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Growth and Yield of Okra with Rock-Phosphate – Amended Organic Fertilizer

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Abstract

Phosphorous supply from organic manures for okra production can be insufficient for optimal fruit yield. The growth and yield of okra (Variety: NHAe 47-4) were assessed in field experiments with an organic fertilizer made from cowdung (CD), fortified with Ogun Rock Phosphate (ORP). The ORP was applied sole at 100 kg ha^{-1} and also with each of 2.5; 5.0; 7.5 and 10.0 t ha^{-1} cowdung. There was a standard check of NPK 20-10-10 applied 2 weeks after planting at 400 kg ha^{-1} and an unfertilized control., Average number of leaves per plant, stem diameter and plant height were all similar, with 4 weeks growth. Average plant leaf area was however higher with ORP added to either 7.5 or 10.0 t ha^{-1} CD, relative to either sole ORP or the unfertilized treatments. At 8 weeks after planting, plant height was highest with 10.0 t ha^{-1} CD + ORP and was comparable only with plants from 7.5 t ha^{-1} CD + ORP application. Plant stem girths were similar with all ORP applications. Number of leaves per plant and average leaf area were highest with 10.0 t ha^{-1} CD + ORP. Applications of 2.5; 5.0 and 7.5 t ha^{-1} CD + ORP had comparable leaf areas. Application of 10.0 t ha^{-1} CD + ORP gave the highest okra fruit yield which was comparable with yields from 2.5; 5.0 and 7.5 t ha^{-1} CD +ORP that ranged from 2.92 to 3.05 t ha^{-1}. Pod length and pod circumference were significantly higher with ORP + 10.0 or 7.5 t ha^{-1} CD. Plants from the unfertilized control treatment had significantly shorter pods with lower circumference than all the fertilized plants. Okra fruit yield is significantly increased with organic fertilizer fortification with ORP.

Keywords: *Abelmoscus esculentus*, fertilizer amendment, fruit yield, pod size

1. Introduction

Use of fertilizers to sustain intensive cropping systems on most tropical soils has been reported necessary due to their low nutrient status (Adetunji, 1991). The importance of phosphorus (P) as a yield – limiting plant nutrient in many Nigerian soils has been well established (Adepetu, 1983; Adetunji, 1994). However, there still exists an inadequacy in basic information required for phosphorus fertilizer rates for annual or seasonal maintenance of most tropical soils. To date, very little is known about the supply of P requirement of okra cropping. The high cost of soluble phosphate fertilizers, has induced considerable interest in the utilization of rock phosphates (RP) (Nnadi and Haque, 1998). The use of locally-available rock phosphates has been adopted as alternatives. Ogun rock phosphate (ORP) is an indigenous phosphate source in Nigeria. The phosphorous content is 25-31% P_2O_5 and has low solubility (Akande, 2005; Adetunji, 2005). Considerale concerns have been expressed on the effectiveness of the rock phosphates for direct application. Direct application of ground rock phosphates has however been proved to be beneficial to crops. Many studies have been conducted on amending rock phosphates to increase their immediate P availability and also possibly to enhance their rate of dissolution after application to soil. Use of composts of RPs with agricultural wastes is known to increase solubility of rock phosphates (Akande et al., 2008; Singh & Amberger, 1990). The degree of solubilization of phosphorus of a given RP varies with the kind and the rate of decomposition of the organic material used (Bangar et al., 1985). Grain yields of maize and cowpea from P-treated plots were significantly higher than from untreated plots (Akande et al., 2011). Evaluating the comparative effects of urea and poultry manure (PM) on solubilization of rock phosphate and on the growth and yield of okra, Akande et al. (2003) reported use of rock phosphate combined with poultry manure and to a lesser degree urea, improved the growth and yield of okra compared to when the materials were used individually. Applications of RP + urea and RP + poultry manure were also found to increase soil Available P by between 112 and 115% and 144 to 153%, respectively.

This study was conducted to determine the optimum ratio of amending Ogun RP with cowdung for optimum growth and yield of okra.

