ASSESSMENT OF MANURE MANAGEMENT PRACTICES AND NITROGEN LEVELS ON SOIL TOTAL NITROGEN IN AN ALFISOL.

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ABSTRACT

An experiment was set up to investigate the effects of cow dung subjected to different management practices and Urea fertilizer on the total nitrogen content of the soil at direct and residual effects in an Alfisol.
The studies were conducted at Samaru at two different locations, Institute for Agricultural Research and Samaru College of Agriculture farms (Lat. 11° 11" N and Long. 7° 38" E), located in the Northern Guinea Savann ecological zone of Nigeria. The treatments and experimental design in the fields comprised of 3 cow dung management practices, 4 storage times and 2 nitrogen levels with a control treatment where no cow dung or urea fertilizer was applied. The study was a factorial experiment, laid out in a randomized complete block design, replicated 3 times. The results showed that there was no single practice or a combination that clearly gave higher values of total nitrogen at both direct and residual effects in the two locations because of the divergent factors affecting the nitrogen release pattern from the organic materials to the soil; among the management practices and duration of field storage that were examined in this study. However, it was observed that the nitrogen amended (+N) treatments mostly gave significantly (P > 0.05) higher total nitrogen values than the direct evaluation (oN) treatments and the control treatments tends to be lower than treatments where cow dung was added at both direct and residual effects.

Keywords: Alfisol, Cow dung, Management practices, Total nitrogen, Urea.

1.0 Introduction

Soils of the Nigerian northern Guinea savanna (NGS) ecological zone have mainly low- activity clays and low soil organic matter (SOM) hence have low buffering capacities (Odunze, 2003a). However, continuous intensive cultivation with application of sole urea fertilizer could alter the soil physical and chemical properties by decreasing the pH and reducing the exchangeable base contents which leads to soil degradation (Odunze*et al*., 2012).

As a result of these problems and the increasing soil degradation, the use of sole urea fertilizer is greatly minimized in crop production practices at present (Vanlauwe *et al.*, 2001a; Odunze *et al.*, 2012). This has led to the increasing research efforts on combining organic and synthetic amendments to enhance crop production to a sustainable level. The combination of organic and synthetic amendments would reduce the amount of synthetic fertilizer needed and the amounts of nutrients contained in the synthetic fertilizers may be more efficiently utilized (Vanlauwe *et al.,* 2002). The loss of soil fertility in many developing countries poses an immediate threat to food production. Agricultural soils lose their fertility by plant nutrient exhaustion among other factors, a real and immediate threat to food security and to the lives and livelihood of millions of people.
The loss of fertility reduces yields and affects water holding capacity leading to greater vulnerability to drought, for the farmer and the entire ecosystem (Alam and Khan, 1999).

Nitrogen and phosphorus are the most deficient nutrient elements in most Nigerian soils (Obigbesan, 1999). Nitrogen use and demand is continuously increasing day by day (Abd El-Lattief, 2011). Since it is highly mobile, it is subjected to greater losses from the soil-plant system (Abd El-Lattief, 2011). Even under the best management practices, 30-50 % of applied N is lost through different agencies (Van Horn *et al*., 2009;Abd El-Lattief, 2011); hence, the farmer is compelled to apply more than the actual need of the crop to compensate the loss (Abd El-Lattief, 2011). Current management systems result in 75 % loss of total N excreted by animals and poultry (Agrotain, 2005). The loss of N not only troubles the farmer, but has also harzadous impacts on the environment (Tadesse *et al*., 2013).

