Soil Phosphorus Availability in Manganese-rich Waste Amended soil

Mohammed Abdalla Elsheikh[1,3], Khatab Abdalla[2,3], Louis Titshall[3], Pardon Muchaonyerwa[3]

[1] Soil and Environmental Science ,University of Khartoum, Sudan, [2] University of Bayreuth, Germany, [3] Soil Science, University of KwaZulu-Natal, South Africa

Introduction

Mining, processing and smelting activities could pollute soil and groundwater resources with heavy metals, which could seriously affect the environment and ecosystems functioning. Land application of industrial and mining waste could increase supply and availability of essential nutrients for plant growth; however, it is negative consequences on plant growth, through the toxicity of pollutant elements is well-known. In this regard, the interactions of the constituent elements in the soil with applied nutrients could reduce the effectiveness of fertilizers. Understanding the behavior of phosphate in manganese (Mn)-rich wastes amended soils, will be a key for sustainable phosphorus management in the soils, e.g. optimization of phosphorus fertilizers input for crop production on Mn waste treated soils. Therefore, the objective of this study was to determine the effects of phosphorus sources (i.e. phosphate rock and KH_2PO_4) and application rate on phosphorus and Mn relationship in a soil amended with Mn-rich waste.

Materials and Methods

A- Materials.

A-1. Electro-winning waste

Electro-winning waste used in this study was obtained from a Mn Mining Company near, Mpumalanga, South Africa. The chemical composition is as follows; pH= 6.89; EC in mSm^{-1} 1735; Total N (g kg^{-1}), 9.25; AMBICP (mg kg^{-1}) = 1.22; CEC (cmolc kg^{-1}) = 9.50; (EDTA)-extractable in (g kg^{-1}) Mn= 5.71; Co= 0.07; Cu=0.02; Pb= 0.014; Ni= 0.006

A-2. Soils

The detailed characteristics of the Hutton and Cartref soil and are on Table 1.

A-3. Phosphorus sources

Two sources of phosphate (phosphate rock and KH_2PO_4). The phosphate rock used in this study was from Langebaan in South Africa and the chemical composition percentage is as follows; Total P = 10.0; Ca = 20.1; Mg = 1.30; Fe = 3.0 ; Mn = 9.0.

B- Incubation experiment.

- The waste was added at 40 g kg^{-1} soil , which was found suitable for growing crops. The P was added as KH_2PO_4 at four rates (0; control, 1P; recommended dose, 2P; double recommended dose and, 3P; threefold recommended dose.
- The treatments were replicated three times. The mixtures were adjusted to field capacity moisture content and incubated at 20 °C for up to 60 days, with sampling after 0, 30 and 60 days of incubation.
- Plant available P was extracted with AMBIC solution (0.25 mol L^{-1} ammonium bicarbonate, pH 8.3), and measured calorimetrically using a spectrometer.

Table 1: Basic chemical characteristics Huton and Cartref soils.

Parameters	abbr.	Huton	Cartref
pH (H_2O , 1:5)	pH	5.34	5.17
Organic carbon (g C $100m^{-l}$)	OC	3.44	3.44
AMBIC P (mg kg^{-1})	P	1.22	0.72
Extractable base cations (cmolc kg^{-1})	Mg	3.04	0.35
	Na	6.63	0.12
	Ca	6.63	1.28
	K	0.47.	0.38
Cation exchange capacity (cmolc kg^{-l})	CEC	12.7	6.10
Particle size distribution (%)	Clay	54.0	19
	Silt	34.3	13
	sand	11.7	68

Results and Discussion

Results

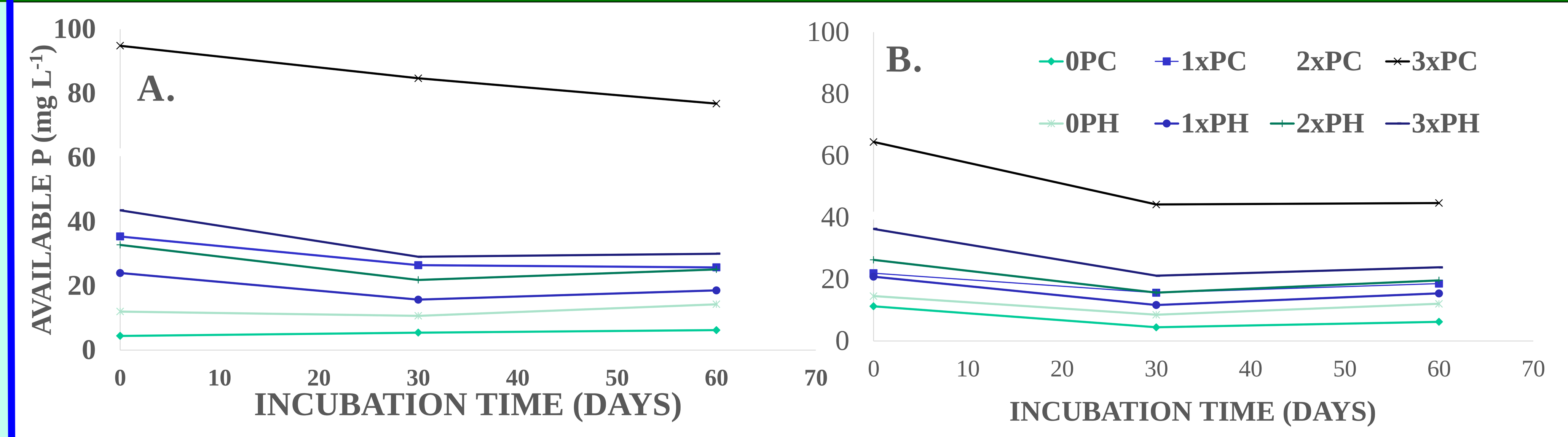

Fig. 1: Available phosphorus in soils incubated with KH_2PO_4 at increasing P (a) without wastes and (b) with wastes. Where C = Cartref , H= Huton soil, W= Mn-rich waste, 0 = No P (control), 1P= recommended P +KH_2PO_4. 2P= 2x P+ KH_2PO_4; 3P= 3x P +KH_2PO_4. 1R= P + phosphate rock; 2R= 2x P +phosphate rock; 3R= 3x P + phosphate rock.

