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Root foraging for Patchy Phosphorus of Plant Species with Contrasting Foraging Strategy - Role of Roots and Mycorrhiza

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Plant nutrients are distributed heterogeneously in soil. Thus the nutrient distribution together with nutrient availability, temporal and spatial development of roots determine nutrient uptake by the plants. Plants have developed several strategies to cope with the patchy nutrient distribution. Preferential root development within nutrient-enriched patches is a prominent response to heterogeneous nutrient distribution. This capacity to precisely allocate roots is called morphological plasticity and is highly variable between plant species. Another strategy is the increased nutrient uptake per unit of root surface in the nutrient-rich patches as compared to root zones outside such patches, so-called physiological plasticity . Additionally, enhanced nutrient uptake from nutrient-rich patches might be supported by increased production of mycorrhizal extraradical hyphae. We refer to this phenomenon as plastic response of the mycorrhiza-plant association. Relative importance for nutrient acquisition of these responses to heterogeneous nutrient distribution might vary between plant species. However, quantitative data are very rare. We will investigate nutrient acquisition and root development over time in sandy substrate with heterogeneous phosphorus (P) distribution of two model plant species with different nutrient foraging strategies (Lotus corniculatus, Trifolium arvense). These plant species are characterized by high and low morphological plasticity, respectively (according to results of preliminary experiments).
We follow three main goals in a single mesocosm experiment, where P is to be homogeneously or patchily distributed in a sandy substrate: 1. - Imaging of root architecture of Lotus corniculatus and Trifolium arvense on a time line. 2. - Assessment of the physiological plasticity of Lotus corniculatus and Trifolium arvense 3. - Determination of the plasticity of mycorrhiza-plant association of Lotus corniculatus and Trifolium arvense associated with either of three species of arbuscular mycorrhizal fungi (AMF; Glomus intraradices, Glomus claroideum, Gigaspora margarita).
Therefore, we will conduct a mesocosm experiment in a 2 x 2 x 5 factorial design, with two plant species, two P distribution patterns (homogeneous, heterogeneous) and five mycorrhizal treatments (three sterilized treatments inoculated with different AMF species, one sterilized inoculated control, one non-sterilized control). We will apply Neutron Radiography (NR)-technique to investigate root architecture on a time line. NR is a non-invasive technique that can be applied to image roots in sand or soil. In the soil-root system, neutrons are mainly retained or scattered by hydrogen. Because of the higher water content, roots appear darker on the image than the surrounding sand/soil. At the end of the experiment, above and belowground biomass will be harvested and P concentrations will be determined. Roots within and outside nutrient-rich patches will be sampled separately. Root architecture will be determined with WinRhizo. We will apply dual radioisotopic labeling of the soil P to investigate physiological plasticity of the roots and/or plant-mycorrhizal association with respect to the P uptake. Ten days before the end of the experiment we will inject carrier-free 32P-orthophosphate solution to the P-rich patch and 33P to the substrate outside the patch. At harvest, we will measure 32P and 33P availabilities in the substrate and the radioisotope contents in plants, and calculate P uptake per unit of root surface within and outside the P-rich patch. We will use real-time polymerase chain reaction assay targeting the species-specific motifs in the ribosomal large subunit to assess abundances of the different AMF species within the roots and in the soil enriched or not with P (i.e. plasticity of mycorrhiza-plant association).