Nitrogen is a primary plant nutrient that plays a major role in achieving the maximum economic yields for crop production. Management of nitrogen and other essential nutrients, is part of a balanced fertility programme. This can lead to increased efficiency and profitability of the grower (Anonymous, 2001). The nutrient content of manure (particularly nitrogen) declines with time during collection, storage and land application. This is due to such processes as ammonia volatilization, as well as leaching and surface runoff of all soluble forms of nutrients (particularly nitrate) (P E I, 2005; Van Horn *et al.*, 2009). They further explain that, proper management can reduce losses, maximize the nutrient value of the manure and minimize potential soil and water pollution. This includes using proper facilities for storage and handling, applying manure to cool, moist soil in fall or early spring and incorporating it immediately (or applying it by subsurface injection). Gehl *et al*. (2005) listed some other soil management practices that can reduce the loss of N as: incorporating straw with high C:N ratio, minimum tillage, timing of fertilizer application, so that nutrient supply is synchronized with plant demand. Also split application of N is one of the methods to improve N use by crops while reducing the nutrient loss through leaching and volatilization (Tolessa *et al*., 1994).

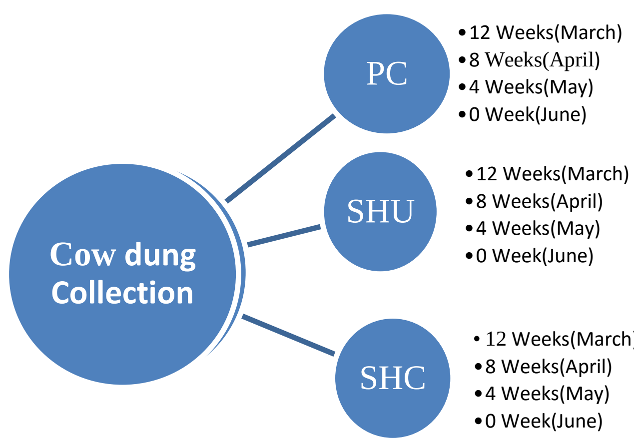
Sathish *et al*. (2011) stated that, the current energy crisis prevailing higher prices and lack of proper supply system of fertilizer calls for more efficient use of organic manure and other organic residues with inorganic fertilizers to sustain yield levels. They also explain that, organic products besides supplying nutrients to the first crop, it also provides substantial residual effect of un utilized nutrients on the succeeding crop. In recent years the focus on soil fertility research has been shifted towards the combined application of organic matter and inorganic fertilizers as a way to arrest the ongoing soil fertility decline in sub-saharan Africa (Vanlauwe, *et al*, 2001c). A combination of organic and synthetic amendments has been reported to improve crop yield, soil fertility levels or both (Palm *et al*., 1997; Vanlauwe *et al*., 2002; odunze *et al*., 2012). Considering the above facts, the present study was under taken to investigate the effects of cow dung subjected to different management practices and inorganic fertilizer (Urea) on the total nitrogen content of the soil at direct and residual effects in an Alfisol.

2.0 Materials and Methods

The studies were conducted at Samaru at two different locations, IAR Research Farm and the Samaru College of Agriculture (SCA) Farm, (Lat. 11^{o} 11" N and Long. 7^{o} 38" E) located in the Northern Guinea Savanna zone of Nigeria.

2.1 Cow dung collection and management practices.

The cow dung that was used for these experiments were collected from the National Animal Production Research Institute (NAPRI), Shika-Zaria in years 2008 and 2009. The cow dung collected was subjected to different management practices as described below (Fig. 1).



Stage 1 Stage 2 Stage 3

Stage 1= Cow dung Collection
Stage 2=Management Practices (composting or incubation) for four weeks
Stage 3= Field Storage (Exposure) before use in the field

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 with a polythene sheet (P C), (ii) cow dung heaped on the ground surface and covered with a polythene sheet (SHC), 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, the ageing period) without any disturbance before it was removed and stored in the field.

This experiment started in February, 2008 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 in March to May (12 weeks of field storage before application to the soil as amendment) (Fig. 2). 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 (incubation) 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 (2009).

Weeks		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Duration of Storage
Month	Treatments	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 2. Diagrammatic Presentation of the collection and storage of Cow dung.

