Biocontrol Files

Canada's Bulletin on Ecological Pest Management

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Biological control in Ontario's greenhouse ornamental industry

Biological control in the greenhouse vegetable industry is a well-established practice, but the ornamental industry is also making significant progress towards biocontrol becoming a mainstream component of pest management.

Greenhouse flower growers in Ontario first began to use biological control in the early 1990s with varied success. However, a number of changes in the years since have resulted in increased usage and greater reliability:

- Development of resistance to pesticides has been a key driver, with frustrated growers realizing that long-term control is not going to arise out of the development of new pesticides
- Loss of older, broad spectrum pesticides and the development of newer products more compatible with biocontrol agents made the establishment of biocontrol programs easier
- The development and introduction of new and more effective biocontrol agents have given growers more options and increased the success of programs
- Finally, experience gained by growers over the years has resulted in a greater depth of knowledge being transferred to others through extension specialists and consultants.

Major pests include western flower thrips (*Frankliniella occidentalis*), various species of aphids, whitefly (*Trialeurodes vaporariorum* and *Bemisia tabaci*), and twospotted spider mite (*Tetranychus urticae*). It is the first of these, *F. occidentalis*, that is often the most difficult to control. However, each of the major pests can present problems, with growers having to confront obstacles such as the impact of pesticide residues on biocontrol agents, well-established pest populations, and their own inexperience when first establishing a biocontrol program.

Over the past few years, a number of growers have developed innovative ways of improving the efficacy of biocontrol. The use of trap plants in particular is creating a lot of interest as a means of focusing pest populations and biocontrol releases. For example, eggplants are being used for attracting and controlling whiteflies in poinsettia crops, flowering plants are being placed within a non-flowering crop for thrips control, and susceptible varieties of chrysanthemum are used as a trap crop for spider mites. These methods allow growers to be more cost effective and efficient in implementing biocontrol programs.

As growers become more aware that control with pesticides is not a long term option, biocontrol is becoming more widely used and growers are becoming more persistent and creative in their efforts to ensure its success. Pesticides will likely always have a place in greenhouse pest management programs, but their position as the first line of defence is gradually giving way to a more supportive role as a backup to biological control. ■

By Graeme Murphy, Greenhouse Floriculture IPM Specialist, Ontario Ministry of Agriculture, Food and Rural Affairs

Whiteflies are attracted to eggplant being used as a trap plant in a commercial poinsettia crop

Biocontrol in the Vineyard

An interview with Hans Buchler, Okanagan valley grape grower

Biocontrol Files: I know that cutworms can be a problem for grape growers. What biological options are there for cutworms?

Hans Buchler: I've talked to Tom Lowery of Agriculture and Agri-Food Canada, and we're looking at vegetation management for cutworm control, and it seems quite promising. In my own experience, crucifers have worked quite well. I've planted shepherd's purse over the last couple of years in one area where I had huge cutworm pressure. I'm not quite sure how it works, but cutworm pressure has been hugely reduced this year.

BF: Do the crucifers act as a trap crop?

HB: Most probably, but I still need to be convinced of this. There might be something else at work.

BF: How about the use of *Anagrus* parasitoid species for classical biocontrol of leafhoppers? Has any practical work been done on this?

HB: We've done some work in my vineyard and other vineyards, releasing *Anagrus daanei* for control of Virginia creeper leafhopper. Where we have good populations of *Anagrus*, they do an excellent job of reducing the leafhopper populations. Unfortunately, the *Anagrus* are so difficult to rear – they're such a tiny wasp – that raising them commercially is probably not going to work. So our approach right now is to enhance habitat. The *Anagrus* need to overwinter on leafhoppers that overwinter in the egg stage, but the Virginia creeper leafhopper overwinters in its adult stage. So we need another species of leafhopper to carry them over the winter. The *Anagrus* is incredibly specialized; it goes after the Virginia creeper leafhopper and doesn't seem to parasitize any other leafhopper eggs. We have another leafhopper here, the western grape leafhopper. It's closely related to the other leafhopper, but is parasitized by a different Anagrus – *Anagrus erythroneurae*. And the *Anagrus* species don't seem to cross over from the one to the other subspecies of leafhopper, interestingly enough.

BF: Is there any other kind of biological pest control happening in grapes right now?

