INFLUENCE OF SOME ANIMAL MANURE ON FORMS OF PHOSPHORUS AVAILABILITY IN SOILS OF BIDA, NIGER STATE.

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ABSTRACT
A screen house experiment was conducted at the Nigeria Cereal Research Institute, Baddegi screen house to investigate the influence of some animal manure sources (poultry, goat, and cow dung) on the availability of phosphorus on soil from Bida, in Southern Guinea Savanna of Nigeria. The treatment consist of three animal manure sources (poultry, goat, and cow dung) and five rates of application (0, 2.5, 5.0, 7.5 and 10.0 ton ha^{-1}).The treatment was arranged in a complete randomized design (CRD) with three replicate. Maize was planted during the first and second trial as test crop. Soil samples were collected and analyzed for available P and inorganic P fractions. The result indicated that NH_4Cl -P and Olsen-P were significantly increased by the treatment of the three animal manure sources. Aluminum phosphate (Al-P), Iron phosphate (Fe-P),Occluded phosphate (Occl-P) and Calcium phosphate (Ca- P) were also mobilized and released irrespective of the source of organic manures. The relative fraction of inorganic P was in the order of Occl-P> Fe-P> Al-P> Ca-P. The pattern of P mobilization by addition of organic manure was observed that the increment on NH_4Cl- P and Olsen-P content was higher in second trial than the first trial. The soil contents of Fe- P, Al-P, and Ca- P decreased with increased in rate of application. These three animal manure have the potential to increase the availability of available P (Olsen and NH_4Cl-P). The practical implication of these processes is that animal manure could be used as a strategic tool to reduce the rates of fertilizer P required for optimum crop growth on acidic and soil fixing soils in Nigeria.

Keywords: Phosphate availability, animal manure, Olsen-P, NH_4Cl-P, Occl-P, Fe-P, Al-P

INTRODUCTION
Phosphorus (P) is one of the most essential elements for plant growth after nitrogen and it is considered the second most limiting element for crops. (Arcand and Schneider, 2006).It plays a vital key role in plant metabolism, structure and energy transformation. Phosphorus determination is an important factor to be considered in the evaluation of soil fertility. The quantity and relative distribution of various forms of P are of great importance to soil genesis and fertility studies. Phosphates fixed by Fe, Al, and Ca in soils is a major cause of low phytoavailability (McBeath *et al.*, 2005), because at least 70–90% of P that enters the soil is fixed, making it difficult for plants to absorb and use (Kou *et al.*, 1999; Liu *et al.*, 2000;Lei *etal*., 2004;). Animal (cattle, sheep, goats,poultry e.t.c) manure have been shown to contain large amount of organic matter, nitrogen (N),and significant concentration of basic cations such as magnesium(Mg),calcium (Ca) and potassium (K) which are essential nutrients for plant growth and development (Ojeniyi,2000;Johnson *el al*,2006;Ojeniyi *el al*,2009).Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect. (Makinde and Ayoola, 2008). The use of mineral fertilizer and some bad farming practices, such as burning of crop residues,continuous cropping and overgrazing have greatly contributed to the reduction in the organic matter content in soils. Besides the physical, chemical, and biological properties of soils are adversely affected. The contribution of soil organic matter to sustainable crop production is well recognized and established but little is known about its different chemistry and different fractions. The application of organic source of nutrient such as animal manure, crop residue sewage sludge, city refuse and compost manure to soil is a current environment and agricultural practice for maintaining soil supplying plant nutrients (Francis *el al*,1990).
Phosphorus determination is an important factor to be considered in the evaluation of soil fertility. The quantity and relative distribution of various forms of P are of great importance to soil genesis and fertility studies. Enwezor and Moor, (1966) worked on some savanna and forest soils and provided the first phosphorus fractionation of Nigeria soils using Chang and Jackson, (1957) procedure. They found that over half of the extractable phosphorus was present as iron phosphorus, the remainder being made up of approximately equal quantities of aluminum and calcium phosphates. The objective of this study was to investigate the effect of these animal manures (poultry, goat, cow dung) on the release of different forms of P.

