EVALUATION OF MANURE MANAGEMENT PRACTICES AND NITROGEN LEVELS ON SOIL NITROGEN AND THE PERFORMANCE OF MAIZE IN AN ALFISOL

Supported by tetfund TERTIARY EDUCATION TRUST FUND

J. Tanimu[1]*, Edward O. Uyovbisere[2] and Sunday W.J. Lyocks[3]

[1]Department of Soil Science and Land Resources Management, Federal University Wukari, PMB 1020, Taraba State
[2]Soil Science Department, Institute for Agricultural Research, Ahmadu Bello University, Zaria
[3]Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria
*Corresponding author: joseph.tanimu@yahoo.com

Received: November 14, 2016 **Accepted:** March 02, 2017

Abstract: Field experiments were carried out in two locations to determine the effects of cow dung subjected to different management practices, time of application and Urea fertilizer levels on the nitrogen content of the soil and maize grain yield in an Alfisol in Samaru, Zaria Nigeria. The experiment consisted of collection of cow dung and subjecting it to three different management practices (surface heaped uncovered, surface heaped covered and pit covered). There were four different types of manure ageing in the field (March – 3 months, April – 2 months, May – 1 month and June – 0 month) and two levels of nitrogen (zero – N_0 and 45 kg N ha^{-1} – N_2). The experiment was laid out in a randomized complete block design, replicated three times. The results show that, manure management practices affected the total soil nitrogen significantly ($P > 0.05$) at harvest in location 2. The months of application had significant ($P > 0.05$) effects on both the nitrogen values in the soil and maize grain yield, though there was no consistency in the two locations. The application of nitrogen at 45 kg N ha^{-1} consistently gave higher values of soil nitrogen and maize grain yield in the field at both direct and residual effects.

Keywords: Alfisol, maize grain yield, management practices, manure, soil nitrogen, urea

Introduction

The moist savanna (Guinea savanna) region of sub-Saharan Africa (SSA) with 42 % of the SSA human population has been recognized to have the potential for increased crop and livestock production (Jabbar, 1996). Increasing agricultural productivity in the region without due attention to natural resource management or the fragile soil resource of the region could impose negative consequences. It is estimated that as much as 85% of the land in this region is threatened by degradation (International Food Policy Research Institute, 1995).

The current global drive for sustainable agricultural systems that optimize use of low inputs, require close monitoring of soil quality (FAO, 1989). To achieve this, integrated soil fertility management systems, by combining the use of chemical amendment, biological and local organic resources, such as crop residues, green manure, biological N- fixation and agro-forestry for low activity clays of the savanna soil have been advocated (Palm *et al*., 1997). The use of both organic and inorganic fertilizer by the farmers has been reported to increase yield and sustain soil productivity (Chukwu *et al*., 2012). Many research works showed that the use of several organic material especially cow dung, poultry droppings and farm yard manure as soil amendments is suitable for increasing crop production particularly among subsistent farmers of West Africa (Asadu and Unagwu, 2012). The recent increases in cost of inorganic fertilizers, has triggered scientific interest towards the evaluation of organic fertilizers based on locally available resources, including crop residues, animal manure and green manures (Reijntjes *et al*., 1992). Focus on soil fertility research has shifted towards the combined application of organic matter and mineral fertilizers as a way to arrest the ongoing soil fertility decline in sub Saharan Africa (Vanlauwe *et al*., 2001c). The organic sources will not only reduce the dependency on costly fertilizers but also provide nutrients that are either prevented from being lost (recycling) or more truly added to the system (biological N-fixation). When applied repeatedly, the organic matter leads to build-up of soil organic matter, thus providing a capital of nutrients that are slowly released and at the same time increasing the soils buffering capacity for water, cations and acidity (Udoh *et al*., 2005; Ikeh *et al*., 2013).

Animal manure called manure (Defoer *et al*., 2000) is an organic fertilizer consisting of partly decomposed mixture of dung and urine. Manure is recognized as a key resource in sustaining soil fertility in the tropics, supplying the soil with a range of macro- and micro- nutrients and organic matter. According to Fulhage (2000) and Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) (2009) 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. The beneficial role of animal manure in crop production has long been recognized (Chukwu *et al*.,2012). The utilization of cattle manure as a soil amendment is an integral part of the Nigerian guinea savanna farmers (Harris and Yusuf, 2001; Iwuafor *et al*., 2002). However, the information lacking to most of the farmers are twofold, methods of manure management practices for optimal quality before field application and time of application of animal manure for optimum crop production. Also, Iwuafor *et al*. (2002) observed that, results of trials conducted in the northern guinea savanna showed the need to investigate ways to avoid losses during manure storage, or at least to establish ranges of N contents for manures with different storage methods.

