Biocontrol Files

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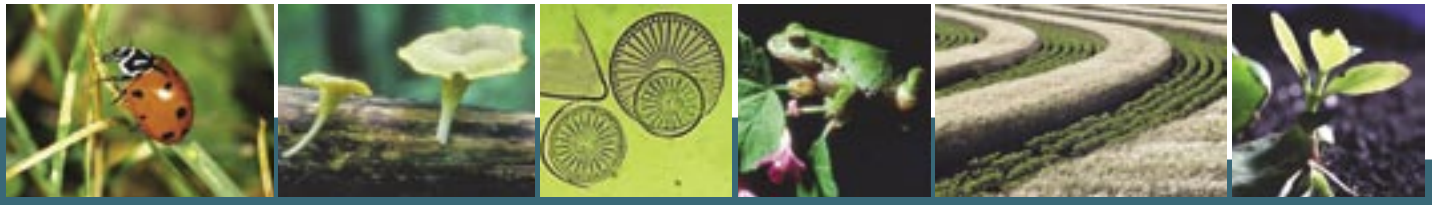
Canada's Bulletin on Ecological Pest Management



Biocontrol research is for the public good

Leaf beetle *Galerucella spp.* feeding on leaves of purple loosestrife

Scientific research is typically funded by investors and by industry on the basis that it will result in a financial return on investment. Some scientific endeavours, however, hold out few possibilities for commercial success or direct profit. Certain biocontrol projects and products fit squarely into this category. While these research efforts have undeniable health and environmental benefits, for reasons chiefly related to the specific characteristics of biological products and the structure of the pest control marketplace, there is little economic incentive to develop and commercialize a product.

The value of biological control and its benefits to the public are undeniable. Consider the following:

- Australian researchers, concerned about the impact of the banana skipper butterfly in Papua New Guinea and its potential migration to the Australian mainland, received federal funding for a three-year project. They succeeded in controlling the butterfly with a small parasitoid wasp and saved the industry from substantial losses. An investment of $700,000 reaped benefits of $424.7 million - a benefit-to-cost ratio of 607:1!
- Introducing natural enemies of a pest which attacks ice plant, an ornamental species used in California to landscape freeways, saved the Department of Transportation $20 million in replanting costs. The total cost of the project: $190,000.
- The introduction and successful control of cassava mealybug by the parasitoid *Epidinocarsis lopezi* over parts of the vast cassava belt in Africa enabled the continued cultivation of this basic staple by subsistence growers, thus helping to reduce hunger for 200 million people.

Natural enemies (predators, parasitoids, parasites and pathogens), along with forces such as fire, cold and rain, regulate populations in nature. The contention that biocontrol is a public good may come into clearer focus by considering what might happen if there were no natural enemies. Without these natural biological controls, a great many more pests would cause negative impacts on forestry, food and fibre crops, rangeland, recreational and environmental resources, and Canadian wildlife. The damage would be extensive and the price tag steep. This is not simply an economic argument – there are social and environmental aspects to which it is hard to assign dollar figures. What price tag could be assigned to the effort to ensure that African waterways are free of choking water hyacinth? Biological control research investigates, builds on, and in some cases commercializes the strengths of natural biological control.

Government bodies have increasingly recognized biological pest control as a public good:

- When the U.S. Environmental Protection Agency mandated the establishment of a Resistance Management Program for genetically modified *Bt* crops, they explicitly recognized *Bacillus thuringiensis* as a "public good".
- The Ontario Horticultural Crop Research and Services Committee stated that the reduced environmental impact associated with apple IPM programs qualified the program as providing public goods and, therefore, justified public funding.
- According to the U.S. National Research Council's 2000 report, "*The Future of Pesticides in U.S. Agriculture*", "public support for research has traditionally been justified by the public-good argument for research that does not lead to commercial innovations. Research that does not generate marketable products that will repay the research is of high priority for public support."
- In 1998-99 the Canadian Agri-Food Research Council recommended, "that agencies funding agricultural research exempt research proposals involving classical biological control research and development from criteria involving commercialization potential, and that such proposals be recognized as public good research because of the benefits that successful classical biological control research and development brings to the public as a whole."

Investment and development of biological pest control technologies fits well with policies espoused through Canada's Agricultural Policy Framework and similar policy frameworks in other sectors and Ministries. These kinds of public good programs often go beyond local, regional or provincial boundaries and are national in scope. Healthy forestry, agricultural and tourism industries, to name but a few, are in the national public interest. As well as protecting value and jobs in these and other sectors, biocontrol may well *create* new jobs, founded on the development of green technologies. Beyond the economic sphere, biological control has the capacity to increase biosecurity and enhance public health and the health of the environment. Canada has the scientific and technical expertise to be a leader in this area. ■

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.

