Combined Effect of Cattle Dung and Urea Fertilizer on Organic Carbon, Forms of Nitrogen and Available Phosphorus in Selected Nigerian Soils

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ABSTRACT

Incubation experiment was conducted on four soil types in Nigeria using cattle dung (CD) at the rate of 2.5g/kg soil (5 t ha^{-1}), Urea fertilizer at the rate of 0.1g/kg soil (200 kg ha^{-1}) and cattle dung (2.5g/kg soil) combined with Urea 0.05g/kg soil (100 kg ha^{-1}) as treatments. The objective of the experiment was to compare the rate of OC, NH_4 – N, NO_3 – N and available P release on soils selected from different agro ecological zones of Nigeria. Ten soil samples were collected and bulked from each of the sandy clay, sandy loam, sandy clay loam and loamy sand soils from three different locations within each soil type. The soils were arranged on completely randomized design in laboratory for 60 days. All the treatments reacted differently in each of the soil type in relation to OC, total N, NH_4 – N, NO_3 – N and available P. In sandy clay and sandy loam soils, all the treatments significantly increased ($p < 0.05$) OC, total N, NH_4 – N, NO_3 – N and available P except OC in sandy loam compared with control. In sandy clay loam and loamy sand soils, all the treatments significantly increased ($p < 0.05$) NH_4 – N, NO_3 – N and available P. Among all the treatments, CD had the highest OC in all the soil textural classes,, urea had the highest NH4-N and NO_3-N while CD + urea had the highest available P (except sandy clay). Cow dung had the highest P in sandy clay. Sand loam and sandy clay loam had highest total N but urea recorded highest value of N in sandy clay while urea+CD mineralized equal amount of total N

Keywords : Ammonium nitrog en, nitrate-nitrog en, mineralization, nitrification and C/N ratio

INTRODUCTION

Nitrogen (N) and Phosphorus (P) are the two most deficient nutrient elements in most Nigerian soils (Obigbesan, 1999). Plants can either absorb N in form of NH_4 – N or NO_3 – N depending on the one available and the type of crop while Phosphorus can be absorbed by plants in form of Phosphate.

Due to the extinction of bush shifting cultivation and short term bush fallow, Nigerian soils loose organic matter (Mba 2006) fast .This needs urgent attention if adequate food supply is to be achieved to feed the teeming population. Farming is Nigerian economic mainstay. Definitely, Nigerian must revamp farming industry in order to develop along the global economic trend. One of the major ways is the improvement of the fertility status of the available soils coupled with the maintenance of soil organic matter content. Nitrogen and available phosphorus are the most deficient plant nutrient elements in Nigeria.

Among the farming practices for soil fertility management in Nigeria, the use of mineral fertilizers and organic manures are widely accepted among the farmers. The commonest mineral fertilizers in use are NPK fertilizers in different formulations, ammonium nitrate, urea and phosphatic fertilizers. Among these fertilizers, urea has the highest N content (43 – 45%) but it is deficient in P, K, Ca, Mg and useful micronutrients and cannot sustain OM. In fact; no any mineral fertilizer can supply all the essential nutrients and conditions required for optimum crop production. Also, the fragility or Kaolinitic nature of the soils, excessive rainfall in the south and excessive sunshine in the northern part of the country does not allow one time application of large amount of fertilizer except split application. Split application of fertilizers is labour intensive since farmers have to apply fertilizers in stages.

Among the commonest organic manures in use in fertility management of soils in Nigeria are poultry manure, cattle dung, swine dung and goat dung. The use of cattle dung by farmers cuts across the country. Researches have shown the usefulness of organic manures in revamping impoverished soils. Apart from supply of major and micro nutrients, it provides favourable conditions for the growth of crops and maintains soil organic matter. The sole use of organic manures as sources of soil improvement is hindered by its bulkiness, low nutrients quality and low mineralization (Ogunlade et al, 2006). Many Researchers have found the integrated soil nutrition management as more feasible in maintaining nutrients status as well as crop production than single application of mineral or organic fertilizers. Ayeni (2010) advocated for the use of combined organic waste and mineral fertilizers.

