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Effect of Three Types of Organic Amendments and Nitrate Concentration on Bacterial and Fungal Populations in a Sandy Loam Soil Adamawa State, Nigeria

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Abstract: ***A pot experiment was conducted at the School of Agriculture Screen House using soil samplescollected from the MAUTECH Farm site at 0-20cm depth to study the effects of cow dung, cowpea straw and maize straw applied as organic amendments and nitrate concentration on soil bacterial and fungal populations. The organic amendments were applied solely as factorial treatments at four levels: 0g, 50g, 70g and 100g per 3kg of soil based on a randomized complete block design with three replications. Routine soil physical and chemical analyses were carried out before and after the experiment. Soils were then incubated with the organic amendments and sampled at 7days, 14 days and 21 days after incubation to determine bacterial count (cfu/ml), fungal count (cfu/ml) and nitrate concentrations (mg/kg). Results obtained revealed that the soil is loamy sandy with high porosity and low levels ofsoil organic matter, total nitrogen (2.1mg/kg) and available phosphorus (0.75 mg kg^{-1}) contents. Bacterial and fungal counts were significantly p<f (0.071) affected by treatments at 14 and 21days after incubation. Nitrate concentration was also significantly affected by the addition of amendments at 100g/kg at 14 and 21 DAI. at 21days organic amendments also significantly affected selected physical and chemical properties of the soil such as WHC, OC, OM, CEC, P, TN. Treatments contributed to the improvement of soil bacteria and fungal population which undoubtedly will have direct effect on the soil fertility status.***

Keywords: cow dung. cowpea straw, maize straw and soil bacteria

1. Introduction

The application of organic amendments to boost biological activities is essential for soil fertility improvement and maintenance in the sandy loam soils of northeastern Nigeria (Ibrahim, 2006). Soil microbial communities are directly related to soil biogeochemical processes, and they play an important role in the soil carbon cycle and soil N turnover.Nitrogen deposition can affect structure and composition of soil microbial communities (Suizon*et al.*, 2006; Stark *et al*., *2008*).Organic amendments contain useful macronutrients such as nitrogen, phosphorus and potassium, as well as large amount of carbon, which serve as substrate for the production of microbial biomass and as source of energy through the use of some hemicelluloses components and products of soil organic matter decomposition (Sugihara *et al.*, 2010). Microbiological activity in soil promote organic matter degradation and to a large extent controls carbon, nitrogen, phosphorus and sulphur cycles and thus influence the bioavailability of soil nutrients for plant uptake in addition to soil structure formation and maintenance which help in the improvement of soil moisture retention and availability to plants. The soil ecosystem is the store house of all microbes involved in the degradation of organic materials. Despite the fact that the soil biota comprises only a small fraction of soil mass, they play a crucial role in providing favorable conditions for plant growth since soil bacteria and fungi are the dominant drivers of soil biochemical processes and transformations (Stark *et al*., 2008). Soil bacteria and fungi play distinct roles in major nutrient cycles and the sensitivity of bacteria to amendments and the resilience of fungi is a basis for understanding that increased nitrogen input via amendments is likely to be of more benefit with pathways driven primarily by bacterial and fungal communities sub arid ecosystems. Furthermore, the decomposition of organic materials and the solubilization of essential nutrients from mineral compounds in soil are aided by certain enzymes and metabolites released by microorganisms into the soil. It is therefore important to understand how soil biological life is affected when organic amendments of different C:N ratio are added to soil for enhancement of biological life in a bid to create a healthy fertile soil for sustainable crop production.

