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Performance of okra (*Abelmoschus esculentus* (L.) Moench) as influenced by organic fertilizer rates

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Abstract

A two year field study was conducted during the late cropping season from September to December 2016 and 2017, to evaluate the response of two okra varieties (Clemson spineless and a local cultivar) to five rates of Pure organic fertilizer ™ (0, 1, 2, 3, 4 t ha^{-1}and NPK 20.10.10 at 120 kg ha^{-1} as check) using a 2 x 6 factorial experiment in randomized complete block design having three replications. Data was collected for agronomic traits as well as yield performance. Analysis of variance was done using GENSTAT Package version 8.1 and means were compared using Duncan's New Multiple Range Test at 5 % probability level. The results obtained from this study showed that organic fertilizer at 4 t ha^{-1} resulted in significantly higher ($p<0.05$) okra yields of 5.12 and 2.84 t ha^{-1} respectively in 2016 and 2017, compared to all other treatment levels. The varietal effect was not significant while some of the interactions were highly significant. Pure organic fertilizer at 4.0 t ha^{-1} is suitable for okra production.

Keywords: Pure organic fertilizer, okra varieties, performance

Introduction

Okra (*Abelmoschus esculentus*) was considered as a minor crop before now hence little attention was given or paid to the crop's improvement in International Research Programs (Sanjeet *et al.*, 2010).Ibrahim *et al.* (2012) reported that the production inefficiency of okra in Nigeria has been attributed to low input supply systems, use of low yielding cultivars and the inherently low fertility status of the soil. Inadequate application of fertilizers remains the major factor that hinders the performance of okra especially in the forest zone of Nigeria (Anonymous, 1980). Reduction in the use of organic manure as a source of plant nutrients and soil improvement because of relative ease of application and fast results with inorganic fertilizer use has further led to decrease in plant yields. Animal manure when properly handled is one of the most important fertilizers available, having both a nutrient supply potential as well as soil improvement capability. Refining organic matter into organic fertilizer from animal and municipalwastes is one way to enable farmers go back to the use of organic manure in crop production due to easier application to the crops, especially in vegetable crop production. According to Senjobi *et al*. (2010), when organic fertilizers are used judiciously they would improve both growth and yield variables of crops. Several workers have reported that organic fertilizers have beneficial effects on soil properties, such as bulk density, moisture content, water holding capacity, and other properties (Adeleye *et al.*, 2010). This study therefore evaluated the effects of pure organic fertilizer rates on growth and yield performance of two okra varieties in Calabar.

Materials and methods

The study was carried out during the late cropping season, September to December of 2016 and 2017 at the Cross River State Agricultural Development Project (ADP) Research Unit Calabar. Calabar is located at 4.5^0N - 5.2^0N, 8.0-8.3^0E, about 39 m ASL (CRBDA, 1985). The site was in secondary vegetation with yellow nut sedge (C*yperus rotundus*), calapogonium (*Calopogonium mucunoides*), purple nut sedge (*Cyperus esculentus*), tridax (*Tridax procumbens*), Stubborn grass (*Eleusine indica*), African marigold (*Aspilia africana*), sensitive plant (*Mimosa pudica*), milk weed (*Euphorbia heterophylla*), broom weed (*Sida acuta*), goat weed (*Ageratum conyzoides*), and morning glory (*Ipomoea involucrata*) as predominant flora. Soil samples were randomly collected from different portions of gross plot using soil auger at 0-30 cm depth and bulked, prepared and analyzed for physico-chemical properties. The fertilizer and soil samples (Table 1) were analyzed following the procedure described by IITA (1975). Manual bush clearing and land preparation were followed by sectioning of experimental plot into units of 1.8 m x 2m giving a total of 3.6m^2, with net plots sized 1.2 m x 1.0 m. The replicates and plots were separated from each other by a 1.0 m wide path.

A 2 x 6 factorial experiment laid out in Randomized Complete Block Design (RCBD) and replicated three times was used to disperse twelve treatment combinations consisting of two varieties of okra (a local cultivar called ‘etighiabakpa’ and a F1 hybrid; Clemson spineless); and six fertilizer specifications which were designated as F0 - F5 (F0-F4 being 0,1, 2, 3 and 4 t/ ha of pure organic fertilizer respectively, and F5 was the recommended N. P. K. 20:10:10 rate of 120 kg/ha). Pure organic fertilizer (product under patenting), was sourced from producer in Calabar and was applied as stated above two weeks after planting. The local short duration okra cultivar (etighi abakpa) was sourced from the local market and the hybrid gotten from TECNISEM Limited. Three (3) seeds of okra were planted per hole at the spacing of 30 cm x 50 cm (0.3 m x 0.5m) at the depth of 2-5cm. The seedlings were later thinned to one per stand 14 days after planting. The number of plant stands per plot was 24, with 8 stands constituting the net plot. The total plant population was 111,111 plants per hectare. Weeds were hand pulled at 3 and 7 weeks after planting.