The objective of this study was to compare the effect of combined cow dung and urea fertilizer on organic carbon (C), N, NH_4 – N, NO_3 – N and available P on selected soils of Nigeria.

MATERIALS AND METHODS.

Site Selection and Description

Soil samples of different textural classes were collected from different farmers field in four ecological zones of Nigeria for the conduct of the experiment. The ecological zones were (i) mangrove forest (ii) forest derived savanna (iii) southern guinea savannah (iv) Sudan savannah.

The sites were selected based on the farming history pattern of the lands. Though different crops were planted, the soils were under cultivation for at least 6 years with high rate of nutrient mining as shown by the secondary weeds dominating the sites.

Four locations were used in each ecological zone with about 20km apart within each zone but the selected ecological zones were far from one another. The nearest towns to which the soils were collected include Lagos in mangrove forest, Ipe Akoko located in derived savanna, Lokoja located in southern guinea savanna and Katsina located in Sudan savannah. .

Collection of Soil Samples

Ten soil samples were collected from each site of the four agro – ecological zones. The soils were sampled with auger, bulked, tagged and transferred to SMO laboratory at Ibadan, South west Nigeria for laboratory study.

Each bulked soil sample used for analysis was separated by triangulation method. The soils were air dried and seived with 2cm mesh in order to remove pebbles and stubs. The incubated soil samples were not passed through 2mm mesh in order to maintain the natural conditions of the soils.

Incubation Study

The treatments were incubated with cattle dung, urea and cattle dung combined with urea fertilizer for 60 days. Incubation of the treatments for 60 days was based on the premise that most arable crops initiate their reproductive cycle within this period. There were four treatments in each of the four ecological zones and the treatments were replicated three times.

Fresh cattle dung was collected from abattoir and applied the fourth day without going through much decomposition. Forty eight small plastic containers were filled with 1kg soil. 0.1g of urea fertilizer was added to each twelve soil samples to represent 200 kg $ha^{-1,}$ while 2.5g of cattle dung to represent 5t ha^{-1} was added to twelve soil samples. 0.05g (100 kg ha^{-1}) of urea fertilizer was also combined with 2.5g $k^{-1}g$ of cattle dung in twelve soil samples. The remaining twelve samples without treatments served as control experiment. The treatments were labeled and moistened with equal amount of water. The containers were covered with wet foam to allow exchange of air but to prevent the soils from drying.

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The soil samples were placed in the air dried room with temperature 27 – 30^{0}C. Thermometer was hung on the wall of the incubation room to read the room temperature and water was added to each sample to field capacity.

Soil Analysis

Soil separates of each soil from the sampled areas were determined before the conduct of the experiment using Bouyoucous method. Organic carbon, total N, NO_3^-N, NH_4 – N and available P were determined after 60 days of incubation. The incubated soils were air dried and sieved through 2mm wire mesh. Organic carbon was determined by the Walkely and Black (1934) chromic acid digestion method. Total N by Kjehdahl method, NH_4-N and NO_3-N by steam distillation technique of Bremner and Keeney of 1966. Available P was extracted using bray 1 method.

Analysis of fresh cattle dung

The cattle dung was air dried and crushed with hammer mill. The same methods used in analyzing the organic carbon (OC), P and total N were used to analyze OC ,P and total N in fresh cattle dung.

Statistical Analysis

Analysis of variance was performed on the data collected and the means were separated by Tukey s - b.

