Soil Chemical Properties and Yield of Maize As Affected by Organic Amendment of River Sand with Cow Dung and Poultry Dropping

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Abstract: The study comprised the incorporation of poultry droppings (PD) and cow dung (CD) as means of amending river sand, and the subsequent use of the amended soil to grow hybrid maize in pots in Kaduna, Nigeria. The values of residual soil chemicals after harvest showed that the poultry droppings produced higher soil pH, electrical conductivity (EC), total nitrogen and available phosphorus (AP), with values of 7.4-7.6, 0.06–0.066 dS/m, 0.0042–0.0075 and 2.39–5.15 mg/Kg, respectively, at the application ratios of 500 g to 1,500 g per pot. The difference in the values is, however, not significant between PD and CD. Cow dung gave higher values in the % organic matter (O.M.) (0.21–0.46 %) and potassium (K) (44–49 mg/Kg). Generally there was significant difference in the residual chemical properties due to levels of application. The yield of maize due to the un-amended sand was zero, while the sand amended with cow dung produced higher mean yield (2.06 t/ha) than poultry droppings (1.87 t/ha). It was recommended that the amendment application rate be increased for more bioavailable nutrients to improve yield, and that the soil be texturally modified through addition of clay portions to create the optimum texture (sandy loam) for best management practice of maize.

Keywords: Sand, soil nutrients, organic amendment, yield, maize

1. INTRODUCTION

Sandy soils as defined in the World Reference Base (FAO-ISRIC-ISSS, 1998) contain less than 18% clay and greater than 65% sand. Generally, the main Reference Group for sandy soils is the Arenosol (FAO-ISRIC-ISSS, 1998). Sandy soils are prevalent in tropical environments especially where felsic volcanic, or siliceous sedimentary rocks and their erosional products are found. Whereas some of these soils are only sandy in the surface layers, others are sandy throughout the root zone. Sandy soils occur in arid, semi-arid and humid rainfall zone the tropics and from coastal lowlands to high altitudes (Bell and Seng, 2005).

Sandy soil, especially river and alluvial sands are very common in Nigeria, and they are the most prevalent aggregate for building construction. It is also important for land reclamation and industrial application (Abam and Oba, 2018). Sand is mined mainly through an open pit but sometimes mined from beaches and inland dunes or dredged from ocean and stream or river beds.

Sand is mined in Nigeria mainly for construction purpose but not many studies are available on the use and improvement of sands for agriculture. Sands, being very available can be improved with amendments to serve as borrowed soils for topping unproductive landscapes and agricultural lands.

Tropical sandy soils have a wide range of limiting factors for agricultural use, these include nutrient deficiencies, low organic matter contents, low fertility, strong acidity, low water retention capacity and poor physical attributes. In addition, the clay fraction is low, the cation exchange capacity (CEC) mostly depends on organic matter which also serves as the major component of the adsorbing complex of water (Bell and Seng 2005; Sam and Vuong, 2008; Hoang, 2008; Bon, 1996). The environments in which they occur are prone to degradation risks from nutrient decline, erosion, leaching, salinity, and acidification. A range of opportunities exist to achieve sustainability of sandy landscapes through plantation forestry, agro-forestry, clay and other mineral soil amendments, maintenance of soil organic matter, balanced fertilization, strategic irrigation, and breeding species for adaptation to the constraints present (Bell and Seng 2005).

The application of organic amendment such as cow dung and poultry droppings has been proved to be reliable and effective in improving soil structure, fertility and biological activities (Scotti et al., 2013). The use of organic amendments to improve soil quality and fertility dates back to thousands of year ago. Greeks and Romans applied animal manure and human sewage to soil (Goss et al., 2013). Organic matter plays a critical role in soil ecosystem because it provides substrates for decomposing microbes (that in turn supply mineral nutrients to plants), improves soil structure and water holding capacity (Abiven et al., 2009), and increases natural suppression against soil-borne pathogens (Bonanomi et al., 2010). Addition of organic amendment to soil helps in maintaining soil organic matter, reclaiming degraded soil, and supply plant nutrients (Aggelides and Londra, 2000). In addition, It also increase soil macronutrients, water holding...
capacity, hydraulic conductivity and decrease bulk density and surface crusting (Haynes and Naidu, 1998).

The objectives of this study are to study the short term effect of organic amendments (poultry dropping and cow dung) on selected soil chemical properties and yield of potted maize.

II. MATERIALS AND METHODS

Study Area

The experiment was conducted during the 2016 farming season in the experimental farm of Federal College of Forestry Mechanization, Afaka, Kaduna, Nigeria (latitude 10°36'N and longitude 07°25'E). The climate of Kaduna is characterized by a clear distinction between dry and rainy seasons. The rainy season lasts from mid-April to early October. Kaduna has an annual mean rainfall of 1206 (FDMS, 2009). The temperature range is 31°C to 33°C for the maximum scale and 14°C to 19°C for the minimum scale.

Description of Experiment

The study was a factorial experiment comprising two organic amendments (poultry dropping (PD) and cow dung (CD)) administered in three levels: 500 g, 1000 g and 1500 g, thoroughly mixed with sandy soil passed through a 2mm sieve to filter out coarser aggregates. The amendments were initially dumped in pits and wetted to allow its decomposition for a period of twelve weeks. Thereafter, the amendments were dried out at room temperature for a period of twelve weeks. The treatments were replicated three times to give a total of 63. Hence, the total number of potted units is 21 x 3 = 63.

