International Journal of Environmental Sciences

(A peer reviewed International Journal)

Effect of Crop Residue Management on the Dynamics of Soil Organic Carbon and Nitrogen in Maize *(Zea mays)* Production

International Journal of Environmental Sciences, Vol. 1 No. 3. pp. 186-195. 2277-1948. 2012

ISSN *2277 – 1948*

Article type *Full Length Research Article*

Submission date *18 June 2012*

Acceptance date *10 July 2012*

Publication date *15 July 2012*

Article URL http://www.crdeep.com/category/ijes

Authors *Dayo Stephen Ogundijo*[I]*, *Michael Tunde Adetunji*[II], *Toyin A. Arowolo*[II], *Adeniyi.A Soretire*

International Journal of Environmental Sciences Vol. 1 No. 3. 2012. Pp. 186-195

Full Length Research Paper

Effect of Crop Residue Management on the Dynamics of Soil Organic Carbon and Nitrogen in Maize *(Zea mays)* Production

Dayo Stephen Ogundijo[iii]*, Michael Tunde Adetunji[1], Toyin A. Arowolo[iv], Adeniyi.A Soretire[1]
[1]*Department of Soil Science and Land Management, Federal University of Agriculture, P.M.B, 2240, Abeokuta, Nigeria*
[1] *Department of Environment management and Management and Toxicology, Federal University of Agriculture, P.M.B 2240, Abeokuta, Nigeria*

****Corresponding Author: Dayo Stephen Ogundijo***

Abstract
Screenhouse and field experiments were conducted in 2007 to determine the effects of fertilizer application and maize residue management on maize yield and the dynamics of soil organic carbon and nitrogen. The treatments consisted of three residue management practices of clean and pack, burnt in situ, spread as mulch as well as two levels of NPK fertilizer (20:10:10) applied at O kg ha^{-1} and 120 kg ha^{-1}. Maize (var. SUWAN 1) was planted in the pots arranged in the screenhouse as a factorial experiment in a randomized complete block design with three replicates. In the screenhouse, three maize cycles were grown each for six weeks while maize was grown to maturity in the field. Soil samples were collected and analyzed for total nitrogen, ammonium nitrogen, nitrate nitrogen and organic carbon before planting and after harvest in the screenhouse and additionally at 8 weeks after planting (WAP) in the field. Results of the screenhouse experiment showed that soil organic carbon increased with each succeeding cycle while the combination of the burnt residue and NPK fertilizer gave the highest increase of 388.6 % over the pretreatment level. In the field, nitrate-nitrogen was not significantly different at all the sampling periods although plots with NPK fertilizer alone had a significant increase of 135.8 % compared with clean and pack without fertilizer. Furthermore, combinations containing NPK fertilizer gave significant increase in yield over clean and pack without fertilizer (control) while other treatments were similar to control.

Keywords: *Crop residue, NPK fertilizer, Soil organic carbon, nitrogen, dynamics, mulch*

Introduction

The most prominent constraint to food production in most parts of the world is low fertility (Bationo & Mokwunye 1991). Increasing human population pressure has decreased the availability of arable land and it is no longer feasible to use extended fallow periods to restore soil fertility. The fallow period which would have restored soil fertility and organic carbon is reduced to lengths that cannot regenerate soil productivity (Nandwa, 2001). High population densities have necessitated the cultivation of marginal lands that are prone to erosion hence enhancing environmental degradation through soil erosion and nutrient mining. As a result, the increase in yield has been due largely to land expansion than to crop improvement potential (FAO, 2003).

Crop residue is a source of organic carbon for soil microorganisms and it also contributes to plant nutrients. In Africa, removal of crop residues from the fields, coupled with a lower rate of macronutrient application compared to losses, has contributed to negative balance (Stroorvogel & Smaling 1990). It has been estimated that only 0.8 million tons of crop residue are applied whereas 4.4 million tons are lost per year (Bationo et al. 2004). Additionally, low and erratic rainfall, high ambient soil and air temperature, inherent poor soil fertility, low water holding capacities and degraded soil structure lead to low crop productivity (Bationo et al. 2004).

Soil fertility is linked to soil organic matter, whose status depends on biomass input and management, mineralization, leaching and erosion (Roose & Barthes 2001; Nandwa, 2001). Crop residue application as surface mulch can play an important role in the maintenance of soil organic carbon (SOC) levels and productivity through increasing recycling of mineral nutrients, increasing fertilizer use efficiency, and improving soil physical, biological and chemical properties and decreasing soil erosion. However, organic materials available for mulching are scarce due to low overall production levels of biomass in Africa as well as their competitive use as fodder, construction materials and cooking fuel (Lamers & Feil, 1993).

