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Instituto Superior de Agronomia
Universidade Técnica de Lisboa

Extractability of P in major soils of Angola as affected by P fertilizers and lime application

centro de estudos florestais

E. Auxtero[a], M. Madeira[a] and M. Horta[b]

[a]Centro de Estudos Florestais, Instituto Superior de Agronomia, Tapada da Ajuda, 1349-017 Lisboa, Portugal
e-mail: eauxtero@iol.pt
[b]Escola Superior Agrária, Quinta da Senhora de Mércoles, 6001-909 Castelo Branco, Portugal

INTRODUCTION

Phosphorus (P) deficiency is the major constraint to crop production in most tropical soils (Sahrawat et al., 2001). In Angola, such constraint (i.e, low concentration and low P solubility) has also been reported to limit crop production in many agricultural soils (Ucuassapi, 2006). These soils may require application of inorganic P through soluble and relatively reactive phosphate rock sources, and lime (Dobermann et al., 2002; Murphy, 2007). However, appropriate P management strategies may require information on the fate of applied P and its interaction with the colloidal constituents. Therefore, information on the different P fractions (inorganic and organic) after the application of different rates of P fertilizers and lime, as fractionated sequentially by the Hedley modified procedure (Tiessen and Moir, 1993) is crucial for making appropriate fertilizer and lime rate recommendations for crops (Islam et al., 2010).

OBJECTIVES

In order to obtain information on soil interactions with different rates of inorganic P fertilizers and lime application, and for deeper understanding on P extractability in Angolan soils, this study was conducted to: 1) determine the amount of different P forms applied with different rates of superphosphate and rock phosphate (Fertigafsa), and lime by sequential fractionation, and 2) evaluate the relationships between soil colloidal constituents and the contents of sequentially fractionated P.

MATERIALS AND METHODS

Surface (0-20 cm) and subsurface (20-50 cm) horizons of soils at Chianga Agricultural Experiment Station (about (2,550 ha) in the province of Huambo, situated at central plateau of Angola, which lies between 12º 14' and 12º 16‘ latitude and between 15º 48' and 15º 52' longitude (Fig. 1) were used. The main properties of the studied soils are shown in Fig. 2. Each soil was treated with two inorganic containing P fertilizers and lime at different rates, (Fig. 3) according to its P sorption maxima. The amounts of P were fractionated following the Hedley modified procedure (Tiessen and Moir, 1992) as shown in Fig. 4.

Fig. 1- Location of the study area

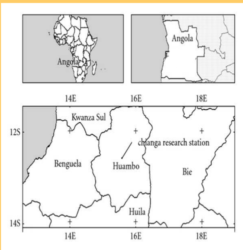
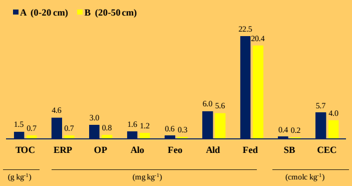


Fig. 2- Selected properties of studied soils.



The surface horizon contains higher amounts of total organic C (TOC), extractable P by Egner Riéhm (ERP) and Olsen (OP), extractable iron and Al by ammonium oxalate (Feo, Alo) and by citrate-dithionite (Fed, Ald), and higher values of cation exchange capacity (CEC) and sum of bases (SB) than the subsurface horizon. Both horizons have high values of Fed/Feo ratio and Fed-Feo, suggesting high contents of crystalline form of Fe.

Fig. 3- Soil samples and treatments

200 g air dried soils (< 2 mm) from surface (0-20 cm) and subsurface (20-50 cm) horizons were placed in plastic bag

⇩

Superphosphate (18% P_2O_5) and finely ground (< 150 μM) rock phosphate (fertigafsi) (26.5% P2O_5) were applied at the rates of 0, 125, 250, 375 and 500 mg P kg^{-1}. Another set were also added with lime at the rates of 0, 1.2, 2.4 and 3.6 t $CaCO_3$ ha^{-1}