Managing editor: Vijay Cuddeford for WWF Canada

Editorial Committee: Julia Langer, Colleen Hyslop, Leslie Cass, Jean-Louis Schwartz, Mark Goettel

Additional writing: Wayne Campbell, Vijay Cuddeford

Scientific review committee: Mark Goettel, Dave Gillespie, Richard Bélanger, Jacques Brodeur

Guest columnist: Don Elliot

Designed and produced by: Design HQ

French translation by: Alain Cavenne

Website production: Biocontrol Network

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Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Guest author Don Elliott

History of the development of greenhouse biological pest control in Canada

Early years

The control of greenhouse pests using biological control agents has a long history in Canada. In 1935, the whitefly parasitoid *Encarsia formosa* was first obtained from England, and mass production began at the Dominion Parasitoid Laboratory in Ontario. Between 1938 and 1954, more than 18 million parasitoids were shipped from this facility to Canadian greenhouse growers. Unfortunately, with the success of DDT and other new pesticides in the 1940s, mass production and use of these parasitoids was all but discontinued by 1955.

The good news is that Canada is again a world leader in biological pest control on greenhouse vegetables. In fact, biological control has replaced pesticides as the primary pest control method. In British Columbia, 99% of greenhouse vegetable growers rely on biological control. The expansion of biological control occurred for several reasons: an increase in pest resistance to pesticides, a resultant escalation in chemical applications and the fact that few new pesticides were being registered for "minor crops". For all these reasons, there was a renewed focus on alternative controls, a rejuvenation of research efforts, and a commercial greenhouse biological control industry began to develop in Canada.

Rejuvenation of Canadian greenhouse biocontrol

Mass production of whitefly parasitoids resumed in Ontario in the early 1970s. Researchers at Agriculture Canada began rearing the parasitoid *E. formosa* and the spider mite predator, *Phytoseiulus persimilis*, while Better Yield Insects Co. started small-scale commercial production of both parasitoids. A pilot program for control of whitefly and spider mites was begun in B.C. vegetable greenhouses, accompanied by the production of these two agents at Agriculture Canada's Saanichton Research Station with free distribution to growers. This enabled the start-up of a large-scale commercial production facility called Applied Bio-Nomics Ltd., located near Saanichton on Vancouver Island. By 1985, pesticide use had been greatly reduced; in B.C., biological control was being practiced by 85% of cucumber growers and 38% of tomato growers.

These developments were paralleled in both Ontario and Quebec, where governments funded research and extension work on greenhouse biocontrol. The first research trials in commercial greenhouses in Quebec were funded by MAPAQ (Ministère de l'agriculture, des pêcheries et de l'alimentation du Québec) and conducted by researchers at McGill University, and subsequently at Université Laval. In Ontario, Graeme Murphy and Gillian Ferguson of OMAF (the Ontario Ministry of Agriculture and Food) worked intensively with ornamental and vegetable growers to promote the use of integrated pest management (IPM) and biocontrol.

From 1985 on, rapid research, development and commercialization was facilitated by the active cooperation of the greenhouse industry, research and extension entomologists, and federal and provincial funding agencies. Decreasing reliance on pesticides allowed bumblebees to be used for pollination of greenhouse tomatoes in 1989, which prompted research on the effects of pesticides on beneficials and bees, and the recognition that many pesticides had negative effects on both.

With both greenhouse whitefly and two-spotted spider mite under biological control and a reduction in the use of broad-spectrum pesticides, some pests which had been previously well-controlled emerged as problems. Since there were few pesticides available that could be integrated with biological control, other alternatives were investigated. Linda Gilkeson, working at Applied Bio-Nomics in 1986, developed rearing and release methods for the predatory aphid midge, *Aphidoletes aphidimyza* and the aphid parasitoid, *Aphidius matricariae*. That same year, Dave Gillespie and Don Quiring at Agriculture Canada developed the use of sticky yellow traps as an early detection and monitoring tool for greenhouse whitefly and thrips.

IPM programs featuring biocontrol of aphids were established for peppers and tomatoes, and pesticide-resistant strains of the spider mite predator *Amblyseius fallacis* were developed by Howard Thistlewood. Mass rearing programs followed for *A. fallacis* (1993) and the spider mite predatory beetle, *Stethorus punctillum* (1996). Dave Gillespie continued to develop a number of new biological control agents, including the thrips and fungus gnat predatory mite, *Hypoaspis aculeifer* (1990), and several others.

