Depletion of Rhizosphere Solution Phosphorus by Corn and Soybean Grown in Soil with a P-solubilizing Copolymer

Renan Costa Beber Vieira[1], John L. Kovar[2*], and Cimélio Bayer[1]

[1]Federal University of Rio Grande do Sul
Soils Department
Porto Alegre, RS 91540-000 Brazil

[2]USDA-Agricultural Research Service
National Laboratory for Agriculture
and the Environment
Ames, Iowa 50011 USA

Background

- Interest in reducing soil phosphorus (P) fixation to enhance P availability for crop plants has led to the development of commercial products intended to maintain P solubility.
- A family of patented dicarboxylic copolymers, which can be used as a coating on granular P fertilizers or mixed into liquid P fertilizers, is thought to complex P-sequestering cations, thus enhancing P availability and allowing more P to be taken up and used by plants.
- Evaluation of P concentration in the rhizosphere solution of crop plants could help in understanding the effects on P availability when copolymer-amended fertilizer is applied to soil.

Objective

The objective of this controlled-climate study was to evaluate the ability of a commercial maleic-itaconic copolymer (marketed as AVAIL®) to maintain a greater pool of plant-available P in rhizosphere solution for uptake by juvenile corn (*Zea mays* L.) and soybean (*Glycine max* L. Merr.).

Methodology

- Three diverse soils (Table 1), classified as Nora-Moody silty clay loam (fine-silty, mixed, superactive, mesic Udic Haplustoll), Muscatine silt loam (fine-silty, mixed, superactive, mesic Aquic Hapludolls), and an Oxisol from southern Brazil, were used in this study.
- Treatments included a control with no P, 50 kg P_2O_5 ha^{-1}, and 50 kg P_2O_5 ha^{-1} + 0.5% maleic-itaconic copolymer.
- P source was ammonium polyphosphate liquid (10-17-0; N-P-K).

Table 1. Selected initial soil chemical properties. Mehlich-3 extraction.

Soil	pH_w	Available P	Exch. K	Exch. Ca	Exch. Mg
		------------------------- mg kg^{-1} -------------------------			
Nora-Moody sicl	7.2	15	231	2864	818
Muscatine sil	6.0	60	228	3532	598
Oxisol	5.2	8	95	856	151

- Following a 2-wk incubation, soil treatments were placed in two-chamber mini-rhizotrons (Fig. 1).
- Corn seedlings were transplanted into the rhizotrons at the two-leaf stage, and grown 10 d; soybean seeds were sown directly into the rhizotrons, and grown for 12 d.
- Soil water content was maintained at –33kPa via an irrigation system.

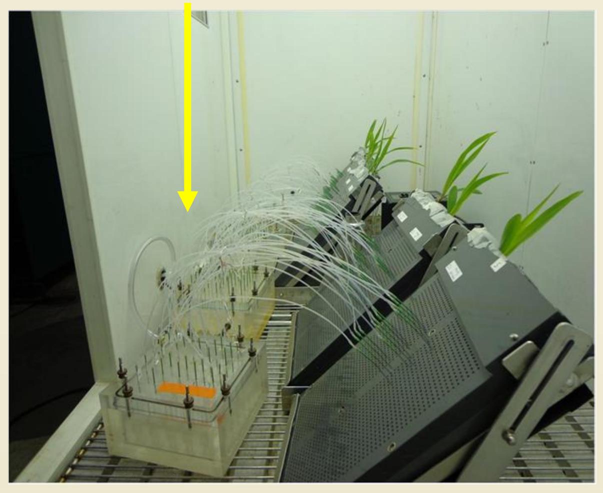

Fig. 1. Corn seedlings in mini-rhizotrons with micro-capillaries and sample collection system.

