Root and rhizospheric phosphatase activity of grassland Poaceae grown under contrasted water and phosphorus supplies

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Comparing to the above ground, a few below ground traits are available for a functional characterization of plants. This gap is quite obvious when considering plant functioning for mineral resource acquisition, specially for phosphorus. We hypothesize that a better understanding of relationships between plants functional traits and phosphatase activity (PA) may allowed to build more consistent plant functional types regarding to the phosphorus nutrition.

Objectives

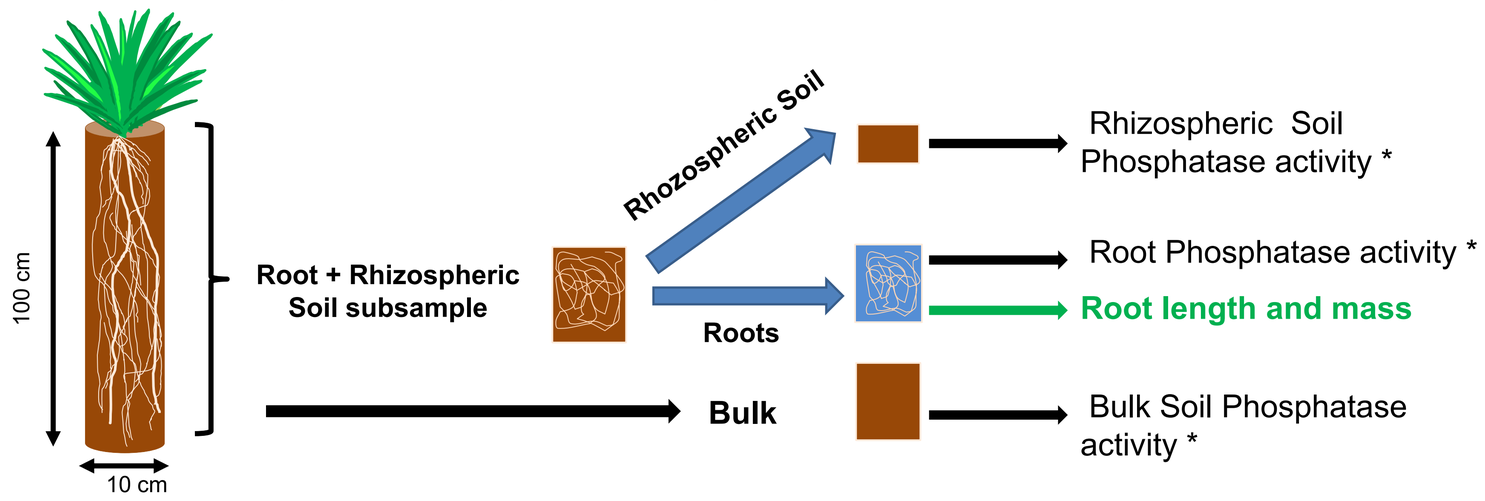
In this work we propose an evaluation of the potential of root PA and rhizospheric PA as a functional trait to indentify plants P limitation and distinguish between acquisitive and conservation species.

Materials & Methods

Experimental design:

Functional Group	Species	Substrate	Water	Phosphorus	Applied treatments
Conservative	*Bromus erectus* Huds.	Sand 65% Silt 19% Clay 16%	W1 = non limited water supply / W0 = 1/3 W1	P1 = non limited phosphorus / P0 = limited phosphorus	W1 & P0
	Lolium arundinaceum (Schreb.) Darbysh.				W1 & P1
Acquisitive	*Dactylis glomerata* L.				W0 & P0
	Holcus lanatus L.				W0 & P1

→ 16 plants (10 repeats by treatments) + 12 bulk = 172 pots



* Alkaline phosphomonoesterase activity was measured as described by Johnson *et al.* 1999.