Current issues

Development of successful biological control programs is long-term work: from research and development through to commercialization requires 5-10 years or more. This fact, along with high local production costs and inefficiencies of scale, has limited the number of commercial biological production facilities in Canada to four: Applied Bio-Nomics Ltd. (B.C.), The Bug Factory (B.C.), Bugs By Nature Banker Plants (B.C.) and Biobest Canada (Ontario). Thus the majority of biological control agents currently used in Canadian greenhouses are produced offshore by the three largest multinationals: Koppert (Holland/Israel), Biobest (Belgium/Morocco) and Syngenta Bio-line (England/U.S.A.).

In Canada, biological control agents fall under the Pest Control Products Act, although importation falls under the Plant Protection Act. In an effort to prevent over-regulation and to develop workable standards for quality control, registration, legislation and ethics, the biological control industry is working toward self-regulation. In North America, the Association of Natural Biocontrol Producers (ANBP) is formalizing industry quality control standards. In Europe, two bodies – the International Organisation for Biological Control (IOBC) and the International Biocontrol Manufacturers Association (IBMA) – are working on these same issues.

The success of biocontrol agents in commercial greenhouse crops shows that, if the stakes are high enough, biological control can work and can replace chemical pesticides. There is little doubt that the commercial development of biological control will continue to grow; in an increasing number of cases, there are few acceptable alternatives. Carl Huffaker, one of the fathers of biological control, summed this up in the statement, *"When we kill off the natural enemies of a pest, we inherit their work."* ■

Due to space limitations, this article represents only a brief summary. A more detailed description will appear in the book: "Biological control: international case studies," *to be published in 2005 by the Biocontrol Network.*

The road to success

The fruitful, and sometimes rocky, road to success

For Hélène Chiasson, Vice-President of Quebec-based Codena Inc., the upcoming registration of the biopesticide Facin by the U.S. Environmental Protection Agency (EPA) is the culmination of 12 years of work, involving a wealth of colleagues. And a variety of funding sources!

Facin is an extract from the plant *Chenopodium ambrosioides var. ambrosioides*, and is soon to be registered for use in commercial greenhouses against whiteflies, thrips, aphids and mites which prey on ornamentals.

The long path to registration began in 1993 when Chiasson was awarded an NSERC post-doctoral fellowship to work at Urgel Delisle et Associés, screening plant extracts with insecticidal properties. From the beginning, Chiasson collaborated with researchers from Agriculture and Agri-Food Canada (AAFC), assisted by AAFC's Matching Investment Initiative program, which provided not only research collaborators, but also a lab in which to work.

Identifying some good leads, the team requested further funding from the National Research Council (NRC). The NRC's Industrial Research Assistance Program (IRAP) granted Chiasson's team full funding for three years, from 1997 to 2000. By the end of that time, the team had developed two formulations, submitted a patent, and explored the registration process with both American (EPA) and Canadian (PMRA) authorities.

It was clear that classification as a biopesticide at the EPA was critical, other avenues being simply too expensive. As Chiasson explains it, this was a critical juncture: there were very few funds available to support work towards registering a product or active ingredient. Finally, a Quebec-based regional development program – the Conseil régional de développement de la Mauricie (CRDM) - came through. Because such regional development funds are oriented towards helping local companies create jobs and support local industry, the funders were more interested in commercialization than research, and so funded the group's first registration costs. With this essential funding in place, the Fonds d'action québécois pour le développement durable (FAQDD) was able to follow through with its support of Chiasson's research program.

Around the same time, Foragen Technologies made a major investment in the product. Foragen became part owner and shareholder; thus, Codena was formed. Chiasson lauds Foragen for being one of the few investors willing to jump in at the early stages of product development.

Says Chiasson, "There are so many things involved in developing a product ... besides obtaining efficacy data, there's the application for patents or intellectual property work, and, especially, the registration process to pursue. You have to continuously look for funding, and it demands a lot of skills." Chiasson says that the regional development programs (the ones that still exist) are particularly valuable at the early stages of product development or company creation because they don't require the kind of high returns that venture capital funding often insists on. ■

Chenopodium ambrosioides var. ambrosioides

Biopesticides with a Cuban rhythm

Oxen in Cuban farming

The breakup of the Soviet bloc had a profound effect on Cuban agriculture. For decades, the Soviet Union had purchased Cuban sugar at several times the market price and supplied Cuba with chemical fertilizers and pesticides. When this arrangement broke down in 1990, Cuban agriculture and society hit the wall. Caloric intake and agricultural production plummeted. Cuba responded by adopting a semi-organic approach to agriculture, characterized by low external inputs and a strong dependency on local resources, especially for pest control.

