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Globodera Alliance Newsletter

Phytosanitary Measures to Minimize Invasive Nematodes

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GLOBAL
Globodera Alliance

Inside this issue:

In short, if all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable, and if, as disembodied spirits, we could then investigate it, we should find its mountains, hills, vales, rivers, lakes, and oceans represented by a film of nematodes."

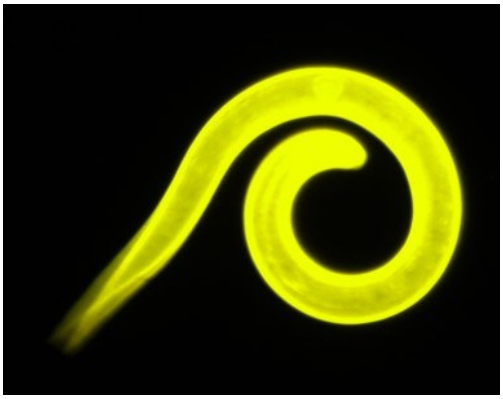
Nathan Augustus Cobb (1914)

Nematode Biology

Nematodes are the most numerically abundant animals on earth. It is estimated that *four out of every five animals* is a nematode and that densities can exceed a million individuals per square meter. Nematodes, also called roundworms, can be free-living in soil or water, or parasites of animals or plants. Nematodes are found in an astonishing range of habitats, from the poles to the tropics, on mountains and in deserts, in lakes, rivers, and in the ocean.

In 1914, N.A. Cobb, the father of nematology in the United States, suggested that:

> *"In short, if all the matter in the universe except the nematodes were swept away, our world would still be dimly recognizable, and if, as disembodied spirits, we could then investigate it, we should find its mountains, hills, vales, rivers, lakes, and oceans represented by a film of nematodes."*



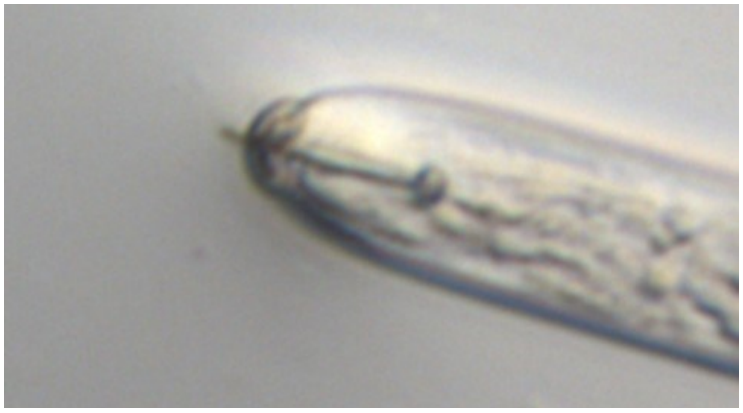
Potato cyst nematode (*Globodera pallida*) with fluorescent stain (PKH26) observed under the microscope (R. Kooliyottil)

Some nematodes feed only on plants and are referred to as plant-parasitic nematodes. They may not appear as impressive as human parasites that cause river blindness, or filariasis in humans, but plant parasitic nematodes are responsible for an approximate 15% crop-loss per year world-wide, equating to some $78 billion.

Plant-parasitic nematodes can come in many different shapes; most are slender and threadlike, but some are lemon-shaped, round or appear swollen. And, being less than 1 mm long, nematodes are almost invisible to the naked eye. They all share some common features. Plant-feeding nematodes have a sharp needle-like structure in their mouth called a 'stylet' which acts like a small hypodermic needle which the nematode uses to invade plant cells and suck out the cell contents. Most are subterranean, living below the soil surface and have adapted to survive in potentially hostile soil environments. Nematodes have evolved many strategies to survive fluctuating soil temperature

and moisture conditions, and to escape predation by other soil organisms such as fungi, bacteria, or even voracious predatory nematodes. Some are able to survive the onset of extreme heat or cold, or drying of soil by entering a state of suspended metabolic activity called cryptobiosis. This ability to survive in an almost inanimate state is one reason some nematode species can survive in soil for many years and resume activity only once favorable conditions return. Some plant parasitic nematodes also evade hostile environments and predators by living most of their lives inside plant roots and have only short periods of time in the soil. By using multiple survival strategies, nematodes withstand seemingly extreme environments.

