Seasonal effects of drought on plant and microbial phosphorus concentration

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Introduction

Drought events are predicted to increase in frequency and magnitude, especially during summer.

Water restriction can affect phosphorus (P) cycle. Drought diminishes P uptake by the plants and P supply in soil, through slower mineralization and reduced nutrient diffusion. Water shortage may further modify plant-microbes relationships.

In this experiment, we focused on the P turnover of two grasslands submitted to drought simulations. In particular, we examined the seasonal influence of drought stress on plant and microbial P.

Experimental Design

We set up a precipitation manipulation experiment (*Fig. 1*) on two permanent meadows in the Jura mountains. The two sites were characterized by similar vegetation, but soils had different P availabilities.

Two factors were tested:
- Watering treatment (control *vs* drought); and
- Period of stress: early (spring) *vs* late (summer).

During the period of stress (8 weeks), drought plots received 30% of the 30-year precipitation average, whereas control plots were watered 100%. The rest of the time, plots were watered according to the average rainfall. Forage and soil samples were analyzed in regard of soil P (Olsen), plant P and microbial P.

Main results

1. Soil extractable P showed great differences between the two sites. The period (season) and the drought treatment also influenced the available P (Tables 1 and 2).
2. Plant P was influenced by the site: P concentrations at site 1 were higher than at site 2 (on average 3.0 and 2.4 $g \cdot kg^{-1}$ DM, respectively; Table 1). Regardless of the site, the drought treatment induced a decrease in the plant P concentrations, which was more pronounced during the late time period (interaction period × drought; Table 2).
3. Similarly to the other tested parameters, microbial P was strongly site-dependent (Table 1). The period (season) had a strong influence on this parameter. The influence of drought was important, but less than the season.

Table 1. Concentrations of phosphorus: mean values ± standard error (n=3). Soil extractable P ($mg \cdot kg^{-1}$), plant P (g/kg DM) and microbial P ($mg \cdot kg^{-1}$ soil).

Site	Period (season)	Drought treatment	Soil P (Olsen)	Plant P	Microbial P
Site 1	Early[1]	Control	64.1 (3.5)	3.1 (0.1)	55.2 (7.3)
		Drought	56.7 (2.9)	2.9 (0.0)	53.1 (9.6)
(P-rich)	Late[2]	Control	40.2 (2.6)	3.5 (0.2)	31.6 (5.7)
		Drought	32.5 (2.1)	2.7 (0.1)	19.7 (5.7)
Site 2	Early	Control	10.0 (1.0)	2.6 (0.2)	39.9 (2.1)
		Drought	8.3 (0.9)	2.5 (0.1)	26.1 (2.1)
(P-poor)	Late	Control	10.6 (1.3)	2.4 (0.2)	22.3 (1.3)
		Drought	7.3 (1.2)	2.0 (0.2)	13.6 (1.9)

1) corresponds to the 8 first weeks of the growing season (spring); *2)* corresponds to the following 8 weeks (summer).

Fig. 1. One of the rain-out shelters

Table 2. Effects of the site, the period (season) and the drought treatment on the extractable P in the soil, the plant P and the microbial P. ANOVA *p* values are in bold when $p < 0.05$.

	Soil P (Olsen)	Plant P	Microbial P
Site (S)	**< 0.001**	**0.001**	**0.012**
Period (Pd)	**< 0.001**	0.166	**< 0.001**
Drought (D)	**0.002**	**0.002**	**0.037**
Pd x D	0.720	**0.048**	0.760
S x Pd	**< 0.001**	**0.029**	0.109
S x D	0.066	0.173	0.597

The interaction between site, period and drought was never significant and does not appear in the Table.

Conclusions

Water shortage lowered plant, soil and microbial phosphorus. Drought had more detrimental effects on plant P during late drought than during early drought.

The different responses of the two grasslands reflect the complex interplay between soil, microbes and plants.