MATERIALS AND METHODS
The study was conducted in the screen house of the Nigeria Cereal Research Institute, Badeggi in Lavun local government area, along Bida road. Latitude 9^o 45'N, and Longitude 06^o 07'E, in the Southern Guinea Savanna Zone of Nigeria. With annual rainfall ranging between 1000mm to1500mm.

Experiment
Pot experiment trial was carried out using the bulk composite soil samples that were taken from the upland rice field of Nigeria Cereal Research Institute, Badeggi. The experiments were conducted in the

screen house of Nigeria Cereal Research Institute, Badeggi, the pot experiment was a 3 x 5 factorial, arranged in a completely Randomized design [CRD], Treatments were three of animal manure sources (poultry,goat and cow dung) sources and five rates (0,2.5,5.0,7.5,and 10 ton ha^{-1}) of application, replicated three times, giving a total of 45 pots. The trial was carried out twice, which was terminated at 6weeks after planting (WAP) for each trial.

The soil samples were collected after each trial, for the analysis of different forms of P. The samples were air dried and grounded to pass a 2-mm sieve for analysis.

Initial soil characterization

Soil particle size distribution was determined by the hydrometer method after dispersion with sodium hexametaphosphate according to the procedure described by I.I.T.A. (1976). Soil pH values of the samples were determined in distilled waterusing a soil - solution ratio of 1:1.(Black, 1965).Total N was determined using the kjeldahl method as described by Bremner (1996). Organic carbon was determined by the Walkley – Black wet oxidation method described by Nelson and Sommers (1982). Available P was determined by the Bray P 1 method (Murphy and Riley, 1962). Total P was determined after digestion with 70% $HClO_4$.

Phosphate in the digest was determined colorimetrically with the molybdate – ascorbic acid procedure.Exchangeable Bases: Na and K were determined from ammonium leachate using flame photometer. While, Ca and Mg was determined by using Atomic Adsorption Spectrophotometer (AAS). Exchangeable Acidity (EA) this was determined titrimetrically using 1.0N KCl extract (McLean, 1982).

Fractionation of the Inorganic Phosphorus

Various fractions of soil inorganic P was extracted sequentially from the treated soils and measured according to the procedure described by Chang and Jackson (1957) .Firstly, 1.0mol L^{-1} of NH_4Cl was used for the extraction of loosely bound P(NH_4Cl-P), then 0.5mol L^{-1} NH_4F for the Al phosphates (Al-P),0.1mol L^{-1} of NaOH for the Fe phosphates (Fe-P), 0.3mol L^{-1} of $Na_3C_6H_5O_7.2H_20$ and $Na_2S_2O_4$ for the occluded phosphates (Occl-P) and lastly, 0.25mol L^{-1} of H_2SO_4 for the Ca-P, Phosphates were determined colorimetrically according to the procedure described by Murphy and Riley (1962) using spectrophotometer.

Statistical analysis

The data collected were subjected to analysis of variance (ANOVA) using a statistical package SAS (2002) version 9.0.The Duncan Multiple Range Test (DMRT) was used to separate the means and specific pair wise comparison of treatment means was also done using Least Significant Difference (LSD) at 5% level of probability.

RESULTS AND DISCUSSION

Physical and Chemical properties of the soil

The result obtained for some selected physical and chemical properties of the soil used for the screen house experiment are presented in Table 1.The particle size distribution revealed that the texture of the soil was loamy sand with moderately acidic in reaction. These suggest that the soils have no acidity problem (pH 5.60) and there will be availability of most nutrients to crop roots. Most plant nutrients are readily available to crop roots at pH range 5.0 to 6.5 (Adeboye *et al*., 2009; Tsado *etel*., 2014).

Organic carbon content of soil was low (6.98 g kg^{-1}). Tsado *et al.* (2014) reported that low to medium organic carbon rate for savanna soil was attributed to scarcity of vegetation cover, rapid mineralization of organic matter, inadequate return of crop residues and short fallow periods. The soil total N and available P were equally low and could be due to low organic matter contents as organic matter is regarded as the major reservoir of P and N (Haynes and Mokolobate, 2001).Furthermore, it can be attributed to continuous cropping and increased land use intensity. (Mafongaya *et al.*,2003). The available P which was low could be due to its fixation by Fe and Al sesquioxides and pH status of the soil as earlier reported by Uzobo and Oti (2004) and Adegbenro *et al*, (2011).

