Editorial

News on Reviews

The abstracts, news and reviews that make up *Biocontrol News and Information* (*BNI*) provide biocontrol and integrated pest management (IPM) researchers and practitioners with a unique information resource, which we strive constantly to improve. Our abstracts provide unrivalled coverage of literature on the use of biotic agents in the control of pests of all types, and over the recent years, we have developed the news section to provide an information source and stimulate debate on important biocontrol and biocontrol-related topics. The news is posted free on the Internet [http://pest.cabweb.org/Journals/BNI/Bnilogin.htm] both to increase awareness of the journal and to canvas as wide a range of opinion as possible. The tremendous response the news section has generated is due in no small part to the many contributors, to whom we would like to extend our thanks.

We now want to focus equal energy on the review section. We are delighted with the high standard of the manuscripts we receive, and we want to capitalize on this, and develop the size and scope of the section. We are, therefore, pleased to invite you to submit original and substantial reviews or studies of important problems or issues in biological control (we do not publish reviews that are purely bibliographic in nature, nor those that simply catalogue natural enemies).

Reviews on the 'history of' and 'prospects for' biocontrol remain the cornerstone of our review section. We encourage authoritative reviews for major pests of all kinds to provide key reference resources, and, for example, we are currently developing reviews on a number of weed and insect pests of worldwide significance. Often such pests are invasive alien species, an issue that is climbing ever-higher on the global agenda. Understanding the nature of a pest outbreak is fundamental to designing an effective solution, be it prevention, eradication, containment, management or mitigation. Reviews of the taxonomy, biology and ecology (and, where appropriate, behaviour) of pest species (and their natural enemies) can set the framework and context in which appropriate biocontrol technologies can be designed and implemented, whether as stand-alone solutions or in combination with other technologies.

Country-based reviews are also valuable, and we actively solicit these in order to make the information more widely available. Valuable results from many countries' biocontrol programmes are available in 'grey' literature and national publications, and these can be usefully synthesized to make the knowledge accessible to a worldwide audience. We may publish case studies, if these are of regional or international significance and form resources for other countries facing similar pest problems.

One of the great challenges is to understand constraints to uptake of biological control solutions, and thence overcome them. We are particularly interested in publishing more about extension and implementation of biological control. In this context, we welcome reviews on methodology, especially where these point to ways of increasing biocontrol adoption rates, and the commercial development of biocontrol agents and technologies. Mass rearing/production, marketing/distribution, and farmer knowledge support, are all areas presently targeted to improve the sustainability of biological control.

Safety of biocontrol, and particularly classical biocontrol, is a key issue – and a hot news topic for a much wider audience. Partly because of the current high profile, many stakeholders, from researchers to national governments, need urgent help in the form of good information and sound guidance in this arena. Quality reviews on biocontrol safety issues including host-range testing, risk assessment, nontarget impacts, monitoring and evaluation, and the development of guidelines, regulations and policy are therefore invaluable.

The days of belief in 'silver bullets' are behind us. Biocontrol may sometimes provide a complete solution to a pest problem, but more often a combination of approaches is needed. We are interested in reviews on the integration of biological control with other compatible techniques, including case studies of major significance. Interactions between biocontrol agents also elicit much interest (and particularly how microbial and macrobial agents interact). On a wider note, we like to include reviews on the role of biocontrol in the sustainability of natural and agricultural ecosystems; included in this is smallholder farming, and the opportunities for biocontrol to improve food security, and contribute to financially and environmentally sound commodity crops.

We will not shy away from controversial issues. We will tackle such topics as biotechnology, either as a tool in developing improved or new biocontrol technologies, or its potential to complement biocontrol in an integrated approach. We will also address the shortcomings of biocontrol and its implementation. If you are hot under your collar over an issue in biological control and can review it in an authoritative way that will advance either the science or the practice of biocontrol, we will be interested.

We plan to build on the ideas above to bring you an informative review section. Over coming issues, for example, we will have a series of reviews on biocontrol in agroforestry systems. These will address many of the cross-cutting themes outlined above including the role of biocontrol in invasive species management, its role as part of integrated crop management (ICM), and initiatives for promoting farmer uptake of biocontrol.

