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SUMMARIES

Summary

The reliance of agriculture on chemical pesticides and fertilizers is becoming increasingly unsustainable due to environmental degradation and the rise of resistance among pests and pathogens. As a result, there is growing interest in environmentally friendly, biologically-based strategies to enhance crop resilience. A promising avenue involves the use of beneficial plant-associated microbiota, particularly those residing in the rhizosphere, the thin layer of soil surrounding roots where microbial activity is tightly linked to plant health. These microbes can suppress pathogens, stimulate plant immune responses, and improve nutrient acquisition. Importantly, plants are not passive recipients of microbial colonization. Under stress conditions, they can selectively recruit beneficial microbes through the release of specific root exudates, a strategy referred to as the "cry for help". While most studies have focused on water-soluble exudates, much less is known about root-emitted volatile organic compounds (rVOCs) as belowground signals involved in this process. This thesis addresses that knowledge gap by investigating how biotic stresses aboveground, specifically foliar infection by the fungal pathogen *Botrytis cinerea* and herbivory by the insect *Spodoptera exigua*, alter rVOC emissions in tomato, and how these changes influence the recruitment of beneficial rhizosphere microbes. For this purpose, two tomato genotypes were used as model species: the wild species *Solanum pimpinellifolium* and the domesticated tomato *Solanum lycopersicum* var. Moneymaker. The results of this thesis revealed that tomato roots emit complex blends of monoterpenes and other rVOCs in a genotype-dependent manner. Aboveground biotic stresses trigger systemic responses in rVOC composition, with rVOCs such as benzyl alcohol, benzofuran, methyl salicylate (MeSA), and dimethyl disulfide (DMDS) consistently induced in response to stress. These systemically induced changes in the root volatilome were associated with alterations in the composition of the root-associated microbiome as was demonstrated using a controlled belowground olfactometer system. Subsequent bioassays further revealed that recruited bacterial taxa, i.e *Pseudomonas* sp. (G17) , *Massilia* sp. (G49.3), and *Ammoniphilus* sp. enhanced seedling growth and resistance to insect herbivory. Collectively, these results provided direct evidence that rVOCs alone, independent of other exudate types, can serve as long-distance signals for recruitment of beneficial bacterial taxa. For these taxa to confer beneficial effects on the host plant, they need to successfully establish in the rhizosphere. This requires traits such as motility, chemotaxis, and biofilm formation. Subsequent experiments revealed that the stress-induced volatile

MeSA modulates bacterial motility, directional movement, biofilm formation, and root colonization in a dose-dependent and strain-specific manner. These results provide mechanistic insight into how specific rVOCs may facilitate microbial recruitment but also establishment and persistence in the root environment. Collectively, these findings support the idea that rVOCs act as dynamic chemical signals through which plants communicate with and recruit microbial allies during stress. While this thesis provides important advances in our understanding of volatile-mediated plant–microbe interactions, further research is needed to address the temporal dynamics, in situ concentrations, and soil-specific diffusion of rVOCs. Additionally, the molecular mechanisms by which bacteria perceive and respond to stress-induced rVOCs, remain important avenues for future exploration. In summary, this work highlights rVOCs as key belowground signals in the cry-for-help strategy of plants under siege, offering new strategies for harnessing beneficial microbes to support sustainable agriculture.