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Effects of Animal Faeces and Their Extracts on Maize Yield in an Ultisol of Eastern Nigeria

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Abstract. In this work, the potential use of organic wastes in improving the productivity of the low-base status of an ultisol was evaluated in the greenhouse using a completely randomized design. There were twelve treatments replicated four times including the control. The treatments were solid poultry droppings, piggery dung and cow dung and their extracts obtained after soaking for one week, two weeks, and more than two weeks. These treatments were properly applied to 2 kg of potted soil (equivalent of 15 t ha^{-1}) and planted with maize grains at a rate of two grains per pot and thinned down to one seedling after germination. The results showed that extract from poultry droppings soaked for more than two weeks gave the highest yield of maize dry matter (18.30 g plant^{-1}), followed by extracts from pig dung soaked for more than two weeks which yielded (18.14 g plant^{-1}) and solid poultry dropping (17.47 g plant^{-1}) while solid cow done or its extracts gave the lowest yield of (5.08 g plant^{-1}) but all were significantly higher than control (1.84 g plant^{-1}). All the treatments significantly increased the soil organic matter, exchangeable bases, cation exchange capacity and the available phosphorus. With the increase of soil nutrients following the application of the organic wastes, all amendments increased maize performance over the control. The recommended best form of the animal manure for optimum maize growth was the liquid form especially that of poultry that was soaked for more than two weeks.

Key words: Animal faeces, maize yield, ultisol

Introduction

Most soils when put under continuous cultivation deteriorate in physico-chemical properties and give low crop yields after a few years of production. The use of organic matter or animal faeces in various forms can restore the productive capacity of these soils. The use of animal faeces or wastes by farmers aims at increasing and sustaining agricultural productivity of soils and crops (Ageeb, 2000). Poultry manure is an excellent source of nutrients and can be incorporated into most fertilizer programmes. It is also the richest animal manure in NPK but must be cured before adding it to the soil otherwise it will burn any plant it comes in contact with (Zublena, 1993). Swine waste is also an excellent source of nutrient for crop production and its nutrient content is also high. Cow dung is a good potential source of plant nutrient, but only in areas where animals are tethered or penned, so that dung can be collected. Cow dung can also be used as topdressing and for soil improvement. Its low nutrient value makes it safe to apply unlimited quantities. The form a nutrient is applied in the soil often determines its availability and long-term effect of the soil.

Maize (*Zea mays*) is one of the most widely grown and used crop in the world. It is the most important cereal fodder and grain crop under both irrigation and rain fed agricultural systems in the semi-arid and arid tropics (Hussan, 2003). These days hybrid maize is grown widely and is well known for its high demand for plant nutrients and other production inputs. It is important to inform farmers that all the conditions required for maximum performance of hybrid maize have to be fulfilled before the desired economic returns can be obtained since maize is sensitive to nutrient deficiency. The form a soil nutrient is applied to the soil determines its availability and readiness for crop use. Liquid fertilizers tend to contain more readily available nutrients. Thus, they influence crop growth and development faster than solid ones. Most animal faeces are in solid form and this form delays the availability of nutrients there in. Farmers who have these faeces may be willing to dissolve them and use their liquid form if they are guided by empirical research results. The objective of this work was to evaluate the response of maize to various forms of animal faeces applied to maize grown in an ultisol.

Materials and Methods

Location

This experiment was conducted in the Greenhouse of the Department of Soil Science, Faculty of Agriculture, University of Nigeria, Nsukka (UNN), between May 3, and June 28, 2012. Nsukka lies in southeastern Nigeria (latitude 06^0 52' N and latitude 07^0 24' E) and is located within the derived savannah region of Nigeria. The soil used was collected from the plots beside the Meteorology station in the UNN premises at the depth of 0-15 cm. The soil is a sandy loam ultisol.