Therefore, the objectives of this study are to determine the effects of dung subjected to different management practices, time of application and urea fertilizer on the nitrogen content of the Soil and the subsequent effect on maize grain yield in an Alfisol in Samaru, Zaria Nigeria.

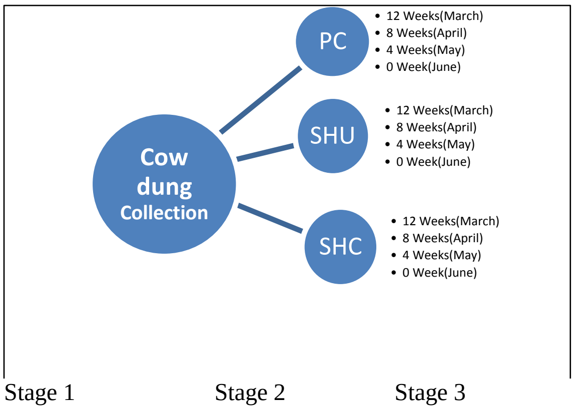
Materials and Methods

Location and description of experimental site

The field studies were carried out at two locations, Institute for Agricultural Research (IAR) Farm and the Samaru College of Agriculture (SCA) Farm, Samaru, 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 from May to September, while the dry season starts from October to April with a mean daily temperature of 24° C (Kowal and Knabe, 1972). The hottest months were those that preceded 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 subjection to management practices

The study consisted of collection and incubation of cow dung and subsequent evaluation in the field. The 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 dung collected was subjected to different management practices as described in Fig. 1.



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

Fig. 1: Diagrammatic presentation of Experimental set up.

Fresh dung was collected early in the morning from pens and piled into a heap. The dung was then mixed thoroughly with a shovel. After mixing, it was subjected to the various management schedules as follows : (i) Dung placed in a pit of 2 x 2 m and 75 cm deep and covered (PC) with a polythene sheet, (ii) Dung heaped on the ground surface and covered (HC) with a polythene sheet, and (iii) Dung heaped on the ground surface and left uncovered (HU). The collection of the Dung and its subjection to the 3 different management practices was repeated for the next 2-3 days as described above until enough dung was gathered. The 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, 2008 with the collection of dung and allowing it to decompose (composting) for 4 weeks which means the field storage (exposure) of the dung was from March to May (12 weeks of field storage before application to the soil as amendment). The same 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 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 (2009).

Cow dung and soil samples preparation

Cow dung samples were taken after subjecting the dung to the three different management practices i.e. (PC, HC and HU) and at the end of field storage (at this stage, the dung treatments must have been exposed at the field in storage after the 1 month of composting for different time durations of 12 weeks, 8 weeks, 4 weeks and 0 week). These were all carefully processed and kept for field trials. 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. The soil was air-dried and sieved to pass through 2 mm sieve and kept for analysis.

Soil and cow dung samples analysis

The surface soil samples (0 to 20 cm depth) 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 and 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 colorimetrically using the spectronic 70 spectrophotometer. Total N was determined by the Kjeldahl procedure (Bremner and Mulvaney, 1982; Bremner, 1982).

Treatments and design

The treatments consisted of surface heaped uncovered (HU) dung, heaped and covered (HC) dung (covered with polythene sheet) and dung placed in a pit and covered (PC) (with polythene sheet). The others were four different times of manure ageing in the field i.e. March (3 months), April (2 months), May (1 month) and June (0 month) (that of June was taken directly to the field after the treatment for incorporation into the soil and the moisture content was taken into consideration), and two levels of nitrogen, zero (N_0) and 45 kg N ha^{-1} (N_2). This makes a total of nine sources of treatments (3 manure management methods, 4 times of manure application to the field and 2 levels of nitrogen). The experiment was laid out in a randomized complete block design (RBCD) and replicated three times.

Field experiments

The field experiments were conducted at two locations. The first trial (Location 1) was carried out at the IAR Farm, Samaru in the year 2008 season. The second trial (Location 2) was established at the SCA Farm, Samaru in 2009 season. Residual effects were also observed in each location after the direct effect in the following year. In all the experiments, the same treatment combinations, experimental design, observations and procedures were maintained.

