Concentration of Available phosphorus in Soil Amended with Rock Phosphate and Palm Oil Mill Effluent

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Abstract

The effect of palm oil mill effluent (POME) on the concentration of available phosphorus in a dystric cambisol (Kulfo series) amended with Sokoto Rock Phosphare (SRP) was investigated in this study. The experiment comprised six treatments replicated three times (POME + SRP) and incubated in the green house. Sub samples of the various treatments were collected at 3 – day intervals for 15 days and analysed for available phosphorus. The results obtained showed that there was significant increase ($P < 0.001$) in the amount of available phosphorus between the untreated and the amended soils. Furthermore, maximum available P concentration was 103.66 and 109.85 mg/kg at constant amount of SRP and POME treatments respectively. The present study has provided further basis for the combined use of POME and rock phosphate in enhancing the availability of P. However, further studies are expected to investigate amongst others, the specific rates of application of SRP and POME that will ensure maximum available P release and utilization by plants.

Introduction

Studies on the use of locally sourced rock phosphate fertilizers as alternatives to single phosphate fertilizers in crop production has gained serious attention recently. It is well documented in literature that reactive rock phosphates can provide a less expensive alternative to manufactured P fertilizers (Hammond et al., 1986; Le Mare, 1991; Isenmila et al., 2003; Talab and Badr, 2007).

A major drawback in the use of these rock phosphate materials is their relatively poor solubility, hence availability in most soils. In general, the availability of nutrients contained in natural minerals depends on many factors, some of which are soil types (Patterson, 2002), soil reaction pH (Barak et al., 1997), soil solution composition (Nakamaru et al, 2000) plant species (Habib et al., 199) and types and ratios of micro organisms (Leyval and Joner, 2000). Furthermore, various organic and inorganic materials have been employed in order to facilitate the release of phosphorus from rock phosphates. One traditional method is the acidulation of rock phosphate with small a mounts of H_2SO_4 or H_3PO_4 to produce partially acidulated rock phosphate (Rajan and Watkinson, 1993, Lowell and Weil, 1995). Other alternative methods include mixing of rock phosphate with various soil amendments or compaction of rock phosphate with water soluble P fertilizers (Bolland, 1996). Finally, microbial approaches have been proposed to improve the agronomic value of rock phosphate materials. Solubilization of rock phosphate by microorganisms excreting organic acids seem to be an attractive approach that has been actively studied for the last decade (Geonadi and Siswanto, 2000; Jasian and Patel, 2000; Chi et al., 2005; Chi et al., 2007).

Palm oil processing is carried out using large quantities of water in mills where oil is extracted from the palm fruits. During the extraction of crude palm oil from the fresh fruits, about 50% of the water results in palm oil mill effluent (POME). Raw POME has Biological Oxygen demand (BOD) values averaging around 25,000 mg/litre, making it about 100 times more polluting than domestic sewage (Maheswaran and Singam, 1977). However, this characteristics of POME can be utilized in effecting the solublization of mineral ore materials such as rock phosphate considering the inherent high microbial loading in POME. This was what necessitated the present study. Hence, the concentration of available phosphorus in soil following the treatment and application of rock phosphate and POME was investigated in this work.

Materials and methods

Soil from the top layer (0-15cm) of an uncultivated area at the Nigerian Institute for Oil Palm Research (NIFOR) main station, Benin City was used for this study. The soils had earlier being classified as Kulfo series (Dystrict Cambisol). The soil sample was processed and characterized for its physicochemical properties using standard

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methods which include; Bouyoucos (1951) for particle size analysis, Bray and Kurtz (1945) for available phosphorus, Bremher and Mulvancy (1982) for total nitrogen, Nelson and Sommers (1982) for total organic carbon and neutral ammodium acetate (PH 7) for exchangeable bases.

After characterization the soil was taken in 1.0 kg lots in perforated plastic cups. Fresh palm oil mill effluent (POME) obtained and characterized at NIFOR alongside ground Sokoto rock phosphate (SRP) were applied to the soil as follows:

Treatments:

T_1 1.0kg soil + 0g RP + 0ml POME
T_2 1.0kg soil + 10g RP + 100ml POME
T_3 1.0kg soil + 10g RP + 200ml POME
T_4 1.0kg soil + 10g RP + 300ml POME
T_5 1.0kg soil + 10g RP + 400ml POME
T_6 1.0kg soil + 10g RP + 500ml POME

T_{21} 1.0kg soil + 0g SRP + 0ml POME
T_{22} 1.0kg soil + 10g SRP + 100ml POME
T_{23} 1.0kg soil + 20g SRP + 200ml POME
T_{24} 1.0kg soil + 30g RP + 300ml POME
T_{25} 1.0kg soil + 40g SRP + 400ml POME
T_{26} 1.0kg soil + 50g SRP + 500ml POME

All the treatments were made in triplicates and placed in the green house. Sub samples were collected at three days interval for 15 days and the soils analyzed for available phosphorus. The results obtained were objected to analysis of variance.