Correspondingly large differences exist in the bacterial and fungal population due to vast differences in the composition of soils, their physical and chemical characteristics and agricultural practices under which they are cultivated. The great diversity of the microbial flora makes it extremely difficult to determine accurately the total number of microorganism present under a certain soil condition (Gaddeyya*et al*.,2012). As such, stability of the microbial community structure has important implications for the rate of soil biochemical processes, for example variation in microbial community structure in the soil influence rates of de-nitrification, nitrification, and nitrogen fixation. Human society benefits from soil biological functional groups in the form of ecosystem services such as maintenance of soil structure and fertility for plant growth, regulation of carbon flux and climate control, decontamination and bioremediation, pest control and regulation of the water cycle (Nannipieri, 2003; Turbe*et al.*, 2010).

Despite the vital functions of organic matter in soil, less attention is given to application of organic materials on marginally fertile soils of the Savanna region to enhance

nitrogen availability which is needed in large quantity by crops and can easily be lost either by leaching or erosion due to the nature of soils in the study area. The maintenance and sustenance of nitrogen in soils of the tropics for crop utilization is a major problem that is yet to be solved. Nitrogen in organic materials differ in quantity and quality depending on the nature of the litters which slowly releases nitrogen during the process of decomposition which according to Anderson and Ingram (1993)the soil nitrogen pool is naturally maintained through microbial activity more so that soil bacteria and fungi play distinct roles in major nutrient cycles based on the sensitivity of bacteria to N rich amendments and the resilience of fungi to low soil N status. This research work focuses on the availability of nitrogen in the organic amendments as it affects bacteria and fungi population in the soils and considerably influences the fertility status of the soils.

2. Materials and Methods

Location and Extend of the Study Area
The experiment was conducted at University Screen House using soil obtained from the Modibbo Adama University of Technology (MAUTECH) Farm site, Yola, Adamawa State. The farm is located on Latitude 9^{o} 16' N and Longitude 12^{o} 35' E situated at 152m above sea level in the Northern Guinea Savannah agro-ecological zone.

Sampling and Sample Preparation
Soil Samples were collected based on ten locations at distance of 500m apart. The soil samples were obtained from the top layer of the soil approximately 0 – 20cm depth using a shovel. The samples were labeledand taken to the soil science laboratory for analysis. The collected soil samples were air-dried in the laboratory grounded using wooden pestle and mortal and sieved through 2mm mesh. The samples were kept in properly labelled clean plastic bags for microbiological and routine laboratory analysis.

Organic materials used included cow dung, maize and cowpea straw that were obtained from various sources, dried, ground and stored in properly sealed containers for analysis and application.

Experimental Design
The experiment was a factorial pot experiment based on completely randomized design layout with three replications which comprised four treatments: the control, cow dung, cowpea and maize straws.The organic materials were weighed into the experimental pots at therate of 0g, 50g, 70g, and 100g per 3kg pot and then incorporated into the soil samples and mixed properly. Water was applied on the first DAI and subsequently after every five DAIs up to 21 DAIs.

Determination of Physical and Chemical Parameters
Particles size distribution was determined using Bouyous method as described by Jaiswal (2003). The texture of the soil was then determined using Marshal's textural triangle. Soil water holding capacitywas determine by gravimetric method as described by the laboratory testing procedure for soil and water sample analysis (Pawar*et al*.,2009).

The pH and electrical conductivity of the soil were measured in a 1:2.5 soil:water suspension and water:KCl suspension using 0.5M KCl solution, glass electrode pH meter and electrical conductivity meter according to Jaiswal (2003).

The organic carbon content of the soil samples was determined according to Walkley and Black (1934) potassium dichromate wet-oxidation method. Total nitrogen content of the soil was determined by the Kjeldahl wet digestion method (Bremnar, 1965). Available Phosphorus content of the soil samples was determined by bicarbonate extraction method (Olsen and Dean, 1965) for near neutral and slightly alkaline soils.