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 (20 m^2) and each plot was separated from the other by one meter. 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 on each plot at 5.0 t ha^{-1} on dry matter weight basis. The plots were then immediately ridged manually at 75 cm between ridges with the hand hoe to incorporate the dung. 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 two weeks after planting.

A blanket application of P was applied as single superphosphate (SSP) at the rate of 60 kg P_2O_5 ha^{-1} and N 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 (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.

Soil samples collection and analysis

The soil samples were collected at 4 WAP and at harvest and analyzed as described for surface soil above. The same thing was done at direct and residual effects observations.

Statistical analysis

The data collected from the field studies were subjected to analysis of variance (ANOVA) using SAS (2012) for the statistical analysis. Significant means were separated using the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Results and Discussion

Some properties of soil at the experimental farms

Some selected physical and chemical properties of soils of the two locations are shown in Table 1. At IAR experimental farm, the texture of the soil is sandy loam. This is typical of the soils of the Nigerian savanna. The soil pH was slightly acidic 5.90 (H_2O) and 5.10 ($CaCl_2$). The soil organic carbon (7.40 g kg^{-1}) and total N (0.53 g kg^{-1}) were both low, a characteristic of the Nigerian savanna soils and a situation which has been attributed largely to the rapid mineralization rate of organic matter under the high temperature and rainfall that exists in the tropics. The available P (6.65 mg kg^{-1}), exchangeable Ca^{2+} (2.00 cmolkg^{-1}), Mg^{2+} (0.80 cmolkg^{-1}) and K^{+} (1.84 cmolkg^{-1}) were all medium in the soil, which makes the soil to be moderate in inherent fertility status, except Na^{+} (18.70 cmolkg^{-1}) that was slightly high. According to the modified FAO suitability classification (Young, 1976), the soil can be classified as moderately suitable for the cultivation of most crops. The soils of the SCA farm is silt loam, while the other soil chemical properties were similar to what was observed on the IAR farm.

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})	7.40	4.40
Total N (g kg^{-1})	0.53	0.70
C/N ratio	14.00	6.29
Bray 1 P(mg kg^{-1})	6.65	2.45
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})	18.70	11.31

Location 1= IAR Farm; Location 2 = SCA Farm

Table 2: Effects of manure management practices, time of application and nitrogen levels on total nitrogen (g kg^{-1}) at direct application and at two locations in the field

Treatments	Location 1		Location 2	
	4 WAP	Harvest	4 WAP	Harvest
Manure mgt methods				
HU	0.64	0.68	0.40c	0.47a
HC	0.67	0.70	0.52a	0.49a
PC	0.65	0.75	0.47b	0.43b
SE±	0.023	0.034	0.014	0.011
Months				
March	0.67	0.75	0.49	0.42b
April	0.63	0.72	0.47	0.49a
May	0.67	0.72	0.45	0.49a
June	0.64	0.64	0.44	0.47a
SE±	0.027	0.039	0.017	0.013
Nitrogen levels				
N_0	0.60b	0.69	0.45	0.44b
N_2	0.71a	0.72	0.47	0.49a
SE±	0.019	0.028	0.011	0.009
Interactions				
Me x Mo	**	*	**	**
Me x N	NS	NS	NS	**
Mo x N	NS	NS	*	**
Me x Mo x N	NS	NS	**	**

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

N_o = zero Nitrogen treatment; N_2 = 45 Kg N/ha; * = significant at 5 % level of probability; ** = significant at 1 % level of probability; Me = Method; N = Nitrogen; Mo = Month; NS = not significant; HU = Heaped uncovered; HC = Heaped covered; PC = Pit covered

Effects of manure handling methods, time of application and nitrogen levels on total N of the soil at direct application in two locations

Table 2 is the results of the effects of manure handling methods, time of application and N levels on total N of the soil at two locations and at two maize growth stages at direct application. The results show that at location 1, there were no significant ($P < 0.05$) differences among the treatments at 4WAP and at harvest. At location 2 and at 4 WAP the HC treatment gave a significantly ($P < 0.05$) higher total N value than the other treatments. At harvest the HC still gave a higher value which was not significantly ($P < 0.05$) different from the HU, but both of them were significantly ($P < 0.05$) higher than the PC. The lower total N of PC must have been caused by the faster rate of N mineralization there by making the N more available for uptake by the roots of crops. This is reflected on the grain yield of maize in Table 4 at location 2 at direct effect (1041.7 kg/ha). Even though there were no significant ($P < 0.05$) differences among the treatments, but the PC treatment gave the highest grain yield value.

