

## **Deficit and excess of water in soil on nutrients acquisition, plant growth and mycorrhizal colonization in *Lotus glaber* plants in a saline-sodic soil**

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The effects of waterlogging and drought on nutrients acquisition, plant grow and the symbiosis between arbuscular-mycorrhizal fungi (AM) and *Lotus glaber* Mill. plants in a saline-sodic soil were studied to investigate the importance of symbiosis that help plants to tolerate and grow under stress conditions imposed by the environment. *Lotus glaber* is the unique naturalized legume on lowland grasslands in the Flooding Pampas of Buenos Aires Province, Argentina. During the rainy season (autumn, winter and part of the spring) flooding is a common climate phenomenon in these lowlands and the duration ranged from a few days to more than seven months depending on topography, soil and season (Escudero and Mendoza, 2005). The soils of these lowlands are characterized by high pH, salinity and sodicity, and in summer are frequently subjected to an alternating sequence of dry and wet pulses originated by rainfall and high evaporation rates.

A total of twenty 2.0 L closed bottom pots were filled with 1.350 g of soil. Five *L. glaber* plants were grown in a Typic Natraquoll saline-sodic soil (pH 9.4; electrical conductivity 5.07 dS/m, exchangeable sodium 60%) in a greenhouse for 75 days and then subjected to waterlogging, drought or kept at field capacity for an additional period of 35 days. After the initial period of growth (75 days) in soil at near field capacity (36% w/w), 5 of the pots were harvested. Five of the remaining 15 pots were flooded with de-ionized water to one cm above the soil surface (waterlogged treatment), 5 pots were kept near -0.19 MPa of soil water potential (drought treatment), and 5 control treatment pots were kept near field capacity, -0.05 MPa (control treatment). Plants of the three treatments (control, waterlogged and drought pots) were grown for an additional 35 days. The effect of waterlogging and of drought on N and P uptake, plant grow and AM-plant symbiosis were evaluated by measuring dry yields, N and P content and the morphology of mycorrhizal colonization and *Rhizobium* nodules in *L. glaber* roots before and after waterlogging or drought treatments. Waterlogging increased %P in both shoots and roots and the total P content per plant but drought treatment had not changed it. Waterlogging also changes the partitioning of P between roots and shoots. Drought and waterlogging decreased or did not provoke changes in N concentration, content, or allocation and total N/nodules.

Waterlogging increased available P in soil whilst drought stress decreased it. Waterlogging decreased soil pH but EC and exchangeable sodium did not show differences between

waterlogging or drought treatments and control plants. Labile C increased with both stresses conditions and labile N was not affected.

Soil waterlogging and drought decreased total root length, root length colonized (AM root length), arbuscular colonization (AC root length) and number of entry points per unit of colonized root length. Waterlogging also increased vesicle colonization (VC root length) and *Rhizobium* nodules in roots, but drought treatment did not affect vesicle colonization and nodule formation. Spore density in soil decreased by waterlogging but it had no changes with respect to drought treatment.

The results indicate that *L. glaber* can grow, become nodulated by *Rhizobium* and colonized by mycorrhizas under waterlogged or drought conditions. Susceptibility index (SI) suggests that soil waterlogging has a greater depressive effect on mycorrhizal colonization morphology than soil drought.

Waterlogging and drought have shown depressive effects on the symbiosis between AM fungi and *L. glaber* by changing the morphology of colonization in roots and plant growth. Arbuscules decreased and vesicles increased in colonized roots of waterlogged plants. Drought also decreased arbuscular colonization but vesicles did not change. However, soil waterlogging decreased spores density at the end of the experience compared to control and drought soils. It was attributed to spore disappearance in waterlogged soil (degradation, mortality, etc.).

The stress conditions decreased colonization units. The EP was 31.70% lower in waterlogged roots and 24.87% than drought roots. These results may be ascribed to differences in spore viability, spore germination and hyphal growth under stress soil conditions. Waterlogging increased nodulation by *Rhizobium* with a substantial proportion of the nodules clustered at the base of the main root near the soil surface.

Soil waterlogging and drought decreased plant growth (total root length, shoot and root dry weight), but waterlogging increased P uptake and decreased N uptake with respect to control and drought plants. Waterlogging increased available P in soil and labile N had not changes with waterlogging or drought. Aerenchyma tissue developed in the cortex of waterlogged and field capacity roots expressed, as the proportion of aerenchymatic tissue was higher in waterlogged roots. Vignolio *et al.* (1999) has previously reported the tolerant of *L. glaber* to flood condition in soil and Mendoza *et al.* (2005) reportes the tolerance of mycorrhizal-*L. glaber* symbiosis to waterlogging.

The results indicate that AM fungi can survive in waterlogged or drought soils, and colonize roots in the next season by a strategy consisting of colonization reduction, production of resistance structures such as vesicles with preference to transfer structures such as arbuscules. This strategy has a significant implication for the understanding of the biology of AM fungi in flooding condition. *L. glaber* is a highly tolerant plant to flooding that would make an important contribution to sustain AM infectivity after a long period of flooding at field conditions.

## References

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