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Introduction

Rhizodeposits, defined here as any organic materials released by living roots, can represent up to 15% of net amount of carbon (C) photosynthesized by a plant (Pausch and Kuzyakov, 2018). Rhizodeposits have been shown to play an important role in plant growth through various mechanisms (e.g. by favoring water uptake through mucilage secretion, or nutrient uptake through the exudation of soluble compounds), and to represent a major contributor to the formation of stable soil organic matter - and thus to the mitigation of climate change through soil C sequestration. Decomposing rhizodeposition into its elementary processes (e.g. exudation, mucilage secretion, cells sloughing) is required for a better understanding of the response of rhizodeposition to various environmental constraints and of its associated-benefits. While many works have attempted to quantify the exudation of soluble organic compounds at the scale of a plant or the net rhizodeposition of C in soils, very few studies have been able to estimate the amount of mucilage or sloughed cells released by a whole root system over time. Consequently, while it has been claimed that the amount of soluble organic C is much higher than the amount of C released as mucilage or sloughed cells by roots (Nguyen, 2003; Rees et al. 2005), the relative importance of distinct rhizodeposition processes in plant's and soil's C balance remains largely unknown. While the comparison of mucilage secretion and citrate exudation within a FSPM has been recently attempted (Landl et al. 2021), no model has been developed so far for simulating such rhizodeposition processes as part of plant's C management. The present work aimed to give a better assessment of the contribution of distinct rhizodeposition processes to the total amount of organic C released by roots, for different plant species, growth stages and environments.

Modelling approach

We used the recently developed root model *RhizoDep*, which aims to simulate rhizodeposition over time and space as a function of plant's environment. Its originality lies in the calculation of a full C balance in each part of the root system, which enables to simulate physiological processes (e.g. growth, maintenance and rhizodeposition) in a plastic way, depending on the variations of root sugar concentrations (Figure 1). Three distinct rhizodeposition processes have been implemented: the exudation of soluble organic compounds, the secretion of mucilage and the sloughing of root cells. The present version also explicitly considers the dynamics of root hairs, as it may significantly influence rhizodeposition processes, e.g. by changing root external surface. Model's parameters were taken from literature or recalculated from published data. The amount of C allocated to the root system over time, which is the major input variable of the model, was either estimated from literature data or simulated by the wheat FSPM *CN-Wheat* (Barillot et al. 2016; Gauthier et al. 2020).

Simulations & first results

We simulated the amount of C released by roots from species that contrast in terms of root architecture and rhizodeposition (e.g. wheat, oilseed rape, faba bean). Simulations were done for different growth stages and environmental conditions (e.g. nitrogen availability, light availability and soil mechanical impedance). Our results show that the exudation of soluble compounds is predominant compared to other rhizodeposition processes, but the secretion of mucilage and the release of cells are substantially increased in certain situations. Mucilage secretion or cells sloughing had until now been investigated only at the scale of a single root and over periods of a few hours. Our work shows that FSPM-modelling offers a unique opportunity to integrate these processes at plant's scale over the whole growth period, while considering various environmental influences on root growth and rhizosphere processes.

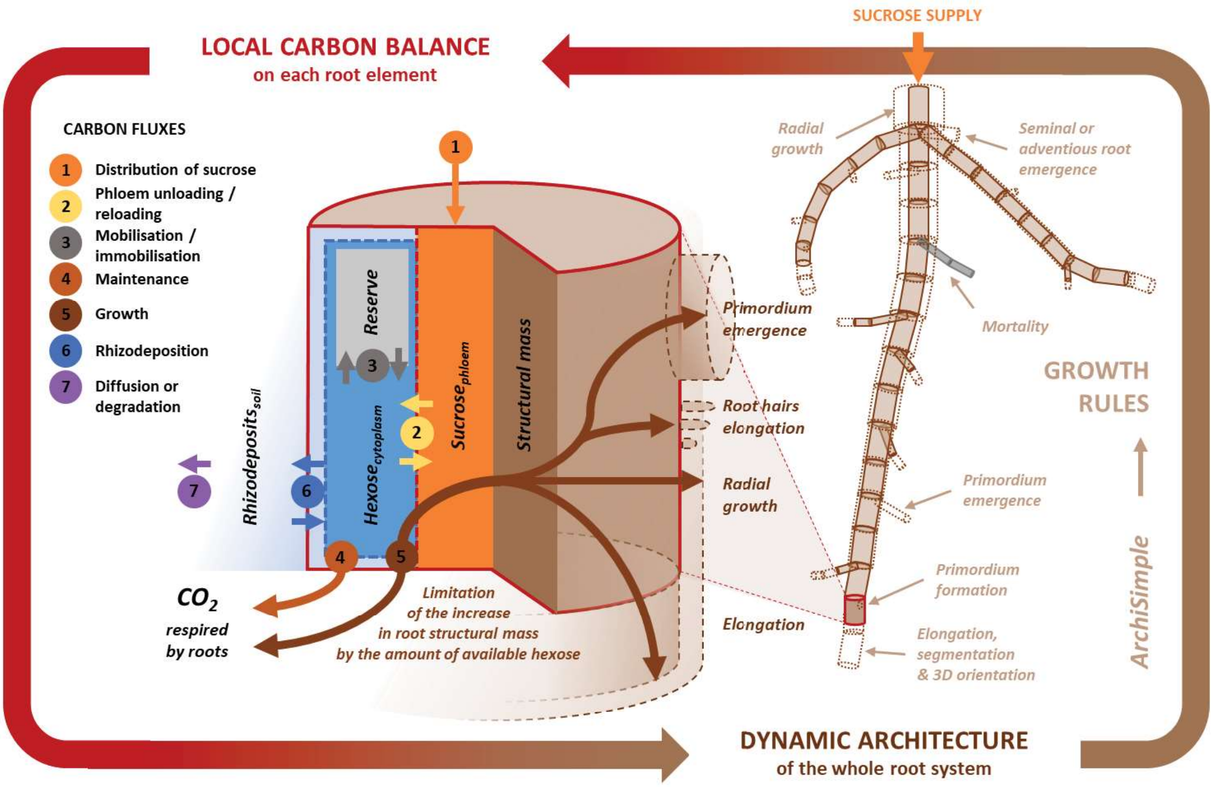

Figure 1: Principles of *RhizoDep* for simulating various rhizodeposition processes within a 3D root system

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