Journal of Agriculture and Sustainability
ISSN 2201-4357
Volume 4, Number 2, 2013, 177-190

Assessment of Manure Management Practices and Nitrogen Levels on Soil Phosphorus in an Alfisol

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Abstract. Field studies were conducted in an Alfisol in two different locations at Samaru-Zaria, Nigeria. The objectives were to determine the effects of cow dung management practices, time of application and urea fertilizer on the soil phosphorus content at direct and residual effects in two locations. The treatments consisted of 3 management practices, 4 durations of field storage and 2 levels of urea arranged in a 3x4x2 factorial experiment fitted to a randomized complete block design with 3 replicates. The soil texture of the two locations were different, this contributed to the differences in the available P of the soils of the two locations. The application of the cow dung irrespective of how it was managed resulted in significant ($P < 0.05$) increase of available P in the soil more than the control. The combination of the management practices (handling methods, time of application and urea levels) significantly ($P < 0.05$) affected the available P of the soil, but none of the treatments showed any consistency at the two locations and at direct or residual effects. The direct effects tend to have high available P values than the residual effects at both 4 Weeks after planting and at harvest in the two locations.

Keywords: Alfisol, available phosphorus, cow dung management, direct and residual effects, duration of field storage, Nigeria, urea.

INTRODUCTION

According to Camberato *et al*. (1996) and Fulhage (2000) the nutrient content of manure varies widely with animal species, age, ration quality and feed consumption, as well as with different methods of storage, handling methods, housing type, temperature and moisture content, treatment and land application. According to Fulhage (2000), manure contains the three major plant nutrients: nitrogen, phosphorus and potassium (NPK), as well as many essential nutrients such as Ca, Mg, S, Zn, B, Cu, Mn. In addition to supplying plant nutrients, Fulhage (2000) further explained that, manure generally improves soil tilth, aeration, and water holding capacity of the soil and promotes growth of beneficial soil organisms. Manure applied in the proper amounts at the appropriate time can supply some, if not all, of the nutrient requirements of many crops.

Phosphorus is one of the main limiting plant nutrients and its deficiency is a major constraint for better crop production in most tropical soils (Tchienkoua and Zech, 2003). Nitrogen and available P are the most deficient plant nutrient elements in Nigeria (Ayeni, 2012). The deficiency of P primarily occurs as a result of shortage of inherent soil P, depletion of soil P by crop removal, sorption and fixation of P with Fe and Al oxides and hydroxides (Solomon andLehmann,2000).In animal manure management, P is the nutrient of major concern on soils with high P fertility levels (Johnson and Eckert, 2009). Phosphorus applied to fields as manure or commercial fertilizer can move into bodies of water during erosion and runoff events, and is largely responsible for the accelerated eutrophication of many bodies of water (Johnson and Eckert, 2009). Phosphorus leaching from soils with elevated P levels due to manure applications is increasingly becoming a concern as a source of eutrophication of streams and lakes (Lehman *et al*., 2005).

There is limited information available with respect to the crop response to manure P (P.E.I., 2005). This explained that crop response to P is dependant on the method of application since P is not as mobile in the soil as nitrogen. When fertilizing with manure for the first time, care should be exercised to ensure that sufficient P is applied. In general, 50% of the total P in manure is available to plants in the first year. To ensure enough P is available to a growing crop, add 14 to 17 kg/ha of P_2O_5 as a starter fertilizer with the seed. Application of P, especially on P deficient soils promotes root growth, stimulates tillering, and influences favourable better growth and thereby better yield and juice quality of sugarcane (Bokhtail and Sakurai, 2003). Phosphorus deficiency leads to reduced metabolic rate and photosynthesis which then leads to reduction in yield and quality. While most soils, contain a high proportion of reserves of total P, most of it remains relatively inert and less than 10 % of the P enters the plant – animal cycle (Pal and Allan, 1992). Quite noticeable in tropical sites are the effects of manure as a P fertilizer and the improved effectiveness of mineral P fertilizers when combined with manure (Mokwunye, 1980). Agboola *et al.,* (1975) described a typical case of this on an extremely acidic, humid tropical site, where they found that mineral P fertilizer had no effect on cowpea. But, when the fertilizer was applied with relatively small amounts of farmyard manure (2.5 t ha^{-1}), increasing the amount of P applied also increased yields. The objectives of this study were to determine the effects of cow dung management practices, time of application and Urea fertilizer on the soil P content in an Alfisol at direct and residual effects in two locations.