Preparation of agar medium for bacterial culture
Twenty eight gram of nutrient broth agar was added to 600ml of distilled water in 1000ml volumetric flask and shaken to dissolve by rotating continually over wire gauze placed on a Bunsen burner until the agar was completely dissolved. The mouth of the flask was plugged with cotton wool wrapped in aluminum foil paper. Flask containing nutrient agar was then placed into autoclave bucket and sterilized at 121^{0}C for 15 minutes. It was allowed to cool to about 50^{0}C. Thereafter 5 ml of the agar medium was pipetted into sterilized Petri dishes kept at room temperature and allowed to cool and solidify.

Samples preparation for culturing of Bacteria
One gram of soil sample was taken from each pot and put into test tubes containing 5ml of distilled water and soaked for 24 hours.Thereafter, a ten-fold serial dilution was made and 0.1 to 0.5 ml were plated evenly on agar medium and incubated for 24 hours.

Bacterial count by colony forming units
Exactly 0.2 ml of 10^{-2} transferred into duplicate of nutrient agar medium plates and labeled. Sterilized glass spreader was used to spread evenly over the entire agar surface before it was covered. The plates were then inverted and incubated at 37^{0}C for 24 hours. Bacterial count was done by dissecting the Petri dish into four sections and the total number of viable cells was reported in colony forming units (CFU). The broth was calculated by the formular:1/volume of plated multiplied by average number of CFU in plates and multiplied by the dilution factor. The same steps were repeated for samples taken at 14 and 21 DAI.

Gram staining of Bacteria
Distinct colonies were made on a clean grease free slide and air dried after which it was heated fixed by passing through a flame. It was flooded with crystal violet for 1 minute and rinsed with water then flooded with gram's iodine for 1minute and rinsed again with water. It was decolorized with 95% alcohol and rinsed immediately with water. It was then counterstained with Safranin for 1 minute and rinsed with water and was al air dried after which it was viewed under ×100 oil immersion objectives (Isaiah, 1995).

Preparation of agar medium for fungi culturing
Forty-six and eight of potato dextrose agar (PDA) was added to 600ml of distilled water into 600ml volumetric conical flask, it was shaken to dissolve the nutrient broth. The flask was rotated continually over wire gauze placed on a Bunsen

burner until the agar was completely dissolved. The mouth of the flask was plugged with cotton wool wrapped with aluminum foil paper. The flask was then placed in the autoclave bucket and sterilized at 121ºC for 15 minute after which it was allowed to cool to about 50ºC. Thereafter 5 ml of the agar medium was taken using a measuring cylinder and poured into sterilized Petri dishes kept at room temperature and allowed to solidify. 0.2ml of 10 was transferred into duplicate of PDA medium plates and labeled. Sterilized wire loop was used to spread evenly over entire agar surface, covered the plates and was kept at room temperature for 5-7 days until fully matured.

Fungal count (filter paper method) and morphological characteristics

The fungi was identified according to appearance; Mycelia, spore, and color according to Cheesbrough (2000). After identification, 300g of freshly peeled potatoes were cut into pieces, washed and put into 1500 ml conical flask. Distilled water was added to mark and heated to boiling and then decanted into a measuring cylinder. To the extract, 22.7g of glucose was added and diluted with 100 ml of distilled water. 15ml of the extracted solution was poured into wash bottles and a colony of different species of fungi were carefully cut out from Petri dish into the wasu bottles containing potato extracted solution and then allowed to stay for 10 days.Well labeled filter papers were oven dried at 60ºC for 60 seconds and weighed to obtained initial weigh, W_1. Four folded oven dried filter paper was inserted into the mouth of the conical flask using a funnel. Extracted solution was then emptied into the filter paper, the residue was collected with the filtered paper, oven dried for 60 seconds at 60ºC and weighed to obtain the final weight of the filter paper, W_2.

The formula used to obtained fungal count =

$$\frac{W_2 - W_1 \times S \times I}{C}$$

Where:- W_1 = initial weight of filter paper in gm
W_2 = final weight of filter paper in gm
S = quantity of soil sample used in gm
I = quantity of inoculation solution used in ml
C = concentration of inoculation solution in ml.