The field experiments were conducted at two locations. The first trial was carried out at the IAR Farm, Samaru in the year 2008 and 2009 seasons. The second trial was established at the SCA Farm, Samaru in 2009 and 2010 seasons. In all the experiments, the same treatment combinations, experimental design, observations and procedures were maintained. The treatments and experimental designs in the fields were 3 cow dung management practices, 4 different storage times after 1 month ageing of each month's cow dung collection before application in the field, 2 levels of N. However there was a control treatment where no cow dung or nitrogen fertilizer was applied. These gave a total of 25 treatment combinations. The study was a factorial experiment with 3 factors, laid out in a randomized complete block design replicated three times.

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 ridged manually at 75 cm between ridges and immediately after cow dung application to avoid the transfer of the manure from one plot to another and to also incorporate the manure into the soil.

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.

Cow dung subjected to different management practices which had been conveyed and stored in the field at different times (12weeks - 0 week) were applied manually at 5.0 t ha $^{-1}$ on dry matter weight basis in the first year of the experiment. The plots were then immediately ridged manually with the hand hoe to incorporate the cow dung. In the second year of the experiment, the residual effect of the first year applications was observed. That is, there was no application of cow dung in the second year.

In both years (direct and residual trials) 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. The same procedure was repeated in the second year, when the residual effect was to be observed.

A blanket application of P was applied as single super phosphate (SSP) at the rate of 60 kg P_2O_5 ha^{-1} and at 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. The second dose was applied at the time of second weeding. 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. All methods carried out in the first year were repeated in the second year of evaluating the residual effect.

2.2 Soil sampling and analysis.

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 each case the samples were carefully air dried, sieved with a 2 mm sieve and stored for analysis.

The soil samples for studies were analyzed by the following methods: for particle size distribution the standard hydrometer method (Klute, 1986) was used. 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 and Sommers, 1982).

Exchangeable bases were determined by extraction with neutral 1 N NH_4O AC saturation method. Potassium in the extract was 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 and Mulvaney, 1982 and Bremner, 1982).

2.3 Statistical Analysis

The data collected from the field studies were subjected to analysis of variance (ANOVA) using the SAS package (SAS Inst., 1999). Significant means were separated using the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

3.0 Results and Discussion

The results of some physical and chemical properties of the experimental sites are presented in Table 1. The results of the soil total nitrogen for IAR farm are shown in Table 2 for years 2008 and 2009 for the direct and residual effects at 4 WAP and at harvest. The total N was significantly ($P < 0.05$) affected by the various treatments. However, the results did not show any particular trend. For year 2008 (direct effect) at 4 WAP, it was the N amended pit covered April (PCA) treatment that gave the highest value (7.0 g kg^{-1}) while the lowest was observed at the pit covered June (PCJ) treatment of direct evaluation (4.3 g kg^{-1}). At harvest, it was the surface heaped uncovered March (SHUM) and control that gave the highest and lowest values 7.9 g kg^{-1} and 4.0 g kg^{-1} respectively. Gichangi *et al.* (2007) reported that the amount of N lost from manures that were covered was lower than that of uncovered manures. Kirchmann and Lundvall (1998) in their study reported low N losses under anaerobic conditions.

The residual effect showed a completely different pattern. At 4 WAP, the surface heaped covered June (SHCJ) treatment of direct evaluation gave the highest value (7.5 g kg^{-1}), while the lowest was recorded at the surface heaped uncovered March (SHUM) treatment (4.0 g kg^{-1}). At harvest the highest value was observed on surface heaped covered May (SHCY) treatment (7.0 g kg^{-1}), while the lowest was on the control treatment (3.9 g kg^{-1}).

