AMERICAN-EURASIAN JOURNAL OF SUSTAINABLE AGRICULTURE
ISSN: 1995-0748, EISSN: 1998-1074
2017, volume(11), issue(4): pages (1-7)
Published Online July 19 2017 in http://www.aensiweb.com/AEJSA/

Potentials Of Animal Wastes In Productivity Of A Sandy Loam In Abakaliki, Southeastern Nigeria

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Received 12 March 2017; Accepted 20 June 2017; Published Online 19 July 2017

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ABSTRACT

Soil productivity has been the focus of agronomists and to this extent enormous research efforts have been and are still made towards evolving enduring approaches to sustain and increase soil productivity and yield of crops, it is imperative to study potential of animal wastes in productivity of sandy loam. This research was carried out to study potentials of animal wastes in productivity of a sandy loam in Abakaliki in the derived Savanah zone of Nigeria. There were four animal wastes and control each applied at $10tha^{-1}$ to plots that measured 3m x 3m and were replicated four times. Assessing and evaluation of potentials of different animal wastes for sustainable productivity is important. The result showed that gravimetric moisture content (GMC), aggregate stability (AS), hydraulic conductivity (HC) and mean weight diameter (MWD) were respectively significantly ($P<0.05$) higher in goat (GD), Cow dung (CD), poultry manure (PM) and sewage sludge (SS) amendments when compared to control and their values in other animal wastes. Nitrogen and cation exchange capacity (CEC) were significantly ($P<0.05$) higher in poultry manure (PM) when compared to other animal wastes amendment and control. The poultry manure significantly decreased soil bulk density and increased pH by 15, 8, 11% and 5.20 compared to values obtained in C, CD, GD and SS amendments. Grain yields of maize were significantly ($P<0.05$) higher by 7–26% in CD and PM amendments than control. Animal wastes amendment relatively improved soil productivity and increased yield of maize than control but for significant improvement in soil pH higher values of application are recommended. By using different animal wastes as soil improver which allows for evaluation of their potentials, and in this case is not limited to a particular waste, soil productivity was increased.

KEY WORDS
animal wastes, potentials, productivity, sandy loam, sustainable

INTRODUCTION

Sandy loam accounts for more than 35% of soils put into crop production in Abakaliki area of southeastern Nigeria. The soil is kaolinitic and lacks most of the essential basic cations such as calcium, magnesium, potassium and major plant nutrients like nitrogen, phosphorus as well as low in organic carbon content [1; 2; 3]. The soil is also characterized by leaching losses which impinge on the productivity. As a result of this inherent low fertility trend and productivity which can be reversed with animal wastes amendment [4;1].

Animal wastes are easily accessible and affordable to local resource farmers and devoid of high cost, scarcity and environmental hazards [5] associated with inorganic fertilizer such as pollution and decrease of soil acidity. Besides, animal wastes improve physicochemical properties of soil especially moisture transmission and nutrient supply capacity [4] and yield of crops [6;7;8;9]. Physical and chemical properties contained in animal wastes facilitate aggregation of mineral particles such as clays which influence soil water regime [10]. Furthermore, wastes from animals have stimulating effect on beneficial microorganisms which interact biochemically to produce humus needed to unleash soil nutrients for improvement of physicochemical properties which culminate in soil higher productivity [11;12].

Maize yield is normally low at farmers level often between 0.5 to 1.5tha^{-1} in the agro-ecology. There is need to increase yield above this marginal level using amendments. Soil amendments such as inorganic fertilizer has been used at different levels, although it increased yield but not greater than between medium to moderate yields of 2.5tha^{1} [13]. Nevertheless, there are opportunities for higher soil productivity or increased yields if the soil is properly prepared and animal wastes applied at appropriate rate and time. This is because animal manure has lasting positive impact on soil properties than inorganic fertilizer which effect is vitiated at a shorter period of time and sometimes may not be enough for high nutrients demanding crops like Maize [14]. This therefore, necessitated this study. The output from this work would provide information to farmers, land users and other critical stakeholders on the best practices that could elicit management technologies for sustainable productivity for sandy loam in the area. The objective of the research was to study potentials of animal wastes in productivity of a sandy loam in Abakaliki, Southeastern Nigeria.

