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RESEARCH ARTICLE

Effect of Integrated Nutrient Management on Soil Chemical Properties and Maize Yield on a Sandy Clay Loam in Abakaliki, Ebonyi State

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ABSTRACT

A study was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki in order to study effect of integrated nutrient management on soil chemical properties and maize yield on a sandy clay loam. The field was laid out in a randomized complete block design (RCBD) comprising of five treatments viz poultry droppings + burnt rice mill waste (PBRMW), cow dung + unburnt rice mill waste (CURMW), goat dung + saw dust (GDSD), NPK 20:10:10 fertilizer and control (C). The treatments were replicated four times. Data from the study were analyzed using ANOVA and means separated with Fisher's least significant difference. The result showed highly significant ($P<0.05$) % OC, pH, Mg and K in PBRMW, CURMW and GDSD amended plots relative to NPK 20:10:10 fertilizer and control, respectively. Exchangeable Ca was significantly ($P<0.05$) higher (10.0 $Cmolkg^{-1}$) in PBRMW than control and other manure treatments, respectively. Total N, available P, Na, ECEC and %BS were 38, 43, 44, 19% and 23% higher than the control values. Plant height (cm), leaf area index and grain yield (tha^{-1}) were 66, 26, 38 and 57% higher in PBRMW amendment compared to control and other manure treatments, respectively. Manure management more than NPK 20:10:10 fertilizer and control enhanced soil chemical properties and yield of maize. Soil chemical properties and maize yield were improved as follows PBRMW> CURMW> GDSD>NPK 20:10:10 fertilizer >C. Based on the foregoing, integrated manure management could be recommended for increasing productivity of sandy clay loam in Abakaliki, Ebonyi State.

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INTRODUCTION

Integrated nutrient management is the maintenance of soil fertility and supply of plant nutrients at an optimum level for sustenance of desired crop production as well as minimizes nutrient losses to the environment (Singh and Balasubraman, 1980). Soil productivity declines through leaching, erosion and crop harvests. These losses are even exacerbated by tropical rainfall and anthropogenic forces. Unless the soil nutrients are replenished through use of organic wastes, crop residues, fallow and reconstruction of soil organic matter, soil fertility loss would continue unabated (Donova *et al.,* 1998).

Recently in Nigeria research interest had diverted to use of organic wastes source of nutrients (Uyovbisere and Elemo, 2000). This is due to scarcity and high cost of inorganic fertilizer. Intensification of use of mineral fertilizer has been reported to cause soil acidity and environmental health hazard. This situation renders use of inorganic fertilizer in sustainable soil productivity counter productive.

Consequently, effort must be geared towards finding a close substitute to fertilizer that would ensure slow and steady supply of soil nutrients. Uyovbisere and Elemo (2000) reported superior effect of integrated nutrient management in increasing soil productivity. Similarly, the potential of agricultural wastes to improve soil properties have long been recognized (Johnston, 1986). Mbagwu and Ekwealor (1990) noted that combination of wastes ensured well balanced nutrient supply and uptake by crops that led to higher yield. Chemical properties of soil receiving farm yard manure and sugar cane filter cake increased soil organic carbon, total N, P and K status (Kaur *et al.*, 2005).

Although there had been numerous studies on organic wastes in Abakaliki, most of them dwelt extensively on sole use of organic wastes treatments. Where integrated nutrient management is possible, it is often on organic wastes either animal wastes or agricultural wastes in combination with mineral fertilizer. This study is a paradigm shift from the status quo. Besides, information is lacking on use of a combination of wastes especially animal and agricultural wastes. This study wa therefore to find out effect of integrated nutrient management on soil chemical properties and maize yield on a sandy clay loam.

MATERIALS AND METHODS

Experimental site

The experiment was conduct at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The area is located by latitude 06^{o}4$'$N and longitude 08^{o}65$'$E in the derived savanna of the southeast agroecological zone of Nigeria. The rainfall pattern is bimodal and spread from April – July and September – November with a short spell in August normally referred to as “August break”. The minimum annual rainfall is 1700 mm while maximum is 2000 mm with average of 1800 mm. Annual mean temperatures range from 27^{o}C and 31^{o}C for minimum and maximum usually experienced in rainy and dry seasons. The relative humidity is 80% during rainy season but declines to 60% in dry season (ODNRI, 1989). The soil is derived from successive marine deposit. The soil according to Federal Department of Agriculture and Land Resources (FDALR, 1985) belongs to the order ultisol classified as Typic Haplushult.