For the time of manure application, at location 1, the treatments did not show any significant ($P < 0.05$) difference at both 4 WAP and at harvest. At location 2 and at 4 WAP there were still no significant ($P < 0.05$) differences among the treatments. However at harvest the March treatment gave the lowest total N value which was significantly ($P < 0.05$) lower than all other treatments, which were statistically not different from each other. This showed that early application of manure in March must have caused the lost of N, either through volatilization, leaching or denitrification (Dewes, 1994; Fulhage, 2000). Fulhage (2000) reported that applying too much manure, at the wrong time or improperly handling it in other ways releases nutrients into air (volatilization) or into the ground (leaching) or surface waters. Thus instead of nourishing crops, nutrients become pollutants. The N levels significantly ($P < 0.05$) affected the total N at 4 WAP. The 45 kg N/ha (N_2) gave significantly ($P < 0.05$) higher value than the zero level (N_0). At harvest the difference between the treatments were not significant ($P < 0.05$), but the 45 kg N/ha still gave a higher total N value. This must have been as a result of crop uptake, because looking at the grain yield, the 45kg N/ha was also significantly ($P < 0.05$) higher than the zero level. At location 2, and at 4 WAP; the differences were not significant ($P < 0.05$) among the treatments, but it still maintains the same pattern with 45 kg N/ha giving a higher value at harvest. This implies that the application of the mineral fertilizer increased the level of total N in the soil. Many workers have already reported an increased in dry matter yield of Stover and plant height as N levels increased. Tanimu *et al.* (2007) reported that higher doses of N fertilizers increased grain yield and yield related components. The grain yield in Table 4 agrees with what has been reported by these workers.

Residual effect of manure handling methods, time of application and nitrogen levels on total N of the soil at two locations

The residual effect of the handling methods, time of application and the N levels on the soil total N at two locations is presented in Table 3. At location 1, and at 4 WAP and at harvest, the results showed no significant ($P < 0.05$) difference among the treatments. Even though the HC tends to give higher total N values at the two growth stages. This was further confirmed at location 2, at 4WAP and at harvest the results gave similar patterns but with a significant ($P < 0.05$) effect. That is the HC treatment gave significantly ($P < 0.05$) higher total N values in the soil at the two growth stages. This was followed by the PC treatment and the HU treatment which gave the least values. However, the values of PC and HU treatments at harvest were statistically the same. HC treatment must have supported slow and steady release of nutrients than the other treatments.

In the case of time of manure application the results showed significant ($P < 0.05$) effects at the two locations and the two growth stages. At 4 WAP, the April treatment gave the highest total N value, which was not significantly ($P < 0.05$) different from the June treatment. The June treatment was also not significantly ($P < 0.05$) different from the May treatment. The March treatment gave the least value, however, it was statistically at par with the May treatment. At harvest, the May treatment was significantly ($P < 0.05$) higher than all other treatments, which were at par with each other statistically.

At location 2, the March and June treatments were significantly ($P < 0.05$) not different from each other at the two stages of growth. However, at 4WAP the May treatment followed them and it was significantly ($P < 0.05$) higher than the April treatment, which gave the lowest value; while at harvest, it was the April treatment that followed and it was significantly ($P < 0.05$) higher than the May treatment which gave the least value. Comparing these values with the grain yield, it did not follow any particular pattern.On N levels at location 1, there were no significant ($P < 0.05$) difference among the treatments, at both 4 WAP and at harvest though the values of total N at 45 kg N/ha (N_2) were higher than the zero (N_0). At location 2 and at 4 WAP there was no significant ($P < 0.05$) difference among the treatments, but at harvest the N_2 gave a significantly ($P < 0.05$) higher N value than the N_0. The addition of N must have increased the available N which in turn increased the Maize grain yield observed in Table 4.