RESULT

The textural properties of the soil samples collected from Lagos showed that the soil contained 558mg kg^{-1} sad, 146g kg^{-1} silt and 296g kg^{-1} clay and classified as sandy clay. The soil sample collected from Ipe contains 778mg kg^{-1} sand, 166mg kg^{-1} silt and 56mg kg^{-1} clay thus it is classified sandy loam. Lokoja soil sample is sandy clay loam with 658 mg kg^{-1} sand, 206 mg kg^{-1} silt and 136 mg kg^{-1} clay. The soils sample collected from Katsina is loamy sand with 838 mg kg^{-1} sand, 66 mg kg^{-1} silt and 76mg kg^{-1} clay. The room temperature ranged between 28 – 30^{o}C during the incubation period. Table 1 showed the effect of cow dun g, urea fertilizer and their combination on soil pH. Compared with control, all the treatments significantly increased soil pH in sandy clay (except CD Mg ha-^{1}) and only CD+100kg ha-^{1} Urea significantly increased soil pH in loamy sand while there were no significant differences among the treatments in sandy clay loam and sandy loam soils.

Table 1 : Effect of cattle dung, urea fertilizer and combination on soil pH in different soil types of selected from agro-ecological zones of Nigeria

Treatment	sandy clay	loamy sand	sandy clay loam	sandy loam
0	6.4	6.1	6.4	5.9
CD 5Mg ha^{-1}	6.8	6	6.9	6
Urea (200 kg ha^{-1})	6.7	6.3	6.8	6.2
CD+100 kg ha^{-1}urea	7.1	6.9	6.4	6.4
lsd 0.05	0.3	0.2	0.27	NS

Fresh cattle dung used for the conduct of the experiment contained 1.47% OC, 0.02% total N, 1.2% phosphorus and 16 C/N.

Sandy clay

Table 2 showed the influence of cattle dung, urea fertilizer and cattle dung combined with urea fertilizer on OC, forms of N and available phosphorus on soils collected from mangrove forest

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(Lagos) of Nigeria. There was significant difference ($P < 0.05$) among the treatments in relation to OC. Cattle dung applied at 5 t ha^{-1} had highest OC followed by urea combined cattle dung when compared with control. Total N was increased by 40% with the application of 5 t ha^{-1} cattle dung while fertilizer combined with cattle dung increased b 60%. Ammonium nitrogen significantly increased ($P < 0.05$) in all the treatments compared with control. Urea fertilizer at 200 kg ha^{-1} recorded the highest NH_4N followed by 5 t ha^{-1} cattle dung applied alone and cattle dung + urea fertilizer. In NO_3 – N release, 200 kg ha^{-1} urea had the highest value followed by urea fertilizer combined with cattle dung and 5 Mg ha^{-1} cattle dung applied alone. There was no significant difference ($P < 0.05$) between 5 t ha^{-1} cattle dung and control in releasing NO_3 – N in sand clay soil. Available P was highest in the soil samples treated with cattle dung combined with urea fertilizer followed by single application of urea fertilizer and cattle dung.

Table 2: Effect of cattle dung, urea fertilizer and cattle dung combined with urea fertilizer on OC, total N, NO_3 – N, NH_4 – N and available P in sandy clay soil

Treatment	OC	Total N	NH_4 – N	NO_3 – N	P	C/N
	%		Mg kg^{-1}			
0	0.66	0.05	22.02	6.23	22.10	13
5t ha^{-1}CD	1.08	0.07	64.44	8.36	41.55	16
200 kg ha^{-1}urea	1.02	0.09	78.00	12.34	28.45	11
100 kgha^{-1}urea+CD	1. 03	0.08	30.12	10.74	31.70	13
LSD (0.05)	0.22	0.02	5.33	3.67	6.63	__

Sandy Loam

Table 3 showed the effect of cattle dung, urea fertilizer and cattle dung combined with urea fertilizer on OC, total N, NO_3 – N, NH_4 – N and available P in sand loam soil samples collected from derived savannah zone of Nigeria. There were no significant differences among the treatments in relation to OC as occurred in sandy clay soil. On total N, cattle dung increased it by 80% but both urea fertilizers and cattle dung combined with urea fertilizer increased total N at the same rate of 20%.

Urea fertilizer individually applied had the highest NH_4 – N followed by cattle dung combined with urea, cattle dung applied alone and control. The trend of NO_3 – N mineralization was in the order of Urea alone > cattle dung + urea > cattle dung alone > control. Cattle dung combined with urea fertilizer recorded the highest available P. Compared with control, all the treatments significantly increased ($P < 0.05$) available P in sand loam soil.

