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Full Length Research Paper

Effects of Phosphate Rock Enriched Cow Dung on Maize and Okra Growth in Cowpea Relay Intercropping

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Field trial was conducted at the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria in 2002 and 2003 to assess the effect of Ogun rock phosphate (ORP) amended with cow dung (CD) manure on the growth and yields of maize and okra in intercrop relayed with cowpea on an Aquic Arenic Haplustalf. Significant treatment effects were observed in plant height and leaf area of maize and okra whereas stem girth was not significantly affected in either crop. The percentage leaf P concentration of maize, okra and cowpea were significantly ($P < 0.05$) affected by treatment application. The percentage ranged from 0.18 - 0.48 and 0.24 - 0.45 in maize, 0.20 - 0.39% and 0.21 - 0.40% in okra and 0.16 - 0.40 and 0.18 - 0.42% in cowpea in 2002 and 2003, respectively. Increase in available P in amended ORP over sole ORP ranged from 44 - 71%, 40 - 71%, and 50 - 67% in the 2nd, 3rd and 4th sampling period. The ORP + 4 t/ha CD gave the highest P content of leaf in all the crops and in both years. The complementary use of Ogun rock phosphate with 3 t ha^{-1} cow dung manure produced the highest yields of maize (3.2 and 2.3 t ha^{-1}), okra (1.6 and 2.5 t ha^{-1}), and cowpea (1.8 and 1.9 t ha^{-1}) in 2002 and 2003, respectively.

Key words: Available phosphorus, cow dung, multiple cropping, Ogun rock phosphate.

INTRODUCTION

In many developing countries, traditional agricultural systems are based on the growing of crops in mixture (Willey and Osiru, 1972). Multiple cropping is the intensification of crops in time and space by growing crops simulta-neously on the same piece of land in a year (Andrews and Kassam, 1976). According to Agboola (1987), multiple cropping is the most dominant cropping system in Nigeria and it is the best cropping system for the soil of the humid tropics. He stated further that resources available to the farmers are well matched in maintaining low but often adequate and relatively steady production. In Nigeria, crop combinations vary a great deal from one ecological zone to another. One of the common combinations in Southwestern Nigeria is maize/okra (Adelana, 1986a, b).

The low nutrient status of most tropical soil neces-sitates the use of fertilizers for intensive cropping systems (Adetunji, 1991). The importance of phosphorus (P) as yield limiting factor in many Nigerian soils is well established (Adepetu, 1983; Enwezor and Moore, 1966; Udo and Ogunwale, 1977; Adetunji, 1994). However the basic information required for designing of annual or seasonal maintenance of P fertilizer rates for an intercrop of most tropical soil is still inadequate. To date, very little is known about the aggregate P requirement or maize/okra intercropping to the extent that fertilizer P recommendation have so far been single crop oriented. The crops, however, may respond differently to P when double cropped due to each using the residual P applied to the previous crop.

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The high cost of soluble phosphate fertilizer, such as single super phosphate, has generated considerable interest in the utilization of rock phosphate (RP) (Nnadi and Haque, 1998). Concerns are often expressed on the effectiveness of RP for direct application. However, direct application of ground rock phosphate had been proved to be beneficial to crops on acid soils. Numerous studies have been conducted amending rock phosphates to increase their immediate P availability and also possibly enhance their rate of dissolution after application to soil. Composting of RPs with agricultural waste is known to increase solubility of rock phosphates (Bangar et al., 1985; May et al., 1986; Singh and Amberger, 1990). The extent of P solubilization of a given RP varies with the kinds and the rate of decomposition of the organic material used (Bangar et al., 1985). For instance, Akande et al. (2003) evaluated the comparative effect of urea and poultry manure (PM) on solubilization of rock phosphate and on the growth and yield of okra (*Abelmochus esculentus*, (L), Moench). Okra growth and yield were significantly enhanced by the addition of the treatments. The use of rock phosphate combined with poultry manure and to a lesser degree urea, significantly improved the growth and yield of okra compared to when the materials were used individually. Application of RP plus urea and RP + PM was also found to increased soil available P by between 112 and 115% and 144 and 153% respectively for two years field trials.

