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Research Article

Comparative Study of Cow dung and Poultry Droppings with or without Mineral Fertilizer on Some Soil Chemical Properties and Yield of Maize in Semi-Arid Sub-Region, Nigeria

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ABSTRACT

A field study was conducted in Maiduguri, (11º 53' N; 13º 16' E) to study the comparative effect of cow dung and poultry droppings singly or in combination with mineral fertilizer on some Soil chemical properties and yield of maize (*Zea mays L*). The treatments consisted of cow dung and poultry droppings (5.0 tons/ha). Singly and combined with four levels of mineral fertilizers (0, 45, 60 and 90 kg/ha N). The experiment therefore contained nine (9) treatments laid out in a randomized complete block design (RCBD). From the result, it was found that cow dung significantly increased the ECEC, soil organic carbon and P content both singly and in combination with mineral nitrogen fertilizer. On the other hand, poultry droppings significantly decreased soil pH, but significantly increased total nitrogen and fulvic acid fraction of organic matter. Maize yield was significantly affected by the different treatments. There was consistent increase in grain yield with addition of cow dung and poultry droppings applied singly and in combination with mineral nitrogen fertilizer in the first and second year of experiment and in combined analyses. Combining sub-optimal rates of nitrogen fertilizer (90 kg/ha N) with cow dung (5.0 tons/ha) gave the highest grain yield especially in the first year (2466.7 kg/ha) and in the combined analysis (1883.7 kg/ha). From this study, it could be concluded that cow dung and poultry droppings either singly or in combination with mineral nitrogen fertilizer significantly improved soil pH, total nitrogen organic carbon content, CEC and organic matter fractions and increased the yield of maize in the study area and is recommended to farmers in the area more and better than sole mineral fertilizer.

Key words: Comparative study, Cow dung, Poultry droppings, Mineral fertilizer, Soil chemical properties Maize yield and Semi-arid sub-region

INTRODUCTION

Despite the beneficial effects of chemical fertilizers, resource- poor farmers are confronted with some problems concerning their use. Firstly, scarcity in supply and high cost prohibit their use by most small-holder farmers, hence they have often resorted to the use of farm yard manure (FYM) and household refuse to build up the soil nutrient status. Secondly, there are also lots of soil problems associated with the use of chemical fertilizers (Foth and Royd, 1988). Application of ammonia (NH_3) containing fertilizers produces an immediate alkaline effect owing to hydrolysis. However, oxidation and subsequent nitrification of such fertilizers produces a long term acidity effect (Osundare, 2008).

$NH_4^+ + 2O_2 = H_2O + H^+ + H^+ + NO_3^-$

Application of these fertilizers on acidic sandy soils can produce soil acidity but their application on alkaline or calcareous soils may be beneficial (Brady and Weil, 2002; Olomilua, *et al*., 2007; Ojo*et al*, 2008). Soil degrades seriously when mineral fertilizers are used to produce crop. The degradation includes the progressive loss of organic matter, soil acidification decline in CEC, buffering capacity and fertility status; particularly K reserves (Graham *et al*., 2002).

Fagbola and Ogunbe (2007) confirmed that the use of chemical fertilizers alone has been found to be detrimental to the soil and the environment with particular reference to soil acidity and underground waters. For instance, oxidation of ammonium sulphate in the soil produces two strong mineral acids, and can easily acidify the soil.

$(NH_4) SO_4 + 4O_2 \rightarrow 2HNO_3 + H_2SO_4 + H_2O$

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(Nitric acid) (Sulphuric acid)

Hydrolysis of urea fertilizer can also lead to soil acidity.

$CO(NH_2)_2 + H_2O \rightarrow (NH_4)_2CO_3$

Urea: Ammonium carbonate (Unstable)

The unstable ammonium carbonate produced will easily be oxidized by micro-organisms in the soil (Nitrosomonas and Nitrobacter) producing nitric acid.

