SCIREA Journal of Environmental

http://www.scirea.org/journal/Environmental

December 3, 2016

Volume 1, Issue1, October 2016

EFFECT OF ANIMAL MANURE ON SOIL NUTRIENTS REPLISHMENT AND PERFORMANCE OF OKRA (*Abelmoschus esculentus* L.) GROWN ON DEGRADED SANDY SOIL IN CALABAR, NIGERIA

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Abstract

A field experiment conducted at the Teaching and Research Farm of the Department of Crop Science, University of Calabar, evaluated the effect of poultry (PM) and goat manures (GM) on soil properties and the performance of okra. Treatments comprised 3 x 3 factorial combinations of PM and GM rates each at 0, 5 and 10 t/ha in randomized complete block design (RCBD) with three replications. Results obtained showed reduced acidity and higher nutrient content in the post-harvest soil. Manure significantly ($P \leq 0.05$) enhanced plant height, leaf production, leaf

area index, flower production, onset of flowering, pod girth and length, and pod yield compared with control. Application of PM and GM sole or combined at 10 t/ha significantly ($P \leq 0.05$) enhanced both growth and pod yield of okra. There were significant ($P<0.05$) PM x GM rates interactions on both growth and yield parameters evaluated. The best vegetative parameters and highest fresh pod yield of 2.74 t/ha obtained in plots jointly fertilized with 10 t/ha of PM and GM strongly indicates that combined application of different organic resources enhances their fertilizer efficiency and should be promoted in organic cropping to fast track soil fertility restoration for sustainable crop production on degraded land.

Keywords: Animal manure, degraded land, okra yield, soil management

Introduction

Okra (*Abelmoschus esculentus* L.) is an annual tropical crop and one of the most important vegetables grown in Nigeria. It is consumed in different forms as fruit and leafy vegetable used in both green and dried states. Nutritionally, green immature fruits are a good source of vitamins, minerals and plant protein and are used as soup thickener. Young leaves contain high amounts of riboflavin (vitamin B) and are commonly used as spinach in stews. Okra seeds contain approximately 21 % protein, 14 % lipids, 5 % ash and 40 % oil content which is comparable to soybean (Akinfasoye and Nwanguma, 2005). Sliced fruits of okra processed into dried okra have remained delicacy in some localities in the dry season and contributes meaningfully to the income of farmers.

Okra has both medicinal and industrial applications. Okra leaves contain considerable amount of roughages and are used to promote digestion and as a cure against ulcers and haemorrhage (Oyolu, 1983). The mucilage is used as a plasma replacement or blood volume expander and is also useful in confectionery industries and for the manufacture of special papers. The bark of the plant produces good quality fibre suitable for paper and cardboard manufacturer and spinning ropes (Alasiri *et al*. 2000; Siemonsma and Jouama, 2004).

Animal manures and composts have been in use in gardening for a long time to maintain soil functions. Manure contributes to the fertility of the soil by adding organic matter and nutrients such as nitrogen trapped by bacteria in the soil (Boller and Hani, 2004). In addition to nutrients, they provide carbon and other constituents that affect soil humus contents, biological activity and soil physical structure (Brady and Weil, 1996).

When used appropriately, manures ensure sustainable crop yields by immobilizing nutrients that are susceptible to leaching. Nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yield (Sharma and Mittra, 1991). Manures are usually applied at higher rates relative to inorganic fertilizers to give strong residual effect on the growth and yield of succeeding crops.

Enhanced nutrient efficiency and higher agronomic benefits of manures are usually obtained when applied in mixture and at appropriate rates. However, organic manures have been poorly used by most farmers in Nigeria due largely to lack of authentic information on combined use of different farmyard manures for different crops. The essence of this research work was to determine the optimum rates of poultry and goat manures for enhanced performance of okra (*Abelmoschus esculentus*)

Materials and Methods

The experiment was carried out in the University of Calabar Teaching and Research Farm, Calabar in 2014. Calabar is located in the high rainforest zone of Cross River State with two distinct weather conditions. The wet season spans from March/April to October/November while the dry season lasts between November/December and February/March. The area is characterized by annual rainfall of 2000 – 3500 mm, temperature range of 27 – 30 ^{0} C and relative humidity of 80 – 90 % (Iloeje, 2001). The land used for the experiment had previously been under cassava cultivation for two seasons.

