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Agronomic Evaluation of Manure Ashes: Effect on Soil Reaction and Electrical Conductivity

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Abstract

Manure ashing seeks to concentrate manure nutrients and reduce their bulkiness. This study is conducted to evaluate the effects of dried manure and their ashes on soil pH, electrical conductivity (EC). The study includes laboratory-incubation, screen house [both completely randomized] and field [randomized complete block design] experiments. Treatments which are control (CON), dried poultry manure (DPM), poultry manure ash (PMA), dried cattle manure (DCM), cattle manure ash (CMA), and dried goat manure (DGM), goat manure ash (GMA) and NPK 15-15-15 were applied at 120 kg P ha^{-1} to soil. Soils taken fortnightly were analyzed for pH and EC. Results showed that averagely, across the weeks of study, the soil incorporated with manure ash had higher pH values relative to the soil with the dried manure treatments. Manures and their ashes increased soil pH, and the incorporation of poultry manure ash led to significant increase in EC when compared to the incorporation of dried manure across the weeks in the incubation experiment. In the field experiment, the application of cattle manure ash led to significant increase in soil pH and EC over the weeks of observation. The study concludes that the effects of manure ashes on soil pH and EC are comparable to those of dried manures thus showing the potential of a good liming material. Hence, the use of animal manure ash in place of dried manures is highly recommended by this study.

Keywords: Animal manure ash, Electrical conductivity, Soil reaction.

1. Introduction

In recent times, the use of organic manures with or as an alternative to inorganic fertilizers in sustainable agricultural practice has increased worldwide, because it improves soil structure and stimulates the biological processes in the soil that help to build fertility (Ano and Agwu, 2005). Olatunji et al. (2006) opined that the application of organic manure has higher comparative economic advantages over the use of inorganic fertilizers.

The quantity of livestock waste generated in Nigeria is large (Nwajiuba and Chimezie, 2000), most of which have potential for use in the maintenance of soil fertility. Irrespective of the massive manure production potential, very little amount of the available animal manure is being utilized for crop production because animal manure is bulky and is not aesthetically pleasing to handle thereby reducing its economic value, which has accounted for a substantial portion of it being disposed of as a waste product.

Kimbi et al. (1992) observed that in extensive livestock grazing systems only about 1% of farmers apply animal manure on land, indicating serious underutilization of such resources. This is mainly due to the lack of scientific basis for enlightening farmers on appropriate application rates, storage techniques, and application methods (Gabriel, 1998). However, as animal production shifts toward fewer but larger operations, the number of confined animals has increased in some geographical locations, resulting in more manure produced than can be assimilated by the available farmland where the animals are raised and the disposal of such manures becomes a major problem.

Due to its bulkiness and unpleasant aesthetics, animal manures have been disposed as waste in tropical countries. There has been, however, a need to determine alternative ways of processing and handling animal manures. The charring or burning of manure has become an alternative method of processing manures. It involves the turning of manure to ash for the purposes of concentrating the nutrients in the manure, reducing the bulkiness, and presenting the nutrient elements in a form that is readily available to the plants.

Masto et al. (2007) showed that the application of manure has a significant effect on the chemical properties of soil, and many of these effects are due to the increased organic matter. Soil pH is the measure of soil acidity or alkalinity. It is an important indicator of soil health. A number of researchers have suggested that organic residues (e.g., animal manures) might be used as alternative liming materials and that their application can increase plant growth in acidic soils by ameliorating aluminum (Al) toxicity (Pocknee and Sumner, 1997; Mokolobate and Haynes, 2002).

Soil pH affects crop yields, crop suitability, plant nutrient availability, and soil micro-organism activity which influence key soil processes. The solubility and availability of most nutrients in soils are determined by the soil pH (Azeez and Van Averbeke 2012). Electrical conductivity (EC) is a measure of soil salinity. Manures added to the soil mineralize and release the nutrients and salts to the soil. Soil electrical conductivity serves as a measure of soluble

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nutrients and indirectly shows the mineralization of organic matter in the soil (De et al., 2000).