3. Results and Discussion

Physical and Chemical Properties of the Experimental Soil

Results of the physical and chemical properties of the soils of MAUTECH Farm site is presented in Table 1. Result obtained revealed that the soil texture is sandy loam in nature as reported by Musa *et al.*, (2007) who conducted studies on the soil which they classified as Typic-Haplustalf. The water holding capacity (WHC) of the soils was 21.88 %. Physical properties of a soil plays an important role with regard to microbial populations and nutrient retention and moisture content because the amount and seizes of soil particles determine the porosity and bulk density which account for nutrient retention and movement in soil. Application of the organic materials significantly increased the water holding capacity of the soil as shown in the Table.

The soil pH in 1:2 soil to water ratio was 6.6 while soil pH in 1:2 soil to $CaCl_2$ ratio was 5.8. The pH ranges from slightly acidic to near neutral. Electric conductivity (EC) of soil was 0.02 dS m^{-1}indicating free salinity level before experiment but increased slightly in EC values of 0.21, 0.32, and 0.19 for CD, MS and CS, respectively, after the experiment which also indicate free salinity level as reported by Zata *et al.*(2008). In general electrical conductivity value between 0 and 0.8dsm^{-1} are acceptable for general growth of plants (Arias *et al*., 2005). Organic carbon/matter, total nitrogen and available phosphorus in both treated pots CD (O.C 7.2m/kg, AVP 0.75mg/kg and TN 2.1 m/kg), MS (O.C 8m/kg, AVP 0.18mg/kg TN 1.4m/kg) and CS (O.C 9.5m/kg, AVP 0.13mg/kg, TN 2.2 m/kg) are low, MS had considerably high amount of organic carbon, even though there is slightly increased in values compared to the soil sample obtained in Table 1. This indicate that organic materials added to the soil caused slight increase in the chemical properties which is supported by Bouajila and Sanaa (2011).The cation exchange capacity, CEC of the soil ranged from4.75 – 4.82cmol$^+$/kg is low and this has been supported by the low clay and organic matter contents as was observed earlier by Balasubramanian *et al.* (1984) in some upland Savannah soils. The low CEC indicates low buffering capacity of the soils and therefore low nutrient retention, meaning that crops will not benefit much from applied nutrients.

Results for physical and chemical properties of soils after the experiment showed slight increases in soils treated with the organic amendments. Water holding capacity was 26.57%, the pH in water was 7.5, while pH in $CaCl_2$ was 6.6. Electrical conductivity was 0.21dS/m. Organic carbon and organic matter contents were 5.8 and 7.4 m/kg, respectively. Cation exchange capacity, available phosphorus, total nitrogen contents and nitrate level were 6.43cmol kg^{-1}, 2.40 mg kg/kg, 2.1m/kg and98 m/kg, respectively. This showed that the soil responded well to the applied organic amendments, an indication that the productivity of the soil can easily be increased to obtain significant increase in crop yields.

Initial Soil Bacterial and Fungal Populations

The result for bacterial and fungal population before the experiment is presented in Table 2. Result obtained showed that soil bacterial populations before treatment were 1.67 x 10^2 at 7 days after incubation (DAI) and decreased to 1.58 x 10^2 at 14 DAI but rose to 1.76 x 10^2 at 21 DAI. Fungal population followed the same pattern at 7 DAI (4.0 ×10^{-3}) and 14 DAI (4.0 x 10^2) but decreased to 2.8 x 10^2 at 21 DAI. Results presented further indicate that bacterial populations are more dominant than fungal populations. Expectedly, the total bacterial counts were generally higher than that of fungi, irrespective of treatments and treatment levels which is in conformity with the report by Leite *et al*., (2010).

Effect of Treatments on Bacterial and Fungal population

Results presented in Table 3 show the effect of organic amendment on bacterial and fungal populations at 7 DAI was non-significant. This might be attributed to the initial phase of organic material decomposition which requires about 14 days before mineralization commences as reported by Anderson and Ingram (1993) and Marinari *et al.* (2000).