The exchangeable bases and CEC that were also low could be trace to low activity of clay and organic matter (Adamu, 2013).However, the base saturation of the soil which was high could be due to the dominance and abundance of the exchangeable cations on adsorption complex.

Table.1: Initial physical and chemical properties of the soil

Soil properties	
Particle size distribution (g kg^{-1})	
Sand	870.40
Silt	87.80
Clay	41.80
Textural class	loamy sand
pH H_20 (1:1)	5.60
Organic C. (g kg^{-1})	6.98
Total N. (g kg^{-1})	0.12

Available P. (mg kg^{-1})	6.89
Exchangeable bases (cmol kg^{-1})	
Ca^{2+}	4.10
Mg^{2+}	2.62
K^{+}	0.21
Na^{+}	0.74
Exch.acidity (H^{+} + Al^{3+}) (cmol kg^{-1})	0.80
CEC (cmol kg^{-1})	8.47
Base saturation (%)	90.55

Inorganic Phosphate Availability

Generally, the amount of NH_4Cl-P and Olsen-P were generally increased for those pots that were treated with animal manure compared to those pots without animal manure (Table 2). The content of NH_4Cl-P and Olsen-P are considered the most available fraction of PO_4 in soils. Although the former cannot exist for a very long time because it is readily transformed into Al-P and as time passes into Fe-P (Zhang *et al*, 2010). It was observed that the increment on these P contents were higher in the second trial which could be due to the residual effect from the first trial.

Also, it was observed that the Fe-P and Al-P were higher than Ca-P content irrespective of the animal manure sources in both the first and second trial(Table 3 and 4). This is supported by Wang *et a*l (2009) and Tsado *et al*, (2014). They further confirmed that phosphate is predominantly precipitated as Fe and Al phosphate in acid soil while Ca-phosphate is the main inorganic P fraction in calcareous soils. There was significant difference in Occls-P, Fe-P, Al-P, and Ca-P among the types of animal manure used and their rates of application. Generally, Occl-P is regarded as unavailable to plants but transformed into available form when animal manure were added. To mobilize Occl-P, an organic acid must first remove its Al-P oxides coat which is generally achievable by complexion Al and Fe with organicligands (Reyes *et al*, 2006). the significant higher total-P content of the soil when animal manure were added compared with no animal manure (control) may be to higher oxides of Fe and organic carbon contents which are effective immobilizers of P as suggested by Chang and Chu (1961).

Generally, there was no significant interaction between the animal manure sources and their rates of application on the different forms of P. The result revealed better P mobilizations effect of animal manure addition during the second trial compared with the first trial, these could be attributed to the residual effect of the first trial of animal manure applications as suggested by Tsado (2014).

TABLE 2. Soil Olsen-P and NH_4Cl-P (mg kg^{-1}) for the first and second trial as affected by animal manure source and rates of application

	Initial trial		Second trial	
Treatments	**Olsen-P**	**NH_4Cl-P**	**Olsen-P**	**NH_4Cl-P**
Animal manure source (AM)				
Poultry manure	54.27[a]	60.13[a]	58.09[a]	63.82[a]
Goat manure	49.17[b]	45.02[b]	51.48[b]	49.12[b]
Cow dung	41.66[c]	35.39[b]	44.43[c]	38.77[b]
$LSD_{0.05}$	0.58	10.27	0.68	1.89
Rates (ton ha^{-1})				
0	31.87[d]	33.34[d]	34.07[d]	36.44[c]
2.5	45.28[c]	42.29[c]	48.61[c]	45.99[b]
5.0	49.73[b]	47.44[b]	53.13[b]	51.61[b]
7.5	56.13[a]	57.10[ab]	58.32[a]	58.38[a]
10	58.87[a]	58.05[a]	61.57[a]	60.43[a]
$LSD_{0.05}$				
Rates	0.78	4.75	0.88	1.75
AM * Rates	NS	NS	NS	NS

Means followed by different letters within the same column and row are significantly different (P<0.05), NS = not significant (p < 0.05), LSD= Least Significant Difference,

TABLE 3. Soil Occl-P and Al-P (mg kg^{-1}) for the first and second trial as affected by animal manure source and rates of application

