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Biotic and Abiotic Interactions: The Key Drivers of Soil Microbiome Composition and Health

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Introduction

A microbiome is a population of microorganisms that can be found coexisting in any given habitat. Whipps described it more specifically in 1988 as "a unique microbial population with distinct physio-chemical features that inhabits a relatively well-defined habitat. Thus, the word refers not only to the microorganisms involved, but also to their environment ". Soil is a non-renewable natural bio-resource that plays a vital role in Earth's ecosystem processes and biogeochemical cycles. Soil health is an important aspect of a soil ecosystem since it is the outcome of both biotic and abiotic processes and is linked to many interactions within the system [1].

Description

These interactions have a significant impact on microbial activity, hence supporting many important soil activities. Soil microorganisms provide a wide range of services, including the cycling of carbon and other nutrients and the stimulation of plant growth. Soil health is also critical for food security and safety, as well as carbon sequestration. Microbial communities and other species in soils are exceedingly complex and diverse. The microbiota is made up of all living organisms of the microbiome.

Most microbiome researchers agree that bacteria, archaea, fungi, algae, and tiny protists should all be considered microbiome members [2,3]. Phage, viral, plasmid, and mobile genetic element incorporation is more contentious. Secondary metabolites have an important role in mediating complicated interspecies interactions and guaranteeing survival in competitive contexts, according to Whipps' "theatre of activity."

Small-molecule-induced quorum sensing helps bacteria to control cooperative actions and adapt their phenotypes to the biotic environment, resulting in cell-cell adhesion or biofilm formation. All live organisms in the microbiome comprise the microbiota. Most microbiome researchers agree that bacteria, archaea, fungi, algae, and microscopic protists are all microbiome members. Incorporation of phages, viruses, plasmids, and mobile genetic elements is more problematic. According to Whipps' "theatre of activity," secondary metabolites play a crucial role in mediating complex interspecies relationships and ensuring survival in competitive environments.

Small-molecule-induced quorum sensing assists bacteria in controlling cooperative behaviours and adapting their phenotypes to the biotic environment, which results in cell-cell adhesion or biofilm formation. Climate change is affecting species distributions while also influencing organism-to-organism interactions. Natural communities are complex, made up of creatures with a wide range of life histories, temperature tolerances, and dispersion abilities. Furthermore, interactions between members of a community can be beneficial, pathogenic, or have little to no functional influence, and these interactions can change in response to environmental stress.

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Because soil community members differ in their physiology, temperature sensitivity, and development rates, climate change affects the relative abundance and function of soil communities. Because soil microorganisms and the activities they facilitate are temperature sensitive, global factors such as warming have a direct impact on microbial soil respiration rates. Warming by 5°C, for example, changed the relative abundances of soil bacteria and raised the community's bacterial to fungal ratio [4]. Microbial communities adapt to warming and other disturbances by exhibiting resistance, which is enabled through microbial trait plasticity, or resilience, which occurs when the community returns to its original composition once the stress has gone.

Temperature changes are frequently accompanied by variations in soil moisture, which may explain some inconsistencies in research investigating how microbial populations respond to climate change. At warmer temperatures, for example, rates of microbial activity can be limited by diffusion and microbial interaction with accessible substrate. Even with minor changes in soil moisture availability (a 30% decrease in water holding capacity), soil fungal communities can transition from one dominating member to another, whereas bacterial communities remain steady [5].

These patterns suggest that fungal plasticity is greater than bacterial plasticity during non-extreme wet-dry cycles. Soil communities accustomed to low water availability or repeated wet-dry cycles may respond less strongly to changing water regimes in terms of composition or function. Bacteria and fungus are frequently found in close proximity to plant roots. These relationships have the potential to influence the expression of plant features such as leaf area and nutrient content.

Conclusion

However, it remains unclear (1) how temperature and moisture, and their interactions, affect specific microbial functional groups within a community, such as methanogens; (2) what effects microbial community changes have on functions such as decomposition of new and old soil organic matter; and (3) which mechanisms drive the net ecosystem response of microbial activities to climate change. We advocate investigating these concerns using factorial warming and community adjustments along temperature gradients. Similarly, using reciprocal transplants of plants and/or soils over environmental gradients could be a viable strategy to answering these concerns.

Acknowledgement

Not applicable.

Conflict of Interest

Not applicable.

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