Protecting crops from nematodes

Just like animals, plants are bombarded by all sorts of pathogens and parasites. Currently, one particular species of nematode is threatening to cause widespread issues for a variety of important crops. At **Clemson University**, South Carolina, USA, **Dr Paula Agudelo** and her team are employing cutting-edge science from a wealth of different fields to develop an array of solutions to defend crops against these worms.

Dr Paula Agudelo

College of Agriculture, Forestry and Life Sciences, Clemson University, USA

PROFILE

Fields of research
Plant Pathology, Nematology

Research project
Investigating the characteristics of the crop pest nematode *Meloidogyne enterolobii*, to help develop effective management strategies and resistant crop varieties

Funder
US Department of Agriculture (USDA)

TALK LIKE A ...

NEMATOLOGIST

Biological control — reducing a crop pest's impact by introducing a natural enemy that reduces its population

Ecological niche — the environmental conditions within which a particular species has adapted to exist

Galling — the development of abnormal growths (galls) on plant tissue, often caused by parasites

Germplasm — a collection of genes or genetic material for use in the improvement of plants, namely crops

Me — scientific shorthand for *Meloidogyne enterolobii*, a species of root-knot nematode (RKN)

Nematode — a worm in the very diverse and populous *Nematoda* phylum

Nematology — the scientific study of nematodes

Root-knot nematode (RKN) – a parasitic nematode from the *Meloidogyne* genus

The world around us is brimming with life impossible to see with the naked eye. This microscopic jungle includes nematodes, which, while tiny in size, are gigantic in number. In fact, it is estimated that 80% of all animals are nematodes, and they have adapted to be present in just about every ecosystem on Earth, from the highest mountains to the deepest parts of the ocean floor. They are very diverse, with perhaps a million species in existence, and are crucial to the health of the planet. However, every so often, particular nematode species come along which pose a major headache to humanity – for instance, by becoming a significant crop pest.

Dr Paula Agudelo is leading efforts to tackle one such nematode species, which has recently arrived in Southeastern USA and is threatening to majorly impact the yields of farmers in the area, and possibly further afield. Based at Clemson University's College of Agriculture in South Carolina, Paula's FINDMe project has the broad task of understanding this nematode in detail, and using this knowledge to develop management strategies and crop varieties that show resistance to this species.

A little bit about Me

This troublesome worm is part of a particularly problematic group of nematode species known as root-knot nematodes (RKN). "RKN feed on the roots of plants and cause galling," says Paula. "This results in reduced yield and quality of crops." The specific species has the scientific name of *Meloidogyne enterolobii*, or Me for short. "Me is able to affect a broad range of important vegetable crops that are otherwise resistant to other RKN species," says Paula. "This aggressive nematode causes severe root galling, leading to significantly reduced quantity and quality of crops, including sweet potato, guava, cucumber and soybeans, as well as many others."

Me is thought to have originated in China, with global trade enabling it to spread further afield. For example, in the early 2000s, it arrived in Brazil and, subsequently, led to the collapse of the country's guava industry. Now, it has been detected in Southeastern USA. "There is an urgent need to understand how to manage Me and develop Me-resistant crops before it spreads to other parts of the world," says Paula. "If it becomes widespread before we learn how to manage it, vegetable production

Soybean field with nematode infection symptoms

could be seriously threatened." This would be a worrying scenario, especially in a world with a growing population and an ever-increasing demand for food and efficient agriculture.

The task at hand

The phrase 'know your enemy' is highly relevant for agriculture. The more knowledge that is amassed about a pest such as Me, the greater the capacity to develop targeted strategies to reduce the threat it poses. With this in mind, Paula's team is focusing on some key issues:

- The characteristics of Me, such as its distribution and the genetic diversity within the species, which affect how it might respond to efforts to manage it.
- Identifying resistance genes in plants that can be used to develop Me-resistant crops.
- The effectiveness of different management tactics, such as nematicides, crop rotations and biological controls.

Naturally, such a broad array of questions requires a broad array of expertise. "Our research team includes expertise in plant breeding, plant pathology, population genetics, nematology, horticulture, economics, and integrated pest management," explains Paula.

It is important that such a real-world issue is not considered as just a scientific brainteaser. Paula is adamant that FINDMe's research outcomes need to be directly useful for those whose livelihoods depend upon crop success. "The Me problem directly affects producers, processors, distributors, researchers and agricultural educators," she says. "To understand how we can make our research as relevant as possible, we are bringing together experts from biology and socioeconomics, alongside principal stakeholders and partners, to inform the direction of our research and its applications."