The search for sustainable soil fertility replenishment techniques is ongoing in which most studies concentrated on the use of dried animal manure; however, limited information on the use of animal manure ash is available. Animal manure is bulky, and not aesthetically pleasing to handle resulting to the substantial portion of it being disposed of as a waste product. The recent practice of converting the dried waste to ashes is a new way of recycling the manure and concentrating the nutrients to reduce its bulkiness: however, there is paucity of data on the agronomic evaluation of animal manure ash in respect to some soil chemical properties. Consequently, the objective of this study is to evaluate the effect of dried animal manure and manure ash on soil reaction and electrical conductivity in incubation, screen house, and field experiments.

2. Materials and Methods

2.1. Soil Sample Collection, Preparation and Analysis

Top soil samples (0-20cm) were collected from four locations in Ogun state based on their different parent materials. The locations are: Alabata and Osiele from basement complex parent materials; Itori and Papalanto from sedimentary parent materials. The soils were air-dried and passed through a 2mm-diameter sieve. The physical and chemical properties of the soils were determined as follows: pH in water using a glass electrode pH meter; particle size distribution, using the hydrometer method (Bouyoucos, 1965). Available phosphorus was determined using Bray-1 procedure. Exchangeable acidity was determined in a 1.0M KCl extract as described by Page et al. (1982). Exchangeable bases were extracted with 1N NH_4OAc buffered at pH 7. Sodium and K in the extract were determined by flame photometer, while Ca and Mg were determined using Atomic Absorption Spectrometry. Soil Fe was analyzed using atomic absorption spectroscopy after HNO_3-H_2O_2-HCl digestion.

2.1.2. Manure Collection, Preparation, Analyses and Experimental Treatment and Design

Cured cattle dung, goat manure without beddings and poultry manure (battery cage) were obtained from Federal University of Agriculture, Abeokuta farm. The manures were air-dried; and some were burnt in an open air to produce ash at temperature 320–450 °C. The dried manure ashes used were digested with nitric and perchloric acid (2:1) (Watanabe et al., 2013). The digests were analyzed for pH, available P, Calcium, Magnesium, Potassium, Sodium, exchangeable acidity, copper, zinc, iron and texture using standard procedures (Kaira and Maynard, 1991).

Incubation and screen house experiments were laid in a completely-randomized design while the field experiment was laid in a randomized complete block design with three replications. Treatments were control, dry cattle manure, cattle manure ash, dry goat manure, goat manure ash, dry poultry manure, poultry manure ash, and NPK 15-15-15 at a rate of 120 kg P ha^{-1}. The control was the soil without manure, the inorganic fertilizer was used as a check.

2.3. Experimentations

In the incubation experiment, two soils each from basement complex (Alabata, Osiele) and sedimentary (Itori and Papalanto) parent materials were used. Plastic containers containing 100g of soil were labeled appropriately with treatments applied individually after which distilled water was added. Soil amendment mixtures were incubated in a dark cupboard for eight weeks. Treatments were applied as above. Sub-samples were taken at two week- intervals for eight weeks (0, 2, 4, 6 and 8 weeks) and analyzed for pH, and electrical conductivity. In the screen house experiment, one soil each from basement complex (Alabata) and sedimentary (Papalanto) were used for this study involving two cycles of maize growth. Plastic buckets were filled with 5kg of the respective soil samples with dried manures applied two weeks before planting and manure ashes and NPK applied two weeks after planting. Water was added to the treated pots bringing them to the field capacity for two weeks to achieve equilibrium before sowing three seeds of maize (BR-9928-DMR-SR-Y) which were thinned to 1 seedling per pot at two weeks after planting. Soil samples were taken from the treatment pots at 0, 4 and 7 weeks for the first cycle and 0, 4 and 6 weeks for the second cycle after planting. The collected soil samples were analyzed for pH, and electrical conductivity according to the method mentioned earlier. The field experiment was done at the Federal University of Agriculture, Abeokuta ($7^0\,12^1$ to $7^0\,20^1$ N and $3^0\,20^1$ to $3^0\,28^1$). The field was cleared mechanically, ploughed, harrowed and divided into experimental plots. The size of the field was 22.0m x 26.0m, plot size was 3m x 4m and net plot size was 1.5m x 2m. Dried manures were applied two weeks before planting. Three seeds of maize were planted per hole with a space of 75 cm x 25 cm after which it was thinned to two plants per stand at two weeks' after planting, manure ashes and NPK were applied two weeks after planting to their respective plots. The plants were monitored on the field for twelve weeks. Soil samples were collected at 0, 2, 4, 6, 8 and 10 weeks after planting (WAP) and analyzed for pH, and EC according to the aforementioned method.

