EFFECT OF APPLICATION RATES OF GLIRICIDIA BIOCHAR AND POULTRY MANURE AT DIFFERENT SAMPLING PERIODS ON CHEMICAL PROPERTIES OF SOIL AT MINNA

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ABSTRACT

An experiment was carried out in the screen house of School of Agriculture and Agricultural Technology, Federal University of Technology, Minna. The objective of this study was to investigate the effectiveness of different rates of Gliricidia Biochar (GB) and Poultry Manure (PM) on some chemical properties of soil in Minna. The treatment consisted of soil amended with four rates of GB (10, 20, 30 and 40 t/ha) and four rates of PM (10, 20, 30 and 40 t/ha) and a control. These were in factorial combinations with three sampling periods of 2, 4 and 6 months after amendments. The GB and PM rates were applied at the same time but the samples were analyzed at three separate months. The experiment was a factorial fitted to Complete Randomized Design (CRD) with three replications. Laboratory analysis of soil chemical properties was conducted. All data collected were subjected to ANOVA at 5% level of probability and the means were separated using Duncan Multiple Range Test (DMRT). Irrespective of the rates of application of GB and PM, there was a significant increase in pH, organic carbon, effective cation exchange capacity, total nitrogen and available phosphorus over the control. Also, the results showed a significant increase of the above parameters with the durations of these amendments. A significant interaction between the rates and duration of GB and PM application of the above parameters was not recorded during this experiment.

Keywords: Gliricidia Biochar, Poultry Manure, chemical properties, rates, sampling period.

INTRODUCTION

Arable soils of the tropics are degraded quickly in physical, chemical and biological properties as a result of continuous cropping with persistent use of inorganic fertilizers, increase soil acidity and physical degradation while crop yield may fall. Some of the fertilizers aggravate nutrient imbalance due to lack of soil testing programme (Ojeniyi, 2002).These soils are low in organic matter, basic cations, available phosphorus and total nitrogen. This low level of organic matter has made the soils susceptible to major chemical, physical and biological limitations which reduce crop yields (Jones and Wild, 1975).

The use of organic materials as a source of nutrient is a well established practice among the small farming sector in many countries including Nigeria.

Biochar is a recent organic material used as a soil amendment to improve soil nutrients for crop production. They are produced during a process known as pyrolysis from the thermoconversion of biomass under little or no oxygen supply for use in soil as an amendment. When biochar is applied to the soil, it increases the soil chemical properties. This is observed in the amount of N retention in the soil, increased organic carbon content, pH cation exchange capacity, decreased exchange acidity, sulphur and zinc (Cheng, *et al.*, 2008).

They are produced from wide varieties of feed stocks. Gliricidia feed stock for the production of biochar was from Gliricidia sepium, a N fixing tree species that grow wildly on fallow lands in the southern and middle belt agro – ecological zones of Nigeria and which does not appear to have any other higher net resources value than to be converted to biochar (Fagbenro, *et al.*, (2016).

Poultry manure is also a major organic materials that are used by a wide range of the farmers as a soil amendment that provides high nutrient content (N P K) and other essential nutrients (Farhad, *et al*, 2009). When compared with chemical fertilizers, it also add organic matter to the soil to improve soil structure, aeration, soil moisture holding capacity and water infiltration rates (Nguyen, 2010).Increase in soil nitrogen and phosphorus was reported by (Thomas and Aluko, 2016) as the rates of application of poultry, goat and diary cow manures increases.

Therefore, the objective of this study was to investigate the effectiveness of different rates and duration of Gliricidia Biochar (GB) and Poultry Manure (PM) on some chemical properties of soil in Minna.

MATERIALS AND METHODS

A pot trial was conducted at the screen house of the Department of Soil Science and Land Management, Federal University of Technology, Minna (Latitude 9053'N and Longitude 6045'E). Minna falls under the southern guinea savanna agro – ecological zone of Nigeria. The climate of the area is sub – humid tropical with mean annual rainfall of about 1284 mm with the mean maximum temperature of around 35.5°C (Ojanuga, 2006).

