Agricultural Science
Volume 1, Issue 3 (2013), 13-23
ISSN 2291-4471 E-ISSN 2291-448X
Published by Science and Education Centre of North America

Effects of Manure Management and Nitrogen Levels on Soil Organic Carbon in the Northern Guinea Savanna, Nigeria

Joseph Tanimu[1]*, Sunday Wakili Jula Lyocks[2], Clement Alex Onwu[1], and Pedro Ezomon Imadojemu[1]

[1]Department of Soil Science and Land Resources Management, Federal University Wukari, Taraba State

[2]Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria

[*]Correspondence: Joseph Tanimu, Department of Soil Science and Land Resources Management, Federal University Wukari, Taraba State. Tel: +2348037039756; E-mail: joseph.tanimu@yahoo.com

Abstract: A two years study was carried out in two locations at Institute for Agricultural Research and the Samaru College of Agriculture Farms (Lat. 11° 11'' and Long. 7° 38'') in the Northern Guinea Savanna zone of Nigeria. The study aimed at investigating the effects of cow dung management practices, time of application when combined with inorganic fertilizer (urea) and their direct and residual effects on organic carbon content of the soil. The treatments consisted of three cow dung management practices, four different storage times after one month ageing and two levels of nitrogen. There was a control treatment where no cow dung or nitrogen fertilizer was applied. The study was a factorial experiment with three factors, laid out in a randomized complete block design replicated three times. The manure amended treatments were generally higher than the control treatments in the two years and at both direct and residual effects. This showed that the addition of cow dung actually increased the organic carbon content of the soil. However, the highest organic carbon value for 2003 and 2004 years of direct effects, at 4 WAP were on treatments pit covered May (54.5 g kg $^{-1}$ and 49.0 g kg $^{-1}$ respectively), while the lowest values were observed on the control treatments (30.7 g kg $^{-1}$ and 24.7 g kg $^{-1}$ respectively). The management practices and the time (month) of application did not show any significant effect on the content of the soil organic matter of the soil.

Keywords: Manure management, Nigeria, Nitrogen, Northern Guinea Savanna, Soil organic carbon, Time of application

1. Introduction

The Organic matter content of most Savanna soils is low (Ewenzor *et al*., 1990). This low level of OM has made the Savanna soils susceptible to major chemical, physical and biological limitations which reduce crop yields (Jones & Wild, 1975). They further explained that, with intensification of cropping OM and Nitrogen are readily depleted. Organic matter is considered as the life of soil as well as a storehouse of plant nutrients (Reddy & Reddi, 1992). It plays important role in maintaining soil fertility and productivity. Karim, Miah, and Razia (1994) have observed that, OM status of the soil is in critical position and if the present rate of degradation is continued, in the near future our soil will become unfertile.

Animal manure according to Defoer and Budelman (2000) is an organic fertilizer consisting of a partly decomposed mixture of dung and urine. They further stated that, 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. In addition to supplying plant nutrients, manure generally improves soil tilth, aeration, and water holding capacity of the soil and promotes growth of beneficial soil organisms (Fulhage, 2000).

Composted Animal manure according to Travis, Crassweller, Halbrendt, Krawczk, and Kleiner (2004) is a complete package. It delivers the microorganisms, provides the nutrients and food reserves needed by the microorganisms to survive and multiply and improves soil water holding capacity, which favors the beneficial microorganisms over disease causing organisms in the soil. Compost allows beneficial soil microorganisms to out compete disease-causing organisms in the soil. Travis *et al.* (2004) concluded that highly mineralized soils that are low in organic matter may actually favor disease organisms in the soil.

The potentialities of organic source are very limited to afford higher crop production due to slow release of plant nutrients from organic matter. Only one fifth to half of the nutrients supplied from manure was recovered in the first year and the remainder was released later gradually, providing a substantial residual effect of unutilized nutrients on the succeeding crop (Miah, 1994; Sathish, Govinda Gowda, Chandrappa, & Nagaraja, 2011). De Ridder and Van Keulen (1990) reported that, application of organic manure generally aims at two major goals: increased supply of nutrient elements to the crop and increased organic matter content in the soil, resulting in more favorable soil physical and chemical properties. These two goals are conflicting, as release of nutrient elements requires decomposition of the organic material, which is thus, lost for the formation of soil organic matter.