2.4. Data Analysis

Data collected were subjected to analysis of variance (ANOVA). The significant treatments were separated using Duncan Multiple Range Test (DMRT) at $p \leq 0.05$. The analysis was carried out using statistical analysis system (SAS).

3. Results

3.1. Characterization of Soils, Dried Manures and Manure Ash

The pH of the soils are shown in Table 1; they ranged from 6.75 in the soil from Osiele to 7.63 in the soil from Itori. The highest pH, available phosphorus, calcium, sodium, and iron were found in the soil from Itori, while the soil from Osiele had the highest magnesium and exchangeable acidity. The characteristics of dried manures and manure ashes are also presented. There was a significant increase in the pH, total P, and exchangeable bases in manure ashes compared with the dried manures. The iron content of these manures also increased after ashing although a significant increase was only observed for the dried cattle manure and dried goat manure after ashing. The highest pH, potassium, sodium, and carbon nitrogen ratio were observed in the goat manure ash, while the total P, calcium, and magnesium were observed to be the highest in the poultry manure ash. The order of total P content was as follows: poultry manure ash > goat manure ash >cattle manure ash >dried poultry manure > dried goat manure > dried cattle manure.

3.2. Effect of Dried Manures and Manure Ash on Soil pH

The application of poultry manure ash increased pH significantly in the soils from Alabata and Osiele, while the dried goat manure resulted in a significant increase in the soils from Itori and Papalanto in the incubation experiment (Table 2). The dried-manure-amended soils differed from manure-ash-amended soils across the weeks. In the soil from Alabata, the highest pH was found at two weeks after treatment incorporation (2WAI). However, at 0WAI and 2WAI, manure ash did not yield any differences compared to dried manures. At 4, 6, 8WAI, a significant increase and decrease in pH were observed, respectively for DGM and DCM in comparison to their manure ashes. At 0WAI, a significantly lower pH was observed in the control soil and the manure ashes of poultry and cattle had significant effects on pH when compared to their dried manures. At 2WAI, the NPK amended soil had a significantly lower pH than other treated soils, although manure ashes, except GMA, showed similar effects. At 4 and 8WAI, application of CMA and GMA led to a significant increase and decrease in the soil pH compared to their manure counterparts.

Table 1. Some properties of soils and manures

Soil	pH	EC	Avail. P	Ca	Mg	K	Na	Fe	Al+H	Texture
		dSm-1	mgkg-1			cmolkg-1		mgkg-1	cmolkg-1	
Alabata	7.16	0.38	10.26	5.13	1.05	0.27	0.47	6.70	0.04	Loamy sand
Osiele	6.75	0.43	9.33	4.06	2.25	0.25	0.47	8.75	0.07	Loamy sand
Itori	7.63	0.73	21.30	6.71	1.34	0.34	0.60	15.45	0.05	Loamy sand
Papalanto	6.84	0.26	6.84	2.56	1.71	0.18	0.31	8.25	0.06	Sandy
Funaab	6.83	0.40	4.98	3.56	1.27	0.47	0.56	7.75	0.05	Loamy sand

