ASSET Series A (2003) 3 (4):137-142

ISSN 1595-9694

EVALUATION OF OGUN PHOSPATE ROCK AS PHOSPHORUS SOURCE FOR SOYBEAN

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ABSTRACT

An experiment was conducted in the laboratory, greenhouse and on the field to determine phosphorus fertilizer requirement of soybean and to compare the effectiveness of indigenous PR (OPR) alone or in combination with single super phosphate (OPR:SSP) and single super phosphate (SSP) as phosphorous source for soybean in a severely phosphorous deficient soil at Abeokuta, South West Nigeria. Sorption study in the laboratory showed that the equilibrium solution phosphorus concentration (SPC) required to achieve 95% maximum yield of soybean in the test soil was 0.05 mgmL-1. On the field, significant responses to phosphorus application were obtained irrespective of phosphorus source and rates. The optimum phosphorus requirement of soybean in the soil was 30 kg Pha^{-1} All the sources showed significant residual effect. After 2 years as much as 56 to 62% 60 to 73% and 77 to 81% of the phosphorus fertilizer applied at 30, 60, 90 kg ha^{-1} respectively were unutilized. This was highest for OPR followed by SSP and least with OPR:SSP. It is concluded that direct OPR application as phosphorus source for soybean in South Western Nigeria soil is feasible and the agronomic efficiency could be increased by mixing OPR and SSP at ratio 1 : 1.

Key Words: Phosphate rock, soybean, Equilibrum solution, sorption.

INTRODUCTION

In Nigeria significant responses to P applied through water-soluble sources have been observed for many arable crops (Adetunji 1994a; 1994b; 1995; 1997; Adepetu, 1983; Udo and Ogunwale, 1977; *Uzu et al.*, 1975; Enwezer and Moore, 1966).

Superphosphate is the most prominent phosphorus fertilizer source used on agricultural soils in Nigeria. However, due to high cost, coupled with gradual removal of subsidy on fertilizer soluble phosphate is fast getting out of reach of the local farmers. In the present situation of high fertilizer prices, replacing relatively higherpriced water soluble source with cheaper and readily available sources such as phosphate rock requires greater attention.

The indigenous phosphate rocks have been reported to be beneficial as a source of phosphorus on a wide range of soils (Bationo *et al .* , 1990, Chien and Menon, 1995. However, the agronomic value of PR depends on the chemical reactivity of the rock. The properties of the soil to which it applied and the type of crop that is. grown (Bationo *et al .* ,1990). Due to the low reactivity of some indigenous PRs, various attempts have been made to increase the efficiency of PRs.

Some PR deposits have been identified in Ogun State, Nigeria. Little or nothing is known about the potential utility of the deposits for agricultural purposes. Our efforts to develop crop production system within the framework of economic viability and ecological, it compatibility which currently focus attention on the development of local sources of agricultural input make thorough evaluation of these local sources of phosphorus a vital subject to study.

This study was conducted in Ogun State, Nigeria with the following objectives: To determine phosphorus fertilizer requirement of soybean through sorption and field studies and to compare the effectiveness of rice direct application of Ogun phosphate rock alone or in combination with single super phosphate and single super phosphate as phosphorus source for soybean.

MATERIALS AND METHODS

Pre-trial soil sample (1 - 15 cm) was collected from the experimental site at the University of Agriculture, Abeokuta, Nigeria teaching and research farm. The sample was analysed for the following parameter of article size analysis was by pipett method and pH was determined using glass electrode in a 1:2 soil water ratio. Organic matter was determined by the chromic acid oxidation method of Walkley and Black (1934). Total nitrogen was by Kjeldahl procedure Exchangeable bases were extracted using neutral amonium acetate in a L 10 soil: solution ratio, sodium and potassium in the extra were analysed using a flame photometer while calcium and magnesium in the extract were determined using atomic absorption spectrophotometer, ration exchange capacity was analysed by neutral ammonium acetate displacement.