HB: One thing I am personally interested in is beneficial fungi and other microorganisms that could reduce or inhibit sporulation of powdery mildew. There are some vegetation management approaches that might have some promise, but we really haven't done any work on this. It would be a huge project – you would have to sample cover crops all over the place, look at the different cover crop management practices, and sample for presence or absence of some of the known bacterial and fungal organisms. To me, it looks like allowing cover crops to grow without much control may reduce pressure of powdery mildew, and possibly other fungal diseases as well.

BF: My impression is that, in general, the grape-growing industry in B.C. is trying to position itself as green and sustainable, and sees this as a selling point. Is it your opinion that part of the grower effort to be responsible in terms of pesticide application is a response to this kind of market branding?

HB: Well, part of it certainly, especially all the wineries that sell much of their wine from their doorstep; they get a lot of questions from the consuming public about management practices in the vineyard. And for them it's a great advantage to be able to sell their practices as green. Many of these green practices actually are beneficial. But leafhoppers are a pest that is difficult to control without insecticides.

BF: Why is that?

HB: Well, primarily because there is not much of a resident natural control population. We are a long way away from areas where wild grapes grow – that might be one of the reasons. In parts of the eastern U.S. or Canada, there are a fair amount of wild grapes that have been there for a really long time, which has probably allowed the establishment of some beneficial organisms that we don't have here. We have a few broad-spectrum beneficials that do go after leafhoppers on occasion, but they're not specific and specialized enough. And the numbers are very large! In my vineyard we trap leafhoppers with sticky bands that we hang below the canopy. We extrapolated our catch numbers and calculated that in low-pressure situations we catch about 500,000 leafhoppers per acre, and in higher pressure areas 1.2 to 1.3 million leafhoppers per acre! So you need something very specific and very aggressive that occurs in fairly large numbers.

I think there is really great potential for the future; we just need to put a little more effort into the research side. There are a lot of new approaches to take. We have to do more work on insect behaviour and understand better what their life-cycles and habitats are. Often that is where you will find some answers. ■

Hans Buchler is a director of the B.C. Grapegrowers Association, the Chair of the B.C. Wine Grape Council, and operates at 20-acre certified organic vineyard near Oliver, B.C.

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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Spinosad – a biopesticide highly compatible in IPM systems

Though the biopesticide Spinosad is the result of an extensive natural product screening program conducted by Eli Lilly and Co., it was actually discovered "by accident" in 1982, when a vacationing scientist brought home an interesting soil sample found near an abandoned sugar rum in the Virgin Islands. The sample was found to contain a new species of soil actinomycete (a kind of gram-positive bacteria) called *Saccharopolyspora spinosa*. Spinosad is a mixture of spinosyns A and D, the two most active metabolites produced by the species (thus, ***spino***syns ***A*** and ***D***). The product was first registered in Korea in 1996 and in the U.S. in 1997.

Spinosad acts as a neurotoxin, and is active via both contact and ingestion, though ingestion is considered 5-10 times more effective. Its effects are rapid, which is considered unusual for a biological product. Insects are paralyzed and cease feeding. Generally speaking, spinosad is effective against caterpillars, flies and thrips, and some species of beetles and grasshoppers, but not against sucking insects or mites.

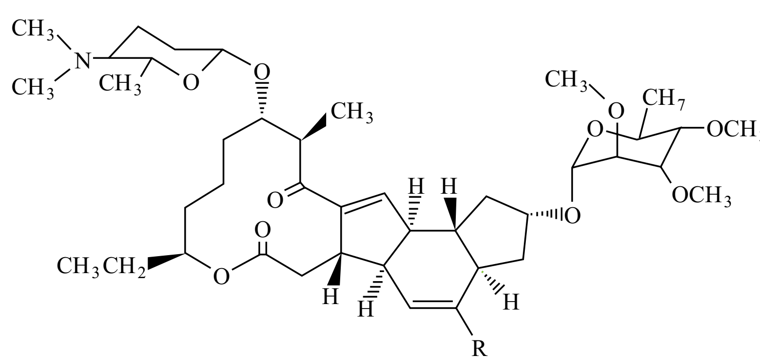
Spinosad is also highly active at low use rates, and appears to have a unique mode of action. It requires no special handling or use restrictions.

Because of its low mammalian, avian and aquatic toxicity, and its comparatively low toxicity to beneficial organisms, spinosad has been touted as highly compatible with IPM programs. A number of studies have tested spinosad's effects on pollinators and natural enemies. Results have been generally favourable, though somewhat mixed.