Green house studies

The experimental design used was a Completely Randomized Design (CRD) replicated four times. The maize used was Manoma maize bought from the Department of Crop Science UNN. The top soil (0-15cm depth), poultry droppings (PD), piggery dung (PgD) and cow dung (CD) used were air dried in the green house. Two kg of the sieved dry soil was weighed out and poured into each of the 52 ceramic pots used for the experiment. The holes at the bottom of the pots were covered with cotton wool to prevent soil loss and allow gradual water drainage. Twenty five grams of each of the dried poultry, piggery and cow faeces were weighed and poured inside 36 plastic buckets after which nine each was soaked for one, two weeks and more than two weeks respectively using 75 cl of water for obtaining the extracts. Another twelve pots also received 25 g of solid poultry dropping, cow dung and piggery dung as the treatment. This solid amendment was properly mixed with the soil in the ceramic pots. The amended soil was incubated for 2 weeks and was watered using 50 cl of water to stimulate microbial decomposition of the manure. The next twelve pots received 50 cl of the liquid gotten from the one week soaking of the animal faeces. The remaining 24 pots received 50 cl of the liquid extracted from the faeces soaked for two weeks though

12 pots out of these last 24 pots received subsequent application of 25 cl of the liquid extract till the end of the experiment. The other pots equally received 25 cl of ordinary water at every other day interval. These amendments were equivalent to 15 t ha^{-1} commonly recommended for the soils of the area (Agbim and Adeoye, 1991). Four pots containing soil without any amendment were used as the control;

Laboratory analysis

The particle size analysis (mechanical analysis) of the soil was done by the Bouyoucos hydrometer method (Bouyoucos, 1962) using NaOH as a dispersing agent. The carbon content was determined by the Walkley and Black (1934) method. The percentage organic matter was derived by multiplying percentage organic carbon by 1.724, which is the correction factor. Total nitrogen was determined by the Kjeldahl method (Bremner, 1965). The exchangeable bases (Na, K, Ca, Mg) were extracted using ammonium acetate. The exchangeable Ca and Mg were determined titrimetrically with EDTA (Ethylene Diaminetetracetic Acid) complexometric method. Exchangeable Na and K were determined by flame photometry. Available phosphorus was determined by the Bray 11 method (Bray and Kutz, 1945).The pH was determined using a pH meter in a soil: liquid ratio of 1:25, the liquid being 0.1N KCl and H_2O while exchangeable acidity was determined trimetrically with NaOH. The cation exchange capacity (CEC) of the soil was determined as specified by Chapman (1965).

Planting and harvesting

The planting was done on May 3, 2012. Maize was planted at the seedling rate of 2 seeds per pot. The pots were wetted every two days. After one week, the maize was thinned down to one stand per pot. The maize was harvested after eight weeks from planting (on 28th of June) by cutting off the plant at the stem-line (just at the soil surface). The shoot was air-dried for few days and then oven-dried at a temperature of 65^{o}C to a constant weight. The following parameters were measured: plant height, total leaf count, leaf area, leaf length and leaf width including the dry matter weight of the plant.

Results and Discussion

The chemical and physical characteristics of the soil used to conduct the experiment before treatments were added to it are presented in table 1. The soil texture is sandy loam, moderately to very strongly acid in reaction with moderate amount of organic matter and available P contents. The exchangeable Mg, Na and K were high, while Ca was very high.

Table: Characteristics of the Soil before Planting

Soil Properties	Values
Textural class	Sandy loam
pH H_2O	5.7
pHKCl	4.7
SOM (gkg^{-1})	1.39
Total N (gkg^{-1})	0.11
Avail. P ($mgkg^{-1}$)	18.7
Ex. Mg ($Cmolkg^{-1}$)	0.4
Ex. Ca ($Cmolkg^{-1}$)	0.6
Ex. Na ($Cmolkg^{-1}$)	0.17
Ex. K ($Cmolkg^{-1}$)	0.12
CEC ($Cmolkg^{-1}$)	4.4
Ex. H ($Cmolkg^{-1}$)	1.0
Ex. Al ($Cmolkg^{-1}$)	Nil

The chemical characteristics of the organic waste used in this study showed that they are very high in organic matter. The bases in all the animal faeces were very low. Nitrogen and phosphorus were also very low in all of them. The pH level of all the animal manure ranged from slightly alkaline to neutral