One of Cuba's key innovations was the development of community-based *Centros de Reproducción de Entomófagos y Entomopatógenos* (CREEs). These cottage-scale biopesticide factories, which are part of agricultural cooperatives, churn out a variety of microbial pesticides which are provided free or at low cost to local producers. By the end of 1997, 280 CREES were supplying services to state, cooperative and private farms. Fifty-three CREEs served areas which grew sugar cane, producing biocontrol agents for pests of sugar production, while the remaining 227 were oriented towards crop and fruit production on state farms or cooperatives. The facilities are maintained and operated by local technicians with college degrees, two years of post-high school vocational training, or high school diplomas. Biocontrol agents are provided free of charge to the hosting cooperatives and are sold at a nominal cost to neighboring farmers, state farms and other cooperatives.

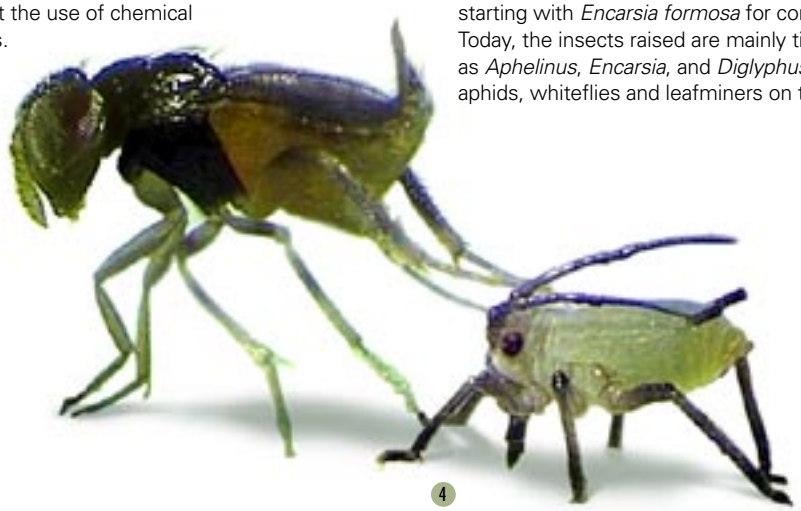
Cuba has developed simple and effective techniques for the production, formulation, application and quality control of numerous entomopathogenic bacteria and fungi, including *Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium anisopliae* and *Verticillium lecanii*. Production methods are designed to take advantage of the best locally abundant substrate. For example, fruit juices are recommended for *Bt* production. For fungi production, a rice waste product is used. Using by-products or wastes from agro-industrial production as substrates for mass production reduces production costs. For example, 1 ton of *B. bassiana* produced in solid culture (rice wastes) can cover up to 100 ha. Using such simple methods, Cuba has produced an average of 2,132 tons of biopesticides annually.

Cuba has truly embraced biopesticides. While the European Union's annual use of biopesticides amounts to about 700 tons per year, Cuba applies some 2,000 tons per year, all produced in Cuba. In 1999, approximately 600,000 ha were treated with these formulations. When *Trichogramma* releases are added (these are also produced and disseminated by CREES), the total area under biological control reaches 982,000 hectares. ■

Trusting the talents of nature

Working the fertile soils of western France, the 150 growers who belong to the market gardening co-operative Saveol harvest 73,000 tonnes of tomatoes per year, making Saveol the biggest tomato producer in France. Saveol also grows smaller volumes of cucumbers, capsicum, flowers, strawberries and shallots in 235 hectares of greenhouses, all without the use of chemical pesticides.

As the company's website, www.saveol.com, explains, production and pest control rely heavily on "the talents of nature." Some years back, frustrated with increasing resistance to pesticides in important tomato pests, the growers created a research unit and turned to biological control. Beginning in 1983, Saveol has raised its own "friendly insects" or "auxiliaries," starting with *Encarsia formosa* for control of whiteflies. Today, the insects raised are mainly tiny wasps such as *Aphelinus*, *Encarsia*, and *Diglyphus*, which control aphids, whiteflies and leafminers on tomatoes. ■



An *Aphelinus* female laying an egg inside an aphid.

Aspergillus flavus A-36

A little competition is a good thing

Aflatoxins are potent liver carcinogens which are produced by some fungi, including *Aspergillus flavus*. Aflatoxins have long been a headache for growers of warm climate crops such as cotton, corn, and peanuts, and tree crops such as almonds, pistachios and walnuts. For cotton growers, the number one reason to control aflatoxins is that cottonseed is used as dairy feed. Because humans consume dairy products, there are very stringent restrictions on aflatoxin levels in cottonseed – 20 parts per billion in the U.S.. Higher concentrations prevent the product from entering the dairy feed market, while products containing levels greater than 300 ppb are unmarketable.