$(NH_4)_2CO_3 + 3O_2 \rightarrow 2HNO_2 + 3H_2O + CO_2$

$2HNO_2 + O_2 \rightarrow 2HNO_3$

According to Rayar (2000) excess and continued application of chemical fertilizers can jeopardize the soil through its effects on soil pH, reduction in CEC through leaching, run-off and soil erosion and reduction in buffering capacity and consequently resulting in nutrient imbalance. Rayar (2000) also stated that intensive use of chemical fertilizers, albeit they increase crop yield could result in deterioration of food quality, destruction of natural soil chemical and biological properties by upsetting natural nitrogen cycle. Olomilua *et al.* (2007) clearly reported that application of chemical fertilizers at a time when the ground is water-logged or when the crop is not able to use the chemical can lead to surface run-off, particularly phosphorus or through leaching, thus, lowering the CEC of the soil with subsequent soil acidity. Sanders (2001), Singh and Singh (2003) identified that continuous application of mineral fertilizers induces K deficiency. In fact, it destroys soil properties in general.

Organic manures could ameliorate these adverse effects of mineral fertilizers (Sikora and Azam, 1993). Application of organic matter and organic manures to the soil serves as mulch which protects the soil surface from solar energy and rain drop effects, thereby increasing buffering capacity, and reduces evapotranspiration (Brady and Weil, 2002). It is a reservoir for various essential elements, a source of cation exchange capacity and soil buffering, and is a large geochemical reservoir of carbon (Bohn *et al*., 2001).

Although, the effects of organic and inorganic fertilizer on some cereal crop production and yield has been well established, changes that occur in the soil chemistry as a result of application of these inputs either singly or in combination on the soils of Northern Nigerian savanna have not been studied in detail. Also, study on the chemistry of the different soil organic matter fractions is scanty.

The objective of the study is to comparatively determine the effectiveness of Cow dung and Poultry droppings with or without Mineral fertilizer in ameliorating some chemical properties of the soil of the study area.

MATERIALS AND METHODS

Field trials were conducted during the two successive rainy seasons at the Teaching and Research Farm of the Department of Soil Science, University of Maiduguri (11°53'N; 13°16'E), on the northern fringes of the Sudan savanna belt of Nigeria. This belt forms part of the semi-arid zone. It is characterized by a short rainy season of 100 – 150 days with a long dry season of at least 7 months, and a mean annual rainfall of about 500 mm (Yunusa and Ikwelle, 1990). The treatments were cow dung and Poultry droppings applied at 5.0 tons/ha each combined with four levels mineral fertilizer ($N_0P_0K_0$, $N_{45}P_{30}K_{30}$, $N_{60}P_{30}K_{30}$ and $N_{90}P_{30}K_{30}$). The experiment was laid out in a randomized Complete Block Design (RCBD) with nine (9) treatments replicated three times giving a total of 27 plots.

The nitrogen fertilizer used was NPK 15-15-15 (standard) supplemented by urea (46% N). Cow dung (CD) was collected from the animal farm of the Borno College of Agriculture, Maiduguri, while poultry dropping (PD) was collected from the Poultry Production Unit (PPU) of the Borno State Ministry of Agriculture, Maiduguri. A certified seed was used and planted in holes about 3 cm deep around second week of July each year. Seedlings were thinned to two plants per stand at about 2 weeks after sowing (WAS). The composite soil samples were collected before planting and after harvest and were analyzed for physical and chemical properties of the soil following discrete procedures.

Five randomly selected plants in each net plot were measured. The cobs harvested from the net plots were sun-dried, threshed using mortar and pestle and then winnowed. Grains were weighed with a physical balance on the farm after sun drying and the grain yield expressed in kg/ha. All data collected from the yield were subjected to analysis of variance (ANOVA) using Statistix 8.0 statistical package. The differences between means were tested with Duncan's Multiple Range Test (DMRT) (Duncan, 1955) at 5% level of probability.

RESULTS AND DISCUSSION

Effects of Cow dung and Poultry dropping with and without Mineral Fertilizer on Selected Soil Chemical Properties

There was significant decrease in soil pH as poultry droppings was applied both singly and in combination with mineral fertilizer in both first and second year and in the combined analysis. The pH value was lowest at 90 kg N/ha in combination with 5.0 tons/ha of poultry droppings.