Research underway

Paula's team has been busy gathering data to understand Me's changing distribution and how it is moving from place to place. "We have sampled fields with Me-infected plants in Southeastern USA, and are now doing a systematic survey of sites in the area that distribute planting material or nursery stock, which are likely a key way that Me is spreading," says Paula. Once these pathways are identified, there is potential to put measures in place to detect Me-infected materials at source and prevent them reaching new places.

For millennia, people have bred crops by selecting those with the best traits, such as their ability to resist pests and pathogens. These days, we have the technology to perform this selection process to a high degree of precision. "Within the natural variation found within host crops, there are likely some variants that are less susceptible to Me than others," says Paula. "By doing controlled crosses between different plant parents, we can develop varieties that have Me resistance as well as other desirable traits." The crop material used as the source for these varieties is known as 'germplasm', a generic term referring to genetic stock material. "So far, we have promising germplasm for sweet potato, watermelon, pepper and eggplant (also known as aubergine or brinjal)," says Paula.

Management strategies

There is a wealth of different strategies that agriculturalists employ to secure high crop yields, and research is an essential cornerstone to improve these strategies and develop brand new ones. In the case of Me, these strategies include:

- Nematicides: pesticides that specifically target nematodes.
- Crop rotations: growing different crops on the field at different times, which can boost soil properties and help reduce Me prevalence in the soil.
- Cover crops: non-commercial crops grown on fields between periods of commercial crop production, to protect or improve the soil, such as by repelling Me.
- Biological controls: introducing living organisms to suppress Me populations, such as Me predators, parasites or pathogens.

"We first test all these different strategies at a small scale in the greenhouse," says Paula. "For those strategies that yield promising results, we then test them in the field under controlled conditions. Those that work best are then tested in real farms under real production conditions." Initial results have been informative, with the team finding that some cover crops such as wheat, sunn hemp and sorghum-sudangrass are effective at managing Me. "These results provide a welcome start to the FINDMe project," says Paula. "Our next steps are to continue investigating all our research questions, from the characteristics of Me, to effective management tactics, to the development of Me-resistant crop varieties."

The FINDMe team

John Mueller, Professor,
Clemson University, Blackville, SC

Antonio Baeza, Associate Professor,
Clemson University, Clemson, SC

Adrienne Gorny, Assistant Professor,
NC State University, Raleigh, NC

Lina Quesada, Professor,
NC State University, Raleigh, NC

Phillip Wadl, Research Geneticist,
USDA-ARS, Charleston, SC

William Rutter, Research Plant Pathologist,
USDA-ARS, Charleston, SC

Zhengfei Guan, Associate Professor,
University of Florida, Wimauma, FL

Johan Desaeger, Associate Professor,
University of Florida, Wimauma, FL

Zane Grabau, Associate Professor,
University of Florida, Gainesville, FL

Tristan Watson, Assistant Professor,
Louisiana State University, Baton Rouge, LA

Intiaz Chowdhury, Assistant Professor,
University of Georgia, Tifton, GA

About *nematology*

Despite being largely unnoticed by the general population, nematodes are a crucial cornerstone of life on Earth. Building our knowledge of nematodes both helps us to understand how ecosystems function and to address very real-world issues such as food security. Paula explains more about her discipline.

"Nematodes are everywhere. They have adapted to a wide variety of hosts, climates and ecological niches. Because they are so diverse, they can be useful indicators of ecosystem health. Nematodes can be bacterivores, fungivores, herbivores and predators. Looking at the abundance and diversity of their populations can help us make inferences about the stability and composition of other living things in the system.

"I find it exciting that there is so much we still don't know about nematodes. I enjoy the complexity of the interactions that their study entails; they affect, and are affected by, soil, water, plants and animals. All of these, of course, also affect us, especially our agricultural practices.

"Current and future nematologists have the challenge of understanding nematode diversity before certain fragile ecosystems disappear. There is also a pressing need to find ways to restore balance in agricultural soils, promoting practices that allow the coexistence of crops and nematodes, without nematodes becoming pests. In particular, we need to find ways to reduce pesticide use as a means of controlling nematodes."