However, higher values of Bacterial populations were obtained with 70g (1.62×10^{-2}), 50g(1.57×10^{2}) and 50g(1.71×10^{2}) for CD, CS and MS, respectively. The control had lowest bacterial count of $1.40x10^{2}$. Fungal count at 7 DAI showed significant (*P≤0.05)* increase due to treatments, $1.4x10^{-2}$, $4.7x10^{-3}$ and $8.7x10^{-3}$, for CD, CS and MS, respectively. The control had the lowest value of $4.0x10^{-3}$.

The result in Table 4 shows the effect of treatments on bacterial and fungal populations at 14 DAI. Both Bacterial and fungal populations were not significantly affected by treatments. Higher values than control were obtained at 100g(1.60×10^{2}), 70g (1.64×10^{2}) and 100g(2.22×10^{2}) in CD, CS and MS respectively, for bacterial populations, while in the case of fungi higher value than control were obtained at 50g(1.0×10^{-2}), 100g(6.0×10^{-3}) and 70g(1.0×10^{-2}) for CD, CS and MS, respectively. The control had $4.0x10^{-2}$.

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Table 5 presents the effect of CD, CS and MS on bacterial population at 21 DAI. The effect of treatments on bacterial populations was not significant. Values recorded showed 100g (), 50g () and 50g () for CD, CS and MS, respectively. Control pot has the save value of $2.3x10^{-2}$ in all treated pots. On the contrary, fungal populations were significantly affected with values of 1.0×10^{-2} for 100g CD treatment, 7.3×10^{-2} for 100g CS treatment and 1.47×10^{-2} for 50g MS treatment.

At 14 DAI of experiment the microbial population increased significantly p<f (0.001) in all the treatments CD, MS and CS respectively, this could also be as a result of adequate soil moisture that increased the activities of the microbes similar with the findings of Griffin, (1981). Subsequently, the 21 DAIs the bacterial count decreased p<f (0.440). The gram staining result showed that all bacterial in the soil sample are gram-positive organism which was also supported by Fierer, *et al.* (2003) that gram positive organism were found to be dominant in soil with low substrate availability. The dominant bacterial in the soil samples were identified as *cocci*, *streptococcus*, *staphylococcus*, and *diplococcus* in cow dung and maize straws in all 3 weeks of experiment while chain baccilus small *bacillus* and *spirillumcocci* in cowpea straw in all three weeks of experiment. Fungal populations were significantly affected as p<f (<0.001at 7DAI, <0.01 14 DAI and <0.001 21 DAI). This showed that fungi count are more abundant even in the control as it show high number of fungi count compared to treatments. Total fungi count was generally higher than bacterial counts in the three treated experiments. This observation corroborates the fact that fungi are normally more resident and abundant in fresh decomposed organic material, than bacteria. The laboratory identification of pathogenic fungi simplified was used to identified the fungi appeared on the inoculated plates, almost all the fungi appeared at 7DAI, 14DAI and 21 DAI of experiment were found to be under contaminants which are further classified into saprophytic fungi and pathogenic fungi. The saprophytic fungi usually grows well at room temperature on a common mycology, they are in general highly pigmented forming bluish-green or green, cream to yellow, orange, brown, deep rose or black colouries and nearly always produce abundant of characteristic reproductive structures about eleven genus of fungi appeared on inoculated plates at room temperature (37^{o}C) these are *Fusarium*sp, *Penicillium*sp, *Monilia*sp,*Mucor*sp, *Alternaria* sp and *Rhizopus*sp in cow dung and maize straw treatments while *Syncephalostrum*sp, *MoniliaSitphila*, *Mucor*sp, Orji *et al.,* (2006) *Aspergillus*spand *Rhizopus* were common in cowpea straw treatments in 7DAI, 14DAI and 21DAIof the experimental weeks. Each of this genus of contaminant are colony fast-growing attaining 40-55 mm between 3-10 DAI, it also has characteristic and morphology that distinguish one genus from another. Fungi sp isolates were mainly of *Aspergillus*, *Penicillium* and *Rhizopus* these are the major biodegradation of complex organic hydrocarbons compound, while *Fusarium*sp and *Mucor*s preported by (Adejumo*et al.,* 2015).

