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Globodera Alliance Newsletter

Developing Potato Varieties with Resistance to Potato Cyst Nematodes

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The Role of Resistant Cultivars

Globodera pallida and *G. rostochiensis*, also known as potato cyst nematodes (PCN), reproduce on potato, tomato, and some related weed species. The females are endoparasites, meaning that they form a feeding site inside the root and deplete plant nutrients. At death, female bodies become cysts – hardened capsules, containing hundreds of eggs, capable of surviving adverse conditions in the soil for up to 30 or more years. When conditions are right, which is typically when roots of a host plant grow nearby, the eggs will hatch and larvae will emerge from the cysts, to start the cycle again. These soil borne nematodes can decrease the yield of a potato crop by up to 80% if not controlled. Fumigation will kill most of the nematodes to protect the crop, but the cost of fumigation, running into thousands of dollars per acre, can take the profit margin out of a potato crop. In most countries, PCN is under quarantine, or requires regulatory action. If unregulated, PCN can result in loss of markets as other countries refuse to allow imports from the infested area.

Pictured (left to right) : 1) *G. pallida* cysts attached to potato root; 2) a closer look at *G. pallida* cysts; 3) *G. pallida* eggs emerging from a cyst broken open in the lab. Note: in the field, cysts do not break open as show, but rather eggs hatch inside the cyst and juvenile nematodes emerge over time. (Photos: L.M. Dandurand)

Crop resistance is a critical component for the control of PCN. Resistant potato varieties make it possible for growers to achieve a profitable return on infested (and non-infested) land and, at the same time, reduce PCN populations.

Globodera rostochiensis (golden nematode) was first detected in the U.S. on Long Island, New York where field symptoms were noted in the late 1930s. Quarantine efforts, practiced since 1944,

have limited the spread of this destructive pest within the state of New York and prevented spread to other parts of the U.S. In 2006, *G. pallida* (pale cyst nematode) was detected in eastern Idaho, and *G. rostochiensis* was detected in southern Quebec, Canada. Quarantine measures were put into place for both of these finds. In 2008 a new *Globodera* species, *G. ellingtonae,* was discovered in Oregon and Idaho.

Progeny of 915—derived from Eden x Western Russet—growing in the USDA-ARS greenhouse in Aberdeen, Idaho. Eden providing the resistance to multiple *Globodera* species. (Photo: R. Novy)

Identifying Resistant Genes

Concerted efforts, over many years, to incorporate a resistance gene (*H1*) into potato has produced many varieties with resistance to *G. rostochiensis.* This gene is very effective for races (pathotypes) Ro1 and Ro4 of the nematode. A scale for resistance ranks variety response to nematodes from 1 (no resistance) to 9 (high resistance). Using this scale, many varieties with the *H1* gene have achieved a resistance ranking of 9. This is considered a single major gene resistance and the H1 gene is inherited in a simple, dominant fashion.

Genetic resistance against *G. pallida* in known potato varieties is not as effective, nor as easily utilized by breeders, as compared to the resistance conferred by the *H1* gene to *G. rostochiensis.* Resistance to *G. pallida* has been found in a few South American relatives of cultivated potato, most notably *Solanum vernei* and *S. tuberosum* subsp. *andigena.* Resistance from these sources has been transferred into a few commercial varieties, none of which comprise major acreages in the U.S.

Greenhouse on the Cornell University campus, where Xiaohong Wang—a GLOBAL Project partner—and Dave Thurston Jr. (pictured) conduct screening for resistance to *Globodera rostochiensis*. (Photos: X. Wang)

Effective resistance to *G. pallida* is not based on major genes, but on the additive contributions of multiple genes, each of which confer partial resistance. These genes are also known as minor genes or Quantitative Trait Loci (QTLs). Recent studies have confirmed that offspring that contain two sources of resistance, coming from two different parents, have a higher level of resistance than offspring that

have inherited only one source of resistance.

While success in controlling *G. rostochiensis* races Ro1 and Ro4 has been achieved with the deployment of varieties carrying the *H1* gene, use of these varieties has, over time, also revealed that some *G. rostochiensis* populations contain yet another race, Ro2 that is not controlled by this gene. Ro2 has become an issue in New York and some European countries where H1 resistance is frequently deployed. Current screening and breeding efforts in New York are focused on identifying and transferring broad scale resistance that is effective against both Ro1 and Ro2 races.

Cysts are separated from soil, by a system of sieves and filters, during the extraction process and are counted under the microscope. (Photos: L.M. Dandurand)

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.

Screening Potential Resistant Potato

When scientists want to screen existing and potential new varieties for resistance, they plant potatoes into a pot and add a set number of nematode eggs. When plants are harvested, the number of newly reared cysts are counted and, if needed, eggs are extracted and counted. A susceptible control variety, typically Desiree, is always included in the study. The results are reported in a variety of ways. They can simply be reported as the number of cysts per plant, number of cysts per gram of soil, or as relative susceptibility numbers. For the relative susceptibility (RS) number, the percent of cysts or eggs in a test variety is compared to the amount produced in the susceptible variety. For example, in unpublished results, the variety Eden produced 10.7% as many cysts as Desiree. This percent can also be reported as an EPPO value (European Plant Protection Organization) where a 1 is susceptible and a 9 is highly resistant. Generally, EPPO scores ≤4 are considered susceptible, 5 to 7 are partially resistant, and ≥8 are resistant. Following this example, Eden's resistance to *G. pallida* is recorded as an EPPO score of 5 (partially resistant) and for *G. rostochiensis* the EPPO score is 9 (resistant), with no cysts produced on this variety.