Manures	pH	Total P	Ca	Mg	K	Na	Cu	Zn	Fe	C/N
				cmolkg-1					mgkg-1	
Dried poultry manure	8.20f	14.7d	44.10b	30.70c	15.20e	15.20e	111b	1248b	4556b	14.75cd
Poultry manure ash	10.45b	30.50a	75.50a	63.00a	55.50b	58.40b	209a	237a	6978b	12.73d
Dried cattle manure	8.70e	2.20f	30.10d	15.00d	10.20f	10.40f	57c	372e	3654a	15.65cd
Cattle manure ash	10.15c	22.30c	33.70c	43.00b	21.90d	22.40d	112c	746c	9325a	20.43ab
Dried goat manure	9.60d	4.60e	17.80f	20.00d	38.70c	38.40c	25d	598d	2829c	15.65cd
Goat manure ash	10.90a	28.10b	25.30e	42.00b	75.20a	76.80a	77c	722c	9304a	22.52a

Means with the same letter in each column are not significantly different at $p \leq 0.05$

Table 2. Effect of manure amendments on soil pH in incubation study.

Treatment	Alabata					Osiele				
kg/ha	0 WAI	2 WAI	4 WAI	6 WAI	8 WAI	0 WAI	2 WAI	4 WAI	6 WAI	8 WAI
CON	6.75ab	7.77a	7.12abc	7.05cd	7.22ab	6.52d	7.50a	7.08bc	6.63a	7.30a
DPM	6.44b	7.30d	7.25ab	7.30ab	7.27a	6.61bc	7.38a	7.14bc	6.63a	7.20b
PMA	6.62ab	7.65abc	7.60a	7.40a	7.85b	6.95a	7.33ab	7.13bc	6.77a	7.13bcd
DCM	7.17a	7.70ab	7.17cd	7.12bcd	7.22ab	6.75bc	7.43ab	6.93bc	6.62a	7.08cd
CMA	7.25a	7.73ab	7.70a	7.15d	7.28a	6.90a	7.40abc	7.43a	6.83a	6.88e
DGM	6.72ab	7.47cd	7.27bcd	7.20bc	7.02c	6.70bc	7.40abc	7.45ab	6.15a	7.52a
GMA	6.95ab	7.53bc	6.92d	6.75e	6.90d	6.52d	7.07d	6.78d	6.82a	7.07cd
NPK $_{(15-15-15)}$	6.95ab	7.72ab	7.50abc	6.70e	7.27a	6.77b	7.18cd	7.35ab	6.60a	7.15bc
	Itori					Papalanto				
CON	7.00b	7.55bc	7.43b	6.93f	6.85e	6.80de	7.63ab	7.20bcd	6.90ab	7.32b
DPM	7.23ab	7.60b	7.47b	7.07de	7.05c	6.97c	7.23b	6.98de	6.83bc	7.13d
PMA	7.07b	7.23d	7.60ab	7.37b	6.77f	6.72e	7.65ab	7.22bc	6.88ab	7.20c
DCM	7.32a	7.75ab	6.97d	6.85f	6.93d	7.48a	7.33ab	6.88e	6.95ab	7.28b
CMA	7.10ab	7.30cd	7.85a	7.20c	7.15b	7.13b	7.36ab	7.05cde	6.82bc	7.17cd
DGM	7.17ab	7.87a	7.73a	7.57a	6.90de	7.18b	7.30ab	7.50a	7.12a	7.72a
GMA	7.31a	7.52bc	7.02cd	6.95ef	7.30a	7.42a	7.35ab	6.88e	6.62c	7.38a
NPK $_{(15-15-15)}$	7.23ab	7.33cd	7.20c	7.18cd	7.12bc	6.90cd	7.37ab	7.28ab	6.87b	7.18cd

Means with the same letter in each column are not significantly different at $P<0.05$

DPM = Dry poultry manure, PMA = Poultry manure ash, DCM = Dry cattle manure, CMA = Cattle manure ash, DGM = Dry goat manure, GMA = Goat manure ash, CON = Control.