Table 2: Characteristics of Organic Wastes used in this Study

Parameters*	CD	PgD	PD
SOM (g kg^{-1})	2.46	2.55	2.01
N (g kg^{-1})	0.07	0.08	0.08
Ex. Na (g kg^{-1})	0.21	0.21	0.24
Ex. K (g kg^{-1})	0.09	0.06	0.24
Ex. Ca (g kg^{-1})	0.03	0.02	0.04
Ex. Mg (g kg^{-1})	0.02	0.02	0.01
Avail. P (mg kg^{-1})	31.3	0.76	0.38
pH H_20	7.8	7.3	7.6
pHKCl	7.2	6.9	7.5

**CD = cow dung, PgD = pig dung, PD = Poultry droppings*

Effects on Soil pH

Almost all the treatments significantly raised the pH of the soil with 18 % increase in soil treated with extracts from poultry droppings soaked more than two weeks (PD3WS) as the highest (Table 3). There was a slight decrease from 5.7 to 5.4 in soils amended with extract from poultry droppings after two weeks of soaking (PD2WS). These results reflect the higher pH values of the animal faeces which were significantly higher than the initial soil pH values. The control also had a slight decrease most probably due to some leaching.

Table 3: Effects of treatments on the Soil pH, available Phosphorus, OM and total N of the Soil

Treatment	pH H_2O	pH KCL	SOM (gkg^{-1})	Total N($g\ kg^{-1}$)	Avail. P. ($mg\ kg^{-1}$)
PD1WS	6.50	5.60	2.20	0.08	22.4
PgD1WS	6.00	4.70	2.29	0.07	19.6
CD1WS	6.30	5.00	2.29	0.07	6.5
PD2WS	5.40	5.10	2.29	0.09	13.1
PgD2WS	6.00	4.90	1.82	0.08	19.6
CD2WS	5.90	4.80	2.11	0.05	5.6
PP3WS	6.70	5.70	2.89	0.09	33.1
PgD3WS	6.20	4.70	2.77	0.05	29.1
CD3WS	6.60	5.80	2.86	0.08	10.3
PDSA	6.40	5.60	1.99	0.07	32.6
PgDSA	5.90	4.90	2.55	0.09	28.0
CDSA	6.50	5.50	2.64	0.08	11.2
Co	5.60	4.85	1.85	0.08	4.2
LSD(<0.05)	0.08	0.21	0.07	0.004	0.39

* *PD1WS = Poultry dung, one week soaking; PgD1WS = Piggery dung, one week soaking; CD1WS = Cow dung, one week soaking, PD2WS = Poultry dung, two weeks soaking; PgD2WS = Piggery dung, two weeks soaking; CD2WS = Cow dung, two weeks soaking; PD3WS = Poultry dung, more than two weeks soaking; PDSA = Poultry dung, solid application; PgDSA= Piggery dung, solid application; CDSA = Cow dung, solid application; C_O=Control*

Effects on organic matter

The levels of organic matter (Table 3) in most of the soils significantly (p = 0.05) increased above the control. The increase was over 80 % of the original values in nine of the twelve treatments. The lowest increase was in soils amended with extracts from pig dung soaked for two weeks (PgD2WS).

Effects on Total N

Total N obtained (Table 3) was highest in soils amended with all the three extracts from poultry dropping (PD1WS, PD2WS, PD3WS) then pig dung applied in solid form (PgDSA) or after two weeks of soaking (PgD2WS), cow dung soaked for more than two weeks (CD3WS), or in solid form (CDSA). The lowest value (0.05 g kg^{-1}) was obtained from the soil treated with extracts from cow faeces soaked for one week.

Effects on Available P.

All the soils (Table 3) that were treated with solid and the liquid extracted from the poultry droppings gave higher available P followed by those that received liquid and solid piggery dung while the level of P in cow dung treated soils had the lowest and had slight increases above the control. There were significant differences ($P= 0.05$) between the other treatments and the control.