Over the last few decades, Dr. Peter Cotty, a research scientist with the U.S. Department of Agriculture in New Orleans, has developed a method which allows a strain of *A. flavus* which does not produce aflatoxins to outcompete aflatoxin-producing strains, literally shifting the fungal population structure in the field away from toxicity. And the cotton industry has enthusiastically backed his efforts.

The story began back in 1988. Representatives from U.S. commodity groups listened closely as Cotty presented research which showed that the degree of aflatoxin-producing ability in *A. flavus* is not associated with competitive ability in the field. This finding opened the door for development of control technologies based on non-aflatoxin producing species outcompeting their more toxic brethren.

Initial funding from the Cotton Foundation of the National Cotton Council got Cotty out into the field for studies. Both the Council and individual growers offered encouragement and constant interaction to make sure the technology was developed and moved forward. This high level of industry interest has meant that, since the beginning, almost all of Cotty's field trials have been conducted on commercial farms.

Over the next few years, field trials continued to show good results. In many fields, aflatoxin levels plummeted by 80-90%. The next step was testing in commercial fields. In 1993, Cotty met with the U.S. registration authorities (EPA), along with senior administrators from the Department of Agriculture's Agricultural Research Service (ARS) and scientists from the National Cotton Council. In 1995 the first Experimental Use Permit (EUP) was granted. It was agreed that the team would proceed with a biopesticide registration. IR-4 (Interregional Research Project #4) helped guide the application through the registration process, acting as an intermediary with the EPA and, from 1996-2003, experimental field trials were conducted on larger and larger acreages.

Arizona cotton growers were enthusiastic about moving towards registration of a product. They decided, however, that, rather than farm the process out to a corporation, the Arizona Cotton Research and Protection Council (ACRPC) would be the registration holder. ACRPC is a grower organization supported by check-off fees, though technically a part of the Arizona state government. While the EUPs had been 'registered' in the name of the ARS, the registrant for the full registration of the product known as *Aspergillus flavus* AF-36 is the ACRPC. This decision was made in part because Arizona cotton growers were unhappy with the process of developing transgenic cotton, arguing that much of the benefit of the technology was extracted from them via the technology fees paid for seed. By registering AF-36 themselves, the growers aimed to keep the profits on the farm. Thus, in 2003, ACRPC was granted a section 3 registration for use of AF-36 on cotton fields in Arizona and Texas.

A. flavus A-36 is delivered onto the soil surface on a substrate of wheat seed. The substrate acts as an initial food source. In addition, because *A. flavus* A-36 is on the soil surface, under the plant canopy, the benign strain has a big head start on aflatoxin-producers, which are trapped in the soil matrix.

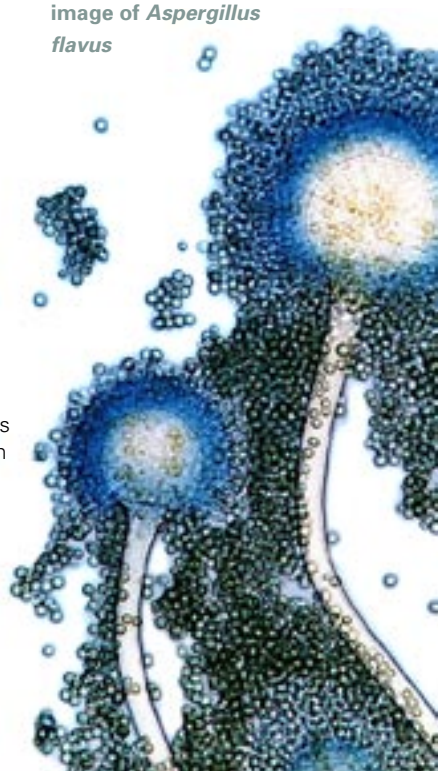
The ARS-ACRPC partnership developed a process for producing commercially significant quantities of biopesticide material, including equipment specially designed for the purpose. Arizona cotton growers built a manufacturing facility based on this process that produces three tons of product per day. Funding was covered partly by an ACRPC contingency fund and check-off funds, and partly by Congress through ARS.

Over the years, the project has been supported by a variety of organizations. In addition to ARS base funds, funding was received from the Cotton Foundation, from the Cotton Incorporated state-support programs of Arizona and Texas, from the IR-4 Biopesticide Program, and from the Texas Cottonseed Crushers Association. Participating growers, gins, cooperatives, ACRPC and the South Texas Cotton and Grain Association all funded aspects of the work. The largest funding source outside the industry was provided by the USDA Multi-Crop Aflatoxin Working Group.