The application of DGM significantly increased the pH of the soil from Itori at 2, 4 and 6WAP than other treatments. However, significant decreases and increases were observed respectively at 2 and 4, 6WAP for PMA and CMA in comparison to their dried manure counterparts, while GMA significantly decreased pH in comparison to its dried manure. At 8WAP, the treatment effects were significant since the control soil had significantly lower pH than other treated soil. CMA and GMA increased pH compared to their dried manures, while the contrary was the trend in the soils treated with PMA. In the soil from Papalanto, the treatment effect was not significant at 2WAP.

At 4, 6 and 8WAP, the highest pH was observed in the DGM treated soils, which was significantly different from the pH in the manure-ash-amended soil. In the screen house experiment (Table 3), the soil pH at 0 and 7WAP was significantly increased with the single application of DGM and DPM, respectively. However, at 4WAP, PMA and DGM significantly increased the pH of the soil from Alabata and Papalanto, respectively. At 4WAP, the soil from Alabata, showed a significantly lower pH for the NPK-amended-soil; however, other treatment effects, did not differ from the control soil. At 7WAP, dried manures and the manure ashes of goat and cattle showed similar results; however, a significant decrease in pH was observed in PMA-amended-soil relative to the DPM-amended-soil. In the soil from Papalanto, treatment effects at 0WAP were only observed for DCM and DCM in comparison with other treatments and control soils. It was also observed that the application of dried cattle manure significantly increased the electrical conductivity of soils used in the screen-house experiment. At 0 and 4WAP, regarding the soil from Alabata, the control soil recorded the lowest EC, while the dried manure-amended-soil had a significantly higher EC relative to the manure-ash-amended soil. In the soil from Papalanto, a significantly lower EC was observed across the weeks for the control soil, and the dried manures significantly increased the soil EC compared to their manure ashes.

Table 5 shows the effects of the treatments on the soil pH during the field evaluation. The application of cattle manure ash led to a significantly higher pH corresponding to other treatments at all weeks of evaluation. At 0WAP, dried manures and manure ash were similar in their effect on soil pH; however, the lowest pH was recorded in the DPM-amended soil. A similar sequence was observed at 2WAP although the GMA-amended soil had the lowest pH which significantly differed from its ash-amended soil. Conversely, the single application of CMA and GMA led to a significant increase and decrease in pH compared to their dried-manure counterparts at 4WAP. At 6, 8 and 10WAP, the application of GMA allowed for a significantly lower pH relative to other amendments. However, at 6 and 10WAP, PMA and GMA did not differ from their dried-manure counterparts, while a significant decrease in pH was observed or PMA and GMA relative to their dried manures at 8WAP.

Table 3. Effect of manure amendments on soil pH and electrical conductivity in the screen house experiment