Table 3: Effect of cattle dung, urea fertilizer and cattle dung combined with urea fertilizer on OC, total N, NH_4 – N, NO_3 – N and available P in sand loam so il

Treatment	OC	Total N	NH_4 – N	NO_3 – N	AV.P	C/N
	%		mg kg^{-1}			
0	0.70	0.05	33.43	7.03	7.06	14
CD 5t ha^{-1}	0.99	0.09	91.52	10.65	10.65	11
Urea (200Kgha^{-1})	0.72	0.06	194.72	21.55	20.15	12
CD+100Kgha^{-1}urea	0.63	0.06	132.08	19.35	50.30	11

LSD (0.05)	NS	0.02	5.22	2.00	4.50	__

Sandy Clay Loam

The soil samples treated with cattle dung, urea fertilizer and cattle dung combined with urea fertilizer in sandy clay loam collected from southern guinea savannah zone of Nigeria had effect on OC, total N, NH_4 – N, NO_3 – N and available P (Table 4). There were no significant differences ($P < 0.05$) among the treatments in relation to OC. Urea fertilizer applied alone had the highest increase in total N and was increased by 50%. There was no difference in the rate of mineralization of total N with application of cattle dung alone and cattle dung combined with urea fertilizers. Both cattle dung applied alone and cattle dung fortified with urea fertilizer had 33% increases in total N when compared with control. Cow dung applied alone had the highest available P followed by urea fertilizer applied alone and cattle dung mixed with urea fertilizer while the control experiment recorded the lowest available P.

Table 4: Effect of cattle dung, urea fertilizer and cattle dung combined with urea fertilizer on OC, total N, NH_4 – N, NO_3 – N and available P in sandy clay loam

Treatment	OC	Total N	NH_4 – N	NO_3 – N	AV.P	C/N
	%		Mg kg^{-1}			
0	0.70	0.05	33.43	7.03	7.06	14
CD 5 t ha^{-1}	0.99	0.09	91.52	10.65	10.65	11
Urea (200$Kgha^{-1}$)	0.72	0.06	194.72	21.55	20.15	12
CD+100$Kgha^{-1}$urea	0.63	0.06	132.08	19.35	50.30	11
LSD (0.05)	NS	0.02	5.22	2.00	4.50	__

Loamy sand

There was no significant difference (0.05) in OC among the soil samples treated with cattle during applied alone, urea fertilizer applied alone and urea fertilizer combined with cattle during (Table 5). Both cattle during and urea fertilizer released equal amount of total N and the increase was 20%.

Urea fertilizer singly applied had the highest increase in both NH_4 – N and NO_3 – N followed by cattle dung combined with urea fertilizer when compared with control. All the treatments significantly increased available P. Cattle during combined with urea fertilizer had the highest available P while the control experiment had the least available P. The order of increase in value of available P were cattle during + urea> urea > cattle dung> control.

Table 5: Effect of cattle dung, urea fertilizer and cattle dung combined with urea fertilizer on OC, total N, NH_4 – N, NO_3 – N and available P in loamy sand

Treatment	OC	Total N	NH_4 – N	NO_3 – N	AV.P	C/N
	------%----------		------------- mg kg-1---------			
0	0.65	0.05	16	3	3.36	13
5t ha-^{1} CD	0.66	0.05	16.76	3.86	15.85	13
Urea (200kgha-^{1})	0.49	0.06	88.96	7.69	10.15	8
CD+ Urea 100kgha-^{1}	0.64	0.06	45.47	7.66	33.45	11