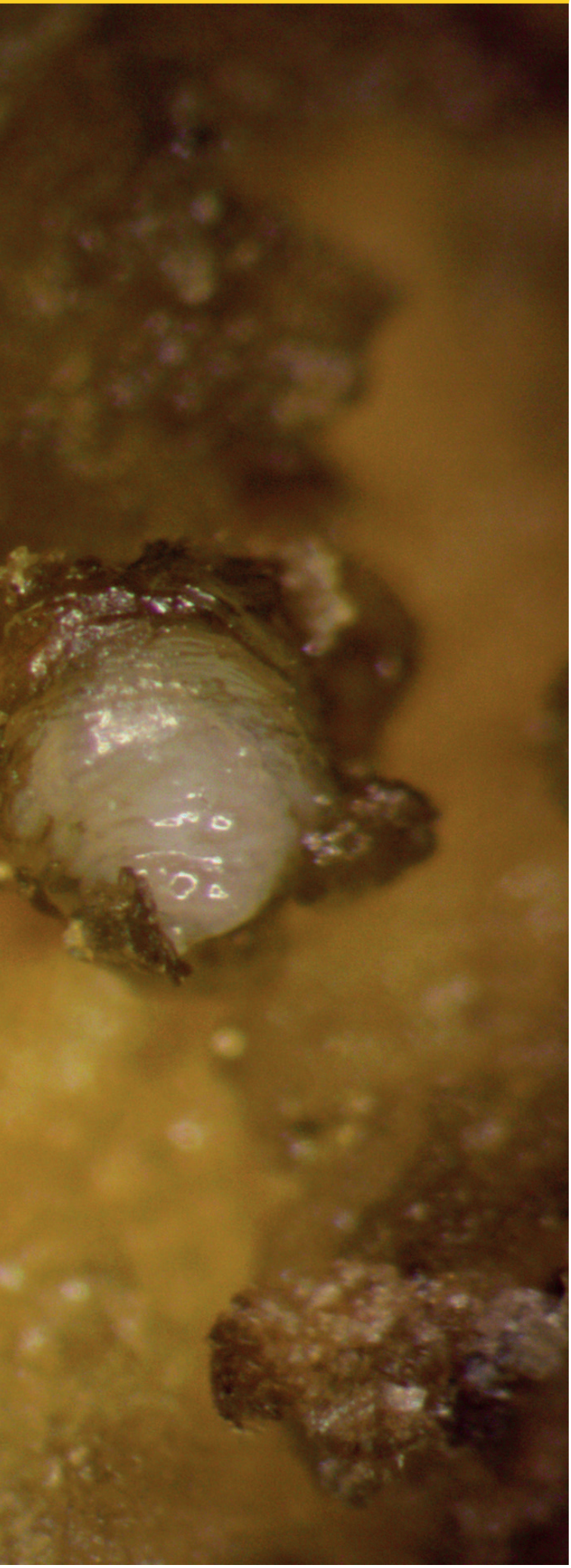
"CURRENT AND FUTURE NEMATOLOGISTS HAVE THE CHALLENGE OF UNDERSTANDING NEMATODE DIVERSITY BEFORE CERTAIN FRAGILE ECOSYSTEMS DISAPPEAR."

Pathway from school to *nematology*

- Useful subjects to study at high school and beyond include biology, chemistry and mathematics.
- University degrees that can lead to a career in nematology include agronomy, biology, plant science and agricultural science. Paula recommends seeking university modules in plant physiology, microbiology, soil science and plant pathology.

Explore careers in *nematology*

- The South Carolina Commissioner's School for Agriculture is a summer programme for high school students that inspires careers in agricultural science and related sectors, as well as nurturing the development of leadership skills: **www.clemson.edu/cafls/sccsa/index.html**
- Clemson University Cooperative Extension 4-H Youth Development is a broad programme open to 5 to 18-year-olds. It runs a variety of clubs, workshops, camps and more, all with the aim of helping young people gain the knowledge and skills to be valuable members of society: **www.clemson.edu/extension/4h/index.html**
- The Society of Nematologists is an international organisation to advance the science of nematology. Its website has a wealth of knowledge, as well as opportunities to make connections and get further involved: **www.nematologists.org**
- The American Phytopathological Society focuses on the advancement of plant pathology. On its website, you can delve into relevant research and find opportunities such as early-career internships: **apsnet.org/Pages/default.aspx**
- According to Salary Expert, the average salary for a nematologist in the US is around $75,600.



Meet *Paula*

My father inspired me to become a scientist. He always experienced the natural world with a sincere curiosity and sense of awe, which he passed on to me.

Teaching is the most rewarding aspect of my career. Striving to become a better teacher has also made me a better researcher.

When encountering obstacles, I try to maintain perspective. I remind myself about how my efforts are helping agriculture and, by extension, the world.

The successes of my graduate students represent my proudest achievements. Their continued engagement in science or science education are their own accomplishments, but I am proud to have contributed to their education.

I aim to continue to educate young people about how new knowledge is created, and the responsibilities we hold to the world. We need to care for our natural resources, and I seek to instil a sense of commitment for students to do good with the knowledge they gain.

Paula's *top tips*

1. Always consider the complexity of interactions between organisms. All diseases are an interaction between the host, the pathogen and the environment. Each of these parts can be influenced by many different factors, which affects how the disease presents itself.

2. Keep an open mind!

Root gall with protruding egg mass