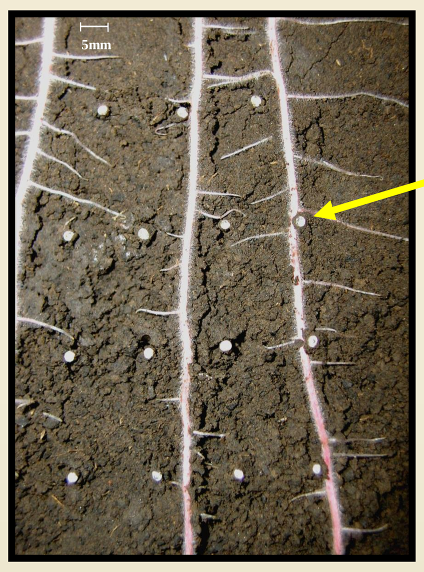

Fig. 2. Placement of micro-capillaries, relative to roots.

- Micro-capillaries (Fig. 2) are ceramic P80 material, maximum pore size 1 µm, in 0.75-mm diameter PEEK tubing; continuous vacuum at -80 kPa.
- Controlled-climate chamber was maintained at 80% R.H., with 14-h daylight, and temperature of 25/20°C day/night.
- Solution P was measured colorimetrically with plate reader.
- Design was a randomized complete block with three replications – One-way ANOVA to test the effects of soil, amendment, and distance from root (<1 mm, 1-8 mm, >8 mm).

Main Points

- P concentrations in rhizosphere solution did not differ with distance from the root surface for either plant species, but were significantly higher in two of the P-amended soils (Nora-Moody and Muscatine), with or without the copolymer (data not shown).
- In the low-P Nora-Moody sicl, P concentrations in solution at the root surface of both species were higher when the copolymer was added to the P fertilizer (Fig. 3).
- Corn shoot and root dry matter production were not affected by P fertilizer applied to any of the soils; soybean root dry matter production increased when P fertilizer was applied to an Oxisol (Table 2).
- Corn and soybean shoot P concentrations did not differ among treatments (Table 2).
- Results are not definitive, but suggest that addition of the copolymer to P fertilizer may affect P solubility in some soils.