The present study was undertaken to investigate the effects of cow dung management practices, time of application, combined with inorganic fertilizer (urea) on organic carbon content of the soil at direct and residual effects in two locations.

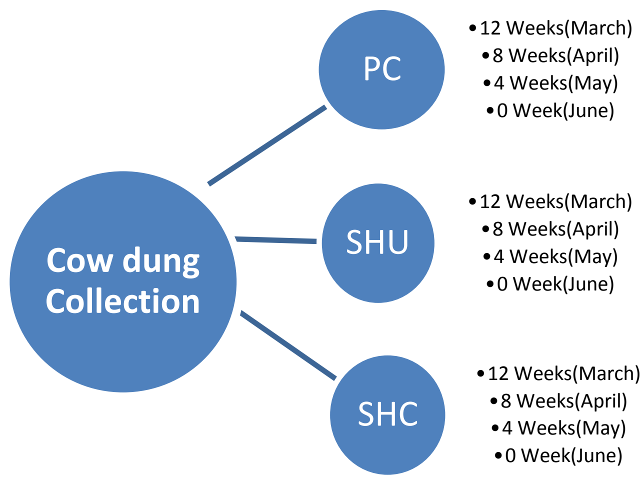
2. Materials and Methods

The studies were conducted at two different locations, Institute for Agricultural Research (IAR) research Farm and the Samaru College of Agriculture (SCA) Farm, Samaru (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 2003 and 2004. The cow dung collected was subjected to different management practices as described below (Fig. 1). 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 harmonizing, 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 3 days as described above until the desired cow dung quantity was gathered. The cow dung was then allowed to decompose (age) for four weeks (one month) 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) (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 (2004).



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 Period (Exposure) before use in the field

Figure 1. Diagrammatic presentation of experimental set up

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												12 weeks
	Treatment 2									Composting				Field Storage								8 weeks
	Treatment 3													Composting				Field Storage				4 weeks
	Treatment 4																	Composting				0 week

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 2003, and 2004 seasons. The second trial was established at the SCA Farm, Samaru in 2004 and 2005 seasons. In all the experiments, the same treatment combinations, experimental design, observations and procedures were maintained. The treatments and experimental design in the field were 3 cow dung management practices, 4 different storage periods 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 immediately after cow dung application to incorporate the manure into the soil and avoid the transfer of the manure from one plot to another.

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).

3. Results and Discussion

The results of soil samples of study areas are presented in Table 1, while the results of soil organic carbon as influenced by the management practices, time of application, nitrogen levels and at direct and residual effects in two locations are presented in Table 2 for year 2003 and Table 3 for year 2004. The results showed that, the organic carbon content was significantly affected in the two years, except at 4 WAP at residual effect where there was no significant difference. The manure amended treatments were generally higher than the control treatments in the two years and at both direct and residual effects. This showed that the addition of cow dung actually increased the organic carbon content of the soil. However, the highest organic carbon value for 2003 and 2004 years at direct effects, at 4 WAP were on treatments pit covered May (54.5 g kg $^{-1}$ and 49.0 g kg $^{-1}$ respectively), while the lowest values were observed on the control treatments (30.7 g kg $^{-1}$ and 24.7 g kg $^{-1}$ respectively). At harvest, the nitrogen amended surface heaped uncovered April treatments (combined application of manure and chemical fertilizer) gave the highest values (49.5 g kg $^{-1}$ and 46.3 g kg $^{-1}$ respectively) while the lowest was observed at the control treatments (30.8 g kg $^{-1}$ and 23.0 g kg $^{-1}$ respectively).