In a study to determine crop residue availability at farm level, Baidu-Forson (1995) reported that at Diantandou in Niger with a long- term annual rainfall of 450 mm, an average of 1.2 ton ha^{-1} of millet stover was produced, at the end of the following year barely 250 kg ha^{-1} remained for mulching. Powel and Mohamed-Sallem (1987) showed that at least 50% of these large on-farm disappearance of millet stover could be attributed to livestock farming. Scarcity of organic matter calls for improvement of SOC stock. One of the options is the application of mineral fertilizer as a pre- requisite for more crop residues at the farm level and the maintenance of soil organic carbon.

Several scientists have reported the effect of organic amendments on crop yield (Mokwunye, (1980); Abdulahi & Lombin (1978); Powell (1986); Bationo & Mokwunye (1991); Bationo et al. (1995), (1998); Adetunji (1997). However, there is not enough information on dynamics of soil organic carbon and nitrogen as affected by crop residue management and inorganic fertilizer under maize crop. This study was therefore, conducted to assess the effect of different crop residue management on the dynamics of soil organic carbon and nitrogen and to investigate interaction between crop residue and inorganic fertilizer.

Materials and Methods

The study involved screenhouse and field experiments. The screenhouse experiment was carried out in the College of Plant Science and Crop Production (COLPLANT) screenhouse of the Federal University of Agriculture, Abeokuta, Nigeria. The field experiment was carried out at Ekha Agro farms site, Owode-Egba, Obafemi- Owode Local Government Area of Ogun State, Nigeria. The location of the field experiment is between latitude 7.10^0 N and latitude 3.26^0 E. The area lies in derived savanna ecological zone of Ogun State, Southwest of Nigeria. The area has a bimodal rainfall pattern with rain usually commencing in late March or early April and ending in the late October or early November with a short dry spell in August. The annual rainfall is about 1470 mm with the maximum rainfall in July and September while the mean monthly temperature ranged between 28^0 C and 32^0C.

Bulk surface soil samples (0-20 cm depth) were collected from the field experiment's site at Owode – Egba. The samples were mixed, air-dried and sieved using a 2 mm size screen. A portion was processed for laboratory analysis while the remaining was used for the screenhouse study. The laboratory sample was analyzed for pH in soil: water slurry of 1:2 using glass electrode pH meter (IITA 1979). Nitrogen was determined by regular Macro – Kjeldahl method (IITA, 1979). The organic carbon (OC) of the soil was determined using the chromic acid digestion method of Walkley and Black (1934). Available P was determined by Bray -1 P method (Bray & Kurtz 1945). Exchangeable bases in the soil were extracted using Ammonium acetate. Sodium and potassium in the extracts was determined using flame photometer, while magnesium in the extract were analyzed using Atomic absorption spectrophotometer (AAS), (IITA 1979). Nitrate-nitrogen and ammonium-nitrogen were determined colorimetrically after an extraction in 0.5 M K_2SO_4. Particle size analysis of the soil was determined by the hydrometer method (IITA 1979). The proportion of sand, clay and silt was used to determine the textural class of the soil using USDA textural triangle.

The screenhouse experiment was a 3 x 2 factorial, laid out in Randomized Complete Block Design with three replications. The treatments consisted of factorial combinations of three crop residue management options (clean and pack, burnt in situ and treatment spread as mulch) and two levels of fertilizer application (0 kg ha^{-1} and 120 kg ha^{-1} NPK 20:10:10).

Ten kilogram of air-dried, sieved (2 mm) soil sample from the field experiment site at Owode -Egba was used per pot. The mulching material was at the rate of 5 tons of residue (maize stover) per hectare and it was the same quantity that was burnt in situ.

Three seeds of maize (SUWAN 1) were sown and thinned to two plants per pot at 7 days after planting. It was grown for 3 cycles at 6 weeks per cycle. Soil samples were collected and analyzed for nitrate-nitrogen, ammonium-nitrogen, total nitrogen and organic carbon before planting and after each growing cycle. The treatments used in the field experiment were the same as those of screenhouse experiment. Both crop residue management and fertilizer application treatments were applied at the same rate as that of screenhouse experiment. The plot size was 4 m x 3 m. Planting was after ploughing, harrowing and application of crop residue management treatments. Inorganic fertilizer- NPK 20-10-10 was used. Maize crop residue was collected from Ekha Agro Farms plot. Test crop was maize –

SUWAN 1 (Early maturing flint and yellow seeded). Planting spacing was 75 cm by 25 cm and weeds were controlled by pre-emergence herbicide at planting. The maize was grown to maturity. Soil samples were collected and analyzed for total nitrogen, ammonium- nitrogen, nitrate – nitrogen and organic carbon on the field before planting, at 8 weeks after planting and at harvest. Agronomic data collected include dry matter yield and the grain yield.