Land preparation and demarcation of unit plots

The land measuring 15 m x 28 m (420m^2) was cleared manually using machete and tilled with hoe and spade. The debris were packed and dumped in the surrounding bush. The area was mapped out and demarcated into unit plots of 2.0m x 3.0m (6.0m^2), separated from each other by 1.5 m pathways and 1.0m between each plot. Predominant weed species at the experimental site included *Pamcum maximum*, *Chromolaena odorata*, *Emilia* spp. and *Euphorbia* spp.

Soil sampling and analysis

The pre-planting and post-harvest surface (0 – 30 cm depth) soil samples were collected at different locations within the land used for the experiment. These components were mixed thoroughly, air-dried, grounded and sieved using 2-mm mesh size sieve prior to routine analysis. Soil particle size was determined by the hydrometer method (Bouyocos, 1962), while soil pH was determined in a 1:1 soil to water suspension using a pH meter. Organic carbon was determined by wet oxidation method (Nelson *et al.*, 1982), while total nitrogen was done by macro-Kjeldahl method and available P by Bray-P1 method (Bray and Kurtz, 1945). Exchangeable bases were extracted with neutral 1M NH_4OAC at a soil solution ratio of 1:10 and measured with flame photometry; exchangeable acidity was determined by titration method (Mclean, 1982).

Treatments and experimental design and manure application

The treatments consisted of three levels (0, 5 and 10 t/ha) of poultry manure (PM) and three levels (0, 5 and 10 t/ha) of goat manure (GM), giving a total of nine (9) treatment combinations. These treatment combinations were evaluated in a 3 x 3 factorial design in a randomized complete block design (RCBD) in three blocks to give 27 treatment units.

The manure was crushed and applied by incorporating them into the soil after tilling. This was done to enable fast decomposition of the organic materials to release the nutrients for the benefit of the crops. The nutrient contents of poultry/goat manures were 3.15/1.40 % Nitrogen, 1.22/1.15 % Phosphorous, 1.10/0.60 % Potassium, 2.96/0.48 % Calcium, 1.68/0.26 % Magnesium and organic carbon content of 1.68/36.14 %, respectively.

Planting materials and sowing of okra seeds

Okra was planted two (2) weeks after incorporation of manure when the temperature of the soil had normalized. The variety of okra used was the Clenson Spineless VGTH-014K popularly known as 'Lady's finger'. The premier brand seeds were obtained from Umudike in Abia State and planted on the 3 July, 2014. Three (3) seeds were planted per hole at a depth of 2 - 3 cm at spacing of 30 cm x 30 cm. The seedlings were later thinned to one plant per stand two weeks after emergence to give 66 plants in each plot and plant population of 111, 111 plants/ha.

Maintenance of experimental plots

Weeding was done manually with hoe and hand pulling as the need arose. During weeding, soil was added around the base of plants to prevent exposure of roots. Cross bund were constructed and maintained to prevent erosion within and around the plots. No serious pest or disease problems were observed in the plots.

Harvesting of okra fruits

Harvesting was carried out when the immature fruits had attained maximum size. Harvesting was done at three days interval to avoid over maturity of fruits. A sharp kitchen knife was used to cut off the fruits neatly to avoid injuries to the plants.

Data collection and analysis

Observations recorded on okra growth were plant height, number of leaves per plant, leaf area index and days to 50 % flowering while yield parameters evaluated were numbers of flowers per plant, number of fruits per plant, pod girth and length, and fresh pod yield per hectare.

Collected data were subjected to analysis of variance (ANOVA) and means were compared using Duncan's New Multiple Range Test (DNMRT) at 5% probability level.

