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Full Length Research Paper

Growth and yield of two okra (*Abelmoschus Esculentus* L. Moench) varieties as affected by organic fertilizer grown on an Oxic Paleustalf in Ekiti State

[1]Omotoso, S. O., [1]F. O. Fawole, [2]M Aluko and [2]A. F Kehinde-Fadare

[1]Department of Soil Resources and Environmental Management, Ekiti State University, P. M. B 5363. Ado-Ekiti, Nigeria.
[2]Department of Crop Production, Horticulture and Landscape Design, Ekiti State University, P. M. B 5363. Ado-Ekiti, Nigeria.

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Soil fertility constraint is one of the factors hindering high productivity of okra (*Abelmoschus esculentus* L. Moench) in South Western Nigeria. Majority of these soils are deficient in nitrogen and phosphorus as a result of progressive loss in organic matter due to intensive cultivation and climatic conditions. Field trial was conducted to assess the effects of organic fertilizer sources on growth and yield of two varieties of okra at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti. Treatments consisted of cow dung (CD), municipal solid waste (MSW), poultry manure (PM) at 15t/ha each, NPK 15-15-15 fertilizer applied at 150kg/ha and no fertilizer (NF) as control as well as two varieties of okra (V-35 and NHAe47-4). The experiment was laid out in a randomized complete block design (RCBD) in three replicates. Top soil (0-15cm) samples were collected before and after the trial for analysis. Data were collected on the following parameters; plant height, number of leaves, leaf area, number of pod plant^{-1}, pod length and pod yield. The result revealed that PM significantly ($P<0.05$) gave the tallest plant (89.6cm), highest number of leaves (14.9), leaf area (444cm^2) and number of pod (6.3) which are 102, 114, 49 and 75% more than control respectively. Application of PM significantly gave maximum pod yield (4531kg/ha) with clemson spineless NHAe47-4 and (2930kg/ha) in V-35 variety with total mean value of 3591 kg/ha which is 96% more than the control. Organic manure increased soil N, P, K but Ca was decreased with NPK application while Mg was decreased in MSW and NPK application. The results are suggestive that PM has the highest potentials as amendment. It therefore suggest that it can be a useful management strategy for sustainable fertility maintenance leading to minimize leaching losses, improve soil structure, and reduce input cost by reducing the use of inorganic fertilizer.

Keyword: Organic fertilizer, municipal waste, okra, varieties, NPK fertilizer

INTRODUCTION

Okra (*Abelmosschus esculentus* L. Moench) is a widely cultivated crop for it immature pods locally consumed (Schipper, 2000). It ranks third in term of consumption (Ibeawuchi, 2007) and constitutes about 4.6% of the total staple food production in Nigeria (CBN, 2004). The varieties of okra cultivated in Southwest, Nigeria vary in time of maturity, fruit size, plant height and colour (Udoh *et al*., 2005). Okra requires fertility for optimum growth and yield. Unfortunately, nutrients in soil are rapidly depleted due to continuous cultivation, erosion, leaching and bush burning. Ayoola and Adeniyan (2006) observed that after a cropping season the adequate nutrient level are rarely restored to sustain food production. To address this soil nutrient shortage, farmers has adopted the used of organic and inorganic fertilizers.

The increasing population growth in developing countries has led to high demand for more food which has put pressure on fertile soil. This has led to the promotion/introduction of various agronomic practices needed to boost food production more so, when the dependence on bush fallows for nutrient and soil organic build-up is not sustainable and cannot cope with the food demand of the teaming population. The introduction and promotion of mineral fertilizers showed promise and produced higher crop yield. However, the aftermath effect on soil acidity and nutrient imbalance (Ansari and Ismail, 2001) couple with the recent concerns about the health and environmental hazard on the people as well as the high cost of mineral fertilizers in developing countries has been a challenge. Hence, the search for alternatives to the existing practices that will be less expensive and environmentally friendly.

Organic fertilizers are environmentally friendly; it promotes population of beneficial microorganisms and generally improves the soil health (Bulluck *et al*., 2002; Oyewole *et al*., 2012). Organic fertilizers has been reported to increase crop production similar to inorganic fertilizers (Heeb, *et al*., 2006: Tonfack, *et al*., 2009) because they contain both micro and macro nutrients in addition to some plant promoting factors and beneficial microorganisms (Sreenivasa *et al*., 2010). Despite the advantages derivable from using organic manures such as the farm yard manures, it bulky nature has made its use not to have been fully harness (Makinde *et al*., 2007, Pennington *et al*., 2015).