Available phosphorus was extracted using Bray-l (0.03 NH_4 F + 0.025 HC 1) extractants at a soil solution ratio of 1:5, phosphate in the extracts was determined colorimetrically using molybdenum blue method (Murphy and Riley, 1962). The inorganic phosphorous was fractioned by successive extraction according to the Chang and Jackson (1957) procedure; of phosphorus in all the extracts was determined colorimetrically with spectrophotometer using molybdenum blue method at a wavelength of 650 nm. Total phosphorus in the soil samples was analysed by digesting the samples in nitric acid and perchloric acid mixture at the ratio 1:1. Phosphorus in the digests was determined as above; organic phosphorus was calculated as the difference between the total phosphorus and the total phosphorus and total inorganic phosphorus. Phosphorus adsorption capacity was measured in the laboratory as follows: five grams air dry soil samples were weighed into extracting bottles. 50 cm^3 of 0.01_M CaCl, containing 0, 5, 10, 20, 30, 40,50, 100, 200, 300 and 400 ppm phosphorus in farm of KH, $P0_4$ were shaken for 24 hours and filtered. Phosphorus in the filtrate was determined colorimatically by the molybdenum blue method (Murphy and Riley, 1962). The differences between phosphorus in supernatant and phosphorus added was assumed to be the amount of phosphorus sorbed. Sorption parameters were estimated from adsorption is other ms constructed using the sorption data.

Greenhouse experiment

A greenhouse experiment was set up to determine the critical equilibrium solution phosphate concentration (SPC). Five kg of sieved soil was placed in plastic pots. From the sorption curve the amounts of P that would give the following levels of solution concentration 0.02, 0.04, 0.08,0.10, 0.12, 0.4, 015, 0.18 0.20, and 0.30 $mgmL^{-1}$ in the soils were estimated and these were added as treatments to the pots as KH, $P0_4$ in 50cm^3 of distilled water and mixed thoroughly. All the post received initially 10 mg N kg^{-1} as NH_4 NO_3 50 mg K kg' as KCI and 2 mg Zn kg^{-1} as Na2, Zn EDTA. There was a

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control pot without P addition. Three soybean seeds (later thinned to 2) were planted per pot. The pots were laid out in the greenhouse in a randomised complete block design with 4 replicates. The crop was grown for 7 weeks. The above-ground plant materials was harvested, dried and weighed. The plant materials were milled and digested in a 4:1 HNO_3 :$HCLO_4$ mixture and analyzed for P using the method of Murphy and Riley (1962). The optimum P solution concentration was determined graphically from the plot of relative dry matter yield against the equilibrium solution concentration of P. The critical equilibrium solution phosphate concentration was estimated as the amount of P in an equilibrium solution concentration required to achieve 90% maximum dry matter yield of soybean (Adetunji, 1997). The quantity of P required to achieve the critical equilibrium solution phosphate concentration was taken as the standard phosphate requirement (SPR) (Adetunji, 1997).

Field experiment.

The soil of the experiment site is an Ultisol (Two series) derived from igneous/metamorphic parent material. Available climatic data indicate that the mean annual rainfall of the area is 1483 mm. Relative humidity ranges from 6083% while temperature ranges from 24-33 C. The experiment was laid out on the field using in randomised complete block design with three replicates. The treatments were made up of Ogun phosphate rock (OPR), single super phosphate (SSP) and OPR:SSP mixture at 1:1 ratio. The fertilizers were applied banded at 0, 30, 60 and 90 kg P ha'. Ogun phosphate rock contains 31 % P, 05 (Akintokun *et al.,* 2003). Nitrogen and potassium were applied at 10 and 30 kg ha^{-1} as urea and muriate of potash respectively. The plot size was 6 m x 3 in with each plot containing five rows. Soybean seeds. cultivar TGX-1019-2EB were planted by drilling in each row. Weeding was carried out two times during the growth period. At maturity, plant top samples were harvested, dried in the oven at 70 C for 48 h and milled. The dried plant tissues were digested using concentrated nitric and sulphuric acid mixture at a ratio of 1:1 phosphorus in the digest was determined colorimetrically by the vanado-molybdate method at a wavelength of 400nm. Dried soybean pods were shelled and weighed and grain yield recorded.

RESULTS AND DISCUSSION

Some properties of the soil at the sites of experiment before treatment are shown in Table 1. The soil was acid, low in organic matter, total nitrogen, available phosphorus, phosphate adsorption capacity and buffering capacity. The phosphorous adsorption capacity 9 mgg' was lower than the values recorded for 15 soils in the same agroecological zone (Adetunji, 1997) and much lower than the 600 mgg recorded earlier for certain soils in south Western Nigeria (Adepetu, 1983).