Field methods

A land area of 0.03ha was used for the experiment. The land was cleared of existing vegetation and debris removed. The field was laid out in Randomized Complete Block Design (RCBD) with five treatments. The plots measured 3 x 3 m with 0.5 m space while the replicates were separated by 1m alley. The treatments were poultry droppings + burnt rice husk dust, cow dung + unburnt rice husk dust, goat dung + sawdust, NPK 20:10:10 fertilizer and control. The treatments except NPK 20:10:10 fertilizer were applied at 20tha^{-1}. The NPK 20:10:10 fertilizer was applied at 400kgha^{-1}. These were spread on the plots and later incorporated into the soil with hoe. The treatments were replicated four times to give a total of twenty experimental plots in the experiment.

The NPK 20:10:10 fertilizer was sourced from Ebonyi State Agricultural Development Programme (EBADEP), Onuebonyi Izzi, Abakaliki. The burnt and unburnt rice husk dusts were collected at rice milling industry and saw dust at timber shade market, Abakaliki.

Maize variety (Oba super II) was used as a test crop. The maize seed was obtained at ministry of Agriculture, Ebonyi State, Abakaliki. The maize seeds were planted at a seed rate of two per hole at a depth of 5 cm and planting distance of 25 x 75 cm two weeks after germination (WAG), the seedlings were thinned down to one per hole replacement was done for those which failed to germinate. There were a total of 53,333 plants for a hectare weeds were removed at three weekly interval till harvest of maize cobs. Grain yield of maize was obtained by harvesting the cobs when the husks were fully dried. The cobs were dehusked, shelled and grains dried to constant weight. Yield was determined at 14% moisture content.

Soil sampling

Composite soil sample was collected with auger at 0-20 cm depth for pre-planting analysis. Soil samples were further collected with cores on each plot for post-planting soil analysis. The core samples were used to determine physical properties of soil.

Agronomic data

A total of twelve plants were tagged and used for agronomic studies. Plant height was determined by using calibrated meter rule to measure from base of plant to the tallest leaf. This was done for every two weeks till 90 days after planting (DAP). Leaf area index determination was done according to the following formula:

$$\text{Leaf area index} = \frac{\text{Leaf area (m}^2\text{)}}{\text{Ground area (m}^2\text{)}} \quad \ldots\ldots\ldots\ldots\ldots 1$$

When the husks were dried, the cobs were harvested, dehusked and shelled. The grain yield was adjusted to 14% moisture content.

Laboratory methods

Soil pH was determined in soil/water ratio of 1.2.5. After stirring for 30 minutes, the pH values were read off using Beckman Zeromatic pH meter (Peech, 1965). Available P determination was by Bray 2 method as described in Page *et al.* (1982). Total N was determined by using modified Kjeldahl digestion procedure (Breminer and Mulvancy, 1982). Nelson and Somneers (1982) method was used in determination of percent organic carbon. Magnesium and calcium were determined by using ethyldiethylene tetra-acetic acid (EDTA) method. Sodium and potassium were extracted with **I N** ammonium acetate solution (NH_4OAC) using flame photometer. Percent base saturation was calculated by using

$$\%BS = \frac{TEB}{CEC} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots 2$$

Where:

Cation exchange capacity determination was by ammonium acetate method (NH_4OAC). Effective cation exchange capacity was calculated by summation method as follows:

$$ECEC = TEB + TEA \quad \ldots\ldots\ldots\ldots\ldots 3$$

Where

ECEC = Effective cation exchange capacity (cmolkg^{-1})
TEB = Total exchangeable bases (cmolkg^{-1})
TEA = Total exchangeable acidity (cmolkg^{-1})
Total exchangeable acidity was determined by titration method.

Data analysis

Data collected were subjected to statistical analysis system (SAS, 1985). Means were separated for significance using Fishers least significant difference according to (Steel and Torrie, 1980). Significance was accepted at 5%.