Result and Discussion

The physico-chemical properties (Table 1) of the pre-planting and post-harvest surface soil samples indicate that clay and silt contents in the post-harvest soil were higher than at the pre-planting stage. The high sand fraction present in all soil samples showed that soil at the site had

sandy texture. Such soils naturally contain low organic matter and low nutrient levels and require good management and amendment with high quality organic materials to remain productive. The size differences between sand, silt, loam and clay textural classes is of paramount agronomic importance as these parameters influence the pore size and nutrient holding capacity and air circulation within the soil (Hamza, 2008).

The pH of the soil also increased in the post-harvest soil indicating that animal manures have potential in reducing soil acidity, and hence enhancing nutrient availability to crops. Like soil pH, organic C, total N, available P, exchangeable Ca, Mg, K, and base saturation were higher in the post-harvest soil than their initial contents. The fluctuation of Na, H^{+}, Al^{3+}, and CEC was minimal at the end of the experiment. Favourable effect of reduced soil acidity on nutrient availability was similarly reported by Lyocks *et al.* (2013), Undie *et al* (2013), Undie *et al* (2015). He observed that soil pH affected the solubility of essential plant nutrients such as P, K, Ca, Mg, Mn and Fe and influences their absorption from the soil by plants. Also, Sanchez *et al.* (1987) reported increased pH in post- harvest soils under manure treatments, confirming agronomic benefits of utilizing organic based plant nutrients like animal manures which could ameliorate the acidity of tropical soils to improve crop production.

Soil nutrient problems related to excessive acidity is common in the high rainfall environments. Both manures showed effective buffering capacity which is reflected in the increased pH from 5.9 in pre-planting to 6.9 in the post-harvest soil (Table 1). Post-harvest soil showed increased soil organic matter, organic nitrogen, phosphorus and cation exchange capacity obviously due to contribution from goat and poultry manures. High quality organic manures are therefore beneficial in the management of nutrient deficient soils to improve their productivity.

Application of manure significantly ($p \leq 0.05$) influenced all vegetative parameters of okra assessed irrespective of the type of animal manure (Table 2). Tallest plants were in plots incorporated with 10 t of manure per hectare, followed by 5 t/ha, while shortest plants were in control plots. Plants attained similar height at the same rate in both types of manure.

More leaves and branches and higher LAI were recorded in plots treated with highest manure rates, while intermediate values were obtained at 5 t of manures per hectare and zero nutrient plots had lowest values of the parameters.

On-set of flowering in okra was also influenced by goat and poultry manure application. Plants attained flowering stage earlier in all manure treatments with those in plots amended with highest manure rates attaining flowering first, followed by those treated with 5 t of the nutrients while unfertilized plants required the longest period of time to transit to the reproductive stage. The period of transition from vegetative to reproductive phases in plants is strongly influenced by the crop growth rate which in turn is determined by the growing environment including soil conditions such as its fertility status during cropping.

Plants growing in plots fertilized with both manure types at 10 t/ha established well, exhibited vigorous growth and produced flowers about two weeks before the control plants. Earliness of flowering or fruiting is important and desirable in fruit trees/vegetables. It ensures a longer productive lifespan and increased productivity.

Interactions between goat and poultry manures on all vegetative parameters were significant with the best influence obtained by combining the highest rates of both manures (Table 2), possibly due to the release of more nutrients for the growth of the crop.

All yield parameters evaluated were also significantly ($p \leq 0.05$) influenced by both manure types with poultry manure having higher values than goat manure at the corresponding rates (Table 3). Control plants were least in all yield parameters while 10 t of each nutrient per hectare produced more flowers and correspondingly highest number of fruits which were larger and longer than those in other treatments, resulting in the highest fruit yield per hectare.

Goat manure x poultry manure effects were also favourable on okra yield parameters. Interaction effect increased with increasing rates of the nutrients combined with the best influence obtained in plots that combined both nutrients at the highest rates (Table 3).

Any rate of goat or poultry manure was better than zero application but when combined better results were achieved. This strongly suggests that combined application of organic resources enhances their fertilizer efficiency and should be promoted in organic cropping to fast track soil fertility restoration for sustainable crop production on degraded land.

