Water and phosphorus stresses: contrasting effects on root functional traits and between grass functional types

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While a large panel of leaf functional traits is available for identification of syndromes associated to species types strategies for resource use, few are available from below ground organs characterization. Moreover little is known about the root functional trait syndrome responses to different kinds of stress and particularly shortage of resources with different mobility in the soil, such as water and phosphorus.

Objectives

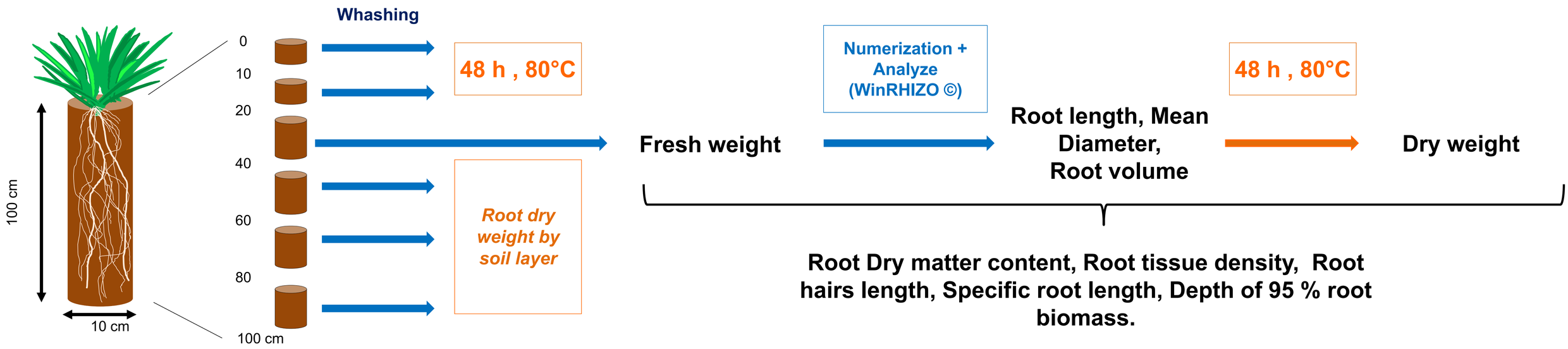
Our objective was to examine the effect of water and phosphorus shortage on perennial grasses belonging to two types with different functional strategies - resource capture or conservation.

Materials & Methods

Experimental design:

Functional Type	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**



Tabel 1 : Root traits measured and their presumed or demonstrated functional significance; (+) and (–) indicate a positive or negative relationship between trait and function, respectively (adapt from Roumet *et al.* 2006; references : 1 to 6)

Traits	Abbreviation (units)	Functional significance
Root diameter	D (mm)	Rate of nutrient uptake (–) Longevity (+) Storage (+) Transport of water (+) Root turnover (+)
Root tissue density	RTD (g per root cm^{-3})	Longevity (+) Resistance to herbivores, drought (+) Root decomposition rate (–)
Root dry matter content	RDMC ($mg.g^{-1}$)	Longevity (+) Resistance to herbivores, drought (+) Root decomposition rate (–)
Specific root length	SRL ($m.g^{-1}$)	RGR (+) Root respiration (+) Rate of nutrient and water uptake (+) Root elongation rate (+) Root turnover (+)
Depth of 95 % root mass	D95% (cm)	Soil exploration (+) Resources access (+) Resistance to drought (+)

Results & Discussion

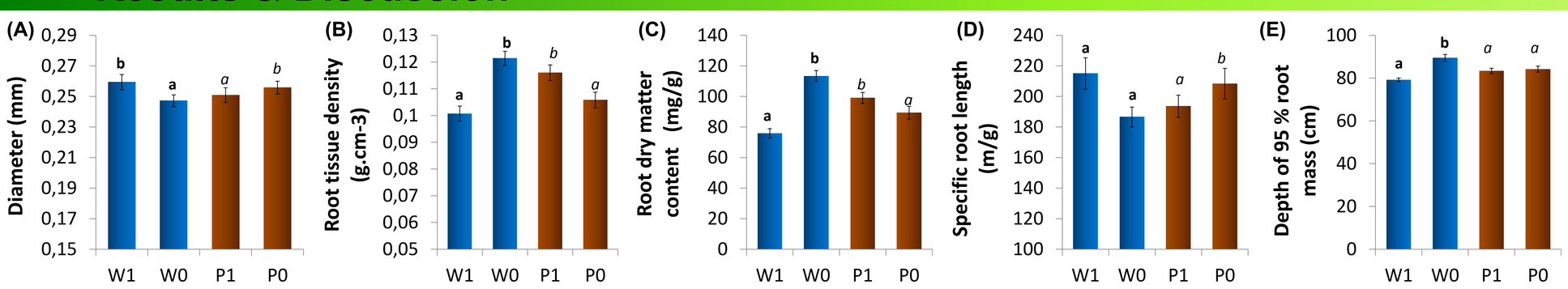


Figure 1: Mean value (± se) of the five root functional traits fort the four modalities (W1, W0, P1, P0). Different letters highlight significant difference within the water or phosphorus modality, bold letters for water effect and italic letters for phosphorus effect (ANOVA, p<0.05)

Mean root diameter and **Specific root length** are the only traits showing a difference between functional types (Table 2), with high diameter and low SRL for conservative species and the opposite for acquisitive species.

Root tissue density and **Root dry matter content** increase with water shortage and decrease with phosphorus limitation.
We hypothesize a reinforcement of root structure under water shortage and/or high phosphorus availability conditions.

The **Depth of 95 percent root mass** increases with water shortage but does not respond to phosphorus stress and to functional type. These two types display the ability to change their root biomass allocation with depth to face water limitation. There is no effect of the phosphorus shortage on this trait.

Table 2 : Effect of plant functional type, water and phosphorus modality on root functional traits (ANOVA, n=160).

		D		RTD		RDMC		SRL		D95%	
	Df	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Functional Type	1	83.01	**<0.001**	0.033	0.8	1.33	0.25	82.16	**<0.001**	0.18	0.67
Water level	1	11.13	**<0.001**	31.79	**<0.001**	68.68	**<0.001**	3.14	0.07	34.16	**<0.001**
Phosphorus level	1	0.06	0.80	5.95	**0.015**	3.95	**0.04**	4.65	**0.03**	0.32	0.56
Water x Phosphorus	1	1.62	**0.20**	0.16	0.68	3.00	0.08	6.57	**0.01**	1.34	0.24
Water x Functional Type	1	0.97	0.32	3.68	0.05	1.35	0.24	4.97	**0.02**	1.09	0.29

The **Specific root length** is the most sensitive trait in our studies; it responds significantly to all the factors except water, for which the effect is not significant (p=0.07, Table 2).

Conclusion

For grasses coming from two functional types morphological root functional traits (D, RTD, RDMC, SRL) display opposite responses to water and phosphorus stress, revealing different kinds of root strategies to acquire these resources. We hypothesize that this behavior could be linked with the water and phosphorus different mobilities in the soil.

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