Talking Beans, Tomatoes, and Marigolds Fend Off Would-Be Predators

Author: Stone, Marcia

Source: BioScience, 63(12) : 988

Published By: American Institute of Biological Sciences

URL: https://doi.org/10.1525/bio.2013.63.12.16

Talking Beans, Tomatoes, and Marigolds Fend Off Would-Be Predators

MARCIA STONE

Plants live in close-knit communities and alert each other to danger through common underground fungal networks. Arbuscular mycorrhizal (AM) fungi, for example, enable an early warning system that helps broad beans thwart predator aphids intent on sucking the life out of them.

That fungi can provide the conduits for systemic defense signaling by plants is not a new idea—Matthias Rillig and E. Kathryn Barto (now Kathryn Morris, at Xavier University in Cincinnati), of the Free University of Berlin, have been predicting this for years—but it is an idea that has only recently been experimentally confirmed. In a simple but elegant study (doi:10.1111/ele.12115), David Johnson and Zdenka Babikova, of the University of Aberdeen, and colleagues elsewhere in the United Kingdom show that danger signals can be sent from aphid-infested to uninfested broad beans by way of a subterranean network composed of branching fungal hyphae known as *mycelia*. "Getting such information to neighboring plants triggers a massive release of volatile organic compounds (VOCs), which both repels the aphids and attracts their natural enemies—particularly, parasitoid wasps," says Johnson.

To establish proof of concept, Johnson and his collaborators set up eight mycorrhizal-rich mesocosms, planted five beans in each, and let them grow for four months. Each of the four "receiver" plants had a different relationship with other plants or with the fungi: One was isolated by a mesh so fine that neither hyphal nor root contact was possible, whereas another was exposed to both. Two plants had mesh barriers that enabled hyphal but not root contact, but one was rotated and lost its initial hyphal contact immediately before the "donor" plant—positioned in the middle—received its aphids.

When the volatile chemicals collected from the air around each receiver plant were tested on the target insects, it came as no surprise to the researchers that wasps spent longer in the chambers containing VOCs from infested or chemically alerted plants than in those containing VOCs from uninfested ones (an average of 3.5 and 1.5 minutes, respectively). In contrast, the aphids lingered for about 3.25 minutes in the control chambers but spent only 1.75 minutes in the VOC-laden ones. "This unambiguous insect choice clearly demonstrates that uninfested plants connected by mycorrhizal networks to infested ones can receive danger signals and mount an infochemical-driven protective response," says Johnson.

"Aphid populations can rapidly escalate, which makes it advantageous for at-risk plants to prepare their defenses before they're attacked," adds Babikova. "A preemptive maneuver against aphids also benefits AM fungi, because infestation with these parasitic insects has a profoundly negative impact on the amount of carbon the plants feed them. [Therefore,] keeping the plants healthy is a fungal priority," she notes.

"We've known for a long time that symbiotic mycorrhizal fungi provide essential nutrients to their plant partners in return for carbon, but we've suspected far more complex interactions," according to Steve Wylie from Murdoch University, in Perth, Australia. "That aphid-infested plants can alert their uninfested neighbors to danger via a mycelial network robust enough to trigger a unified preemptive response that involves calling in killer wasps is a notably complex and calculated interaction any military commander would be proud of."

The first evidence suggesting that disease-alerting signals could be transferred from one plant to another through a common mycelial network came from Ren Sen Zeng, of the South China Agricultural University, in Guangzhou, and his colleagues in 2010 (doi:10.1371/journal.pone.0013324). These scientists showed that mycorrhizal-connected tomato plants experimentally infected with the leaf-blight-causing fungus *Alternaria solani* were less likely to sicken than their unconnected counterparts and those that did develop blight had milder symptoms.

A year later, Barto and her collaborators reported (doi:10.1371/journal.pone.0027195) that two plant-inhibiting, or *allelopathic*, chemicals released by marigolds accumulated at higher levels in soils with common mycorrhizal networks than could be achieved by diffusion alone, and the increased accumulation was associated with reduced growth of the target plants. These scientists argue that because approximately 80% of terrestrial plants have mutualistic relationships with AM fungi, the bioactive zones of allelochemicals are greatly expanded in the wild, which makes what goes on in the laboratory deceptive. "The Barto and Zang groups' findings provide compelling evidence that the roles of fungal networks in pest control, both plant and animal, need further investigation—hence our current study," Johnson says.

Such research is crucial because climate change causes insects and pathogenic fungi to spread, adding to the major concerns about food security in many countries. Using protective strategies that plants devise on their own is a very promising way to deal with these threats, especially as resistance to pesticides and fungicides evolve. Intensively farmed plants are at particular risk from migrating crop pests, because they get all the fertilizer they need from farmers and rarely connect to mycorrhizal fungi, according to Johnson. Therefore, one important expected outcome of these studies is the development of natural land-management practices that promote fungal formation: intercropping with pest-repelling mycorrhizal-enhanced plants, for example.

Marcia Stone (mstone99@verizon.net) is a science journalist based in New York City.

doi:10.1525/bio.2013.63.12.16