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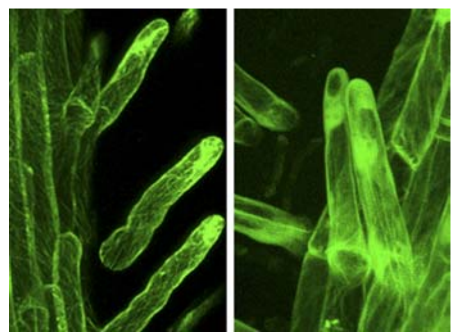
Study: Friends, Enemies Communicate With Plants in Similar Ways

FOR IMMEDIATE RELEASE

Two soil-dwelling strangers – a friend and a foe – approach a plant and communicate with it in order to enter a partnership. The friend wants to trade nitrogen for food. The foe is a parasite that wants to burrow in and harm the plant.



Fluorescence confocal microscope images of plant epidermal and root hair cells expressing Green Fluorescent Protein (GFP) fused with microtubule associated protein, MAP4 (left), and actin binding protein, Talin (right). New evidence confirms that root-knot nematodes and rhizobia produce an essentially identical cytoskeletal response in these tiny root hairs of *L. japonicus*.

In a new finding published in *Proceedings of the National Academy of Sciences*, researchers at North Carolina State University have found that the two strangers communicate with the plant in very similar ways. The plant's responses to both friend and foe are also remarkably similar.

Using high-tech microscopy and florescent imaging techniques that allow for real-time, three-dimensional study in living cells over time, the NC State researchers discovered that the model legume *Lotus japonicus* responded similarly to signals from both rhizobia, the friends that fix nitrogen for the plant, and root-knot nematodes, the parasitic foes that want to harm the plant. Signals from both outsiders induce rapid changes in distribution of the plant's cytoskeleton, which is part of a pathway that leads to a series of growth changes that include the formation of either nodules housing bacteria or giant cells from which the nematodes feed.

The scientists also discovered that, like rhizobia and contrary to popular belief, the root-knot nematode signals plants from a distance and therefore does not need to attach itself to the plant to elicit a response.

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When the researchers studied *L. japonicus* plants missing the receptors that receive signals from other organisms – certain genes in the plant were modified to accomplish this – they discovered that the plants failed to respond to signals from both friend and foe, and therefore no changes were viewed in the plant's cytoskeleton.

"This exquisite system that plants have developed to allow beneficial interactions with other organisms like rhizobia is being exploited by nematodes," says Dr. David Bird, associate professor of plant pathology, co-director of NC State's Center for the Biology of Nematode Parasitism and co-author of the paper. "Nematodes have not only found a weak link in plants but may be using the very same bacterial machinery against it."

The study started as a graduate research project of Ravisha R. Weerasinghe, the lead author of the paper, in the lab of Dr. Nina Allen, professor of botany and co-author of the paper. Weerasinghe first observed the changes in the plants triggered by signals from rhizobia, called Nod factors, and then saw the similar changes occurring when plants were signaled by root-knot nematodes. In the paper, the researchers call the nematodes' signals "Nematode factors."

After rhizobia perceive plant signals and send back Nod factors, the plant's root hairs curl around the good bacteria. The rhizobia then migrate into the root and form special structures called nodules, where they turn atmospheric nitrogen into usable nitrogen for the plant and, in return, take some of the plant's energy to survive. A similar relationship appeared when Weerasinghe studied the signals between plants and nematodes, even though the nematode provides no benefit to its host. Root-knot nematodes form feeding cells – so-called giant cells – in the plant and later galls or knots on it.

"We don't know the precise structure of Nematode factor, but it appears that the nematodes may have actually acquired genes from rhizobia to exploit this signal pathway," Bird says.

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Note to editors: The abstract of the paper follows.

"Root-knot Nematodes and Bacterial Nod Factors Elicit Common Signal Transduction Events in *Lotus japonicus*"

Authors: Ravisha R. Weerasinghe David McK. Bird and Nina S. Allen, North Carolina State University

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Abstract: The symbiosis responsible for nitrogen fixation in legume root nodules is initiated by rhizobial signaling molecules [Nod factors (NF)]. Using transgenically tagged microtubules and actin, we dynamically profiled the spatiotemporal changes in the cytoskeleton of living *Lotus* *japonicus* root hairs, which precede root-hair deformation and reflect one of the earliest host responses to NF. Remarkably, plant-parasitic root-knot nematodes (RKN) invoke a cytoskeletal response identical to that seen in response to NF and induce root-hair waviness and branching in legume root hairs via a signal able to function at a distance. Azide-killed nematodes do not produce this signal. A similar response to RKN was seen in tomato. Aspects of the host responses to RKN were altered or abolished by mutations in the NF receptor genes *nfr1*, *nfr5*, and *symRK*, suggesting that RKN produce a molecule with functional equivalence to NF, which we name NemF. Because the ability of RKN to establish feeding sites and reproduce was markedly reduced in the mutant lines, we propose that RKN have adapted at least part of the symbiont-response pathway to enhance their parasitic ability.