Growth measurements for plant height, number of leaves per plant, days to 50 % flowering and total dry matter were taken every two weeks and harvesting done every three days for yield data such as number of pods per plant and fresh pod yield (t ha^{-1}).

Data collected was subjected to analysis of variance (ANOVA) for factorial in Randomized Complete Block Design (RCBD), using the GENSTAT Package Version 8.1 and significant means were compared using Duncan's New Multiple Range Test at 5% level of probability.

Results and discussion

The Organic fertilizer had a pH of 9.7, organic carbon content of 5.74 % and 0.49 % of Nitrogen. The phosphorus was 198.0 mg/kg hence the material is described as rich in phosphate. Soil had low acidity with a pH of 5.08, organic carbon content of 1.6 % and total nitrogen of 0.12 %. Available Phosphorus was 52.63 mg/kg while the soil texture was described as sandy loam (Table 1).

Effects of fertilizer rates on growth and yield characteristics of okra varieties

The effects of pure organic fertilizer (POF) rates on the growth of okra in both seasons are presented in Table 2. From the results, plant height and number of leaves increased significantly ($p < 0.05$) as the rates of organic fertilizer increased from 1 to 4 t ha^{-1} compared to plants in the control plots that received no fertilizer, while at the same time the number of days to 50% flowering were significantly reduced in 2016 only. The 4 tha^{-1}pure organic fertilizer application rate resulted in significantly higher ($p<0.05$) expressions of plant height, number of leaves and lower number of days to 50 % flowering compared to the recommended NPK fertilizer rate.

Plant height and number of leaves were statistically similar among plants that received 2 tha^{-1}pure organic fertilizer application rate and in the control plots, while days to 50 % flowering was lowest at 3 - 4 t ha^{-1}POF and the recommended NPK level (Table 2). Total dry matter was significantly higher ($P<0.05$) among 4 t ha^{-1} POF treated plants, closely followed by the 3 t ha^{-1} plants than the untreated plants in control plots. Total dry matter of plants treated with NPK fertilizer was statistically at par with those that received 2 t ha^{-1} of organic fertilizer (Table 3). The number of pods of okra and the yield per hectare increased ($P<0.05$) with each increment in POF rates. However, only the 4 t ha^{-1} application of organic fertilizer resulted in the highest expression of number of pods and pod yield.The number of pods and pod yield per ha $^{-1}$ were statistically similar from 0 – 2 t ha^{-1} but significantly higher at 3 and 4 t ha^{-1} respectively. While the number of pods from plots that received the recommended NPK levels was statistically at par with the number of pods from plots treated with 3 t ha^{-1}, pod yield was statistically similar at 2 t ha^{-1} and the recommended NPK level. In all instances, the plants treated with NPK as the check were closely related in performance to the 2.0 and 3.0 t ha^{-1} (POF) treated plants (Table 3).

Effect of okra varieties:

The effects of variety on the performance and yield of okra were not significant during both years of the study. Whether Clemson spineless or ‘etigi abakpa’ received NPK or pure organic fertilizer was not contributive to varietal performance as observed in their characteristics.

Interaction effects of fertilizer treatments on performance and yield of okra varieties in two seasons:

The interaction effects of fertilizer rates and okra varieties were significant ($P<0.05$) except for plant height in 2016 and days to 50 % flowering in 2017 respectively.The interaction between Clemson spineless and the local cultivar ‘etigi abakpa’ receiving 4.0 t ha^{-1} of POF resulted in significantly ($P<0.05$) taller plants and number of leaves than at other treatment combinations, with the Clemson spineless x 1.0 t ha^{-1} POF yielding the shortest plants and least number of leaves (Table 2). On the other hand, the NPK fertilizer treated plants were statistically similar ($P>0.05$) for plant height in 2017 and number of leaves in both years irrespective of variety (Table 2) and closely related to the control. In 2016, total dry matter of ‘etigi abakpa’ that received 4.0 t ha^{-1} of POF was significantly higher ($P<0.05$) than that obtained from plants of the same cultivar that received no fertilizer (Table 3).