Nitrate Concentration Due to Treatments

The results for nitrateconcentration due to treatmentsare presented in Tables 6, 7 and 8for NO^{-}_{3} concentration at 7DAI, 14 DAI and 21 DAI. The control showed low level of nitrate for all and across treatments as was expected.

The results at 7 DAI were not significant showing the same trend as revealed in the results for treatment effects on bacterial and fungal counts. Gaddeyya (2012) reported that bacterial population is directly proportional to nitrate concentration in incubated soils. This shows that the results are in agreement especially because bacterial population was also insignificantly low. There was however increase in the nitrate concentration with increase in the amount of treatment level. The highest concentration, 201.7mg/kg, was recorded with the addition of maize straw at 100g/kg.

At 14 DAI, there was a concomitantly significant (*P≤0.05*) increase in nitrate concentration in the soil which is undoubtedly due to increased bacterial populations. Even though values obtained were significant (*P≤0.05*), the amounts varied with type and amount of amendment as reported by Adeleye *et al*. (2010). Across all the treatments, application of organic materials resulted in significant (*P≤0.05*) increase in NO^{-}_{3} availability. This is in conformity with the findings reported by Mader *et al.,* (2002). The highest value, 186.7, was obtain with the application of maize straw at 100g/kg followed by 160g/kg due to the application of 100g/kg of cowpea straw. Nitrate availability from applied organic amendment also depends on the rate of nitrogen mineralization which differs for different types under different soil conditions since the inorganic/organic fraction and quality of organic N varies (Fontaine and Mariotti, 2003 and Adenle, 2010).

The results of effect of treatments on nitrate concentration at 21 DAI indicate that highest significant(*P≤0.05*) values were obtained with the application of cowpea straw at the rate of

100g/kg, an average of 105mg/kg followed by maize straw treatment at 100g/kg which resulted in 98.0 mg/kg and the least was 93.0mg/kg due to cow dung treatment at 100g/kg.

4. Conclusion

This study was conducted to evaluate the effect of three organic amendments on bacterial and fungal populations and to what extent has the addition of organic amendments contributed to NO_3^-availability in the soils of the study area. Results obtained showed that the bacterial and fungal populations were generally not significantly affected by treatments at 7 DAI but highly significantly affected at 14 and 21 DAI due treatments which vary with the type of organic amendment applied. NO_3^- availability was also highly significant at 14 and 21 DAI. Treatments also positively influenced the water holding capacity of the soil. There were significant increases in pH, EC, Organic Carbon and CEC. Cowpea straw gave distinct features of microbial characteristics both in bacterial and fungi identification, as *streptococci*, *diplococcic*, *staphylococci* and *cocci* were found to be common in maize straw and cow dung, while bacillus, small bacillus, chain bacillus and sprillun appeared in cowpea straw treated soils. In the case of fungi ,*Fusariumsp, Alterneriasp, Moniliasitophilasp, and rhizopussp* are common in cow dung and maize straw treated soils, while in cowpea straw treated soils, *Syncephalostrumsp, Moniliasitophilasp, Mucorsp, Aspregillussp,* and *Rhizopus* were found indicating that different features and kind of bacteria and fungi population depends on substrate available to favour their activitieswith consequent improvement of soil quality and sustainable productivity.