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 (H2O)	5.90	5.90
pH 1:2.5 (CaCl2)	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

Note: IAR = Institute for Agricultural Research; SCA = Samaru College of Agriculture

Ullah, Islam, Islam, and Haque (2008) reported that soil organic carbon was decreased by chemical fertilizer but was increased with all types of organic manure application and the highest was recorded with the combined application of manure and chemical fertilizer. Shave, Ter-Rumum, and Enoch (2012) also reported an increase of 25 % and 27 % of organic carbon content of the soil after intercropping Mucuna to Maize at 6 WAP in two locations of a degraded soil. The improved physico-chemical properties of soils with intercropping of Mucuna at 6 WAP might be attributed to greater biological activity (e.g., earthworm abundance and microbial biomass) that are known to occur in organically managed soils than in conventionally managed soils (Maeder *et al*., 2002).

The residual effect (2004) at 4 WAP, the treatments did not affect the organic carbon content of the soil significantly. But at harvest and at direct evaluation, the pit covered June treatment gave the

Table 2. Effects of manure management practices, time of application and nitrogen levels on soil organic carbon (g 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	44.2ab	49.2a	39.3ab	38.3ab	45.0	41.5	40.8ab	40.2ab
SHUA	46.0ab	48.0a	42.5ab	49.5a	43.2	44.7	43.8ab	36.2ab
SHUY	48.3a	49.3a	45.2ab	47.2a	41.3	51.0	43.8ab	44.0ab
SHUJ	44.0ab	47.0ab	39.3ab	46.7a	41.7	49.5	40.0ab	34.2ab
SHC								
SHCM	41.0ab	48.8a	41.7ab	45.2ab	35.5	40.5	33.7ab	36.7ab
SHCA	44.2ab	51.7a	41.5ab	49.0a	34.8	45.5	39.7ab	39.8ab
SHCY	48.3a	47.8a	45.7a	41.7ab	46.7	49.5	41.0ab	41.2ab
SHCJ	46.0ab	47.2a	44.8ab	45.0ab	46.8	41.5	42.2ab	37.8ab
PC								
PCM	42.7ab	45.2ab	45.0ab	43.2ab	49.5	40.8	40.3ab	42.3ab
PCA	51.7a	49.3a	48.2a	44.2ab	48.5	46.8	37.7ab	39.7ab
PCY	54.5a	45.3ab	45.7a	41.5ab	50.7	50.3	43.0ab	41.2ab
PCJ	47.4a	50.3a	41.8ab	45.3a	51.5	46.3	51.0a	41.3ab
Control	30.7b		30.8b		32.0		26.0b	
SE±	4.90		4.77		6.42		5.90	

Note: 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 organic carbon (g 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	37.0ab	40.7ab	30.7abc	35.7abc	34.0ab	32.0ab	30.0ab	27.3ab
SHUA	42.7a	39.9ab	38.0abc	46.3a	31.0ab	40.0ab	32.7ab	28.3ab
SHUY	36.3ab	39.0ab	32.7abc	37.0abc	32.7ab	36.0ab	37.7a	32.3ab
SHUJ	40.7ab	40.0ab	34.5abc	37.7abc	31.7ab	36.3ab	32.0ab	28.7ab
SHC								
SHCM	38.3ab	39.3ab	33.7abc	36.7abc	29.7ab	30.7ab	27.3ab	26.0ab
SHCA	40.0ab	47.7a	37.0abc	44.7ab	28.7ab	33.0ab	28.0ab	30.3ab
SHCY	40.3ab	46.0a	38.0abc	36.7abc	38.0ab	43.0a	30.0ab	29.0ab
SHCJ	36.3ab	36.7ab	37.0abc	35.0abc	32.3ab	30.3ab	31.0ab	33.0ab
PC								
PCM	37.7ab	35.0ab	45.3ab	33.3abc	39.0ab	35.3ab	29.7ab	35.0ab
PCA	42.0a	45.7a	39.3ab	39.0ab	37.3ab	29.3ab	31.3ab	26.7ab
PCY	49.0a	34.3ab	34.0abc	30.0bc	37.0ab	30.7ab	29.7ab	33.3ab
PCJ	39.0ab	38.7ab	30.7abc	34.7abc	30.0ab	34.7ab	35.7ab	35.0ab
Control	24.7b		23.0c		24.0b		22.0b	
SE±	4.93		4.57		4.92		4.21	