MATERIALS AND METHODS

Location and description of experimental site.

The field studies were carried out at Samaru at two different locations within the same zone at the IAR Research Farms and the Samaru College of Agriculture (SCA) Farm, Samaru, which are both located at Latitude 11^o 11" N and Longitude 7^o 33" E in the Northern Guinea Savanna zone of Nigeria.

Samaru has mean annual rainfall of about 1050 mm, spanning the periods from May to September, while the dry season starts from October to April with a mean daily temperature of 24^o C (Kowal & Knabe, 1972). The hottest months are those that precede the rains (March to April) and coldest months occur in November to January, October and February are considered as transition months. The global radiation is evenly distributed throughout the year, ranging from 440 cal. cm^2 day^{-1} in August to 550 cal. cm^2 day^{-1} in April to May (Kowal, 1972).

Cow dung collection and subjected to management practices.

The study consisted of collection and incubation of cow dung and subsequent evaluation using field experiments. The cow dung that was used for these experiments were collected from the National Animal Production Research Institute (NAPRI), Shika-Zaria in years 2003 and 2004. The cow dung collected was subjected to different management practices as described in figure 1.

Weeks	Treatments	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Duration of Storage
Month		January				February				March				April				May				
Activity	Treatment 1					Composting				Field Storage												12wks
	Treatment 2									Composting				Field Storage								8wks
	Treatment 3													Composting				Field Storage				4wks
	Treatment 4																	Composting				0 wk

Figure 1. Diagrammatic Presentation of Experimental set up.

Fresh cow dung was collected early in the morning from pens and piled into a heap. The cow dung was then mixed thoroughly with a shovel with the aim of harmonizing it. After mixing it thoroughly, it was then subjected to the various management schedules as follows: (i) cow dung placed in a pit of 2 x 2 m and 75 cm deep and covered (PC) with a polythene sheet, (ii) cow dung heaped on the ground surface and covered (SHC) with a polythene sheet, and (iii) cow dung heaped on the ground surface and left uncovered (SHU). The collection of the cow dung and its distribution to the 3 different management practices was repeated for the next 2 days as described above until adequate cow dung was gathered. The cow dung was then allowed to decompose for four weeks (one month, composting) without any disturbance before it was removed and stored in the field.

This experiment started in February, 2003 with the collection of cow dung and allowing it to decompose (composting) for 4 weeks which means the field storage (exposure) of the cow dung was from March to May (12 weeks of field storage before application to the soil as amendment). The same cow dung treatment as described for February above was repeated in March against April to May (8 weeks of field storage before application to the soil as amendment), April against May (4 weeks of field storage before application to the soil as amendment) and May against June (0 week) where cow dung was collected at the termination of composting and applied to the field immediately, without field storage (the moisture content was taken into consideration). The same procedure was repeated in the second year (2004).

Cow dung and Soil sampling and preparation.

Cow dung samples were taken after subjecting the cow dung to the three different management practices i.e. (PC, SHC and SHU) but before taking them to the field for storage. This set of cow dung after collection was air dried and stored for analysis. The second sampling of the cow dung was done at the end of field storage, before application and incorporation into the soil in the field (at this stage, the cow dung treatments must have been exposed at the field in storage after the 1 month of composting for different time durations of 12 weeks - 0 week). These were all carefully processed and kept for analysis and for use in the field.

Before the commencement of the experiment surface soil sample (0 to 20 cm depth) was collected from the field where the field experiment was conducted at IAR and SCA farms. After the experiment had been established, soil samples were collected at two stages of plant growth with a soil auger at 0 to 20 cm. The first sampling was at 4 WAP and the second sampling was at harvest. Samples were taken from each plot in the 3 replicates. Soil samples were collected at 3 different points diagonally across the plot and bulked together and a subsample taken. In the second year of the experiment, when the residual effect was to be observed, the same plots were maintained and the ridging was also done manually to avoid the transfer of soil from one plot to another. The same procedure for soil sampling and processing carried out in the first year was maintained in the second year. In each case the samples were carefully air dried, sieved with a 2 mm sieve and stored for analysis.