There have been increased in human and farm yard waste due to increase in human population and their activities. Municipal solid waste, cow dung and poultry manure are readily available and its management is a challenge to the community where they are produced. This environmental menace can be put to beneficial usage particularly in soil fertility restoration in organic fertilizer. Thus, this study is therefore aim at investigating the effects of municipal solid waste, cow dung and poultry manure in relation to NPK mineral fertilizer on performance of two varieties of okra.

*Corresponding Author's Email:seguntoso@yahoo.com

MATERIALS AND METHODS

Site description

A trial was conducted at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Nigeria during the rainy seasons of 2014 and 2015 cropping seasons. The location is characterized by a bimodal rainfall distribution with mean annual rainfall and rainy days of 1,367.7mm, 112 and 27^{o}C, respectively. The rainy season extends from late March to October with a dry spell in August. The soils of the study sites have been described as an Alfisols developed on basement complex rock, highly leached with low to medium organic matter content (Fasina *et al.,* 2005),. The sites had been cultivated to some arable crops for some years before it was left to fallow for two years, prior to the commencement of this study.

Soil Sampling and Laboratory Analysis

Prior to planting, ten core soil samples randomly collected from 0-15cm soil depth were bulked to form a composite sample, which was analyzed to determine the physical and chemical properties of the baseline fertility status of the trial sites. Another set of soil samples was taken at the end of the planting season to examine the influence of these fertilizers on the chemical properties of the soil. The samples were thoroughly mixed, air-dried, crushed and allow to pass through a 2 mm sieve. The samples were analyzed for particle size distribution with the hydrometer method. Soil pH was determined in soil solution ratio 1:2 in 0.01M $CaCl_2$ using Coleman's pH meter, organic carbon was determined by the Wakley and Black, (1934) dichromate oxidation method and total N by the macro-kjeldahl digestion method (Breminer and Mulraney, 1982). Available P was extracted with Bray P-1 extractant and determined by the molybdenum blue method while exchangeable bases were extracted with neutral 1M NH_4OAc at a solution ratio of 1:10; Calcium, Potassium and Sodium were measured by flame photometry while Magnesium was determined with an atomic absorption spectrophotometer. The exchangeable acidity was with 1M KCl extract and titrated against 0.05MNaOH to a pink end point using phenolphthalein as indicator (McLean, 1982).

Effective cation exchange capacity (ECEC) was obtained by summation method (i.e. sum of Ca, K, Mg, Na and exchange acidity).

Treatments and Experimental Design

Treatment consisted of four organic fertilizer sources (Cow dung (CD), Municipal solid waste (MSW) and poultry manure (PM) each applied at 15t/ha, NPK 15-15-15 fertilizer applied at 150kg/ha and two varieties of okra (V-35 and NHAe47-4). The experiment was laid out in a Randomized Complete Block Design in three replicates. Plot size was 3 × 2 m with 0.5 m paths between plots while the replicates were separated by 1 m path. Organic fertilizers sources were applied two weeks before planting and the mineral fertilizer was applied two weeks after planting. Two seeds of each okra variety (cv. V-35 and NHAe47-4) were planted per hill and later thinned to one plant at a spacing of 60cm inter-row and 30 cm intra-row.

Data collection

There were five (5) sampling times, at two-week intervals starting from 2 weeks after planting (WAP). The following parameters were taken; Plant height was measured from the ground level to the tip of the highest leaf using a meter rule; number of leaves was by visual counting while stem girth was done using a digital vernier caliper. Leaf area of each plant was determined by graphical method and the area obtained was multiplied by the total number of leaves to obtain the total leaf area per plant. Fruits were harvested at four day intervals. Numbers and weights of fruit were determined. Yield was computed on fresh weight basis. Number of fresh pods involved the physical counting of all the fresh fruits that have emerged. Pod weight was measured by weighing together of all the fresh fruits harvested per plot while pod length involved measuring of the fresh fruit length using meter rule.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) using the statistical analysis system (SAS, 2006). Means were separated using Duncan's Multiple Range Tests (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

