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Effects of organic ammendments on some soil properties and nutrient uptake of *Zea mays* in soils of different parent materials

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ABSTRACT

Understanding of organic soil amendment sources on soil properties is needed for exploration of the full benefits of such amendments. Thus, a pot experiment was conducted at Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, to evaluate the effects of organic ammendments on some soil properties and nutrient uptake of *Zea mays* L. (maize plant) in soils of different parent materials. The experiment was a split plot laid out in a ramdomized complete block design (RCBD) with soils formed over coastal plain soils, sandstone and shale as the main plot treatment and animal manure [poultry droppings (PD), cowdung (CD), goat droppings (GD)] as the subplot treatments. Treatments were replicated three times. The results of the study show that organic ammendments increased plant height, stem girth and number of leaves relative to control. Nutrient uptake by *Z. mays* plant (Ca, Mg, K and P) from soil formed over shale was significantly higher ($p<0.05$) than those of soil formed over sandstone and coastal plain sand, respectively. Application of poultry droppings resulted to higher nutrient uptake by maize plant compared to other treatments. There was significant interaction of soil type and organic ammendment on maize dry matter yield which shows that the effect of organic ammendments on the maize dry matter yield depends on the soil type.

INTRODUCTION

Maize (*Zea mays* L.) also called corn, is one of the most crucial and strategic cereal crops in Africa and the developing world in general (FARA, 2012). Maize is a stable food crop for most tropical Africans of which Nigeria is inclusive with per capital kg/year of 40 (FAOSTAT, 2003). It is one of the oldest cultivated world's cereals. It is an important source of carbohydrates and if eaten in the immature state, it provides useful quantities of vitamin C. Nutrient uptake and utilisation efficiencies are known to vary in maize varieties, as well as in their adaptability to different soil types (Duncan and Baligar, 1990; Horst et al., 1993; Machado et al., 1999). For normal growth, maize requires a wide range of well drained soils, sandy loam to clayey loam, rich in organic matter and plant nutrients (Norman et al.,1995).

Nevertheless, majority of the soils in humid tropical Africa are infertile, thus a considerable portion of agricultural soils in Nigeria can be classified as low fertile soils due to disruption by weather (IFPRI, 2004). Babalola (2002) and Eshett (1993) also observed that

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tropical soils are inherently infertile, highly weathered, leached and contain low activity clay minerals which make them sieve like in nature, retaining little water during rainfall and irrigation and low plant nutrients. Also, organic matter content of the soil, the seat of the plant food is very low and this confers a weak structure on the soil. Thus, the soils are fragile and their aggregates collapse readily under the impact of raindrops making them highly susceptible to soil erosion (Babalola, 2002).

The growing world population is presenting a challenge of adequate and balanced nutrition. Thus, the need for sustainable crop production that will preserve the environment. The nutrient reserve of agricultural soils must be replenished regularly in order to maintain crop production which maize is inclusive. Researchers have tried using various methods to improve the infertile nature of tropical soils and this includes replacement of soil nutrient by addition of inorganic fertilizers (Giller et al., 2009). Use of Biological Nitrogen Fixation (BNF) which is also a major source of plant nutrient with respect to nitrogen in tropical soils. Bohlool et al. (1992) reported that the contribution to soil nitrogen economy through this system is as high as 360 kg/ha. Several scientist have discovered that organic ammendments can also be used to improve infertile tropical soils and it is relatively cheaper and more eco-friendly when compared with inorganic fertilizers. Darwish et al. (1995) reported that high organic matter content reduced soil physical degradation and improved soil strength. Agboola and Unamma (1991) discovered that all trace elements were more available to plant when organic matter was applied and there was increase in crop yield. Organic matter supplies the soil with various nutrients which helps to improve soil structure, texture, water infiltration and water holding capacity of the soil. Kang and Balasubramanian (1990) pointed out, that organic matter helps to regulate soil temperature and pH, increases the cation exchange capacity of the soil, enhances microbial activities and also reduces erosion and leaching of soil nutrients.

However, more than 50% of inorganic N – fertilizer applied to remedy the problem of low soil nutrient fertility in the tropics polluted the environment (Ladha et al., 1998) through acidification of soil (Kennedy and Tchan, 1992) and NO_3 pollution of groundwater through leaching (Shrestha and Ladha, 1998). Biological nitrogen fixation can only introduce nitrogen in tropical soil which is not the only nutrient required for crop production. On the other hand, little or nothing has been done on the comparison of the effects of organic matter as ammendments on soil properties and its influence on nutrient uptake of crops in soils of different parent materials.

Mineralization of the nutrients tied up in organic matter that are used as ammendments occur slowly that most nutrients are taken up so that very little is lost by leaching. Also the mineralization of a particular organic matter as soil ammendment may vary with the soil type. In order to effectively target the use of organic matter as soil ammendment, there is need to assess the nutrient uptake from different organic matter used as soil amendments on different soil types.