It was estimated from the sorption study in the greenhouse and in the laboratory that the equilibrium solution phosphorus concentration (SPC) required to achieve 95% maximum yield of soybean in the test soil was 0.05 $mgml^{-1}$ This value is much lower than the range 0.08 to 0.15 mgL established for maize in some South Western Nigerian soils (Adetunji, 1995) but at the lower range of 0-03 to 0.19 $mgmL^{-1}$ established for rice in South Western

Table 1. Some properties of the experiment site

pH H2O _	15.10
Organic matter (%)	1.10
Total Nitrogen (%)	0.06
Available P (mg kg -')	2.80
Exch - Ca (cmol kg⁻')	1.51
Exch - K (c mol kg⁻')	0.23
Exch - Mg (c mol kg')	0.48
Exch - Na (c mol kg⁻')	0.09
Total P (mg kg')	482
Organic P. (mg kg⁻')	258
Absorption capacity (ugg')	' 97.5
S P C (ug ml⁻)~_	0
S P R (kg ha $^{-1}$)	32.8
PBC(mlg	:
Texture	Loamy sand

Nigerian soils (Adetunji, 1997). Thus the equilibrium solution phosphorus concentration, to which the soil could be fertilized to achieve optimum yield, varies greatly with soil type and plant species. It would seem therefore that the use of 0.2 mgL-' proposed by Beckwith (1965) as the critical soil solution phosphorus is of no practical value or of justifiable applicability in Nigerian soils.

The standard phosphorus fertilizer requirement of soybean (SPR) was calculated to be only 32.8 kg Pha' ha despite the low level of soil phosphorus. This could be explained, in part, by the low buffering capacity and the sandy nature of the soil of the site.

On the field significant responses to phosphorus application were obtained at 30kgP ha' irrespective of phosphorus sources and rates (Table 2). In 1995, the highest yields were obtained with SSP at 30 kg P ha' (1.90 ha) and at 60kg P ha' (1.8 1 ha'). Differences between OPR and OPR:SSP at all levels were not significant. Thus the optimum phosphorus requirement of soybean in this soil is 30kg P ha' which is in agreement with the sorption study which fixed the standard phosphorus requirement of soybean at 32.8 kg P ha'. In 1996, differences between the phosphorus sources were no longer significant. However, significant increase over the control were still observed with all sources at all rates. It was observed that while significant yield increases were recorded in OPR and OPR:SSP plots, over the 1995 results the yields actually decreased in the SSP plots. Although all the sources showered beyond the first cropping season. This kind of delayed effect maybe due to the show dissolution rate of the OPR.

Table 2. Effect of phosphorus sources on soybean grain yield (t ha⁻')

	1995	1996
	0.72	
	1.30	
	1.10	
OPR_{90}	1.32	
SSP_{30}	1.91	1.66
SSP_{60}	1.81	1.52
SSP_{90}	1.72	1.60
Lsd 0.05	0.31	0.26

The recovery of added phosphorus was calculated as the increase in phosphorus uptake resulting from fertilization. The values obtained were expressed as percentages of added fertilizer (Table 3). The recovery of applied phosphorus fertilizer was significantly different among sources and rates. In general, the percent recovery was higher at lower fertilizer rate than at high rate irrespective of sources. The highest recovery was obtained with SSP in 1995, which were 31.7, 23.7 and 17.3% when SSP was applied at 30, 60 and 90 kg ha^{1} respectively. The lowest recovery values were obtained with OPR in the same year which were 12.7, 5.7 and 7.9% when OPR was applied at 30, 60, a 90 kg ha^{-1} respectively. These values are within the earlier reported values in Nigerian rainforest zones (Kang and Fox, 1978) as well as savanna zones (Jones and Wild, 1975). In 1996, the highest recovery values were obtained with OPR followed by OPR:SSP and least with SSP. It was observed that even after two years and at low level of phosphorus fertilizer application (30 kg P ha) only 38, 42 and 43.7% of the applied phosphorus in OPR, SSP and OPR:SSP had been utilized. Thus between 56 to 62%, 60 to 73% and 77 to 81% of the phosphorus fertilizers applied at 30, 60 and 90kg P ha-' respectively were unutilized. This is a reflection of slow release nature of OPR.

Table 3. Effect of phosphorus sources on phosphorus recovery by soybean (%)

Treatments	1995	1996	1997
OPR_{30}	12.7	25.3	38.0
OPR_{60}	5.7	20.8	26.5
OPR_{90}	7.9	10.8	18.7
SSP_{30}	31.7	10.3	42.0
$OPR:SSP_{60}$	19.0	20.8	39.8
$OPR:SSP_{90}$	11.9	9.8	
Lsd 0.05			4.08

These results suggest that OPR at 30 kg P ha"' is quite effective for optimum soybean yield in an Ultisol with low available P and low pH and consequently, direct OPR application as P source for soybean is feasible.

DEDICATION

This paper is dedicated to the memory of the first author, Dr. (Mrs) O. O. Akintokun nee Owoeye. This paper forms a part of her Ph.D thesis awarded posthumously.

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