Characteristics of the soil used

The soil samples taken before cropping and characteristics of the organic materials were presented in Table 1 and 2. The soil was sandy loam, weakly acidic with pH of 6.0. Particle size analysis showed 782 g kg^{-1} sand, 118g kg^{-1} silt and 100 g kg^{-1} clay. Organic carbon was 12 $g.kg^{-1}$ with Total N of 1.36 $g.kg^{-1}$ and available P of 6.40 mg kg^{-1}. The result shows that the nutrients were grossly inadequate for okra production. (NIHORT, 1986) and lower than the critical level of 0.10% for N and 10.0 mg kg^{-1} soil available P as established for soils of South-West, Nigeria (Adepetu, 2014). Exchangeable bases were 2.42, 1.74, 0.97 and 0.26 cmol $kg^{-1}$for Ca, Mg, K and Na respectively. Using the critical levels of 0.16-0.20cmol kg^{-1} K, 2.0 cmol kg^{-1} exchangeable Ca, and 0.40 cmol kg^{-1} exchangeable Mg recommended for crop production in ecological zones of Nigeria (Akinrinde and Obigbesan, 2000). The exchangeable K and Mg were adequate.

Effects of Organic fertilizer sources on growth characteristics

The effects of organic fertilizer sources on plant height (Table 3) were significant across the period of growth. The highest height (89.6 cm) was obtained with PM application at 10WAS which was followed by NPK fertilizer application (76.3 cm) and plants from the control had significantly shorter (44.3 cm) plants. The significant increase in height was such that Pm gave 28.5, 40.8, and 17.4% over CD, MSW and NPK 15-15-15 respectively. However, Plant treated to CD and MSW were not comparable at 10WAS. The significant increase in plant height is an indication that okra plants were able to utilize the nutrients in the fertilizer material (Odeleye *et al*., 2005). The result is consistent with the findings of Ojeniyi *et al*., (2007) who reported significant increase in plant height and yield with application of poultry manure. This result corroborates the earlier findings of Omotoso and Johnson (2015) that PM significantly increases plant height of okra variety NHAe47-4 over TAE-38. Also, plant height of Clemson spineless (NHAe47-4) okra variety was higher than the V-35 variety at 8 and 10WAS. The interaction effect were only significant at 8 and 10 WAS.

The effect of organic fertilizer sources and varieties on number of leaves is indicated in Table 4. Irrespective of the organic fertilizer sources, number of leaves increased as plant matured. Also, number of leaves were not comparable among the fertilizer types during the first 6th week of growth. Okra plants in the control treatment were consistently lower. However, significantly highest number of leaves (16.8) was recorded in PM at 10 WAS which was 60, 63 and 24% increases relative to CD, MSW, NPK and control 114% respectively. There was no varietal difference in number of leaves.

Leaf area per plant increased up to 8 WAS, thereafter fell slightly except PM and NPK fertilizer. At this time of highest leaf area production, PM gave the best value (444 cm^2) which does not differ from those plants that received NPK fertilizer (Table 5). Okra that received CD and MSW were not comparable between 4-10WAS but at

Table 1. Physical and Chemical characteristics of soils used

Soil Characteristics	Ado-Ekiti
Chemical Properties	
pH (H_2O)	6.02
Organic carbon (g kg^{-1})	12.00
Total N (g kg^{-1})	1.36
Available P (mg/kg)	6.40
Exchangeable bases (cmol/kg)	
Ca	2.42
Mg	1.74
K	0.97
Na	0.26
Exchangeable acidity	0.40
ECEC	6.29
Base saturation %	80.09
Physical Properties (g/kg)	
Sand	782
Silt	118
Clay	100
Textural class	SL

SL= sandy loam

Table 2. Chemical characteristics of organic fertilizer sources used

Characteristics	Cow Dung	Poultry Manure	Municipal Solid Waste
pH (H_2O)	5.80	8.60	7.20
Electrical conductivity (dS m^{-1})	-	-	5.2
Organic carbon (%)		3.18	10.40
Total N (g/kg)	2.50	2.80	0.80
Available P (mg/kg)	22.00	0.79	10.30
Ca (mg/kg)	1.42	1.63	46.40
Mg (mg/kg)	1.30	0.52	36.00
K (mg/kg)	0.26	2.17	48.00
Na (mg/kg)			0.15
Zn	-	-	22.00
Mn	-	-	19.50
Cu	-	-	6.90