In 2017 however, when both varieties received 4 t ha^{-1} POF, total dry matter was statistically at par but significantly higher ($P<0.05$) than the NPK treated plants (Table

3). The number of pods from 'etigi abakpa' treated with 4.0 t ha^{-1} of POF was significantly higher (P<0.05) in both seasons than other fertilizer treatments. In 2016, pod yields of Clemson spineless and 'etigi abakpa' treated with 4.0 t ha^{-1} of POF were statistically similar, and significantly higher (P<0.05) than yields from the NPK treated plants. In 2017 however, Clemson spineless treated with 4.0 t ha^{-1} of POF had significantly higher (P<0.05) okra pod yield per ha, closely followed by the yield of 'etigi abakpa' that received 4.0 t ha^{-1} of POF. Clemson spineless plants that received no fertilizer whatsoever had the least pod yield in the study (Table 3).The significant increase in the growth attributes of okra in the plots that received pure organic fertilizer as compared with the control could be attributed to the supply of essential nutrients necessary for the growth and development of crops. This is consonant with the findings of Attarde (2012) who reported that the application of organic fertilizers significantly increased the growth and yield variables of okra due to the high level of increased soil nutrients. Folorunso (1999) also reported positive effects on yield and nutrient contents of Amaranths and okra from the application of organic fertilizer as compared with the untreated control.

A higher number of leaves would lead to an enhanced interception of solar radiation resulting in an increased availability of photo-assimilates from effective photosynthesis. Several workers have reported increased availability of total nitrogen, organic carbon, organic matter, potassium and base saturation with the application of organic based fertilizers (Udom and Bello, 2009 and Agba, *et al*., 2012). This observation is consonant with reports of Ayuso *et al*., (1996) and Eifediyi and Remison (2010), who observed that organic manures can sustain cropping systems through better nutrient recycling, giving rise to improved growth and development as well as yield.

Waldrip (2011) also reported that, addition of poultry manure into the soil promotes transformation and mineralization of less mobile inorganic and organic phosphorus into mobile phosphorus in the rhizosphere, resulting in higher root phosphorus concentration and higher phosphorus uptake by plants. Organic fertilizer containing high levels of N, P and K (Adediran *et al*., 2003) could also improve soil structure, water holding capacity, aeration and drainage (Cooke, 1980). Similar reports have also been made by Kissetu and Assenga (2013). The favourable environment thus provided the crop by the addition of pure organic fertilizer was effectively converted to establish a good yield structure which translated to higher yields.

Uwah and Iwo, (2011) reported an increase in fresh pod weight of okra by 94 and 57% and mean fresh pod yield by 160 and 115% when 10 t h a^{-1} poultry manure and 4.0 t h a^{-1} mulch rates were used, respectively compared to the un-amended control plots.

Conclusion

The highest values in number of pods per plant and pod yield were recorded in the plots that received 4.0 t ha^{-1} of pure organic fertilizer, with yields at 4.0 t ha^{-1}POF rates being significantly different from yield at 3tha^{-1}in both years. This indicates that the 4 t $ha^{-1}$of pure organic fertilizer is suitable for okra production.

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Table 1. Physico-chemical analysis of soil and pure organic fertilizer

No	Properties	Organic fertilizer	Soil Analysis
1.	pH	9.7	5.08
2.	Organic carbon	5.74%	1.6 %
3.	Nitrogen	0.49%	0.12 %
4.	Phosphorus	198.0mg/kg	52.63 mg/kg
5	Calcium	15.2cmol/kg	4.0 cmol/kg
6.	Magnesium	9.5cmol/kg	2.2 cmol/kg
7.	Potassium	0.35cmol/kg	0.13 cmol/kg
8.	Sodium	0.35cmol/kg	
9.	Aluminium ion	0.0cmol/kg	0.32 cmol/kg
10.	Hydrogen ion	0.0cmol/kg	0.48 cmol/kg
11.	ECEC	-	7.13 cmol/kg
12	Base saturation		88.78%
13.	Clay	-	8.0 %
14.	Silt	-	14.0 %
15.	Sand	-	78.0 %

Table 2.Effects of fertilizer rates and variety on growth characteristics of okra in Calabar in two seasons

