Available phosphorus extracted by Ion exchange resin and Pi strips in Brazilian tropical soils treated with phosphogypsum

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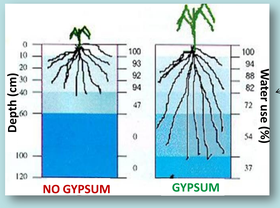
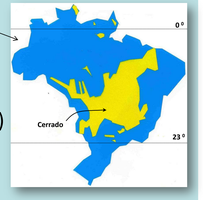
INTRODUCTION



Most Brazilian soils present generalized deficiency of nutrients. In these conditions the use of gypsum ($CaSO_4.2H_2O$) can be a valuable tool in order to minimize some soil fertility problems.



Al-Merey et al. (2004) showed problems in Olsen (0.5 M $NaHCO_3$) and resin (HCO_3^-) methods to extract available P due to the high content of natural gypsum (Gypsiferous Soil – Alkaline).

They hypothesized that the HCO_3^- may have reacted with $CaSO_4$ to form $CaCO_3$, which may adsorb and/or precipitate extractable P in soil solution.

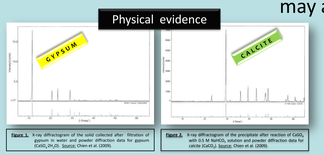
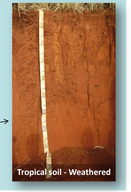


Figure 1. X-ray diffractogram of the solid collected after filtration of gypsum in water and powder diffraction data for gypsum ($CaSO_4.2H_2O$). Source: Chien et al. (2008)

Figure 2. X-ray diffractogram of the precipitate after reaction of $CaSO_4$ with 0.5 M $NaHCO_3$ solution and powder diffraction data for calcite ($CaCO_3$). Source: Chien et al. (2008)

However, **there is no information** on possible similar interaction **in tropical acid soils,** where gypsum is often applied to improve the subsoil for plant growth.



MATERIAL AND METHODS

Five soil samples (40g) were treated with phosphogypsum (PG) up to 75 g kg^{-1}. These samples also received 100 mg kg^{-1} of P as triple superphosphate (TSP) or Arad phosphate rock (PR). The soil samples were incubated for 25 days. After, available P was measured.

Soil	pH	K⁺	Ca²⁺	Mg²⁺	Na⁺	CEC	BS	S	Available P		$CaCO_3$	Sand	Silt	Clay
									Resin	Pi-Paper				
	$CaCl_2$	mmol$_c$ dm^{-3}					%		mg dm^{-3}		g kg^{-1}	%		
[A] – Oxisol	5.9	1.2	24	13	*	51.2	75	12	11	8	0,85	760	60	180
[B] – Ultisol	6.3	5.0	58	15	*	98.0	80	15	12	5	1.49	360	80	560
[C] – Quartzipsamment	4.3	0.4	5	1	*	34.4	19	11	13	8	*	920	20	60
[D] – Vertisol	7.3	3.3	190	40	3	244.3	97	10	23	6	4.92	470	130	400
[E] – Entisol	6.7	4.2	44	23	12	92.2	89	194	16	14	0.50	570	250	180

RESIN (Raij et al., 1986)

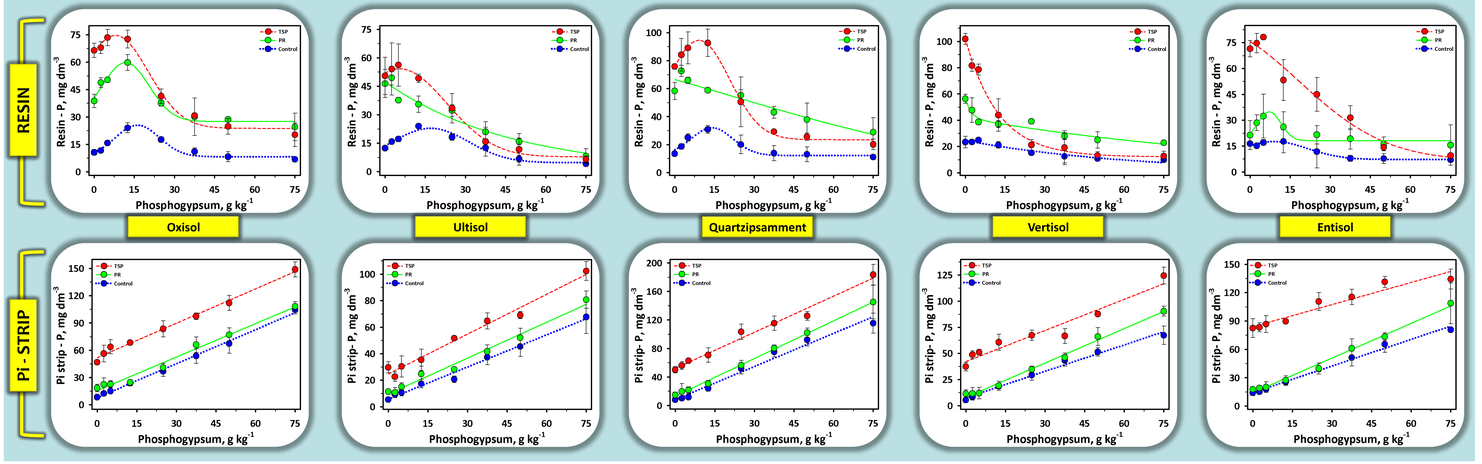
A 2.5-g soil sample was shaken with resin-2.5 cm^3 in 25 mL of deionized water for 16 h followed by shaking with 50 mL of 0.8M NH_4Cl + 0.2M HCl for 1.0h to desorb P.