Data collected were subjected to analysis of variance (ANOVA) using SAS and means were separated using Duncan's Multiple Range Test. Percentage average change over pre treatment level was calculated thus:

$$\text{Change \%} = (M\text{-}X / X) \times 100$$

Where, M – means of the 3 cycles
X- value before application of treatments.

Results

Characteristics of the experimental soil

Some of the properties of the experimental soil are shown in Table 1. The soil was slightly alkaline in reaction (pH 7.3), low in organic carbon and available P but relatively high in total nitrogen, exchangeable K and Ca. This soil is sandy in texture with the clay content lower than 5 %.

Table1: Some properties of the experimental soil before planting

	Soil property	Value
	pH	7.30
	Organic carbon	6.77 g kg^{-1}
	N	0.27 %
	Available P	0.30 mg kg^{-1}
Exchangeable -	K	0.90 cmol kg^{-1}
-	Na	1.05 cmol kg^{-1}
-	Mg	1.72 cmol kg^{-1}
-	Ca	22.5 cmol kg^{-1}
	$N0_3^- – N$	12.43 mg kg^{-1}
	$NH_4^+ – N$	6.04 mg kg^{-1}
	Sand	92.0 %
	Silt	3.8 %
	Clay	4.2 %
	Textural class	Sand

Screenhouse Experiment

Effect on agronomic parameters

The influence of the treatments on the maize plant height was significant (P<0.05) only at second crop of maize growth (Table 2). Treatment with burnt maize stover and fertilizer application was significantly higher than treatments where maize stover was applied as mulch with or without fertilizer application in terms of plant height. Pots that were bare and without fertilizer were not significantly different from pots where maize stover was burnt and without fertilizer application in terms of plant height.

There was a general decrease in the plant height of maize across the cycles, and this follows the order: first cycle>second cycle>third cycle and also treatments with fertilizer gave higher maize plant height than the unfertilized. In the first cycle, the dry matter yield was highest in pots treated with combination of stover mulch and fertilizer and least in those treated with stover mulch without fertilizer. Similarly, pots treated with burnt maize stover + fertilizer application had significantly higher dry matter yield than those treated with stover mulch without fertilizer application in the second cycle of maize growth. Generally, dry matter yield at third cycle was lower in value than the two previous cycles

.

Table 2: Effects of crop residue management and fertilizer application on plant height and plant girth at 6 weeks after planting in the screenhouse.

		Plant height (cm)			Dry matter yield (g pot^{-1})		
		1st cycle	2nd cycle	3rd cycle	1st cycle	2nd cycle	3rd cycle
Treatments							
	Bare	97.88a	84.33abc	69.00a	7.42ab	10.69ab	4.88a
Without	Burnt	114.86a	90.00abc	75.03a	8.77ab	11.01ab	4.96a
fertilizer	Mulched	98.54a	81.67c	80.67a	5.68b	7.57b	7.05a
	Bare	118.19a	93.67ab	82.17a	8.81ab	10.78ab	6.16a
With	Burnt	116.85a	95.50a	80.50a	9.49a	11.83a	6.60a
fertilizer	Mulched	121.18a	82.33bc	81.50a	9.93a	9.49ab	5.11a

Means in a column followed by the same letters are not significantly different at 5% probability.

Effect on soil organic carbon

At first cycle of maize, soil organic carbon (SOC) was significantly ($P<0.05$) higher in the pots treated with burnt stover + fertilizer application than other treatment combinations (Table 3). However, the treatment combinations with no fertilizer application were not significantly different. At this first cycle, SOC was higher in pots treated with stover mulch + fertilizer than those treated with fertilizer only. At second cycle, SOC was significantly higher in the pots treated with burnt stover without fertilizer application than those treated with stover mulch without fertilizer and bare pots without fertilizer. Generally, pots treated with burnt stover and stover mulch+ fertilizer had greater SOC than those treated with fertilizer only.

