Comparative Evaluation of Phosphorus mineralization by Bone meal and Sokoto Rock Phosphate as Fertilizers for Organic Okra (*Abelmoschus esculentus*) Production

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ABSTRACT

This preliminary study investigated the responses of okra (*Abelmoschus esculentus L Moench*) to Bone meal and Sokoto Rock Phosphate (SRP) as organic fertilizers. The experiment replicated four times was conducted in the screen house of the Department of Agronomy, University of Ibadan, Nigeria in a randomized complete block design. The treatments were bone meal, rock phosphate, mineral fertilizer (NPK 15-15-15) and control (no soil additive). All the treatments (except the control) were applied at 50 kg N, 45 kg P, and 40 kg K/ ha. The data obtained were analyzed using analysis of variance (ANOVA) and means were compared using least significant difference (LSD). Incubation studies were also carried out on all the treatments to evaluate their rate of P release. The incubation study of the applied fertilizer treatments revealed that Sokoto Rock Phosphate mineralized its P within 10 weeks after incubation (WAI) and in a higher quantity than Bone meal while Bone meal commenced mineralization at 10 WAI and still showed a potential to continue to release its P after the 15 WAI when the study was terminated. The yield of okra revealed that there was no significant difference ($P<0.05$) in both the fresh and dry yields of okra across the treatments. However, considering the rate of release in the incubation study, it could be concluded that rock phosphate could support short season crop like okra while it is advisable to incorporate bone meal for about 3 months in the soil before planting such crops. While combination of both the two could be suggested in raising long season crops, however, their application may not be encouraged on a sandy soil.

Key words: *Abelmoschus esculentus*, Bone Meal, Phosphorus, Rock Phosphate

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INTRODUCTION

Phosphorus is an essential nutrient element needed by fruit for optimum yield of crops. Normal plant growth cannot be achieved without phosphorus. It enhances seed germination and early growth; stimulate blooming, bud sets, seed formation and maturity (Tucker, 1999). One of the constraints to raising fruit vegetables in organic farms is P limitation of most organic fertilizers. Works have been done on several organic materials whether of plants or animal origin, as sources of fertilizers. These include farm yard manure (Eifediyi *et al*., 2010; Cooke, 1982; *Gliricidia sepium* (AdeOluwa, 1999); cocoa fruits (Adeoye *et a*l., 2001).

Rock phosphate and bone meal are very rich in P - 25.2 and 20% respectively (Andrews, 2011; Imogie *et al*., 2011). Akande *et al*. (2006) reported that the complementary use of Ogun rock phosphate with 3 t/ha cow dung manure improved the yields of maize, okra and cowpea. According to Tinubu (2007) and Akande *et al*. (2010) application of fertilizer in okra production favoured okra growth and yield, and resulted into higher income.

In Nigeria, okra is among the foremost vegetable crops, in terms of consumption and production area (Iremiren and Okiy, 1999). The immature pods are used as boiled vegetable while its dried form is used as soup thickener (Owonubi and Yayock, 1981). The green fruits are rich sources of vitamins, calcium, potassium and other minerals (Lee *et al.*, 2000).

This study was therefore set up to evaluate the rate of release of P by Rock Phosphate and Bone meal under incubation in the laboratory and to assess their potentials as organic fertilizers for producing okra (*Abelmoschus esculentus),* a fruit vegetable which requires phosphorus for fruit formation in the screen house.

MATERIALS AND METHODS

The experiment was carried out in the screen house at the Department of Agronomy, University of Ibadan, Nigeria. There were four treatments and each treatment was replicated, four times in a randomized complete block design. Sixteen 5 kg-pots were filled each with 2 mm sieved and properly leached river sand. Planting was done once. Experimental soil was very low in N (0.03 g / kg), P (7 mg / kg) and K (0.1 cmol / kg) and the textural class is sand. The treatments used were Bone meal, Sokoto rock phosphate (SRP), mineral fertilizer (NPK 15-15-15) and control (no soil additive). All the treatments (except control) were applied at 50 kg N, 45 kg P, and 40 kg K/ha according to (FMA&RD, 2002). Leaching of nutrients from the potted plants was prevented by placing flat plates under each pot.