Treatment	Alabata						Papalanto					
kg ha^{-1}	0 WAP	4 WAP	7 WAP	0 WAP	4 WAP	6 WAP	0 WAP	4 WAP	7 WAP	0 WAP	4 WAP	6 WAP
Soil pH												
	Cycle 1			Cycle 2			Cycle 1			Cycle 2		
CON	7.48bc	6.92ab	7.28c	7.28c	7.12b	7.67ab	7.15b	6.65b	6.95c	6.95c	7.12b	7.67ab
DPM	6.87d	7.07ab	7.78a	7.78a	7.13b	7.75a	7.33b	6.40bc	7.58ab	7.58ab	7.13b	7.76a
PMA	7.36c	7.17a	7.52b	7.52b	7.43ab	7.30c	7.17b	6.38bc	7.70a	7.70a	7.43ab	7.30c
DCM	7.70ab	6.85b	6.50d	6.50d	7.43ab	7.73a	7.73a	6.47bc	7.30b	7.30b	7.43ab	7.70a
CMA	7.42c	7.12ab	6.48d	6.48d	7.42ab	7.70a	7.27b	6.62bc	6.87cd	6.87cd	7.42ab	7.73a
DGM	7.88a	6.83b	7.38bc	7.28c	7.73a	7.53ab	7.72a	7.05a	7.52ab	7.52ab	7.73a	7.47bc
GMA	7.70ab	7.82b	7.28c	7.38bc	7.48ab	7.47bc	7.20b	6.27c	6.60d	6.60d	7.48ab	7.53ab
NPK $_{(15-15-15)}$	7.45c	6.30c	7.42bc	7.42bc	6.38c	7.72a	6.73c	6.35c	6.72cd	6.72cd	6.38c	7.72a
Soil Electrical Conductivity												
CON	0.63g	0.46f	0.44c	0.44c	1.28e	0.58cd	1.04h	1.09h	0.31f	0.31f	1.28e	0.58cd
DPM	3.76b	0.89e	0.35e	0.35e	1.11e	0.84c	2.05e	3.77b	0.45c	0.45c	1.11e	0.84c
PMA	0.85g	0.36g	0.40g	0.40g	0.80f	0.31d	1.67g	3.13d	0.29f	0.29f	0.80f	0.31d
DCM	5.38a	3.34a	1.02a	1.02a	3.92a	6.48a	5.75a	5.55a	1.14a	1.14a	3.92a	6.48a
CMA	1.63e	1.02d	0.32f	0.32f	1.88d	0.77c	1.86f	1.68f	0.83b	0.83b	1.88d	0.77c
DGM	2.68c	2.04c	2.04c	2.04c	3.40b	0.85c	3.89b	1.22g	0.44cd	0.44cd	3.40b	0.85c
GMA	2.06d	0.94e	0.46c	0.46c	2.24c	1.28b	2.15d	3.45c	0.42d	0.42d	2.24c	1.28b
NPK $_{(15-15-15)}$	1.30f	3.15b	0.42cd	0.42cd	2.08cd	1.59b	3.42c	1.76e	0.36e	0.36e	2.08cd	1.59b

Means with the same letter in each column are not significantly different at P<0.05

DPM = Dry poultry manure, PMA = Poultry manure ash, DCM = Dry cattle manure, CMA = Cattle manure ash, DGM = Dry goat manure, GMA = Goat manure ash, CON = Control

3.3. Effect of Treatment on Soil Electrical Conductivity

Table 4 shows the effects of the amendment on soil EC during the incubation experiment. The application of DCM significantly increased the electrical conductivity of the soils at all weeks of incubation except at 0WAI for the soil from Alabata, and at 4 and 6WAI for the soil from Osiele and Papalanto. Regarding the soil from Alabata and Osiele, the control soil had significantly lower EC compared to other treated soil at all weeks except at 4WAI. Dried-manure-amended soil had higher EC compared to the manure-ash amended soil from Alabata. However, in the soil from Osiele, the incorporation of poultry-manure ash led to a significant increase in EC compared to its dried manure across the weeks while the contrary trend was observed for other manure ashes only that a significant increase was observed for EC in the CMA-amended soil when compared to its dried manure at 4WAI. In the soil from Itori and Papalanto, the application of dried manures showed a significant effect on EC compared to the manure ash.

Table 4. Effect of manure amendments on Soil Electrical Conductivity (EC) in incubation