2. Materials and Methods

Field experiments were conducted in 2010 and 2011 at Abeokuta, Ogun State, Nigeria (latitude 7°12' N; longitude 3°20' E) at 100 m above sea level. There is usually a bimodal rainfall pattern, with a long rainy season between March and July and a short rainy season, usually from September to early-November, after a short dry spell in August and a longer dry period from December to February. The soil was an Aquic Arenic Haplustalf that had been cultivated for four years with arable crops. The site was ploughed and harrowed. Ten core soil samples were randomly collected from the top 20 cm depth prior to cropping, bulked and analyzed for chemical and physical properties. Samples were air dried, crushed and passed through a 2 mm sieve. Routine analyses were carried out following IITA (1979) procedures. Soil pH was determined in distilled water at 1:1 (w/v) soil: water ratio. Percent organic matter was derived by multiplying percent organic carbon by a factor of 1.72 (Broadbent, 1953). Total N was determined by the micro-Kjedahl digestion method. Available P was determined by the Bray's P1 test, using 0.03 NH_4F in 0.02N HCl as the extractant and measuring extracted P colorimerically at 660 nm by the molybdenum blue method (Bray and Kurtz, 1945). Exchangeable bases were determined by extraction with neutral normal NH_4OAC at a soil: solution ratio of 1:10. Extraction of exchangeable Ca, K, Mg and Na was with 1N ammonium acetate, pH 7.0, and measured with a flame photometer (Model PFP 7, Jenway, Camlab, Cambridge, UK). Magnesium was determined by atomic absorption spectrophotometry (Model CE 2041-2000 series, Cecil, Hitchin, UK). Exchangeable acidity was determined by titration of 1 M KCl extract against 0.05 M NaOH to a pink end point using phenolphthalein as the indicator (McLean, 1982). Soil particle size distribution was determined by a hydrometer method (McLean, 1982), with sodium hexametaphosphate (Calgon) as the dispersing agent. The soil was slightly acidic, with a pH of 6.2. It had an organic matter content of 4.3%. The N, P and K contents were 2.5%, 11.6 mg kg^{-1} and 0.4 cmol kg^{-1}, respectively. It was a loamy sand (Table 1). The cowdung was slightly alkaline with a pH of 8.1. It had an organic carbon content of 19.4%. Total nitrogen content was 1.9 % with P and K contents of 0.3 % and 2.9 % respectively. The calcium content was 3.4 % (Table 2).

Table 1. Pre-cropping soil analysis

Property	Value
pH	6.2
Organic carbon	0.3 %
Organic matter	4.3 %
Total N	2.5 %
Available P	11.6 mg kg^{-1}
Exchangeable K	0.4 cmol kg^{-1}
Na	0.5 cmol kg^{-1}
Ca	4.3 cmol kg^{-1}
Sand	87.2 %
Silt	3.2 %
Clay	9.6 %
Texture	Loamy sand

Table 2. Manure chemical analysis

Property	Value
pH	8.1
Organic carbon	19.4 %
Organic matter	33.5 %
Total N	1.9 %
Available P	0.3 %
Exchangeable K	2.9 %
Ca	3.4 %
Na	0.9 %

The experiment was arranged in a randomized complete block design with 7 treatments replicated 3 times. Plot size was 2.7×3.0 m with 1 m margin round the plots. Ogun rock phosphate (ORP) was crushed and mixed with the cowdung which was incorporated into the soil at land preparation, two weeks before planting. Combined applications of 2.5; 5.0; 7.5 and 10.0 t ha^{-1} Cowdung each, with 100 kg ha^{-1} ORP were investigated. This was equivalent to: 40 kg, 20 kg, 13.33 kg and 10 kg ORP per ton CD, respectively. There was also a sole application of the ORP and a standard check of NPK 20-10-10 at 400 kg ha^{-1} applied 2 weeks after planting with an unfertilized control. Okra seeds of NHAe 47-4 variety were sown in May at 60 x 60 cm spacing, 2 weeks after manure application. Plots were manually weeded at 4 weeks after planting, with supplementary hand weeding at 7 WAP. Application of Karate® (lambda-cyhalothrin 2.5 EC) at 1 L·ha^{-1} was done at 6 and 8 WAP to control infestation of beetles.