The soil used in the pot trial was collected from the Teaching and Research Farm of Federal University of Technology, Minna at the depth of 0 – 20cm using soil augar. The soils were air dried, crushed and sieved through 2mm mesh and the pre-treatment analysis carried out (Table 1).

The treatment consisted of : (i). control (no amendment), four rates of Gliricidia biochar (GB) (10, 20, 30 and 40 t ha^{-1}) and four rates of Poultry manure (PM) (10, 20, 30 and 40 t ha^{-1}). (ii). Three sampling duration (2, 4 and 6 months after the establishment of the experiment). The experiment was a 9 x 3 factorial fitted to Completely Randomized Design (CRD) with three replications.

Two kilogram of soil samples thoroughly mixed with the amendments were weighed into eighty one poly pots (drainage holes were earlier made on each of the poly pot but covered with linning materials before filling with the soil). And on weekly basis, the soil column were wetted with 700 ml of water. Five hundred grams soil sample were collected at interval of 2 months after the establishment of the experiments.

Soil samples were air-dried and gently crushed to pass through 2 mm and 0.5 mm sieve. pH values of the samples were determined in 1.0 N $CaCl_2$ solution using a soil - solution ratio of 1:2.5 (McLean, 1982). Organic carbon was determined by the Walkley-Black wet oxidation method (Allison, 1965). Exchangeable basic cations were extracted with neutral 1N NH_4OAc with potassium (K) and sodium (Na) determined by flame photometry and calcium (Ca) and magnesium (Mg) by atomic absorption spectrophotometry. Exchange acidity was determined by shaking the samples with 1.0 M KCl and titrating them with 0.1 M NaOH. Available P was determined by the Bray P1 method (Bray and Kurtz, 1945). Effective cations exchange capacity was obtained by summation of the exchangeable basic cations. Total nitrogen (TN) was determined by the micro Kjeldhahl method.

The data generated was subjected to analysis of variance (ANOVA) at 5 % level of significance, while the means were separated using Duncan Multiple Range Test (DMRT).

RESULTS AND DISCUSSIONS

The properties of the soil before the application of the treatment (Table 1) showed that the soil was sandy loam in texture with 668 g kg^{-1}, 160 g kg^{-1} and 172 g kg^{-1} of sand, silt and clay respectively. The soil is moderately acidic in reaction and low in organic carbon (8.24 g kg^{-1}), total nitrogen (0.45 g kg^{-1}) and available phosphorus (8.89 mg kg^{-1}). These values and the others in Table 1 implies that the soil used for the trial was low and as such with low fertility Jones and Wild (1975) reported that low to medium organic carbon rate for savanna soil was attributed to paucity of vegetation cover, rapid mineralizatioh of organic matter, inadequate return of crop residue, bush burning and short fallow periods.

In Table 2, the result shows that all the treatments applied significantly ($P<0.05$) increased the soil pH more than the control except at 10 t/ha. However, the significant increase was observed as the rates of application increases for both GB and PM. It was also observed that there was a significant difference in pH as the duration increases. When organic materials are applied to the soil, basic cations are released which will certainly improved the base saturation of the soil and thereby reducing the soil acidity. Soil reaction is an important factor in controlling the nutrient availability and processes that take place in the soil (Onwuka and Nwangu, 2016).

Results for the organic carbon (OC) and total nitrogen (TN) (Table 2) showed that there was a significant increase in both OC and TN content of the soil as the rates of application of GB and PM increases. It was further observed that the TN increases with the OC simultaneously. This could be fact that organic matter is the major source of N in the soil. Higher OC and TN of the treated soil over non treated confirm the fact that GB and TN is an excellent source of soil amendment providing both organic matter and N. It could also be attributed to the presence of N P and K contained in the GB and PM. The positive effect of biochar may be due to a number of factors which may includes gradual abiotic and biotic oxidative release of nutrients and humic substances contained in the biochar (Chan *et al.*, 2008;Fagbenro *et al.*, 2016).

