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Agricultural management affects below ground carbon input estimations

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Root biomass and rhizodeposition carbon (C release by living roots) are among the most relevant root parameters for studies of plant response to environmental change, soil C modelling or estimations of soil C sequestration. Below ground C inputs of agricultural crops are typically estimated from above ground biomass or yield, thereby implying constant below to above ground C ratios. Agricultural management practices affect above ground biomass considerably; however, their effects on below ground C inputs are only poorly understood.

Our aims were therefore to (i) quantify root biomass C and rhizodeposition C of maize and wheat grown in agricultural management systems with different fertilization intensities and (ii) determine management effects on below/above ground C ratios and vertical distribution of below ground C inputs into soil.

We conducted a comprehensive field study on two Swiss long-term field trials, DOK (Basel) and ZOFE (Zurich), with silage (DOK) and grain (ZOFE) maize in 2013 and winter wheat in 2014 (ZOFE) and 2015 (DOK). Three treatments in DOK (2 bio-organic, 1 mixed conventional) and 4 treatments in ZOFE (1 without, 1 manure, 2 mineral fertilization) reflected increasing fertilization intensities. In each of 4 replicated field plots per treatment, one microplot (steel tube of 0.5m depth) was inserted into soil, covering an area of 0.1m2. The microplot plants were pulse-labelled with 13C-CO_2 in weekly intervals throughout the respective growing season. After harvest, the microplot soil was sampled in three soil depths (0 – 0.25, 0.25 – 0.5, 0.5 – 0.75m), roots were separated from soil by picking and wet sieving, and root and soil samples were analysed for their δ13C values by IRMS. Carbon rhizodeposition was calculated from 13C-excess values in bulk soil and roots.

(i) Average root biomasses of maize and wheat were 1.9 and 1.4 tha 1, respectively, in DOK and 0.9 and 1.1 tha 1, respectively, in ZOFE. Average amounts of C rhizodeposition of maize and wheat were 1.4 and 0.7 tha 1, respectively, in DOK and 0.5 and 0.6 tha 1, respectively, in ZOFE. Both root biomass and C rhizodeposition were similar among treatments on both sites but were significantly higher for silage maize (DOK) than for grain maize (ZOFE) and winter wheat (DOK and ZOFE).
(ii) With increasing fertilization intensities, below/above ground C ratios of both maize and wheat significantly decreased from 0.43 to 0.16 for maize and 0.57 to 0.15 for wheat. Vertical distribution of below ground C inputs into soil was not affected by agricultural management but differed significantly between crops: In the subsoil (0.5 – 0.75m), below ground C inputs of wheat were twice as high as those of maize on both sites.

Increasing fertilization intensity leads to a considerable increase in above ground biomass but does not affect below ground C inputs of maize and wheat on two Swiss agricultural sites. This finding shows that below ground C inputs cannot be estimated from above ground biomass in order to provide soil C models with input data. A differentiation according to the management system is strongly needed.