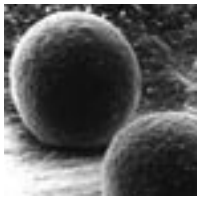
According to Cotty, the bulk of the support for the project has come from the industry and the growers themselves. Farmers participating in field studies have paid for the materials and application costs; thus the project has conducted a great deal of research on a very broad scale with minimum expense. Farmers are currently charged five dollars per acre for the product and application costs range from one to seven dollars per acre. The cost benefit ratio may reach 1:5 or better for the farmers. ■

Arizona cotton

Light microscope image of *Aspergillus flavus*



Bt: poster child for the biopesticide industry



Magnified image of undiluted droplets of *Bt* spray on a fir needle

By almost any measure, biopesticides have not made significant inroads in the worldwide pesticide industry, accounting for only 0.5 % of the annual $30 billion in sales. Within this 0.5 %, one product, based on a protein toxin from the bacterium *Bacillus thuringiensis*, is responsible for more than 90% of the market. *Bt* is the biopesticide poster child, the only blockbuster product. It owes its success to the public's concern over chemical sprays and to *Bt*'s minimal impact on the environment.

Bt was first identified as the cause of a silkworm disease in Japan in 1901. In the early 1920s, a *Bt* preparation was used in France to control flour moths, and it was used in the U.S. to manage the spread of European corn borer. The first commercial preparation, Sporeine, became available in France in 1938. However, interest in *Bt* and other biopesticides vanished in 1939 with the introduction of DDT.

While DDT was highly effective, the chemical's toxic effects in the environment soon became apparent. Looking for alternative controls for the spruce budworm, the Canadian government opened an Insect Pathology Laboratory at Sault Ste. Marie in the 1950s, focusing on, among other things, *Bt*. According to Kees van Frankenhuyzen, a *Bt* expert at the Sault Ste. Marie Centre, the bacterium's mode of action (how it kills insects) was first established in a paper written in 1954. The protein appears to cause holes in the cells of insects' gut lining, causing the gut to disintegrate and eventually kill the insect host. The paper touched off a worldwide wave of interest in *Bt*.

American and Canadian governments pushed ahead with aerial spraying of a *Bt* preparation called Thuricide. Kees van Frankenhuyzen: "After about 20 years of research to improve the insecticide's potency as well as optimize the application method, dosage, timing and frequency, aerial spray trials finally began to be effective."

In the early 1970s, Abbott Laboratories entered the *Bt* business, focusing on the forestry market with its "single point of entry" (only governments buy the product, but in huge volume orders). Abbott worked with the Canadian and U.S. governments to develop a *Bt* product that was as efficacious as the chemical of choice, though it was 2-3 times more expensive at the time.

When environmental and public health fears led to a ban on aerial chemical sprays in forestry, *Bt*, with its high specificity to insects, was exempted. The ban drove demand for *Bt* up while sending prices downward. Higher *Bt* potencies in smaller volumes of spray also led to big savings, making the biopesticide still more competitive.

With the huge commercial success of *Bt* in the forestry market, companies turned to agriculture, particularly vegetable markets - organic growers have used *Bt* sprays for years - and other specialty markets such as sprays for mosquitoes and black flies. The breadth of potential target pests derives from the fact that there are over 330 different *Bt* genes that code for insecticidal proteins, arranged in 50 groups, with each having its own spectrum of activities. Since the mid-1980s, *Bt israelensis* has been used to combat black flies and mosquitoes, vectors of various human and livestock diseases. It is hoped that the development of this multi-varied insecticide can be replicated with other biopesticides, setting the stage for significant growth in the industry. ■

Who says scientists don't have a sense of humour???

Check out the following scientific names (it helps to say the names aloud.)

- *La cucaracha, La paloma* (pyralid moths)
- *Lalapa lusa* (tiphiid wasp)
- *Aha ha* (sphecid wasp)
- *Agra vation, Agra phobia* (carabid beetles)
- *Ytu brutus* (beetle)
- *Leonardo davincii* (moth)
- *Phthiria relativitae* (bombyliid fly)
- *Heerz lukenatcha, Heerz tooya, Panama canalia, Verae peculya* (braconid wasps)
- *Godzillius, Pleomothra* (crustaceans)
- *Apopyllus now* (spider)
- *Abracadabrella birdsville* (jumping spider)
- *Strigiphilus garylarsoni* (owl louse named for cartoonist Gary Larson)
- *Ba humbugi* (endodontoid snail)
- *Bombylius aureocookae* (bee fly)
- *Cyclocephala nodanotherwon* (scarab)
- *Dissup irae* (a hard-to-see fossil eremochaetid fly)
- *Eurygenius* (pedilid beetle)
- *Notnops, Taintnops, Tisentnops* (caponiid spiders) These Chilean spiders were originally placed in the genus Nops, but were separated into these new genera upon re-examination.
- *Pieza kake, Pieza pi, Pieza rhea* (mythicomyiid flies)

Interview with Murray McLaughlin, CEO, Foragen Technologies

Biocontrol Files: What are the major factors an investor considers when deciding whether to fund development and commercialization of a biological pest control product?

