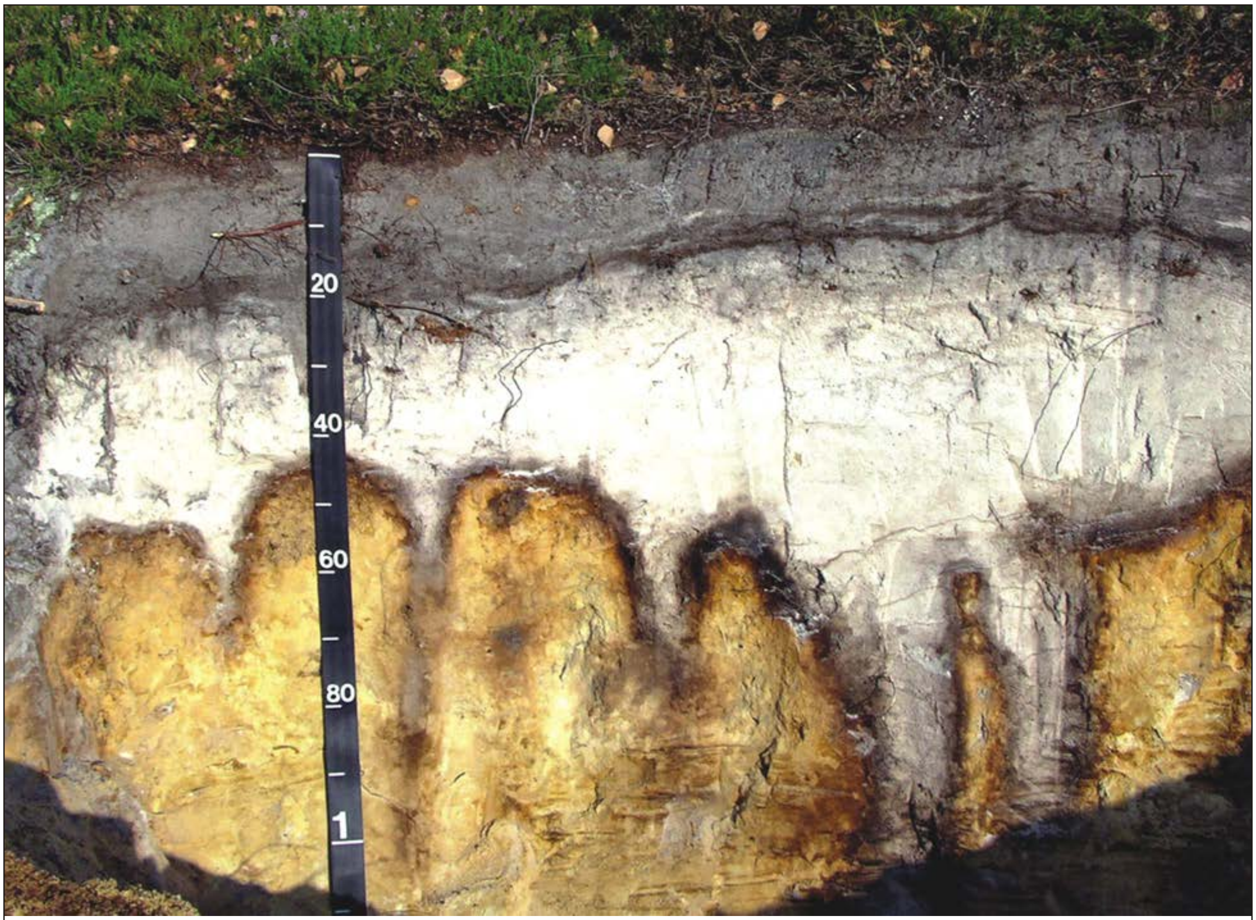

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Effect of Cattle Dung and Urea Fertilizer on pH and Cations of Soils Selected from Agro-ecological Zones of Nigeria