In order to compare the phosphorus stress levels among species and between growth strategies we calculated an index of stress intensity (derivate from Callaway *et al.* 2002) :

$$Phosphorus\ Stress\ Intensity\ Index = \frac{Mean\ (Biomass\ \ in\ P1) - \ Biomass\ in\ P0}{Max(Mean(Biomass\ in\ P1), Biomass\ in\ P0)}$$

Results & Discussion

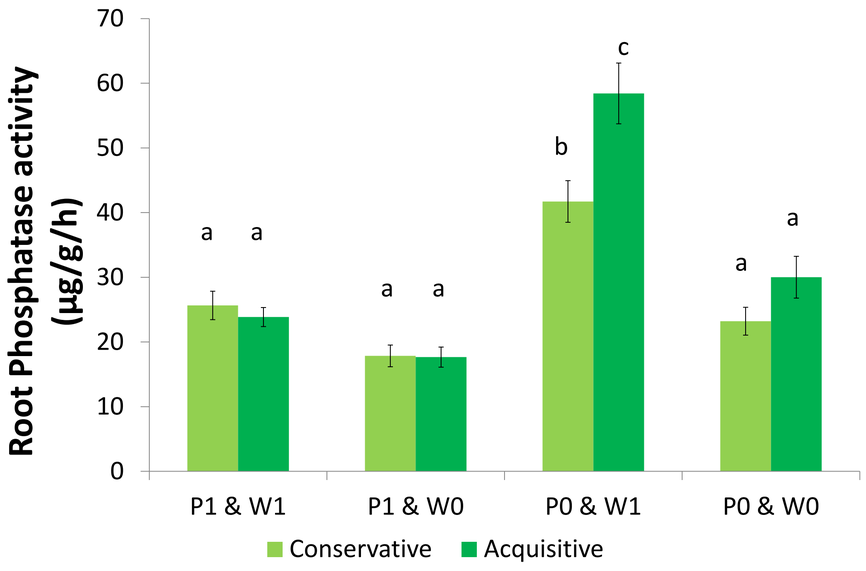


Figure 2: Root phosphatase activity (mean ± se) for crossed phosphorus treatment, water treatment and plant strategy. Different letters highlight significant difference (ANOVA, p<0.05).

We observe a positive and significant effect of the lack of P supply and a positive effect of the water supply on root PA (ANOVA p<0.001).
Acquisitive species have higher root PA than conservative ones in case of P starvation (ANOVA, p<0.001).
Moreover this difference is higher in the case of non limited water supply, when the plants demand of phosphorus for growth is higher.