The positive effects of the faeces on the soils are not surprising because they are well known to increase and sustain agricultural productivity of soils and crops (Ageeb et al; 2000). Exchangeable Mg and Ca increased in all the treated soils and this could be because there was addition in excess of maize needs for growth and development.

Table 4 illustrates that the soils treated with extracts obtained from cow dung after two weeks of soaking (CD3WS) and solid poultry dropping (PDSA) gave the highest levels of exchangeable Ca plus Mg followed by those treated with extracts from poultry and pig faeces after two weeks of soaking as well as dry cow dung and extracts from poultry droppings after one week of soaking (PD1WS). The values from the treatments were marginally below that of the control but above the original soil values. The values of exchangeable H and Al were abnormally high but the treatment effects were generally significant ($P< 0.05$).

Table 4: Effects of treatments on the Soil's Exchangeable bases and acidity.

Treatment	H (Cmol kg^{-1})	Al (Cmol kg^{-1})	Ca (Cmol kg^{-1})	Mg (Cmol kg^{-1})
PD1WS	1.20	0.60	1.00	1.20
PgD1WS	0.60	0.80	1.00	0.60
CD1WS	0.80	0.60	1.00	0.60
PD2WS	1.60	0.60	0.80	0.80
PgD2WS	1.00	0.80	1.00	0.80
CD2WS	0.80	0.80	1.20	0.40
PD3WS	6.40	0.40	1.40	0.80
PgD3WS	0.40	1.00	0.80	1.40
CD3WS	1.00	0.20	1.20	1.40
PDSA	8.00	0.20	1.00	1.60
PgDSA	1.00	0.60	1.00	0.60
CDSA	0.80	0.40	1.20	1.00
Co	1.00	1.10	0.85	0.90
LSD (<0.05)	0.33	0.08	0.04	0.42

** PD1WS = Poultry dung, one week soaking; PgD1WS = Piggery dung, one week soaking; CD1WS = Cow dung, one week soaking, PD2WS = Poultry dung, two weeks soaking; PgD2WS = Piggery dung, two weeks soaking; CD2WS = Cow dung, two weeks soaking; PD3WS = Poultry dung, more than two weeks soaking; PDSA = Poultry dung, solid application; PgDSA = Piggery dung, solid application; CDSA = Cow dung, solid application; C_O = Control*

Maize Yield

There were significant (p = 0.05) treatment effects on plant height, leaf area and leaf number throughout the study period but only values at seven and eight weeks after planting are presented (Table 5). Poultry dropping and its extracts led in the improvement of the maize yield parameters followed by those the pig dung. However, others were still higher than those values from the control pots. This is an indication of the positive effects of all the animal faeces on maize performance.

This could be as a result of variations in the nutrient value of the treatments and their varying rate of decomposition and utilization by the plant. The trend of growth, that is, some treatments leading to the production of higher leaf number, plant height and leaf area and other treatments leading to the lower yield of them was maintained from the first week to the eight weeks of growth and this could be as a result of the homogenous nature of greenhouse and the equal irrigation of animal waste extract and normal water to the soil.

Table 5: Effects of treatments on Leaf area, Plant height and Leaf number of the plant for the seventh and eight week of growth

Treatment	Leaf Area (cm^2 $plant^{-1}$)	Plant Height (cm $plant^{-1}$)	Leaf No.	Leaf Area (cm^2 $plant^{-1}$)	Plant Height (cm $plant^{-1}$)	Leaf No.
Seven weeks after planting				Eight weeks after planting		
PD1WS	340.20	46.25	8.75	419.90	56.95	11.00
PgD1WS	284.50	36.65	7.25	354.90	43.30	7.50
CD1W	231.20	35.20	6.50	276.60	42.25	6.75
PD2WS	336.30	39.38	7.75	376.70	52.85	8.50
PgD2WS	303.60	35.25	8.00	345.80	49.50	9.25
CD2WS	244.90	33.92	7.50	273.60	43.83	7.75
PD3WS	397.20	45.50	10.00	441.20	55.00	11.25
PgD3WS	349.80	38.92	8.50	406.70	49.02	9.00
CD3WS	318.80	35.08	8.25	363.80	42.95	8.25
PDSA	350.70	40.40	9.00	409.10	48.98	9.25
PgDSA	307.60	34.15	6.50	363.80	45.50	8.00
CDSA	238.6	34.23	7.25	285.50	45.23	7.50
Co	118.4	21.65	5.75	141.60	26.95	6.00
LSD($P<0.05$)	25.38	1.24	0.98	31.55	1.71	1.20

