Biocontrol Files

Canada's Bulletin on Ecological Pest Management

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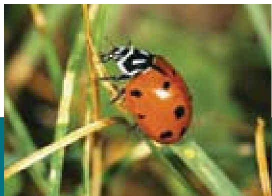

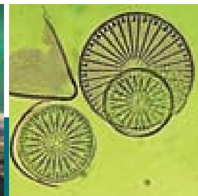
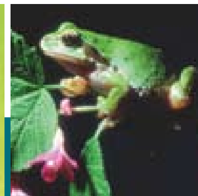

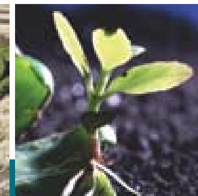

Good news for Canadian biocontrol: Registration of Abietiv, a new, made-in-Canada bioinsecticide

Dr. Chris Lucarotti examining the BFS virus

In Biocontrol Files #5, we reported that Canadian Forestry Service (CFS) insect pathologist Dr. Chris Lucarotti's decade-long effort to commercialize the virus-based agent, Abietiv, for management of balsam fir sawfly, was drawing to a close (*Beating Back a Balsam Fir Pest with Biocontrol*). The good news is that, on April 20, 2006, Abietiv Flowable Biological Insecticide was registered for use in forest pest management in Canada.

The active ingredient in Abietiv is a naturally occurring baculovirus within the genus *Nucleopolyhedrovirus*, which selectively infects and kills larvae of the balsam fir sawfly (*Neodiprion abietis*), a major forest pest in Newfoundland and Labrador.

During much of 2005, in the latter part of the long journey to registration, Lucarotti and his colleagues were kept busy responding to identified 'deficiencies' in the Abietiv registration package. In March 2006, some editorial changes to the label were required, with a conditional registration being granted in April.

On a parallel track to the registration process, a licensing agreement was signed in May 2005 between the CFS Atlantic Forest Centre and the Fredericton-based firm, Forest Protection Limited (FPL), whose board of directors includes representatives from the provincial government and the New Brunswick forest industry. FPL, in cooperation with BioAtlantech, has established a company, Sylvar Technologies Inc., to market Abietiv and to develop and commercialize other baculoviruses.

There was quick uptake of the product after registration. Sylvar Technologies sold $750,000 of Abietiv to the province of Newfoundland and Labrador, which applied the product to 15,000 hectares of balsam fir sawfly-infested forest in western Newfoundland in July 2006. Says Lucarotti: "We've got our registration. We've signed a licensing agreement for the commercialization and marketing of the virus. It's been commercialized and the product has been sold. We've done everything we said we'd do."

Lucarotti sees this as a good news story for several reasons. For one thing, Abietiv is only the second viral product for forestry application that's been registered in Canada since 1987. And, because the successful development and commercialization of the product is at least in part due to the Biocontrol Network, it's a positive story for the Network. As well, says Lucarotti, it should prove to be a plus for the Canadian Forestry Service.

Lucarotti notes that Sylvar Technologies is interested in developing other baculoviruses for forestry use, and has applied – in conjunction with Canadian Forest Service employees - for a grant from the Atlantic Innovation Fund. One of the products that Sylvar is interested in developing is a baculovirus which targets the white-marked tussock moth, whose populations are on the rise in Nova Scotia.

Lucarotti is clear that Abietiv is a positive development for the Canadian biocontrol sector. "We've demonstrated that you can get a baculovirus registered and have a product marketed and available. While it required a lot of input from the federal government to do it, we shouldn't forget that the forest industry covered the costs of the three years of efficacy trials required for registration." The province has a useful product where none existed in the past. "And all the work that we've done, all the efficacy trials - we've shown that it works." ■

Weed Biocontrol in Field Crops

By Alec McClay

Field crops are a challenging environment for biological control of weeds. Because weeds often affect crop yields at early growth stages, control must take effect early in a growing season to be economically viable. The crop environment is subject to many disturbances, including cultivation, pesticide use, and harvest operations, and it changes drastically from year to year as a result of crop rotation. Consequently, it is more difficult for classical biological control agents to persist and build up their populations in field crops than in uncultivated habitats.

