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Commentary

Soil microbial interactions and their influence on plant-plant communication

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ABOUT THE STUDY

The intricate web of life beneath our feet plays a crucial role in shaping the health and productivity of ecosystems. Soil, often considered a mere substrate for plant growth, harbors a complex community of microorganisms that engage in intricate interactions. Among these interactions, the relationships between soil microbes and plants have garnered significant attention due to their profound impact on plant health, nutrient cycling, and overall ecosystem dynamics. In recent years, research has unveiled a fascinating dimension of this interaction and the influence of soil microbial communities on plant-plant communication.

Soil microbial community

These microbial community is incredibly diverse, comprising bacteria, fungi, archaea, protozoa, and viruses. These microorganisms form complex networks and engage in various interactions that influence nutrient availability, disease suppression, and plant growth. Mycorrhizal fungi, for example, form mutualistic associations with plant roots, enhancing nutrient uptake and providing plants with a competitive advantage (Bennett et al.,2019). Bacteria contribute to nutrient cycling by fixing nitrogen and solubilizing phosphorus, while other microbes play essential roles in decomposing organic matter.

Microbial interactions in the rhizosphere

The rhizosphere, the region surrounding plant roots, is a hotspot for microbial activity. As roots release organic compounds, they create a nutrient-rich environment that attracts a diverse array of microbes (de Vries et al., 2023). This dynamic zone is not only a bustling hub for microbial interactions but also serves as a crucial interface for plant-microbe communication.

Mycorrhizal networks: One of the fascinating aspects of soil microbial interactions is the formation of mycorrhizal networks. Mycorrhizal fungi connect the roots of different plants, creating an underground network known as the "Wood Wide Web." Through this network, plants can exchange nutrients, signaling compounds, and even warn each other of impending threats. Recent studies have shown that the plants are connected through mycorrhizal networks exhibit enhanced resistance to herbivores and diseases, highlighting the role of soil microbes in mediating plant-plant communication.

Root exudates and chemical signaling: Plants release a plethora of organic compounds into the soil through their roots, collectively known as root exudates (Ding et al., 2021). These compounds not only serve as a nutrient source for microbes but also play a crucial role in chemical signaling. Soil microbes, in turn, respond to these signals by modulating their activity. Recent research suggests that certain microbial metabolites can act as signaling molecules, influencing the growth and behavior of neighboring plants. This chemical crosstalk between plants mediated by soil microbes represents a sophisticated form of inter-plant communication.

Induced Systemic Resistance (ISR): Soil microbes can induce systemic resistance in plants, a phenomenon known as Induced Systemic Resistance (ISR). When plants are exposed to beneficial microbes, they activate defense mechanisms that not only protect them from the initial microbe but also confer resistance against pathogens. This priming effect extends beyond individual plants, as the activated defense responses can be communicated to neighboring plants through airborne signals or root exudates. Thus, soil microbial interactions not only enhance the fitness of individual plants but also contribute to a communal defense strategy.

Plant-plant communication mediated by soil microbes

The intricate dance between soil microbes and plants sets the stage for plant-plant communication that extends beyond physical proximity. Several mechanisms underpin this communication, revealing the interconnectedness of plants within a shared microbial environment (Jing et al., 2022).

Airborne signaling: Volatile Organic Compounds (VOCs) released by plants in response to microbial interactions can serve as airborne signals. These VOCs can travel through the air and be detected by neighboring plants, triggering physiological responses that prepare them for potential stressors. This form of communication allows plants to "eavesdrop" on the experiences of

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their neighbors and adjust their defense mechanisms accordingly.

Root-to-root signaling: The exchange of chemical signals through the rhizosphere provides a direct avenue for root-to-root communication. Plants can release specific compounds into the soil that, when sensed by neighboring plants, induce changes in gene expression and metabolic pathways. This communication allows plants to coordinate responses to environmental challenges, such as nutrient deficiencies or impending herbivore attacks (Mariotte et al., 2018).

Nutrient signaling: Mycorrhizal networks not only facilitate nutrient exchange but also serve as conduits for signaling compounds. Plants connected through these networks can share information about nutrient availability and allocate resources accordingly. This mutualistic exchange not only benefits individual plants but also contributes to the overall health and resilience of the plant community.

Implications for agriculture and ecosystem management

Understanding the intricate interplay between soil microbes and plant-plant communication has significant implications for sustainable agriculture and ecosystem management.

Enhanced crop resilience: Harnessing the power of soil microbial interactions can enhance the resilience of crops to environmental stresses. Incorporating beneficial microbes into agricultural practices can stimulate induced systemic resistance (Thakur et al.,2021), reducing the reliance on chemical pesticides and fertilizers. This approach not only benefits individual crops but also promotes a healthier agroecosystem.

Biodiversity conservation: Recognizing the role of soil microbes in mediating plant-plant communication sheds light on the importance of preserving biodiversity in natural ecosystems. Diverse plant communities support a rich microbial network, enhancing the capacity for inter-plant communication and ecosystem resilience (Wiche et al.,2018). Conservation efforts aimed at preserving biodiversity can thus contribute to the maintenance of healthy soil microbial communities.

Climate change mitigation: As climate change poses new challenges to plant communities, understanding the role of soil microbes in plant-plant communication becomes crucial. By promoting the health of soil microbial communities, we may be able to enhance the adaptive capacity of plant species, facilitating their response to changing environmental conditions (Zhu et al.,2022).

The intricate relationships between soil microbes and plants, particularly their influence on plant-plant communication, unveil a hidden dimension of ecosystem dynamics. From mycorrhizal networks to airborne signaling, the interplay between soil microbes and plants orchestrates a symphony of interactions that shape the health and resilience of ecosystems. Recognizing the importance of these relationships has profound implications for agriculture, biodiversity conservation, and climate change mitigation.

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