Filamentous Friends and Mycological Messiahs

Canada Thistle Rust Fungus Shows Promise in Colorado

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What is Biocontrol?

Biocontrol is the use of natural enemies (predators, pathogens, parasites, and herbivores) to control insects, weeds or other pest organisms. Natural controls are inexpensive, permanent, safe for the environment, safe for human health, and they are self-propagating. Self-propagating means that small releases may expand into large and persistent populations for long-term pest control. Biocontrol works by establishing a balance between the target pest and the natural control agent. The pest and the agent will always be present, but after an ecological balance is achieved, the pest population will be lower. Biological pest control helps decrease agriculture's reliance on chemical controls and thus lowers production costs, as well as the amount of chemicals entering the environment.

Is Biocontrol Safe?

Releasing a new species comes with risks, but the risks are small due to the years of research and testing that are required before a new biocontrol agent is approved for release in the U.S.A. Newly-introduced weed biocontrol agents will have been through at least ten years of extensive testing by the United States Department of Agriculture and overseas cooperators to ensure no impact on native species. Because of these precautions, the safety record for noxious weed biocontrol in the U.S.A. has been excellent.

Colorado Leading the Way

The Colorado Department of Agriculture has promoted the use of biocontrol in pest management since the 1940s. At that time, the Insectary in Palisade, CO (Figure 1) first released

Figure 1. Insectary Facility located in Palisade,CO, and run by the Colorado Department of Agriculture.

Figure 2. Spotted knapweed biocontrol weevil (*Cyphocleonus achates*).

parasitic wasps (*Macrocentrus ancylivorus*) for use against the Oriental fruit moth (*Grapholita molesta*), a serious pest of peaches in the fruit growing regions of western Colorado's Grand Valley. The program was a success and continues to this day. Following this first success, other biocontrol agents were released for a number of insect pests and difficult-to-control noxious weeds. The Palisade Insectary is now home to the Biological Pest Control Program, within the Conservation Services Division of the Colorado Department of Agriculture. For readers of FUNGI who've ever driven west on I-70 on their way to the Telluride Mushroom Festival, you drove right by the Insectary!

Current Weed and Insect Programs

Approximately 20 noxious weed control agents are being cultured and released on weed infestations throughout Colorado. The Insectary is Colorado's receiving station for new biological control agents developed primarily by federal agencies and overseas collaborators. Foreign exploration in noxious weeds' native ranges leads to discovery of species that are known to control invasive plant and insect pests here in the USA. These exotic species are exposed to a strict quarantine procedure, including testing, before they become available to cooperating states for general release. This ensures that potentially hazardous species are not accidentally introduced with the beneficial insects. Today, programs at the insectary include the biological control of invasive: thistles, toadflax, knapweed (Figure 2), field bindweed, leafy spurge, puncturevine, loosestrife, and tamarisk. One of the most promising new controls we distribute is the Canada thistle rust fungus (*Puccinia punctiformis*).

What is Canada Thistle?

Canada thistle (CT; *Cirsium arvense*) is a perennial invasive plant known to invade disturbed, mostly riparian, habitats (Figures 3, 4, 5). It was introduced to North America in the 1600's from Europe. It is generally distinguished from other invasive thistles by its smaller marble-sized seed-heads, comparatively short (mostly 3 ft tall) dense growth habit, and virtually spineless stems. It colonizes new areas through the

Figure 3. Canada thistle flower.

Figure 4. Canada thistle seed-head.

Figure 5. Canada thistle rosette.

production of nearly 1,500 seeds per stem. Once established, it spreads through clonal underground shoots. It is a major weed of agricultural fields, causing significant economic losses, and one of the worst weeds of temperate regions worldwide

Biological Control of Canada Thistle

Since the 1970's, a CT gall-fly (*Urophora cardui*) and a stem-

Figure 6. Cluster of systemically infected Canada thistle shoots exhibiting symptomatic characteristics.

Figure 7. Aphids attracted to sweet nectar of systemically infected stem.

Figure 8. Aphid inadvertently spreading spores that adhere to its body.

Figure 9. Transformation from typical leaf tissue (top) to rupturing spore pustules (bottom).

mining weevil (*Hadroplontus litura*) have been used in an attempt to control CT in North America. However, these two insects have proven ineffective. The CT rust was first suggested as a plant pathogen biocontrol clear back in 1893 by farmers at the New Jersey Agricultural Experiment Station. Recent research conducted by Dr. Dana Berner (USDA-ARS) has now allowed us to utilize the rust fungus that was likely introduced with early CT infestations and has so far been found in every state where CT occurs. It is host-specific, in this case meaning it can only complete its life cycle on a single species.