Nematodes are aquatic, but can swim only short distances to reach their hosts. They use the moisture in spaces between soil particles to move through the water. Nematodes can be dispersed over long distances on nematode-infested soil clinging to farm equipment, muddy shoes, or in plant material such as tubers, bulbs, or roots. Nematodes can easily be transported across borders in infested plant material or in soil. Essentially any process that moves soil or plants is a pathway for introduction of these potentially invasive species. Invasion of agricultural lands by nematodes has come about though inadvertent movement in trade of infested agricultural products such as bulbs, nursery stock, seeds, tubers, or on contaminated equipment. Once introduced, apparent damage from nematodes has often gone unnoticed and has been easily attributed to other factors such as nutritional deficiency.



The head of a potato cyst nematode (*Globodera pallida),* viewed under microscope, with feeding stylet visible (R. Kooliyottil)

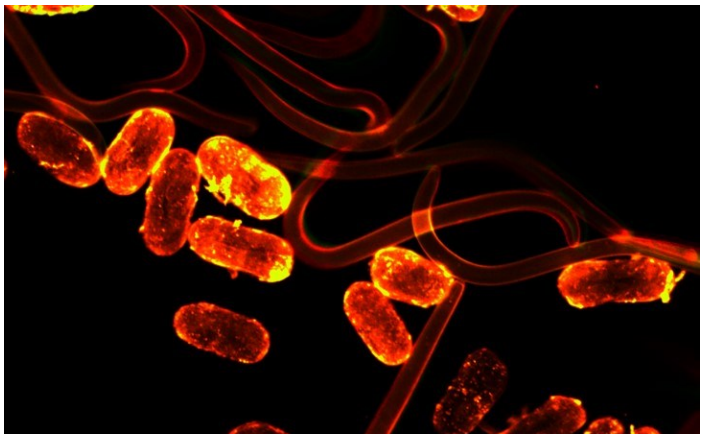
Historical Regulation

As more has become known about nematodes and their damaging impact on crops, governments have increasingly placed nematodes on plant health legislation to prevent their introduction or spread. In the U.S., phytosanitary action specifically addressing plant parasitic nematodes was first implemented in 1909 against root knot nematode infested cherry trees from Japan. Soon after, in 1912, the U.S. Congress approved the first Plant Quarantine Act to minimize the threat posed from this nematode. A number of years later, the damaging impact of the potato cyst nematode, *Globodera rostochiensis*, the golden nematode (GN) was recognized. The Golden Nematode Act was passed in 1948 by the U.S. Congress to protect the U.S. potato industry from the spread of this damaging nematode. Europe's first phytosanitary legislation, the Beet Eelworm Order, was adopted in 1943 to manage spread and levels of infestations of the sugar beet cyst nematode in Britain.

International Agreements

In today's globalized world, intensified international trade has increased the risk of an introduction of noxious pests, including nematodes. Phytosanitary measures for the exclusion, suppression, containment, or eradication of plant pests have been developed throughout the world to prevent risk of an entry from potentially damaging pests. Many of these measures are designed to minimize the transport and worldwide spread of pests or pathogens harmful to plants which may need to be contained, or excluded. Legislation in most countries is based on international treaties and conventions. The International Plant Protection Convention (IPPC) is an international treaty that aims to secure coordinated, effective action to prevent and to con-

trol the introduction and spread of pests of plants and plant products. The IPPC is administered by the Food and Agriculture Organization (FAO) of the United Nations and is recognized by the World Trade Organization under the Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement). The Commission on Phytosanitary Measures (CPM) is the governing body of the IPPC and has developed the International Standard for Phytosanitary Measures (ISPM) No. 5 called the Glossary which was adopted in 1997 by the FAO. The WTO-SPS agreement, an outcome of the General Agreement on Tariffs and Trade (GATT), states that the purpose of an SPS is limited to the protection of human, animal or plant life or health; it applies to all sanitary and phytosanitary measures that can affect international trade. Phytosanitary measures for the purpose of preventing spread or introduction of plant pests can only be applied to regulated pests. 'Quarantine pest' as defined by the Glossary is 'a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled'.