Results

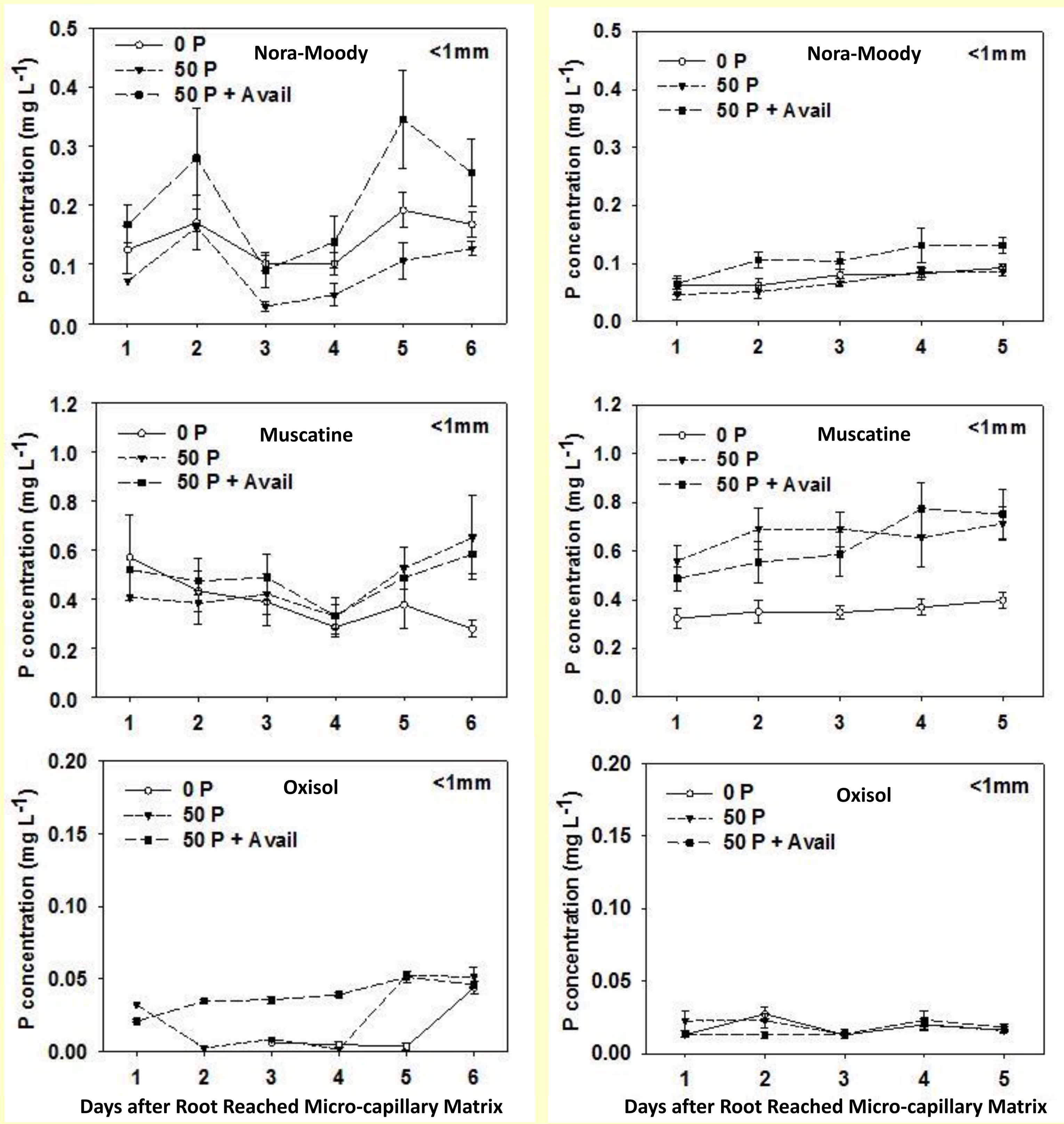

Fig. 3. Time course of P concentration in rhizosphere solution at the root surface for corn (left column) and soybean (right column) plants grown in three soils without P fertilizer or amended with P both with and without a maleic-itaconic copolymer. Individual points in each figure are means of all sampling points within this distance class on that day.

Table 2. Shoot dry matter, root surface area, and shoot P concentration of corn and soybean plants grown in three soils without P fertilizer or amended with P both with and without a maleic-itaconic copolymer.

		Corn			Soybean		
Soil	Treatment	Shoot DM	Root Surf. Area	Shoot P	Shoot DM	Root Surf. Area	Shoot P
	kg P_2O_5 ha^{-1}	g $plant^{-1}$	cm^2	g kg^{-1}	g $plant^{-1}$	cm^2	g kg^{-1}
Nora-Moody sicl	0	0.26a†	215a	1.7a	0.44a	53a	3.0a
Nora-Moody sicl	50	0.25a	210a	1.9a	0.42a	50a	3.2a
Nora-Moody sicl	50 + copolymer	0.27a	222a	1.9a	0.46a	59a	3.2a
Muscatine sil	0	0.34a	229a	3.4a	0.43a	49a	3.9a
Muscatine sil	50	0.28a	173a	3.4a	0.42a	48a	3.9a
Muscatine sil	50 + copolymer	0.42a	252a	3.2a	0.44a	49a	4.6a
Oxisol	0	0.23a	217a	1.7a	0.39b	46b	3.9a
Oxisol	50	0.17a	197a	1.5a	0.47a	63a	2.7b
Oxisol	50 + copolymer	0.17a	177a	1.7a	0.43ab	53ab	3.0b

†Within each soil type, values in a column followed by the same letter are not significantly different (Tukey; P≤0.05).

Acknowledgement

The authors gratefully acknowledge the Brazilian National Council of Technological and Scientific Development (CNPq) for providing a Fellowship to R. Vieira. The authors also thank T. Tindall and G. Mooso of J.R. Simplot Co. for providing the fertilizer and copolymer materials.