Cow dung and Soil analysis.

The surface soil samples for field studies were analyzed by the following methods: particle size distribution using the standard hydrometer method (Klute, 1986) . The soil pH was determined in water and 0.01 M $CaCl_2$ with a pH glass electrode using a soil: solution ratio of 1:2.5. Organic Carbon was determined by wet oxidation method of Walkley–Black (Nelson & Sommers, 1982).

Exchangeable bases were determined by extraction with neutral 1 N NH_4O AC saturation method. Potassium and Sodium in the extract were determined by the flame photometer, while Ca and Mg were determined by atomic absorption spectrophotometer (Juo, 1979). Available P was extracted by the Bray 1 method. The P concentration in the extract was determined calorimetrically using the spectronic 70 spectrophotometer. Total N was determined by the Kjeldahl procedure (Bremner & Mulvaney, 1982; Bremner, 1982).

Field Experiments.

The field experiments were conducted at two locations. The first trial was carried out at the IAR Farm, Samaru in the year 2003 season. The second trial was established at the SCA Farm, Samaru in 2004 season. In all the experiments, the same treatment combinations, experimental design, observations and procedures were maintained.

The experiment was a factorial experiment with 3 factors, laid out in a randomized complete block design replicated three times. The treatments were: 3

cow dung management practices, 4 different storage times after 1 month incubation (composting) before application to the field, 2 levels of N (3x4x2). There was a control treatment where no cow dung or nitrogen fertilizer was applied. These gave a total of 25 treatment combinations.

The land was plowed and harrowed and the field was mapped out into plots in the first year of the experiment. The plot sizes were 4 x 5 m (20m^2) and each plot was separated from the other by one meter. The plots were then immediately ridged manually at 75 cm between ridges with the hand hoe to incorporate the cow dung. Cow dung subjected to different management practices which had been conveyed and stored in the field at different times (March for 12 weeks, April for 8 weeks, May for 4 weeks and June for 0 week) were applied manually at 5.0 t ha^{-1} on dry matter weight basis.

In both years of the experimentation, maize (Var. Oba super II) dressed with Fernasand D was sown at two seeds per hole, at a spacing of 25 cm within the row. The seedlings were later thinned to one plant per hill at two weeks after planting.

A blanket application of P was applied as single super phosphate (SSP) at the rate of 60 kg P_2O_5 ha^{-1} and 45 kg N ha^{-1} as urea was applied in two split equal doses to the appropriate plots. The first application was done immediately after the first weeding (3 WAP). The second dose was applied at the time of second weeding (6 WAP). In each case the fertilizer was applied by single band about 5 cm deep, made along the ridge, 5-8 cm away from the plant stand and covered immediately.

RESULTS AND DISCUSSION

The results of some physical and chemical properties of the experimental sites are presented in Table 1. The soil texture of the two locations was not the same, a sandy loam in IAR farm and a silt loam in SCA farm. This must have contributed to the differences on the results that were observed in the two locations. I t has been reported that differences in soil texture could lead to differences in available P (Ayeni, 2010); different soil textures might result in different microbial activities, pH buffering capacity, infiltration rate and accretion (Ayeni, 2012).

The results of the soil available P was significantly ($P < 0.05$) affected by the various treatments in the two locations (Tables 2 and 3), however there was no clear relationship. Management practices, duration of field storage and urea fertilizer, did not clearly affect the available P content of the soil. Larney *et al.* (2005) reported a similar result that, the manure handling treatments did not have a significant effect on percent available phosphorus of manure.

