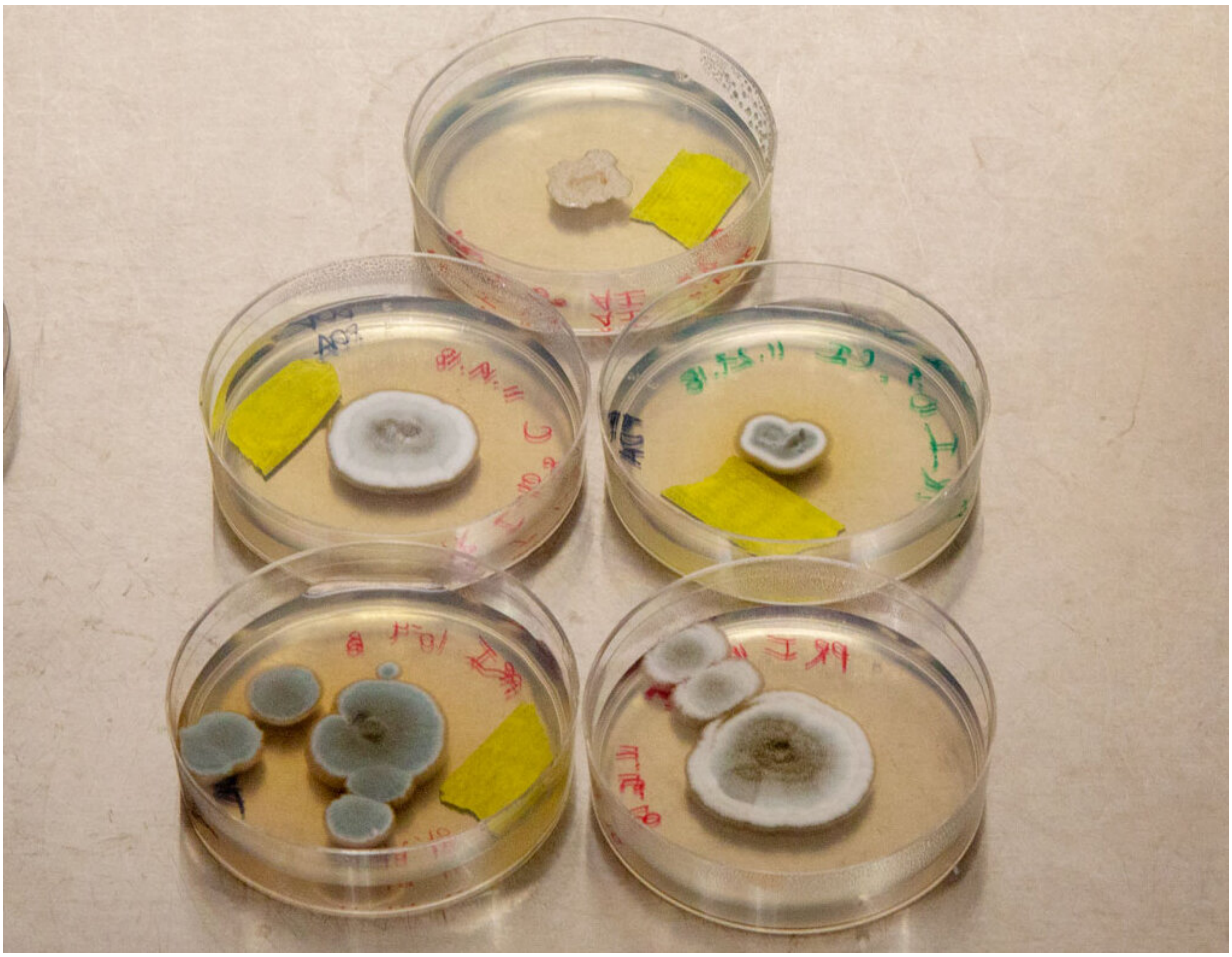
Are no-fun fungi keeping fertilizer from plants?

March 27 2019



Different fungal species isolated from native and disturbed soils within Florida International University's Miami campus and Everglades National Park. Credit: Mary Tiedeman.

Crops just can't do without phosphorus.

Globally, more than 45 million tons of phosphorus fertilizer are expected to be used in 2019. But only a fraction of the added phosphorus will end up being available to crops.

In south Florida, for example, "it is thought that less than twenty percent of phosphorus applied as fertilizer is taken up by plants before it becomes unavailable," says Mary Tiedeman, a researcher at Florida International University.

The impact is two-fold: financial and environmental. "Fertilizer costs are significant for farmers in south Florida," says Tiedeman. "And phosphorus rock, the most widely used source of phosphorus fertilizer, is in low supply across the globe. It is thought that phosphorus rock resources will only be available for the next 50 to 200 years."

Tiedeman is exploring whether a rarely-studied process involving soil fungi could contribute to low phosphorus availability to plants in south Florida. This research could also help unravel how land use influences fungal communities in soil. It may also help us better understand vital soil-phosphorus dynamics.

"In general, fungi play a tremendous role in cycling phosphorus within soils," Tiedeman says. "They can release phosphorus from mineral (rock) and organic (decaying matter) sources. From there, plants take up the released phosphorus."

But under specific environmental conditions, like those found in south Florida soils, fungi may be contributing to the problem of phosphorus unavailability. Some fungi are capable of making minerals out of elements dissolved in soil water. This process is called "bioprecipitation". Tiedeman wonders if fungi can take dissolved (plantavailable) phosphorus and convert it to less available mineral forms.

The soils of south Florida add another layer to the puzzle. "Agricultural soils in south Florida are quite unique," says Tiedeman. "They were created by pulverizing limestone bedrock to create rocky calcareous soil."

Limestone is made of calcium carbonate. When phosphorus is in the presence of carbonates in solution, it forms a microscopic layer on the surface of the limestone. Even without fungi, phosphorus availability is quickly suppressed in south Florida's soils.

"Over time, this coating can become a 'seed' for more stable, less available forms of phosphorus." says Tiedeman.

Without freed-up phosphorus, crops can't grow successfully. So many farmers in south Florida have kept adding phosphorus to soils. In a continuing cycle, most of this phosphorus becomes unavailable to plants. Over time, large amounts of unavailable phosphorus have collected in these soils. "Some agricultural soils in the area have 100-200 times more phosphorus than what was naturally present. Along with high concentrations of P, the types of P compounds present in these soils are perplexing. Recent studies have documented the presence of apatite—a phosphorus crystal that generally requires intense heat and pressure in order to form. One hypothesis, which is driving Tiedeman's research, is that microorganisms in the soil are creating stable phosphorus minerals.

To investigate whether fungi are able to create phosphorus minerals, Tiedeman is bringing the fungi into the lab. This allows her to explore several questions: How do local soil fungi respond to doses of available phosphorus while living in limestone soils? Do fungi contribute to the crystallization of phosphorus?

"We plan to analyze fungal samples and any biproducts of their growth using a scanning electron microscope," says Tiedeman. "That would allow us to actually look for crystal forms of phosphorus. It may also help us better understand how fungi get crystals to form." The study's findings aren't limited to south Florida, though. An estimated 10 percent of all arable soils are high in carbonates that behave like limestone's calcium carbonate. "Investigating south Florida's limestone soils may have implications beyond a regional scale," says Tiedeman.

"Identifying all processes involved in phosphorus unavailability in calcareous soils will be useful in developing strategies to improve fertilizer use efficiency. This could be of great benefit to producers and the environment."

Tiedeman presented her research at the International Meeting of the Soil Science Society of America, Jan. 6-9, San Diego.

Provided by American Society of Agronomy