In year 2009, at SCA farm the pattern of behavior was completely different from what was observed in 2008 at IAR farm (Table 3). However, the control treatment consistently gave the lowest total N in the two years, except at 4 WAP of direct evaluation. Many reasons had been attributed to differences in the release of N from the organic materials to the soil. These include among many other factors: the mineralogy of the soil, chemical and physical characteristics of the manure, pH, environmental conditions (temperature, rainfall etc), the quality of the soil organic N, rate of application, nutrient release pattern, and the quality of the organic inputs to the soil. These results agrees with the work of Beckwith and Parsons (1980), that the amount of nitrogen mineralized from manure and compost depends on soil mineralogy, also the organic material, chemical and physical characteristics (Catellanos and Pratt, 1981; Janssen, 1996) and environmental conditions (Adriano *et al.*, 1974, and Kissel, 1995). The rate of mineralization depends on many factors including temperature and rainfall, the quality of the soil organic nitrogen and the quality of organic inputs to the system (Palm *et al.,* 1997). Again since N mineralization is microbially driven (Bartholomew, 1965), it is influenced by many factors, including temperature and soil moisture, soil pH and manure characteristics (Pathak and Sarkar, 1994).

Larney *et al*. (2005) reported that, the fate of manure nutrients in Beef cattle (*Bos Taurus*) feedlots is influenced by handling treatments. But, comparing traditional practices (fresh handling , stockpiling) with newer ones (composting), on nutrient level and mass balance estimates of feedlot manure at Lethbridge, Alberta and Bradon, Manitoba, total N concentration was not affected by handling treatments. According to Van Horn *et al.* (2009) even with a "tightly" managed system, there is considerable N loss through ammonia volatilization. Current management systems result in 75 % loss of total N excreted by animals and poultry (Agrotain, 2005). The amount volatilized is influenced by level of N in the manure (particularly the part originating in the urine) and by the method of application. They further explained that, N in urine is originally excreted in the form of urea. Urease enzyme of bacterial origin is present almost everywhere manure is voided or stored so that N in urea is readily converted to ammonia which will be lost to the air as free ammonia unless the conditions of storage are acidic. According to them, it was estimated that 41 to 50% of the manure N from lactating dairy cows is in urea or ammonia form (mostly from the urine). This portion is potentially volatilized very rapidly. Most of the fecal N from cattle is in a more stable form; however, even organic N is freed and volatilized during anaerobic digestion. In analysing the sources of N losses Gelh *et al* (2005) and Van Horn *et al.* (2009) stated that, leaching losses also may occur. That is application of manures outside the growing season or in amounts which exceed crop needs may result in nitrate leaching losses of 25% or more of the applied N (after manure N has been converted to nitrate N in the soil). A high utilization of N by crops can be achieved with lowered environmental risks when manures are applied at a time when crops can absorb the mineral-N and at rates that do not exceed crop needs.

The other source of N loss as described by Van Horn *et al*. (2009) was denitrification. It is dependent upon a bacterial energy source, usually in the form of soluble organic matter, and progresses most rapidly under high moisture and/or low oxygen soil conditions. While collection and storage losses will be accounted for by sampling prior to land application, volatilization and denitrification losses after the manure leaves collection/storage are more difficult to quantify. Denitrification losses are harder to estimate on the farm but can be extensive. Measured denitrification losses have been found to be in excess of 120 lb/acre (54.43 kg/0.41 ha) during some years with manure application rates and systems (Newton *et al*., 1995).

To the farmers these losses account for high percentage cost of production. Since nitrogen is lost in large quantities annually, manure management practices will go a long way to reduce production costs and increased farmers' income especially in the ecological zone under study.

4.0 Conclusion

The total nitrogen of the soil is very difficult to be conserved because of the divergent ways it can easily be lost. The lost can be at the point of collection, handling/storage, land application or even after application in the soil. This loss has immense economic implications on cost of production visa vice returns. Its presence in the soil is also influenced by many factors, including the management practices and duration of field storage that were considered in this study. From the results there was no single practice or a combination that clearly gave higher values of total nitrogen at both direct and residual effects in the two locations. So whatever value(s) that was observed, was as a result of the combined divergent factors affecting total nitrogen in the soil. However, it was generally observed that the nitrogen amended (+N) treatments values were higher than the direct evaluation (oN) treatments and the control treatments tends to be lower than treatments where cow dung was added at both direct and residual effects and 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 Total Nitrogen (g kg $^{-1}$) in IAR Farm.