Laboratory tests have shown that spinosad is highly toxic to bees when applied directly or provided in the diet. Thus, direct application and spray drift onto bees and bee colonies should be avoided, as should use when a crop is in full bloom. However, field tests on a number of crops have shown that, because its persistence is quite short, a three hour weathering period is sufficient to negate any toxic effects. Some field tests have shown the honey bee to be considerably more tolerant than either the alfalfa leafcutter bee or the alkali bee. For both honeybees and bumblebees used in greenhouse pollination, there may be a transient effect on development for the first several days after application. This is apparently due not to exposure to dried residues but to pollen and nectar from sprayed plants.

A survey article published in 2003 calculated that 71% of laboratory studies and 79% of field-type studies on natural enemy predators found spinosad not to be harmful. However, hymenopteran parasitoids were found to be significantly more susceptible, with 78% of laboratory studies and 85% of field studies showing moderately harmful or harmful effects. It should be added that toxicity to parasitoids, for example fruit fly parasitoids, is absent when spinosad is used as a bait application. All studies agree that spinosad residues degrade quickly in the field, with little residual toxicity at three to seven days post-application. The 2003 survey article concluded that spinosad is one of the most prudent insecticides available to conserve predator populations, but that its use should be evaluated carefully when conservation of parasitoid populations is of prime concern.

Spinosad has certainly achieved commercial success. It is registered in 60 countries on more than 250 crops – for pests of fruits and vegetables, ornamentals, turfgrass, stored crops, and many other uses. In the U.S., it is used on a wide variety of fruit and vegetable crops, with highest usage (more than 40% of all farms) on cabbage, cauliflower, celery, honeydew, lettuce, bell peppers, and spinach. In Canada, six products containing spinosad are registered for control of pests of turfgrass, ornamentals, and a wide variety of fruit and vegetable crops. Two spinosad products registered in Canada are approved by the Organic Material Review Institute (see issue #10) for use on organically-grown crops. ■



spinosyn A: R = H, MW = 731.98
spinosyn D: R = CH_3, MW = 746.00

Measuring uptake of biocontrol in fruit and vegetable crops

In Biocontrol Files issue #10, we reported on uptake of biocontrol practices in field crops in the U.S. and Canada. In this issue, we cover uptake in fruit and vegetable crops.

The National Agricultural Statistics Service of the U.S. Department of Agriculture surveys a sample group of farmers every year on a variety of topics, including their pest management practices. Included in the surveys are questions which estimate uptake of biological pest control. One survey question asks growers which pest control products they use. Other questions estimate the percentage of farmers and acreage using beneficial organisms, natural/biological based products or biological pesticides.

A number of biologically-based products were used on the 25 vegetable and 30 fruit crops surveyed in 2004 and 2005. Chart I shows the percentage of farms using three of the most widely-used biopesticides in five of the fruit and vegetable crops with relatively high levels of biopesticide use.

U.S. fruit and vegetable crop growers were asked the following question: "Were any biological pesticides such as Bt (*Bacillus thuringiensis*), insect growth regulators (Courier, Intrepid, etc.) neem or other natural/biological based products sprayed or applied to manage pests in this field?" Growers were also asked two additional questions. One question asked: "Were floral lures, attractants, repellents, pheromone traps or other biological pest controls used on this field?" A second question asked growers if they had released *beneficial organisms* (insects, nematodes, fungi). Chart 2 shows the percentage of farms growing vegetable crops that responded positively to these questions, and the highest percentage of positive responses from any state, while Chart 3 shows the percentage of farms growing fruit crops that responded positively to the three questions.

Chart 1: Percentage of U.S. growers of selected fruit and vegetable crops using 3 biopesticides