Nonetheless, some classical biological control organisms have shown potential against weed species that are problems in field crops. Perennial weeds may be more suitable candidates for classical biocontrol than annual weeds, and the growing use of zero-tillage may provide an environment that is more favourable for the establishment of biological control agents. Gall mites (Eriophyoidea) are of particular interest as biological control agents in field crops because of their very short generation time and ability to build up large populations rapidly. A European gall mite, *Aceria malherbae*, is well established at some sites in Alberta against field bindweed, a serious perennial cropland weed. The mite overwinters on the root system and colonizes the new bindweed shoots as they emerge in the spring, stunting their growth. Work in the U.S. has shown that the mite can easily be redistributed to new sites on galled field bindweed foliage. Another European mite, *Cecidophyes rouhollahi*, was approved for release as a classical biological control agent against cleavers, a major weed of annual crops on the prairies. It does not survive the winter in Alberta, but could be useful in areas with milder winters.

The need for rapid control early in the growth cycle of the weed, and the difficulty of establishing classical agents, has led to greater interest in inundative biological control, in which large numbers of a biological control agent are released. Inundative control often employs indigenous pathogens that can be cultured, mass produced, and formulated for field application. The first biological herbicide registered in Canada was a fungus for the control of round-leaved mallow. The product was first sold in 1992 under the name BioMal. However, because of production problems and the small market size for this bioherbicide, it is no longer distributed.

Several groups in Canada and the U.S. have been studying the potential of the bacterial disease caused by strains of *Pseudomonas syringae* as a biological control agent for Canada thistle. These pathogens inhibit chlorophyll synthesis, causing foliage to bleach and inhibiting growth.

Conditions in crop fields, especially on the prairies, are often hot and dry, inhibiting the germination and infection processes of many pathogens that have potential as biological control agents. Pathogens that attack leaves or stems, like BioMal, often require extended dew periods to allow germination. Soil-borne pathogens may not be subject to this limitation, and the Agriculture and Agri-Food Canada research group at Saskatoon is studying several rhizobacteria (root-colonizing bacteria) as potential control agents. They have patented several *Pseudomonas* strains as pre-emergent biocontrol agents for grassy weeds such as green foxtail, crabgrass, and wild oat.

Another tactic to enhance the effectiveness of bioherbicides is integration with chemical herbicides. The Saskatoon group has found that the fungus *Colletotrichum truncatum* has a synergistic effect with some herbicides when applied against scentless chamomile, a major crop weed on the prairies. Tank mixes of the fungus with these chemicals could enhance the effectiveness of both agents against the weed.

An area that deserves further study is the role of natural enemies in reducing the weed seed bank, either before or after weed seeds are dispersed. A moth larva, *Coleophora lineapulvella*, destroys many seeds of redroot pigweed before they disperse. Ground beetles that feed on seeds, such as Harpalus and Amara species, are abundant in many agroecosystems, and soil microorganisms can play an important role in mortality of weed seeds in soil. Research on ways to enhance the activity of these naturally-occurring weed control agents might lead to still more approaches to managing weeds in field crops.

These examples illustrate that, despite the challenges of implementing weed biocontrol in the field crop environment, there are many types of biological approaches with the potential to reduce herbicide use in field crops. ■

Biocontrol Files: Canada's Bulletin on Ecological Pest Management is a quarterly publication which reports on tools and developments in ecological pest management. The co-publishers World Wildlife Fund Canada, the Biocontrol Network and Agriculture and Agri-Food Canada welcome additional partners and sponsors committed to advancing knowledge and adoption of ecological pest management.

Submissions and letters to the editor are welcomed. Guidelines for submission are available on request from biocontrol-network@umontreal.ca.

