Potato Progress

Research & Extension for the Potato Industry of Idaho, Oregon, & Washington

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www.nwpotatoresearch.com

Volume XVI, Number 17 | *27 December 2016*

Pale Cyst Nematode Eradication Research

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Potato is the world's most important non-grain crop and the third most important food crop. In the U.S., potatoes are grown commercially on more than 1 million acres throughout 30 states, with Idaho leading production. Potato production, and the ability to market U.S. potatoes abroad, is threatened by the presence and potential geographic spread of invasive potato cyst nematodes in the genus *Globodera*. Potato cyst nematodes are of worldwide regulatory concern, and are one of the most economically impactful pests of potato. Over 125 countries besides the U.S. have potato cyst nematodes on their action lists because they can cause in excess of 80% yield loss if not controlled.

At the present time, potato cyst nematodes are found only in a few, widely scattered places in the U.S. The golden nematode, *Globodera rostochiensis,* was first reported in New York in 1941, and through rigorous regulatory measures has been successfully contained to that state. However, after 67 years, over 220,000 acres still remain regulated in three counties. Over the years resistant varieties of potatoes have been developed for New York, which has minimized the impact of this infestation. In a more recent discovery, the pale cyst nematode (PCN), *Globodera pallida* was found in Idaho in 2006. Currently, cooperative monitoring efforts by APHIS and the Idaho State Department of Agriculture have identified 2,897 infested acres within a 7.5-mile radius in northern Bingham and southern Bonneville counties. An additional 4,837 acres are regulated because of association to an infested field. The rapid response from regulatory agencies to this devastating pest of potato has allowed for containment of the pest to less than 1% of the total potato acreage grown in Idaho.

The introduction and potential spread of potato cyst nematodes has serious implications for the U.S. In response to the Idaho detection, Canada, Mexico and South Korea suspended importation of potatoes from Idaho, while Japan suspended importation of potatoes from the entire U.S. Canada shut down Idaho's nursery stock exports as well. Containment of PCN is one of the program's most important goals to safeguard the Idaho and U.S. potato industries. A critical component of this effort has included aggressive interstate and intrastate movement regulations by APHIS and ISDA, respectively. Another goal is to conduct delimiting surveys to ensure the infestation is limited to the current known areas. Over 580,000 soil samples have been collected throughout Idaho since 2006 to demonstrate freedom of PCN. Additional samples collected annually outside of Idaho also indicate the absence of PCN. Our trading partners have recognized

the success of the PCN response program. Evidence of this is demonstrated by having reopened each of the closed markets to Idaho potatoes with the exception of Japan for Idaho potatoes. But negotiations with Japan are ongoing. Our trading partners agree that potatoes outside the current regulated area have minimal PCN risk.

Another USDA-APHIS program goal is to eradicate PCN. Chemical treatments have been the primary tool in this effort. Testing after each treatment has shown a PCN viability reduction of over 95% after the first treatment and over 99% after the second treatment. Seventeen of twenty previously treated fields show no viable eggs after conducting viability screens in the USDA-APHIS laboratory in Idaho Falls. Once no viable eggs are found by the USDA-APHIS facility, field-collected cysts are further evaluated for inability to reproduce in a greenhouse assessment conducted at the University of Idaho. Of the twenty fields that no longer have viable eggs, eight have completed the greenhouse assessment which shows that PCN is no longer viable and does not reproduce. This then allows resumption of potato production with some PCN testing after each crop while remaining under some regulatory oversight. One field was planted to potatoes in 2015 which was the first infested field to resume potato production since 2006. After crop harvest the field was sampled by USDA-APHIS. No viable eggs were detected in this field suggesting that the eradication program is effective. Unquestionably, the USDA-APHIS program has made great strides to eradicate PCN in Idaho.

The difficulty in controlling potato cyst nematodes is in part because the "cyst" is the body of a dead female nematode containing hundreds of eggs. The cyst is a protective shield for the eggs, where the eggs remain inactive and protected from chemical and biological stresses found in soil. Cysts with viable eggs can persist in soil for decades. For *G. pallida*, the requirement for potato root diffusate is nearly absolute, with few larvae hatching in water. This allows the nematodes to remain dormant in soil for up to 30 years in the absence of a host, since even under favorable conditions some proportion of viable PCN eggs do not hatch. Eggs hatch only in response to chemicals released by potato roots, and once hatched the juvenile nematode can infect potato roots. In the root, the nematode tricks a susceptible potato plant into forming a feeding site where the nematode obtains its nutrients and develops into the adult stages. The female remains sedentary in the root, is fertilized by the male and a new batch of eggs are then formed. PCN has been found to multiply by as much as 50-fold within one growing season. As some viable PCN eggs (found in cysts) can persist in soil even after repeated fumigation, new strategies are needed to protect the investment in eradication efforts, as well as to manage potential new infestations.

A broad suite of other eradication methods is also being investigated as adjuncts to chemical fumigation methods, at the University of Idaho as well as by USDA-ARS collaborators in Corvallis (OR), Prosser (WA), Aberdeen (ID), and Ithaca (NY). The use of trap crops, biological control agents, biofumigants, and other chemical fumigants are all being evaluated as tools against PCN for deployment in infested fields.