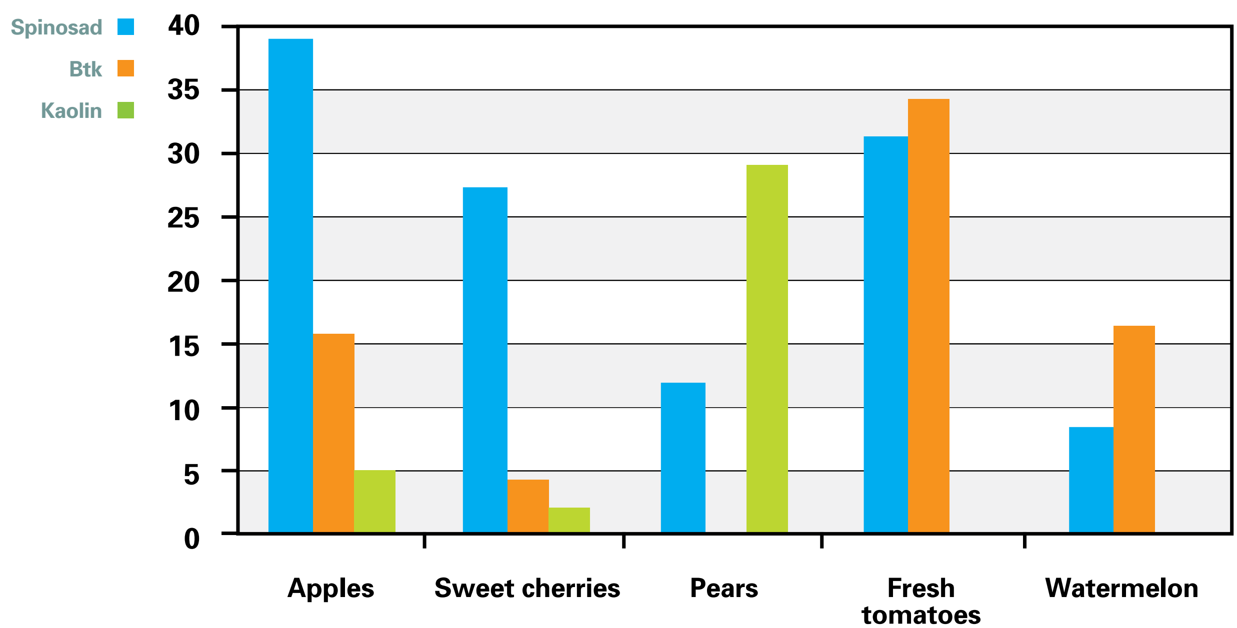


Chart 2: Percentage of U.S. vegetable farms using biological pest management options

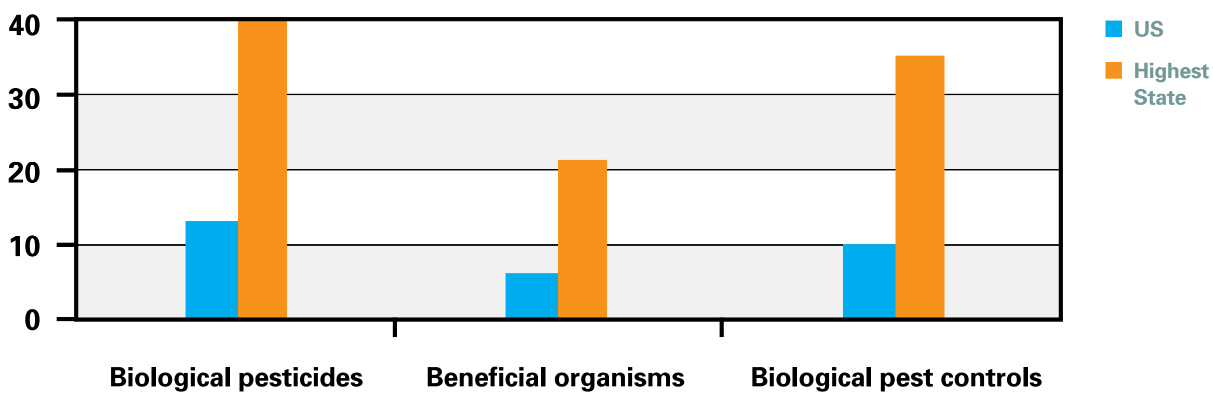
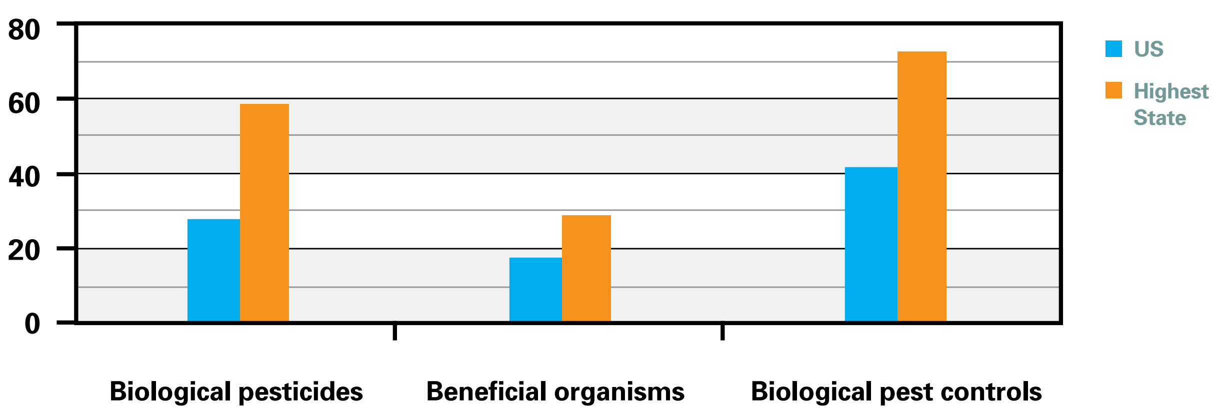