The objective of this study was to evaluate the effects of cow dung manure on release of P from RP and yields of maize and okra in intercrop relayed with cowpea.

MATERIALS AND METHODS

Field trial was carried out in the Research Farm of Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria in the early and late growing seasons of 2002 and 2003. The site of the experiment lies between Latitude 7^0 31^1N, Longitude 3^0 54^1E. Mean annual rainfall which is bimodally distributed is 1350 mm. The soil is an Aquic Arenic Haplustalf.

The site was ploughed and harrowed. Soil samples for chemical analysis were randomly collected from the top 15 cm depth prior to cropping in 2002. Soil analysis results were 6.0 pH (water) and 0.34, 0.32, 2.27, 0.55 cmolkg^{-1} for exchangeable Na, K, Ca and Mg respectively. The total N and available P were 0.9% and 4.39 cmol kg^{-1} respectively. The cow dung chemical analysis results were pH 5.8, and 9.8, 1.68, 0.89, 1.69, 0.26 1.34 and 0.08% for organic matter, N, P, K, Na Ca and Mg, respectively. Soil samples were taken from the plots for chemical analysis following the first harvest in 2002 and prior to and after the second cropping harvest in 2003.

The design of the experiment was a randomized complete block with three replications. The blocks were 1 m apart, and each block consisted of six plots, each measuring 5 x 3 m with a space of 0.5 m between plots. The treatments consisted of control (no fertilizer), Ogun rock phosphate (100 kg P_2O_5ha^{-1}) alone, and Ogun RP (100 kg P_2O_5 ha^{-1}) combined with four levels (1, 2, 3, 4 t/ha) of cow dung (CD1, CD2, CD3 and CD4, respectively). Basal application of urea (100 kg N ha^{-1}) and muriate of potash (60 kg K_2O ha^{-1}) were mixed with the treatments.

Maize, CV, DMR-ESR-Y, and okra, CV. V35 was intercropped. Two seeds were planted per hill with a spacing of 75 x 30 cm inter row. 1:1 method of planting was adopted for both crops. Paraquat and Cypermethrin were used to control weeds at the rates of 40 and 100 ml, respectively per 15 L, of water. Treatments were applied a week after seedling emergence. Nuvacron at the rate of 50 ml per 20 L of water was applied on okra plants to control insect attack at 3 week after planting. Plant height, stem girth, leaf area and fresh fruit of okra yield were determined. Okra fruits were harvested at 3 days interval. Maize was allowed to dry on the stalk before harvesting. Yield was determined at 12% moisture content. Leaf samples of both crops were taken for chemical analysis. For maize, the index leaf taken was the one directly opposite and below the ear leaf, while that of okra was recently mature leaf before the onset of flower initiation. In the late season of 2002, cowpea was planted on the plot to assess the residual effect. In 2003 the experiment was repeated.

RESULTS AND DISCUSSION

Agronomic parameters

Maize and okra plant height were significantly influenced by either sole or complementary use of rock phosphate and cow dung manure in both years of cropping. Mean maize height was 190 and 180 cm in 2002 and 2003, respectively. The complementary application of ORP plus cow dung produced taller plants than the sole use of ORP. The percentage increase in maize heights under complementary use of ORP and cow dung over sole ORP ranged from 10 - 24% and 11 - 22% in 2002 and 2003, respectively. All treatments except sole ORP (in 2002) significantly increased okra plant heights in both years (Table 1). Stem girth of maize was not significantly influenced by treatment application in the two years. Okra stem girth was significantly increased when ORP was combined with 3 and 4 t/ha of cow dung in 2002 and 4 t/ha of cow dung in 2003. Leaf area of maize was positively affected by treatment application in both years. Amended ORP obtained significant higher leaf area of maize than un-amended ORP in each year of cropping. However, there was no significant difference among the rates of cow dung used. Whereas, there was significant difference in okra leaf area due to the treatments applied, there was no significant difference among the treatments except 2 and 3 t/ha CD in 2002 and 3 t/ha CD in 2003 which gave statistically higher leaf area than ORP.