Incubation study was also carried out on all the treatments to evaluate their rate of P release. A total of twenty incubation cups were filled with 40 g 2mm mesh sieved leached river sand. Each of these served as an experimental unit. The cups were set up in the drawer in the laboratory. All the four treatments (except control of no soil additive) replicated five times were randomly applied on dry matter basis at the rate of 50 kg N, 45 kg P, and 40 kg K/ ha per experimental unit. Application of the treatments involves thorough mixing with the sand, the mixture moistened and each cup was covered and the drawer was pushed into the laboratory table.

Each of the five (5) replicates for each treatment was harvested at 0, 7, 9, 11, and 13 weeks after incubation (WAI). The 0 WAI was not incubated at all but preserved for chemical analysis. The 7 WAI replicate for each treatment was removed from incubation at 7 WAI, air dried and preserved for chemical analysis including the Available Phosphorus, pH and CEC. The same procedure was followed for others in order of their WAI. Projection of all the soil properties was done for 15 WAI for all the treatments using regression. The pH and CEC of the treatments at 15 WAI were compared with that of the pre-incubated soil thereby measuring the effect of the applied treatments on the soil properties at 15 weeks of Incubation.

The fertilizer treatments in the experiment correspond to

- Treatment II ; 300 kg / ha of NPK
- Treatment III ; 130 kg / ha SRP + 110 kg / ha Urea + 70 kg / ha MOP
- Treatment IV ; 230 kg / ha BM + 110 kg / ha Urea + 70 kg / ha MOP

Table 1: Nutrient composition of Bone meal and Sokoto Rock phosphate (SRP) used for this study

Elements	Bone meal (%) *	SRP (%) **
Nitrogen	1	-
Phosphorus	20	25.2
Potassium	0	0.23
Calcium	20	14.25

Source: *Pacific Calcium, Inc., WA, United States
** Imogie *et al*., 2011

RESULTS AND DISCUSSION

Rate of P release in soil

Comparative rate of release of P across 15 weeks of incubation of applied fertilizer treatments is shown in Fig 1. The result showed that NPK had the highest value of 23 mg/kg at 7 WAI while SRP had the lowest value of 8 mg/kg at 15 WAI. It also showed that for the 15 weeks of incubation, on the average, NPK had the highest rate of release followed by control and then Bone meal while SRP had the least. However, Bone meal had the least rate of release until the 10 WAI when it became higher than that of Sokoto Rock Phosphate (SRP) and 14 WAI when it became higher than that of NPK and control. Although Bone meal had the least rate of release within the first 9 WAI, it had the highest value at 15 WAI as the curve shows its potential to release more P beyond 15 weeks of incubation.

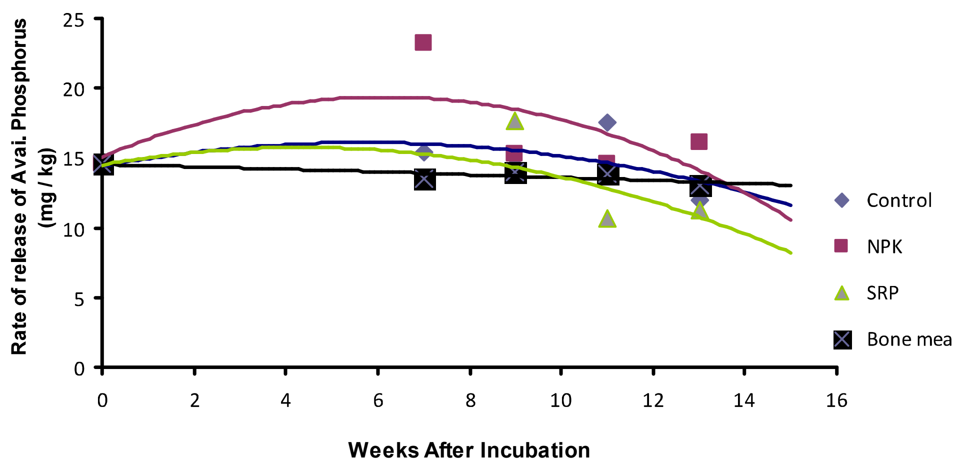

Fig. 1: Comparative rate of release of Available P by the phosphorus sources across weeks of incubation

Effects of the applied treatments on the soil properties at 15 weeks of Incubation

The result (Table 2) showed that among the applied treatments, only Bone meal maintained the soil pH range (slightly acidic) at 15 weeks after Incubation while NPK and SRP left the soil strongly acidic. It also showed that although both the Bone meal and SRP did not improve the CEC of the soil.