Potato cyst nematode (*Globodera pallida*) eggs and juveniles stained fluorescent (PKH26) (A. Duarte)

About the GLOBAL Project

GLOBAL stands for "Globodera Alliance", an international group of research, extension, and education professionals working to eradicate *Globodera spp.* in U.S. potato production.

GLOBAL Project members include scientists from the University of Idaho, Oregon State University, Cornell University, U.S. Department of Agriculture (USDA), Agriculture and Agri-Food Canada, The James Hutton Institute, and the French National Institute of Agricultural Research.

Follow the GLOBAL Project online at:

www.globodera.org

Funded by the USDA National Institute of Food and Agriculture.

National Legislation and Regulations

National legislation and regulations provide the framework for protecting agricultural, and other plant resources from invasive pests. Implementing regulations or measures that ensures low pest prevalence in the exporting country, treatment of consignments, importing dormant plants and restricting import to certain seasons, or prohibiting the import of affected commodities are some of the measures taken to prevent or mitigate introduction of pests through trade. IPPC recognizes the right of countries to regulate the import of certain plant species to avoid entry of a pest, to inspect or quarantine specific consignments, and to define which pest species are not allowed entry. According to this agreement, countries have the right to decide their own level of acceptable risk, and to apply phytosanitary measures as required to protect plant health as long as these measures do not discriminate against certain countries or commodities and has as little impact on trade as possible. Phytosanitary measures need to be science based or based on international standards such as the ISPM set by the IPPC.

Regional Plant Protection Organizations (RPPOs) were recreated by the IPPC and allow for regional collaboration and coordination

of phytosanitary issues and standards for respective regions. Nine RPPOs are currently recognized by the IPPC. The U.S. is a member country of the North American Plant Protection Organization along with Canada and Mexico. Individual countries have their own National Plant Protection Organization (NPPO). In the U.S., the NPPO responsible for operating the regulatory framework for phytosanitary measures based on international standards is the United States Department of Agriculture's Animal Plant Health Inspection Service (USDA APHIS).

Potato Cyst Nematodes

Potential quarantine pests that meet the above criteria are evaluated through a pest risk analysis. Nematode pests of potato are among some of the most highly regulated pests in the world due to their impact on trade and production systems and because they are readily transported and spread in infested tubers or in soil clinging to potato tubers. Phytosanitary measures work best for nematode species that have a narrow host range, and a slow rate of reproduction. For the U.S., examples of regulated nematode pests include the potato cyst nematodes, *Globodera rostochiensis*, which is regulated by 119 countries worldwide, and *Globodera pallida*, which is regulated by 80 countries worldwide. Both potato cyst nematode species originated in South America. Introduction of *G. rostochiensis* into the U.S. is believed to be from Europe on military equipment contaminated with infested soil used during the Great War, World War I. While the *G. pallida* infestation discovered in 2006 in Idaho remains of uncertain origin.

Globodera pallida cysts attached to potato root (J. Rowley)

Canada and the U.S. have developed a bilateral set of guidelines for phytosanitary actions for potato cyst nematodes. Potato cyst nematodes are not widely distributed in either Canada or the U.S. and are under official control in both countries. Scientifically recognized as long lived and capable of being highly destructive, both PCN species survive in soil for decades as eggs contained in a protective cyst which are difficult to detect. Potato cyst nematodes are difficult to control, which necessitates the use of phytosanitary measures including surveillance and sanitation to minimize the risk of PCN spread. Although host plant resistance to some races of *G. rostochiensis* is commercially available for the northeast U.S. and Canada, full resistance to *G. pallida* in commercially relevant russet-type potatoes grown in the northwest is not currently available.