At third cycle of maize, SOC was significantly ($P<0.05$) higher in the pots treated with burnt stover + fertilizer application than those treated with burnt stover without fertilizer application and bare pots without fertilizer application (Table 3). Generally, substantial increases in the soil organic carbon over the value prior to planting (6.77 g kg^{-1}) were observed in all the treatments. On the average, the highest (388.45 %) increase was observed in the pots where maize stover was burnt with fertilizer application while the lowest (35.74 %) increase was observed in the clean and pack treatments without fertilizer application. However, the means of the soil organic carbon of the three crop cycle were not significantly different.

Effect on total nitrogen, nitrate and ammonium

The pots treated with burnt stover without fertilizer application was significantly ($P<0.05$) lower in total N than those treated with stover mulch without fertilizer and bare pots with fertilizer application at the second cycle of maize growth (Table 3). At third cycle, there was no significant difference in the total nitrogen content of the unfertilized pots. However, bare pots with fertilizer and mulched pots with fertilizer application were significantly higher in total N than pots where maize stover was burnt with fertilizer application.

Table 3: Effects of crop residue management and fertilizer application on the soil organic carbon (g kg^{-1}) and total nitrogen in the screenhouse

		Organic Carbon g kg^{-1}					Total nitrogen (%)				
		1st cycle	2nd cycle	3rd cycle	Mean of 3 cycles	Change %	1st cycle	2nd cycle	3rd cycle	Mean of 3 cycles	Change %
Treatments											
	Bare	7.11c	8.36c	12.10bc	9.19	35.74	0.06a	0.06ab	0.10ab	0.07	-74.07
Without	Burnt	12.06c	35.10a	7.09c	18.08	167.05	0.06a	0.05b	0.09ab	0.07	-74.07
fertilizer	Mulched	7.04c	12.35c	23.01ab	14.13	108.71	0.07a	0.07a	0.10ab	0.08	-70.37
	Bare	9.96c	8.53c	25.46ab	14.65	116.39	0.06a	0.06a	0.11a	0.08	-70.37
With	Burnt	42.39a	29.95ab	26.86a	33.07	388.45	0.06a	0.06ab	0.07b	0.06	-77.77
fertilizer	Mulched	20.37b	24.51b	19.91abc	21.60	319.03	0.06a	0.06ab	0.10a	0.07	-74.67

Means in a column followed by the same letters are not significantly different at 5% probability

Total nitrogen decreases in all the treatments compared with pre-treatment level (0.27 %) are shown in Table 3. The means obtained showed that total nitrogen at third cycle was significantly higher than the first two cycles

The crop residue management and fertilizer application at first and second cycles of maize did not have significant effects on soil nitrate (Table 4). At third cycle, nitrate in the pots treated with stover mulch without fertilizer application was significantly ($P<0.05$) higher than in pots treated with stover mulch + fertilizer application. There were no significant differences between other treatment combinations. Nitrate decreased substantially over pre-treatment level in all the treatments in the screenhouse (Table 4)**.**

The response of soil ammonium to the crop residue management and fertilizer application at all the three cycles of maize growth was not significant ($P>0.05$) (Table 4). However, the highest ammonium –nitrogen value (8.38 mg kg^{-1}) was recorded where mulch and fertilizer was applied at third crop while bare pots without fertilizer application also gave the lowest value (1.70 mg kg^{-1}). At the third cycle, treatments with stover mulch + fertilizer gave a marginal increase in ammonium values over pre planting level while treatments with burnt maize stover + fertilizer application gave largest decrease of 38.74 % and closely followed by bare pots with fertilizer 38.58 % (Table 4).

Field Experiment

Effect on agronomic parameters

Maize plant height responded significantly ($P<0.05$) to the crop residue management and fertilizer application at weeks 6 and 8 after planting (Table 5). At 6 weeks after planting, plant height for bare plots with fertilizer application was significantly higher than bare plots without fertilizer application and plots where mulch was applied without fertilizer application. Similarly, plots with fertilizer application only was significantly higher than plots where maize stover was burnt without fertilizer application and where maize stover was applied as mulch without fertilizer application in the 8 weeks after planting.

Maize grain yield as affected by crop residue management and fertilizer application in the field experiment are presented in Table 5. Maize grain responded significantly ($P<0.05$) to the crop residue management and fertilizer application. Grain yield in bare plots with fertilizer application was significantly higher than those in bare plots and burnt plots without fertilizer application. Similarly, plots where maize stover was applied as mulch with fertilizer was significantly higher than bare plots without fertilizer application and plots where maize stover was burnt without fertilizer application.