Therefore the objective of this study was to assess the nutrient uptake from poultry droppings, goat manure and cow dung on soils formed over coastal plain sand, shale and sandstone using maize as a test crop.

MATERIALS AND METHODS

The soil samples used for this research work were collected at a depth of 0–15 cm from three locations in Southeastern Nigeria, which includes Okigwe, Bende and Umudike representing soils formed over sandstone, shale and coastal plain sand, respectively. The organic matter used for soil ammendment (that is, cow dung, poultry droppings and goat droppings) were obtained from Michael Okpara University of Agriculture, Umudike, Animal Farm. Soils formed over coastal plain sands and sandstone were air dried and passed through 2 mm sieve to separate the fine particles from the coarse ones while soil formed over shale was dried for a week crushed into smaller particles from large clods and then passed through 2 mm sieve in order to separate the fine shale soil from cloded ones. Soil samples were subjected to some physical and chemical analysis while the organic matter were subjected to some chemical analysis.

Physical and chemical characteristics of the soil samples and organic matter were as follows: Coastal plain sand, Sandstone and Shale (789, 762 and 195 g/kg Sand,) (65, 715 and 146 g/kg Silt), (145, 165 and 658 g/kg Clay); [pH(H_20) 5.8, 5.9 and 4.7]; (32.9, 22.6 and 30.3 g/kg organic carbon) and Exchangeable Ca, Mg in Cmol/kg (4.15, 3.20 and 14.19)(2.17, 2.70 and 9.83), respectively. poultry droppings, cowdung and goat manure pH in H_2O was (5.85, 5.58 and 5.37); g/kg organic carbon (26.3, 30.8 and 28.5); Exchangeable acidity in Cmol/kg (1.68, 1.82 and 2.08), respectively.

Experimental design

The experiment was a split plot laid out on a randomized complete block design (RCBD). The three different soil types constituted the main plot factor while the three different organic amendments and a control constituted the subplot factors. There were 12 treatment combination in all which were replicated three times. The experiment was setup using pots and each pot contained 10 kg of soil amended with different levels of manure (poultry droppings 52 g, cowdung 57 g and goat manure 52 g) while the control has no organic amendment.

The variety of maize seed used was Oba super two and it was planted 2 weeks after watering of the soil.

Table 1. Effect of soils formed over different parent materials on maize growth.

Soil type	Height (cm)	Girth (mm)	Number of leaves/pot
SS	50.41	8.50	6.25
CPS	45.58	5.95	6.00
SHL	62. 25	2.44	6.58
LSD (0.05)	11.89	2.44	0.83

SHL, Shale; CPS, coastal plane sand; SS, sand stone, LSD, least significant difference.

Table 2. Effects of organic amendments on some growth parameters of maize.

Treatment	Height (cm)	Girth (mm)	Number of leaves
PM	66.11	10.00	7.55
CD	57.00	7.78	6.22
GD	51.88	7.55	6.44
Control	36.00	4.66	4.88
LSD (0.05)	7.82	2.14	0.83

PM, Poultry manure; CD, cowdung; GD, goat dropping; LSD, Least significant difference.

Data collection

Data were collected on plant height, stem girth, number of leaves, dry matter yield and nutrient uptake of maize. Using one meter rule (1 m) graduated in cm, plant height was measured from base to the tip of the leaves. A venir calliper graduated in millimetre (mm), was used in measuring the stem girth while the number of leaves were counted from one plant/pot and records were taken. Plants were then harvested at 5th week after planting which were used to determine the dry matter yield and nutrient uptake of maize.

Statistical analyses

Data collected were subjected to analysis of variance (ANOVA) while treatment means were separated using Least significant difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

Effect of soils formed over different parent materials on maize growth

Plant height and number of leaves of maize grown on soils formed over shale and sandstone were found to be significantly higher ($p<0.05$) compared to those grown on soils formed over coastal plain sands while maize grown on soils formed over sandstone was however significantly higher ($p<0.05$) in stem girth compared to maize grown on soils formed over coastal plain sands and shale (Table 1).

Effect of organic amendment on maize growth

Application of organic amendment significantly increased maize height, girth and number of leaves relative to control. Maize grown on soils amended with poultry dropping was significantly higher ($p<0.05$) in height, girth and number of leaves compared to those soils amended with goat droppings and cowdung (Table 2). The highest growth values obtained by maize grown on soil amended with poultry manure is an indication that the mineralization rate of poultry manure is faster when compared with the rate of mineralization of goat droppings and cowdung. This is in accordance with Mbagwu (1992), who reported that poultry manure showed the highest rate of mineralization with low C/N ratio over other organic matter he worked with in Nsukka, Nigeria. Rhaman (2004), also reported that poultry manure is essential for establishing and maintaining optimum soil physical condition which is important for plant growth.