MATERIALS AND METHODS

Study Area:

The experiment was carried out in 2016 between April to October at the Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The area is located by latitude 06^{o} 4$^{/}$N and Longitude 08^{0} 65$^{/}$E in the derived savanah zone of Nigeria. Abakaliki area is characterized as humid tropics. It has bimodal pattern of rainfall which spreads from April to July and September to November with a short dry spell in August commonly referred to as "August break". Annual rainfall ranges from 1700 – 2000mm with a mean annual rainfall of 1800mm. Temperatures vary from 27^{o}C to 31^{o}C for the rainy and dry periods of the year. Relative humidity is low (60%) during dry season but high (80%) in rainy months of the year. Geologically, the Abakaliki area is underlain by sedimentary rocks derived from successive marine deposits of the cretaceous and tertiary periods. The area lies within "asu river group" and consists of olive brown sandy shales, fine grained sandstones and mudstones. The soil is shallow with unconsolidated parent materials of shale residuum found within 1m of the soil surface. The soil is sandy loam at 0 – 20 cm depth and belongs to the order ultisol, which is classified as typic haplustult [15].

Field Methods:

A land area of approximately 0.03ha was used for the study. The site was cleared of existing vegetation manually and debris removed without burning. The field was laid out in randomized complete block design (RCBD). The plots measured 3m x 3m and were separated by 0.5m spaces. The four replications were set apart by 1m alley each. The plots were raised into beds with traditional hoe. The animal wastes each of poultry manure (PM), cow dung (CD) sewage sludge (SS) were sourced from Animal Science Department of Ebonyi State University. The five treatments except control were applied each at 10tha^{-1} equivalent to 9 kg plot^{-1}.The treatments were replicated four times to give a total of twenty experimental plots in the replication. These treatments were spread on the surface of the plots after their preparation and afterward carefully raked into the soil. The animal wastes treatments were allowed for two weeks to age before planting the test crop. Maize variety (Oba Super II) collected from Ebonyi State Agricultural Development Programme (EBADEP) at Onuebonyi Izzi, Abakaliki was used as a test crop. The maize seeds were planted two per hole at a depth of 5 cm and planting distance of 25 cm x 75 cm. Two weeks after emergence, the seedlings were thinned down to one per hole while weak ones and those that did not germinate were replaced by replanting maize seeds. This gave approximately 53, 333 plants per hectare. Weeds were removed at two weekly intervals till harvest.

Soil Sampling:

A composite soil sample was collected with auger at 0 – 20 cm plough layer from the site before cultivation and treatment application. Core and auger samples were further collected from each plot at 0 – 20 cm depth at two months after planting maize seeds for post-harvest soil analysis.

Agronomic Data:

Six maize plants were sampled from each plot for plant height and grain yield evaluations. Metric rule was used to determine plant height by measuring each plant from base to tip of leaves at 90 days after planting to determine plant height. When the husks had turned brown, the cobs were harvested, dehusked, shelled and grain yield determined at 14% moisture content.

Laboratory Methods:

Bulk density was evaluated by dividing oven dry mass of soil (105^{o}c) with volume of soil. Total porosity was determined using the following equation.

$$TP = \frac{(1 - BD)}{Dp} \times \frac{100}{1} \quad (1)$$

where
TP = Total porosity (%)
BD = Bulk density (gcm^{-3})
Dp = Particle density assumed at 2.65gcm^{-3}

Moisture content of soil was determined by using gravimetric moisture content method. Hydraulic conductivity determination was done using constant-head approach. Mean weight diameter was determined using [16] method. The particle size distribution was assessed using the method of [17]. Soil samples < 2 mm was used to determine soil pH in soil/water suspension ratio of 1:2.5 and values read off with calibrated pH meter. Organic carbon was determined using the method described in [18] while organic matter was evaluated by multiplying a value of organic carbon by Van Bemmeler factor of 1.724. Total nitrogen determination was done using micro kjeldahl distillation. The ammonia from the digestion was distilled with 45% NaO Hinto 2.5% boric acid and determined by titrating with 0.05 N KCL. Carbon nitrogen ratio was calculated by dividing the value of carbon by nitrogen. Exchangeable Ca, Mg, K and Na were determined by flame photometry method after extraction with 1N NH_4OAC. Cation exchange capacity was determined by using ammonium acetate method while base saturation determination was done as follows:

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

where
BS% = Percent base saturation
TEB = Total exchangeable basses ($cmolkg^{-1}$)
CEC = Cation exchange capacity ($cmolkg^{-1}$)

Data Analysis:

Soil and maize data were subjected to ANOVA while separating significant ($P<0.05$) means with Fishers Least Significant Difference [19].

Results:

Table 1 shows properties of soil before planting. The texture of soil was sandy loam. The soil was strongly acidic. Results of exchangeable acidity, CEC and base saturation confirmed acidity of soil. Available phosphorus, organic carbon and organic matter were moderate but nitrogen was very low. Exchangeable Ca, Mg, K and Na were very low. These results depict soil low in fertility and need for amendment. Nutrient composition of animal wastes is shown in Table 2. The nutrient concentrations were generally higher in animal wastes than in soil. Organic carbon and nitrogen contents of poultry manure were higher compared to those of other animals. Available phosphorus and exchangeable Ca, Mg, K and Na were higher in sewage sludge than in other animal wastes. Carbon-nitrogen ratio of poultry manure was better than the values obtained in alternate animal wastes. Nutrients composition in the animal wastes are of the order of PD>SS>GD >CD.