- Fig. 1 A and B shows the results for the effect of the addition of KH_2PO_4 at a different rate in sand and clay soils with and without manganese-rich wastes on ASP.]
- The concentration of ASP was significantly increased by increasing rate of KH_2PO_4 application and were decreased after application of Mn-rich waste with irrespective of soils types.
- Fig. 1 also shows that the amount of ASP in sandy soil is higher than clayey soil.

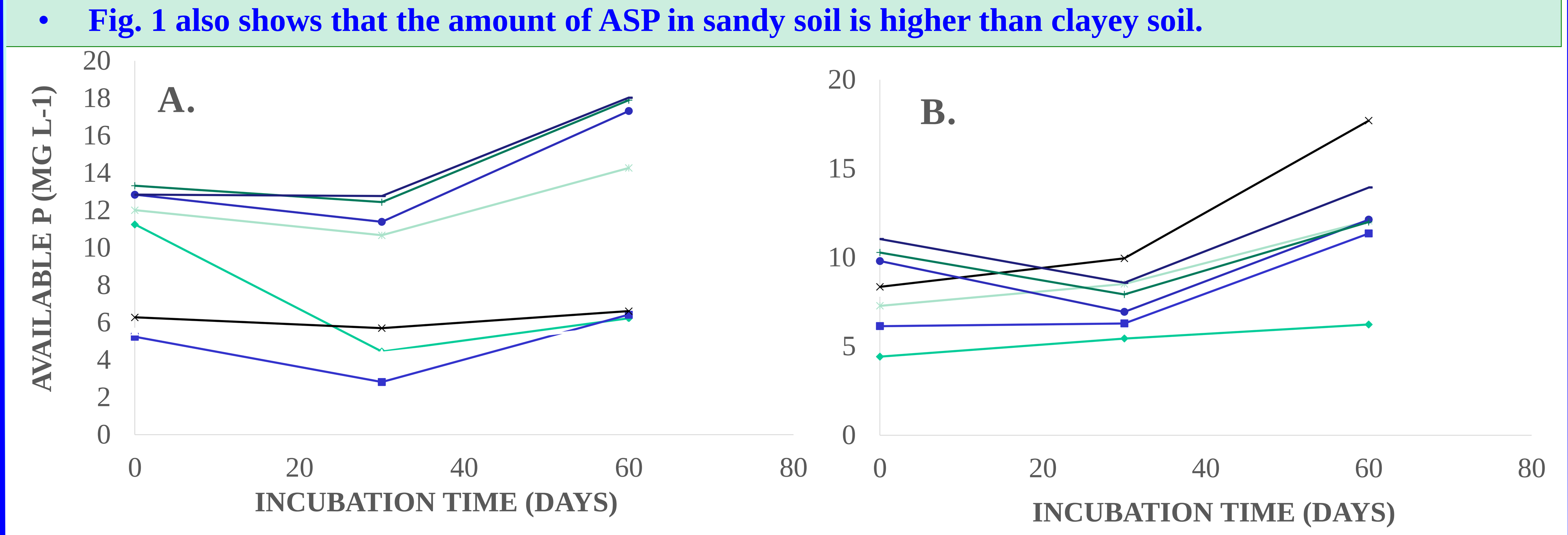

Fig. 2: Available phosphorus in soils incubated with phosphate rock at increasing P (a) without wastes and (b) with wastes .

- Fig. 2 a and b shows the results for the effect of the addition of phosphate rock at a different rate in sand and clay soils with and without manganese-rich wastes on available soil P (ASP).
- The addition of phosphate rock increased the amounts of ASP in in sand and clay soils with and without manganese-rich wastes, the increasing were significantly for all cases.
- However, the increasing rate varied depending on phosphate rock amount, Mn- rich waste application, type of soils and incubation time.

Discussion

- The P concentrations was decreased after application of Mn-rich waste, maybe due to precipitate in solution in the presence of Mn. Phosphorus concentration in sand soil was higher than clay soil, thus could be due high surface area in the clay soil compared to the sandy soil.
- Thus, the clay has more sorption site react with P, consequently, more P adsorption, and less P release. Comparing between two P sources, the addition of phosphate rock gave the lower amount of P compare to KH_2PO_4.
- Phosphate rock was characterized by low solubility and take much time to dissolute as P element into the soil.

Conclusion

- Mn-rich waste caused a reduction in the amount of P. Therefore, more P than the recommended dose is needed, when crops are grown Mn-rich waste amended soil.
- The phosphate rock as a source of P has more benefit than readily available in terms of applying of Mn-rich waste as due to its low availability over a longer time.
- Further research is needed to mitigate Mn-rich waste, causing a reduction in the amount of available soil phosphorus such as phytoremediation technique.