There was a significant increase in ECEC with addition of both cow dung and poultry dropping in the first and second and in the combined analysis. The ECEC was significantly highest in soil treated with cow dung applied at 5.0 tons/ha in the second year (14.09 cmol/kg). The ECEC was least in soil applied with poultry dropping in the first year (5.73 cmol/kg), the second year (8.46 cmol/kg). Cow dung at 5.0 tons/ha combined with 90 kg N/ha of mineral fertilizer had significantly highest amount of ECEC in the second year and in the combined. Application of mineral fertilizer in combination with poultry droppings also showed increasing effect. This was in line with the results of Jones and Wild (1975), Bhardwal and Patil (1982) and Rayar (2000). Rayar (2000), in particular observed that organic manures and their fractions reduce acidification of the soil that comes from continued cropping especially where ammonium fertilizers are often used. This may be due to large base content (Ca, Mg, K, and Na) of the manures. Bhardwal and Patil (1982), earlier, reported that increase in soil organic matter content due to organic manuring raised the CEC of the soil.

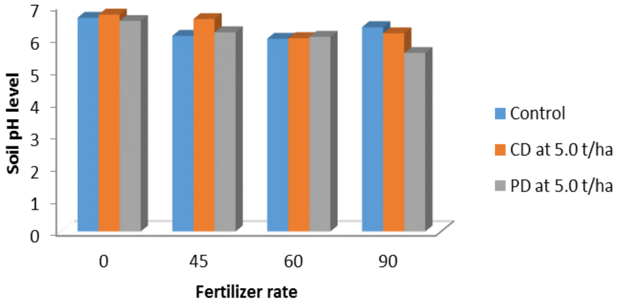


Fig. 1: Effect of cow dung and poultry dropping with and without Mineral Fertilizer on soil pH (1:2.5H_2O).

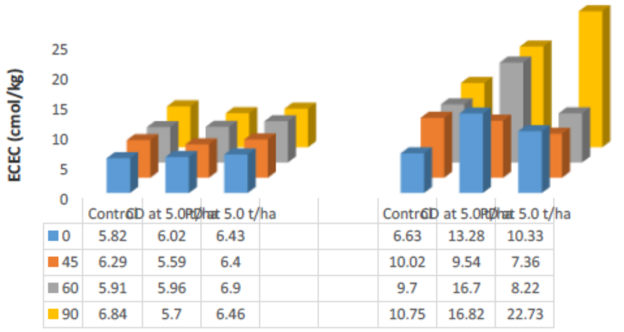


Fig. 2: Effect of cow dung and poultry droppings with and without Mineral Fertilizer on ECEC in the fist and second year experiments.

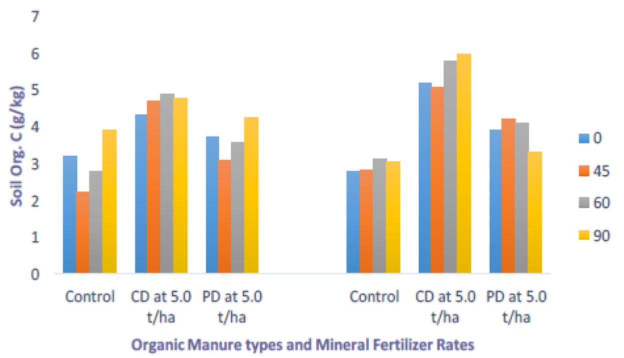


Fig 3: Effects of Cow dung and Poultry droppings with and without Mineral Fertilizer on Soil Org. Carbon.

Table 1: Physical and chemical Properties of the Soil of the study area

Soil characteristics	Value
pH (1:2.5 H_2O)	6.20
EC (dS/m)	0.01
CEC (Cmol/kg)	4.46
Exch. Acidity (H^+ + Al^{3+}cmol/kg)	0.20
ECEC (cmol/kg)	4.66
Organic carbon (g/kg)	19.0
Total Nitrogen (g/kg)	1.0
C : N Ratio	19.0
Available Phosphorus (Bray-1 P mg/kg)	2.80
Exchangeable Potassium (cmol/kg)	0.24
Humin (g/kg)	983.14
Humic Acid (g/kg)	7.58
Fulvic Acid (g/kg)	56.94
Percentage Sand (g/kg)	762.0
Percentage Silt (g/kg)	116.0
Percentage Clay (g/kg)	122.0
Textural class	Sandy loam