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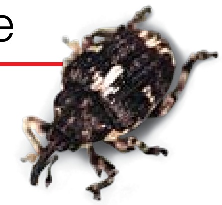
Interview with Rosemarie De Clerck-Floate



Rosemarie De Clerck-Floate, weed biocontrol researcher, Agriculture and "Agri-food" Canada

Aphthona lacertosa **(above-left) a flea beetle used to control leafy spurge**

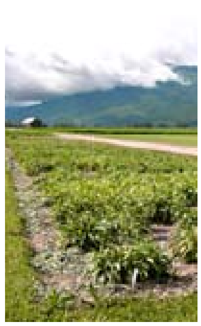
Biocontrol Files: Can you summarize some of the rangeland weed biocontrol programs that are going on in western Canada?

Rosemarie De Clerck-Floate: Well, Rob Bourchier and I are the only federal people in classical weed biocontrol using insects. Rob has been working on leafy spurge in western Canada and on knapweed. I've got two projects that are just wonderful. One involves Dalmatian toadflax, which is a real problem in the southern interior of B.C., where it can totally cover hillsides. In 1991, we released a stem-boring weevil from Europe and it's done quite well. While the larvae feed in the stems and cause some damage, it's the adults that have really hurt the plant. They feed on the growing shoots, which prevents flowering and stunts further growth. They are also great dispersers. That's the beauty of biocontrol - once you get an agent that works like that, you don't have to reapply. It works and spreads on its own.

The other project is just awesome in terms of getting a lot of grassroots support, especially from the ranching community in B.C. This is the houndstongue project. We received approval for release of a root-feeding weevil from Europe and released it in 1997. Within two years, not only did it establish at the majority of sites in both B.C. and southern Alberta, but it has been phenomenal in controlling the weed at a patch scale. It's one of these rare agents that, instead of slowing down the plant and making it less competitive with other species, actually kills its host outright.

In 1999 we started an experiment to determine the optimum number of insects needed to achieve patch level control. We couldn't believe it. The weed was virtually wiped out in those patches where we had released greater numbers of insects, and in three years all the patches were gone. The insects were venturing out and finding new patches on their own, even going through forested areas to find their host plant.

Houndstongue crop for mass production of *Mogulones cruciger* in Creston Valley, B.C.



BF: How far is it travelling to find these patches?

RDCF: Well, I'm sure individual insects are going much further, but the 'front' of insects was moving about half a kilometre per year. So the ranchers are very happy – they don't want to have to spray this weed, because it's in under the canopy of the forest. They would have to go out with a backpack and spot spray, which is very time-consuming and expensive.

We took a few ranchers on a tour to see the success of this agent. They were so excited that they wanted the insects right away and approached me about mass-producing them in the lab. My response was to say that I could do that, but it would be very costly. I suggested that we try a new kind of research project, which would involve scaling up the outdoor rearing of the insects to the farm-scale. I teamed up with an agronomist on a four-year project and we developed a method of growing houndstongue as a row crop, with the intent of producing big healthy plants that could be fed to our insects. After several generations, the plan was to harvest the insects en masse and ship them to ranchers. As it turned out, the ranchers and other project supporters received about 80,000 insects from our houndstongue crops.

Mogulones cruciger **weevil in houndstongue root**

BF: Is the idea for the ranchers to actually propagate the houndstongue on their own?

RDCF: Yes, we developed a very simple and cost-effective method for them to do just that. When we calculated all the costs of growing houndstongue as a crop and propagating the insects, it was between $10 and $12 per hundred weevils. This compares very well to the price of other weed biocontrol agents. For example, the *Aphthona* leafy spurge beetles sell for $50 per hundred, and other agents can be more expensive. And even if the ranchers don't use the methods themselves, they can use some of the concepts we developed, like adding nitrogen fertilizer to the soil, which increases the egg laying potential of our weevils by 25%.

I think the turning point for the houndstongue project was when I took the ranchers out and showed them a control plot where the houndstongue was big and healthy and green. Then I took them to a site where 300 weevils had been released two years previously, and the houndstongue that remained was sick looking. One of the ranchers pulled up a root, and when he cracked it open, it was just writhing with larvae. That was it; that was the clincher. And that's why it's important to get the ranchers personally involved. ■

Interview with Rico Thorsen

Rico Thorsen, propagation manager, Bylands Nursery, Kelowna, B.C.