Table 4: Effects of crop residue management and fertilizer application on the nitrate-nitrogen and ammonium-nitrogen in the screenhouse

		NO_3^- - N (mg kg^{-1}) 1st cycle	2nd cycle	3rd cycle	Mean of 3 cycles	Change %	NH_4^+ - N (mg kg^{-1}) 1st cycle	2nd cycle	3rd cycle	Mean of 3 cycles	Change %
Treatments											
Without fertilizer	Bare	4.57a	6.65a	2.79ab	4.67	-62.43	7.23a	5.63a	1.70a	4.85	-19.70
	Burnt	5.58a	6.20a	2.87ab	4.88	60.74	7.97a	5.93a	2.20a	5.37	-11.09
	Mulched	3.07a	5.85a	4.45a	4.46	-64.12	7.57a	3.73a	2.57a	4.62	-23.50
With fertilizer	Bare	3.35a	6.37a	2.69ab	4.14	-66.69	3.73a	3.63a	3.77a	3.71	-38.58
	Burnt	3.58a	4.51a	2.98ab	3.69	-70.31	4.40a	4.23a	2.47a	3.70	-38.74
	Mulched	5.52a	6.23a	1.95b	4.57	-63.23	7.30a	4.20a	8.38a	6.63	9.77

Means in a column followed by the same letters are not significantly different at 5% probability

Table 5: Effects of crop residue management and fertilizer application on the plant height in the field

		Plant height (cm) WAP 4	6	8	Grain yield (ton ha^{-1})
Treatments					
Without fertilizer	Bare	72.50a	101.08b	156.17ab	3.44b
	Burnt	66.33a	106.92ab	152.08b	3.07b
	Mulched	70.25a	100.75b	151.83b	3.55ab
With Fertilizer	Bare	81.08a	141.00a	193.75a	3.98a
	Burnt	79.25a	128.67ab	184.25ab	3.65ab
	Mulched	90.42a	136.00ab	186.08ab	4.23a

Key: WAP – Weeks after planting

Means in a column followed by the same letters are not significantly different at 5% probability

Effect on soil organic carbon

Change in the soil organic carbon in the field as affected by crop residue management and fertilizer application is presented in Table 6. There was a substantial decrease in soil organic carbon in all the treatments over the pre-treatment level (6.77 g kg^{-1}.). Plots with burnt maize stover with fertilizer application gave highest average organic carbon (2.04 g kg^{-1}) while plots with burnt maize stover without fertilizer application gave lowest (1.42 g kg^{-1}.). Soil organic carbon content at 8 weeks after planting was significantly higher than at harvest when their means were compared. However, soil organic carbon behaves differently in the field experiment from that of greenhouse

Effect on total nitrogen, nitrate and ammonium

Total nitrogen decreases marginally over pre-treatment level (0.27%). Plots mulched with maize stover and fertilizer application showed lowest average decrease below pre-treatment level. Generally, fertilized plots showed marginal lower decrease when compared with the corresponding unfertilized plots (Table 6).

Nitrate concentration in the soil was lower at harvest than at 8 weeks after planting. Nitrate in bare without fertilizer decreased with an average of 88.82 % below pre-treatment level. Soil nitrate decrease was pronounced in all the treatments (Table 7). This pronounced reduction in nitrate over time in the field experiment could probably be due to the loss of nitrogen through the leaching beyond the sampling depth (0-20cm) as this could also be enhanced by sandy nature of the soil and volatilization.

Table 6: Dynamics of soil organic carbon and total nitrogen in the field

		Organic carbon (g kg^{-1})				Total nitrogen (%)			
Treatments		**8 WAP**	**At harvest**	**Mean**	**Change %**	**8 WAP**	**At harvest**	**Mean**	**Change %**
	Bare	2.92a	1.00ab	1.96	-71.05	0.16b	0.10a	0.13	-51.85
Without fertilizer	Burnt	1.75a	1.09ab	1.42	-79.03	0.20ab	0.09a	0.15	-44.44
	Mulched	1.89a	1.30ab	1.60	-76.37	0.25a	0.17a	0.21	-22.22
	Bare	1.99a	1.04ab	1.52	-77.55	0.19ab	0.12a	0.16	-40.74
With Fertilizer	Burnt	2.51a	1.57a	2.04	-69.37	0.20ab	0.09a	0.15	-44.44
	Mulched	2.56a	0.88b	1.72	-74.59	0.24a	0.20a	0.22	-18.52

Means in a column followed by the same letters are not significantly different at 5% probability.