	Initial trial		Second trial	
Treatments	**Occl-P**	**Al-P**	**Occl-P**	**Al-P**
Animal manure source (AM)				
Poultry manure	143.49^{c}	29.61^{b}	140.06^{b}	30.32^{b}
Goat manure	164.12^{b}	33.37^{a}	158.56^{a}	32.16^{ab}
Cow dung	168.31^{a}	34.68^{a}	164.31^{a}	32.47^{a}
$LSD_{0.05}$	1.58	10.27	2.86	1.89
Rates (ton ha^{-1})				
0	181.55^{a}	40.15^{a}	181.00^{a}	37.43^{a}
2.5	163.64^{b}	35.12^{b}	157.19^{b}	33.86^{b}
5.0	156.33^{b}	32.93^{b}	149.99^{bc}	31.66^{b}
7.5	149.69^{bc}	29.30^{c}	144.02^{c}	28.68^{c}
10	142.00^{c}	25.28^{c}	140.39^{c}	26.80^{c}
$LSD_{0.05}$				
Rates	1.25	4.75	5.22	1.75
AM * Rates	NS	NS	NS	NS

Means followed by different letters within the same column and row are significantly different ($P<0.05$), NS = not significant ($p < 0.05$), LSD= Least Significant Difference,

TABLE 4. Soil Fe –P and Al-P (mg kg^{-1}) for the first and second trial as affected by animal manure source and rates of application

	Initial trial		Second trial	
Treatments	**Fe-P**	**Ca-P**	**Fe-P**	**Ca-P**
animal manure source (AM)				
Poultry manure	88.81^{b}	8.06^{b}	97.51^{b}	7.36^{c}
Goat manure	93.92^{a}	8.15^{b}	99.14^{ab}	8.48^{b}
Cow dung	95.95^{a}	10.27^{a}	102.15^{a}	9.62^{a}
$LSD_{0.05}$	1.29	4.85	11.92	11.57
Rates (ton ha^{-1})				
0	111.23^{a}	10.16^{a}	106.20^{a}	9.65^{a}
2.5	93.31^{b}	9.21^{ab}	103.40^{b}	8.68^{ab}
5.0	89.64^{b}	8.94^{b}	98.96^{b}	8.26^{b}
7.5	86.12^{b}	8.77^{b}	97.03^{b}	7.98^{b}
10	84.17^{b}	8.32^{b}	96.30^{b}	7.87^{b}
$LSD_{0.05}$				
Rates	2.94	1.57	8.27	4.20
AM * Rates	NS	NS	NS	NS

Means followed by different letters within the same column and row are significantly different ($P<0.05$), NS = not significant ($p < 0.05$), LSD= Least Significant Difference,

TABLE 5.Soil Total –P (mg kg^{-1}) for the first and second trial as affected by animal manure source and rates of application

	Initial trial	Second trial
Treatments	**Total –P**	**Total-P**
Animal manure source (AM)		
Poultry manure	346.97^{a}	349.02^{a}
Goat manure	340.25^{b}	348.86^{a}
Cow dung	340.20 ^{b}	330.20^{b}
$LSD_{0.05}$	17.18	21.52
Rates (ton ha^{-1})		
0	376.82^{a}	370.70^{a}
2.5	344.00^{b}	349.11^{b}
5.0	330.78^{c}	340.47^{bc}
7.5	324.00^{cd}	336.09^{c}
10	317.82^{d}	332.13^{c}
$LSD_{0.05}$		
Rates	12.63	26.58
AM * Rates	NS	NS

Means followed by different letters within the same column and row are significantly different (P<0.05), NS = not significant (p < 0.05), LSD= Least Significant Difference.

CONCLUSION

This study has shown that animal manure (poultry, goat and cow dung) greatly increase Olsen-P and NH_4Cl-P thus increasing the availability of P in the soil. While Al-P, Fe-P, Occl-P and Ca-P were also mobilized and released to various degrees irrespective of the animal manure sources and rates of application. The influence of animal manure release P occurred in order of poultry manure> goat manure> cow dung. The practical implication of this experiment is that animal manure could be used to reduce the rates of fertilizer P required for optimum growth on acidic and P-fixing soils in Nigeria.

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