Table 1. Physical and chemical properties of surface soil samples at the experimental site

Soil parameter	Value	
	Pre-planting	post-harvest
Clay (%)	9.0	12.1
Silt (%)	6.7	6.9
pH	5.9	6.9
Organic C (%)	1.39	1.62
Total N (%)	0.13	2.31
Available P ($mgkg^{-1}$)	46.5	79.6
Ca ($cmolkg^{-1}$)	4.1	6.4
Mg ($cmolkg^{-1}$)	2.2	7.0
K ($cmolkg^{-1}$)	0.12	0.20
Na ($cmolkg^{-1}$)	0.08	0.14
Exchangeable H^{+} ($cmolkg^{-1}$)	1.05	1.12
Exchangeable Al^{+++} ($cmolkg^{-1}$)	0.00	0.05
Effective cation exchangeable capacity (ECEC) ($cmolkg^{-1}$)	7.3	7.6
Base saturation	85.0	92.8

Table 2. Effect of poultry and goat manure rates on vegetative growth parameters of okra

Manure Rates (t/ha)	Plant ht (cm)	Leaves plant^{-1}	Branches plant^{-1}	LAI	Days to 50 % flowering
Goat Manure					
0	44.68c	7.44c	3.4b	33.12c	85.67c
5	59.99b	8.33b	3.5b	38.91b	76.78b
10	60.07a	9.44a	4.5a	41.88a	74.67c
Poultry manure					
0	42.68c	7.33c	3.6b	33.92c	82.44a
5	55.07b	8.44b	4.2a	38.97b	76.11b
10	61.99a	9.60a	4.8a	41.92a	74.86c
Interactions					
GM0 x PM0	34.73i	6.00h	3.4c	27.62g	89.00a
GM0 x PM1	47.30g	7.87g	3.6c	35.71e	82.00b
GM0 x PM2	52.00e	9.67d	3.8b	38.89cd	80.33c
GM1 x PM0	43.63h	7.67g	3.4c	32.56f	77.33d
GM1 x PM1	55.93d	8.90e	4.2a	37.80d	78.00d
GM1 x PM2	65.40C	11.33b	3.9b	46.45b	80.33c
GM2 x PM0	49.67f	8.33f	3.6c	36.32de	74.00e
GM2 x PM1	61.97b	10.67c	4.2a	39.52c	77.00d
GM2 x PM2	68.57a	12.33a	4.4a	49.99a	69.00f

Means followed by the same letter within the column are not significantly different at 5 % level according to Duncan's New Multiple Range Tests (DNMRT).

*GM = goat manure; PM = poultry manure

Table 3. Effect of poultry and goat manures on yield parameters of okra

Manure Rates (t/ha)	Number of flowers/ Plant	Number of pods/ plant	Pod girth (cm)	Pod length (cm)	Pod yield (t/ha)
Goat Manure					
0	4.70c	4.67c	7.74c	6.91c	1.99c
5	5.61b	5.39b	8.97b	7.67b	2.35b
10	6.62a	6.33a	10.04a	8.89a	2.51a
Poultry Manure					
0	4.14c	3.93c	6.60c	6.18c	1.92c
5	5.73b	5.54b	8.96b	7.73b	2.30b
10	7.06a	6.91a	11.18a	9.56a	2.54a
Interactions					
GM x PM					
GM_0 x PM_0	2.80f	2.63g	5.66h	4.90g	1.41g
GM_0 x PM_1	4.67d	4.77e	7.43f	6.67e	2.16e
GM_0 x PM_2	6.63b	6.60bc	10.17c	9.17b	2.48c
GM_1 x PM_0	4.13e	3.90f	6.40g	5.60f	2.02f
GM_1 x PM_1	5.67c	5.43d	9.07d	8.03d	2.32d
GM_1 x PM_2	7.03b	6.83b	11.43b	9.37b	2.69b
GM_2 x PM_0	5.50c	5.27d	7.77e	8.03d	2.29d
GM_2 x PM_1	6.87b	6.43c	10.40c	8.50c	2.30d
GM_2 x PM_2	7.50a	7.50a	11.97a	10.13a	2.74a

*Means within a column followed by the same letter are not significantly different at 5 % probability level according to Duncan's New Multiple Range Test (DNMRT)

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