Table 3 shows effect of animal wastes on particle size distribution. Sand fractions were predominant in both control and under animal wastes amendment. There were no pronounced changes in distribution of particle sizes after planting. The texture remained sandy loam. Soil physical properties as affected by animal wastes treatment is shown in Table 4. Effect of animal wastes amendment on physical properties did not follow a particular trend. Nevertheless, GMC, AS, HC and MWD were significantly ($p<0.05$) higher in GD, CD, PM and SS when respectively compared to control and their values obtained in other animal wastes amendment. The value of AS was 2% lower in SS than in control. Bulk densities were 15, 8 and 11% lower in PM amended plot compared to their counterparts in C, CD, GD and SS respectively. Total porosities followed the trend obtained in bulk densities in the amendments. Animal wastes application significantly reduced bulk density and increased total porosity of soil. The soil structure was improved as it stabilized thereby increasing pore volume for storage and transmission of water. Generally, the wastes from animals significantly improved physical properties. These observations lend credence to the amendment of animal wastes in the soil. Effect of animal wastes amendment on soil chemical properties (Table 5) indicates that P, N, OC, Ca, Mg, CEC, K and BS were significantly ($p<0.05$) higher in CD and PM amended plots than control. The PM and SS amendment improved the soil by increasing pH, hence it was moved from 5.0 to 5.10 and 5.20 respectively after planting. Similarly, the animal wastes upon decomposition and mineralization yielded nutrients that improved the studied chemical properties of soil. The chemical properties ranged respectively from 38.80–48.80 mg/kg^{-1}, 0.14-0.17% and 1.46–1.76 gkg^{-1} and 1.6-2.0, 0.8–1.6, 0.11 – 0.09 $cmolkg^{-1}$ and 3.80 – 5.02 $cmolkg^{-1}$ and 74–92% for P, N, OC, Ca, Mg, K, CEC and BS and were higher compared to their respective values in control or initial values before amendment. Plant height and grain yield of maize as influenced by animal wastes application (Table 6) showed significant ($P<0.05$) treatment effect on grain yield of maize except on plot receiving sewage sludge. Positive influence of animal wastes amendment is indicated on agronomic yield of maize. This is shown by taller maize plants ranging from 42.88 – 50.18(cm) and significant grain yields of maize 2.4– 2.7 t ha^{-1} for the animal wastes amended plots, respectively. This translated to 7–26% increments in grain yields of maize in plots amended with CD and PM when compared to control.

Discussion:

The texture remained sandy loam after planting. This observation is expected since texture is a property of soil used as a mapping unit. It is permanent and least affected by cultural practices. The nutrients compositions of animal wastes (OC, N, P, Ca, Mg, K and Na) are to be released into the soil during decomposition and mineralization. They are expected to improve the nutrient status of soil. The animal wastes reduced soil bulk density and increased total pore volume. The stabilized Soil structure consequently increased water storage without the problem of ponding. Higher hydraulic conductivity reduced the risk of "anaerobiosis" as there was adequate aeration. Essentially, these conditions favoured root elongation and proliferation with the advantage of higher rhizospheric effect. These observations are intandem with the reports of [4;20;21;22;23]. The animal wastes respectively improved soil pH, P, N, OC, Ca, Mg, K, CEC and BS. Hence their values in amended plots were higher than control. The soil pH remained strongly acidic in all the treated plots which could be attributed to low rate of wastes application. This is an evidence that the soil benefited from the added animal wastes although not enough to significantly increase soil pH. Available P, OC, CEC and BS moved away from critical before planting to moderate and high-values in the post-harvest assessment [24;25] The relative superior performance of PM when compared to other animal wastes amendment in improving nutrient status of soil is in line with the findings of [26;27;28;29]. The positive response of maize plant height to application of animal wastes is attributable to nutrients released to the soil [30]. This significantly influenced grain yield which varied according to animals wastes. Animal manure amendment [31;8] had been noted to significantly increased grain yield of maize [32].