Phosphorus content in plant leaves

The percentage P content in maize, okra and cowpea leaves sampled after treatment application are presented in Table 2. Significant increases in leaf P concentration were produced in all the crops by the treatment applied. In the case of maize, the percent leaf P concentrations ranged between 0.18 and 0.48 in 2002 and 0.24 and 0.45% in 2003. Amendment of ORP with CD significantly

Table 1. Effects of treatments on growth parameters of maize and okra.

Treatment	2002						2003					
	Maize			Okra			Maize			Okra		
	Height (cm)	Stem girth (cm)	Leaf area	Height (cm)	Stem girth (cm)	Leaf area	Height (cm)	Stem girth (cm)	Leaf area	Height (cm)	Stem girth (cm)	Leaf area
Control	154c	4.8a	361d	36b	3.7b	109c	140c	4.5a	313d	38c	3.5bc	88c
ORP	174b	5.5a	388c	39ab	4.2ab	132b	166b	4.9a	412c	50b	4.6b	112b
ORP + CD1	203ab	5.5a	402b	44a	4.3ab	136ab	189b	5.1a	464b	59ab	5.1ab	127ab
ORP + CD2	216a	6.0a	570a	44a	4.5ab	158a	184b	5.4a	509ab	57ab	5.3ab	133ab
ORP + CD3	202ab	5.8a	537ab	45a	4.7a	161a	200a	5.8a	538a	64a	5.8ab	147a
ORP + CD4	192ab	5.4a	538an	43a	4.9a	144ab	203a	5.9a	554a	55ab	6.3a	126ab

Means having the same letter(s) in a column are not significantly ($p \geq 0.05$) different according to DMRT.
ORG = Ogun rock phosphate.
CD1, CD2, CD3 and CD4 represents 1, 2, 3 and 4 t/ha of cow dung, respectively.

Table 2. Phosphorus concentrations (%) in leaves of maize, okra and cowpea.

Treatment	2002			2003		
	Maize	Okra	Cowpea	Maize	Okra	Cowpea
Control	0.18d	0.20c	0.16d	0.24c	0.21d	0.18d
ORP	0.30c	0.28b	0.24c	0.35b	029c	0.26c
ORP + CD1	0.40b	0.34ab	0.30b	0.40ab	0.34b	0.30ab
ORP + CD2	0.45ab	0.36a	0.34ab	0.43a	0.36ab	0.34ab
ORP + CD3	0.46ab	0.38a	0.35ab	0.44a	0.38a	0.40a
ORP + CD4	0.48a	0.39a	0.40a	0.45a	0.40a	0.42a

Means having the same letter(s) in a column are not significantly ($p \geq 0.05$) different according to DMRT.
ORG = Ogun rock phosphate.
CD1, CD2, CD3 and CD4 represents 1, 2, 3 and 4 t/ha of cow dung, respectively.

increased leaf P concentration. There was a slight increase in P content as the rate of cow dung increased though this was not significant except between ORP plus CD1, and ORP plus CD4 in 2004. ORP + CD_4 produced the highest P content in both years. The percentage P content in okra leaves ranged from 0.20 - 0.39 and 0.21 - 0.40 in 2002 and 2003, respectively. The trend was similar to that of maize plant. The percentage increase in leaf P content of okra treated ORP plus different rates of cow dung over sole ORP ranged from 21 - 39% and 17 - 38% in 2002 and 2003, respectively. The percentage P con-tent in cowpea leaves ranged from 0.16 - 0.40% and 0.18 - 0.42% in 2002 and 2003, respectively. It was observed that as the rate of cow dung increased the P concentration also increased in both years for all the crops.

Soil available phosphorus

After the first cropping, soil P had significantly increased by all the treatments except the control that declined. Cow dung amendment produced significant increase in soil available P above un-amended ORP. The percen-tage increase ranged from 44 - 71%, 40 - 71% and 50 - 67% in prior to the 2^{nd}, 3^{rd} and 4^{th} cropping, respectively. Also, the percentage increase in sole ORP over the control were 93, 338 and 513 in prior to 2^{nd}, 3^{rd} and 4^{th} cropping, respectively (Table 3).