RESULTS AND DISCUSSION

Soil chemical properties at initiation of study

Table 1 shows result of chemical properties of soil at initiation of study. The soil pH value in KCL was 5.7 and slightly acidic according to Landon (1991). Percent organic carbon and total N were low (Enwezor *et al.*, 1989). Calcium and magnesium dominated the soil exchange complex. Exchangeable available K and Na were low (Asadu and Nweke, 1989). Available P recorded low value of 18.65 mgkg^{-}1 (Landon, 1991). Effective cation exchange complex (17.20 Cmolkg^{-1}) was very low (Asadu and Nweke, 1999). Base saturation approximately 69% indicates that indeed, the soil was acidic.

Effect of treatments on % OC, total N, available P and soil pH

Percent organic carbon, total N, available P and soil pH following treatment application is shown in Table 2. Percent organic carbon in amended plots was significantly (P<0.05) higher than control. Similarly, percent organic carbon in poultry dropping + burnt rice mill waste (PBRMW) and goat dung + saw dust (GDSD) treatment significantly (P<0.05) increased relative to NPK 20:10:10 fertilizer and cow dung + unburnt rice mill waste (CURMW) treatments, respectively. Furthermore, soil pH in plots treated with PBRMW and GDSD were significantly (P<0.05) higher compared to the ones treated with CURMW, NPK 20:10:10 fertilizer and control, respectively. Although, total N and available P were not affected by treatments, these soil parameters were higher in amended plots relative to control. The PBRMW amended plot increased by 3% respectively when compared with control for total N and available P. The improvements recorded in this soil chemical properties suggest that incorporation of organic materials could raise soil fertility. Ayoola and Odedina (2006) noted that organic material incorporated into soil raised organic matter level. High organic matter in soil would have positive effect on total N, soil pH and available P (Table 2). Consequently, the low values of soil parameters in plots treated with NPK 20:10:10 fertilizer could be attributed to readily available nutrients and their dissipation (Ayoola, 2006) relative to their organic sources.

Effect of treatment on exchangeable bases, effective cation exchange capacity and base saturation

The result (Table 3) shows effect of amendments on exchangeable bases, effective cation exchange capacity and percent base saturation. Significantly (P<0.05) higher exchangeable Ca, Mg, K and effective cation exchange capacity (ECEC) were obtained in amended plots relative to control, respectively. Poultry droppings + burnt rice mill waste (PBRMW) amended soil was significantly (P<0.05) higher by 13, 27, 39 and 73% respectively for Ca, Mg, K and ECEC when compared to NPK 20:10:10 fertilizer treated plots. Similarly, PBRMW amendment significantly (P<0.05) increased Ca, Mg, K and ECEC by 28, 21, 34 and 44% over cow dung + unburnt rice mill waste (CURMW) and goat dung + saw dust (GDSD) treated plots. Even though, exchangeable Na and %BS of control and amended plots were not significantly different, the values for these soil properties were higher in all treated plots than control. Exchangeable Na (0.23 cmo/kg^{-1}) and %BS (66.89%) were highest for PBRMW amendment compared to other treatments, respectively.

The significant increase in exchangeable Ca, Mg, K and ECEC could be attributed to release of these exchangeable bases upon mineralization of added organic wastes in the soil. Agboola and Fagbenro (1985) and

Table 1: Soil properties at initiation of study

Soil parameters	Unit	value
pH in KCL		5.7
Organic carbon	%	1.8
Organic matter	%	3.0
Total nitrogen	%	0.2
Available phosphorus	Cmolkg^{-1}	18.7
Na	Cmolkg	0.2
K	Cmolkg	0.3
Ca	Cmolkg	7.6
Mg	Cmolkg	3.8
ECEC	Cmolkg	17.2
Base saturation	%	69.2

ECEC – effective cation exchange capacity

Table 2: Effect of treatments chemical properties of Soil

Treatment	pH KCL	OC%	N%	P mgkg^{-1}
Control	6.4	2.5	8.76	16.54
NPK 20:10:10 fertilizer	6.4	2.9	0.17	22.90
PBRMW	7.0	3.5	0.22	23.65
CURMW	6.6	2.9	0.18	19.01
GDSD	6.7	3.3	0.18	22.70
FLSD(0.05)	0.1	0.2	NS	NS