Conclusion:

The results of this study had shown that animal wastes can be used to reclaim degraded sandy loam to sustainable soil productivity and profitable maize crop production. Amending soil with different animal wastes significantly improved GMC, AS, HC and MWD as well as P, N, OC, Ca, Mg K, CEC and BS status of soil. The positive effects of these amendments on physicochemical properties of soil gave rise to taller maize plants and significant grain yields of maize. It is recommended that animal wastes be used for soil amendment for sustainable higher soil productivity and profitable production of maize in Abakaliki agricultural ecology although higher rates are necessary for significant improvement in the soil pH. It is believed that information from this study would increase awareness and knowledge of farmers and other land users in the area for proper management of soil to achieve sustainability in soil productivity. This study therefore, postulates that CD and PM could be effective replacement for inorganic fertilizer for soil amendment for increased productivity as they moved grain yield of maize away from medium to moderate yields to higher yields more than GD and SS. Use of animal wastes could save farmers from high cost of fertilizer and their associated problems. Besides it is a veritable means of recycling the wastes to avoid environmental pollution. Further research may be necessary to determine impact of long term application of animal wastes on soil productivity and agronomic yield of maize in the agro ecology.

Table 1: Initial Properties of Soil before Planting

Soil Properties	Values
Sand gkg^{-1}	600
Silt gkg^{-1}	250
Clay gkg^{-1}	150
pH kcl	5.00
Phosphorus $mgkg^{-1}$	25.00
Nitrogen gkg^{-1}	0.10
organic carbon gkg^{-1}	1.25
Organic matter gkg^{-1}	2.16
Calcium $cmolkg^{-1}$	1.60
Magnesium $cmolkg^{-1}$	o.46
Potassium $cmolkg^{-1}$	1.10
Sodium $cmolkg^{-1}$	0.20
Exchangeable acidity $cmolkg^{-1}$	1.04
Cation exchange capacity $cmolkg^{-1}$	3.33
Base saturation %	69

Table 2: Nutrient Composition of animal wastes

Nutrient	← Animal wastes →			
	PM	SS	GD	CD
Organic carbon gkg^{-1}	16.0	2.73	5.20	3.35
Nitrogen gkg^{-1}	2.10	0.20	1.80	0.13
Available phosphorus $mgkg^{-1}$	2.18	12.30	2.10	38.40
Calcium $cmolkg^{-1}$	6.20	6.40	3.20	3.80
Magnesium $cmolkg^{-1}$	2.00	2.56	1.30	0.29
Potassium $cmolkg^{-1}$	3.30	9.14	0.40	0.14
Sodium $cmolkg^{-1}$	0.70	4.28	0.24	0.09
Carbon-nitrogen ratio %	8.00	26.59	2.60	13.92

PM – poultry manure, SS – Sewage sludge, GD – Goat dung, CD – Cow dung

Table 3: Effect of Animal wastes on particle size distribution

Treatments	← Particle size distribution gkg^{-1} →			Texture
	Sand	Silt	Clay	Sandy loam
Control	590	260	150	Sandy loam
Cow dung	590	240	170	Sandy loam
Goat dung	590	250	160	Sandy loam
Poultry manure	580	230	180	Sandy loam
Sewage sludge	580	250	170	Sandy loam

Table 4: Effect of Animal wastes on soil physical properties

Treatments	BD Mgm^{-1}	%TP	%GMC	%AS	HC $cmhr^{-1}$	%MWD
Control	1.40	47	16.5	9.90	5.70	1.51
Cow dung	1.30	51	16.6	22.19	8.57	2.34
Goat dung	1.30	51	21.5	17.74	7.22	1.93
Poultry manure	1.19	56	18.4	17.97	10.07	2.12
Sewage sludge	1.35	49	18.0	9.22	5.83	2.40
FLSD ($p<0.05$)	NS	NS	2.10	0.97	1.74	0.18

BD –, TP –, GMC –, AS –, HC –, MWD –, NS – not significant at $p<0.05$

Table 5: Effect of animal wastes on soil chemical properties

Treatments	pH H_2O	P $mgkg^{-1}$	$Ngkg^{-1}$	OC gkg^{-1}	← $cmolkg^{-1}$ →				
					Ca	Mg	K	CEC	BS %
Control	4.90	25.0	0.07	1.25	2.0	0.4	0.44	2.80	74
Cow dung	5.0	48.0	0.14	1.73	2.0	1.2	0.11	3.80	76
Goat dung	5.0	38.8	0.16	1.52	2.0	1.4	0.09	4.72	92
Poultry manure	5.2	45.1	0.17	1.76	2.0	1.6	0.14	5.02	80
Sewage sludge	5.1	40.1	0.14	1.46	1.6	0.8	0.06	3.65	92
FLSD ($p<0.05$)	NS	51	0.01	0.86	0.0	0.1	0.01	0.15	2.4

NS – Not significant at $p<0.05$

Table 6: Effect of animal wastes on agronomic yields of maize

Treatment	Plant height cm	Grain yield tha^{-1}
Control	41.95	2.0
Cow dung	47.46	2.7
Goat dung	50.18	2.5
Poultry manure	42.88	2.7
Sewage sludge	48.44	2.4
FLSD ($P<0.05$)	NS	0.3

NS – Not significant at $p<0.05$.

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