Treatments	**Growth characteristics**					
Pure organic fertilizer t/ha	Plant height (cm)		No. of Leaves		50 % flowering	
	2016	2017	2016	2017	2016	2017
F_0 Control	23.84bc	23.05ab	10.40b	12.89ab	52.50a	45.00a
F_1 (1 t/ha)	29.67c	24.44ab	9.52b	13.27ab	47.67b	44.70a
F_2 (2 t/ha)	27.73bc	25.51ab	9.36b	13.00ab	45.50b	43.33a
F_3 (3 t/ha)	33.23b	26.14a	12.60a	15.08a	36.00c	45.00a
F_4 (4 t/ha)	40.29a	26.11a	13.65a	13.49a	36.00c	45.00a
F_5 (NPK 20:10:10)	32.19b	23.93ab	10.54b	12.80ab	38.33c	45.00a
Variety (V)						
V_1 –' E. Abakpa'	31.64a	24.80a	10.80a	13.27a	42.06a	44.29a
V_2 – Clemson spineless	30.68a	24.00a	11.23a	13.49a	43.28a	45.00a
Interaction (F x V)						
V_1 F_0	20.78a	22.28cd	8.10c	11.72c	56.00a	45.00a
V_1 F_1	29.65a	24.58bc	9.50c	13.58ab	45.33b	43.33a
V_1 F_2	30.45a	25.07bc	9.23c	12.66bc	43.00bc	41.67a
V_1 F_3	35.02a	24.86bc	12.93ab	13.40bc	36.00c	45.00a
V_1 F_4	41.45a	27.65a	14.05a	15.50a	36.00c	45.00a
V_1 F_5	32.50a	24.19cd	10.96bc	12.89bc	36.00c	45.00a
V_2 F_0	26.90a	20.00d	12.70ab	14.07ab	49.00b	45.00a
V_2 F_1	29.69a	24.30bc	9.54c	12.95bc	50.00b	45.00a
V_2 F_2	25.02a	21.03cd	9.49c	13.33bc	48.00b	45.00a
V_2 F_3	31.44a	26.17bc	12.26ab	13.58ab	36.00c	45.00a
V_2 F_4	39.14a	27.22a	13.25a	14.67a	36.00c	45.00a
V_2 F_5	31.88a	23.67cd	10.20bc	12.72bc	40.67bc	45.00a

Means with similar letters in a column are not significantly different at 5% probability level of Duncan's New Multiple Range Test.

Table 3. Effects of fertilizer rates and variety on yield performance of okra in Calabar in two seasons

Treatments	**Yield**					
Pure organic fertilizer t/ha	Total dry matter (g)		No. of pods plant^{-1}		Pod yield (t ha^{-1})	
	2016	2017	2016	2017	2016	2017
F_0 Control	4.73c	5.05c	3.10c	3.50bc	1.86d	1.16b
F_1 (1 t/ha)	8.72bc	7.90bc	3.02c	3.83bc	2.40c	1.18b
F_2 (2 t/ha)	7.90bc	9.17bc	3.34c	4.50ab	3.13b	1.26b
F_3 (3 t/ha)	18.25b	13.20a	4.65b	4.92ab	4.64ab	1.33b
F_4 (4 t/ha)	24.32a	14.32a	5.71a	5.83a	5.12a	2.84a
F_5 (NPK 20:10:10)	9.17bc	8.72bc	4.15b	4.83ab	3.73b	1.37b
Variety (V)						
V_1 – 'E. Abakpa'	13.14a	13.14a	4.10a	4.88a	3.46a	1.50a
V_2 – Clemson spineless	11.22a	11.22a	3.89a	3.95a	3.46a	1.12a
Interaction (F x V)						
V_1 F_0	3.17f	8.03cde	2.92d	3.00de	1.54d	1.46b
V_1 F_1	10.47cd	12.00bc	3.14cd	4.00cde	1.95d	1.51b
V_1 F_2	8.03d	6.30e	3.51cd	4.66bcd	3.49c	1.15bc
V_1 F_3	22.00b	8.03cde	5.03ab	6.33ab	4.49b	1.23bc
V_1 F_4	27.13a	17.13a	6.01a	7.66a	5.62a	2.02bc
V_1 F_5	8.03de	6.97e	3.99cd	3.33de	3.64c	1.32bc
V_2 F_0	6.30de	12.40bc	3.29cd	3.66cde	2.19cd	0.87c
V_2 F_1	6.97de	10.30cd	2.90d	3.00de	2.53cd	1.02bc
V_2 F_2	7.77de	15.50ab	3.18cd	4.00cde	2.77cd	0.99bc
V_2 F_3	14.50c	14.50ab	4.27bc	4.50cde	4.79b	1.14bc
V_2 F_4	21.50b	16.90a	5.42ab	6.33ab	5.63a	2.68a
V_2 F_5	10.30cd	12.70bc	4.31bc	5.33bc	3.82c	1.41bc

Means with similar letters in the column are not significantly different at 5% probability level of Duncan's New Multiple Range Test.