Metabolomics as tool to decipher plant-microbe interactions

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1. Introduction

In nature, plants are surrounded by a large diversity of microorganisms. The microorganisms colonise the aboveground parts but especially belowground. The rhizophere, the soil zone surrounded and influenced by plant roots, is inhabited by a multitude of microorganisms, including fungal and bacterial species. The interactions between plants and microorganisms can be either mutualistic or antagonistic. In the chemical interplay between microorganisms and plants, a wide range of compounds play a significant role. Many soil bacteria and fungi produce and emit a wide range of so called volatile organic compounds (VOCs). This chemically diverse group of compounds can travel longer distances in soil than other metabolites. The ecological functions of these VOCs are, however, often not well understood.

Here, we studied the effects of VOCs emitted by beneficial bacteria belonging to the *Streptomyces* species on the growth of the fungal root pathogen *Rhizoctonia solani* as well as on the growth and resistance of *Arabidopsis thaliana* seedlings. In addition, we studied the effects of VOCs emitted by *R. solani* on the growth and resistance of *A. thaliana* to an insect herbivore (1,2).

2. Approach

We characterised the composition of VOCs emitted by 12 *Streptomyces* species that were isolated from the rhizosphere of sugar beet seedlings grown in a soil suppressive to *R. solani*. We also profiled the VOCs produced by *R. solani*. VOCs were collected using static (SPME) as well as dynamic headspace (Tenax TA) trapping techniques. Samples were thermally desorbed and then analysed by gas chromatography mass spectrometry (GCMS) (1,2).

Raw data were processed using an untargeted metabolomics approach including multivariate statistical analyses as established at Wageningen UR.

In a number of different bioassays phenotypic changes of *R. solani* (growth inhibition) and *A. thaliana* (growth promotion and resistance to *Mamestra brassicae*) were studied after being exposed to blends of different VOCs. To identify the VOCs responsible for these changes, *A. thaliana* seedlings and the fungal pathogen *R. solani* were *in vitro* exposed plants to synthetic compounds.

3. Results and Discussion

VOCs of several *Streptomyces* isolates inhibited hyphal growth of *R. solani* and significantly enhanced plant shoot and root biomass. Several VOCs identified in the headspace of the Streptomyces species were tested for their antifungal activity. Two synthetic compounds identified in the headspace of *Streptomyces* cultures showed some inhibitory effect on the growth of the fungal pathogen *R. solani* suggesting that *Streptomyces* VOCs have a role in disease suppressive soils.

VOCs emitted by *R. solani* enhanced growth and accelerated development of *A. thaliana*. Fungal VOCs did not affect plant resistance to infection by the VOC-producing pathogen itself but reduced aboveground resistance to the herbivore *M. brassicae*.

Our results indicate that the promotion of plant growth by VOCs appears to be more common phenomenon, not only observed for beneficial microorganisms but also for root pathogens. VOCs induced phenotypic changes are thereby not limited to the plant itself but may also have direct and indirect consequences on other trophic levels indicating their potential to shape plant's food web community.

References

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