Climate Predicts the Dominant Form of Plant-Microbe Symbiosis in Forests at a Global Scale

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https://mykophile.com/plant-microbe-interactions/mutualistic-niche/

Project Goals: The goal of this research project is to understand how microbial symbioses can be used to maximize the potential of forest trees, such as those in the genus *Populus*, for use in the production of biofuels across a wide range of climatic and environmental conditions. As a first step in guiding this work we aim to establish whether global scale patterns exist in the dominant forms of plant-microbial root symbioses, and identify the climate and environment factors that drive these patterns.

While microbes have long been viewed as agents of disease, recent explorations of the microbiome have led biologists to recognize that beneficial microbes play an equally vital role in maintaining the health of plants and animals. Perhaps the most ubiquitous form of beneficial interaction in terrestrial ecosystems occurs between fungi and plant roots, known as mycorrhizas. Despite the emerging consensus that plant-root symbioses play a critical role in determining the current and future status of forested ecosystems, little progress has been made in mapping their distributions. In one of the earliest efforts to map the functional biogeography of symbiosis, Read (1) categorically identified major biomes by their perceived dominant mycorrhizal associations and proposed that slower decomposition rates at high latitudes favors microbial symbionts with stronger decomposition abilities that enable them to compete directly for organic nitrogen. The existence of a latitudinal gradient in symbiosis would represent one of the major biogeographic patterns on the planet, on par with the latitudinal diversity gradient. Yet definitive support for the Read hypothesis does not yet exist.

As the first step in a multi-component research project to determine how climate, soil environment, and mycorrhizal interactions determine the growth potential of trees in the genus *Populus* we are leading a collaborative, global mapping project of forest root-symbioses. To do this, we have begun analyzing data from a global forest database including 1.2 million plots and 8,000 species, covering all major forested biomes. We conducted a literature search to classify all tree species in the database for their ability to form major types of microbial symbioses (arbuscular mycorrhizal, ectomycorrhizal, ericoid mycorrhizal, nitrogen-fixers, non-mycorrhizal) and used this to estimate the relative abundance of each symbiosis type across the global plot network. By linking the identity of forest trees with their associated symbionts, we generate the first spatially-explicit map of tree symbiosis functional types at a global scale.

Our map shows that there are strong latitudinal gradients in the dominance of major microbial symbiosis types, with arbuscular mycorrhizal fungi dominating lower latitude forests and ectomycorrhizal symbiosis dominating higher latitude forests. We also explored the relationships between these functional groups and broad climate variables using a random forests machine learning approach. Our analyses show that these latitudinal patterns in symbiosis are strongly tied to seasonality of temperature and precipitation.

Future experiments will provide mechanistic understanding of the patterns in these biological communities by directly testing the physiological factors that provide a competitive advantage to different mycorrhizal symbioses using *Populus*, a genus of tree which can associate with both ectomycorrhizal and arbuscular mycorrhizal fungi. By doing so we can provide important basic insights into the way beneficial interactions shape the natural world and also have a direct impact on predicting the suitability of particular sites for bioenergy projects in the light of current and future climate variability.

References

1. Read, D.J. (1991). Mycorrhizas in ecosystems. Experientia *47*, 376-391.

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