Biocontrol Files: Can you describe the biocontrol work you've been doing with propagation materials at Bylands Nursery?

Rico Thorsen: We raise about two million plants from seedlings and cuttings – woody ornamentals, roses, climbers, and all types of ornamentals. It's always been hard to set up a chemical program that would work for such a wide range of things. So about two years ago, with the help of Mario Lanthier from the B.C. Ministry of Agriculture, we started to use biocontrol products. The first thing we tried was the mycorrhizal product, endoROOTS. [*Ed. Note: Mycorrhizae are not usually known as biocontrol agents, but, as living organisms that prevent other disease-causing organisms from being established, they perform the same function as biocontrol agents.*] We did some trials and it became very clear that it was really working. We had double the growth. Plants were much cleaner, much more branched. But, while mycorrhizae certainly helped us create clean plants, it didn't offer us any disease protection as such. Then we had a visit from Doctor Hoitink from the University of Ohio. He was able in a very detailed manner to tell us how and when to use *Trichoderma*. After his visit, we added *Trichoderma* – Rootshield - to the majority of our propagation soils, knowing that it would be active for eight to ten weeks.

About 12-14 days after using the *Trichoderma*, we found a kind of a netting, almost like a spider web, growing up the stem of a lot of the cuttings. We panicked at first, because it certainly looked like a disease! We quickly pulled some cuttings out, called Mario Lanthier, and said we think we have a disease. But, when we scraped the netting off the stems of some cuttings, it was completely green underneath. We called Doctor Hoitink, and he confirmed that it was *Trichoderma*. Mario suggested that we just monitor it, because, at least theoretically, the *Trichoderma* should attack the disease – which was botrytis - and hold it in check.

Traditionally, once you see botrytis you immediately spray to control it. But we found that the infected area stayed about four to six inches in diameter and never spread. Within ten days, there was very little left.

BF: I understand that you now use the mycorrhizae and *Trichoderma* together – is that right?

RT: Yes. We add *Trichoderma* to our propagation soil. It offers us protection during the rooting process. After eight to ten weeks, we apply a half rate of mycorrhizae, which slowly takes over when the *Trichoderma* is no longer effective. Three weeks later, we apply the other half. Between those two, we have been extremely successful with our cuttings. Our spraying has been reduced by 80% or more. We also get great protection against powdery mildew. I think the only thing we didn't find good protection for is black spot on roses.

BF: Do you use any other bioproducts?

RT: We use *Streptomyces* – Mycostop - for our seedlings, especially for our aspen trees. The aspens germinate really fast, and in the first two weeks, they are attacked by damping off. We used to spray them every 48 hours. We started to use Mycostop, one application right at seeding, and then once a week, at least three times. Now we have no damping off at all. We use Mycostop when seeding, and we add mycorrhizae later when the *Streptomyces* doesn't have any effect any more.

BF: Has using these products changed your thinking about disease management?

RT: Well, it's just a brand new world and a different way of thinking. It's been a brand new experience for us to not simply say, "There's a disease, let's spray." When applied at the proper rates and the proper time, these things are truly effective. The biggest thing for me is not so much that they work but that you have to change how you think. You really have to back off and live with some degree of disease. And that's a big leap.

BF: You had mentioned earlier that you had been helped by Dr. Hoitink. Would you say that growers need that kind of external help to be able to use these products wisely?

RT: You know, the biggest thing is that people need to really take the products and do trials of their own, not just on the rate, but so that they understand what they are about to see, and what is about to be acceptable to them. It's a big step, a big learning curve.

BF: How do these products compare with the chemical regime you were using in terms of cost effectiveness?

RT: Talking about the *Trichoderma* and mycorrhizae program for softwood cuttings, the biocontrol products are less than half the cost – and more effective! There's an initial cost, but that cost is gained back many times over by not spraying. There's so much to learn now about bioproducts. In the future, we'll use less and less product and it will be more and more effective for pest control, for the environment, and for the grower's wallet. It will be quite exciting! ■

Sclerotinia: hard to handle

Cosmopolitan. Polyphagous. Slimy.