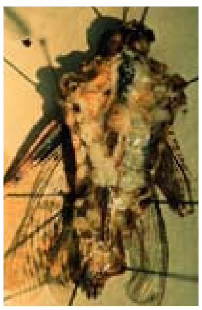
Chart 3: Percentage of U.S. fruit farms using biological pest management options



As indicated in issue #10 of Biocontrol Files, Stats Canada conducted a survey of Canadian carrot, apple and grape growers in the winter of 2006, financed by Agriculture and Agri-Food Canada's Pest Management Centre. The survey included questions on pest management practices, including one on the release of beneficial insects. As of the date of publication, the results are still being analyzed.

As mentioned in issue #10, analysis of the results is difficult, in part because U.S. survey questions do not consistently isolate biocontrol options, but lump them in with other "alternatives" to chemical pesticide use. It is clear, however, that in U.S. fruit and vegetable production, and especially in crops such as apples, pears, sweet cherries, and tomatoes, biopesticides and other biological options are becoming part of mainstream pest management. When the Stats Canada study mentioned above and the most recent Farm Environmental Management Survey are analyzed, we should have a clearer picture of the level of popularity of biological pest management in Canadian crop production. ■

Nosema locustae: a protozoan with an important part to play?



***Nosema locustae* spores fill the fat body tissues of an infected grasshopper, causing them to appear lumpy and white**

Nosema locustae holds the distinction of being the only protozoan species registered as a biocontrol agent. The spore-forming pathogen of orthopteran adipose (fat) tissue was selected in the U.S. in the early 1960s as an agent for long-term suppression of rangeland grasshoppers, and has been registered there since 1980.

N. locustae is effective only when ingested. Protozoan spores germinate in the insect gut and release sporoplasms, which enter the cells of the fat body, the insect's main energy storehouse. Infection and hypertrophy of the fat body effectively starve the insect host of energy reserves.

Use in U.S. and Canada

N. locustae is most effectively formulated as a wheat bran bait. Field applications have produced varied results, but have generally demonstrated adverse effects on development, reproduction, feeding, and, to a lesser extent, survival of grasshoppers. However, early optimism that *N. locustae* would achieve comparable efficacy to short-acting chemical insecticides was tempered by the realization that the agent requires four to eight weeks for detectable impacts on a host population. Based on available data, the U.S. Animal and Plant Inspection Service (APHIS) recommended that *Nosema's* use be limited to the suppression of rangeland grasshoppers in "environmentally sensitive areas where cost and acute insecticide control are not primary concerns and proposed higher rates and/or multiple applications when environmental issues outweigh economic issues." Canadian studies generally mirrored those done in the U.S., though some studies displayed strong mortality (60%), and extremely high infection rates (95-100%). High infection rates and mortality are known to occur in natural populations.

Argentina

In Argentina, *N. locustae* was widely tested as an inundative biological control agent between 1978 and 1982. As in U.S. trials, the agent did not provide rapid mortality of the host. However, more recent field research on the pathogen's occurrence and host range, coupled with its known effects on survival, fecundity, and the behaviour of infected grasshoppers, indicate that it can be efficacious over the longer term. Monitoring has shown widespread infection of at least 13 species of grasshoppers in the western Pampas, with prevalences much higher than those recorded in areas where the pathogen is native (North America, South Africa and India). Susceptible species appear to be less abundant in areas where unusually high prevalences have previously been observed. In areas where *N. locustae* has become established, there have been no problems with grasshoppers since its release, though problems were recurrent and serious before introduction. Furthermore, areas with similar climate, physiography, land uses, and composition of grasshopper communities but without *N. locustae*, continue to suffer recurrent grasshopper outbreaks.