LSD(0.05)	NS	NS	4.47	2.66	6.63	-

DISCUSSION

Presence of N and P in cattle dung was expected to affect the rate of OC, N and P mineralization in this experiment. Also, the differences in textural classes of the soils were also expected to affect nutrient mineralization. Presence of N and P in cattle dung and N in urea fertilizer might have led to the increase in OC, total N, NH_4- N, NO_3- N and available P. The pH condition of the fertilized soil samples is adequate for optimum mineralization of N and P. The parameters observed in this experiment reacted differently in all the soil types. For example, application of 5 t ha^{-1} cattle dung led to increase in total N by 40% in sandy clay 80% in sand loam, 33% sandy clay loam and 20% loamy sand. The rate of OC, NH_4 – N, NO_3- N and available P also differ in all the treatments. The differences in the rate of mineralization in total N could not be assumed to be due to differences in environmental state of the ecological zones from which these soil samples were collected because all the treatments and the soil samples were subjected to the same conditions but it could be due to differences in their textural classes (Ayeni,2010). Different soil textures might result in different microbial activities, pH buffering capacity, infiltration rate and accretion.

It was noted that urea fertilizer applied alone released the highest amount of NH4-N and lowest C/N in all the soil types. This might be due to minimum denitrification, volatilization and immobilization of NH_4-N (Samuel et al .2003) Urea fertilizer also released the highest amount of NO_3 – N in all the soil types. This might be as a result of faster nitrification of NH_4 – N to NO_3 – N by nitrifying bacterial. Ayeni and Adeleye (2011) and Ayeni (2011) obtained similar result in the experiment conducted on rate of nutrient release as influenced by organic wastes. Curtis et al (1991) opined that volatilization of Urea depends on the soil pH and temperature of 45^0C above. The temperature under which this experiment was conducted was lower than 45^0C hence; high presence of forms of N in the soil samples fertilized with urea. The very low C/N might also have enhanced N mineralization. In this experiment, sandy clay and sandy clay loam seemed to share the same characteristics in relation to NH_4 – N and NO_3 – N while sandy loam and loamy sand followed the same trend.

Increase in NH_4 – N in sandy clay and sandy clay loam led to a corresponding decrease in NO_3 – N. The decrease might not only be caused by C/N because the C/N ratios in all the soils and the cattle dung were low but might be as a result of lower temperature below the critical level and high moisture. Contrary, in sandy loam and loamy sand there was corresponding increase in NO_3 – N as NH_4 – N was increasing in the soil samples amended with cattle dung alone. This clearly shows that other factors apart from C/N ratio caused the differences in the rate of nutrient release in these soils. During the incubation period, it was observed that sandy clay and sandy clay loam absorbed more water than sandy loam and loamy sand. This shows similarities in the characteristics of the soils that belong nearly to the same textural class; and the dissimilarities in the properties of the soils that belong to different textural class. Agbede (1984) reported variation in N mineralization due to variation in soil moisture content of some Nigerian soils.

The same trend of mineralization as occurred in N was recorded for P. Sand clay and sandy clay loam responded to cattle dung applied alone in term of P release while cattle dung combined with Urea recorded highest amount of P in sandy loam and loamy sand. The increase might be as a result of P available in cattle dung together with the native organic P already present in the soils. Urea fertilizer had no P in its formulation yet the soil samples fertilized with it were high in available P combined with control and even with combined cattle dung and urea fertilizer. The treatments applied i.e. urea and cattle dung might have provided favourable condition for phosphatase enzymes in the mineralization of P in the soil. The increase in available P in soil samples fertilized with Urea substantiated the assertion that the P mineralized was not totally from the cattle dung. Samuel et al. (2003) emphasized that P availability is strongly correlated with OC. Presence of OC in the soils fertilized with urea might also enhance P mineralization.

In all the soil samples, all the treatments released adequate P (Obighesan, 1999) but the treatments were not sufficient to raise the total N and NO_3 – N to the critical level needed for optimum production of arable crops in Nigeria; thus; there is need to raise the treatments rates. There might not be sufficient time for cattle dung to mineralize the total N and P present in it as it was not allowed to decompose before application.

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CONCLUSION

This experiment showed that different soil types reacted differently to application of organic manure, mineral fertilizer and their combination. Generally, urea fertilizer, cattle dung and cattle dung + urea increased forms of N and available P.

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