Note: 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 4. Effects of manure management practices, time of application and nitrogen levels on maize grain yield (kg ha^{-1}) in IAR and SCA farms

Treatments	IAR farm				SCA farm			
	Direct effect(2003)		Residual effect(2004)		Direct effect(2004)		Residual effect(2005)	
	oN	+N	oN	+N	oN	+N	oN	+N
SHU								
SHUM	1120.8c-f	1925.0a-e	675.0fg	1462.5ab	241.7i	1308.3c-g	550.0ef	1225.0ab
SHUA	904.2ef	2341.7ab	691.7efg	1433.3abc	500.0hi	2158.3ab	633.3c-f	1066.7a-d
SHUY	1645.8a-e	2195.8abc	962.5b-g	1241.7a-f	800.0e-i	1633.3a-d	416.7f	1058.3a-d
SHUJ	1341.7b-f	1966.7a-e	691.7efg	1550.0a	225.0i	1083.3d-h	583.3ef	1208.3ab
SHC								
SHCM	959.2def	1629.2a-e	633.3g	1470.8ab	243.3i	1316.7c-g	566.7ef	1508.3a
SHCA	1270.8b-f	2545.8a	820.8d-g	1712.5a	691.7f-i	2308.3a	616.7def	1500.0a
SHCY	1312.5b-f	1987.5a-e	875.0c-g	1262.5a-e	441.7hi	1466.7b-e	558.3ef	1166.7ab
SHCJ	1395.8a-e	1875.0a-e	816.7d-g	1550.0a	525.0hi	1050.0d-h	525.0f	1091.7abc
PC								
PCM	1079.2c-f	2090.8a-e	770.8efg	1366.7a-d	508.3hi	1950.0abc	558.3ef	1158.3ab
PCA	1412.5a-e	2112.5a-e	679.2fg	1420.8abc	766.7e-i	1766.7a-d	508.3f	1058.3a-d
PCY	1387.5a-e	2120.8a-d	669.2fg	1358.3a-d	608.3ghi	1416.7c-f	533.3f	1083.3a-d
PCJ	1345.8b-f	1904.2a-e	708.3efg	1445.8abc	208.3i	1108.3d-h	458.3f	1016.7b-e
Control	211.7f		405.0g		275.li		650.0c-f	
SE±	348.65		174.78		230.96		142.69	

Note: 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}

highest value (51.0 g kg $^{-1}$), while the control treatment still gave the lowest value (26.0 g kg $^{-1}$). The treatments affected the organic C content of the residual effect in year 2005. The surface heaped covered May treatment of nitrogen amended at 4 WAP gave the highest value (43.0 g kg $^{-1}$), while the lowest value was observed at the control (24.0 g kg $^{-1}$). At harvest, it was the direct evaluation surface heaped May treatment that gave the highest value (37.7 g kg $^{-1}$), while the control still gave the lowest value (22.0 g kg $^{-1}$). This can be attributed to the reasons already advance above at the direct effect, since manure application impact is felt some years after the first year of application (Ullah *et al*., 2008; Shave *et al*., 2012).

Table 4 presents the maize grain yield in IAR and SCA farms at direct and residual effects. The results showed that the manure amended treatments generally gave higher maize grain yields than the control treatments at both direct and residual effects in the two farms. This results agrees with the organic carbon results (Tables 2 and 3), where all treatments that received manure gave higher organic carbon values. Manure provides nutrients to crops for several years (Camberato, Lippert, Chastain, & Plank, 1996). The results from the residual manure treatments showed that, the residual effect of manure could last at least seven years (Kihanda, Warren, & Micheni, 2006). All the N amended treatments gave significantly ($P < 0.05$) higher grain yields than the control treatment, while most of the non N amended treatments were statistically at par with the control treatment. This showed that, the application of cow dung alone that have been subjected to different management practices, was not enough to give a significant difference on maize grain yield. This agreed with the work of Uyovbisere and Elemo (2002) who stated that organic matter cannot be used alone, but with some level of inorganic fertilizer. It has been recognized that the combined application of organic matter and inorganic fertilizer is required to increase crop production and arrest soil nutrient depletion in West Africa (FAO, 1999; Giller, 2002; Iwuafor *et al*., 2002). Tanimu, Iwuafor, Odunze, and Tian (2007) reported higher doses of N fertilizers increased grain yield and yield related components of maize in the savanna.