Murray McLaughlin: When we look at a technology – Codena is an example (see page 3) – we look at three things. First, the intellectual property: what's the patent status? Can it be patented? Second, the people. Third, we look at market opportunities. How big is the market? What's the cost of getting to the marketplace?

BF: When you say 'people', what do you mean?

MM: Mostly I mean personalities. You ask yourself, "Are these people that I can work with on a regular or daily basis?" At Foragen we take a very hands-on approach because we're investing very early, which means that we're working with a lot of science people. We're looking for people who understand what their role is, who understand how they want to participate in the company. Not everybody makes the ideal CEO.

BF: What are some of the barriers to success with biocontrol products?

MM: I think a lot of people have high expectations of the technology. They look at the marketplace and say, "Well, the market for insecticides is a billion dollars," and they think their technology is going to capture that billion dollars. The reality is that, if they're lucky it'll capture a few tens of millions of dollars. If they're really lucky, it might capture 50 to 100 million dollars. You need to understand the marketplace, how your technology will fit in, and what it's going to take to get there. You can't just drop the product in the marketplace because it's green technology. You still have regulatory hurdles, and a lot of marketing capability is required before you capture your market. I think people tend to overestimate the market and underestimate the time it takes to get to the market, to develop the regulatory package, get the efficacy data and so on.

BF: Are biopesticides still a good investment?

MM: It depends on the definition of biopesticide. For example, microbials are very much a niche market. The main reason is that they're very specific: they manage a single insect or a single disease. And there's a lot of management that's required from the producer ... there's a whole education around handling them, their stability, how active they are. We've learned how to use and handle *Bt*. But a lot of the other microorganisms are much more difficult to deal with – they're affected by climate, by temperature, by light, by heat ... there's a lot of variability that can impact the product. If you look at Codena's product, it's very different, it's a plant extract, a natural product, used and formulated and sprayed to control the insect. It's got stability from a utilization perspective – it's used very similarly to a conventional insecticide. But even there, there are a lot of variables to deal with. Producers have to be educated, you need to know whether you can capture significant market or not, how big that market is, and the costs of production. It's more expensive to produce a product made from a plant extract than it is to produce a synthetic chemical.

BF: Do you have the sense that biocontrol developers are a little bit more aware of these types of things? Are you seeing better preparation?

MM: There's a lot of hit and miss. But there's a change happening now from a consumer perspective. A lot of municipalities are banning chemical pesticides. How will they react to some of the new green technology that comes along - are they going to allow them to be utilized or not? If they do, that will probably help drive an increased focus on green pesticides.

BF: So you think there may be more market share in some of the non-agriculture sectors?

MM: Yes - home and garden, turf use, ornamental greenhouses. Ornamental greenhouses are a better fit for biopesticides because that sector can withstand higher prices as well. They're also a good fit for microbials because you have a controlled environment. But you've got to know if the market is big enough to both recover your costs and create some profitability. Marketability means understanding competition as well – what other compounds are out there, what's new – on the chemical side as well, not just the biological/natural area. Having that market knowledge is really critical. But, having said that, I think there's definitely going to be opportunities with biological products. We have a better understanding of the science today. Whether we call it biotechnology or just understanding biological systems better, we now have a better ability to find some of these new biological compounds that'll work more effectively. ■

Resources:

Conferences

July 16-20, 2005: Institute of Food Technologists Food Expo and Annual Conference, New Orleans, Louisiana. Information at: http://www.am-fe.ift.org/cms/?pid=1000113

August 11-14, 2005: American Community Gardening Association Annual Conference, Minneapolis/St. Paul, Minnesota. Information at: http://www.communitygarden.org/05Conference.pdf

Sept. 15-18, 2005: Natural Products Expo East, Washington, DC. Information at: http://www.expoeast.com/

September 20-23, 2005: IFOAM (International Federation of Organic Agriculture Movements) Organic World Congress, Adelaide, Australia. Information at: http://www.nasaa.com.au/ifoam/

Oct. 30-Nov. 3, 2005: 6th Pacific Rim Conference on the Biotechnology of *Bacillus thuringiensis* and its Environmental Impact, The Fairmont Empress, Victoria, BC, Canada. Information at: http://biocontr.prestosite.net/prc/pacrimconf.html

