Plant Soil
https://doi.org/10.1007/s11104-017-3522-4

REGULAR ARTICLE

Rhizodeposition under drought is controlled by root growth rate and rhizosphere water content

Maire Holz · Mohsen Zarebanadkouki · Anders Kaestner · Yakov Kuzyakov · Andrea Carminati

Received: 18 July 2017 / Accepted: 29 November 2017

Abstract
Aims Rhizodeposition is an important energy source for soil microorganisms. It is therefore crucial to estimate the distribution of root derived carbon (C) in soil and how it changes with soil water content.
Methods We tested how drought affects exudate distribution in the rhizosphere by coupling $^{14}CO_2$ labelling of plants and phosphor imaging to estimate C allocation in roots. Rhizosphere water content was visualized by neutron radiography. A numerical model was employed to predict the exudate release and its spatiotemporal distribution along and around growing roots.
Results Dry and wet plants allocated similar amounts of ^{14}C into roots but root elongation decreased by 48% in dry soil leading to reduced longitudinal rhizosphere extension. Rhizosphere water content was identical (31%) independent of drought, presumably because of the high water retention by mucilage. The model predicted that the increase in rhizosphere water content will enhance diffusion of exudates especially in dry soil and increase their microbial decomposition.
Conclusion Root growth and rhizosphere water content play an important role in C release by roots and in shaping the profiles of root exudates in the rhizosphere. The release of mucilage may be a plant strategy to maintain fast diffusion of exudates and high microbial activity even under water limitation.

Keywords Root exudates · Rhizosphere extension · Mucilage · Convection–diffusion model · ^{14}C imaging · Neutron radiography

Responsible Editor: Eric Paterson

M. Holz (✉) · Y. Kuzyakov
Department of Agricultural Soil Science, University of Goettingen, Goettingen, Germany
e-mail: maire.holz@forst.uni-goettingen.de

M. Holz · M. Zarebanadkouki · A. Carminati
Division of Soil Physics, University of Bayreuth, Bayreuth, Germany

A. Kaestner
Paul Scherrer Instiute, Villigen, Switzerland

Y. Kuzyakov
Institute of Environmental Sciences, Kazan Federal University, 420049 Kazan, Russia

Introduction

The rhizosphere is the small soil volume around the roots where nutrient accessibility is increased due to a higher microbial abundance and turnover compared to the bulk soil (Hamilton and Frank 2001; Herman et al. 2006; Landi et al. 2006). Low molecular weight root exudates (hereinafter referred to as root exudates), are one important energy source for soil microorganisms (Gunina and Kuzyakov 2015). It is therefore important to estimate the radial and longitudinal distribution of root exudates in the rhizosphere (Darrah 1991a, b; Toal et al. 2000). The distribution of C in the rhizosphere is affected by: (a) the amount of exudates released by the roots, (b) the diffusion of exudates, (c) convection, i.e. the fluxes of water to the root, (d)

Published online: 15 December 2017