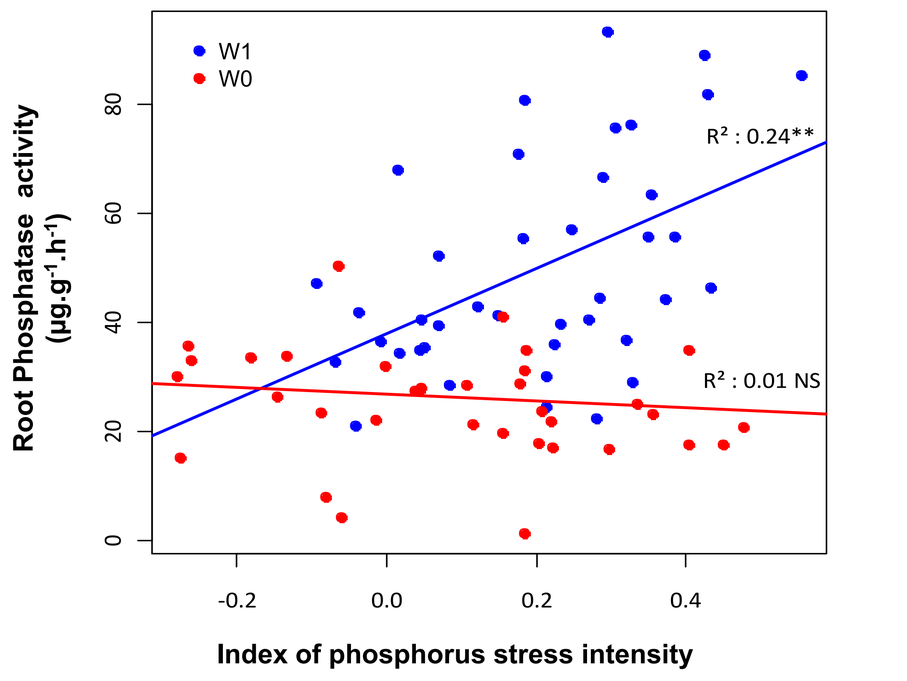


Figure 1: Root phosphatase activity (µg.g^{-1}.h^{-1}) against the Index of phosphorus stress with water treatment used as a covariate.

When water does not limit the plants growth the root PA increases significantly with the phosphorus stress level (ANCOVA, Fig. 1). However under limited water supply there is not relationship between the phosphorus stress index and the root PA..

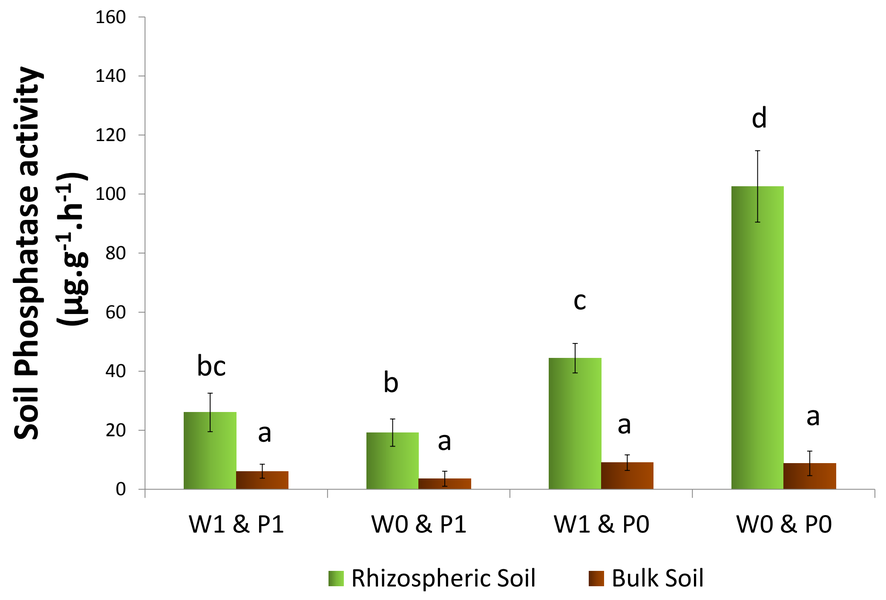


Figure 3: Rhizospheric and Bulk soil phosphatase activity (mean ± se, µg.g^{-1}.h^{-1}) for crossed water and phosphorus treatments. Different letters highlight significant difference (ANOVA, p<0.05).

For all treatments PA measured on the rhizospheric soil is significantly higher than the one which is measured for the bulk soil (Fig. 3), revealing a significant positive impact of the root proximity on the soil PA.
The rhizospheric soil PA is significantly improved by phosphorus starvation and also by water limited supply in case of phosphorus starvation (Fig. 3).

Conclusion

Phosphatase activity measured on root and rhizospheric soil is associated to the level of plant phosphorus stress and is also very sensitive to the water supply level. These traits allowed the species separation between capture & conservation strategy, but only in phosphorus stressful conditions.

Références :

Johnson D, Leake JR, Lee JA (1999) The effects of quantity and duration of simulated pollutant nitrogen deposition on root surface phosphatase activities in calcareous and acid grasslands: a bioassay approach. New Phytol 141:433–442.
Callaway RM, Pennings SC, Richards CL (2003) Phenotypic plasticity and interactions among plants. Ecology 84(5) 1115-1128