The description may read like ad copy for the latest prime-time soap, but what we're really talking about is the plant disease, sclerotinia rot.

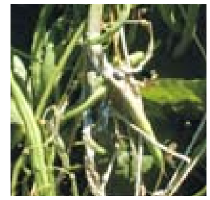
Plant diseases caused by the soil-borne fungal pathogens *Sclerotinia sclerotiorum* and *S. minor* are undeniably cosmopolitan and highly polyphagous. They infect more than 400 plant species worldwide. In Canada, they cause economically important losses in canola and soybean (stem rot), cabbage (head rot), carrots, sunflower (head and stalk rots) and beans (white mould), among other crops.

One reason sclerotinia pathogens are so hard to handle is their ability to survive in the soil for several years. That's why crop rotation, which minimizes damage from many soil-borne pathogens, cannot completely eradicate sclerotinia. Even tillage must be approached carefully, as it generally moves the overwintering structures - the sclerotia - near the soil surface where they can readily infect new hosts.

The life-cycle of the sclerotinia pathogen is illustrated in Figure 1.

Growers can reduce damage from sclerotinia with cultural practices. These include planting in well-drained soil, rotating with tolerant or non-susceptible crops, controlling cruciferous weeds which may act as alternative hosts, avoiding irrigation where extended periods of high humidity may occur, and avoiding contact between crops and wet soil.

Currently, chemical fungicides are a major component of the sclerotinia control strategy for some crops, but even the best products may provide limited efficacy under the very wet conditions which are conducive to infection. A number of biological control options have been investigated, with perhaps the best-studied agent being *Coniothyrium minitans* (see article on page 6). Other biological agents which have been tested include: *Penicillium griseofulvum*, *Trichoderma virens*, *Pseudomonas chlororaphis* (PA23), *Bacillus amyloliquefaciens* (BS6), *Pantoea agglomerans*, and various soil amendments. Some of these will be featured in subsequent issues of Biocontrol Files. ■



Pods with white mycelium and black sclerotia forming

Stem with white mycelium beginning to form sclerotia (still white)

Fig. 1. Development and symptoms of diseases of vegetables and flowers caused by *Sclerotinia sclerotiorum*.

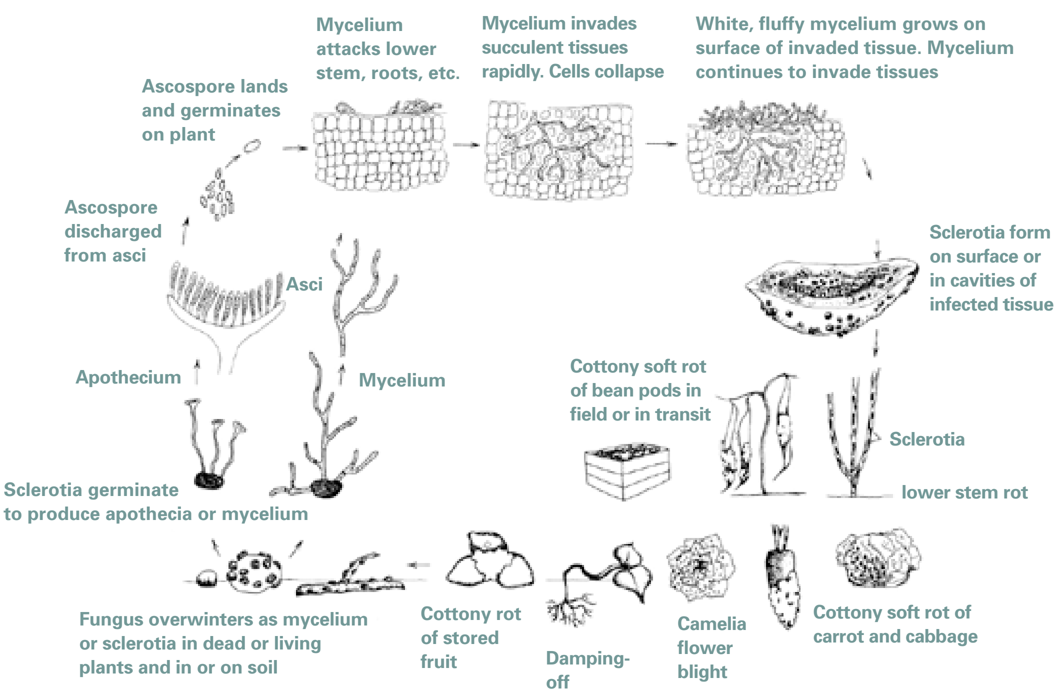
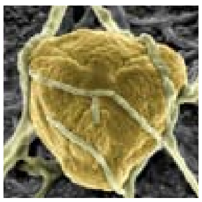