Nov 6-9, 2005: Agricultural Institute of Canada (AIC) Annual Conference: "Identifying Strategies to Support Sustainable Agriculture in Canada", Quebec City. Information at: http://www.aic.ca/conferences/pdf/AIC_Program_ENG_July5.pdf

Websites:

Alternative Farming Systems Information Center, operated by the U.S. National Agricultural Library. Offers a wide range of resources, including bibliographies, on organic and sustainable agriculture. http://www.nal.usda.gov/afsic/index.html

Pesticide Free: A Guide to Natural Lawn and Garden Care. Toronto Public Health. 2004. http://www.toronto.ca/health/pesticides/pdf/natural_lawn_guide.pdf

Erratum: In the article "Bti: Control of Mosquitoes and Black Flies," published in the first issue of Biocontrol Files, we indicated that the product Aquabac is manufactured by Montreal-based AFA Environment Inc. This product is actually manufactured in the U.S. AFA Environnement Inc. is the Canadian registrant and distributor.

Funds for farmers to try biological control

Canadian producers interested in biological pest management may qualify for financial assistance by next growing season. Under the environment priority of the federal Agricultural Policy Framework, Agriculture and Agri-Food Canada, in conjunction with the provinces and territories, is offering the National Farm Stewardship Program (NFSP). The NFSP provides incentives to assist with producers implementation of eligible Beneficial Management Practices (BMPs).

One of the BMPs being funded under the category of 'Improved Pest Management' is *Biological Control Agents* (BCAs). Producers will be eligible for up to 30% cost-share of expenditures on microbial pesticides and predators, up to a maximum of $5,000. To qualify for funding, BCAs must be approved by the Federal/Provincial working groups in each province, compatible with existing biocontrol programs, and implemented in accordance with established guidelines and procedures for handling, application, and follow-up management.

To be eligible for NSFP funding, producers must have an acceptable completed and reviewed environmental farm plan or equivalent agri-environmental plan.

Producers who are interested in following up on this potential funding stream should contact the organization responsible for delivery of Environmental Farm Plan initiatives in their province. ■

For more information on the BMP program, see: www.iisd.org/natres/agriculture/pdf/shaw.ppt

Canadian tax incentives for Biocontrol Research

Canada's Scientific Research and Experimental Development (SR&ED) program provides incentives, in the form of Investment Tax Credits (ITCs), for companies which either perform research and development in Canada or directly support research at other institutions or universities.

The program provides incentives in three ways:

First, current research expenditures can be deducted to reduce taxes in the current year, or carried forward indefinitely to reduce liability in future years. Costs must be incurred in Canada and may include wages, materials, equipment, some overhead costs, SR&ED contracts, and third party payments to universities, research centres, etc.

Second, investment tax credits (ITCs) for expenditures can be received as a cash refund, a tax credit to reduce taxes payable, or both. Unused tax credits can be carried forward 10 years or back 3 years.

Third, qualifying capital expenditures can be written off in the same year.

There are **two levels of ITC incentives:** Canadian-controlled private corporations (CCPC) can receive ITCs for 35 per cent of the first $2 million of qualified expenditures, and 20 per cent on anything over $2 million. Other Canadian corporations, proprietorships, partnerships or trusts can receive non-refundable tax credits for 20 per cent of qualifying expenditures.

In order to qualify for the incentives, research and development must meet the **legislative definition** of SR&ED: "systematic investigation or search carried out in a field of science or technology by means of experiment or analysis." Qualifying work can be basic research, applied research and experimental development. Support work, i.e., work that directly supports and is commensurate with the needs of the research, also qualifies.

SR&ED work can be undertaken either by a company or by others on its behalf, on a contract basis or through payments to organizations such as universities, research institutes, other Canadian companies and approved organizations.

There are **two criteria** by which claimed work can qualify. First, work must be undertaken to achieve a **technological advancement**, (i.e., an increase in the technology base of the company from where it was at the beginning of the project), whether the work is successful or not. When work involves a systematic investigation or search and was undertaken by experimentation or analysis to resolve a technological uncertainty, the program requirements of attempting to achieve a technological advancement are met.

The second criterion is **scientific or technical content**. It must be established that qualified personnel, with relevant education and/or experience, have performed systematic investigation through experiment or analysis.

It is recommended that companies wishing to explore SR&ED tax incentives, especially first-time claimants, either speak to their local tax services office, attend a public information seminar held by the Canadian Revenue Agency, or consult the CRA website at www.cra-arc.gc.ca/taxcredit/sred/aboutus-e.html. ■