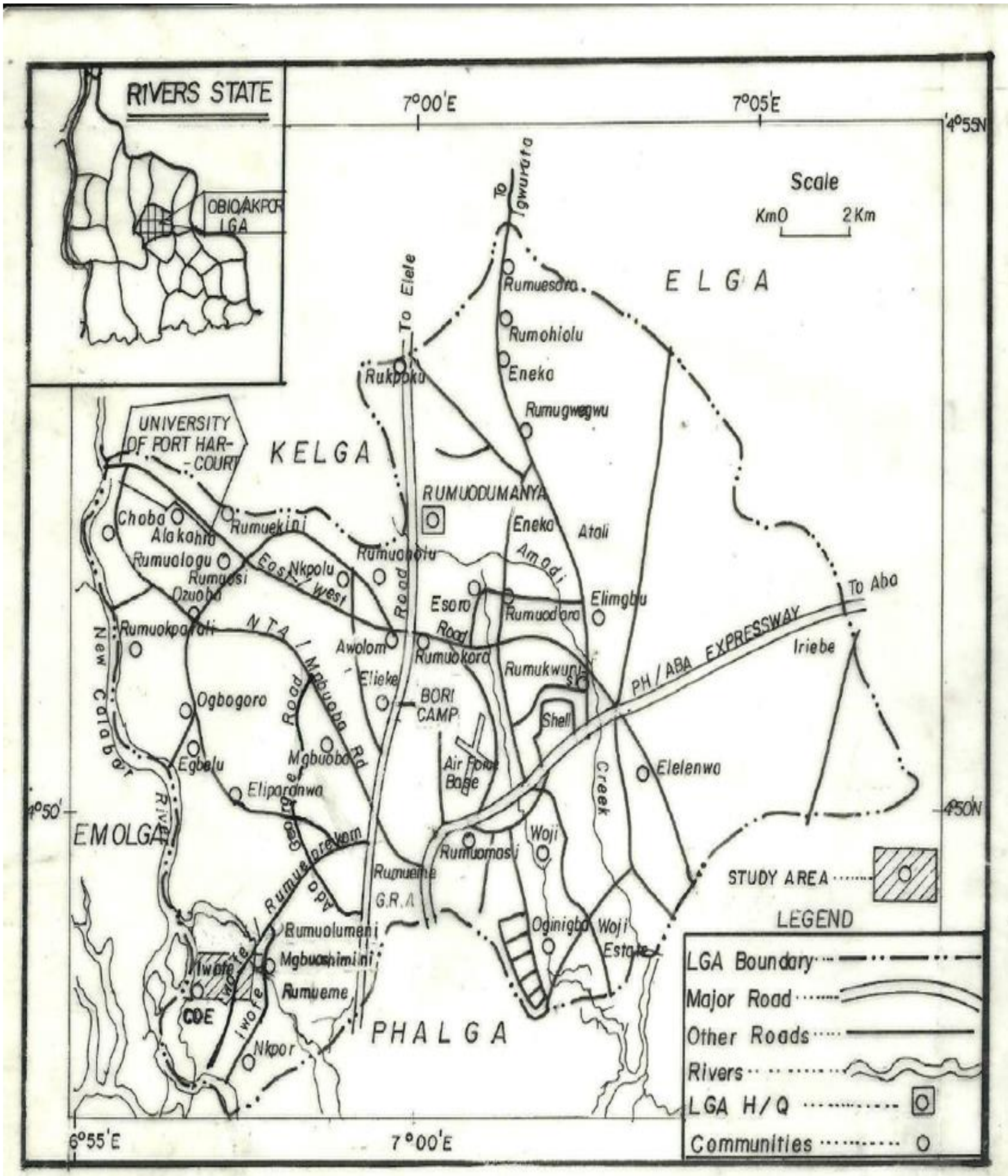

Figure 1. Map of Obio/Akpor LGA, showing the location of the study area.

with August having the lowest rainfall and July the highest. The mean temperature during the growing season ranged between 25.81 and 28.15°C with August having the lowest mean temperature and May the highest (Table 1). Map of Obio/Akpor LGA, showing the location of the study area is as shown in Figure 1.

