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EVALUATION OF NUTRIENT RESTORATIVE ABILITY OF SOME SELECTED CROP AND SOIL MANAGEMENT PRACTICES IN MAKURDI, SOUTHERN GUINEA SAVANNA, NIGERIA

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ABSTRACT

Field experiments were carried out at the Teaching and Research Farm of the University of Agricultrue, Makurdi Southern Guinea Savanna, during 2007 and 2008 cropping seasons to evaluate the nutrient restorative ability of some selected crop and soil management practices on soil productivity and yield of maize.

The experiment was laid out in Randomized Complete Block Design (RCBD) arranged in a split-plot with four levels of crop and soil management practices including no fertilizer (control), NPK (300kg/ha), NPK (300kg/ha) + poultry manure (PM) (5 t/ha) and NPK (300 kg/ha) + Cow dung (CD) (5t/ha) and two tillage practices (no tillage and 30 cm raised seed bed) and replicated four times. The study used the percentage change in post harvest nitrogen content to develop an index of restorative rationgs. Results of the study showed that the plots amended with NPK + PM gave higher seed yield of Maize (4 6t/ha) and higher left over N of 93.6 kg and 109/2 kg for 2007 and 2008 respectively. The highest P1 rating of +9.0 was also obtained from the same plot. The index developed could help farmers to predict the depletive or restorative effect of certain crop and soil management practices.

Key words: Poultry manure, cow dung, maize, productivity index.

INTRODUCTION

Most soils of Nigeria are dominated by low activity clay minerals that are strongly weathered with low nutrient status (Ano, 1990). Bationo and Mokwunye (1991), also reported that the soils of the tropics are low in fertility. Tropical soils can not supply the quantities of nutrients required and yield levels decline rapidly once croping commences. Soil degradation and nutrient depletion have become serious threats to agricultural productivity in Nigeria. In solving the infertility problem of tropical soils, traditional African farmers engaged in shifting cultivation. However, the demand for more land arising from increase in population pressure had led to a decrease in or complete disappearance of fallow periods. Continuous cultivation leads to reductions in organic matter and soil productivity. Other efforts developed to restore and improve the productivity of these soils include crop rotations, intercropping, fertilization and organic manuring, mulching and agro forestry (Adekunle *et al.,* 2004*).*

The need for improved management practices, especially through the use of external inputs from organic and inorganic sources on these soils has been stressed (Busari *et al.,* 2004). Complimentary use of organic and mineral fertilizer has proved a sound soil fertility management strategy in many countries of the world (Busari *et al*., 2004, Adeniyan and Ojeniyi 2005). The practice has a greater beneficial residual effect than can be derived from the use of either inorganic fertilizer or organic manure when applied alone (Makinde *et al.,* 2001; Adekunle *et al.,* 2004). Cultivation practices play a major role in nutrients and water sustainability. They are needed to increase agronomic stability and productivity while enhancing the environment (Hatfield *et al*., 1999). Therefore, complementary use of organic and inorganic fertlizer combined with appropriate cultivation practice becomes inevitable in fertility restoration in the tropical soils. This work was therefore, designed to evaluate the efficacy of different crop and soil management practices on soil fertility restoration and growth and yield of maize.

MATERIALS AND METHODS

Experiment was carried out during the 2007 and 2008 cropping seasons at the Teaching and Research farm of University of Agriculture Makurdi; in the southern Guinea savanna zone of Nigeria. A total land area of 23 m x 43.5 m (1000.5 m^2) was used. The experimental design was a split – plot in a randomized complete block design with two tillage techniques and four management practices replicated four times. The tillage techniques served as the main plots while the management practices (soil amendments) as the sub plots treatment. The treatment, factors and rates are as follows:

Tillage techniques
- T_{no} = No tillage
- T30 = $_{30}$ cm till – raised seed bed

The crop management practices
- M_{no} = Maize + no soil amendments
- M_{npk} = Maize + NPK fertilizer (300 kg/ha)
- M_{npk} + PM = Maize + NPK fertilizer (300 kg/ha) + poultry manure (5t/ha)
- M_{npk} + CD = Maize + NKP fertilizer (300 kg/ha) + cow dung (5t/ha)

The animal waste: cow dung and poultry manure were evenly spread on appropriate plots and worked into the soil during tillage. The amendments were allowed to decompose 14 days before planting the test crop (maize).