One goal of this research has been to develop and deploy trap crops as a tool against PCN. Non-host trap crops which stimulate egg hatching but do not support nematode reproduction is a useful strategy because hatched juveniles have limited food reserves and die if they do not successfully parasitize potato roots. We are investigating a trap crop species which is closely related to potato, *Solanum sisymbriifolium* commonly known as litchi tomato, which stimulates suicide hatch and is a non-host to PCN.

Litchi tomato is an annual herb native to South America that can reach up to 3 feet in height. The stems and branches are armed with spines that can be up to ½ inch in length. The flowers are white to pale blue. Litchi tomato is preferred as a trap crop because it combines strong hatch

stimulus with immunity to PCN. In a field trial, cropping with litchi tomato reduced PCN populations at the end of a growing season by 30-40% compared to the fallow control. When potato was planted after litchi tomato, reproduction of PCN on potato was 87% less than when potato was cropped after a fallow season. However, while nematode hatch typically can be increased in the presence of a trap crop, it is rare to have all eggs hatch from cysts in a single year, so that population carry-over typically requires additional years of trap cropping. One goal of this project will be to quantitatively evaluate the importance of such "residual cysts," and to incorporate this information into an eradication framework.

Several genera of nematode-killing fungi are known to be natural enemies of cyst nematodes. In research at the University of Idaho, fungi in the genera *Plectosphaerella*, *Purpureocillium*, *Trichoderma*, and *Chaetomium*, obtained from potato field soil, all show promise for control of PCN. Beneficial fungi that attack PCN have potential to provide a multipronged control strategy, since nematode-parasitic fungi destroy eggs in cysts, and in some cases kill the infective larvae in the soil. Some of the nematode-attacking fungal strains that we have identified are effective root colonizers of different plants, so that the rhizospheres of trap or host crops can serve as a reservoir for the biocontrol fungus. The fungus may use the trap crop as a base from which to attack nematode eggs and larvae in soil. In field trials conducted in Shelley ID, *Trichoderma harzianum* and *Plectosphaerella cucumerina* when applied singly reduced egg content by approximately 25-30%, but when applied in combinations with litchi tomato, egg content was reduced by 70 to 83% compared to the bare soil only. Because control approaches including fungal biocontrol agents and trap crops can potentially exploit or create weaknesses in the nematode's life cycle, an integrated approach using trap crops and biological control organisms is being developed to optimize their cumulative impact.

Biofumigants, such as mustard seed meal produce biologically active compounds that are potentially valuable in nematode eradication strategies. *Brassica* spp. produce a broad range of glucosinolates (GSLs) that break down to toxic metabolites that can be utilized in biofumigation for nematode management. Experimental bioassays point to *Brassica juncea* as the most promising mustard for management of PCN by biofumigation. In laboratory experiments, we found 100% kill of PCN eggs after exposure to *B. juncea* seed meal when applied at a rate of 4 T/acre; but decreasing the application rate to a more feasible amount (1 T/acre) resulted in variable kill of *Globodera* eggs. The rate of mustard meal required for field application limits the utility of using mustards meals in nematode-control strategies. To overcome this obstacle, we have developed procedures to extract the active ingredients from mustard seed meal, concentrate the extracts, and formulate shelf-stable powdered products. Seeds of these crop species typically produce only one predominant type of GSL. For *B. juncea*, sinigrin is the glucosinolate most toxic to PCN and other nematode species. Our shelf-stable sinigrin extract effectively kills PCN even at low rates of application. In our Shelley, ID field trial, egg content was reduced by 76% when exposed to a formulated biofumigant containing the active ingredient sinigrin.

Our research focuses on finding effective methods for controlling this devastating pest of potato. Our long-term goals are to develop and deploy effective eradication measures for potato cyst nematodes and to develop a comprehensive strategy including nematicides, trap crops, biological control agents, and biofumigants for use in infested fields.

Upcoming Potato Conferences in Pocatello and Kennewick

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Idaho Potato Conference & Ag Expo
Jan. 18-19, 2017

Pond Student Union Building, Idaho State University, Pocatello, Idaho

The 49th Annual University of Idaho Potato Conference and 38th Ag Expo will be held on the Idaho State University campus in Pocatello, 8 a.m. to 5 p.m., Wednesday, Jan. 18, and 8:30 a.m. to 12:30 p.m., Thursday, Jan. 19.

The conference covers a wide range of industry topics ranging from variety development, management practices and economics, marketing and political issues. There are Idaho and Washington Department of Agriculture Pesticide Handler credits available. There is also a series of nine presentations on industry topics presented in Spanish. The Ag Show is held in Holt Arena and there is an extensive Trade Show in the ballroom of the SUB. There is also a Grower-Speaker Social Wednesday evening, poolside at the Red Lion Inn.

For more information and links to registration, see:

https://www.uidaho.edu/cals/potatoes/conferences/idaho-potato-conference

Washington/Oregon Potato Conference
January 24-26, 2017

Three Rivers Convention Center, Kennewick, Washington

This conference includes a Spanish-language session on Tuesday morning, a Cultivar Performance Workshop on Tuesday afternoon, General Sessions on Wednesday and Thursday, plus numerous side meetings, evening events, and a top-notch tradeshow.

For more information and a link to registration, see:

http://potatoconference.com