Results and Discussion

The results of the analysis of the phosphorus content of the milled rock phosphate, selected physicochemical properties of the POME and soil used are shown in Tables 1 – 3 respectively. Similarly, the results of the amount of available phosphorous are as contained in Tables 4 and 5.

The rock phosphate had relatively high amount of total phosphorous in the perchloric acid extract (36.98%) P_2O_s, while 148.00mg/L P was obtained in the POME. The soil was sandy with mean P amount of 18.59 mg/kg. It can be seen therefore that the various materials used for this study possessed varied levels of phosphorus. The POME had a pH of 4.9 which showed more acidic property compared to the soil. (pH, 5.7). The amount of available phosphorus determined at constant amount of SRP (Table 4) showed that there was a sharp increase after 6 days of application of the materials with maximum P released after 9 days. Similarly, available P increased with time at constant amount of POME applied to the soil (Table 5). Maximum P amount was 107.85 mg/kg at 50g SRP applications. Furthermore, the amount of available phosphorus was more even after the 12 days when compared to results obtained at constant amount of SRP (Table 4). It seem to appear that increasing the amount of POME may not necessarily lead to significant availability of P when compared to its application at a constant rate.

The concentration of available P has been shown to increase with rate and time of applied POME significantly in soil (Lim, 1984), suggesting a high P sorption in the soil or a possible precipitation of phosphate. In a similar study (Isenmila et al., 2006), four fresh organic manures namely cow dug, goat manure, palm oil mill (POME) and poultry droppings were used to amend SRP to enhance P dissolution and nutrient availability. The report indicated that addition of the various organic amendments generally increased P by 22 to 579% and enhanced maize seeding height, leaf production in the two cropping except SRP + POME treatment. This findings is consistent with the rate of increase of available P in the present study

Conclusion

The present study has revealed further that amendment of soil with POME and SRP will enhance the availability of phosphorus in soil. However, further research work is required to establish the following; the type and mechanism of microorganism involved in the process, the specific rates of application of both SRP and POME that will ensure maximum P release and utilization by plants and the various soil sorption mechanisms associated with the release retention of P in soil treated with POME and SRP.

The abundance and ready availability of these materials for improved crop production cannot be over-emphasized.

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Table 1: Phosphorus composition of Sokoto Rock Phosphate material (Milled) P_2O_5 (%)

IM HCI	6M HCI	Perchloric acid	water
28.62	25.16	36.98	1.24

Table 2: Physicochemical composition of the POME

Ph	BOD (mg/1)	Cod(mg/1)	Mg(mg/1)	K (mg/1)	P(mg/1)	N (mg/1)
4.9	18,370	33,408	1.03	1,489.01	148.00	584.17

Table 3: selected Physicochemical Properties of the Soil

pH	C (%)	N (%)	P (mg/kg)	CEC (cmol/kg)	Sand (%)	Silt (%)	Clay (%)
5.7	2.13	0.19	18.59	16.50	90.64	4.34	5.02

Table 4: Concentration of available phosphorus (mg/kg) at constant amount of Sokoto Rock phosphate treatment

Treatment	Time (day)				
	3	6	9	12	15
T_1	18.59	20.51	19.26	11.31	7.18
T_2	19.35	96.11	97.42	15.69	13.38
T_3	22.17	80.30	81.38	16.22	5.57
T_4	6.17	98.35	101.97	54.88	9.24
T_5	15.51	100.12	103.66	16.22	4.59
T_6	20.61	101.51	102.18	18.90	23.50
I.S.D.	1.79	1.30	1.57	0.61	0.60
CV (%)	5.8	2.5	0.9	1.5	3.1

Table 5: Concentration of available phosphorus (mg/kg) at constant amount of POME treatment

Treatment	Time (day)				
	3	6	9	12	15
T_{21}	18.59	18.28	10.56	10.08	8.78
T_{22}	21.01	96.37	108.81	10.70	4.92
T_{23}	17.69	96.09	98.70	17.29	10.28
T_{24}	8.93	99.78	105.13	37.43	9.21
T_{25}	12.98	96.37	104.21	31.65	11.49
T_{26}	53.50	98.62	107.85	36.07	10.09
I.S.D.	1.61	0.65	1.26	1.76	0.96
CV (%)	4.0	0.4	0.7	4.1	5.8