The initial chemical properties of the soil were determined from bulked composite samples before planting. At harvest, soil samples were taken from each plot at 0 – 15cm depth, air dried and passed through 3mm sieve. Thereafter, the following soil chemical properties were determined. The soil pH was determined in water and 0.1N KCl using the method described by MacLean (1982). Organic carbon by Walkley and Black (1934), total N by the macro–Kjeidahl digestion (Bremmer, 1965), available P by Bray and Kurtz no. 1 method (1945). The cations were extracted using ammonium acetate and K was evaluated using flame photometer, and Ca and Mg by atomic absorption spectrophotometer (Juo, 1979). Soil productivity index calculation was formulated in terms of percentage changes in N content (Cook, 1962). The percentage change in N was used to determine the index of productivity for forecasting the effect of each management practice on soil productivity.

Plant height, stem growth and leaf area index were taken at 9 WAP. Maize grain yield was determined at harvest. Data on soil N, growth parameters and seed yield were analyzed using correlation, regression and analysis of variance (F – test) to determine treatment effect. Means were separated using the LSD technique at 5% level.

RESULTS AND DISCUSSION

Soil properties of the site and chemical analysis of poultry manure and cow dung used for the experiment

The soil used for the experiment was low in organic matter. N, P and K and cation exchange capacity (table 1). Thus, the soil used was typical of upland soils in the tropics particularly Alfisols (Sanchez and Logan, 1992). The low organic matter obtained may be partly due the effect of high temperature and relative humidity which facilitate rapid mineralization of organic matter. The soil has very low CEC reflecting intensely weathered status. The low CEC, low organic matter, and low total N are indicators of low inherent fertility status, which underscore the need for improved soil management techniques. The N and available P of the poultry manure were higher than that of the cow dung (Table 1). Cow dung however, contained higher K, Ca and Mg. If adequately applied, poultry manure contains reasonable amount of N that will raise the productivity of the soil and increase the yield of maize.

Effect of crop and soil management practices on growth and yield of maize

The main effect of crop and soil management practices on mean leaf area index (LAI), stem growth, plant height and seed yield for 2007 and 2008 is presented in Table 2. Result of the study show that fertilizer application significantly ($P < 0.001$) increased LA1, stem growth, plant height and seed yield. Cumulative results show that maize plots amended with NPK + PM had 81%, 53%, 83% and 232% increases in LA1, stem growth, plant height and seed yield respectively. This may be as a result of the combined beneficial effects of poultry manure and NPK fertilizer which make available nutrients especially nitrogen and organic matter for enhanced crop growth and higher grain yield. Higher grain yield resulting from the application of manurial treatments has been reported from other studies (Ojeniyi, 2000; Ojeniyi and Adejobi 2002; Adeniyan and Ojeniyi, 2005).

Similarly, results of the study also show significant ($P < 001$) effects of tillage practices on LA1, stem growth, plant height and seed yield (Table 2). The tilled plots had 32%, 19%, 23% and 67% increases in LA1, stem growth, plant height and seed yield respectively relative to the no till plots. The improvement in soil physical properties following application of NPK + PM could have enhanced root proliferation, shoot growth and eventual seed yield. Upawansa (1997), earlier reported improvement in soil fertility exceeding expectations in an integrated system, probably because of combined effect of soil conservation, nutrient enrichment, enhancement of biological activities and improvement in moisture retention capacity.