China

In China, several studies have shown reduced populations of various grasshopper species after inundative applications of *N. locustae*. Application in conjunction with a chemical insect growth regulator has resulted in better control, lasting at least 45 days. One study found that lower application rates of *N. locustae* were effective in controlling low or medium density locusts for more than two years, while a higher rate plus application of an insect growth regulator was similarly effective for high density locust situations.

India

Field experiments in India in the late 1980s concluded that *N. locustae* was an effective agent for long-term suppression of grasshopper populations, due to its persistence in field populations through transmission from generation to generation.

Africa

Studies evaluating the efficacy of *N. locustae* against grasshopper and locust species in Cape Verde, Mali, Senegal, South Africa and other African countries have produced variable results. However, as in Argentina, in areas where *N. locustae* has been released, no major grasshopper outbreaks were recorded for ten years after its introduction.

Conclusion

Although *N. locustae* does not provide significant immediate control and is not generally effective for short-term, inundative uses, it does appear to become established in grasshopper/locust populations and cause reduced fitness, especially lower fecundity, over a period of years. Indeed, its sublethal effects, such as reductions in feeding, reproductive activity and insect dispersal may be much more potent indicators of its effectiveness than short-term mortality rates.

As Chris Lomer, leader of the LUBILOSA project from 1993-1999, stated in his discussion of the project (see Biocontrol Files #10), the use of *N. locustae* as a grasshopper and locust biocontrol agent should be viewed as part of a long-term suppression effort rather than as a microbial insecticide competing with chemical pesticides. Now that *Metarhizium* is established as a faster-acting control agent, Lomer suggests that it may be time to revisit the use of *Nosema* in Africa as a complementary and persistent microbial agent. ■

Biocontrol News Digest

OXFORD UNIVERSITY, APRIL 14TH, 2007: Invasive Species Take To The Air – Far-flung regions with similar climates that are suddenly linked by a busy flight route are at an increased risk of an invasion of foreign species, according to scientists at Oxford University. The new research also identified an "invasion window" across the global air network from June to August when climatic conditions at regions linked by long haul routes are most similar to one another and the higher number of flights increases the chances of exotic species hitching a ride to somewhere new.

While the spread of invading species once they reach a new area has been extensively studied, relatively little work has been done on how such organisms might initially be transported to and survive in new areas. Recently, international air travel has been pinpointed as a significant factor in the movement of economically damaging pest species, with 73% of recorded pest interceptions in the U.S. occurring at airports. For example, the Mediterranean fruit fly has been consistently imported in airline luggage, plant pathogens are often found in air cargo, and disease-carrying mosquitoes have survived long haul flights in aircraft cabins.

Oxford scientists analysed data from over 800 airlines for 12 months (from 1 May 2005 to 30 April 2006), detailing over three million flights. They then examined the mean temperature, rainfall and humidity at each region linked by a flight route to see how the global air network provides seasonal links to places with similar climates.

"When we combined this monthly climate data with information on how busy flight routes were in particular months the results were striking," said Dr Andy Tatem of Oxford's Department of Zoology, who led the work with Dr Simon Hay, "the June to August period stood out as the time when the busiest flight routes connect geographically distant but climatically similar locations. This combination potentially increases the overall chances of dispersal and successful invasion of foreign species."

The research will help airport and government personnel to identify where and when a heightened risk of an invasion of foreign species may occur, enabling them to target their surveillance and control efforts more effectively. During the 12 months of the study, there were 3,219,774 scheduled flights operating between 3570 airports on 44,285 routes. A report on the research entitled "Climatic similarity and biological exchange in the worldwide airline transportation network" is published on-line in the journal Proceedings of the Royal Society B.

AGRICULTURAL RESEARCH SERVICE, USDA, MAY 20TH, 2007: Possible New Control For Whiteflies Discovered – An unusually durable fungus that was first spotted on tiny insects feeding on eggplants in Texas may become a new biological control for the widespread and costly agricultural pests known as whiteflies.