Sources of materials

Local maize variety, pumpkin pods and N:P:K (15:15:15) were obtained from Port Harcourt in Rivers State.

Experimental methods

The land used for the experiment was manually cleared and debris was packed. The experiment was Randomized Complete Block Design (RCBD). It consisted of six (6) treatments, namely, control (no application), cover crop (pumpkin cover), 10 t/ha dry guinea grass mulch (dead mulch), 10 t/ha poultry manure, 250 kg/ha N:P:K 15:15:15 and 10 t/ha dry guinea grass as bush burning material.

The treatments were replicated four times. Each plot measured 3 × 4.5 m with an alley way of 2 m each between plots and replicates. There were thus a total of 24 plots occupying an area of approximately 0.07 ha. All the treatments were applied to their respective plots at two weeks before planting 2 Weeks after planting (WAP) except N:P:K 15:15:15 which was applied at the recommended rate of 250 kg/ha by using ring method at 2WAP. Pumpkin seeds were planted in between two maize rows at spacing of 50 × 50 cm at cropping pattern of 1:2. The control plot had no treatment application. Planting of maize was done on the 14th May 2016 at a spacing of 60 cm between rows and 90 cm within rows at the rate of three seeds per hill and the seedlings were thinned to one per stand at 2WAP to give 25 plants per plot which is equivalent to 18,518.52 plants per hectare. Hand pulling and hoeing was done twice at 3 and 7 WAP.

Microbiological analyses

Soil samples for microbiological analysis were collected at four weeks, seven weeks and eleven weeks after application of treatments. The samples were placed in sterile bottles, and analyzed under aseptic conditions for enumeration in colony forming unit (CFU) and identification of bacteria and fungi.

Bacterial count and isolation

The total heterotrophic bacteria count was determined using the serial dilution and spread plate technique on Nutrient Agar (NA) according to Fawole and Oso (2001).

Fungal count and isolation

The total heterotrophic fungi count was determined using serial dilution and spread plate technique on Potato Dextrose Agar according (PDA) to Monica (2005).

Soil analysis

Composite soil samples were collected randomly with an auger of diameter 8 cm at a depth of 0 to 20 cm from the experimental site for analysis. Some of soil physiochemical properties that were analyzed for were pH, total organic matter, total nitrogen and particle size distribution. They were analyzed using standard laboratory procedures.

Earthworm sampling

The population of earthworms was estimated at point of harvest from each of the experimental plot. This was determined through counting of the biogenic deposits of these organisms, also referred to as casts.

Maize yield datum collection

Maize yield was obtained from the middle row of each plot and the yield was expressed in kilogram per hectare (kg/ha).

Statistical analyses

All data collected were subjected to analysis of variance (ANOVA) and treatment means were compared using the least significant difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Soil properties of the experimental site before the experimentation

Some of the physiochemical properties of the soil in the study area are presented in Table 2. The soil was sandy loam, strongly acidic with low nitrogen and total organic matter content. The initial bacteria count was 2.0 × 10^6 CFU/g, fungi (1.7 ×10^5 CFU/g) and earthworm casts (0). The sandy loam of the soil, the low nitrogen and total organic matter content could be attributed to leaching effect caused by rainfall and high temperature that occurred in the study area.

Microbial population

Generally, there were more of total bacterial counts than fungal counts in the study. This confirms the report of Isirimah et al. (2006) that bacteria are known to predominate over other microorganisms in the soil.

Soil bacteria population

The effect of soil management practices on soil bacteria population is presented in Figure 2. The bacteria population differed significantly throughout the sampling intervals. At 4 weeks after application of treatments (WAA) burnt plot had the highest bacteria population (5.0 × 10^6 CFU/g) which was statistically at *par* with poultry manure (4.4 × 10^6 CFU/g) and the control (4.0 × 10^6 CFU/g), while the lowest (0.75 × 10^6 CFU/g) was in plot treated with NPK. At 7 WAA, the highest (3.9 × 10^6 CFU/g) population of bacteria was in cover crop (pumpkin cover) which was at *par* with NPK (3.6 × 10^6 CFU/g) dead mulch (3.4 × 10^6 CFU/g) and control plot (3.4 × 10^6 CFU/g) while the lowest was in poultry manure (2.3 × 10^6 CFU/g) which was at *par* with bush burning (2.4 × 10^6 CFU/g). At 11 WAA, NPK had the highest (4.6 × 10^6 CFU/g) population of bacteria while the lowest (2.0 × 10^6 CFU/g) was in the control which was statistically similar with of the burnt plot (2.2 × 10^6 CFU/g).