** PD1WS = Poultry dung, one week soaking; PgD1WS = Piggery dung, one week soaking; CD1WS = Cow dung, one week soaking, PD2WS = Poultry dung, two weeks soaking; PgD2WS = Piggery dung, two weeks soaking; CD2WS = Cow dung, two weeks soaking; PD3WS = Poultry dung, more than two weeks soaking; PDSA = Poultry dung, solid application; PgDSA = Piggery dung, solid application; CDSA = Cow dung, solid application; C_O = Control*

Analysis of shoot dry matter yield showed that there was a significant differences (p = 0.05) between the majority of the treatments and those values obtained from soils amended with cow dung forms (Table 6). Thus solid and extracts from cow dung had the least positive effects on the shoot dry matter of maize. The yields were not significantly different from those obtained from the control.

Table 6: Effects of treatments on the dry matter weight of Maize

Treatments	Dry matter weight (g/plant)
PD1WS	14.81
PgD1WS	12.42
CD1WS	5.08
PD2WS	15.62
PgD2WS	15.48
CD2WS	8.40
PD3WS	18.30
PgD3WS	18.14
CD3WS	10.35
PDSA	17.47
PgDSA	12.10
CDSA	5.87
Co	1.84
LSD (P<0.05)	5.24

* *PD1WS = Poultry dung, one week soaking; PgD1WS = Piggery dung, one week soaking; CD1WS = Cow dung, one week soaking, PD2WS = Poultry dung, two weeks soaking; PgD2WS = Piggery dung, two weeks soaking; CD2WS = Cow dung, two weeks soaking; PD3WS = Poultry dung, more than two weeks soaking; PDSA = Poultry dung, solid application; PgDSA = Piggery dung, solid application; CDSA = Cow dung, solid application;* C_O *= Control*

The stunted growth of maize and yellowing of leaves which were seen in the control and some of the ones that were treated with the different forms of cow dung could be nitrogen deficiency symptoms (Foth and Schafer. 1980) because nitrogen encourages vigorous vegetative growth and impacts dark green colour to the leaves of plants.

The nitrogen deficiency symptoms could be due to leaching, and/or low nitrogen content in the original soil. The results of the experiment shows that the effects of organic wastes on the soil were more pronounced in the soil that received the subsequent application of the soaked poultry droppings. This agrees with the work of Waly et al (1987) where they discovered that with prolonged application of sewage water there were increases in soil organic matter, CEC, total nitrogen as well as the available phosphorus. These effect of the liquid extracted from the poultry manure that was soaked for more than two weeks on the soil which reflected on the plant could be due to the readily available nutrients from the liquid extracts to the soil and this soaked poultry manure was easily mineralized because it has larger surface area than the solid form though the nutrient that will not be utilized in the solid form will then be made use of by the subsequent plants cultivated on the same soil. The action of the extracts was like that of liquid fertilizers. Also, it should equally be noted that there is a tendency of utilizing almost, if not all the nutrients in the wastes soaked for more than two weeks and was used for subsequent application than for those that were soaked one and two weeks respectively because some of their nutrients might still be left out in their residues especially for the insoluble nutrients.

Conclusion

All the treatments were very effective in contributing to soil improvement but poultry and pig faeces were better in improving maize growth and development than cow dung whose effect was marginal to the control. The above implies that the fertility status of an ultisol can be improved by the application of liquid and solid organic manure. Poultry manure especially the liquid extract can be used by farmers for maize production.

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