Life Cycle of the Rust Fungus

In spring, infected root stock sends up systemically diseased Canada thistle shoots that appear unusually tall, sparsely leaved, lack flowers, and are covered with yellow spermagonia on the underside of the leaves (Figure 6). During this time, the diseased stems emit a sweet floral fragrance that attracts passing insects like aphids and flies to cross-fertilize the heterothallic (sexually dioecious) fungus (Figures 7, 8). In summer, aeciospores on leaf tissues will turn the iconic red-brown rust color (Figure 9). These spores are windblown to infect neighboring Canada thistle stems throughout the

Figure 10. Canada thistle leaf that has become infected and is producing urediniospores.

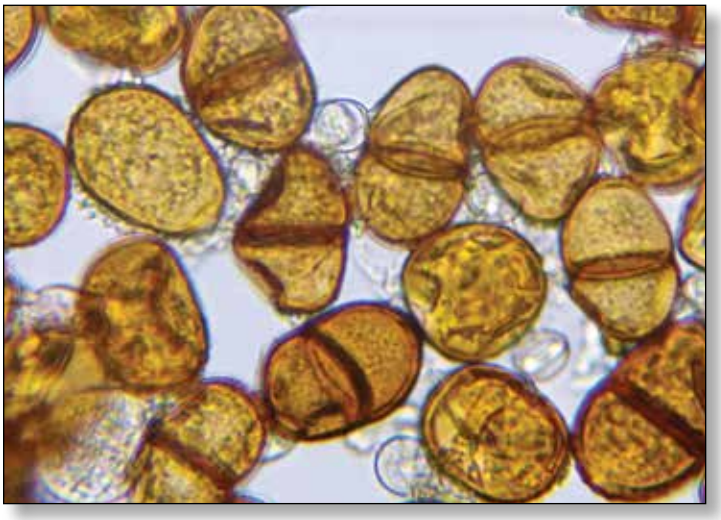

Figure 11. Two-celled teliospores.

Figure 12. Dying systemically infected Canada thistle.

Figure 13. Canada thistle infestation at ranch study site with significant infection 2015.

Figure 14. Canada thistle infestation at ranch study site with significant infection 2017.

summer which in turn produce urediniospores (Figure 10). Finally, during fall, spore-laden leaves fall on late emergent rosettes. The now teliospores (Figure 11) germinate on the rosettes and basidiospore hyphae grow through the stem and into the roots to survive winter underground as a root parasite. The rust's killing drain is done on the root system,

Figure 15. Infected Canada thistle plants in the drying process in preparation for lab storage.

so above ground symptomatic stems are typically not an accurate representation of the infection rate overall. The rust is autoecious and requires no alternate host to complete its life cycle.

How Effective is It?

Because the rust fungus is so effective at killing its host plant (Figure 12), it spreads slowly to ensure new thistles will be present to infect in later years. However, after many years of study, we have recently determined the best way to spread the disease farther and faster than occurs in nature: inoculation. Unlike many classical biological control agents that limit or control the spread of an infestation, CT rust fungus has a greater potential to significantly decrease CT stands. Preliminary data in Colorado suggests most sites inoculated with rust will decline by roughly 50% within a couple years. After three or four years, the thistle stand is often just a small percentage of its original infestation (Figures 13, 14).

How Does a Property Owner Use It?

The rust is an obligate biotroph and can thus only propagate on living tissue. This makes lab production nearly impossible and field collection essential (Figure 15). As a biological control agent, interstate movement is federally regulated; however, Canada thistle rust fungus is likely already nearby your property. It is completely possible for landowners to find rust locally, collect it, and redistribute it on newly established and high-priority CT infestations likely lacking the limitations of disease presence. Appropriate application timing and methods are being evaluated in Colorado (Figure 16).

Figure 16. Ground up infected Canada thistle leaf tissue containing millions of spores ready for application.

As a state-run facility, our program's main focus is to serve the citizens of Colorado. If you live within the state, please feel free to call our office or click on the "Request-a-bug" link found at our website (www.palisadeinsectary.com). There you can request biocontrol agents shipped right to your door.

For current information on the CT rust program, contact Joel Price (Office: 970-464-7916). Joel has been studying CT for the last seven years and has helped pioneer the rust project for the last three years. He has a B.S. degree in ecology and a M.S. in entomology from the University of Idaho. During his education, a love of insects and plants has really "grown" on him! Joel moved to Colorado in 2014 with his wife and three young boys to work for the Colorado Department of Agriculture and has recently left to run the noxious weed biocontrol program for the Oregon Department of Agriculture.