The soil available P increased with increasing rate of CD. Soil available P with 3 and 4 tonnes CD was similar and statistically higher than 1 and 2 tonnes CD that were also similar. The same trend was sustained after the second cropping, prior to the third cropping. Prior to the fourth cropping, the results still showed significant increase in soil available P due to treatments applied. However, the effect of amending ORP with CD was no longer significant, showing that amendment sustaining the soil available P increase for three consecutive crops. The efficacy of cow dung in facilitating the release of P from applied rock phosphate resulted in significantly higher available P than using rock phosphate alone. This must have been responsible for the remarkable yield increase observed from the co-application of ORP and cow dung. Similar yield increases of maize and cowpea

Table 3. Effect of treatments on soil available P (mg kg^{-1}).

Treatment	Prior to 2nd cropping	Prior to 3rd cropping	Prior to 4th cropping
Control	3.39d	2.48d	1.98c
ORP	6.54c	8.76c	10.14b
ORP + CD1	9.42b	12.29b	15.23ab
ORP + CD2	9.89b	12.77b	15.44ab
ORP + CD3	10.48a	14.38a	16.48a
ORP + CD4	11.21a	14.98a	16.96a

Means having the same letter(s) in a column are not significantly ($p \geq 0.05$) different according to DMRT.
ORG = Ogun rock phosphate.
CD1, CD2, CD3 and CD4 represents 1, 2, 3 and 4 t/ha of cow dung, respectively.

Table 4. Effects of treatments on grain yield (t/ha) of maize, okra and cowpea.

Treatment	2002			2003		
	Maize	Okra	Cowpea	Maize	Okra	Cowpea
Control	1.1d	0.4c	0.8c	0.3d	0.3d	0.6c
ORP	1.8c	0.7b	1.2b	0.9c	1.2c	1.3b
ORP + CD1	2.7b	1.1b	1.4ab	1.2b	1.6b	1.6ab
ORP + CD2	3.0ab	1.4ab	1.7a	1.5b	1.9ab	1.8a
ORP + CD3	3.2a	1.6a	1.8a	2.5a	2.3a	1.9a
ORP + CD4	2.7b	0.9b	1.6a	2.2a	1.6b	1.7ab

Means having the same letter(s) in a column are not significantly ($p \geq 0.05$) different according to DMRT.
ORG = Ogun rock phosphate.CD1, CD2, CD3 and CD4 represents 1, 2, 3 and 4 t/ha of cow dung, respectively.

has been reported by Akande et al. (2005) through the combined use of rock phosphate composted with poultry manure.

The increase in P availability observed through amendment of rock phosphate with organic materials was also explained by Khanna et al. (1983) as resulting from the conversion of rock phosphate P to water soluble form and greater efficiency of the dissolved P in terms of availa-bility to plant.

Yields of maize, okra and cowpea

Ogun rock phosphate significantly improved grain yield of maize resulting in as much as 63 and 200% yield increases in 2002 and 2003 respectively. Cow dung applied along with ORP resulted in further significant yield increases, the highest being obtained when CD was applied at 3 t/ha in the two years of cropping. This was significantly higher than ORP + CD1 and ORP + CD4 both of which produced statistically similar maize grain yield. At the optimum level CD (3 t/ha) increased yield by 77.7 and 160% over and above sole ORP in 2002 and 2003 respectively (Table 4). Fresh fruit yield of okra was also markedly improved by application of ORP solely or in combination with CD. Only 3 t/ha CD gave significantly higher yield than sole ORP in the two years of cropping. Other rates of CD were not significantly different. Cowpea followed a somewhat similar trend. Treatments involving CD gave significantly higher yields than sole ORP except CD1, in the first year and CD4 in the second. No significant difference, were observed among all the rates of CD used. Maize yield were higher in 2002 than in 2003, this could be due to dearth of rainfall observed after the trial establishment in 2002 whereas the reverse was the case for okra and cowpea.

Conclusion

The results of this study showed that ORP amended with cow dung manure was superior to the control and sole application of ORP. This shows that the effectiveness of ORP on crop production was remarkably improved through the solubilizing effect of cow dung manure. Furthermore, the complementary use of rock phosphate with 3t/ha cow dung manure gave the optimum yield in maize and okra intercropped relayed with cowpea, while above this rate there was declined in yield of the component crops.

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