Diagram from Agrios, G.N. Plant Pathology. 5th ed. San Diego. Academic Press. 2005.

Coniothyrium minitans

Hitting sclerotinia diseases where they live



***Coniothyrium minitans* fungus on alfalfa pollen**

Photo © Minister of Public Works and Government Services Canada 2002

Coniothyrium minitans is a soil fungus whose natural habitat is almost entirely confined to sclerotia, the overwintering structures of the fungal genus *Sclerotinia*. Two important plant pathogens, *Sclerotinia sclerotiorum* and *S. minor*, belong to this genus.

C. minitans invades and kills the sclerotia of these pathogens in the soil. Spores of *C. minitans* germinate in contact with sclerotia, penetrate their hyphal walls, and cause cell plasmolysis (a shrinking of the cytoplasm away from the cell wall due to outward osmotic flow of water) and the collapse of hyphal walls. Infection appears to be mediated via production of several antifungal metabolites.

The fungus has been commercialized as a microbial biopesticide for management of sclerotinia diseases. *Contans®*, manufactured by Prophyta Biologischer Pflanzenschutz GmbH, is the most widely available *C. minitans* product in the world. It is registered in the European Union, Mexico, the US, and Japan for control of sclerotinia diseases on a variety of crops. The company is currently preparing the application documents for registration in Canada. It has been approved for use in organic agriculture in the U.S. and the EU.

C. minitans works best under certain soil conditions. Optimum spore formation occurs at 25 to 30° C, and all activity ceases when soil temperatures fall below freezing or rise above 30° C. Spore formation is also dependent on sufficient soil moisture. One caveat is that, according to the U.S. EPA's registration document for *C. minitans*, while the bioagent may be effective at reducing primary inoculum in the form of sclerotia, it is not as effective in preventing secondary spread between plants after primary infection has occurred. This means that, in conditions where the disease cycle has a longer time to development, e.g., longer growing seasons, it is possible that *C. minitans* may be relatively less effective than chemical fungicides.

C. minitans requires two to three months to destroy sclerotia in the soil; it is therefore recommended that the product be applied well before sclerotia come out of dormancy and start producing primary inoculum (ascospores) Applications should be made before or at planting time, while post-harvest applications can also be useful. Products are sprayed directly onto the soil, and then incorporated into the top soil layer. To avoid unearthing untreated sclerotia from lower soil layers, soil should be tilled no deeper than the treated layer.

A number of Canadian studies have tested the efficacy of *C. minitans* against sclerotinia diseases of various crops. One study found that *C. minitans* was effective in reducing the production of ascospores of both white mould of bean and sclerotinia blight of pea. A trial of *C. minitans* on canola and safflower found it effective for reducing ascospore production of *S. sclerotiorum*, and thereby reducing incidence of sclerotinia stem rot of canola and sclerotinia head rot of safflower. Another study found that *C. minitans* was effective in controlling both seed and pod rot of alfalfa. A European trial found a significant reduction of stem rot in canola when *C. minitans* was applied aerially, similar in effectiveness to the chemical fungicides benomyl and vinclozolin.

