Invasion of the Beneficial Fungi

Plant scientist Carol Janerette's pet fungi may save millions from starvation by making poor soils productive again

By Julie Langsdorf Willoughby

If Carol Janerette asks for some space in your greenhouse to grow a few asparagus plants, be prepared to give up a lot of terrain. Janerette, associate professor of plant science, has what might mildly be called a way with plants.

University greenhouse manager Paul Dennison would be the first to agree. Janerette has turned a 6- by 25-foot area of one greenhouse into an indoor thicket with approximately 80 asparagus plants. A few months ago, the 6-foot plants towered over nearby 12-inch-high soybean plants. "It was growing like a jungle," Dennison says. "It was all over the aisles. You couldn't walk through."

When things got completely out of hand, they cut the plants down to 2-inches tall. That helped for a while, but after six weeks, the plants dwarfed Dennison and other greenhouse workers at heights of 7 and 8 feet.

Janerette's green thumb soon may become much more than a curiosity at the greenhouse. The methods she uses to nourish her giant, fast-growing asparagus soon may increase the Earth's food supply and reduce the use of fertilizers by helping plants grow bigger and better in poor soil. She has two patents pending on this method, which involves a beneficial relationship between plants and a special group of fungi called mycorrhizae, that enhances the establishment, growth and survival of plants.

Janerette became interested in mycorrhizae a decade ago, when she began researching ways to bring plant life back to areas ravaged by strip-mining for the U.S. Department of Agriculture's Forest Physiology Laboratory in Beltsville, Md.

Mycorrhizae, which means fungus root, were first identified in the 19th century. The fungi's symbiotic relationship with plants had been researched and used to stimulate plant growth long before Janerette first studied it. In one classic example, the USDA used mycorrhizae during the 1950s to help foresters in Puerto Rico who had attempted to grow pine trees for more than two decades. "No matter what they did, they couldn't get the seedlings to grow," Janerette explains.

Researchers brought in mycorrhizae-rich soil from a pine forest in Georgia and planted the Puerto Rican seedlings in it. "In three years, they had pine trees that were 8-feet tall," Janerette says. The control seedlings were under 2-feet tall, "if they were alive at all," she adds. Studies showed that the mycorrhizal fungi caused the enhanced growth.

Similar results have been observed in other mycorrhizae-infected plants: The growth rate of corn increases by 122 percent, wheat by 220 percent, strawberries by 250 percent, cedar trees by 926 percent and onions by 3,155 percent.

Despite these startling results, mycorrhizae have not been used extensively on a commercial basis because of technical difficulties that Janerette believes she is well on her way to solving.

• • •

Mycorrhizae exist in the soil in a relationship that appears to be the rule instead of the exception in nature. The infection takes place when a fungus comes into contact with a root in soil that lacks nutrients. The fungus helps the root absorb nutrients more efficiently and it gets food (simple sugars) in return.

Mycorrhizae fall into two main categories: ectomycorrhizae, which form on the roots of woody plants like pine, walnut, oak and chestnut trees; and endomycorrhizae, which form on the roots of herbaceous plants like corn, wheat, asparagus and tomatoes. Endomycorrhizae can only be seen under a high-powered microscope, but ectomycorrhizae are visible to the eye.

"[Ectomycorrhizae] really do look very irregular. ... Instead of a nice, net-like pattern, you get short, thick swollen roots," Janerette explains. Their appearance some-

Plant scientist Carol Janerette's pet fungi seem to make plants grow nearly as big and fast as Audrey, the man-eating plant in Little Shop of Horrors. *Here she is surrounded by a few of her giant experimental asparagus plants. Janerette has two patents pending on a technique for inoculating herbaceous plants—including corn, wheat, tomatoes and asparagus—with the fungi that more than double the growth rate of many food plants.*

times resembles colorful sea corals. "Some of them are rather pretty," she says, pointing to a slide of a bulbous brown and white root. "Sometimes students wonder about [my] definition of pretty."

Most of the fungi that form mycorrhizae work best with a particular plant. But unfortunately, as the Puerto Rican pine case illustrates, the specific type of fungus and its host are not always in the same location. The best way to bring the two together is to inoculate the soil or plants, but that isn't as easy as it sounds. The inoculum is difficult to produce and to preserve.

Endomycorrhizae are formed by spores, but, because the fungal parent is unknown, they have never been grown in culture. To create an endomycorrhizae inoculum, the spores from specific fungi must be sifted out of the soil and separated from other spores—including disease-causing spores.