Table 2: Effects of the applied treatments on the soil properties at 15 weeks of Incubation

Treatments	Parameters	
	pH	CEC
Pre incubated soil	6.6	1.9
Control	6.0	2.2
NPK	4.3	1.9
SRP	3.5	1.3
Bone meal	6.2	1.8

Okra fruit yield

Comparative effects of the treatments on fresh and dry yields (g / plant) of okra fruit at 16 WAP are shown on Table 3. The result showed that there was no significant difference ($P<0.05$) in both the fresh and dry yields (g / plant) of okra fruits across the treatments.

Table 3: Comparative effects of phosphorus sources on fresh and dry yields (g / plant) of okra at 16 weeks after planting

Treatments	Fresh	Dry
Control	8.89	1.00
NPK	8.84	0.97
Sokoto Rock phosphate	7.72	0.89
Bone meal	6.30	0.71
LSD $_{(0.05)}$	6.94	0.78
	Ns	Ns

Ns: Not significant

The control treatment showing a higher release of P on the average than that of Sokoto Rock Phosphate (SRP) and Bone meal suggested that the rate of mineralization of the available P from the fertilizer treatments was probably influenced by the texture of the soil (sandy soil) used for this study vis-à-vis its high bulk density. This is in line with the report of Torbert and Wood (1992) who observed from sandy coastal plain soils that respiration decreased with increase in bulk density, therefore showing that bulk density could impact microbial activity.

It, however, showed that SRP had a higher rate of release than Bone meal up till 10 WAI when Bone meal started releasing P at a higher rate than other fertilizer treatments in this study. This showed the tendency of Bone meal as an organic fertilizer for a long season crop. While, SRP could be suggested for a short season crop as it mineralized P early and reached its peak shortly after application to soil. It may be advisable to incorporate Bone meal for about 3 months in the soil before planting okra as slow release but adequate quantity of nutrients by fertilizer is a desirable property in sustainable production. This would have allowed mineralization of a reasonable amount of P mineralized in the soil for uptake by the okra plant. However, combination of SRP and Bone meal could be suggested in raising long season crops since SRP mineralizes early while Bone meal has the tendency to mineralize slowly.

Considering the effects on the soil properties, Bone meal tend to maintain the soil pH and CEC while SRP reduced them drastically which could imply the ability of the Bone meal as a better organic fertilizer than SRP. This result is in contrary to the report of Zaharah, *et al*. (1985) who reported that Rock Phosphate treatment increases the soil pH and CEC in a 17 consecutive years of application of Christmas Island Rock Phosphate. However, this may be due to the pure sand nature of the soil used for this experiment.

Fresh fruit yield (with 0.66 t / ha as the highest) within the observation period was generally low for all the fertilizer treatments; compared to the average yield of 3 - 5 t / ha that have been obtained from okra in the same region (Akande *et al*., 2010; Ijoyah *et al*., 2010), though on different soils. The difference in yield could be because of the poor structure of the soil (pure river sandy soil) and may be the volume of the soil per pot. It was observed that the okra did not fruit until 12 WAP as against 7 WAP expected of the early maturing okra variety used in the study which could be due to the nature (pure sand) of the soil used. Application of both SRP and Bone meal resulting in lower yield of okra in this study could have been caused by lower concentration of P as shown in the results of the incubation study (Fig. 1). This revealed the importance of good characterization of fertilizer treatments and proper understanding of their potentials before use in a particular soil.

CONCLUSIONS

The results of this research work within the time frame of the study revealed that while Sokoto Rock Phosphate could be suggested for a short season crop as it mineralizes P early and reaches its peak, it is advisable to incorporate Bone meal for about 3 months in the soil before planting okra whereas combination of the two could be suggested in raising long season crop, however, their application may not be encouraged on a sandy soil. The study also showed that Bone meal had a better impact on the soil pH and CEC compared with SRP. Further study on the performance of both Rock phosphate and Bone meal for production on okra on the field is needed to validate this result.

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