The two types of organic manure used had significant effects on the soil organic carbon content. Cow dung in particular significantly increased organic carbon content in the first and second year of experiment and in the combined analysis. Cow dung application in combination with mineral fertilizer significantly increased soil organic carbon content in the first and second year and in the combined analysis. The content of organic carbon increased progressively as the rates of fertilizer combination increased. Poultry dropping in combination with mineral fertilizer shows a decreasing effect in the first year, but an increasing effect in the second year. Bhardwal and Patil (1982) also showed that increase in organic manures application increases the content of organic carbon and organic matter in the soil.

There was a significant effect of organic manure on soil total nitrogen content. The content of total nitrogen was highest in soils treated with 5.0 tons/ha of poultry droppings in the first (2.96 g/kg), and second year (4.01 g/kg). Both cow dung and poultry droppings in combination with mineral fertilizer significantly increased total nitrogen contents in all the analyses. The N content continued to increase as the N fertilizer with their combinations increased. Organic manure types and their different rates had significant effect on total nitrogen in the first and second year, showing that organic manure increased total nitrogen content in the soil. High content of nitrogen in soils supplied with poultry droppings showed that poultry manure adds more nitrogen to the soil than other organic materials. Delin (2011) reported that poultry manures differ from that of mammals because of its content of uric acid which is rapidly converted to ammonium (NH_4^+) and therefore has a higher fertilizer value than other organic nitrogen in manure. Shukla (1990) also found that addition of organic materials to the soil of the savanna reduces K fixation but enhances N-fixation thus increasing nitrogen content of the soil. Awotundun *et al.* (2005) also observed that organic colloid which is the product of organic matter decomposition releases and supplies most of the important plant nutrients especially N, P and S. Awotundun *et al.* (2005) concluded that the value of organic manure added to the soil is greater than can be assessed by the consideration of its content as plant nutrients. Awotundun *et al*. (2005) similarly observed that both organic and nitrogen fertilizers combination provide the needed nutrients for plant. Awoduni and Olafusi (2007) also conclusively stated that combined application of organic manure especially FYM and nitrogen fertilizer particularly urea at sub-optimal rates ensured more availability of macronutrients in the soil.

Carbon: Nitrogen (C: N ratio) was another very important soil property that was influenced by the addition of cow dung and poultry dropping**.** Cow dung in particular, had increasing effect on the C: N ratio in both years. The C: N ratio increased significantly with increase in the application of the two organic manures. Poultry droppings on the other hand significantly decreased C: N ratio in the first and second year and in the combined analysis. Poultry dropping in combination with mineral fertilizer also significantly decreased C: N ratio in all the analyses. The ratio was lower in soils treated with 90 kg N/ha in combination with 5.0 tons/ha poultry droppings in

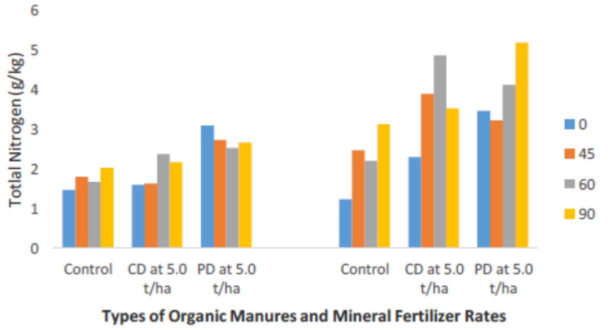
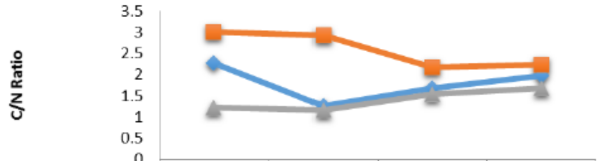
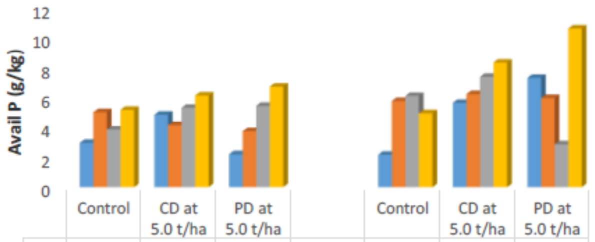


Fig 4: Effects of Cow dung and Poultry droppings with and without Mineral Fertilizer on Total Nitrogen.