PBRMW – Poultry dropping + burnt rice mill waste, CURMW – Cow dung + unburnt rice mill waste, GDSD-goat dung + saw dust, % OC-organic carbon, N-% nitrogen, P-available phosphorus. NS – not significant

Table 3: Effect of treatments on exchangeable cations

Treatment	Ca	Mg	K	Na	ECEC	%BS
Control	5.73	1.52	0.23	0.16	16.18	54.24
NPK 20:10:10 fertilizer	8.76	2.32	0.34	0.22	17.85	63.95
PBRMW	10.01	3.18	0.56	0.23	19.25	66.89
CURMW	7.22	3.06	0.42	0.20	18.73	56.31
GDSD	7.45	2.50	0.37	0.20	18.40	57.35
FLSD(0.05)	0.53	0.15	0.12	NS	1.11	NS

PBRMW – Poultry dropping + burnt rice mill waste, CURMW – Cow dung + unburnt rice mill waste, GDSD-goat dung + saw dust, ECEC – effective cation exchange capacity, %BS – percent base saturation, NS – not significant

Table 4: Effect of treatments on agronomic yield of maize

Treatment	Plant height (cm)	LAI	Grain yield (tha^{-1})
Control	140.15	503.56	0.50
NPK 20:10:10 fertilizer	177.05	625.05	0.78
PBRMW	188.90	671.34	0.83
CURMW	157.70	601.05	0.60
GDSD	145.72	559.48	0.53
FLSD(0.05)	18.67	51.37	NS

LAI – leaf area index, NS – not significant

Mbagwu (1992) in their studies reported that application of organic wastes in soil increased exchangeable properties which enhanced ECEC.

The higher % BS in PBRMW amended plot is in agreement with Agboola and Fagbenro (1985) findings that organic wastes added to the soil increased percent base saturation.

Agronomic yield of maize

Effect of treatments on agronomic yield of maize is shown in Table 4. Plant height and leaf area index were significantly ($P<0.05$) higher in amended plots compared to control. Poultry droppings + burnt rice mill waste amendment produced taller plants and more leaf area which was significantly ($P<0.05$) higher relative to cow dung + unburnt rice mill waste (CURMW) and goat dung + saw dust (GDSD), respectively. These were higher by 17 and 23% for plant height, 10 and 17% for leaf area index compared to CURMW and GDSD treated plots, respectively. Grain yield of maize was statistically the same in both control and treated plots.

However, PBRMW amended plot increased grain yield of maize by 40, 60, 28 and 36% respectively over control, CURMW and GDSD amendments. The relative agronomic yields obtained in the treatments indicate order of their releases of nutrients in the soil. The order in agronomic yields follows PBRMW>NPK 20:10:10 fertilizer>CURMW>GDSD>C for plant height, leaf area index and grain yield of maize. This order is intandem with the report of Obi and Ebo (1985) and Zsolnay and Gorlitz (1994) of agronomic yield of maize in organic wastes and fertilizer amended plots. Furthermore, this order observed in agronomic yield of maize could be a reflection of improvement of physicochemical properties of soil by the amendments. The low values recorded in grain yield of maize in this study are attributable to drought experienced during the filling of the grains on cob. This was exacerbated by pest and disease incidence observed in the farm.

Conclusion

The results of this study indicate that organic wastes and NPK 20:10:10 fertilizer could be used for improving soil productivity. Generally organic wastes amendment out performed NPK 20:10:10 fertilizer in improvement of soil chemical properties except in agronomic yield of maize. In assessing the overall enhancement of chemical properties by the amendments, they could be rated as follows PBRMW>GDSD>CURMW>NPK 20:10:10 fertilizer>C. However, the order for their increasing agronomic yield is as follows PBRMW>NPK 20:10:10 fertilizer>CURMW>GDSD>C. Poultry droppings + burnt rice mill waste application proved most superior in increasing soil productivity when compared to other organic wastes amendment and control. Consequently, poultry droppings in combination with burnt rice mill waste treatment could be used for sustainable soil productivity.

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