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Root hairs increase root exudation and rhizosphere extension

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Plant roots employ various mechanisms to increase their access to limited soil resources. An example of such strategies is the production of root hairs. Root hairs extend the root surface and therefore increase the access to nutrients. Additionally, carbon release from root hairs might facilitate nutrient uptake by spreading of carbon in the rhizosphere and enhancing microbial activity. The aim of this study was to test: i) how root hairs change the allocation of carbon in the soil-plant system; ii) whether root hairs exude carbon into the soil and iii) how differences in C release between plants with and without root hairs affect rhizosphere extension.

We grew barley plants with and without root hairs (wild type: WT, bald root barley: brb) in rhizoboxes filled with a sandy soil. Root elongation was monitored over time. After 4 weeks of growth, plants were labelled with $14CO_2$. A filter paper was placed on the soil surface before labelling and was removed after 36 h. 14C imaging of the soil surface and of the filter paper was used to quantify the allocation of 14C into the roots and the exudation of 14C, respectively. Plants were sampled destructively one day after labeling to quantify 14C in the plant-soil system. $14CO_2$ release from soil over time (17 d) was quantified by trapping CO_2 in NaOH with an additional subset of plants.

WT and brb plants had a similar aboveground biomass and allocated similar amounts of 14C into shoots (170 KBq for WT; 152 KBq for brb) and roots one day after labelling. Biomass of root, rhizosphere soil as well as root elongation were lower for brb compared to the wild type. WT plants transported more C from the shoots to the roots (22.8% for WT; 13.8% for brb) and from the root into the rhizosphere (8.8% for WT 3.5% for brb). Yet lower amounts of $14CO_2$ were released from soil over time for WT. Radial and longitudinal rhizosphere extension was increased for WT compared to brb (4.7 vs. 2.6 mm; 5.6 vs. 3.1 cm). The total exudation which was estimated based on the grey values of the filter paper images was 1.6 times higher for WT compared to brb.

After one month, brb plants performed as good as WT plants, presumably because nutrients and water were not limiting for young plants. Under nutrient limiting conditions higher C release as well as increased longitudinal and radial rhizosphere extension for WT may maintain higher nutrient accessibility compared to root hair free plants.