Table 3: Effects of organic fertilizer sources on plant height (cm) of okra

Treatments	Weeks After Sowing				
	2	**4**	**6**	**8**	**10**
Fertilizer Types					
Control	5.60c	13.48b	29.70ab	38.78ab	44.27d
CD	6.67b	10.00c	27.90b	50.20b	69.72c
MSW	6.45b	15.88ab	35.62a	54.93ab	63.60c
PM	8.80a	16.40a	38.05a	66.38a	89.60a
NPK 15-15-15	6.35b	15.92ab	36.75a	55.62ab	76.34b
Mean	6.77	14.34	33.60	53.18	68.71
SE±	0.24	0.43	1.72	2.16	2.20
Varieties					
V-35	3.32a	12.20a	25.05a	46.73b	60.73b
NHAe47-4	4.10a	15.66a	37.36a	72.90a	72.90a
V x F	ns	ns	ns	**	**

Means with the same letter(s) for each value in columns are not significantly different at 5% level of probability by DMRT. NF-no fertilizer, CD-cow dung, MSW-municipal solid waste, PM-poultry manure, NPK- npk fertilizer

Table 4: Effects of organic fertilizer sources on number of leaves of okra

Treatments	Weeks After Sowing				
	2	**4**	**6**	**8**	**10**
Fertilizer Types					
Control	3.80b	4.80b	5.40c	6.10d	7.84c
CD	3.30b	5.18b	6.20b	8.10c	10.50b
MSW	3.65b	5.83b	6.80b	9.30b	10.30b
PM	4.60a	6.50a	8.50a	12.50a	16.80a
NPK15-15-15	4.30a	7.50a	8.20a	10.90b	13.54b
Mean	3.93	5.96	7.02	7.20	11.80
SE±	0.21	0.27	1.70	2.14	2.86
Varieties					
V-35	4.30a	5.96a	7.33a	10.84a	14.62a
NHAe47-4	3.83a	6.10a	7.50a	9.12a	13.80a
V x F	ns	ns	ns	ns	ns

Means with the same letter(s) for each value in columns are not significantly different at 5% level of probability by DMRT. NF-no fertilizer, CD-cow dung, MSW-municipal solid waste, PM-poultry manure, NPK- npk fertilizer

Table 5: Effects of organic fertilizer sources on leaf area (cm^2) of okra

Treatments	Weeks After Sowing				
	2	4	6	8	10
Fertilizer Types					
Control	220c	243c	281a	306c	297c
CD	237b	254bc	341a	380b	372b
MSW	210bc	246bc	320a	384b	356b
PM	302a	326a	362a	420a	444a
NPK15-15-15	243b	282b	360a	396b	442a
Mean	243	270.	332	377	382
SE±	21.2	16.4	23.2	24.8	33.1
Varieties					
V-35	232a	321a	360b	422b	436b
NHAe47-4	284a	342a	397a	486a	460a
V x F	ns	ns	**	**	**

Means with the same letter(s) for each value in columns are not significantly different at 5% level of probability by DMRT. NF-no fertilizer, CD-cow dung, MSW-municipal solid waste, PM-poultry manure, NPK- npk fertilizer

Table 6. Effects of organic sources on soil chemical characteristics after cropping

Treatments	pH	SOM	N	P	K	Ca	Mg
	(H_2O)	(%)		mg/kg	(cmol/kg)		
Initial	5.8		0.13	6.40	0.45	2.42	1.74
Control	5.10c	0.43c	0.85d	6.56d	0.08c	0.52d	0.24c
CD	6.06b	2.19ab	3.50b	11.30b	0.22c	4.49c	1.76a
MSW	6.90b	1.96b	1.10c	12.60b	0.26c	6.40b	0.56b
PM	7.19a	2.31a	4.28a	14.65a	0.37a	9.36a	1.89a
NPK	4.78d	1.67b	1.46c	8.63d	0.15b	0.16d	0.35c
Mean	6.01	1.71	2.24	10.75	0.22	4.19	0.96

10WAS, the significant increase was obvious such that PM gave 19, 24, 0.5 and 50% more than CD, MSW, NPK and Control.

