Syndrome “basses richesses” disease induces heterogenic allocation of carbon in growing sugar beet

Kwabena Agyei[1], Justus Detring[2], Ralf Metzner[1], Gregor Huber[1], Daniel Pflugfelder[1], Omid Eini[2], Mark Varrelmann[2], Anne-Katrin Mahlein[2] and Robert Koller[1]

[1]Institute for Bio- and Geosciences, Plant Sciences (IBG-2), Forschungszentrum Jülich GmbH, 52428 Jülich, Germany.

[2]Institute of Sugar Beet Research, Holtenser Landstraße 77, D-37079 Göttingen, Germany.

Syndrome “basses richesses” (SBR) is a recently emerging sugar beet disease. A cixiid planthopper is the main vector of the proteobacterium and the phytoplasma that cause SBR. SBR leads to a significant reduction in beet biomass and sugar content, negatively affecting the sugar economy.

SBR causing bacteria are known to be restricted to the phloem. It is speculated that the entire phloem integrity from source to sink elements is altered under SBR attack. But mechanistic understanding regarding carbon (C) transport and accumulation in the beet under SBR attack is currently incomplete.

Therefore, the main aim of this study was to uncover C transport patterns and quantify temporal dynamics of taproot development under SBR attack. We assumed that SBR impairs allocation of C within infected plants, thereby impairing growth of the developing taproot.

Sugar beet plants were cultivated under controlled conditions in natural field soil. We deployed magnetic resonance imaging (MRI) and positron emission tomography (PET) as a deep phenotyping approach to non-invasively characterize SBR effects on the developing sugar beet taproot. Inoculated and control plants were imaged weekly with MRI for structural effects and in combination with PET for C allocation patterns in 3D from 21 until 63 days after inoculation (dai).

Image data analysis revealed a reduction in taproot volume and width of inner cambium ring structures as early as 42 dai. We observed a heterogenous distribution of recently fixed C for inoculated plants, predominantly at later imaging days (56 and 63 dai). Also, post-harvest analysis of belowground beet showed a significant reduction in beet fresh weight and maximum beet diameter for inoculated plants.

Our results illustrate how a pathogen affects sink capacity of developing taproot and opens perspectives in uncovering mechanisms of SBR-sugar beet interaction.