"You've got to separate these things under the microscope," Janerette says. "There can be millions." A plant must then be inoculated with the spores almost immediately, and, because there is no good way to sterilize the inoculum, plant diseases can still spread. It's a slow process that's not guaranteed to work.

Some of the fungi that form mycorrhizae on woody-plant roots can be grown in culture, but they grow slowly and they're finicky, according to Janerette. "Many times they can die," she says. One ectomycorrhizae inoculum that has been sold commercially has a shelf life of only five to six weeks.

One way to extend the shelf life for woody plant inoculum would be to make an inoculum using a resting form of the ectomycorrhizal fungi. Sclerotia, which are reproductive structures that permit the fungus to remain dormant until conditions are right, would be the ideal vehicle. Unfortunately, only a few ectomycorrhizal fungi form sclerotia, and, until Janerette came along, no one had induced sclerotia to grow in sterile cultures.

Janerette first induced sclerotia growth while she was with the USDA. If the experiment was reproducible, she knew the sclerotia could be used to produce mass quantities of sterile inoculum with a long shelf life. She was in the process of repeating the experiment when she was informed that the USDA laboratory in Beltsville would be closing down in a matter of months.

"I had to dump it," she says. "I couldn't let it grow to fruition. I was sick about it."

Janerette picked up where she left off when she came to the University in 1985. She went to work getting fungi to produce sclerotia as a survival mechanism. "You might starve it, among other things, to induce it to produce [them]," she says. "You might freeze it, burn it—I know that sounds mean."

While examining the treated fungi with a microscope, Janerette noticed swelling on the fungal strands and some sporelike structures. "Many of them looked like those endomycorrhizae spores, but they were much smaller," she says.

She suspected that these tiny, sporelike structures not only looked like, but could act like endomycorrhizae spores. Janerette

Janerette's research indicated that ectomycorrhizal fungi could be used to infect non-woody plant roots, in addition to woody plant roots—something that no one had ever reported doing. "I was almost ecstatic when I found some of these things," she remembers. "Every two weeks I was grabbing plants and looking and saying, 'Infect, infect,'" she says, laughing.

set up an experiment with onions, wheat, corn and asparagus. She germinated the plant seeds sterilely, planted them in an inert medium, then inoculated them with several different kinds of ectomycorrhizal fungi. To make sure there were no experimental errors, she planted several pots of each plant with each fungus.

"I set up 20 plants for each combination. I just about worked myself to death," she says. Combining the onions with seven varieties of fungi, she ended up with a total of 180 onion plants. Altogether, she had more than 300 plants.

After two months, it looked like the fungi were infecting the plants. Janerette noticed clumps on the surface of the roots of the samples that she examined. The clumps appeared to be microsclerotia, a dormant stage of fungus that has never been reported to be formed by ectomycorrhizal fungi. Janerette's research indicated that ectomycorrhizal fungi could be used to infect non-woody plant roots, in addition to woody plant roots—something that no one had ever reported doing.

"I was almost ecstatic when I found some of these things," she remembers. "Every two weeks I was grabbing plants and looking and saying, 'Infect, infect,'" she says, laughing.

After four months, fungi were distinctly visible, along with many of the traits associated with endomycorrhizal infections, Janerette says. "When I saw this, I knew I wanted to file for a patent."

Janerette is still waiting for action on the patent she has filed on using ectomycorrhizae to infect herbaceous plants. Her first articles on the subject soon will be published in scientific journals, she says.

Paleomicrologist Kris A. Pirozynski, curator of fossil fungi for the National Museum of Natural Science in Ottawa, is associate editor of one of those articles.

"I thought that she had fascinating results and if she's right, it's going to throw a wrench into the system. ... Many people will be uncomfortable ... all of a sudden it weakens their previous interpretations," Pirozynski says. "Even if she is not completely right, she has stumbled on something significant.

"She probably will have a hard time convincing the skeptics," he adds.

Joseph B. Morton, an associate professor of plant pathology and agricultural microbiology at West Virginia University who also has worked with Janerette, says that if her research findings prove out, they will change scientists' views on the ability of fungi to change form under varying conditions.

More importantly, though, widespread use of mycorrhizae sclerotia as an inoculum will allow crops to grow in soils where they cannot now. They will be larger than usual and grow at greatly accelerated rates, Janerette says.

"If you think on a worldwide basis, there are billions spent on fertilizers," she continues. The use of mycorrhizae could cut food production costs while helping feed starving people around the world without creating new environmental hazards.

"These are normal soil organisms. They're found everywhere, so it's not like you're adding anything new or different." **D**