Biological control of Canada thistle: more work needed

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Canada thistle is a big headache for livestock producers managing pastures. Animals won't eat this spiny, tough plant, reducing productivity of pastures and livestock. Despite being on Wisconsin's noxious weed list and a target for serious control for many years, it is still a significant, widespread problem.

A naturally occurring disease that attacks Canada thistle has potential to control this problem plant. With support from CIAS, researchers at UW-Madison found that this bacterium, in its current state, does not cause enough disease to significantly reduce Canada thistle populations. To control Canada thistle, the bacteria, *Pseudomonas syringae* pv. *tagetis* or PST, must be strengthened either by finding strains that produce more toxin, or by creating environmental conditions where it can thrive.

Why is Canada thistle so tenacious?

Canada thistle is a perennial plant with an extensive horizontal and vertical rhizome and root system, which can spread 15' wide and 6-15' deep. Plants primarily regrow and spread from rhizomes, but infestations can also start from seed. A single Canada thistle plant can release more than 5,000 plumed seeds, easily carried several yards by the wind. These seeds remain viable in the soil for many years. Musk, plumeless, and bull thistles are biennials and are less difficult to control. These thistles die in their second year and can be controlled by mowing.

What is PST?

Canada thistle plants in non-disturbed locations occasionally turn yellowish white when infected by PST and some infected shoots may die. This spontaneous infection makes PST an attractive biological control option. While PST cannot eradicate Canada thistle in the short run, it can weaken plants by reducing their root reserves, lessening competitiveness over the long run. Farmers who are already growing good pastures by using managed grazing, choosing well-adapted pasture species, seeding pastures at recommended rates, and maintaining soil fertility will find their pastures can out-compete weakened Canada thistles.

Why use PST on thistles in pastures?

Biological control overcomes some of the problems of other control methods. Mowing Canada thistle in the bud stage is one typical approach to controlling it, as is spraying with herbicides. But mowing and spraying to control Canada thistle can damage desirable pasture plants, including legumes like clover and trefoil. Because PST is plant family-specific, affecting Canada thistle and ragweed, other desirable pasture plants won't be damaged by it. In addition, spraying with commercial herbicides is not an option for pastures that are certified organic.

What were the research questions?

UW-Madison Weed Scientist Jerry Doll and agronomy graduate assistant Ryan Tichich initiated a project assessing PST as a Canada thistle control. Prior research in Minnesota showed that PST applications infected and slowed the growth of Canada thistle. Doll and Tichich wanted to learn how best to infect Canada thistle plants with PST and what environmental conditions are best for spreading the disease. They hypothesized that repeated applications of PST would increase the severity of this disease, and applying greater concentrations and volumes of PST would also increase disease incidence and severity. They thought that spraying PST just before rainy weather would strengthen the disease because the bacteria grow best in wet conditions.

How was the research conducted?

The researchers established experimental plots in pastures at four sites in southern Wisconsin (see table on back). All of the pastures had similar plants and were infested with 10 to 12 Canada thistle shoots per square meter.

The researchers chopped naturally infected Canada thistle foliage and mixed it with water, filtered it, and blended it with a surfactant to help it adhere to

Canada thistles turn yellow when infected with PST. Researchers are working to develop this bacteria as a natural control agent.

healthy thistles. Three by three meter areas within each plot were randomly chosen, marked off, and Canada thistle plants were sprayed with the PST mixture. The researchers then measured how many plants became infected and how severely the plants were affected.

To evaluate bacterial growth when PST is applied in a wet or dry environment, they measured the total PST population and the proportion of bacteria inside the leaf. Higher proportions of PST inside the leaf are correlated to higher disease incidence. Researchers measured total and internal leaf PST populations following spraying and throughout the growing season.

What did the researchers find out?

While the applied PST infected the Canada thistles, the levels of disease did not suppress this tenacious weed. But the researchers learned about conditions and management strategies that make this disease thrive, which may lead to the future development of PST as an effective biological control for Canada thistle.

"Varying the concentration of PST and spray volume did not affect the level of disease we observed, but multiple applications did," Doll reports. Furthermore, PST populations were greatest in the thistles following application in mid-July rather than mid-June or mid-August. "Applying PST to thistles during the middle/latter part of July will hit the plants when conditions are most favorable for PST growth, if weather conditions and rainfall amounts follow typical patterns," says Doll.

The researchers also observed that plots sprayed in 2001 had noticeable infections in 2002, suggesting that PST can overwinter and may affect Canada thistle for multiple years.

Due to different responses at different sites and fairly light rains for the wet environment experiment, the results regarding application in a wet or dry environment were not conclusive. But the measurements taken throughout the growing season showed that total and internal leaf PST populations increased and oscillated during rainy periods. The researchers hypothesize that internal populations increased in rainy weather because the impact of the rain drove the bacteria into the pores of the leaf or because the bacteria grew more rapidly in wet conditions. "These data suggest that it would probably be beneficial to apply PST during a rainy period," Tichich notes.

Results of four studies of PST application on Canada thistle

Concentration and spray volume study

Location	Year	Application date/thistle stage
Lancaster	2001	June 27/bud
Lancaster	2002	June 6/vegetative
Utica	2002	June 5/vegetative

Results: Spraying increased disease incidence (DI, % plants infected) and disease severity (DS, % of diseased tissue in an infected plant) compared to control, but varying concentration and spray volume did not affect DI or DS.

Seasonal application study

Location	Year	Application date/thistle stage
Arlington	2001	June 19/vegetative –July 16/flower – August 14/post flower
Spring Green	2001	June 18/bud – July 16/late flower – August 14/post flower

Results: Mid-July was the best time to apply for maximum DI and DS; this was correlated to rainfall.

Multiple applications study

Location	Year	Application date/thistle stage
Arlington	2001	5 times from June 25/bud to July 23/post flower
Utica	2002	5 times from June 17/bud to July 15/post flower

Results: Multiple applications made a difference for DI, especially in a rainy year (2001); multiple applications did not affect DS.

Wet and dry environment study

Location	Year	Application date/thistle stage	
Arlington	2002	At both	Wet-June 13/vegetative
Spring Green	2002	sites:	Dry-June 24/bud

Results: Dry environment had stable and low total and internal populations of PST; wet environment led to high/low oscillating total and internal populations.

What's next?

"For PST to become a more effective biological control agent against Canada thistle, we need to find methods that increase the disease incidence of a single application, either by producing more toxin per cell or by increasing the number of PST cells on the leaf," concludes Doll. "Since we had limited success in our second year trying to manipulate PST concentration, future research should expand on the exploration of environmental conditions when PST is applied."

A few Wisconsin sites have a 90% or higher natural PST disease occurrence on Canada thistle. Future research at these sites, including nutrient levels and PST's bacterial competitors, can help researchers determine favorable conditions for PST. Ultimately, this may result in an effective biological control strategy for an extremely troublesome weed.

For more information, contact:
Jerry Doll, UW-Madison Agronomy, 608-263-7437,
e-mail: jddoll@wisc.edu

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