In the U.S., stringent adherence to phytosanitary programs have contained *G. rostochiensis* to eight counties in New York, fewer than 6,000 acres, despite its documented presence since 1941. The infestation of *G. pallida*, first found only in Idaho in 2006, continues to be contained to 3,047 acres which is less than 1% of the total acreage planted to potato in Idaho. Efforts in Idaho by both USDA APHIS and the Idaho State Department of Agriculture have concentrated on containment, sanitation and eradication of *G. pallida.* Of the 25 infested fields that have been treated, 20 no longer have detectable viable eggs. Of those 25 invested fields, 8 have cleared a greenhouse bioassay at the University of Idaho and are again eligible to return to potato production while remaining regulated and subjected to surveys after each of the next three potato crops. One field was planted with a susceptible potato crop and post-harvest surveys did not detect viable PCN. Trade of potato from the U.S. and from Idaho, originally interrupted by the detection of *G. pallida*, has resumed with Canada, Mexico and South Korea, whereas negotiations to resume export of potato from Idaho to Japan are ongoing.

Nematodes are excellent at invading new territory and becoming established before they can be detected. Nematodes almost always have help from humans in this invasion. Also, nematodes are impossible to detect without collecting soil. One cannot

look at a field and say that specific plant parasitic nematodes are present or not without taking soil samples and extracting the nematodes from the soil. An acre of soil contains approximately 267,000 gallons of soil down to 10 inches. The delimiting sample system currently in use by the USDA takes four 2000 cubic centimeter samples per acre of soil and is the most stringent potato cyst nematode sampling protocol in the world. When nematode infestations are very small, surveys (even high intensity surveys) may not detect the infestation. *Globodera* populations can increase in number very quickly under the right conditions, usually increasing a minimum of twenty to fifty times over a single cropping season (so that 10 cysts in a field become 200 to 500 cysts in a field after just one host crop). With the current survey method being used by USDA, very small infestations can be detected after only two or three host crops, well before the populations are likely to spread to additional fields with appropriate sanitation.

Intervention strategies aimed at preventing their establishment through early detection, exclusion, quarantines, containment, and eradication decreases the probability of an introduction, prevents spread, and minimizes the risk of damage to economically valuable crops. Phytosanitary programs are essential for maintaining plant health in any country or region, especially when applied to nematode infestations. The challenge continues to be understanding nematode biology so that they can be detected, identified, and intercepted to prevent their introduction and minimize their damage.

Upcoming Event:

2017 Idaho Potato Conference & Ag Expo

January 18-19, 2017
Pocatello, Idaho

GLOBAL Project Investigators will be presenting several workshops at the Idaho Potato Conference, including an update on work underway to control PCN and develop PCN resistant potatoes. A workshop about PCN will also be conducted in Spanish.

To register for the conference go to: **www.idahopotatoconference.com**

GLOBAL Investigators

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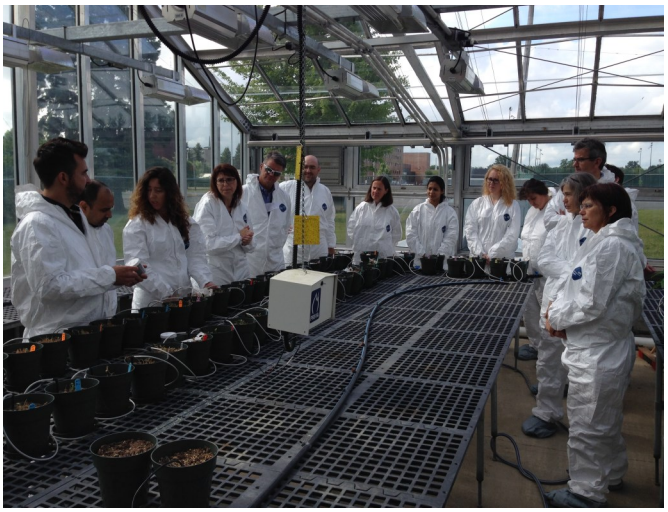
- Benjamin Mimee, PhD, Agriculture and Agri-Food Canada
- Rich Novy, PhD, USDA ARS
- Mike Thornton, PhD, University of Idaho
- Xiaohong Wang, PhD, USDA ARS and Cornell University
- Jonathan Whitworth, PhD, USDA



GLOBAL Project scientists tour the potato cyst nematode greenhouse research facility at Agriculture and Agri-Food Canada, a GLOBAL partner agency (I. Zasada)

GLOBAL Advisory Committee consists of potato industry, state and federal regulatory and academic individuals who have volunteered their time and efforts. We thank them!

GLOBAL Advisory Committee

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