Table 3: Effects of Manure management practices, time of application and nitrogen levels on total nitrogen (g kg^{-1}) at residual effect in two locations in the field

Treatments	Location 1		Location 2	
	4 WAP	Harvest	4 WAP	Harvest
Manure mgt methods				
HU	0.62	0.59	0.44c	0.46b
HC	0.67	0.63	0.50a	0.52a
PC	0.66	0.60	0.49b	0.47b
SE±	0.026	0.021	0.005	0.007
Months				
March	0.55c	0.53b	0.50a	0.53a
April	0.73a	0.59b	0.43c	0.49b
May	0.63bc	0.71a	0.47b	0.40c
June	0.70ab	0.59b	0.50a	0.52a
SE±	0.030	0.025	0.005	0.007
Nitrogen levels				
N_0	0.63	0.58	0.48	0.47b
N_2	0.67	0.63	0.47	0.50a
SE±	0.021	0.018	0.004	0.005
Interactions				
Me x Mo	*	**	**	**
Me x N	NS	NS	**	**
Mo x N	NS	NS	**	**
Me x Mo x N	NS	NS	**	**

Means with the same letter(s) within the same column are not significantly different at 5 % level of significance using DMRT.
N_o = zero Nitrogen treatment; N_2 = 45 Kg N/ha; * = significant at 5 % level of probability; ** = significant at 1 % level of probability; Me = Method; N = Nitrogen; Mo = Month; NS = not significant; HU = Heaped uncovered; HC = Heaped covered; PC = Pit covered

Table 4: Effects of manure management practices, time of application, and nitrogen levels on grain yield (Kg/ha) of maize at direct application and residual effects at two locations in the field

Treatments	Location 1		Location 2	
	Direct Effect (2008)	Residual effect (2009)	Direct Effect (2009)	Residual effect (2010)
Manure mgt methods				
HU	2366.7	1334.4	993.8	842.7
HC	2238.5	1343.8	1005.4	941.7
PC	2321.7	1307.9	1041.7	796.9
SE±	100.45	86.42	81.05	50.73
Months				
March	2006.7c	1198.6	928.1bc	927.8
April	2163.9bc	1355.6	1365.3a	897.2
May	2488.9ab	1320.3	1061.1b	802.8
June	2576.4a	440.3	700.0c	813.9
SE±	115.99	99.79	93.59	58.57
Nitrogen levels				
N_O	2049.3b	956.7b	480.0b	542.4b
N_2	2568.6a	1700.7a	1547.2a	1178.5a
SE±	82.01	70.56	66.18	41.42
Interactions				
Me x Mo	NS	NS	NS	NS
Me x N	NS	NS	NS	NS
Mo x N	NS	NS	NS	NS
Me x Mo x N	NS	NS	NS	NS

Means with the same letter(s) within the same column are not significantly different at 5 % level of significance using DMRT.
N_o = zero Nitrogen treatment; N_2 = 45 Kg N/ha; * = significant at 5 % level of probability; ** = significant at 1 % level of probability; Me = Method; N = Nitrogen; Mo = Month; NS = not significant; HU = Heaped uncovered; HC = Heaped covered; PC = Pit covered

Effects of manure handling methods, time of application and nitrogen levels on the grain yield of maize in the field

The results of the effects of manure handling methods, time of application and nitrogen levels on the grain yield are presented in Table 4. Looking at the two locations and at direct manure application and the residual effects there were no significant ($P < 0.05$) effects of the handling methods on the grain yield of maize. The handling methods did not appreciably affected the total nitrogen content of the dung in location 1 after subjecting it to different handling methods which was also reflected on the grain yield. OMAFRA (2009) reported that the rate of ammonium nitrogen loss will depend on the soil moisture and weather conditions at the time of application. They explain further that, moist soils increase the opportunity for ammonium to be absorbed in soil water. Warm temperatures and dry soils increase the rate of ammonium loss to the air which is the case in the area of study. According to studies by OMAFRA (2009), manure incorporated after four days under warm conditions (> 25^{o}C) ammonium nitrogen can be lost between 44 – 72% depending on whether the soil is wet or dry. Since the nitrogen content was not significantly affected as a result of different handling methods, its application to the soil must have had little or no effect on the total N of the soil. This was equally reflected on the maize grain yield in the field. This is expected, because cereal crops in the study area demand high amounts of N for improved yield.

Considering the time of dung application to the field at location 1, it had a significant ($P < 0.05$) effect on the maize grain yield. The application of dung in June at direct application gave a significantly ($P < 0.05$) higher grain yield than the ones applied in April and March, but it was statistically not different from the May treatment. At location 2, it was the application of dung in the month of April that gave a significantly ($P < 0.05$) higher grain yield. This was closely followed by the applications in the months of May, March and June respectively. This result is completely different from what was observed in location 1. The results were totally not consistent in the two locations.