Several studies found that treatment with *C. minitans* in conjunction with soil amendments provides good management of sclerotinia diseases. One study found that treatment with a variety of organic soil amendments combined with either *C. minitans* or *Trichoderma virens* enhanced control of *S. sclerotiorum*. Another study compared different application methods for *C. minitans,* and found a foliar spray plus soil amendment with *C. minitans* was as effective as treatment with the fungicide benomyl in reducing the incidence of white mould of bean. A third study found that adding biocontrol agents such as *C. minitans* and others enhanced the suppressive effects of organic soil amendments on *S. sclerotiorum*. ■

Biocontrol News Digest

APRIL 12, 2006, ARS NEWS SERVICE: Natural fumigant for apple orchards – Biofumigation of apple orchards is leaping ahead in Washington and California where rapeseed, mustard and other *Brassica* species are gaining popularity as a natural means of controlling soilborne pests before planting time. But, though Brassicas are known to release a variety of chemical byproducts upon decomposing, mechanisms other than biofumigation could be at work against *Rhizoctonia solani*, according to Mark Mazzola, plant pathologist with the U.S. Agricultural Research Service's Tree Fruit Research Laboratory in Wenatchee.

In trials using ground-up rapeseed as a soil amendment, Mazzola observed that release of isothiocyanates from the rapeseed had nothing to do with Rhizoctonia control. Rather, the control stemmed from changes the rapeseed caused to the soil environment and microbes living there. For example, *Pythium* spp - other replant disease culprits - and *Streptomyces* bacteria strains that produce nitric oxide both thrived. Nitric oxide has been identified as a signaling compound that may trigger a pest-fighting response called systemic acquired resistance in some plants. Mazzola theorizes that increases in *Streptomyces* numbers resulting from rapeseed amendments stimulated this resistance response in apple tree roots, suppressing *Rhizoctonia* survival long after the isothiocyanates have disappeared from the soil.

However, the increases in *Pythium* density required chemical control with mefenoxam. Thus, Brassica's pest control effectiveness isn't so clear-cut, according to Mazzola, whose studies appear in the journal Plant Disease.

APRIL 29, 2006, NEW SCIENTIST: Call for biowar on drugs – Congressman Mark Souder has been busy in his personal war on drugs. As well as fighting against the legalisation of cannabis for medical use, the Indiana Republican has slipped a provision into a bill calling for the fungus *Fusarium oxysporum* to be used as a biological control agent against drug crops in foreign countries.

The CIA, however, has had moral doubts about using the fungus. In 2000, a CIA official told *The New York Times* that it was unsafe both for humans and for the environment: "I don't support using a product on a bunch of Colombian peasants that you wouldn't use against a bunch of rednecks growing marijuana in Kentucky."

The Department of Agriculture and the Drug Enforcement Agency agree. *Fusarium* species are highly prone to mutation, so they can readily change hosts and infect plants they were not supposed to. This was the main reason Florida's Department of Environmental Protection rejected the fungus in 1999 as a biocontrol agent for outdoor marijuana crops.

MAY 10, 2006, ARS NEWS SERVICE: Seed-rotting microbes sought to battle weeds – New, integrated approaches to battling annual broadleaf weeds may enlist beneficial soil microbes that 'hit' the pesky plants where it hurts–their seed banks.

Seed banks are reserves of thousands, even millions, of weed seeds that lie dormant beneath the soil awaiting favorable conditions to germinate, says Joanne Chee-Sanford, a microbiologist with the U.S. Agricultural Research Service in Urbana, Illinois.

Since 2002, Chee-Sanford has been studying how certain fungi and bacteria cause decay in dormant weed seeds, killing them or diminishing their fitness. While classical biological control would call for unleashing the microbes against a targeted weed, Chee-Sanford has a different tactic in mind. Rather than apply microbes as biological control agents, she envisions bolstering the activity of existing soil microbes, possibly by using some kind of amendment.