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ABSTRACT

Laboratory incubation study gives insight to the condition of the field when treatment is applied. In order to determine the effect of cattle dung combined with urea fertilizer on soil pH and cations on soils from selected agro-ecological zones of Nigeria, an incubation study was carried out on four treatments in each of the agro-ecological zone. Soil samples were collected from Lagos (Mangrove forest), lpe Akoko (forest derived savanna), Lokoja (Southern Guinea savanna) and Katsina (Sudan savanna). Cattle dung was applied at the rate of 1.25 and 500 g soil to represent 5 t ha^{-1} and 0.05 and 500 g soil to represent 200 kg ha^{-1} urea fertilizer. Urea fertilizer was either applied singly or combined to give four (4) treatments in each of the agro ecological zone. The treatments were replicated three times and were arranged on Completely Randomized Design. Compared with control, cattle dung applied alone and cattle dung combined with urea fertilizer significantly increased ($p<0.05$) soil pH but at different level of increment in Lagos, Lokoja and Katsina while there were decreases in soil Al^{3+}+H^+ from all the ecological zones. The treatments had no significant effect on Al^{3+}+H^+ in the soil sample collected from Ipe Akoko. Soil types react to application of cattle dung and its combination with urea fertilizer in different ways in Nigeria.

Key words: Incubation, mangrove forest, derived savanna, Guinea savanna, Sudan savanna soils

INTRODUCTION

Several workers (Ojeniyi, 1995; Nnadi and Arora, 1985) have observed that continuous application of mineral fertilizers especially urea and ammonium sulphate fertilizers increase soil acidity in Nigeria. Soil acidity is one of the major constraints affecting soil productivity. Many soil fertility researchers are still of the opinion that mineral fertilizers cannot be totally replaced with organic manures contrary to what organic farmers advocate. According to Omoti *et al.* (1991), about 60% of incremental food out put achieved in Nigeria in the recent past is attributable to use of fertilizers introduced into the farming systems. Thus, fertilizers have had a very significant impact in crop production in Nigeria, to the extent that in some parts of the country, crop production is not possible without the use of inorganic fertilizers. There is need to produce food that can feed the teeming population. Urea fertilizer releases nitrogen (N) for crop use on time so its use as N fertilizer cannot be under estimated if sustenance in crop production is to be achieved (Babalola *et al.*, 2012).

Many conventional forms of nitrogenous fertilizers depress soil pH. However, urea and ammonium fertilizers were identified as one of the strongest acidifiers of them all (Ano, 1990). Continuous use of urea fertilizer result in loss of bases as a result of displacement of the bases by ammonium present in it and consequent release of H^+ ions and finally result in increase in soil acidity. The process of nitrification also increases H^+ ions in the soil which can result in increase in soil acidity. The importance of urea fertilizer in crop production cannot be underestimated. In 1990, worldwide urea fertilizer use was about three times that of ammonium nitrate (Samuel *et al*., 2003). Urea fertilizer has fewer tendencies to stick and cake than ammonium nitrate and less sensitive to fire and it is very easy to handle. Abundance of Al^{3+} and H^+ antagonize Phosphorus (P), Calcium (Ca), Magnesium (Mg) and Potassium (K). Continuous use of urea fertilizer will aggravate the problem of soil acidity.

There is need for material that can counteract the negative effect of mineral fertilizers. Mineral limes are costly and in some cases are not economically advisable in terms of crop production at this period that the prices of agricultural inputs are astronomically increasing (Ayeni and Adeleye, 2011). Whalen *et al*. (2000) opined that animal manure amendments can increase the pH of acidic soils. Increasing the pH of acidic soils improves availability of macronutrients while reducing the solubility of Al^{3+} and Mn^{2+} (Hue and Licudine, 1999). Cattle dung is common in all the ecological zones of Nigeria. Its availability may not be a problem as it is cheap and readily available. The main objective of this study was to determine the effect of cattle dung fertilized with urea on soil pH and cations in the soils collected from different agro-ecological zones of Nigeria.

MATERIALS AND METHODS

Laboratory incubation study was conducted in December, 2010-February, 2011 to determine the liming effect of cattle dung on urea in soils of four agro ecological zones of Nigeria. The selected ecological zones were mangrove forest (Lagos), Derived savanna (Ipe Akoko), southern Guinea savanna (Lokoja) and Sudan savanna (Katsina).