Key: WAP – Weeks after planting

Ammonium decreased generally over pre treatment level on the field (Table 7). The highest average ammonium was observed on the plots with maize stover as mulch and fertilizer application while the lowest average ammonium was recorded on the bare plots with fertilizer application. Highest average ammonium concentration was recorded in treatments mulched with maize stover and fertilizer application both at screenhouse and field experiment

Table 7: Dynamics of nitrate-nitrogen and ammonium-nitrogen in the field

		NO_3^- - N (mg kg^{-1})				NH_4^+ - N (mg kg^{-1})			
Treatments		**8 WAP**	**At harvest**	**Mean**	**Change %**	**8 WAP**	**At harvest**	**Mean**	**Change %**
	Bare	1.73b	1.05ab	1.39	-88.82	2.80a	2.87b	2.84	-52.98
Without fertilizer	Burnt	2.15ab	1.61ab	1.88	-84.88	2.19a	0.81c	1.50	-75.17
	Mulched	2.34ab	0.62b	1.48	-88.09	2.36a	3.19ab	2.78	-53.97
	Bare	4.08a	2.87a	3.48	-72.00	1.34a	1.32c	1.33	-77.98
With Fertilizer	Burnt	2.10ab	1.33ab	1.72	-86.16	1.20a	3.47ab	2.34	-61.26
	Mulched	2.08ab	1.21ab	1.65	-86.73	2.98a	4.63a	3.81	-36.92

Key: WAP – Weeks after planting

Means in a column followed by the same letters are not significantly different at 5% probability

Discussion

The soil pH was high probably as a result of high exchangeable K and Ca in the soil. The organic carbon and nitrogen content were low probably because the site had been under continuous cultivation for about three years. Maize plant height was higher in the fertilized pots than the corresponding unfertilized pots in the screenhouse experiment. The high values over unfertilized pots suggest an improvement in nutrients status in the pots where fertilizer was applied. At second crop, pot with burnt stover and fertilizer was significantly higher than mulched pots with maize stover either with or without fertilizer. On the field, bare plots with fertilizer application perform better than other treatments in terms of plant height. This may be attributed to the fact that bare plots with fertilizer application gave highest value of nitrate at both 8 weeks after planting and at harvest.

Bare plots with fertilizer application gave the highest (3.01 ton ha^{-1}) dry matter on the field while bare plots without fertilizer gave the lowest (1.64 ton ha^{-1}). This may be linked to the high nitrate (4.08 mg kg^{-1}) content recorded on the bare plots with fertilizer at the time of sampling (8 weeks after planting). Also, bare plots without fertilizer recorded lowest value of nitrate (1.73 mg kg^{-1}).

The highest average maize grain yield (4.23 ton ha^{-1}) was recorded in the fertilized plots mulched with maize stover while the lowest (3.07 ton ha^{-1}) was on the plots with burnt maize stover without fertilizer application. This high value recorded over both bare plots with fertilizer and plots with burnt maize stover and fertilizer application suggests an improvement in the nutrient status of the soils where maize stover as mulch with fertilizer as applied. This was similar to findings reported by Adetunji (1997) and Bahrani et al.(2006). Also, average total nitrogen was higher in the plots with maize stover as mulch and fertilizer application than bare plots and plots with burnt maize stover and fertilizer even at critical stage of seed development (8 weeks after planting). This was in agreement with results reported by O'leary and Connon (1997) that total N uptake was strongly related to wheat grain yield.

Soil organic carbon content of treatments with burnt maize stover and fertilizer application was significantly higher than other treatments at first cycle. Soil organic carbon increased substantially over pre-treatment level in all the treatments except in control that showed a marginal increase over pre-treatment level. This may be as a result of mineralization during the cropping period. However, soil organic carbon behaves differently in the field experiment. In all the treatments the soil organic carbon decreased substantially below the pre-treatment level. The trend observed in the field might be due to other extraneous factors like rainfall, temperature and microbial population. Decrease in soil organic carbon with time had been reported by Biedebeck et al. (1980); Adetunji (1997); Bahrani et al. (2006).