Pi-PAPER (Menon et al., 1989, modified by Habib et al., 1998)

A 1.0-g soil sample was shaken with one Pi strip (2x10 cm) in 40 mL of 0.2M KCl for 16 h and the Pi-P was then recovered by shaking with 40 mL of 0.1M H_2SO_4 for 1.0h.

Concentration [P] = Ammonium molybdate-ascorbic acid method.

RESULTS AND DISCUSSION



Extractable P by Pi strips increased linearly with PG rates due to the presence of 0.3% P in the composition of the PG. Pi-P of the PR treatment was found to be as low as Pi-P of control due the *"Ca common-ion-effect"* from $CaSO_4$ in the dissolution of the Apatite.

The results of Resin-P show a sharp contrast to Pi-P, explained by the following reaction:

$$CaSO_4.2H_2O + Resin\text{-}2(HCO_3) \rightarrow Resin\text{-}SO_4 + CaCO_3\downarrow + CO_2\uparrow + 3\ H_2O$$

The reaction may bring out two negative effects on resin-P due to:

(1) Weakened strength of resin-HCO_3 to extract P;

(2) Formation of $CaCO_3$ that may adsorb and/or precipitate extractable P in soil solution.

Although the rates of gypsum normally used do not exceed 10 Mg ha^{-1}, some studies showed that the rates could be as high as 20 Mg ha^{-1} (Chhabra et al., 1981), 35 Mg ha^{-1} (Toma et al., 1999), and even 100 Mg ha^{-1} (Mays & Mordvelt, 1986). In addition, some Brazilians farmers are using high rates of natural gypsum or phosphogypsum (60 Mg ha^{-1}). Technique called ***"White Irrigation"***.

In these cases the use of resin-HCO_3 method to evaluate P availability may be **considerably underestimated** when the soil samples are enriched with gypsum, and thus may overestimate the rates of P fertilizer recommended.

ACKNOWLEDGMENTS

FAPESP

Gratitude is expressed to FAPESP (Foundation for Supporting Research in the State of Sao Paulo, Brazil) for the research scholarship and financial support that made this study possible.

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REFERENCES

AL-MEREY, R.; AL-HAMEEDI, M.; CHIEN, S.H.; ASFARY, A.F. P-paper: as an evaluation method of available phosphorus in gypsum-calcareous soils. **Communications in Soil Science and Plant Analysis**, v. 35, n. 5/10, p. 1357-1367, 2004.

CHHABRA, R.; ABROL, I.P.; SINGH, M.V. Dynamics of phosphorus during reclamation of sodic soils. **Soil Science**, v. 132, n. 5, p. 319-324, 1981.

CHIEN, S.H.; HUNTER, F.R.; CALVO, C.G. Under-estimation of available phosphorus by Resin-HCO_3 and Olsen tests in calcareous soil treated with gypsum. **Communications in Soil Science and Plant Analysis**, v. 40, n. 11, p. 1924-1936, 2009.

HABIB, L.; CHIEN, S. H.; MENON, R.G.; CAMARDELLA, G. Modified iron oxide-impregnated paper strip test for soils treated with phosphate fertilizers. **Soil Science Society of America Journal**, v. 62, n. 4, p.972-976, 1998.

MAYS, D.A.; MORDVELT, J.J. Crop response to soil applications of phosphogypsum. **Journal of Environment Quality**, v. 15, p.78-81, 1986.

MENON, R.G.; CHIEN, S.H.; YAMAMORO, L.L. **The P soil phosphorus test: a new approach to testing for soil phosphorus.** Muscle Shoals: International Fertilizer Development Center. 33p., 1989a. 10p.

RAIJ, B. van; QUAGGIO, J. A.; SILVA, N. M. Extraction of phosphorus, potassium, calcium and magnesium from soils by an ion-exchange resin procedure. **Communications in Soil Science and Plant Analysis**, v. 17, n. 5, p. 547-566, 1986.

TOMA, M.; SUMNER, M.E.; WEISS, G.; SAIGUSA, M. Long-term effects of gypsum on crop yield and subsoil chemical properties. **Soil Science Society of America Journal**, v. 63, n. 4, p.891- 895, 1999.