The first probable cause of increased in bacteria population in burnt plot at 4WAA may be due to the increase in soil pH as a result of the liming effect which burning had on the soil, hence creating an environment optimal for certain species of microorganisms while the second probable cause might be attributed to the increased organic matter and nitrogen contents in the burned soils, as well as an improved quality of substrate for bacterial growth (Hatten and Zabowski, 2009). The observed increase in bacterial population and activities at 4WAA in the poultry manure treated plots, could be

Table 2. Soil properties of the experimental site before the experimentation.

Soil properties	Values
Bacteria (CFU/g)	2.0×10^6
Fungi (CFU/g)	1.7×10^5
Earthworm casts	0
Sand (%)	73.00
Silt (%)	15.00
Clay (%)	12.00
Textural class	Sandy loam
Total N (%)	0.10
Total organic matter (%)	2.09
Soil pH (water)	4.80

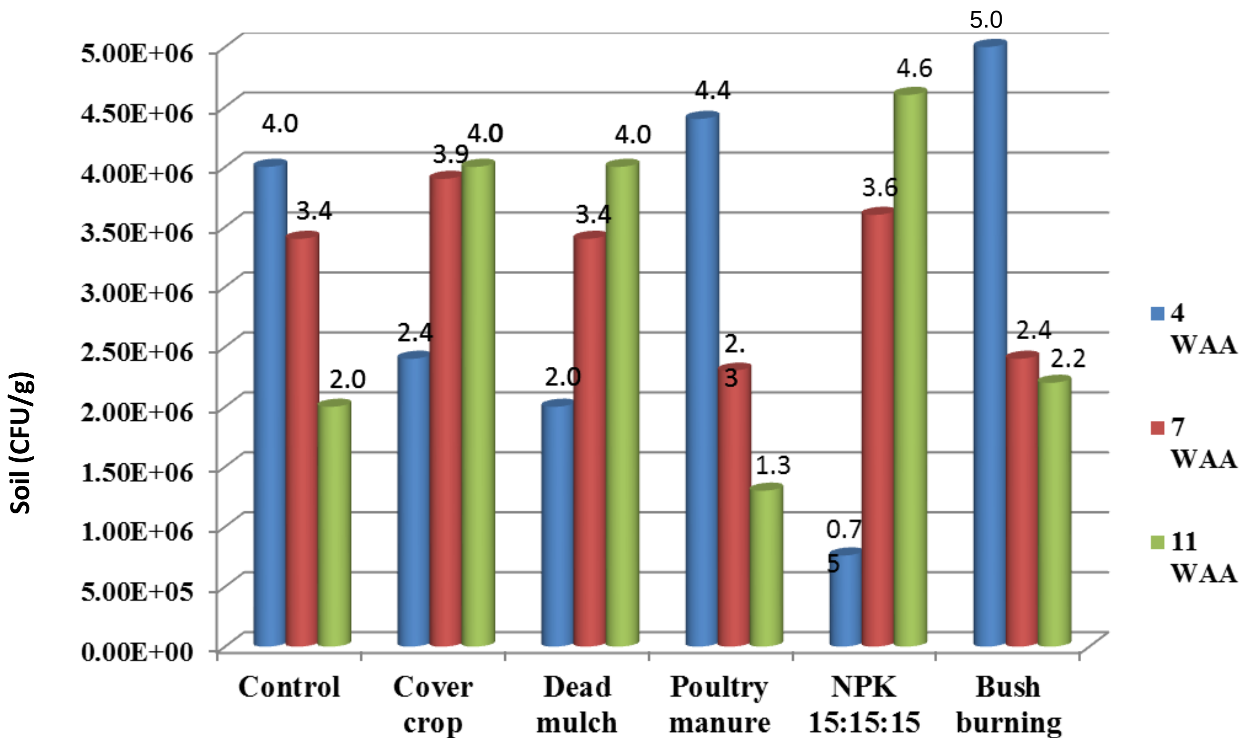

Figure 2. Bacterial population under different management practices at 4, 7, and 11 weeks after application (WAA) of treatments. LSD: 4WAA = 1.1×10^6; 7WAA = 9.3×10^5; 11WA = 5.5×10^5.