In one study, 99 percent of velvetleaf seeds underwent microbial decay after three months. The prime decay agents–*Bacteroidetes* and *Proteobacteria*, found in many soils–are known to degrade natural seed polymers. But Chee-Sanford is still trying to ascertain whether they were the initial cause of the seeds' decay, or mere contributors.

Chee's efforts are part of a broader program to furnish midwestern farmers with new weed-management systems that integrate biological, chemical, cultural and mechanical control methods.

MAY 16, 2006, ACCRA, GHANA: Ministry of Health signs MOU for biological control of malaria – The Ghanian Ministry of Health on Tuesday signed a Memorandum of Understanding (MOU) with Labiofam, a Cuban agency, for the use of biological agents to eradicate malaria. The project would integrate biological vector control into the National Malaria Control Programme.

Major Quashigah, the Minister of Health, said the signing of the MOU marked the beginning of an era to focus on the control of mosquitoes in high breeding areas, instead of promoting the use of treated mosquito nets.

The project would involve the application of biolarvicides such as Bactivec and Griselef against larval mosquitoes, and include environmental sanitation and educational activities to diminish risks of the disease.

It is hoped that malaria mortality can be reduced by 50 percent by the year 2010, through prevention and improvement in case management and the use of biolarvicides as an augmenting strategy. ■

Ed. Note: The active ingredients in Bactivec and Griselef are, respectively, Bacillus thuringiensis var. israelensis and Bacillus sphaericus strain 2362.

Resources:

Books

Said to be the first book of its kind, *Sterile Insect Technique, Principles and Practice in Area-Wide Integrated Pest Management*, takes a generic, comprehensive, and global approach in describing elements of SIT (sterile insect technique). The substantial (802 pages), 2005 volume scientifically evaluates the strengths, weaknesses, successes, and failures of the SIT. V.A. Dyck and co-editors present a wealth of information and references prepared by a 50-author international group (19 countries represented reflecting the global breadth of the SIT). The hardbound work contains material not found to date in any single previous publication. Subjects covered range from the technique's history, basis, components, application, economic and management considerations, and impact, to its prospects for improvement and greater utilization in the future. Springer, PO Box 17, 3300 AA Dordrecht, The Netherlands. Web: http://www.springer.com.

The second, extensively updated, edition of *Residential, Industrial, and Institutional Pest Control* has added information about school IPM programs, including how to select appropriate pesticides, and other key factors. The 256-page manual offers answers for solving institutional and household pest problems, emphasizing structural, food, and fabric pests, along with extended information for managing rodents, birds, and weeds. ANR pub. no. 3334. ANR Catalog, Univ. of California, 6701 San Pablo Ave., 2nd. Floor, Oakland, CA 94608-1239, USA. E-mail: anrcatalog@ucdavis.edu. Fax: 1-510-643-5470. Web: http://danrcs.ucdavis.edu.

Entomologists at Michigan State Univ. have published a new, pocket-size guide for *Identifying Natural Enemies in Field Crops.* This 46-page publication divides beneficial insects into major groups such as beetles, true bugs, spiders, and more, and includes full color photos accompanied by brief descriptions and distinguishing characteristics. With a spiral lay-flat bound, plastic-coated page format, the guide, with glossary and index, provides a useful field reference. Sample pages can be viewed at http://ipm.msu.edu/pubs-natural.htm. Ext. bull. E2949. MSU Bulletin Office, 117 Central Stores, Michigan State Univ., East Lansing, MI 48824-1001, USA. Fax: 1-517-353-7168. Phone: 1-517-353-6740. Web: http://www.emdc.msue.msu.edu.

Websites

For many years crop protection specialists in the Pacific Northwest region of the U.S. collaborated to produce printed regional pest management handbooks individually addressing weed, insect, and disease management. Now all three works, regarded as invaluable current references containing information with far broader applicability than their indicated limited geographical focus, have been translated into freely available on-line versions, as well as still being offered in hard copy format. The three volumes, now referred to as "IPM Handbooks", can be found at http://ipmnet.org/IPM_Handbooks.htm. Each of the three sites includes information for ordering the respective print versions.

Disrupting the mosquitoes' breeding cycle