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Table 1: Physical and Chemical Properties of the Experimental Soils Before and After the Experiment

Parameters	Soil before exp.	Soil + CD	Soil + MS	Soil + CS
% Sand	64.10	64.10	64.10	64.10
% Silt	21.11	21.11	21.11	21.11
% Clay	14.79	14.79	14.79	14.79
Textural Class	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Water Holding Capacity (%)	21.88	22.57	22.01	22.13
pH (water)	6.6	7.5	7.9	8.4
pH (KCl)	5.8	6.6	6.5	7.6
EC (dS/m)	0.02	0.21	0.32	0.19
O.C (m/kg)	7.1	5.8	8.5	10.4
O.M (m/kg)	12.3	7.4	9.0	14.5
$\mathbf{NO_3^-}$ (m/kg)	69	98	74.	98
Total N (m/kg)	2.1	2.8	4.8	4.9
A.V.P (mg/kg)	0.75	2.40	1.40	1.48
Na^+($cmol^+$/kg)	0.68	0.55	0.85	1.43
K^+($cmol^+$/kg)	0.04	0.22	0.71	0.87
Ca^{2+}($cmol^+$/kg)	0.65	1.60	1.24	1.25
Mg^{2+}($cmol^+$/kg)	0.10	0.72	0.50	0.80
CEC ($cmol^+$/kg)	4.75	4.82	4.77	4.80

Key: CD = cow dung, MS = maize straw, CS = cow straw, Avp. = Available phosphorus, CEC = Cation Exchange Capacity

Table 2: Soil Bacterial and Fungal Population Before the Experiment

	Bacterial Count, cfu			Fungal Count, cfu		
	7 DAI	14 DAI	21 DAI	7 DAI	14 DAI	21 DAI
Soil Sample	1.67×10^2	1.58×10^2	1.76×1^{-2}	4.0×10^{-3}	4.0×10^{-3}	2.8×10^{-2}

Key: DAI = Days After Incubation, cfu = Colony Forming Unit

Table 3: Effect of Treatments on Bacterial and Fungal Population at 7 DAI

Treatment	Bacterial Population, cfu			Fungal Population, cfu		
Levels	CD	CS	MS	CD	CS	MS
0g	$1.40x10^{2}$	$1.40x10^{2}$	$1.40x10^{2}$	$4.0x10^{-3}$	$4.0x10^{-5}$	$4.0x10^{-3}$
50g	$1.56x10^{2}$	$1.57x10^{2}$	$1.71x10^{2}$	$3.3x10^{-3}$	$6.0x10^{-3}$	$8.0x10^{-3}$
70g	$1.62x10^{2}$	$1.56x10^{2}$	$1.65x10^{2}$	$3.7x10^{-3}$	$7.3x10^{-3}$	$8.7x10^{-3}$
100g	$1.57x10^{2}$	$1.56x10^{2}$	$1.70x10^{2}$	$1.4x10^{-2}$	$4.7x10^{-3}$	$8.7x10^{-3}$
P<f	0.070	0.065	0.071	<0.001	<0.001	<0.001
LSD	21.00	20.05	21.06	0.0101	0.0100	0.0101
S.E	10.20	10.35	10.20	0.0039	0.0045	0.0049

Key: cfu = colony forming unit, CD = cow dung, MS = maize straw, CS = cow straw, LSD = Least significant difference, S.E. = Standard Error