attributed to the stimulation of zymogenous organisms and incorporation of exogenous organisms as a result of poultry manure application. This finding is in conformity with the finding of Scaffers (2000), who noted an increase in bacteria population as a result of soil amendment with compost.

The high increased in bacteria population under cover crop could be attributed to low soil temperature as a result of the pumpkin cover, thereby making it more conducive for bacteria growth while the increase in dead mulch could be attributed to decomposition processes of the grass materials. Researchers have shown that incorporation of organic amendments such as green manure or dry grass chippings increased microbial activity (Elliot and Lynch, 1994), diversity, and density of bacteria in the soil (Bruggen-Van and Semenov, 2000).

The high bacteria population recorded in plot treated with NPK at 11WAA might be due to the breakdown of the fertilizer, thereby resulting in the availability of major nutrient elements utilized by these organisms for easy

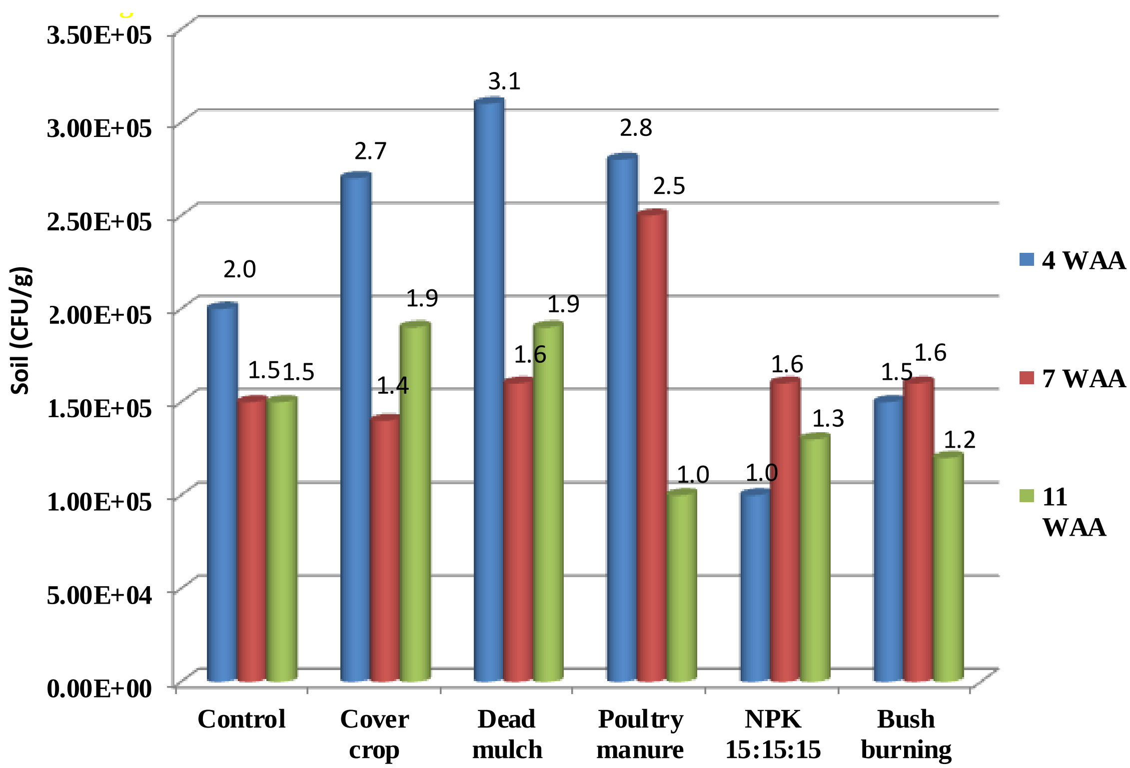

Figure 3. Fungal population under different management practices at 4, 7, and 11weeks after application of treatments. LSD: 4WAA= 1.2 × 10^5; 7 WAA= 1.3 × 10^5; 11 WAA = 3 ×10^4.

uptake by plant. Bolton et al. (1985) also noted an increase in microbial populations in response to fertilization over time.