Ten soil samples were randomly collected at about 100 m distant apart in three locations within each ecological zone. The ten soil samples collected from each zone were bulked and air dried. Part of the soil samples were used for routine soil analysis while the remaining were used for the incubation study.

Fresh cattle dung was collected from abattoir in Ondo southwestern Nigeria and stored in the laboratory one week before it was applied as treatment.

0.05 g of urea fertilizer (200 kg ha^{-1}) was either applied to 500 g soil alone or combined with either 1.25 g of cattle dung to represent 5 t ha^{-1}. Five t ha^{-1} of cattle dung was applied to 500 g soil without the addition of urea fertilizer. There was a control experiment without any treatment applied in each of the four soils collected from each zone. The four treatments from each agro-ecological zone were replicated three times.

The soil samples used in the laboratory were only sieved with 2 cm mesh in order to remove the pebbles but not sieved with 2 mm mesh in order to maintain the natural condition of the soils. Fertilized soils were packed in labeled plastic pots, moistened with water to field capacity and covered by wet foam which allowed air exchange but prevented the soils from drying out. They were placed in the dark at the Science Laboratory of Adeyemi College of Education, Ondo, Nigeria for three months. The mean temperature where the experiment was conducted ranged between 29-30°C. The period of three months for the incubation study was purposely selected because most arable crops such as maize, rice, sorghum, tomato, okra and millet are expected to complete their vegetative and reproductive cycles.

Cattle dung was also selected for the experiment because its abundance and uses cuts across all the ecological zones of Nigeria. It has no religious implication or barriers.

Soil samples were analyzed before and after the termination of the experiment. Soil samples were air dried, partially ground and passed through the 2 mm sieve. Soil pH was determined using glass electrode in a soil-water ratio of 1:1 (McLean, 1976).

Organic Carbon (OC) was determined by Walkely-Black wet dichromate oxidation method and the result multiplied by 1.73 on the assumption that there was about 58% burnt of carbon. Exchangeable bases (Ca, Mg and K and Na) were extracted with ammonium acetate (pH 7.0) and determined by atomic absorption spectrophotometer (McLean, 1976). Exchange acidity (Al^{3+}+H^{+}) was determined by KCl extraction method (McLean, 1976). Total exchangeable bases were calculated by summation of basic cations. Available P was extracted with Bray-1-extract and determined by colorimetry (Bray and Kurtz, 1945).

The nutrients composition of cattle dung (%) used for this experiment were 1.19, 0.31, 2.60, 0.56, 0.19, 0.48 and 12.3 for N, P, Ca, Mg, Na, K and OC.

Analysis of cattle dung: Cattle dung was air dried and ground into powdery form. It was thereafter ashed in muffle furnace. Total N was determined by Kjedahl method. For other nutrients, ground samples were subjected to wet digestion using 25-5-5 mL of HNO_3-H_2SO_4-$HClO_4$ (AOAC, 1990). The filtrate was used for nutrients determination as done in routine analysis.

The cattle dung analyzed for its nutrient composition was air dried before analysis.

Statistical analysis: Data collected were subjected to analysis of variance and means were separated by Tukey s-b.

Brief description of sampled areas: Lagos is located in the mangrove forest area of Nigeria with mean annual rainfall between 1.913-2.060 mm annum^{-1}. The rainfall pattern is bimodal. The atmospheric condition is very humid. It is located in longitude 3° 24' and latitude 6° 27'. Humid forest soils belong to ferrasols, nitosols and gleysols according to FAO classification system (Salako, 2003).

Ipe Akoko is located in forest derived savanna with latitude 7° 43' and longitude 5°11'. The atmospheric condition is humid. It has rainfall of about 1.200 mm annum^{-1}. The rainfall pattern is bimodal. The derived savanna soils belong to luvisols, arenosols, acrisols and ferrasols.

Lokoja is located in Central Niger-Benue trough in Southern Guinea savanna with annual rainfall 1.310 mm. The atmospheric condition is sub humid. The rainfall is unimodal. It is located in latitude 7° 49' and Longitude 6° 45'. The soils are mainly Luvisols.