	0	45	60	90
Control	2.27	1.27	1.67	1.97
CD at 5.0 t/ha	3	2.93	2.17	2.23
PD at 5.0 t/ha	1.23	1.17	1.53	1.67

Fig. 5: Effects of cow dung and poultry droppings with and without Mineral Fertilizer C/N ratio in the first year.



	Control	CD at 5.0 t/ha	PD at 5.0 t/ha		Control	CD at 5.0 t/ha	PD at 5.0 t/ha
0	3	4.9	2.23		2.2	5.7	7.4
45	5.07	4.2	3.79		5.83	6.3	6.03
60	3.9	5.37	5.5		6.17	7.47	2.9
90	5.23	6.2	6.8		5	8.43	10.73

Fig 6: Effects of Cow dung and Poultry droppings with and without Mineral Fertilizer on Available P (g/kg).

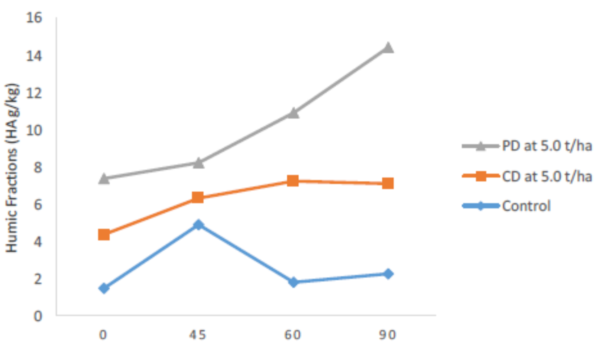


Fig 7: Effects of Cow dung and Poultry droppings with and without Mineral Fertilizer on Humic acid Content in the Second year.

the second year (0.67). Organic manure types had significant effect on the C: N ratio. The ratio increased with addition of organic manure especially in the first year. This showed that nitrogen fertilizer in combination with organic manure narrowed the C: N ratio of the soil as a result of their effect on organic matter decomposition through their effect on the population and activities of microorganism in the soil.

Organic manure types had significant effect in the content of available P in the soils in both years and in the combined analysis. Both cow dung and poultry droppings gave significant increase in available P in the first and second year of experiment. The P content continued to increase with increase in the rate of application of the manures. Combination of poultry droppings with mineral nitrogen fertilizer significantly increased the available P content in the first and second year and the combined analysis. Nitrogen fertilizer at 90 kg N/ha in combination with 5.0 tons/ha of cow dung had the highest content of available P in the first (6.20 mg/kg), and second year (8.43 mg/kg). Similar trend was also found between nitrogen (90 kg N/ha) combined with 5.0 tons/ha poultry droppings. Generally, P content was higher in the soils in the second year than in the first year irrespective of the treatment. This was in line with the findings of Awotundun*et al.* (2007) which indicated that application of organic manures in form of animal dung and poultry droppings increase availability of phosphorus in the soil solution and reduce phosphate adsorption.