Fungi population

The effect of different soil management practices on soil fungal population is presented in Figure 3. The fungal population differed significantly ($p<0.05$) throughout the sampling intervals except at 7WAA. At 4WAA, dead mulch plot had the highest (3.1 × 10^5 CFU/g) fungal population but statistically at par with poultry manure (2.8 × 10^5 CFU/g, cover crop (2.7 × 10^5 CFU/g) and control plot (2 × 10^5 CFU/g), while the lowest was recorded in NPK (1.0 × 10^5 CFU/g) which was at *par* with bush burning (1.5 × 10^5 CFU/g) and control plot (2 × 10^5 CFU/g). At 11WAA, cover crop and dead much plot produced the highest (1.9 × 10^5 CFU/g) population of fungal while the lowest was in poultry manure plot (1.0 × 10^5 CFU/g) which was at *par* with bush burning plot (1.2 × 10^5 CFU/g) and NPK treated plot (1.3 × 10^5 CFU/g).

The decrease in fungal population in control, cover crop, dead mulch, poultry manure and burnt plots at 11WAA when compared with 4WAA might be attributed to reduction in organic matter and moisture content of the soil. Ankita and Rajeev (2015) noted organic matter and moisture content is essential to ensure the presence of an active microbial population in the soil. Despite the decrease in fungal population, there were more of fungal population in dead mulch plot and cover crop plot. The more fungal population noticed in dead mulch plot might be attributed to decomposition of grass materials that enhanced the production of organic matter which promoted fungal population while that of cover crop plot might be attributed to the decomposition of leaf litters which enhanced organic matter production for fungal population. Besides, these two treatments provide a conducive environment for fungal growth as result of their cooling effect in the soil. The low fungal counts in manure plot might be attributed to slowly releases of nutrients as opposed to quick release of nutrients by plots treated with N. P. K. Fertilizers provide some of the nutrients needed by soil organisms and will favor those species that can best use these forms of nutrients. The low fungal population in burnt plot might be attributed to some vital nutrients lost which could help to make the soil less fertile for more fungal growth.

Earthworm population in soil at point of harvest

The effect of soil management practices on soil number of earthworm cast at the point of harvest is presented in