Katsina is situated in Sudan savanna zone (semi arid continental) with average rainfall of 791 mm annum^{-1}. Rainfall is unimodal. Katsina lies in latitude 13° 01'N and longitude 07° 41'E. The soil is mostly regosols characterized by Psamments (Owonubi *et al.*, 1991).

In Nigeria, as one move from the south to the north, the rainfall pattern dwindles while sunshine period and intensity increase.

RESULTS

Table 1 shows the initial soil properties of the soil used to conduct the experiment. The available P of the soil from mangrove forest (Lagos) was adequate while the soils derived from

Table 1: Properties of the soils used for the experiment

Soils properties	Lagos	Ipe-Akoko	Lokoja	Katsina
pH (H_2O)	6.2	5.7	6.2	6.4
Sand (%)	55.8	77.8	65.8	83.8
Silt (%)	14.6	16.6	20.6	6.6
Clay (%)	29.6	5.6	13.6	7.6
OC (%)	1.89	1.19	0.66	0.68
Total N (%)	0.13	0.09	0.06	0.04
Available P (mg kg^{-1})	22.1	7.06	5.57	4.36
Exchangeable bases (cmol kg^{-1})				
K	0.22	0.13	0.11	0.09
Ca	3.40	1.52	3.24	1.36
Mg	0.42	0.49	0.50	0.56
Na	0.39	0.39	0.32	0.43
TEB	4.43	2.53	4.05	2.44
Al^{3+}+H^+	0.30	0.60	0.30	0.50
ECEC	4.73	3.13	4.35	2.94
Ca/Mg	8.09	3.25	6.48	2.43
Ca/K	15.46	11.69	29.46	15.11
K/Mg	1.91	2.65	0.22	1.62

Lagos: Mangrove forest zone Ipe-Akoko: Derived savanna zone, Lokoja: Southern savanna zone, Katsina: Sudan savanna zone

savanna (Ipe-Akoko), southern Guinea savanna (Lokoja) and Sudan savanna (Katsina) were low in available P. Ipe-Akoko and Lokoja soils were both deficient in Ca and K. The textual characteristics indicate that Lagos is sandy clay, Ipe-Akoko is sandy loam, Lokoja is sandy clay loam and Katsina is loamy sand. The soil samples collected from Lagos had highest OC, Ca, TEB, ECEC and Ca/Mg ratio, soil from Ipe had the highest K/Mg with lowest pH and Ca/K while Katsina soil had the highest pH and Na content (Table 1).

Effect of fresh cattle dung on urea fertilizer on soil reactions and nutrients interactions exhibited different characteristics in the soils collected from different ecological zones of Nigeria. Compared with control in the selected zones, all the soil samples treated with 5 t ha^{-1} cattle dung increased soil pH but at different rates of increment (Fig. 1). Compared with control, cattle dung applied without urea fertilizer and cattle dung+urea fertilizer significantly increased soil pH while there was slight reduction in pH level of the soil fertilized with urea alone in the soil samples collected from Lagos. In Ipe Akoko, there were no significant differences in the pH of the soils that were treated with any type of fertilizer but all the treatments slightly increased soil pH with cattle dung alone having the highest soil pH. In the soil samples collected from Lokoja, compared with control, single application of cattle dung and cattle dung combined with urea fertilizer significantly increased soil pH. Katsina soil significantly increased soil pH when cattle dung alone and cattle dung combined with urea fertilizer were applied while urea alone significantly reduced soil pH.

Compared with control, Al^{3+}+H^+ was slightly reduced due to the addition of 5 t ha^{-1} of cattle dung in the soil samples collected from the four ecological zones while urea fertilizer applied alone significantly increased Al^{3+}+H^+ (Fig. 2). Compared with control, single application of cattle dung reduced Al^{3+}+H^+ by 0.1 while cattle dung combined with urea fertilizer reduced it by 0.2. Urea