Data were collected on growth and fruit yield of okra from 6 tagged plants per plot from the inner rows. Plant height, stem diameter, number of leaves/plant and average leaf areas were used to assess plant growth. Plant height was measured from ground level to the growing tip. Plant stem diameter was determined at the 15 cm height. Numbers of fully-expanded leaves were counted. Leaf area was estimated by the non-destructive method of Olasantan and Salau (2008).

Fresh fruit yield, fruit length and fruit diameter were determined to assess yield. Cumulative pod yield over 4 harvests at 5 days intervals was used to assess fruit yield. Data for the two years were pooled and subjected to analysis of variance using SAS (SAS, 1990). The significant different mean values were separated using DMRT ($p \leq 0.05$).

3. Results

3.1 Plant Growth

Plant heights with 4 weeks growth were similar with the unfertilized plants. Sole ORP had plants even shorter than the unfertilized plants while the tallest plants were from ORP + 5.0 t ha^{-1} CD application. They were however all similar, with a range of 8.9-10.9 cm. (Table 3). By 8 WAP, plant heights were different. Plants fertilized with ORP + 10.0 t ha^{-1} CD had taller plants which were only comparable with plants fertilized with ORP + 7.5 t ha^{-1} CD.

Plant stem diameters were also comparable at 4 WAP, ranging from 15.1 – 22.4 mm. The unfertilized control plants had the lowest stem diameter while application of ORP + 5.0 t ha^{-1} CD had the highest stem diameter. By 8 WAP, stem diameters were different. Plants treated with ORP mixed with either 7.5 or 10.0 t ha^{-1} CD had higher stem diameters than the NPK – fertilized check plants and the unfertilized plants but comparable with the other ORP – treated plants (Table 3).

Average number of leaves per plant at 4 WAP was similar, ranging between 6 and 7. However, by 8 WAP, ORP + 10.0 t ha^{-1} CD application had higher number of leaves per plant which was only comparable with ORP + 5.0 t ha^{-1} CD application (Table 3). The NPK – fertilizer check plants and the unfertilized plants had lower number of leaves per plant than all the ORP – treated plants (Table 3).

Average leaf areas per plant were different with 4 weeks growth, with ORP + 7.5 or 10.0 t ha^{-1} CD giving higher average leaf areas. ORP + 5.O or 2.5 t ha^{-1} had lower but comparable leaf areas. The NPK- fertilized check and the unfertilized plants had even lower leaf areas. By 8 WAP, average leaf areas were generally higher, maintaining almost same trend as at 4 WAP. The highest was still from ORP + 10.0 t ha^{-1} CD. Applications of ORP with lower

CD of 7.5; 5.0 and 2.5 t ha^{-1} had comparable leaf areas. Both the NPK- fertilized and the unfertilized control plants had significantly lower leaf areas (Table 3).

Table 3. Okra growth parameters with ORP-amended cowdung

	Plant height (cm)		Stem diameter (mm)		Av. No. of leaves / plant		Av. Leaf area (cm^2)	
	4	8	4	8	4	8	4	8 WAP
No Fertilizer	9.57	17.21e	15.1	42.2b	5.53	9.45d	63.46d	391.20c
ORP	8.90	20.63de	16.1	56.0ab	6.13	14.21c	87.70c	673.50b
ORP + 2.5 t ha^{-1} CD	10.79	25.54cd	21.7	62.9ab	6.87	15.56c	129.10b	759.50ab
ORP + 5.0 t ha^{-1} CD	10.93	29.36bc	22.4	64.5ab	7.13	16.88bc	132.90b	877.40ab
ORP + 7.5 t ha^{-1} CD	10.66	35.98ab	17.6	69.9a	6.67	18.83ab	150.60a	903.60ab
ORP + 10.0 t ha^{-1} CD	9.76	36.93a	18.9	70.8a	6.73	21.80a	159.18a	951.20a
NPK Fertilizer	9.11NS	17.43e	13.2NS	43.9b	5.62NS	10.95d	60.21d	428.60c

NS: Values not significantly different (P≤ 0.05); CD: Cowdung; WAP: Weeks after planting.