Treatment	Alabata [EC (dSm^{-1})]					Osiele [EC (dSm^{-1})]				
kg ha^{-1}	0 WAI	2 WAI	4 WAI	6 WAI	8 WAI	0 WAI	2 WAI	4 WAI	6 WAI	8 WAI
CON	0.61e	0.34h	0.44e	0.29f	0.46de	0.73d	0.31h	0.48c	0.26g	0.31g
DPM	1.04c	0.44f	0.56c	0.58d	0.54c	0.90cd	0.39f	0.43d	0.50d	0.58c
PMA	0.74de	0.38g	0.36f	0.41e	0.42e	0.97cd	0.80b	0.48c	0.81a	0.64b
DCM	1.35b	1.04a	0.83a	1.03a	0.89a	1.81a	0.89a	0.46cd	0.71b	0.90a
CMA	1.07c	0.61c	0.57c	0.68b	0.51cd	1.11bc	0.40e	0.79b	0.62c	0.42f
DGM	1.68a	0.71b	0.76b	0.70b	0.72b	1.22b	0.55c	0.87a	0.43e	0.65b
GMA	0.81d	0.49e	0.47d	0.40e	0.41e	0.90cd	0.36g	0.47cd	0.32f	0.54d
NPK $_{(15-15-15)}$	0.76de	0.57d	0.56c	0.63c	0.70b	1.20b	0.42d	0.39e	0.69b	0.48e
	Itori [EC (dSm^{-1})]					Papalanto [EC (dSm^{-1})]				
CON	1.13cd	0.67d	0.86b	0.63e	1.23a	0.80c	0.40d	0.61abc	0.36c	0.47c
DPM	1.23bcd	0.63e	0.64d	0.79cd	0.86c	0.94c	0.42d	0.86ab	0.43c	0.46c
PMA	1.05d	0.57f	0.55f	0.66de	0.61d	0.70c	0.42d	0.37a	0.44c	0.43c
DCM	2.03a	1.14a	1.68a	1.88a	1.29a	3.09a	0.63a	0.75ab	0.59c	0.82a
CMA	1.32bc	0.55g	0.92a	0.99b	0.89c	0.97bc	0.44c	0.60abc	0.56c	0.68b
DGM	2.19a	0.87b	0.93a	0.90bc	1.05b	1.05bc	0.55b	0.45bc	0.39c	0.35d
GMA	1.37b	0.55g	0.61e	0.56e	0.63d	0.90c	0.34f	0.50bc	0.40c	0.36d
NPK $_{(15-15-15)}$	1.30bc	0.82c	0.88b	0.87bc	0.93c	1.37b	0.38e	0.40c	0.40c	0.48c

Means with the same letter in each column are not significantly different at $p \leq 0.05$
DPM = Dry poultry manure, PMA = Poultry manure ash, DCM = Dry cattle manure, CMA = Cattle manure ash, DGM = Dry goat manure, GMA = Goat manure ash, CON = Control.

Table 5 shows the effect of the amendments on soil EC in the field experiment. The application of cattle-manure ash led to a significant increase in the soil EC at weeks of observation except 0WAP. At 0WAP, significantly lower EC was observed in the control soil; the highest EC was observed with DCM. At 2WAP, the application of manure ashes significantly increased EC in comparison to their dried manures, and the lowest EC was recorded in the NPK-amended soil. A similar response was observed at 4WAP only that GMA and DGM did not differ. At 6 and 10WAP, only the manure ash of poultry and cattle led to a significant increase in EC in comparison to their dried manures.

Table 5. Effect of amendments on soil pH and electrical conductivity in field evaluation

Treatment	Soil pH						Soil EC (dSm^{-1})					
(kg ha^{-1})	0WAP	2 WAP	4 WAP	6 WAP	8WAP	10 WAP	0WAP	2 WAP	4 WAP	6 WAP	8WAP	10 WAP
CON	6.75ab	7.02d	7.43b	6.90ab	7.22ab	7.30b	0.73d	0.48c	0.54b	0.57c	0.44d	0.46e
DPM	6.44b	7.28bcd	7.47b	6.83bc	7.27a	7.20b	0.90cd	0.43d	0.42c	0.59c	0.54c	0.50d
PMA	6.61ab	7.33abc	7.60ab	6.88ab	7.15b	7.13bcd	0.87cd	0.48c	0.59b	0.64b	0.42e	0.71b
DCM	7.17a	7.43ab	6.97d	6.95ab	7.22ab	7.08cd	1.81a	0.46cd	0.44c	0.42e	0.51cd	0.62c
CMA	7.25a	7.52a	7.73a	7.12a	7.28a	7.75a	1.11bc	0.87a	0.86a	0.90a	0.89a	0.80a
DGM	6.72ab	7.40abc	7.50ab	6.82bc	7.02c	7.05d	1.22b	0.47cd	0.39c	0.65b	0.72b	0.43e
GMA	6.95ab	7.01d	7.02cd	6.62c	6.90d	7.07cd	0.90cd	0.79b	0.40c	0.54c	0.41e	0.32f
NPK $_{(15-15-15)}$	6.95ab	7.18cd	7.20c	6.87b	7.27a	7.15bc	1.20b	0.39e	0.40c	0.48d	0.70b	0.69b

