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A heterogeneous boron distribution in soil influences the poplar root system architecture development

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Poplars are well suited for the phytomanagement of boron (B)-contaminated sites, due to their high transpiration rate and tolerance to elevated soil B concentrations. However, the uptake and the fate of B in poplar stands are not well understood. This information is crucial to improve the design of phytomanagement systems, where the primary role of poplars is to reduce B leaching by reducing the water flux through the contaminated material. Like other trace elements, B occurs heterogeneously in soils. Concentrations can differ up to an order of magnitude within centimetres. These gradients affect plant root growth and thus via preferential flow along the roots water and mass transport in soils to ground and surface waters. Generally there are three possible reactions of plant roots to patches with elevated trace element concentrations in soils: indifference, avoidance, or foraging. While avoidance or indifference might seem to be the most obvious strategies, foraging cannot be excluded a priori, because of the high demand of poplars for B compared to other tree species. We aimed to determine the rooting strategies of poplars in soils where B is either homo- or heterogeneously distributed.

We planted 5 cm cuttings of Populus tremula var. Birmensdorf clones in aluminum (Al) containers with internal dimensions of 64 x 67 x 1.2 cm. The soil used was subsoil from northern Switzerland with a naturally low B and organic C concentration. We setup two treatments and a control with three replicates each. We spiked a bigger and a smaller portion of the soil with the same amount of B(OH)3-salt, in order to obtain soil concentrations of 7.5 mg B kg-1 and 20 mg B kg-1. We filled the containers with (a) un-spiked soil, (b) the 7.5 mg B kg-1 soil and (c) heterogeneously. The heterogeneous treatment consisted of one third 20 mg B kg-1 soil and two thirds control soil. We grew the poplars in a small greenhouse over 2 months and from then on in a climate chamber for another 3 months. We irrigated the poplars with modified Hoagland's solution that contained no B. We imaged the roots in the soil every 3rd week using neutron radiography (NR) at the Paul-Scherrer Institute. Living roots can be visualised in soil by NR because of their higher water content compared to the surrounding soil. At the end of the growing period, the Al containers were opened and the soil surface was scanned by a standard office scanner. The soil in the containers was divided into nine equal portions representing different depths and spiked or un-spiked regions in soil profile. We separated roots and soil as well as the aerial parts (stems and leaves). We obtained data on root morphological parameters like root length and root density by evaluating scans of the washed root samples with an image evaluation software. All soil and plant samples were dried, weighed and analyzed for B and mineral nutrients using ICP-OES.

Plant vitality parameters like water use, growth and number of living leaves did not show any reaction to the treatments. The oldest poplar leaves from poplars in the B-spiked treatments showed signs of light to serious necrosis. From the neutron radiographs it was apparent that poplar roots reached the walls of the Al- containers during the experiment. Primary roots grew at first strongly in lengths in horizontal as well as in vertical direction and only after this lateral root growth was visible. Although the filling and packing of the containers was done with great care to establish an ideally homogeneous soil profile settlement occurred in some containers resulting in gaps in the profile. However, roots growth did not seem to be deranged since roots simply crossed these gaps and continued growth in the adjacent soil patch. The complete results will be available at the time of the conference.