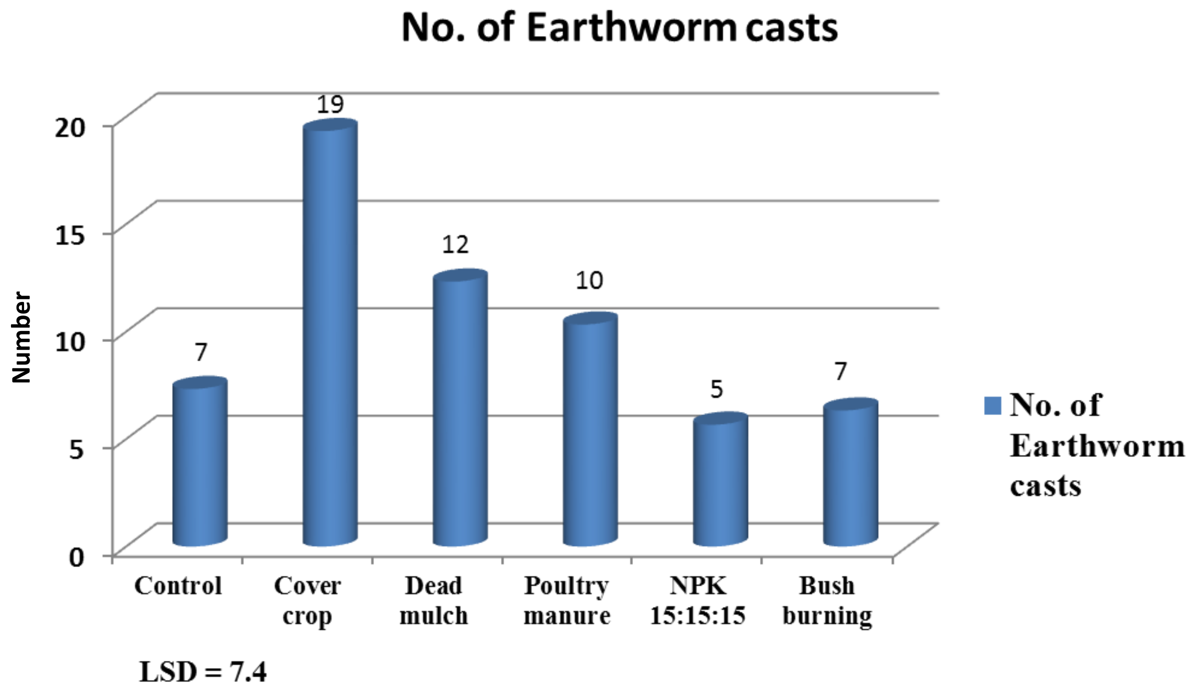

Figure 4. Number of earthworm cast at point of harvest.

Figure 4. The earthworm population differed significantly ($p<0.05$) with cover crop plots having the highest cast (19) which at was *par* with dead mulch plot (12), while the lowest (5) was in NPK treated plot which was at *par* with bush burning (7), poultry manure (10), and dead mulch (12) plots. The highest earthworm population in the cover crop plots could be attributed to lower soil temperature created by the pumpkin vines, thereby making it more conducive for earthworm activities. Also, it may be attributed to the presence of high amount of organic crop residues in the soil, which served as a source of food supply to the earthworms. The lowest population of earthworm cast could be as a result of the strongly acidic nature of the soil after the application of fertilizer.

Microbial isolates

The microbial isolates identified before and at 11WAA are presented in Table 3. The most predominant bacteria isolates across the various soil management practices were *Bacillus* and *Pseudomonas* species, while that of fungi were *Aspergillus niger* and *Candida* species.

Maize grain yield

The effect of different soil management practices on maize grain yield is presented in Table 4. The soil management practices differed ($p<0.05$) significantly in maize yield. The yield ranged from 50 to 170 kg/ha. Plots that received N:P:K 15:15:15 produced the highest yield (170 kg/ha) which was not significantly ($p > 0.05$) different from that of bush burning (150 kg/ha) and poultry manure (120 kg/ha), while the lowest grain yield (50 kg/ha) was produced in plot with pumpkin cover which was statistically at *par* with the control (70 kg/ha) and dry guinea grass mulch (80 kg/ha). N:P:K plot had a better yield when compared to other treatments. The most probable reason for this is quick released of nutrients for maize growth. Burnt plot also produce high maize yield probable as result of the ash materials produced by burning which helped to neutralize the soil as liming material. The low yield recorded in plot mulched with dry guinea grass might be attributed to some toxic materials produced by dry guinea grass. The control plot had poor yield because of its poor inherent soil fertility status which could be caused by high intensity of rainfall and leaching effect. The low yield recorded in plot covered with pumpkin might be attributed to severe inter specific competition for available growth resources between the maize and pumpkin.

Conclusion

The results from this study showed that microbial population was superior at 11WAA. Plot fertilized with NPK had the highest bacteria population while cover crop and dead mulch plots had the highest fungal population.

Table 3. Microbial isolates identified before and after application of treatments.