⇩

Treatments were arranged in Randomized Complete Block Design with two replicates

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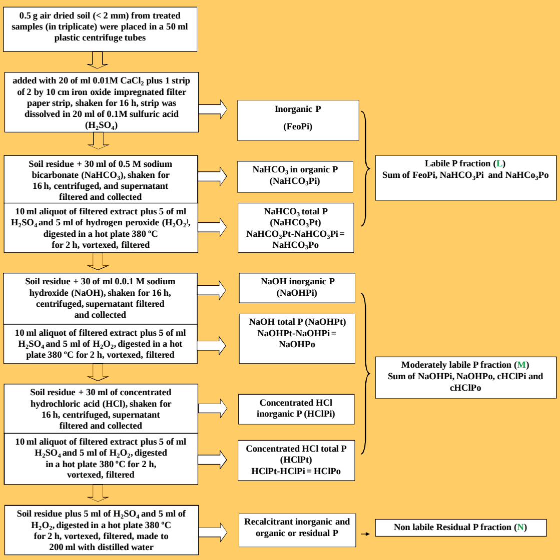
Treated soils were incubated at 25ºC at laboratory room conditions for 6 months and maintained at 80% water holding capacity

Fig. 4- Determination of P Fractions

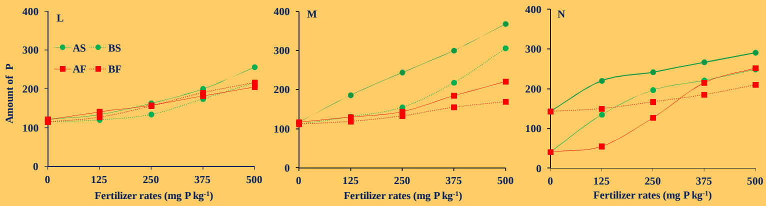


P in filtered extracts (Whatman # 5) from each sequence was determined by molybdenum blue method (Murphy and Riley, 1962), using spectrophotometer at 882 nm.

The first author gratefully acknowledged the financial assistance of the *Fundação para a Ciência e Tecnologia*, for the conduct of this research.

RESULTS AND DISCUSSION

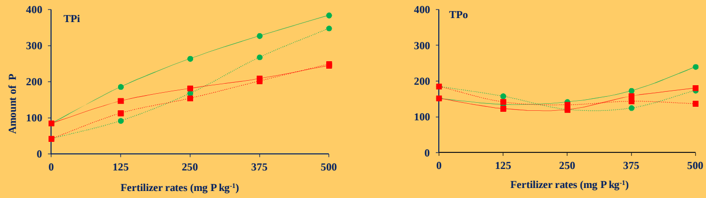
Effects of superphosphate (S) and fertigafsa (F) application on the amounts of labile (L), moderately labile (M), non labile (N), total inorganic (TPi) and total organic (TPo) P fractions (mg kg^{-1}), in the surface (A, 0-20 cm) and subsurface (B, 20-50 cm) horizons.



- Addition of 375 and 500 mg kg^{-1} superphosphate and fertigafsa fertilizers doubled the amounts of labile P fraction in the surface and subsurface horizons;

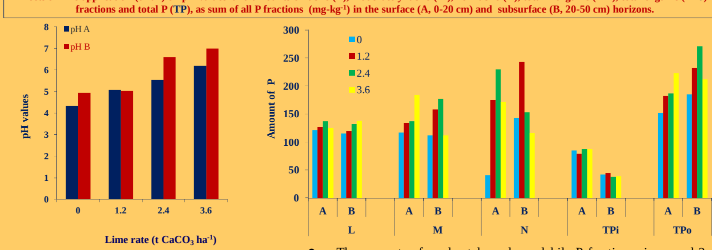
- Addition of 125 to 500 mg kg^{-1} of superphosphate increased the amounts of moderately labile P fraction 2 to 3 times in the surface horizon, while this fraction were 2 to 3 times higher in the subsurface horizon with the addition of 375 to 500 mg kg^{-1}. With the addition of 375 to 500 mg kg^{-1} fertigafsa this fraction increased 2 to 3 times in the surface horizon, and only doubled with the addition of 500 mg kg^{-1} in the subsurface horizon;

- Addition of 500 mg kg^{-1} superphosphate and fertigafsa increased the amounts of non labile P fraction 6 times in the surface horizon. This fraction only doubled in the subsurface horizon with the application of 500 mg kg^{-1} superphosphate.