There was decrease in total nitrogen in all the treatments in relation to pretreatment level in the screenhouse experiment. Treatments with burnt maize stover and fertilizer application showed highest average decrease of 77.77 % below pre-treatment level. This decrease in average total nitrogen below pre-treatment level may be as a result of demand on the soil nitrogen by the growing crop (maize), which was reflected in the growth parameters measured at first and second crop of maize growth. Total nitrogen in the field experiment also decreased below pretreatment level. Plots mulched with maize stover and fertilizer application gave the least average decrease below the pretreatment level of about 18.52 % and closely followed was plots mulched with maize stover but without fertilizer application (22.22%). The general decrease in total nitrogen recorded on the field may be also as a result of or demand on the soil nitrogen by the growing crop and the lower percent total nitrogen decrease obtain in the mulched plots suggests reduction in loses that was associated with soil erosion, leaching and volatilization. This was similar to the observation of Sinha (1993) in India Savanna, Roose and Barthes, (2001) and Adetunji (1997).

There was a general substantial decrease in average nitrates in screenhouse experiment in relation to pretreatment level. Similar trend was also observed in the field experiment. This pronounced reduction in nitrate over time in the field experiment could probably be due to the loss of nitrogen through the leaching beyond the sampling depth (0-20cm) as this could also be enhanced by sandy nature of the soil and volatilization. Similar findings were reported by Azeez et al. (2007).

Ammonium dynamics followed almost a similar trend as nitrate. Only pots mulched with maize stover and fertilizer application in screenhouse experiment show a marginal increase over pre-treatment level. There was no significant effect of crop residue management and fertilizer on ammonium concentration in the soil of screenhouse experiment. Similar findings were reported by Malhi et al. (2006). Highest average ammonium concentration was recorded in treatments mulched with maize stover and fertilizer application both at screenhouse and field experiment. This was probably as a result of reduction in losses that was caused by effect of the mulch material. Soil erosion and leaching loss seems to be minimal in residue incorporated plots than bare and burnt plots was observed by Adetunji, (1997).

Conclusion

Scarcity of organic matter calls for improvement of soil organic carbon stock. One of the options of achieving this is the application of mineral fertilizer as a pre-requisite for more crop residue at the farm level and the maintenance of soil organic carbon. However, there is not enough information on dynamics of soil organic carbon and nitrogen as affected by crop residue management and inorganic fertilizer under maize crop. This study was conducted therefore, to assess the effect of different crop residue management on the dynamics of soil organic carbon and nitrogen, and to determine its effect on growth and yield of maize.

It could be observed that plant height, dry matter, and grain yield were generally higher in fertilized plots than the corresponding unfertilized plots. The highest dry matter yield was observed when only 120 kg ha^{-1} of NPK 20-10-10 fertilizer was applied. Application of 5 ton ha^{-1}of maize stover as mulch with 120 kg ha^{-1} of NPK 20-10-10 fertilizer gave highest maize grain yield.

Soil organic carbon increased substantially over the pre-treatment level in the greenhouse experiment which was contrary to decrease pattern observed in the field experiment. Total nitrogen in the greenhouse experiment and field experiment followed the same trend. Total nitrogen generally decreased below pre-treatment level at both field and greenhouse experiment with plots mulched with maize stover given the least decrease at both fertilized and unfertilized on the field. In the greenhouse nitrate generally increased as second cycle>first cycle>third cycle. Ammonium measured at the three crops are not different from each other. Plots with maize stover as mulch and fertilizer gave the lowest decrease in ammonium below pre-treatment level in the field experiment. Change in nitrate concentration over pre-treatment followed similar trend in both greenhouse and field experiment. It was observed that nitrate reduces with time and this was pronounced on the field. The highest average ammonium concentration was observed in the greenhouse and field on plots mulched with maize stover and fertilizer application. Soil organic carbon, nitrate, ammonium and total nitrogen at both greenhouse and field experiment were not significantly correlated.

Following the above observations, it could therefore be recommended that application 5 ton ha^{-1} of maize crop residue as mulch coupled with 120 kg ha^{-1} of NPK 20-10-10 fertilizer will give highest maize yield among the treatment considered. However, its economic viability must be considered since it was only truly higher than yield from bare plots and plots where 5 ton ha^{-1} of maize stover was burnt without application of NPK 20-10-10 fertilizer.

It was also obvious that the dynamics of soil organic carbon and different forms of nitrogen cannot be predicted on the basis of management of maize stover and NPK 20-10-10 fertilizer at the rate of 120 kg ha^{-1} applied. This appears to be challenging and therefore there is need to look into other types of crop residue especially legumes and probably different rate of fertilizer application in order to establish the dynamics of soil organic carbon and nitrogen based on the management practices.