3.2 Fruit Yield

Application of ORP + 10.0 t ha^{-1} CD gave the highest okra fresh pod yield which was comparable with yields from lower rates of cowdung. Sole ORP and the NPK – fertilizer check gave similar yields which were higher than yield from the unfertilized plants (Table 4).

Pod length was significantly higher with ORP + 10.0 or 7.5 t ha^{-1} CD. Pods from 5.0 t ha^{-1} CD were comparable only with pods from 7.5 t ha^{-1} CD. Application of ORP + 2.5 t ha^{-1} CD had shorter pods which were longer than pods from sole ORP and pods from NPK fertilizer. The unfertilized plants had even shorter pods.

Table 4. Okra fresh pod yield and yield components with ORP - amended cowdung

	Yield (t ha^{-1})	Fruit length (cm)	Fruit Circumference (cm)
No Fertilizer	0.98c	5.13e	5.42e
ORP	1.39b	6.14d	6.03d
ORP + 2.5 t ha^{-1} CD	2.92a	7.41c	7.58c
ORP + 5.0 t ha^{-1} CD	2.99a	8.17b	8.48b
ORP + 7.5 t ha^{-1} CD	3.05a	8.86ab	9.23a
ORP + 10.0 t ha^{-1} CD	3.27a	9.43a	9.73a
NPK Fertilizer	1.40b	6.66d	6.23d

Values with same letter in a column are not significantly different (DMRT≤0.05); CD: Cowdung.

Pod circumference was also highest from ORP – 10.0 t ha^{-1} CD and was comparable only with pods from ORP – 7.5 t ha^{-1} CD. Pod circumference decreased as the quantity of cowdung in mixture decreased. Sole ORP application and NPK-fertilized plants had lower but comparable pod circumferences. Plants from the unfertilized control treatment had lower pod circumference than all the fertilized plants (Table 4).

4. Discussion

The low nutrient status of the soil is a result of previous years' consecutive croppings. This however, qualifies it for a study on crop response to the rock phosphate. The cowdung was only moderate in nutrient contents and therefore will require fortification to support cropping. The phosphorous content was not high and so, has the potentials to show response to the rock phosphate. Sole application of ORP or NPK fertilizer was not able to support optimum

plant growth but complemented ORP and cowdung, indicating better nutrient use efficiency with the complemented sources. This agrees with earlier observations of Akande et al. (2005), Akande et al. (2011) that crop growth is better supported with complemented ORP and cowdung. Nutrients seemed not released fast enough from all the fertilizer sources to effect a difference with the unfertilized plants with 4 weeks of growth. This will account for the observed similar plant height, stem diameter and number of leaves per plant. It however seemed early enough to effect difference in leaf area expansion. High concentration of ORP, up to 20 kg per ton CD seemed not favourable for early leaf area expansion. 8 weeks seemed good enough time to enable optimum plant growth. Fortifying cowdung with not more than 13 kg per ton CD seemed adequate for supporting plant height, number of leaves and leaf area development.

Cultivating okra with sole ORP on a soil with 2.5% N and 0.34 cmol kg^{-1} K in the tropics gives comparable yield as NPK fertilizer application. However, complementing a ton of cowdung with 10 – 40 kg ORP gives higher okra fruit yields. Both the growth and the yield of okra were more favoured as the dilution of the rock phosphate was increased with higher rates of cowdung. Similar increase in okra yield with fortified organic manure application has been reported by Akande et al., 2005. Crop yields increase has been reported to be a benefit derived from phosphate applications (Yusuf et.al, 2003).

Optimum okra fresh pod yield is supported with 100 kg ORP mixed with 10.0 t ha^{-1} Cowdung.

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