4. Conclusion

The results showed that, the organic carbon content was significantly affected in the two years. The manure amended treatments were generally higher than the control treatments in the two years and at both direct and residual effects. This showed that the addition of cow dung actually increased the organic carbon content of the soil. However, the highest organic carbon value for 2003 and 2004 years at direct effects, at 4 WAP were on treatments pit covered May (54.5 g kg $^{-1}$ and 49.0 g kg $^{-1}$ respectively), while the lowest values were observed on the control treatments (30.7 g kg $^{-1}$ and 24.7 g kg $^{-1}$ respectively). At harvest, the nitrogen amended surface heaped uncovered April treatments (combined application of manure and chemical fertilizer) gave the highest values (49.5 g kg $^{-1}$ and 46.3 g kg $^{-1}$ respectively) while the lowest was observed at the control treatments (30.8 g kg $^{-1}$ and 23.0 g kg $^{-1}$ respectively).The management practices and the time (month) of application did not show any significant effect on the content of the organic matter of the soil.

References

[1] Bremner, J. M. (1982). Total nitrogen. In C. A. Black (Ed.), *Methods of Soil Analysis Part II. Chemical and Microbiological Properties* (pp. 1149-1178). American Society of Agronomy, Madison, WI.

[2] Bremner, J. M., & Mulvaney, C. S. (1982). Nitrogen—Total. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of Soil Analysis Part 2: Chemical and Microbiological Properties* (2nd ed., pp. 595-624). American Society of Agronomy, Madison, WI.

[3] Camberato, J., Lippert, B., Chastain, J., & Plank, O. (1996). *Land application of animal manure*. Retrieved from http:/hubcap.clemson.edu/~blpprt/manure.html.

[4] Defoer, T., & Budelman, A. (Eds.) (2000). *Managing soil fertility in the tropics: A resource guide for participatory learning and action research*. Amsterdam, The Netherlands : Royal Tropical Institute (KIT).

[5] De Ridder, N. & Van Kuelen, H. (1990). Some aspects of the role of organic matter in sustainable intensified arable farming systems in the West-African semi-arid-tropics (SAT). *Fertilizer Research, 26*(1-3), 299-310.

[6] Ewenzor, W. O., Udo, E. J., Osoroh, N. J., Ayotade, K. A., Adepetu, J. A., Chude, V., & Udegbe, O. (1990). *Fertilizer use and management practices in Nigeria*. Federal Ministry of Agriculture and Natural Resources and Rural development.

[7] F.A.O. (1999). *Soil fertility initiative for sub-Saharan Africa*. Proc. SFI/FAO consultation, Rome. 19-20 Nov. 1999. FAO, Rome.

[8] Fulhage, C. D. (2000). *Reduce environmental problems with proper land application of animal manure.* University of Missouri Extension. USA.

[9] Giller, K. E. (2002). Targeting management of organic resources and mineral fertilizers: Can we match scientists' fantasies with farmers' realities? In B. Vanlauwe, J. Diels, N. Saginga, & R. Merckx (Eds.), *Integrated plant nutrient management in Sub-saharan Africa* (pp. 155-171). From concept to practice. Wallingford, Oxon, UK: CAB International.

[10] Iwuafor, E. N. O., Aihou, K., Jaryum, J. S., Vanlauwe, B., Diels, J., Saginga, N., & 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 B. Vanlauwe, J. Diels, N. Saginga, & R. Merckx (Eds.), *Integrated plant nutrient management in Sub-saharan Africa* (pp. 185-197). Wallingford, Oxon, UK: CAB International.

