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Increased belowground C release during initial plant development of Populus deltoides x nigra grown under light and C reserve limited conditions

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Plants might be a key factor for the long-term stabilisation of carbon (C) in the soil, e.g. through enhanced physical protection of root-derived C against microbial decomposition in soil aggregates. On the other hand C released by the plants into the soil might promote the decomposition of native soil organic matter (SOM) through the stimulation of microbial activity.
We measured the C budget of developing plant-soil systems (Populus deltoides x nigra, Cambisol soil) in the laboratory under controlled environmental conditions. In order to distinguish plant-derived from native C in the SOM and the soil CO_2 efflux, we labelled the poplar shoots continuously with 13C-CO_2 from first emergence of leaves (sprouting from stem cuttings). Throughout the experiment the CO_2 fluxes (photosynthetic assimilation, dark respiratory loss, soil CO_2 efflux) were measured frequently (every 30 min) and the 13C was traced in the soil CO_2 efflux (1-2 times a week). After 10 weeks the plant-soil systems were destructively harvested and the distribution of the 13C distribution was analysed.
The plants developed slowly (compared to previous experiments), most likely due to limitation in C reserves (long term cutting storage) and C supply (low light intensities). The amount of 13C recovered in the roots, microbial biomass and soil CO_2 efflux was directly correlated with the leaf area of the different plant individuals. After 3-4 weeks of plant development we observed a high peak in the total soil CO_2 efflux. During this time the relative belowground C release was increased massively over the basal rate of 17 % of net C assimilated, whereby the variability between the plant individuals was large. The smallest plants, i.e. the plants that were most resource limited, obtained the highest belowground C release accounting at the peak time for up to 57 % of net assimilated C. We hypothesize that the plants released specific compounds, which either directly (enzymatically) or indirectly (priming) enhanced the decomposition of native SOM as a survival mechanisms (e.g. mine for nutrients).
The results of this study confirm linear correlations between aboveground plant traits (leaf area) and belowground C allocation into roots, microbial biomass and plant-derived respiration. However it also highlights that plant-soil systems are not permanently in a steady state. C allocation patterns can change massively when the plant is under stress, which affects other fluxes within the terrestrial C cycle, such as the microbial decomposition of SOM.