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Effects of the distribution, amount, and size of beech fine roots on the C-turnover in the topsoil and subsoil of a sandy podzolic Cambisol

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The function of soil to act as a sink for CO_2 is affected by the decomposition intensity of plant roots entering the mineral soil at different depths. Little is known about the key factors governing the mineralization kinetics of beech fine roots in different soil depths. We aimed to analyze the effects of the distribution, amount, and size of beech fine roots on their decomposition in the top- and subsoil. Topsoil (2 - 10 cm) and subsoil (145 - 152 cm) samples were taken from 3 profiles of a sandy Cambisol under beech located near Hannover (Germany). Incubation experiments were carried out for 300 days at 10°C and water contents at 50% of the water-holding capacity and CO_2 emission rates were determined using an automated microcosm system. Treatments included control soils (either homogenized and sieved <2 mm or as intact soil column) and application of dried beech fine roots of different sizes (<2 mm and 1-2 cm) at different application rates (2 g kg-1 and 8 g kg-1) either homogenously mixed with homogenized soil or added in form of hot spots to the columns. First order models were applied to the cumulative C mineralization data. Calibration of a one-pool model was carried out for the C mineralization of the control topsoil. A two-pool model was calibrated to C mineralization data of the treatment with root application to subsoil at the rate of 2 g kg-1. Models were validated in the treatments using topsoil and root application at the rate of 2 g kg-1 (using the three pools obtained in the calibration) and at the rate of 8 g kg-1 (using the three pools obtained in the calibration and multiplying the maximum mineralizable root amounts by 4). The C mineralization data for the samples containing roots <2 mm, homogenously distributed at a concentration of 2 g per kg topsoil and subsoil and at a concentration of 8 g per kg subsoil were well described (calibration) or estimated (validation) indicating that root composition and amount were highly important for the C-turnover. The C mineralization rates measured for the samples containing the 1-2 cm roots and for those where the roots were added in hot spots were less satisfactorily estimated with the chosen model approach indicating pronounced effects of the root size and distribution on the mineralization kinetics. Especially for the subsoil samples with root concentrations of 8 g kg-1, the CO_2 emission rates were distinctly larger for the samples that received the 1-2 cm roots compared to those containing the <2 mm roots. The differences between topsoils and subsoils in the CO_2 emissions rates were lowest for the samples containing 2 g of <2 mm homogenously distributed roots per kg soil. The largest differences were detected for the samples where 8 g <2 mm roots per kg soil were distributed in hot spots. Our results indicate that size and distribution effects have to be taken into account for the elucidation of differences in the decomposition kinetics of roots between topsoil and subsoil.