In the two farms all the treatments that did not receive manure application gave the lowest available P values at both direct and residual effects, though the pattern was a little bit different in the SCA farm. Comparing the results of the direct and residual effects in the two locations, the direct effects tend to have high available P values than the residual effects at both 4 WAP and at harvest. There was no treatment that showed any level of consistency in the two locations and at the two stages of sampling. These results showed that the addition of manure generally increased the soil available P. Ayeni (2012) reported a similar result, that the addition of cattle dung, cattle dung + urea and urea a lone increased the available P of the soil more than the control treatment. But because of the various interactions of factors (temperature, rainfall, microbial population and activity)that are involved on the various treatments, which could affect the available P there was no consistency on the behaviour of the treatments for the two locations and at the direct and residual effects. It has been reported that a deficit of P or a decrease in its availability on cultivated soils can be counteracted by fertilizing with farm yard manure (Godefroy, 1979; Prasad and Singh, 1980). The reasons why manure brings about an increase in available P are both chemical (higher pH, lower C/P ratio) and biological (heightened biological activity, increased mineralization of P compounds, increased root activity etc). Ayeni (2012) explained that the increase might be as a result of P available in cattle dung together with the native organic P already present in the soils. That the treatments applied 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 organic carbon. Ofori (1980) suggested the following additional reasons for P availability due to manure application in the soil: organic colloids prevent dissolved phosphate from coming into contact with free aluminium and iron; when organic matter decays, the carbonic acid then forms dissolved phosphate; organic phosphorus is less strongly fixed by the soil and microorganisms mineralized organic phosphate compounds.

CONCLUSION

The soil texture of the two locations were different, this must have contributed to the differences in the available P of the soils of the two locations. The application of the cow dung irrespective of how it was managed, time of application and with or without urea resulted in significant ($P < 0.05$) increase of available P in the soil more than the control. The combination of the management practices (handling methods, time of application and urea levels) did not significantly affected the available P of the soil, and none of the treatments showed any consistency at the two locations and at direct or residual effects. The direct effects tend to have high available P values than the residual effects at both 4 WAP and at harvest in the two locations.

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Table 1.Some physical and chemical properties of the soil of the first and second experimental sites at commencement of study.

Parameters	IAR Farm	SCA Farm
Sand (g kg^{-1})	640	360
Silt (g kg^{-1})	210	540
Clay (g kg^{-1})	150	100
Texture	Sandy loam	Silt loam
pH 1:2.5 (H_2O)	5.90	5.90
pH 1:2.5 ($CaCl_2$)	5.10	5.20
Organic Carbon (g kg^{-1})	74.0	44.0
Total N (g kg^{-1})	5.3	7.0
C/N ratio	14.0	6.3
Bray 1 P (mg kg^{-1})	7.00	2.00
Exchangeable Calcium (cmol kg^{-1})	2.00	1.60
Exchangeable Magnesium (cmol kg^{-1})	0.80	1.00
Exchangeable Potassium (cmol kg^{-1})	1.84	0.49
Exchangeable Sodium (cmol kg^{-1})	1.87	1.13

IAR = Institute for Agricultural Research

SCA = Samaru College of Agriculture

Table 2 Effects of manure management practices, time of application and nitrogen levels on soil available phosphorus (mg kg $^{-1}$) in IAR farm.

Treatments	Direct effect(2003)				Residual effect(2004)			
	At 4 WAP		At harvest		At 4 WAP		At harvest	
	oN	+N	oN	+N	oN	+N	oN	+N
SHU								
SHUM	16.0abc	12.0c	14.0a-d	13.0cd	11.0b-f	8.0efg	6.0d	6.0d
SHUA	10.0c	11.0c	22.0a	22.0a	7.0fg	15.0a	8.0bcd	7.0cd
SHUY	10.0c	13.0bc	12.0cd	9.0cd	8.0d-g	13.0a-d	12.0ab	12.0ab
SHUJ	15.0abc	13.0bc	13.0bcd	14.0a-d	8.0d-g	7.0fg	8.0bcd	14.0a
SHC								
SHCM	16.0abc	21.0ab	11.0cd	14.0a-d	7.0fg	8.0d-g	6.0d	6.0d
SHCA	10.0c	13.0bc	11.0cd	10.0cd	8.0fg	9.0c-g	11.0abc	6.0d
SHCY	17.0abc	22.0a	18.0abc	11.0de	8.0d-g	9.0c-g	8.0bcd	9.0bcd
SHCJ	10.0c	11.0c	18.0abc	10.0cd	16.0a	13.0abc	6.0d	8.0bcd
PC								
PCM	9.0c	10.0c	11.0dc	11.0cd	10.0b-f	5.0g	6.0d	10.0bcd
PCA	11.0c	11.0c	12.0cd	15.0a-d	17.0a	12.0a-d	7.0cd	8.0bcd
PCY	11.0c	17.0abc	14.0a-d	9.0cd	14.0ab	10.0c-f	9.0bcd	9.0bcd
PCJ	10.0c	11.0c	15.0a-d	9.0cd	9.0c-f	11.0b-f	8.0bcd	9.0bcd
Control	9.0c		9.0d		7.0fg		6.0d	
SE±	2.57		2.63		1.37		1.22	

