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Damage Control: Bioengineering Root-knot Nematode Resistant Plants

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The development of a novel resistance gene effective against the world's most damaging plant-parasitic nematodes has the potential to revolutionize root-knot nematode resistance in all crops, especially in crops for which natural resistance genes do not exist.

Figure 1. Galls on a tomato root system infected with the root-knot nematode.

Root-knot nematodes, the world's most economically important group of plant-parasitic nematodes, attacks nearly every food and fiber crop grown and some 2,000 plant species in all. These nematodes are widely distributed throughout the United States, and cause losses in field crops, vegetables, fruits, small grains, forage crops, ornamentals, and turf grasses. The soil-borne root-knot nematodes invade plant roots and feed on root cells, causing the roots to grow large galls, or "knots", called root-knot disease. The damage to the root system prevents the plant from properly absorbing water and nutrients. As a result, plant growth is stunted and crop yield diminished. Four common root-knot nematode species account for 95 percent of all root-knot nematode infestations in agricultural land.

Development of root-knot nematode resistant plants is the most cost-effective and environmental friendly method to prevent nematode damage and limit crop losses. However, only a small number of plant species are naturally resistant to root-knot nematodes and there are many crops for which appropriate resistance genes have not been identified.

Science In Action

Scientists at the University of Georgia directed their research to understand the molecular tools used by root-knot nematodes to infect plants. This information is essential to effectively bioengineer plant resistance to these agriculturally important pests.

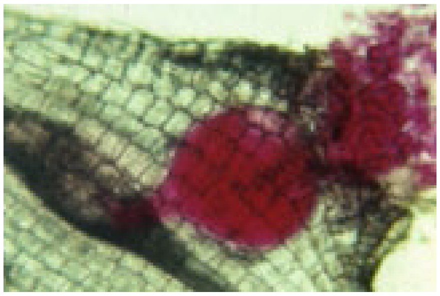

Figure 2. Female root-knot nematode feeding on the vascular tissue inside a root gall. Nematode and egg mass are stained red.

A)

B)

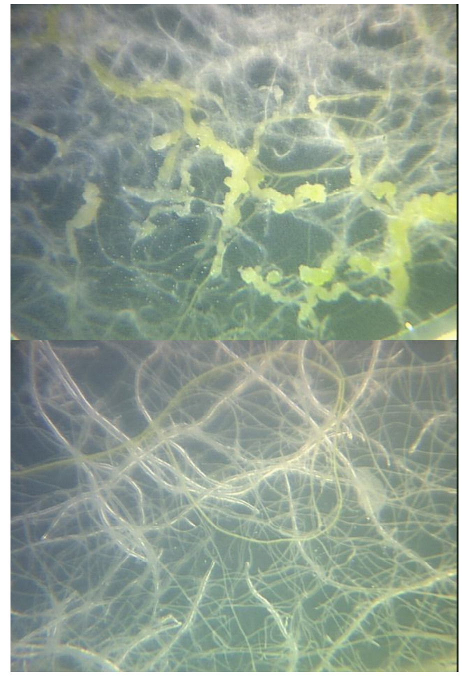

Figure 3. RNAi inhibition of root-knot nematode infection of Arabidopsis roots. A) Control vector-transformed roots with numerous galls and B) the bioengineered roots showing no galls eight weeks after inoculation (Huang et al., 2006, PNAS, 103:14302-14306)

Turning Biology Against Itself

The scientists identified a parasitism gene in the root-knot nematode essential for the nematode to infect crops. Using a technique called RNA interference (RNAi), the researchers have effectively turned the nematode's biology against itself. The scientists genetically modified the plants to produce double-stranded RNA. This specialized RNA silences, or shuts down, the specific parasitism gene when the nematode begins to feed on the plant's roots. Silencing the parasitism gene disrupts the nematode's ability to infect the plant. Thus, the modified plant becomes resistant to the nematode. No plants with natural root-knot resistance has as an effective range of resistance to the root-knot nematode as this newly developed plant.

The resistance gene is effective against the four most common species of root-knot nematodes. This spectrum of resistance circumvents many of the challenges associated with the narrow specificity of natural root-knot resistance genes.

Using this knowledge, the researchers developed a way to effectively halt the damage caused by one of the world's most destructive group of plant pathogens. This research was funded by USDA's National Research Initiative Entomology/ Nematology and Suborganismal Biology of Arthropods and Nematodes Programs as well as State and Hatch funds for the Georgia Agricultural Experiment Stations.

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