Bringing Resistant Varieties to Market

Varieties like Eden, which was developed in Scotland, can be used as a starting point in the U.S. to breed for resistance against more than one nematode species. Developing nematode resistant varieties for the major market classes in the U.S. by conventional breeding takes 12-15 years. The use of molecular markers can reduce this time by a few years, but reliable markers that are closely linked to the resistant nematode gene are needed first. Some of these markers have been developed and are now in use, but resistant progeny identified with markers still need to be screened, ideally against multiple nematode populations, as differences in a nematode population's ability to reproduce on a host can exist.

Resistant potato populations have been developed for the GLOBAL project and they combine different sources of resistance (those QTLs mentioned earlier). These populations are being screened for resistance to the PCN species, with resistant individuals being further evaluated for their potential for release as varieties. Some may be resistant to *G. pallida* and not *G. rostochiensis* or vice versa. Ideally, they would be resistant against more than one nematode species. Unpublished data from this project suggests that many potato breeding clones resistant to *G. rostochiensis* will also be resistant to *G. ellingtonae*.

Lomoka, an Ro1-resistant chipping variety (left) and Lehigh, an Ro1-resistant yellow-fleshed variety (right). (Photos: W. DeJong)

Resistant Varieties as Part of an Integrated Pest Management Strategy

Like the principles learned with Integrated Pest Management (IPM), use of more than one strategy is often needed to provide durable resistance against nematodes. Other strategies to be used in combination with resistant varieties could be limited fumigation, rotation, and trap crops (a crop that stimulates a nematode hatch, but doesn't support nematode growth). It has been shown that nematode populations can adapt, as they also have a gene pool which allows adaptation to external forces that challenge their survival.

Extensive sampling of Idaho fields since 2006 has shown that the infestation is limited and the quarantine measures taken have allowed the U.S. and Idaho to regain important foreign markets that initially closed due to the presence of the nematode. Eradication efforts for *G. pallida* in Idaho are ongoing with the goal to return fields to normal production. These efforts include fumigation, extensive sampling, and a core set of parameters that must be met before a field is released for potato production.

Research efforts to develop varieties suitable for U.S. producers with high resistance to *G. pallida* and *G. rostochiensis* (Ro1 and Ro2) as well as *G. ellingtonae* are a goal of this project. Achievement of this goal has brought together a research team composed of nematologists, breeders, and molecular biologists. While not a short-term research endeavor, the development of resistant varieties will ultimately contribute greatly to the reduction or eradication of quarantined PCN species.

Upcoming Events in 2017:

Hosted by

University of Idaho, College of Agriculture and Life Sciences

Snake River Pest Management Tour

8:30 a.m. – 12 noon

June 20th. Kimberly Research & Extension Center, 3806 N. 3600 E., Kimberly, ID

June 21st, Aberdeen Research & Extension Center, 1693 S. 2700 W., Aberdeen, ID

The Pest Management Tour is free, open to the public. This year's event will include information on management of PCN trap crops. Registration starts at 8 a.m. day of event; lunch is provided.

Twilight Tour

July 19th, 5 – 8 p.m.

Aberdeen Research & Extension Center

1693 S. 2700 W., Aberdeen, ID

The annual Twilight Tour is free and open to the public. This year's tour will provide an opportunity to hear about ongoing research and recommended farming practices to contain, control, and eradicate the pale cyst nematode from potato fields.

For more information contact:

Don Morishita (Kimberly Center, Ph: 208.423.6616) or Pam Hutchinson (Aberdeen Center, Ph: 208.397.4182)

Organization of Nematologists of Tropical American Annual Mtg. July 10-14,

Mayagüez, Puerto Rico: http://www.ontaweb.org/

Potato Association of America Annual Mtg. July 23-27

Fargo, North Dakota, http://potatoassociation.org/welcome-to-the-paa-website

American Phytopathological Society Annual Mtg. Aug. 5-9

San Antonia, Texas, https://www.apsnet.org/meetings/annual/Pages/default.aspx

Society of Nematologists Annual Mtg, **Aug. 13-16**

Williamsburg, Virginia, https://nematologists.org/

GLOBAL Investigators

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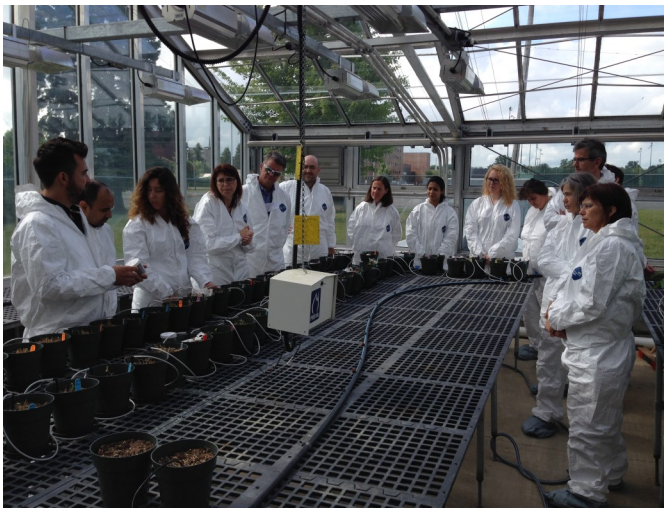

GLOBAL Project scientists tour the potato cyst nematode greenhouse research facility at Agriculture and Agri-Food Canada, a GLOBAL partner agency (Photo: I. Zasada)

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

- Bill Brewer, Oregon Potato Commission
- David Chitwood, PhD, USDA ARS
- Lorin Clinger, potato grower
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