Table 1: Chemical analysis of Poultry Manure and Cow dung used for the Experiment

Parameters	Soil	PM	CD
Nitrogen (g kg^{-1})	0.20	4.48	3.12
Organic matter (g kg^{-1})	0.50	-	-
Phosphorus (g kg^{-1})	6.20	1.98	0.35
Potassium (g kg^{-1})	6.22	1.53	13.99
Calcium (g kg^{-1})	2.50	7.63	8.6
Magnesium (g kg^{-1})	2.50	0.39	5.63
CEC (g kg^{-1})	7.50	-	-

PM = Poultry manure
CD = Cow dung

Table 2: Mean effect of crop and soil management practices on maize growth parameters and seed yield

Treatment Fertilizer	LA1	Plant Height (cm)	Stem growth (cm)	Seed yield (t/ha)
Control	0.09	26.1	5.0	1.27
NPK	0.11	26.5	5.4	2.98
NPK + CD	0.23	49.9	6.3	3.57
NPK + PM	0.19	96.5	7.4	4.22
LSD	0.01	9.75	0.47	0.39
Tillage Practices				
T_{no}	0.14	43.2	5.7	2.41
T_{30}	0.17	56.2	6.3	3.80
LSD	0.01	6.80	0.33	0.28

Quantifying the effect of crop and soil management practices on soil productivity

The pre-cropping N, added N and post harvest N contents from the experiment are presented in Table 3. Results of the findings showed that the initial (pre-cropping) N for all the plots was 936 kg/ha. Prior to planting in each season, plots amended with NPK, NPK + CD and NPK + PM received 45 kg/ha, 60.6 kg/ha and 67.4 kg N/ha respectively. The highest value of post harvest soil N content was found in plots amended with NPK + PM while the lowest post harvest N value was found in unamended plots.

Results of annual "left over N" for each crop and soil management practices for 2007 and 2008 cropping seasons are presented in Table 4. The results show that the lowest "left over N" was found in unamended plots while the highest "left over N" was found in the plots amended with NPK + P in the two cropping seasons. Unamended plots had annual loss of 62.4 kg N/ha and 46.8 kg N/ha in 2007 and 2008 respectively. The maize plots amended with NPK alone had identical loss of 31.2 kg N/ha in both 2007 and 2008. The "left over N" however, increased from the plots amended with NPK + CD and NPK + PM. The increase in "left over N" for NPK + CD plots was 31.2 kg N/ha and 46 kg N/ha for 2007 and 2008 respectively. Similarly, the increase in "left over N" for plots amended with NPK + P were 93.6 kg N/ha and 109.2 kg N/ha for 2007 and 2008 respectively. A significant relationship between soil post harvest N content and seed yield was observed (table 5). This showed that the soil amendments applied could deplete or restore the fertility of the soil differently.

Table 3: Pre-cropping N, added N and post harvest soil N content (kg/ha) for crop and soil management practices during the 2007 and 2008 planting seasons

Crop management Practices	Pre-cropping N + added N	Post harvest N + added N	Post Harvest N
Control (unamended)	936 + 0	873.6 + 0	826.8
NPK	936 + 45	904.8 + 45	873.6
NPK + CD	936 + 60.6	967.2 + 60.6	1014
NPK + PM	936 + 67.4	1029.6 + 67.4	1138.8
LSD		0.1847	0.0462

NB: The top soil (0 – 10 cm) of the study area has a weight of 1.56×10^6 kg/ha thickness of 10 cm and bulk density of 1.56 g/cm^3.