The level of available phosphorus (Table 2) increased significantly with the addition of GB and PM over the control and observed that there is a greater increase at different levels of their application. The increase in N and P after the application of GB and PM could be as a result of increase in microbial activities which could aid the decomposition of organic forms of N and P in the soil (Uwah *et al.*, 2014). The level available P is also observed to be dependent of the duration.

Effective Cation Exchange Capacity (ECEC) in Table 2 revealed that there is a significant increase as both GB and PM were added. The increment was observed to be significantly consistence as the rates of these amendment increases. This was corroborated by Mbah and Mbagwu (2006) and Thomas and Aluko (2016) that reported an increase in ECEC after the application of PM which was further attributed to the availability and adequate supply of organic matter. The ECEC of the soil increases significantly as the duration increases.

Generally, it was observed that all the chemical parameters recorded increased as the duration increases. The increment of these chemical constituent with duration could be attributed to the fact that the nutrients contained in organic materials are slowly released over time as also reported by Onwuka and Nwangu (2016).

CONCLUSION

The results of this study have shown that the addition of organic materials such as Gliricidia Biochar and Poultry Manure greatly improved the chemical properties of the soil. From the study, application of beyond 20 t ha^{-1} is thus recommended. It can also be concluded and recommended that farmers should apply these organic materials not less than two months before cultivation so as to achieve the full benefits of the application in terms of the release of the nutrients.

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Table 1: Physical and chemical properties of the pre – treatment soil

Parameters	values
Particle size (g kg^{-1})	
Sand	668
Silt	160
Clay	172
Textural Class	Sandy loam
pH(H_2O)	5.86
pH($CaCl_2$)	5.52
Organic Carbon (g kg^{-1})	8.24
Total Nitrogen (g kg^{-1})	0.45
Avail. Phosphorus (mg kg^{-1})	8.89
Exchangeable bases (Cmol kg^{-1})	
Ca^{2+}	4.23
Mg^{2+}	1.52
Na^{+}	0.43
K^{+}	0.78
ECEC	4.77

Table 2. Effect of rates and durations of GB and PM on selected soil chemical properties

Rate (R) (t ha^{-1})	pH ($CaCl_2$)	Org, Carbon (g kg^{-1})	Total Nitrogen (g kg^{-1})	Available phosphorus (mg kg^{-1})	ECEC (Cmol kg^{-1})
0	5.52^{bc}	8.20^{d}	0.39^{c}	8.99^{c}	4.62^{c}
10 GB	$5,87^{b}$	10.55^{c}	0.77^{b}	10.69^{b}	6.88^{b}
10 PM	5.94^{b}	10.03^{c}	0.68^{bc}	$10,98^{b}$	6.76^{b}
20 GB	6.33^{ab}	10.98^{c}	0.74^{b}	13.75^{b}	6.97^{b}
20 PM	$6,42^{ab}$	12.45^{bc}	0.82^{ab}	13.44^{b}	7.11^{b}
30 GB	6.85^{a}	14.98^{b}	0.94^{a}	$15,58^{ab}$	13.65^{ab}
30 PM	6.72^{a}	16.66^{b}	0.95^{a}	17.32a	12.98^{ab}
40 GB	6.82^{a}	20.42^{a}	0.97^{a}	22.16^{a}	16.85^{a}
40 PM	6.85^{a}	18.87^{ab}	0.94^{a}	21.68^{a}	17.77^{a}
SE	0.61	1.19	0.17	4.24	4.34
Duration(D)					

2 Months	5.88[b]	11.24[b]	0.74[b]	9.11[c]	8.43[b]
4 Months	6.38[a]	18.33[a]	0.79[b]	14.67[b]	16.96[a]
6 Months	6.79[a]	18.86[a]	0,96[a]	22.33[a]	16.75[a]
SE	0.27	1.62	0.11	2.01	0.35
Interaction					
R*D	NS	NS	NS	NS	NS

Means with the Same letter in a column are not significantly different at 5%. ECEC = Effective Cation Exchange Capacity. NS = Not significant at 5%