The exchangeable K was significantly affected by organic manure types. Both cow dung and poultry dropping had significant decreasing effect on exchangeable K content in the first and second year of experiment and the combined. Mineral nitrogen fertilizer in combination with cow dung had significant effect on exchangeable K content in both years of experiment and the combined. However, the trend was not regular. Similar to that of cow dung, nitrogen fertilizer in combination with poultry dropping had significant effect on K content in the first and second year. All the three organic matter fractions (HN, HA and FA) were significantly affected by the organic manure types. Poultry droppings increased HA and FA contents but had a decreasing effect on HN content. Humic acid (3.65 g/kg) and FA (52.05 g/kg) contents were highest in soils treated with 5.0 tons/ha of poultry dropping while it had the lowest content of HN (885.9 g/kg). Soils treated with 60 kg N/ha in combination with 5.0 tons/ha of cow dung had the highest content of HA (5.44 g/kg). Highest content of HA was recorded in soil treated with 90 kg N/ha in combination with 5.0 tons/ha of poultry droppings. In a similar way, organic manure types and their rates significantly affected the fractions of organic matter. The content of fulvic acid was highest in soils treated with poultry droppings. This might be due to the fact that poultry dropping contained more nitrogen than the other manures. Generally, irrespective of treatment factor or rate of application, fulvic acid was higher in all the soils than humic acid fraction. This was in line with the report of Krieger (1975), which indicated greater quantities of fulvic acid than humic acid fraction and attributed possibly to the greater percentage of nitrogen (protein) in fulvic acid than in humic acid, while carbon was higher in humic acid than in fulvic acid. Bohn *et al* (2001) reported that the low molecular weight fulvic acid have higher oxygen content and low carbon content than the higher molecular weight humic acid. This is responsible for the higher solubility of the former.

Table 2: Some Chemical Characteristics of the Different Organic Manures used

Sample	pH (1:2.5 H_2O)	Org. C (%)	N (%)	C: N Ratio	P (g/ kg)	K (g/kg)	HN (g/kg)	HA (g/kg)	FA (g/kg)
Cow dung (CD)	7.31	14.63	0.39	37.52	2.9	19.7	883.19	15.77	83.03
Poultry droppings (PD)	6.85	11.31	0.45	26.13	0.5	5.7	773.47	11.17	93.05

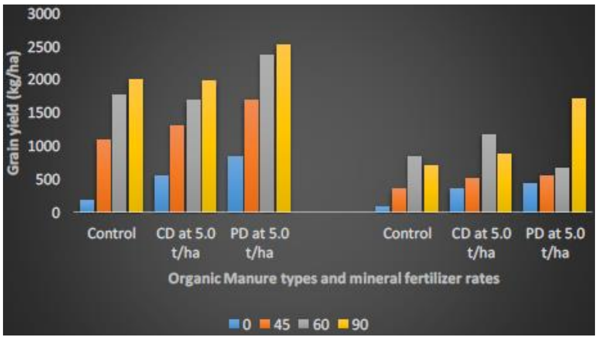


Fig 8: Effects of Cow dung and Poultry dropping with and without Mineral Fertilizer on Grain Yield (kg/ha) in the First and Second Year

Organic manure types had significant effect on grain yield of maize in the first and second year and in the combined analysis. There was a significant increase in grain yield with the application of both cow dung and poultry droppings. Cow dung significantly increased the grain yield. However, in the first year the yield was higher than in the second year of experiment. But grain yield was significantly highest in all the soils supplied with poultry dropping. Irrespective of organic manure type or their application rates, grain yields were generally higher in the first year than in second cropping season. High yield in the soils treated with poultry droppings might be attributed to the fact that poultry manure contained higher content of N than the other manures. According to Awotundun (2005) maize requires heavy fertilizer N application for optimum yield. This was similar with the reports of FPDD (2002) and Kwari and Bibinu (2002), which recommended that five tons per hectare (5.0 t/ha) of cow dung annually will maintain yield of maize under continuous cultivation.

Conclusion

Poultry manure (5.0 tons/ha) in combination of mineral nitrogen fertilizer (90 kg/ha) significantly increased total N and P but reduced soil pH thereby inducing soil acidification. Grain yield significantly increased with the application nitrogen fertilizer (90 kg N/ha) in combination with cow dung and poultry droppings at the rate of 5.0 tons/ha. It could be concluded, therefore, that cow dung (5.0 tons/ha) could be regarded as best among the three organic manures used in respect of stabilizing soil pH and improved soil chemical properties especially when combined with 90 kg N/ha of nitrogen fertilizer.

Recommendation

From the findings of this study, the following recommendations were proposed;

1. For improving the chemical properties of the soil, cow dung at the rate of 5.0 tons/ha was regarded best and to be applied with optimal rate of nitrogen fertilizer (60 or 90 kg/ha).
2. Nitrogen fertilizer rate of 60 or 90 kg/ha in combination with poultry manure or cow dung (5.0tons/ha) will give optimum yield of maize on the savanna soils.

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