Means with the same letter in each column are not significantly different at $p \leq 0.05$
DPM = Dry poultry manure, PMA = Poultry manure ash, DCM = Dry cattle manure, CMA = Cattle manure ash, DGM = Dry goat manure, GMA = Goat manure ash, CON = control

4. Discussion

It is well established that crop production on acid soils can be improved greatly when soil pH is adjusted to near neutral. Soil pH affects nutrient solubility and influences the sorption or precipitation of nutrients with Al and Fe (Hue, 1992). The pH of the soils were slightly acidic to neutral. The fertility of the soils was generally low to moderate, hence, a specific response to the application of organic manure would be expected. The soils had organic carbon levels above 11 g kg^{-1} indicating a moderate to high organic matter. The available P content ranged from low to moderate (1 – 20 mg kg^{-1}). The available P content of the acid soil is lower than that of the neutral soil. This indicates that Fe ions and Al ions will form complexes with phosphate, therefore making the release of P for plant use higher in the neutral soil than the acidic soil. Manuring is a practice that helps increase the organic carbon content of soils, which may induce better water infiltration, increased capacity to retain nutrients. The alkaline pH observed in the manures indicates the presence of excess basic cation at the expense of acidic ones. Equally, the acidic nature of some of the soils was expected to be controlled by the cations supplied by the manure that was alkaline in reaction and generally high in macro and micronutrients. The composition of micro nutrients in poultry for this study conformed to the findings of Azeez and Averbeke (2010) that feed additives including antibiotics and growth stimulants in poultry diet could be responsible for the increased micronutrients in the poultry litter, with a large quantity metabolized in the body of the birds and the excess excreted as wastes. The trends of nutrient distribution in manures vary. This reflects the differences in the feed composition of the animals. The higher P concentration in the manure ash resulted from the elimination of the carbon during the burning of the ash. The exchangeable bases in the manure ash are more than those in the dried manure. Lal and Ghuman (1989) reported that the conversion of biomass to ash increased the levels of cations and other nutrient elements.

The highest pH values were observed in the amended soils because the addition of organic waste wastes (animal manures) to acidic soils is potentially a reliable strategy for increasing soil pH. Also, this could be attributed to the high content of exchangeable bases in the manures. Other studies have reported a similar effect on soil pH after the application of fresh or composted soil animal manure (Eghball 1999). Ano and Ubochi (2007) reported that animal manures significantly increased the soil pH from 4.6 to values above 5.6. The pH of the ash-manure-amended soil was higher than that of the soil amended with dried manures. This could be attributed to the fact that the initial pH of ash manures was higher than that of the dried manure in addition to the higher amount of exchangeable bases. Ash manures have a high content of calcium hence increasing the liming properties. Adekayode and Olojugba (2009) reported that exchangeable bases were significantly higher in plots treated with wood ash compared to plots treated with other amendments. Electrical conductivity (EC) was significantly increased in the amended soils, in comparison to the EC value obtained in the control. The increase can be explained by the input of nutrients and salt contained in the manure. Goff (2006) reported that salts in manures are sourced from feed additives. Dried manures had higher EC than ash manures. This could be a result of the low carbon nitrogen content of dried manures which allows them to mineralize faster than their ash and hence releasing greater amount of cations that form salts. Azeez and Van Averbeke (2012) found that the electrical conductivity of the soils significantly increased with the application of poultry, cattle, and goat manures, and the potential manure-induced soil salinization was very high in the poultry manure compared with the cattle manure.

5. Conclusions

The present study concludes that the effects of manure ashes on soil pH and EC was comparable to those of the dried manures, thus showing a great potntial as a good liming material. However, the manure ash performed better in terms significant increase in soil pH and EC in comparison to the control and the dried manures. Hence, the use of animal manure ash in place of dried manures is highly recommended for use.

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