Treatments	Direct effect(2008)				Residual effect(2009)			
	At 4 WAP		At harvest		At 4 WAP		At harvest	
	oN	+N	oN	+N	oN	+N	oN	+N
SHU								
SHUM	4.9bc	6.8ab	5.6abc	7.9a	4.7ab	4.0c	4.9bc	4.7bc
SHUA	4.4c	5.2abc	4.9bc	6.3abc	4.9bc	6.1abc	5.5abc	6.1ab
SHUY	5.0abc	4.9bc	5.3abc	5.5abc	5.2bc	5.9abc	4.9bc	5.7abc
SHUJ	5.7abc	4.9bc	5.2abc	5.3abc	6.0abc	5.5abc	4.4bc	6.1ab
SHC								
SHCM	6.6ab	5.6abc	4.6bc	5.4abc	5.6abc	5.3bc	5.3abc	5.3abc
SHCA	4.3c	6.2abc	6.5abc	6.4abc	5.9abc	5.4abc	4.6bc	5.8ab
SHCY	5.8abc	6.6ab	6.4abc	7.3ab	5.0bc	6.2abc	7.0a	5.9ab
SHCJ	5.6abc	6.8ab	5.2abc	5.9abc	7.5a	6.1abc	5.9ab	6.1ab
PC								
PCM	5.2abc	5.6abc	6.7abc	4.8bc	5.8abc	6.0abc	5.6abc	6.1ab
PCA	6.1abc	7.0a	6.0abc	6.3abc	6.1abc	6.6ab	5.5abc	4.7bc
PCY	5.2abc	6.1abc	5.7abc	6.2abc	5.6abc	4.9bc	4.7bc	5.4abc
PCJ	4.3c	5.1abc	6.2abc	5.5abc	4.6bc	6.4ab	5.2abc	5.9ab
Control	5.1abc		4.0c		4.2c		3.9c	
SE±	0.61		0.80		0.65		0.53	

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 $^{-1}$

Table 3. Effects of Manure Management Practices, Time of Application and Nitrogen Levels on Soil Total Nitrogen (g kg $^{-1}$) in SCA Farm.

Treatments	Direct effect(2009)				Residual effect(2010)			
	At 4 WAP		At harvest		At 4 WAP		At harvest	
	oN	+N	oN	+N	oN	+N	oN	+N
SHU								
SHUM	3.5de	5.4bc	3.2ef	5.3bc	5.3b	3.4c	5.2b	5.4b
SHUA	3.4de	5.2bc	3.3ef	6.7a	3.3c	5.4b	5.2b	5.4b
SHUY	3.4de	2.4e	5.2bc	3.4ef	5.2b	3.6c	3.4c	3.7c
SHUJ	5.2bc	3.5de	5.3bc	5.4b	5.3b	3.6c	3.5c	5.3b
SHC								
SHCM	6.8a	4.1cd	3.3ef	3.8de	5.3b	5.2b	5.2b	5.4b
SHCA	3.5de	5.5bc	5.3bc	5.3bc	3.3c	3.4c	3.3c	5.2b
SHCY	5.5b	5.3bc	5.2bc	7.4a	3.3c	7.2a	6.7a	3.6c
SHCJ	5.3bc	5.4bc	3.4ef	5.4b	7.2a	5.4b	5.2b	6.8a
PC								
PCM	4.1cd	5.4bc	5.4b	3.8de	5.4b	5.5b	5.2b	5.4b
PCA	5.2bc	5.5bc	3.8de	5.0bc	5.3b	5.3b	5.2b	4.8b
PCY	5.2bc	5.3bc	4.4cd	3.5def	5.4b	3.3c	3.4c	3.4c
PCJ	3.4de	3.4de	5.2bc	3.3ef	3.7c	5.5b	5.2b	5.3b
Control	5.1bc		2.8f		3.2c		2.8d	
SE±	0.41		0.32		0.13		0.17	

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 $^{-1}$