Tree root research confirms that different morphologies produce similar results

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Despite markedly different root morphologies and resulting disparities in nutrient-uptake processes, forest trees of different lineages show comparable efficiency in acquiring soil nutrients, according to researchers in Penn State's College of Agricultural Sciences.

Some tree species produce thick, slow-growing roots, referred to as magnolioid-type, while other species grow thin roots, called graminoid-type, with rapid root proliferation. Trees that grow the thicker roots expend more energy and resources on them than those that grow the finer roots, and the thicker roots last longer before dying than the thinner roots.

"Yet, notwithstanding this significant difference in root growth, trees with magnolioid roots are common components of forests and often have as rapid a rate of growth as those with graminoid-type morphology," said David Eissenstat, professor of woody plant physiology. "This lack of a link between root construction and whole-plant nutrient acquisition in relatively fertile soils is in contrast to the strong link between leaf structure and carbon assimilation in leaves."

Eissenstat explained that to grow, the thick-root trees use a close symbiotic association with mycorrhizal fungi in soils to take up nutrients, while the trees with thinner, more extensive roots are less dependent on the fungi. However, the ensuing root-foraging efficiency of the two ecological strategies is comparable.

In a study conducted at Penn State's Stone Valley Experimental Forest in Huntingdon County, researchers tested the root-foraging efficiency of trees in approximately 70-year-old stands that varied widely in root morphology.

Trees included in the research, which was published recently in *New Phytologist*, were red maple, ash, black walnut, tulip poplar, cucumber magnolia, American elm and slippery elm.

Researchers used a porous root-bag technique to analyze root growth. Woody lateral roots were traced from the trunks of trees to a point where the root had tapered to about 4 millimeters in diameter. Usually, woody roots of the appropriate diameter were found within the top 20 centimeters of forest soil.

Scientists cut the 4-millimeter diameter woody root and inserted about 25 centimeters of the root into the root bag. Prior to inserting in the bag, the root was pruned of any absorptive roots, ensuring that future absorptive roots extending from the woody root were new growth. After approximately 23 weeks in the ground, the bags were excavated, and the roots inside were analyzed, weighed, measured, dissected and examined with an optical scanner.

"Because of the compensatory mechanism of close symbiosis with soil fungus, tree species with different root morphologies do not differ in the overall ability to extract nutrients from nutrient-rich patches, explaining their co-occurrence in natural vegetation," Eissenstat said. "We found that traits such as root diameter and specific root length were highly correlated with root-branching intensity, with thin-root species having higher branching intensity than thick-root species."

In both fertilized and unfertilized soil, species with thin absorptive roots and high branching intensity showed much greater root length and mass

proliferation but lower mycorrhizal soil fungal colonization than species with thick absorptive roots. Across all species, fertilization led to increased root proliferation and reduced mycorrhizal colonization.

"These results suggest that in nutrient-rich soil patches thin-root species forage more by root proliferation, whereas thick-root species forage more by mycorrhizal fungi," Eissenstat said.

"The identification of plant functional traits that can be linked to ecosystem processes is of wide interest, especially for predicting vegetational responses to climate change. The diameter of the finest absorptive roots may be one plant trait with wide significance that can be used in efforts to model diverse plant responses to changes in the environment."

Provided by Pennsylvania State University

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