References

Abdulahi, A., Lombin, G. (1978). Long fertility studies at Samaru-Nigeria: Comparative Effectiveness of separate and combined Application of Mineralizer and Farmyard Manure in Maintaining Soil Productivity Under Continuous Cultivation in the Savanna, Samaru Miscellaneous Publication No75. Ahmadu Bello University, Zaria, Nigeria.

Adetunji, M.T. (1997). Organic residue management, soil nutrient changes and maize yield in a humid U-ltisol. Nutrient Cycling in Agroecosystems 47:189-195.

Azeez, J.O., Adetunji, M.T., Adebusuyi B. (2007). Effect of residue burning and fertilizer application on soil nutrient dynamics and dry grain yield of maize (*Zea mays* L.) in an Alfisol. Nigerian Journal of Soil science17: 71-80.

Bahrani, M.J., Raufat, M.H., Ghadiri, H. (2006). Influence of wheat residue management on irrigated corn grain production in a reduced tillage system. Soil and Tillage Research. doi:10.1016/j.still.2006.08.004

Baidu- Forson, J. (1995). Determinants of the availability of adequate millet stover for mulching in the Sahel. Journal of Sustainable Agriculture 5, 101-116.

Bationo, A., Kimetu, J., Ikerra, S., Kimani, S., Mugendi, D., Odendo, M., Silve, M., Swift, M.J., Sanginga, N. (2004). The African network for soil biology and fertility: new challenges and opportunities. In; Bationo, A. (Ed.), Managing Nutrient Cycles to sustain soil fertility in Sub- Saharan Africa. Academy Science Publishers, Nairobi, Kenya.

Bationo,A and Mokwunye ,A.U.(1991). Alleviating soil fertility constraints to increased food production in West Africa: The experience of the Sahel. Fertilizer Research 29: 95-115.

Bieberbeck, V.O., Campbell, C.A., Browen, K.E., Schitzer, M., Mclverk, R.N. (1980). Effect of burning cereal straw on soil properties and grain yield, in Saskatchewan. Soil Science Society of American Journal 44:103-111.

Bray,R.H. and Kurtz,L.T. (1945). Determination of total organic and available forms of phosphorus in soils. Soil science ,59:39-45.

FAO (Food and Agriculture Organization) (2003). FAOSTAT Agriculture Data, http://apps.fao/cgi-binnph-db.pl?Suset=agriculture. FAO, Rome, Italy.

IITA (1979). Selected methods for soil and plant analysis International Institute of Tropical Agriculture. Manual series. No.1 pp. 1-53.

International Institute of Tropical Agriculture (IITA) Farming Systems Program Annual Reports, (1973)

Lamers, J.P.A., Feil P.(1993). The many uses of millet residues. ILEA Newsletter 9, 15.

Malhi, S.S., Lemke, R., Wang, Z.H., Chhabra, B.S. (2006). Tillage, nitrogen and crop residue effects on crop yield, nutrient uptake, soil quality, and greenhouse gas emissions. Soil and Tillage Research 90:171-183.

Mokwunye, A.U. (1980). Interaction between Farmyard Manure and NPK Fertilizer in Savanna soils. In: FAO (Food and Agricultural Organization of the United Nations), Organic recycling in Africa. FAO soils Bulletin 43. FAO, Rome, Italy, pp 192-200.

Nandwa, S.M. (2001). Soil organic carbon (SOC) for sustainable productivity of cropping and agro-forestry systems in Eastern and Southern Africa. Nutrient Cycling in Agroecosystems 61:143-158.

O'Leary, G.J., Connor, D.J. (1997). Stubble retention and tillage in a semi-arid environment.3. Response of wheat. Field crop research 54:39-50.

Powell, J.M., Mohamed-Sallem, M.A., (1987). Nitrogen and phosphorus transfer in a crop livestock system in West Africa. Agricultural Systems 25: 261-277.

Roose, E., Barthes, B. (2001). Organic matter management for soil conservation and productivity restoration in Africa: a contribution from francophone research. Nutrient cycling in Agroecesystems 61: 159-170.

Sinha, A.(1993). Release of nitrogen, phosphorus and potassium from the decomposition of litter of savanna. Journal Pot. Research 9:66-71.

Stroorvogel, J., Smaling, E.M. (1990). Assessment of soil nutrient depletion in Sub-Saharan Africa : 1983-2000 Main Report, Vol.1. The Winand Staring Centre, Wageningen. The Netherlands.

Walkley A.,Black,C.A.(1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of chromic acid titration method. Soil science 39:29-38.