The residual effects did not have significant ($P < 0.05$) effects on grain yields on the two locations either. It has been reported, that the impact of farmyard manure on yields depends strongly on the site – that is, on the primary effect on soils (as N or P fertilizer, biological, physical properties, etc.) and on the state of the soil. For example, on a dry savanna site in the Sudan, yields of sorghum were increased from 1.3 t/ha to 2.4 t/ha (i.e. by over 80 %) by using just 4.0 t manure/ha (Musa, 1975). In contrast, 15.0 t/ha had little effect on a site in highland of Rwanda. The maize yield increased by only 30 % to 1.3 t/ha. On a neighbouring degraded site in the same country, the maize yield was increased from 0.6 to 1.3 t/ha. The effect here, with a rise of 116 %, was very definite. Altogether, the results from Rwanda show that farmyard manure can positively affect yields in the second and sometimes even in the third subsequent cropping season (Pietrowiez and Neumann, 1987). To assess the full effect of manure on yields, it is vital that the delayed effects be taken into account. Whereas in temperate climates the residual effects of fertilizing with farmyard manure last well into the third or even the fourth year (Sauerlandt and Tietjen, 1970), in the tropics they will subside more quickly. The organic-N component is available over time as the organic matter breaks down, similar to a slow released nitrogen fertilizer. About 20 – 30% of the organic nitrogen component of manure is assumed to be available to the growing crop in the year of application.

When the nitrogen levels were compared, the results showed that the N_2 treatments (45 kg N/ha) gave significantly ($P < 0.05$) higher grain yield in the two locations than the N_0 (zero N treatment) at the direct manure application and at the residual effect. The complimentary effect of farmyard manure and mineral fertilizers has been confirmed by many workers in Nigeria (Asadu and Unagwu, 2012; Chukwu *et al*., 2012). Tanimu *et al*. (2007) reported a significant increase in yield and yield related parameters of Maize with increase in nitrogen application in this same ecological zone.

Conclusion

The manure management practices, time of application did not consistently affect the total N significantly. However, HC treatment tends to perform better than the other treatments. The addition of urea naturally increased the soil total N value. The months of application had significant effects on both the total N value in the soil and maize grain yield. The May treatment gave the highest total N at harvest in the two locations at direct effect. The June treatment gave the highest maize grain yield at location 1, while at location 2, direct effect April treatment gave the highest grain yield. The behaviors of the treatments on soil total N at the residual effect were not consistent in all cases. The application of N at 45 kg N ha^{-1} consistently gave higher values of N in the soil and higher maize grain yield in the field at both direct and residual effects in the two locations.

References

Asadu CLA & Unagwu BO 2012. Effect of combine poultry manure and inorganic fertilizer on maize performance in an Ultisolof southeastern Nigeria. *Nig. J. Soil Sci*., 22(1): 79-87.

Bremner JM 1982. Total nitrogen. In, C.A. Black (ed) Methods of Soil Analysis Part II. *Chemical and Microbiological Properties. Am. Soc. of Agron.* Madison Wisconsin, pp. 1149-1178.

Bremner JS & Mulvaney CS 1982. Nitrogen-total. In: Page AL (ed). *Methods of Soil Analysis, Part 2. American Society of Agronomy,* Madison, Wisconsin, pp. 595-624.

Chukwu LI, Ano AO & Asawalam DO 2012. Effects of poultry manure and NPK fertilizer on soil properties and nutrient uptake of maize (*Zea mays* L.) plants growth in an Ultisol. Proceedings of the 36th Annual conference of the Soil Science Society of Nigeria (SSSN) on 7th – 11th March, 2012, University of Nigeria Nsukka.

Defoer T, Budelman A, Toulmin C & Carter SE 2000. Managing soil fertility in the tropics. In: Defoer T & Budelman A (eds). Building common knowledge. Participatory Learning and Action Research (Part 1). A research guide for participatory learning and action research. Amsterdam, the Netherlands: Royal Tropical Institute.

Dewes T 1994. Nitrogen losses from manure heaps. *Biol. Agric. & Horticul.,* 11: 309-317.

FAO 1989. Sustainable Agricultural Production implication for International Agricultural Research. *FAO Research and Technical Paper,* No. 4 Rome Italy.

Fulhage CD 2000. Reduce environmental problems with proper land application of animal manure. University of Missouri Extension. USA.

