Fungi adapted to mines boost plant growth

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Acid mine runoff is one of the challenges faced by restoration professionals. Coal contains sulfur which leaches into the water and forms sulfuric acid. The low pH allows heavy metals to dissolve, creating a toxic sludge. Photo by Wendy Taheri

(PhysOrg.com) -- Repopulating the moon-like terrain around abandoned mines is slow, plodding work, but a new Indiana University Bloomington report in *Applied Soil Ecology* suggests symbiotic fungi specifically adapted to toxic zones can give colonizing plant partners a strong foothold. Fungi recently adapted to living in the nutrient-poor soils around abandoned coal mines had a significant impact on plant growth -- even plants grown in non-mine soils.

"We are learning soil organisms in old mining areas are incredibly important and therefore useful to mine reclamation projects," said biologist Wendy Taheri, the report's lead author. "We need to know more about the organisms in soil, particularly the fungi, to learn how they impact, support and sustain plant communities."

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"We saw as much as a 69 percent boost in plant growth in the presence of mine-adapted fungi in non-mine soils, and as much as a 59 percent boost in mine soils," Taheri said. "It got us thinking about whether plants used in reclamation projects should be inoculated with soil microorganisms already adapted to harsh conditions."

Biologists Wendy Taheri and James Bever examined a grass and a forb (Andropogon virginicus and Plantago lanceolata, respectively) and a community of fungal mutualists that help most plants grow. The fungi were arbuscular mycorrhizae (AM), a type of fungal symbiote that actually penetrates plant root cell walls with its microscopic hyphae. Most AM fungi are mutualists, acting as intermediaries in soil nutrient uptake. The plant hosts get improved access to soil minerals, and the fungi receives food sent down to the roots from the plants' greener parts.

The scientists wanted to learn how adaptation to the unique environmental qualities of abandoned mines might be influencing the grass-fungi symbiotic relationship.

The two plants and AM fungi are endemic in the two study sites Taheri and Bever chose, a coal mine abandoned in 1993 near Midland, Ind., and an area near a different coal mine whose soil quality and plant diversity suggest it was minimally disturbed by human activity.

The AM fungi were a bouquet dominated by Paraglomus occultum, with some contribution from Glomus mosseae and an unknown Entropospora species.

The scientists took soil samples from the polluted and non-polluted study sites. Fungal spores and hyphae were extracted from the soil and separated from nematodes and insect eggs, so that what remained was an inoculum containing only AM fungi. Inocula containing no fungi, nematodes, or insect eggs were also set aside. Soil was then sterilized for use in greenhouse growth experiments.

Taheri and Bever also collected A. virginicus and P. lanceolata seeds from each study site. These seeds would represent plants adapted to mine and non-mine conditions.

Samples were then combined experimentally into 24 different treatments with 10 plants each. The scientists then examined each plant's total biomass, while also measuring the individual contributions of each plant's roots and shoots to the total.

"Many early experiments of this type have looked only at total biomass," Taheri said. "But for certain key species, like grasses, which have particularly expansive root systems, we thought it more instructive to look at roots and shoots separately."

Not so surprisingly, seeds grown without AM fungi produced stunted seedlings, if the seeds emerged at all. Plants grown in mine soil without AM fungi did particularly poorly.

What surprised Taheri the most, she said, was how well plants in non-mine soil grew in the presence of mine-adapted AM fungi. The grass A. virginicus produced 69 percent more biomass in non-mine soil (relative to plants grown in the same soil with their native AM fungi), and 59 percent more biomass in mine soil. The forb P. lanceolata produced 36 percent more biomass with mine fungi in non-mine soil relative to plants grown with non-mine fungi in non-mine soil. With the forb, however, mine soil seemed to be an equalizing force of sorts -- plants responded the same to both inocula. Because the scientists saw forbs grow 11 percent more root tissue relative to total biomass, Taheri and Bever believe the forb is particularly sensitive to the mine soil's low nutrient density.

"If what you're trying to do is help plant communities re-establish themselves quickly, it seems pretty clear now that soils -- particularly the organisms living in those soils -- matter," she said. "We are also finding that AM fungi can improve restoration of native prairie plant species in Northern Indiana," said Bever. "The next step is for us to get a handle on identifying which fungal species are doing what, which ones are best for which plant species. Getting a grip on fungal genetics is crucial there," said Taheri.

More information: "Adaptation of plants and arbuscular mycorrhizal fungi to coal tailings in Indiana," *Applied Soil Ecology* (in press; early online access), by Wendy I. Taheri and James D. Bever.

Provided by Indiana University

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