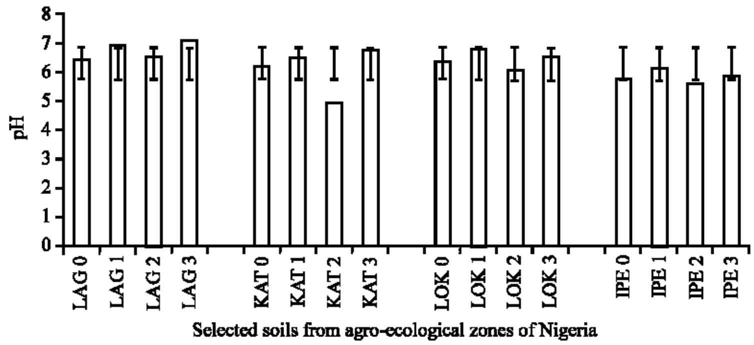

Fig. 1: Effect of cattle dung and its combination with urea fertilizer on pH in selected soils from agro ecological zones of Nigeria, Lag: Lagos-mangrove forest, Kat: Katsina-Sudan savanna, Lok: Lokoja-Guinea savanna, Ipe: Ipe Akoko-Derived savanna, 0: Control, 1: 5 t ha^{-1} cattle dung, 2: 200 kg ha^{-1} urea fertilizer, 3: 5 t ha^{-1} cattle dung+200 kg ha^{-1} urea fertilizer, Vertical lines on each bar indicates the standard error of the mean values of pH

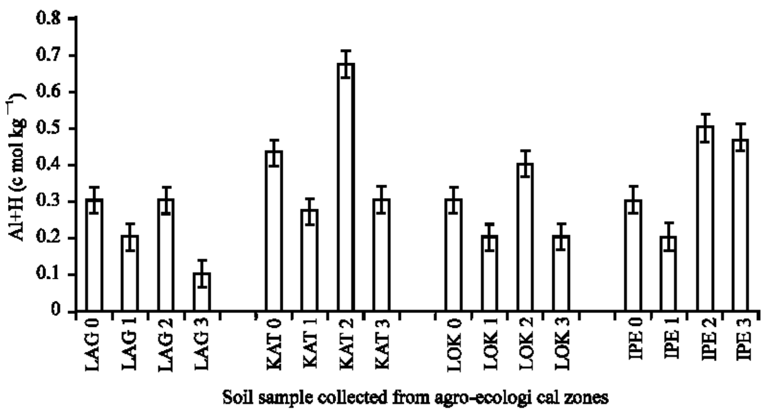

Fig. 2: Effect of cattle dung and its combination with urea fertilizer on Al^{3+}+H^{-+} in selected soils selected from agro ecological zones of Nigeria, Lag: Lagos-mangrove forest, Kat: Katsina-Sudan savanna, Lok: Lokoja-Guinea savanna, Ipe: Ipe Akoko-Derived savanna, 0: Control, 1: 5 t ha^{-1} cattle dung, 2: 200 kg ha^{-1} urea fertilizer, 3: 5 t ha^{-1} cattle dung +200 kg ha^{-1} urea fertilizer, Vertical line on each bar indicates standard error

fertilizer applied alone had no effect on Al^{3+}+H^{+} in Lagos soil in relative to control. In the soil samples collected from Katsina, urea fertilizer alone increased Al^{3+}+H^{+} by 0.24 while cattle dung plus urea reduced it by 0.13. In Lokoja soil there was increase of 0.1 on Al^{3+}+H^{+} with addition of 200 kg ha^{-1} urea alone while combined 200 kg ha^{-1} urea fertilizer and 5 t ha^{-1} cattle dung reduced it by 0.1 when compared with control experiment. In the soil samples collected from Ipe, urea fertilizer applied alone increased Al^{3+}+H^{+} by 0.2 while urea fertilizer combined with cattle dung reduced Al^{3+}+H^{+} by 0.03 when they were compared with control.