The fungus was first isolated by Agricultural Research Service (ARS) entomologist Enrique Cabanillas, working with entomologist Walker Jones at the ARS Beneficial Insects Research Unit, Weslaco, Texas.

The silverleaf whitefly, *Bemisia argentifolii* (previously known as *B. tabaci* biotype B), may be small in stature, but it can be deadly as a pest, sucking and feeding on the juices of a myriad of host plants. Heavy feeding can give plants under attack a yellow, mottled look and eventually kill them. Whiteflies cause major crop losses, both directly by feeding and indirectly by transmitting plant viruses.

Pesticides have been ineffective for controlling whiteflies because of resistance, the need for repeated applications, and the potential hazard some insecticides may pose to the environment, animal life or humans.

Isolated by Cabanillas in 2001, the new fungal species has been named *Isaria propawskii*. In the Lower Rio Grande Valley of Texas, it has been shown to kill both larval and adult stages of silverleaf whitefly. In fact, since 2001, it has periodically wiped out whiteflies at the ARS insect-rearing facilities in Weslaco.

Notable aspects of *I. propawskii* include its natural establishment in a semiarid region where temperatures can reach 42 degrees Centigrade (107° F), and its continuing persistence, even in the absence of insect hosts. A high spore production in common culture media makes this fungus comparatively easy to grow in vitro, in the laboratory.

These features, plus its high pathogenic potential against a second major insect pest - the glassy-winged sharpshooter, *Homalodisca vitripennis* (previously known as *H. coagulata*) - make the *I. propawskii* fungus a promising candidate for practical biological control of two major U.S. farm pests. ■

Resources:

Books

Editors S.B. Chincholkar and K.G. Mukerji have enlisted over 30 international specialists from a broad swath of impacted disciplines to contribute 15 chapters of material for a 2007 monograph, *Biological Control of Plant Diseases*. The result is a contemporary summary of disease management relying on biocontrol agents. The experts examine and discuss antagonistic microbes, rhizosphere microflora, genetic engineering, antifungal metabolites, predators, and other related technical topics. Various mechanisms of pathogen management are covered including inherent resistance. In their preface to the softbound, 441-page work, the editors mount an impassioned defense for broader usage of biocontrol, noting that it "alone is the logical path forward for a sustainable ecosystem," and should therefore be given "a fair chance to prove its ability." Haworth Press, 10 Alice St., Binghampton, NY 13904, USA. Fax: 1-607-771-0012. Phone: 1-607-722-5857. E-mail: orders@haworthpress.com Website: http://www.haworthpress.com

On-line database

A U.S.-based program recently launched an on-line searchable database of biopesticide and organic pest management, intended as an aid for growers of specialty (so-called "minor") crops. The database, prepared by the Interregional Research Project No. 4 (IR-4), and found at: http://tinyurl.com/27vvcf, can be queried by crop, pest, and location, and promptly responds with a list of U.S. Environmental Protection Agency registered product labels that fit the indicated criteria. A choice allows users to limit searches to only "organic" approved pest management products. The site also presents a rationale to answer the question "why use biopesticides," such as overcoming time limits for re-entering treated areas, or for harvest soon after treatment. In some cases there are no "conventional" products registered for a particular circumstance, thus possibly suggesting use of a biopesticide, the site notes. IR-4 is dedicated to providing safe and effective pest management solutions for specialty crop growers. For more information, contact M.P. Braverman, IR-4 Biopesticide Manager, Suite 201 W., 500 College Rd. East, Princeton, NJ 08540-6635, USA. E-mail: Braverman@aesop.rutgers.edu Fax: 1-609-514-2612.

Conferences

September 29 – October 3, 2007. 57th Annual Meeting Joint Meeting, Entomological Societies of Canada and Saskatchewan, Saskatoon, SK, Canada: "Microscale Subjects for Megascale Insects." Contact D. Hegedus at HegedusD@agr.gc.ca. Website: http://www.sfn.saskatoon.sk.ca/science/ess/ESS-ESC/intro.html

August 12 – 16, 2007. 40th Annual Meeting of the Society for Invertebrate Pathology and the 1st International Forum on Entomopathogenic Nematodes and Symbiotic Bacteria, Quebec City, Quebec, Canada. Visit http://www.sip2007quebec.com/ for more details.

Spiderman meets Dungbeetleman