[11] Jones, M. J., & Wild, A. (1975). *Soils of the West African savanna: the maintenance and improvement of their fertility.* Farnham Royal, Eng.: Commonwealth Agricultural Bureaux. doi: 10.1017/S0014479700007055

[12] Juo, A. R. S. (1979). *Selected methods for soil and plant analysis*. IITA Manual Series. No. 1, Ibadan, Nigeria.

[13] Karim, Z., Miah, M. M. U., & Razia, S. (1994). Fertilizer in the national economy and sustainable environmental development. *Asia Pacific Journal on Environment and Development, 1*(2), 48-67.

[14] Kihanda, F. M., Warren, G. P., & Micheni, A. N. (2006). Effects of Manure application on crop yield and soil chemical properties in a long-term field trial in Semi-arid Kenya. *Nutrient Cycling in Agroecosystems, 76*(2-3), 341-354. doi: 10.1007/s10705-006-9024-z

[15] Klute, A. (Ed.) (1986). *Methods of Soil Analysis. Part 1: Physical and mineralogical properties, including statistics of measurement and sampling. Monograph No. 9* (2nd ed.). American Society of Agronomy, Madison, Wisconsin.

[16] Maeder, P., Fliessbach, A., Dubois, D., Gunst, L., Fried P., & Niggli, U. (2002). Soil Fertility and Biodiversity in Organic Farming. *Science, 296*(5573), 1694-1697.

[17] Miah, M. M. U. (1994). *Prospects and Problems of organic farming in Bangladesh* (pp. 26-28). Paper presented at the workshop on the integrated nutrient management for sustainable agriculture held at SRDI, Dhaka.

[18] Nelson, D. W., & Sommers, L. E. (1982). Total carbon, organic carbon and organic matter. In A. L. Page, R. H. Miller, & D. R. Keeney (Eds.), *Methods of Soil Analysis. Part 2, Chemical and Microbiological properties. No. 9* (pp.539-579). American Society of Agronomy, Madison, Wisconsin.

[19] Reddy, T. Y., & Reddi, G. H. S. (1992). *Principal of Agronomy* (1st ed., pp 190). Kalyani Publishers, Calcutta India.

[20] Sathish, A., Govinda Gowda, V., Chandrappa, H., & Nagaraja, K. (2011). Long term Effect of Intergrated Use of Organic and Inorganic Fertilizers on Productivity, Soil Fertility and Uptake of Nutrients in Rice and Maize Cropping System. *International Journal of Science and Nature*, *2*(1), 84-88.

[21] Shave, P. A., Ter-Rumum, A., & Enoch, M. I. (2012). Effects of time of Intercropping of Mucuna (*Mucuna cochinchinensis*) in Maize (*Zea mays*) for Weed and Soil Fertility Management. *International Journal of Agriculture & Biology*, *14*(3), 469-472.

[22] Tanimu, J., Iwuafor, E. N. O., Odunze, A. C., & Tian, G. (2007). Effect of incorporation of leguminous cover crops on yield and yield components of Maize. *World Journal of Agricultural Sciences, 3*(2), 243-249.

[23] Travis, J. W., Crassweller, R., Halbrendt, J., Krawczk, G., & Kleiner, B. (2004). Evaluation of orchard floor treatments at an apple replant site to determine the effect on tree health, productivity, soil microbial activity, and the reduction of root diseases , wooly apple aphid infestation and nematodes. *Penn Fruit News, 84*(2), 13-18.

[24] Ullah, M. S., Islam, M. S., Islam, M. A., & Haque, T. (2008). Effects of Organic Manures and Chemical Fertilizers on the Yield of Brinjal and Soil Properties. *J. Bangladesh Agril. Univ.*, *6*(2), 271-276.

[25] Uyovbisere, E. O., & Elemo, K. A. (2002). Effect of foliage of locust bean (*Parkia biglobosa*) and neem (*Azadirachta indica*) on soil fertility and productivity of early maize in a savanna Alfisol. In B. Badu-Apraku, M. A. S. Fakorede, M. Ouedraogo, & R. J. Carsky (Eds.), *Impact, challenges and prospects of maize research and development in West and Central Africa* (pp.185-194).