Effect of soil type and different organic amendment on maize dry matter yield

The effect of poultry droppings on maize dry matter yield was significantly higher ($p<0.05$) when compared to effect of cowdung and goat droppings (Table 3). This is in

Table 3. Effects of soil types and different organic amendments on maize dry matter yield (g/pot).

Soil type	PM	CD	GD	Control	Mean
SHL	58.93	23.43	24.80	15.00	30.54
CPS	20.50	3.90	4.26	0.63	7.32
SS	24.83	8.00	3.76	0.86	9.36
Mean	34.75	11.77	10.94	5.50	

LSD (0.05) Manure = 5.05; LSD (0.05) Soil Type = 7.73.
SHL, Shale; CPS, coastal plane sand; SS, sand stone; LSD, least significant difference; PM, poultry manure; CD, cowdung; GD, goat dropping.

Table 4. Nutrient uptake (mg/pot) of maize from soils formed over different parent materials.

Soil Type	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	P(mg/kg)
Shale	49.55	24.45	19.6	208
CPS	19.95	8.47	6.66	64
Sandstone	15.89	8.40	5.68	84
LSD (0.05)	23.77	2.87	4.39	116

SHL, Shale; CPS, coastal plane sand; SS, sand stone; LSD, least significant difference.

confirmation with work done by Mbagwu and Ekwealor (1990), who observed that poultry dropping is a better source of plant nutrient than other source of organic matter and show high rate of mineralization. Deksissa et al. (2008) also indicated that poultry manure is appreciably richer in plant nutrients especially nitrogen and phosphorus than other animal manure. Tang et al. (2007) obtained the highest significant wheat dry matter with application of poultry litter. It was also observed from the same table that maize dry matter yield was significantly higher ($p<0.05$) on soil formed over shale when compared with maize dry matter yield on soil formed over coastal plain sand and sandstone. This may be due to the larger surface area of finer particles and greater absorption sites for nutrients of the shale which helps reduce soil nutrient loss, increase water holding capacity, improve nutrient availability.

Effect of soils formed over different parent materials and organic amendment on nutrient uptake (kg/pot) of maize

Nutrient uptake by maize plant (Ca, Mg, K and P) from soil formed over shale was significantly higher ($p<0.05$) than those of soil formed over sandstone and coastal plain sand respectively (Table 4). The lower nutrient uptake which was observed from soil formed over coastal plain sands and sandstone could be as a result of the general intensive weathering and high leaching of these nutrient in the study area (Akinrinde et al., 2005).

Application of organic amendments (poultry droppings, goat droppings and cowdung) resulted to a higher nutrient uptake (Ca, Mg, K and P) by maize plant relative to control. However it was observed that poultry manure application resulted to significantly higher ($p<0.05$) nutrient uptake by maize plant when compared with goat dropping and cowdung which were significantly not different from each other (Table 5). The significantly higher nutrient uptake by maize observed on application of poultry manure was similar to work done by Ali (2005), who reported that poultry manure contain plant nutrient more than other organic matter he worked on. Ewulo (2005), pointed out that poultry manure contains high percentage of nitrogen and phosphorus for the healthy growth of plants. Ojeniyi et al. (2013), also discovered that poultry manure influenced significantly higher nutrient uptake by cocoyam compared to other organic amendment he worked on.

Conclusion

The results obtained from this study show that organic matter amendment increased maize height, stem girth and number of leaves relative to the control. However, poultry manure produced highest values for these maize growth parameters. There was significant interaction of soil type and organic amendment on maize dry matter yield which shows that the effect of organic amendment on maize dry matter yield depends on the soil type.

The effect of soil type on nutrient uptake was observedto be significantly higher ($p<0.05$) in soil formed over shale but low in soils formed over coastal plain sand and sandstone while the effect of organic amendment on nutrient uptake by maize plant was observed to be

Table 5. Effect of different organic amendments on nutrient uptake (mg/pot) of maize.

Manure	Ca	Mg	K	P
	Percentage (%)			
PM	62.36	33.22	23.95	21.92
CD	24.34	7.55	7.88	8.93
GD	18.36	9.51	7.23	8.85
Control	8.78	4.53	3.52	7.93
LSD (0.05)	15.14	10.73	4.19	7.73

PM, Poultry manure; CD, cowdung; GD, goat dropping; LSD, least significant difference.

significantly higher in poultry manure when compared with goat and cow manure.

On the basis of evidence from this, soil formed over shale gave the best performance than others in maize growth parameters. This may be due to the larger surface area of finer particles and greater adsorption site for nutrient of shale which helps reduce nutrient loss, increase water holding capacity, improve nutrient availability. Poultry manure showed more suitability for amendment of tropical soils (soils formed over shale, coastal plain sand and sandstone).

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