In all the soil samples collected from the ecological zones, compared with control (Table 2), all the treatments significantly increased exchangeable Mg, K (Katsina), BS and ECEC. Application of 5 t ha^{-1} cattle dung alone in all the soils collected from different ecological zones had the highest Ca when compared with 200 kg ha^{-1} urea alone and 200 kg ha^{-1} urea combined with 5 t ha^{-1} cattle dung. In all the soil samples irrespective of ecological zones, cattle dung combined with urea

Table 2: Effect of cattle dung, urea fertilizer and cattle dung plus urea fertilizer on soil cations at 90 days of incubation

	Concentrations (cmol kg^{-1})					
Treatment	Ca	Mg	K	Na	BS	ECEC
Lag 0	3.42^{b}	0.45^{c}	0.24^{c}	0.42^{c}	4.53^{d}	4.83^{d}
Lag 1	6.40^{a}	0.82^{a}	0.42^{a}	0.57^{a}	8.23^{a}	9.43^{a}
Lag 2	3.60^{b}	0.65^{a}	0.32^{b}	0.51^{a}	5.08^{c}	6.08^{c}
Lag 3	4.52^{b}	0.52^{b}	0.41^{a}	0.42^{b}	6.87^{b}	8.07^{b}
Kat 0	1.39^{b}	0.11^{c}	0.19^{b}	0.41^{a}	2.10^{c}	2.53^{c}
Kat 1	3.95^{a}	0.81^{a}	0.23^{a}	0.40^{a}	5.39^{a}	6.39^{a}
Kat 2	1.76^{b}	0.66^{b}	0.27^{a}	0.40^{a}	3.09^{b}	4.99^{b}
Kat 3	3.58^{a}	0.81^{a}	0.23^{a}	0.40^{a}	5.02^{a}	6.72^{a}
Lok 0	3.26^{c}	0.12^{c}	0.23^{a}	0.32^{b}	4.22^{c}	4.52^{c}
Lok 1	5.76^{a}	0.96^{b}	0.23^{a}	0.40^{b}	7.35^{a}	8.45^{a}
Lok 2	3.60^{b}	1.06^{a}	0.24^{a}	0.38^{b}	5.28^{b}	6.68^{b}
Lok 3	4.00^{bc}	1.19^{a}	0.27^{a}	0.56^{a}	5.82^{b}	7.02^{ab}
Ipe 0	1.55^{c}	0.50^{b}	0.13^{b}	0.40^{b}	2.58^{c}	2.88^{c}
Ipe 1	1.60^{c}	1.19^{a}	0.34^{a}	0.51^{a}	3.64^{b}	5.34^{b}
Ipe 2	2.90^{b}	1.16^{a}	0.32^{a}	0.48^{b}	3.96^{a}	5.36^{b}
Ipe 3	3.15^{a}	1.10^{a}	0.27^{a}	0.46^{b}	4.91^{a}	6.31^{a}

Means with the same letter are not significantly different using Duncan Multiple Range Test, Lag: Lagos-mangrove forest, Kat: Katsina-Sudan savanna, Lok: Lokoja-Guinea savanna, Ipe: Ipe Akoko-Derived savanna, 0: Control, 1: 5 t ha^{-1} cattle dung, 2: 200 kg ha^{-1} urea fertilizer, 3: 5 t ha^{-1} cattle dung+200 kg ha^{-1} urea fertilizer

fertilizer released more Ca, K and Mg to the soil than urea fertilizer alone but at different level of increment.

DISCUSSION

The presence of macronutrients in cattle dung is widely reported (Ayeni and Adetunji, 2010; Whalen *et al.*, 2000). Addition of cattle dung to the soil samples was expected to have influence on the chemical properties of the soil. It was discovered in this research that the soil samples treated with 5 t ha^{-1} cattle dung without urea fertilizer significantly increased soil pH with corresponding decrease in Exchange Acidity (EA). The increase in pH might be as a result of cations especially Ca^{3+} present in cattle dung (Babalola *et al.*, 2012). Adeniyan *et al.* (2011) obtained similar result in an experiment conducted on comparative study of different organic manures and NPK fertilizers for improvement of soil chemical properties and dry matter yield of maize in two different soils. Onwuka and Ogbona (2009) asserted that the basic cations present in organic wastes displaced the acidic cations from the soil exchangeable complex by neutralization and precipitation thereby increased soil pH with corresponding decrease in EA.