Test Parameters and Sample collection

Before sowing, the composite sandy soil was analyzed for necessary chemical constituents as required in the study: pH, electrical conductivity, organic carbon, percentage total nitrogen, available phosphorus, potassium and nitrate. The parameters were also analyzed after harvest to evaluate the degree of amendment and their effects on the crop yield. Soil samples were taken from each plot by means of bucket type soil auger. Composite soil samples of each treatment were collected in labeled polythene bags, air dried and taken to the laboratory for analysis. In the laboratory the soil samples were sieved through 2mm mesh filter for sample preparation.

Sample Digestion and Parameters Determination

1g of sieved soil sample was weighed into a beaker and digested with Mehlich-3 reagent according to extraction procedures as described by Mehlich (1984) for bioavailability of soil nutrients, in this case, nitrogen (N), phosphorus (P), and potassium (K). The concentration of the phosphorus was determined by UV-Spectrophotometer S-67 model and the concentration of potassium was measured by Flame Atomic Emission Spectroscopy (FAES).

III. RESULTS AND DISCUSSION

Soil chemical properties as Affected by Organic Matters

The effects of the application of poultry dropping and cow dung at the administered rates on residual chemical properties are presented graphically in Figures 1-7.
The soil pH was generally higher in all the levels of application for PD than for CD. However, analysis of variance (ANOVA) of the pH shows that there is no significant difference in the pH due to PD and CD amendments, and due to the levels of application as administered in this study. In both cases, increase in the level of organic amendments produced increasing effects on the soil pH. This result is in conformity with UF-IFAS (2017) which stated that animal manure increases soil pH due to calcium and magnesium contents therein. These values were, however, within the pH range (6.0-7.5) for normal growth of most arable crops (Jauron, 2002; Jensen, 2002).

Total nitrogen (TN) content in soil due to PD was higher than that due to CD (Figure 4). The difference was, however, not significant ($P = 0.3106; P > 0.05$). Also, TN did not increase significantly with increased application rates ($P = 0.0815; P < 0.005$) at the administered rates. Roy and Kashem (2014) presented a similar result in which PD produced higher $NH_4^+$-N in soil than CD, in a laboratory manure incubation experiment.

Figure 5 showed that PD produced higher available phosphorus than CD at 500 and 1000 Kg application rate. The available phosphorus increased significantly with increase in with increasing rates of manure application, but the effect due to a particular type of manure compared to the other cannot be generalized as it primarily depends on the feed administered to the animals producing the manure.
application rate \((P = 0.001705; P < 0.05)\) but did not increase significantly between PD and CD within same application levels. Farmwest (2019) showed that poultry manure contains more acid-soluble phosphorus than cattle manure. This is thought to occur because poultry produce very little of the phytase enzyme required to utilize phytate-P in grain (Barnet, 1994). In contrast, cattle generally produce sufficient phytase, although the amounts vary with age and health, which leads to fluctuations in acid-soluble phosphorus in the manure.

Residual soil potassium content (Figure 6) was not significant between the two amendments (PD and CD), and among application rate. The percentage composition of potassium in chicken manure and cow manure have been estimated to be about 0.5% each of the manure nutrient contents (Allotment Garden, 2019).

Yield of Maize as Affected by Organic Amendments

The yield of the maize grown in pots with organically amended soils is given in Table 2. The highest yield was obtained from the treatment with 1500 Kg application rate using poultry dropping, followed by that due to cow dung at the same application rate, while the lowest yield was obtained in the treatment with 500 Kg application rate with poultry dropping. Yield generally decreased with decreasing level of application. No yield was produced from pure sand without amendments. The yield of the maize is low compared to the mean yield in open field cultivation within the same area. Olaniyan and Lucas (2004) reported the mean yield of hybrid maize in Samaru, Kaduna State, within the same experimental region, to be between 5.72 to 6.12 t/ha. This represents 53% to 56% percentage reduction in yield. The yield can be improved upon by applying higher rates of the organic amendments and further modification of the sand by introducing some percentage clay to transform it to sandy loam which is more ideal for arable crops.

Table 2: Yield of maize as affected by different levels of organic amendment

<table>
<thead>
<tr>
<th>Organic amendment level, Kg</th>
<th>Maize yield, t/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD</td>
<td>CD</td>
</tr>
<tr>
<td>1500</td>
<td>2.7a</td>
</tr>
<tr>
<td>1000</td>
<td>1.71b</td>
</tr>
<tr>
<td>500</td>
<td>1.21b</td>
</tr>
<tr>
<td>0</td>
<td>0.00c</td>
</tr>
</tbody>
</table>

Means followed by the same letter(s) within each column are not significantly different at \(P \leq 0.05\)

IV. CONCLUSION

Poultry dropping and cow dung affected the soil chemical properties positively by adding or increasing the soil macro-nutrients and soil organic matter content. The evidence of this can be seen in the zero yield performance of the treatment without organic amendments. The cow dung produced a relatively higher mean yield (2.06 t/ha) than poultry dropping (1.87 t/ha), howbeit; the difference is not statistically different. The yield is only about 44% of what may be expected under good open field management practice for maize in the same location. The yield can be improved by increasing the organic amendment rates and by introducing a percentage of clay in the sand that will be enough to transform it to sandy loam textural group.

REFERENCES


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