Means with the same letter(s) within the same group are not significantly different at 5% level of significance

SHUM = Surface heaped uncovered March, SHUA = Surface heaped uncovered April, SHUY = Surface heaped uncovered May, SHUJ = Surface heaped uncovered June

SHCM = Surface heaped covered March, SHCA = Surface heaped covered April, SHCY = Surface heaped covered May, SHCJ = Surface heaped covered June

PCM = Pit covered March, PCA = Pit covered April, PCY = Pit covered May, PCJ = Pit covered June

oN = Direct evaluation, +N = 45 kg N ha $^{-1}$

Table 3 Effects of manure management practices, time of application and nitrogen levels on soil available phosphorus (mg kg $^{-1}$) in SCA farm.

Treatments	Direct effect(2004)				Residual effect(2005)			
	At 4 WAP		At harvest		At 4 WAP		At harvest	
	oN	+N	oN	+N	oN	+N	oN	+N
SHU								
SHUM	25.0bc	14.0f-j	16.0de	11.0g	11.0def	8.0h-k	8.0g-j	9.0e-h
SHUA	13.0f-j	14.0f-j	35.0a	37.0a	5.0l	15.0c	13.0cd	10.0def
SHUY	13.0hij	12.0hij	17.0d	12.0fg	12.0d-g	13.0d	17.0a	13.0b
SHUJ	21.0d	12.0hij	15.0d-g	22.0c	7.0ijk	8.0h-k	10.0def	17.0a
SHC								
SHCM	25.0bc	32.0a	14.0d-g	13.0efg	8.0ijk	6.0jkl	7.0hij	7.0hij
SHCA	16.0e-h	18.0e	12.0fg	12.0fg	7.0jkl	8.0g-k	11.0de	8.0g-j
SHCY	26.0b	33.0a	28.0b	12.0fg	10.0e-i	10.0d-h	7.0hij	8.0g-j
SHCJ	13.0f-j	10.0j	24.0c	11.0g	22.0a	10.0d-i	7.0hij	9.0fgh
PC								
PCM	11.0j	12.0hij	11.0g	14.0d-g	12.0de	6.0kl	6.0j	13.0bc
PCA	16.0efg	11.0ij	12.0fg	24.0c	22.0a	16.0c	10.0d-g	11.0cde
PCY	17.0ef	23.0cd	14.0d-g	12.fg	19.0b	8.0h-k	12.0bcd	8.0f-j
PCJ	13.0g-j	12.0hij	15.0def	11.0g	7.0ijk	8.0g-k	8.0f-j	8.0f-j
Control	15.0e-i		14.0d-g		9.0f-j		9.0f-j	
SE±	1.02		1.05		0.83		0.63	

Means with the same letter(s) within the same group are not significantly different at 5% level of significance

SHUM = Surface heaped uncovered March, SHCM = Surface heaped covered March, PCM = Pit covered March,
SHUA = Surface heaped uncovered April, SHCA = Surface heaped covered April, PCA = Pit covered April,
SHUY = Surface heaped uncovered May SHCY = Surface heaped covered May PCY = Pit covered May
SHUJ = Surface heaped uncovered June SHCJ = Surface heaped covered June PCJ = Pit covered June

oN = Direct evaluation, +N = 45 kg N ha $^{-1}$