Effects of organic fertilizer on soil chemical properties

The effects of organic fertilizer on soil chemical properties after cropping are indicated in Table 6. Application of Cow dung, MSW and PM caused an increased in pH while NPK fertilizer reduce it. The soil pH increased from 5.8 to 6.06, 6.90 and 7.19 respectively. This confirms findings of Akande *et al.,* (2003) that application of organic materials could ameliorate slightly acidic tropical soil to improve crop production. However, inorganic NPK fertilizer significantly reduced soil pH from 5.8 to 4.7 and caused an increased in N and P content of the soil. This is in agreement with Olatunji *et al.,* (2012) and Omotoso and Johnson, (2015). The decline in pH of plots treated with inorganic fertilizer could be attributed to their rapid rates of release of nutrient, which are immediately used up by plants, leading to poor accumulation of exchangeable bases that neutralizes soil acidity. Plots that received manure had higher pH than the control plots but the trend was different in plots that received inorganic fertilizer where the pH of the control plot was higher than the pH of plots that received NPK fertilizer. The soil pH determines the availability of nutrients and the potency of toxic substance especially the tendency for absorption of heavy metals at high level.

All the treatments increased soil N, P and K content but Ca were decreased with NPK application while Mg was only decreased in MSW and NPK application. This indicates that manure has the potential as amendment for ameliorating acidic soil.

Fresh fruit Yield (Kg ha^{-1})

Table 7 showed the effects of fertilizer sources on okra fresh fruit yield and yield components. The highest number

Table 7. Effects of organic fertilizer sources and varieties on yield and yield components of okra

Treatments	Varieties		
	V-35	NHAe47-4	Mean
		Number of Pod	
Control	2.67c	3.20bc	2.94c
CD	3.60bc	5.33b	4.47b
MSW	3.60bc	3.30bc	3.45c
PM	4.00a	6.30a	5.15a
NPK15-15-15	3.40b	5.21b	4.31b
Mean	3.45	4.67	4.06
SE±	0.025	0.082	0.171
		Pod length (cm)	
Control	4.87d	8.77c	6.82c
CD	6.33c	10.80b	9.49b
MSW	5.32cd	11.33b	8.33b
PM	9.54a	14.33a	10.33a
NPK15-15-15	8.17b	11.20b	10.37a
Mean	6.85	11.29	9.07
SE±	0.035	0.052	0.044
		Yield (kg/ha)	
Control	1202d	1795d	1831d
CD	2651b	2832b	2362b
MSW	1682c	2052c	1870d
PM	2930a	4531a	3591a
NPK15-15-15	1504e	2462c	2154c
Mean	1993	2734	2362
SE±	236.761	216.514	238.128

Means with the same letter(s) for each value in columns are not significantly different at 5% level of probability by DMRT. NF-no fertilizer, CD-cow dung, MSW-municipal solid waste, PM-poultry manure, NPK- npk fertilizer.

of pod was recorded in PM in V-35 and 47-4 varieties with mean value of 5.15 which represent 15, 49 and 75% more than CD, MSW and control respectively. The length of pods was highest with PM in both varieties. There was no significant difference in pod length of both varieties between CD and MSW. However, the control significantly gave the least mean value. Organic sources led to a corresponding increase in total yield of okra varieties with the highest pod yields of (4531.6 kg ha^{-1} and 2930 kg ha^{-1}) obtained from PM in 47-4 and V-35 varieties. However control gave lowest pod yield of (1795 kg ha^{-1} and 1202 kg ha^{-1}) in 47-4 and V-35 respectively.

CONCLUSION

This study has demonstrated the effectiveness of PM, CD and MSW materials in improving the fertility of the soil for okra production. These wastes material enhanced the growth and development of okra compared to the untreated plots and the mineral NPK fertilizer. PM gave the tallest plant which resulted to the highest number of leaves and number of pod. There was an increase in soil N, P, K and Mg in plots treated to wastes material compared to untreated plots. PM gave the highest yield but there was an increase in Clemson spiness over V-35 variety. It therefore suggest that application of these wastes can be a useful management strategy for sustainable fertility maintenance leading to minimize leaching losses, improve soil structure, and reduce input cost by reducing the use of inorganic fertilizer.

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