Change in soil pH with cattle dung combined with urea was very marginal when compared with urea fertilizer alone. The significant increase in the pH agreed with the assertion of Ojeniyi (2000) that increase in organic manures is dependable on the level of organic manures. The cations present in 5 t ha^{-1} cattle dung and the native soils used for the experiment might be sufficient enough to raise the soil pH to a significant level. Cattle dung integrated with urea fertilizer also increased soil pH and cations.

Urea fertilizer alone decreased soil pH and increased EA compared with cattle dung without urea combination and urea combined with cattle dung. The reduction in pH might be the acidic effect of urea fertilizer. Ammonia and carbon (iv) oxide released into the soil during nitrification might have lowered the pH.

The fact that urea fertilizer reduced soil pH more than cattle dung alone and cattle dung fertilized with urea in all the soils collected from the different ecological zones shows the liming effect of cattle dung (Ayeni and Adeleye, 2011). Compared with control, urea fertilizer reduced soil pH in contrast with the increase in soil pH exhibited by cattle dung in all the soil samples at different level. The reduction in the soil pH might not only be the acidic effect of urea fertilizer or organic acids presents in the cattle dung but also cations originally present in the soils before the conduct of the experiments. Also, mangrove forest and southern Guinea savanna soils had higher pH more than derived savanna and Sudan savanna zones. Lagos (mangrove forest) is located in rain forest region that is more or less hydromorphic in nature likewise Lokoja (southern Guinea savanna) the confluence of the two biggest rivers in Nigeria. The two locations exhibited similar characteristics by increasing pH more than soils collected from Sudan and derived savanna zones. The reason for the difference might be as a result of different parent materials from which the soils are derived because all the soil samples were subjected to the same treatment. This suggests the dissimilarity in soil reactions when treatments were applied. During the period of incubation, it was observed that Lagos and Lokoja retained more water than Ipe-Akoko and Katsina soils. It is known that a soil with high percentage of sand does not retain moisture and nutrients. In addition to high proportion of sand, the parent materials of the soil might be acidic and with low buffering capacity. The inherent soil acidity might have been increased by the addition of acidic materials (urea fertilizer) as treatments. The soil might have got high residual or potential acidity that might have been converted to active acidity. In both Katsina and Ipe-Akoko soils, presence of acidic cations such as Manganese (Mn) and Iron (Fe) might be high which might render the soils unproductive. Samuel *et al.* (2003) opined that presence of acidic cations is likely to reduce soil pH and basic cations.

Response of the effect of organic manures on soil acidity has not been consistent. Decomposition of organic matter has been known to lead to introduction of organic and inorganic acids with concomitant increases in soil acidity (Agbede, 2009). The study of Agbede (1984) with application of residues showed that the significant pH improvement obtained with lighter soils was not observed in heavier ones. Ayeni (2010) showed that loamy sand and clay loam respond differently to application of organic residues and mineral fertilizer in the experiment conducted to determine the effect of cocoa pod ash, NPK fertilizer and their combinations on soil chemicals properties and yield of tomato (*Lycopersicon lycopersicum*) on two soils. The different characteristics exhibited by the different soil types might also be attributed to differences in soil textures, parent material and nutrient status of the soils as earlier stated.

With the different characteristics exhibited by the soil samples collected from the different ecological zones of Nigeria, it may not be scientific enough to generalize that cattle dung can increase soil pH and cations without considering at which level they interact with different soil types. Blanket recommendation may cause more harvoc to the soils than good. Nutrients present in the soils and the nutrients present in animal dung must be tested before application. This is because in this experiment, different types of the soil used for the experiment respond to cattle dung, urea fertilizer and cattle dung combined with urea fertilizer in different ways. Urea fertilizer does not have much acidic effect on 5 t ha^{-1} cattle dung when the two fertilizers were integrated.

CONCLUSION

The laboratory experiment conducted to show the effect of cattle dung, urea fertilizer and the cattle dung combined with urea fertilizer on soil pH and cations in the soils selected from different agro ecological zones of Nigeria shows that the cattle dung increased soil pH and cations at different rate of increment. Different soil types react to application of cattle dung and its combination with urea fertilizer in different ways. Blanket application of organic manures to soils without adequate soil test simply because, it performed well in one soil does not necessarily mean that other types of soil may react in the same way.

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