- Addition of 125 to 500 mg kg^{-1} superphosphate increased the amount of total inorganic P (TPi) fraction 2 to 5 times in the surface and 2 to 8 times in the subsurface horizons. With the addition of 125 to 500 mg kg^{-1} fertigafsa, this fraction increased 2 to 3 and 3 to 6 times in the surface and subsurface horizons, respectively;
- The amount of total organic P (TPo) fraction doubled only in the surface horizon with the addition of 500 mg kg^{-1} superphosphate.

Effects of lime application (t ha^{-1}) on pH values and amounts of labile (L), moderately labile (M), non labile (N), total inorganic (TPi), total organic (TPo) P fractions and total P (TP), as sum of all P fractions (mg-kg^{-1}) in the surface (A, 0-20 cm) and subsurface (B, 20-50 cm) horizons.



- The pH of unlimed surface and subsurface soil horizons were 4.33 and 4.95, respectively. Application of the highest rate of lime (3.6 t ha^{-1}), raised soil pH to 6.2 and 7.0, respectively.
- The amounts of moderately and non labile P fractions increased 2 and 4 times, respectively with the addition of 3.6 t $CaCO_3$ ha^{-1} in the surface horizons. However, these differences, including those of all other fractions with the addition of different rates of lime were not significant, indicating that the addition of lime did not increase extractability of P in Angolan soils.

Correlation coefficient (*r*) between P fractions and soil colloidal constituents and values of sum of bases (SB) (**, *** $p < 0.01$ and 0.001, respectively; ns, not significant) in fertilized soil horizons

P fractions	(r, p)				
	Alo	Ca^{2+}	Mg^{2+}	Na^+	SB
All horizons					
Superphosphate					
Labile	0.53**	0.90***	0.92***	0.82***	0.92***
Moderately labile	0.54**	0.86***	0.90***	0.74***	0.87***
Non labile	ns	0.73***	0.56**	0.70***	0.73***
TPi	0.48**	0.92***	0.95***	0.84***	0.90***
TPo	ns	ns	ns	ns	Ns
Fertigafsa					
Labile	ns	ns	0.60***	0.79***	0.80***
Moderately labile	ns	ns	0.73***	0.73***	0.48**
Non labile	ns	ns	0.63***	0.76***	0.65***
TPi	ns	ns	0.78***	0.69***	0.88***
TPo	ns	ns	ns	ns	Ns

P fractions	(r,p)		
	TOC	Feo	Alo
All horizons			
Lime			
TPi	0.75***	0.76***	0.54**

- Except total inorganic P fraction (TPi), the amounts of all other P fractions in superphosphate fertilized soil were positively correlated with the content of Alo, Ca^{2+}, Mg^{2+} and Na^+ ions, and values of the sum of bases. In soils fertilized with fertigafsa, these amounts were only correlated with Mg^{2+} and Na^+ ions, and values of the sum of bases.
- In lime applied soils, only the total inorganic P fraction (TPi) showed positive correlation with total organic C (TOC), Alo and Feo contents.

CONCLUSIONS

- The addition of superphosphate and rock phosphate (fertigafsa) at the rates of 125 to 250 mg kg^{-1} increased the amounts labile P within the threshold limit for P extractability tests.
- Addition of different rates of lime did not increase extractability of all P fractions, but addition of 3.6 t lime ha^{-1} was effective to raise soil pH of the surface (4.3) and subsurface (4.9) horizons to 6.2 and 7.0, respectively.
- Basic cations (Ca^{2+}, Mg^{2+} and Na^+), and active noncrystalline (amorphous or poorly crystalline inorganic and organically bound forms of aluminium (Alo) played the major role on the extractability of all P fractions in fertilized Angolan soils.
- Addition of superphosphate and fertigafsa fertilizers increased all soil P fractions, especially the labile P status. However, their effects in combination with lime on uptake of P by plants need to be addressed further.

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