Trees rely on a range of strategies to hunt for nutrient hot spots

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Credit: Wikipedia.

On the surface, trees may look stationary, but underground their roots—aided by their fungal allies—are constantly on the hunt and using a surprising number of strategies to find food, according to an international team of researchers.

The precision of the nutrient-seeking strategies that help trees grow in

temperate forests may be related to the thickness of the trees' roots and the type of fungi they use, according to David Eissenstat, professor of woody plant physiology, Penn State. The tree must use a variety of strategies because nutrients often collect in pockets—or hot spots—in the soil, he added.

"What we found is that different species get nutrients in different ways and that depends both on that species' type of root—whether it's thin or thick—and that species' type of mycorrhizal fungi, which is a symbiotic fungus," said Eissenstat. "What we show is that you really can't understand this process without thinking about the roots and the mycorrhizal fungi together."

Tree species with thicker roots—for example, the tulip poplar and pine - avoid actively seeking nutrient hot spots and instead send out more permanent, longer-lasting roots. On the other hand, some trees with thinner roots search for nutrients by selectively growing roots that are more temporary, or by using their fungal allies to find hot spots.

Eissenstat added that fungi form mutually beneficial partnerships with trees. The fungi receive carbon from the trees while helping trees acquire nutrients.

Nutrient-gathering strategies in thin-rooted trees depend on their fungal partner, according to the researchers, who report their findings today (July 18) in the *Proceedings of the National Academy of Sciences*. One type of thin-rooted trees, including maples, which teams with fungi called arbuscular mycorrhizas, tend to grow their roots to find nutrient-rich hot spots. Another type of thin-rooted trees, including oaks, relies on fungi called ectomycorrhizas, which are capable of producing wide-spreading strands—hyphae—to bring in nutrients.

Trees approach their nutrient-seeking strategies similar to the way

investors plan their speculations.

"The investment analogy is used quite a bit in ecology because there is this whole idea of cost versus benefit," said Eissenstat. "If you're building thick roots it's really expensive to put on new pieces because they have to live a long time and if they can't get their resources back for that investment, it's not a wise strategy. But, if you're building thin cheap roots, then it's easier to build something and get it paid back quickly. They tend to die quickly, but are more opportunistic."

Understanding the function of roots and fungi could help researchers better predict the effect of climate change on forests, according to Weile Chen, doctoral candidate in ecology, Penn State, who worked with Eissenstat.

"From our study we know that different tree species may have different foraging strategies, so if the species change for some reason, such as because the climate changes, the foraging of the whole system may change," said Chen.

The researchers used a common garden at Penn State's Russell E. Larson Agricultural Research Center to conduct the study. The garden consisted of 16 tree species planted in eight similar blocks. In each block, researchers planted six individual trees from a specific species. The trees, which are now between 10 and 18 years old, are planted about 3 meters apart with 5 meters of spacing between neighboring plots. The distance helps keep the root systems separate.

"The unique experimental setting is important, too, because, in the forest there are a lot of different species of trees, but their roots are all intertwined, so it's hard to know what is really going on," said Eissenstat. "We established, about 20 years ago, a garden where each tree species is in its own block, so now we can study in the field a species' roots and

that helps us overcome a big research barrier."

Unlike more widely known processes in tree biology, such as photosynthesis and water acquisition, the complex relationship between roots and fungi is only beginning to be understood, the researchers suggested

"This is a beginning process and it's an incremental process and we're just starting to pull away the curtains and try to understand what's going on," said Eissenstat. "Some of these findings may be widely supported in other forests, or they may not be supported."

More information: Root morphology and mycorrhizal symbioses together shape nutrient foraging strategies of temperate trees, www.pnas.org/cgi/doi/10.1073/pnas.1601006113

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