Therefore:

$$\text{N kg/ha} = \frac{\text{N (\%)}}{100} \times \frac{1{,}560{,}000}{1}$$

Table 4: Mean annual "left over N" (kg/ha) for crop and soil management practices

Crop management Practices	(N kg/ha) 2007	2008
Control (unamended)	- 62.4	- 46.8
NPK	- 31.2	- 31.2
NPK + CD	+ 31.2	+ 46.8
NPK + PM	+ 93.6	+ 109.2

NB: (1) pre-cropping N – post harvest N 2007 = left over N 2007
(2) post havest N 2007 – post harvest N 2008 = left over N 2008

Table 5: Relationship between seed yield (y) and post harvest soil nitrogen (N) content (X)

Dependent Parameter	Year	Regression Model	Coefficient of Determination
Maize	2007	Y = -12.81 + 0.824(x)	0.84**
Seed			
Yield	2008	Y = -7.230 + 0.892(x)	0.90**

Table 6: Percent change in post harvest N and seed yield of maize under different management practices

Crop management Practices	Percentage change in N 2007	2008	Percentage change in seed yield
Control (Unamended)	- 7.1	- 5.7	- 13.3
NPK	- 3.4	- 3.6	- 5.3
NPK + CD	+ 3.2	+ 4.6	+ 8.1
NPK + PM	+ 9.1	+ 9.6	+ 13

Soil productivity index (P1) for estimating safe or unsafe cropping systems

The percentage changes in N content in relation to the changes in crop seed yield under the different crop and soil management practices presented in Table 6 were used to develop an index of productivity rating (P1) to be used by farmers to calculate safe or unsafe cropping systems. The ascribed productivity index ratings are presented in Table 7. The productivity indexes were derived directly as the mean of percentage change in nitrogen between 2007 and 2008 cropping seasons.

Results of the study as presented in Table 7 show that the plots amended with NPK + PM had the highest rating (+9.0). This was closely followed by plots amended with NPK + CD with the rating of + 4.0. The unamended plots had the lowest rating of + 6.0. The results obtained show that the crop and soil management practice with P1 of +9.0 is better than all the other practices with lower P1 values. This P1 can help farmers to compare the productivity of soils of different sites. It will also help farmers to predict the depletive or restorative effect of certain crop and soil management practices.

Table 7: Soil productivity ratings for four management practices

Management practice	Productivity index (P1)
Control (unamended)	- 6.0
NPK	- 4.0
NPK + CD	+ 4.0
NPK + PM	+ 9.0

NB: Ascribed productivity index (P1) was derived directly from the percent N change in each year for each management practice and is defined as average annual percent change in soil post harvest nitrogen content.

Calculation of safe or unsafe cropping system

In Table 8, a hypothetical four year cropping programme was used to illustrate the use of this productivity index (P1) for selected crop and soil management practices. This illustration would determine whether productivity would increase or decrease in the different cropping systems adopted (Table 8). The soil producivity ratings derived from the percent change in nitrogen in each year for each management practice were used in calculating whether the cropping systems were safe or unsafe. An assumed four hectares of farm land was used. In the four hectares, each hectare had different management practices for four years. The total productivity index (P1) at the end of each year was calculated (Table 9).

Table 8: Hypothetical four year cropping programme using different crop and soil management practices

Plot/Year	1	2	3	4
1	Maize + NPK	Maize + NPK + CD	Maize + NPK + PM	Maize + NA
2	Maize + NPK + PM	Maize + NPK	Maize + NPK	Maize + Na
3	Maize + NPK + CD	Maize + NPK + PM	Maize + NA	Maize + NPK
4	Maize + NPK + PM	Maize + NPK + CD	Maize + NPK	Maize + NPK

NA = No amendment
CD = Cow dung
PD = Poultry droppings

Table 9: Calculated productivity index for the crop and soil management practices

Plot/Year	1	2	3	4
1	- 4	+ 4	+ 4	- 6
2	+ 9	- 4	- 4	- 6
3	+ 4	+ 9	+ 9	- 4
4	+ 9	+ 4	+ 4	- 4

CONCLUSION

The study revealed that the crop and soil management practices adopted were efficient in soil productivity improvement. This P1 can help farmers to compare the productivity of soils of diffeent sites. It will also help farmers to predict the depletive or restorative effect of certain crop and soil management practices.

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