Table 4: Effect of Treatments on Bacterial and Fungal Population at 14 DAI

Treatment	Bacterial Population cfu			Fungal Population cfu		
Levels	CD	CS	MS	CD	CS	MS
Og	$1.48x10^{2}$	$1.48x10^{2}$	$1.48x10^{2}$	$4.0x10^{-3}$	$4.0x10^{-5}$	$4.0x10^{-3}$
50g	$1.52x10^{2}$	$1.61x10^{2}$	$2.20x10^{2}$	$1.0x10^{-3}$	$5.3x10^{-3}$	$8.7x10^{-3}$
70g	$1.60x10^{2}$	$1.64x10^{2}$	$2.08x10^{2}$	$8.0x10^{-3}$	$4.7x10^{-3}$	$1.0x10^{-2}$
100g	$1.61x10^{2}$	$1.46x10^{2}$	$2.22x10^{2}$	$4.0x10^{-3}$	$6.0x10^{-3}$	$8.7x10^{-3}$
P<f	<0.001	<0.001	<0.001	<0.01	<0.01	<0.01
LSD	31.72	33.71	35.72	0.0035	0.0046	0.0048
S.E	17.21	17.31	17.31	0.0015	0.0021	0.0023

Key: cfu = colony forming unit, CD = cow dung, MS = maize straw, CS = cow straw, LSD = Least significant difference, S.E. = Standard Error

Table 5: Effect of treatments on Bacterial and Fungal Population at 21 DAI

Treatment	Bacterial Population cfu			Fungal Population cfu		
Levels	CD	CS	MS	CD	CS	MS
Og	$1.56x10^{2}$	$1.56x10^{2}$	$1.56x10^{2}$	$2.3x10^{-3}$	$2.3x10^{-5}$	$2.3x10^{-3}$
50g	$1.69x10^{2}$	$1.66x10^{2}$	$1.61x10^{2}$	$6.7x10^{-3}$	$4.7x10^{-3}$	$1.47x10^{-2}$
70g	$1.67x10^{2}$	$1.73x10^{2}$	$1.66x10^{2}$	$6.7x10^{-3}$	$6.7x10^{-3}$	$5.3x10^{-3}$
100g	$1.70x10^{2}$	$1.52x10^{2}$	$1.62x10^{2}$	$1.0x10^{-2}$	$7.3x10^{-3}$	$5.3x10^{-3}$
P<f	0.340	0.430	0.440	<0.001	<0.001	<0.001
LSD	22.20	24.20	23.20	0.0045	0.0056	0.0055
S.E	10.24	11.54	11.24	0.0021	0.0024	0.0027

Key: cfu = colony forming unit, CD = cow dung, MS = maize straw, CS = cow straw, LSD = Least significant difference, S.E. = Standard Error

Table 6: Nitrate Concentration at 7 DAI

Treatment Levels	$N0^{-}_{3}$Concentration (m/kg)		
	CD	CS	MS
0	92.0	99.0	130.0
50	83.0	153.3	143.3
70	91.0	153.3	143.3
100	119.7	173.3	201.7
P<F	<0.001	<0.001	<0.001
LSD	18.40	17.04	18.02
S.E	7.62	5.96	8.73

Key: cfu = colony forming unit, CD = cow dung, MS = maize straw, CS = cow straw, LSD = Least significant difference, S.E. = Standard Error

Table 7: Nitrate Concentration at 14 DAI

Treatment Levels	$N0^{-}_{3}$Concentration (m/kg)		
	CD	CS	MS
0	89.0	65.0	90.0
50	89.3	128.0	129.7
70	111.7	138.0	150.0
100	136.7	160.0	186.7
P<F	<0.001	<0.001	<0.001
LSD	30.34	30.75	34.50
S.E	1571	14.75	16.71

Key: DAI = Days After Incubation, CD = cow dung, MS = maize straw, CS = cowpea straw, LSD = Least significant difference, S.E = Standard Error

Table 8: NitrateConcentration at 21 DAI

Treatment Levels	$N0^-_3$Concentration (m/kg)		
	CD	CS	MS
0	77.0	88.0	49.0
50	96.0	153.3	90.0
70	93.0	153.3	163.3
100	110.0	180.0	126.7
P<F	<0.001	<0.001	<0.001
LSD	32.76	32.96	33.86
S.E	16.42	15.05	16.41

Key: DAI = Days After Incubation, CD = cow dung, MS = maize straw, CS = cowpea straw, LSD = Least significant difference, S.E = Standard Error