Treatments	Bacteria isolates	Fungi isolates
Before experiment After experiment	*Pseudomonas* spp., *Staphylococcus* spp., *Bacillus cereus*	*Aspergillus niger, Candida tropicalis, Mucor, Stachybothrys chartarum*
Control	*Bacillus cerus, Proteus mirabilis, Nocardia* spp., *Pseudomonas aeroginase, Alcaligenes* spp., *Micrococcus* spp.	*Candida krusei, Candida tropicalis, Microsporum* spp., *Aspergillus niger, Rhizopus, Mucor*
Cover crop	*Bacillus cereus, Alcaligenes* spp., *Klebsiella* spp., *Proteus mirabilis, Pseudomonas* spp., *Staphylococcus aureus*	*Penicillium* spp., *Candida rugosa, Aspergillus niger, Fusarium, Sporothrix schenckii, Trichoderma* spp., *Rhizopus, Trichosporon asahii*
Dead mulch	*Pseudomonas* spp., *Micrococcus* spp., *Bacillus cereus, Streptococcus faecalis, Staphylococcus* spp., *Proteus mirabilis*	*Microsporum* spp., *Aspergillus fumigatus, Aspergillus niger, Acremonium strictum, Trichoderma* spp., *Candida krusei, Fusarium, Mucor, Penicillium.*
Poultry manure	*Micrococcus* spp., *Pseudomonas* spp., *Staphylococcus* spp, *Bacillus cereus, Klebsiella* spp., *Salmonella* spp., *Escherichia coli, Bacillus subtilis*	*Candida rugosa, Candida tropicalis, Aspergillus niger, Taenia* spp., *Mucor, Rhizopus*
NPK15:15:15	*Bacillus cereus, Alcaligenes* spp, *Nocardia* spp., *Proteus* spp, *Staphylococcus* spp., *Streptococcus* spp., *Pseudomonas* spp.	*Aspergillus niger, Mycosphaerella pinodes, Penicillium, Fusarium* spp., *Trichosporon asahii, Candida tropicalis, Streptomyces*
Bush burning	*Bacillus cereus, Pseudomonas aeroginase, Alcaligenes* spp., *Staphylococcus aerus, Streptococcus foacalis*	*Aspergillus niger, Aspergillus fumigatus, Candida rugosa, Candida tropicalis*

Table 4. Effect of different soil management practices on maize grain yield (kg/ha).

Treatments	Grain yield
Control	70
Cover crop	50
Dead mulch	80
Poultry manure	120
NPK 15:15:15	170
Bush burning	150
LSD (P=0.05)	50

Earthworm casts were higher under plots with cover crop. Although the microbial population and earthworm cast did not follow a particular trend among the soil management practices, but soil managed with NPK had the highest grain yield and thus recommended to farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Ankita S, Rajeev KM (2015). Changes in soil characteristics and fungal population dynamics in a pigeon pea field. J. Soil Sci. Environ. Manage. 6(2):29-34.

Bolton H, Elliot LF, Ppendick RI, Bezideck DF (1985). Soil microbial biomass and selected soil enzyme activities. Effects of fertilization and cropping practices. Soil. Biol. Biochem. 17:297-302.

Brevault T, Bikay S, Maldès JM, Naudin K (2007). Impact of a no-till with mulch soil management strategy on soil macrofauna communities in a cotton cropping system. Soil Till. Res. 97(2):140-149.

Bruggen-Van AHC, Semenov AM (2000). In search of biological indicators for soil health and disease suppression. Appl. Soil Ecol. 15:13-24.

Cherr CM, Scholberg JMS, McSorley R (2006). Green ma-nure approaches to crop production: a synthesis // Agronomy J. 98:302-319.

Elliot LF, Lynch JM (1994). Biodiversity and soil resilience. In: Soil resilience and sustainable land use, Greenland, D.J. and Szabolc, I., (Eds). CAB International, Wallingford, UK. pp. 353-364.

Enwall K, Nyberg K, Bertilsson S, Cederlund H, Stenström J, Hallin S.(2007). Long-term impact of fertilization on activity and composition of bacterial communities and metabolic guilds in agricultural soils. Soil Biol. Biochem. 39:106-115.

Fawole MO, Oso BA (2001). Laboratory manual of Microbiology: Revised edition spectrum books Ltd Ibadan P. 127.

Hatten JA, Zabowski D (2009). Changes in soil organic matter pools and carbon minerealization as influenced by fire severity. Soil Sci. Soc. Am. J. 73:262-273.

Isirimah NO, Igwe, C, Ogbonna DN (2006). Soil microbial population as indicator of changes resulting from different land use and management in Rivers state of Nigeria NJSS. 16:164-169.

Monica C (2005). District laboratory practice in tropical countries. 2nd edition pp. 62-72.

Scaffers AP (2000). In situ annual nitrogen mineralization predicted by simple properties and short period field incubation. Plant soil 221:205-219.