Harris F & Yusuf MA 2001. Manure management by smallholder farmers in the Kano close-settled zone, Nigeria. *Experimental Agriculture,* 37: 319-332.

IFPRI, (1995). A 2020 Vision for Food Agriculture and Environment in Sub-saharan Africa. Discussion paper 4. O. Badiane and C. Delgado. (Eds) International Food Policy Research Institute (IFPRI), Washington DC, USA.

Ikeh AO, Ndaeyo NU, Akpan EA, Udoh EI & Akata OR 2013. Evaluation of complementary use of organic manure for sustainable water yam production in Uyo, southeastern Nigeria. *Amer. J. Res. Comm.,* 1(2): 33-48.

Iwuafor ENO, Aihou K, Jaryum JS, Vanlauwe B, Diels J, Saginga N, Lyasse O, Deckers J & Merckx R 2002. On-farm evaluation of contribution of sole and mixed applications of organic matter and Urea to Maize grain production in the Savanna. In: Vanlauwe B, Diels J, Saginga N & Merckx R (Eds). Integrated plant nutrient management in Sub-saharan Africa. CAB International, Wallingford, Oxon, UK, pp. 185-197.

Jabbar MA 1996. Energy and the Evolution of Farm systems-the potentials mixed farming in the moist Savanna of Sub-saharan Africa. *Out Look on Agric.,* 25: 27-36.

Juo ARS 1979. Selected methods for soil and plant analysis. IITA Manual Series. No. 1, Ibadan, Nigeria.

Klute A 1986. Methods of Soil Analysis, No. 9. Part 1, second edition, American Society of Agronomy, Madison, Wisconsin.

Kowal JM 1972. Radiation and Potential crop protection in Samaru, Nigeria. *Savanna*, 1: 89-101.

Kowal JM & Knabe DT 1972. An Agro-Climatological Atlas of Northern Nigeria with explanatory notes. Ahmadu Bello University, Zaria Press.

Musa MM 1975. A method for conservation of Cattle manure. *FAO Soil Bulletin,* 38: 89-95.

Nelson DW & Sommers LE 1982. Total carbon, organic carbon and organic matter. In: Page AL, Miller RH & Keeney DR (eds). Methods of Soil Analysis No. 9, Part

2, Chemical and Microbiological properties. *Am. Soc. Agron.* Madison, Wisconsin, pp. 539-579.

Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) 2009. Soil fertility and nutrient use: Manure management. http:/www.omafra.gov.on.ca/english/crops/pub811/9manure.htm. Accessed on 3/2/2017.

Palm CA, Myers RJ & Nandwa SM 1997. Organic-inorganic nutrient interaction in soil fertility replenishment. In: Buresh RJ, Sanchez PA & Calhoun F Eds., *Replenishing Soil fertility in Africa*, Soil Science Society of America, Madison, pp. 193-218.

Piettrowicz P & Neumann I 1987. Fertilisation et amelioration des sols. Etudes sur l' application d'engrais vert, de la fumure organique et des engrais mineraux. Etudes et Experiences No. 11 Projet Agro-pastoral de Nyabisindu Rwanda, Nyabisindu/Eschborn.

Reijntjes C, Haverkrot B & Waters-Bayer A 1992. Farming for the future. An Introduction to Low External Input and Sustainable Agriculture. Macmillan Press, London, UK.

Statistics for Agricultural Sciences (SAS) 2012. SAS/STST User Guide, Version 9.1. SAS Institute, Carry, North Carolina, USA.

Sauerlandt W & Tietjen C 1970. Humuswirschaft des Ackerbaues. DLG-verlag. Frankfurt, 239.

Tanimu J, Iwuafor ENO, Odunze AC & Tian G 2007. Effect of incorporation of leguminous cover crops on yield and yield components of Maize. *World J. Agric. Sci*., 3(2): 243-249.

Udoh DJ, Ndon BA, Asuquo PE & Ndaeyo NU 2005. Crop production techniques for the tropics. Concept publication limited, Lagos, Nigeria, p. 446.

Vanlauwe B, Wendt J & Diels J 2001. Combined application of organic matter and fertilizer. In: Tian G, Ishida F & Keatinge JDH (Eds). *Sustaining Soil Fertility in West Africa*. SSSA special publication No. 58, Soil Science Society of America, Madison, Wisconsin, USA, pp. 247-279.

Young A 1976. Tropical Soils and Soil Survey. First Edition. Cambridge University Press, London UK, p. 468.