Today, more than ever, there is a need for information dissemination: between researchers, between researchers and extension workers, between extension workers and farmers, and between researchers and farmers. All have a great deal to share as well as a great deal to learn. Much of value is known but not synthesized into usable knowledge. *BNI* has a role in filling this gap, so if you have an idea for a review, or want to suggest a topic for us to develop, let us know.

And now to the news, which this issue contains large chunks of potato. We begin, though, with a classical success story, and a new biopesticide.

❑

Are we on your mailing list?

BiocontrolNews and Information is always pleased to receive news of research, conferences, new products or patents, changes in personnel, collaborative agreements or any other information of interest to other readers. If your organization sends out press releases or newsletters, please let us have a copy. In addition, the editors welcome proposals for review topics.

General News

Biocontrol of Diamondback Moth in St Helena

The diamondback moth (DBM), *Plutella xylostella*, is a serious pest of crucifer crops on the island of St Helena, a small British island in the South Atlantic Ocean. Farmers were heavily dependent on chemical pesticides, often overdosing and mixing several pesticides when recommended dosages were not effective. Surveys in cabbage fields revealed that the only parasitoid of DBM on St Helena was the ichneumonid larval-pupal parasitoid *Diadegma mollipla*, which also occurs in several countries on the African mainland. As most supplies to St Helena, including fresh produce, are shipped from Cape Town, it was assumed that DBM as well as *D. mollipla* have been introduced into the island with cabbages from South Africa. Because *D. mollipla* was not able to reduce DBM populations on St Helena to below economic damage levels, a biological control project managed by the IPM Project on St Helena, NRInternational, UK and funded by DFID (the UK Department for International Development) was initiated. The Plant Protection Research Institute (PPRI) in Pretoria, South Africa was contracted to supply parasitoids of DBM to St Helena and train personnel of the IPM Project in mass rearing the moth and its parasitoids, parasitoid release methods and the follow up of parasitoid dispersal and establishment.

During May 1999, a consignment of the braconid *Cotesia plutellae*, a larval parasitoid, and the ichneumonid *Diadromus collaris*, a pupal parasitoid, was shipped to St Helena. It was assumed that if these parasitoids became established they would not compete with the local larval-pupal parasitoid *Diadegma mollipla.* St Helena does not have an airport, and the consignment was flown from Pretoria to Cape Town and then undertook a 6-day sea voyage on board the RMS St Helena to the island.

The consignment contained all developmental stages of the parasitoids, i.e. adult wasps, parasitoid cocoons and parasitized DBM larvae and pupae. Daily on board the ship, adult wasps were fed with honey and water, and the parasitized DBM larvae were provided with fresh cabbage leaves until parasitoid cocoons formed or the larvae pupated.

On St Helena a rearing facility was established in which a DBM culture was maintained on potted cabbage plants and the two parasitoids were mass reared in separate wooden cages. In order to boost the genetic material of the parasitoid cultures in St Helena, an additional consignment of *C. plutellae* and *Diadromus collaris* was sent from PPRI in Pretoria in December 1999.

Before the releases of the parasitoids, extension officers of the IPM Project visited many farms and recommended that in order to give the introduced parasitoids a chance to establish, farmers replace chemical insecticides with *Bt* sprays to combat DBM outbreaks.

The two parasitoids were released into the field continually from May 1999 to September 2000. A total of 17,500 *C. plutellae* and 23,500 *D. collaris* were released in ten different farms across the island.

During January to March 2000, a preliminary survey was conducted in the ten release sites and in an additional nine farms (a total of 19 farms) to monitor the dispersal and establishment of the introduced parasitoids.

As expected in this early stage of the project, *Diadegma mollipla* was the most abundant and widely distributed parasitoid found in the survey. It emerged from DBM samples taken from 17 farms.

Samples of DBM larvae were collected in 16 farms and *C. plutellae* was present in samples from 15 farms. In eight of these farms parasitoids have never been released. The proportion of DBM larvae parasitized by *C. plutellae* was relatively high. For example, in Briars 34 *C. plutellae* emerged from 104 collected larvae (32.7% parasitism), in Mulberry Gut 19 *C. plutellae* emerged from 70 larvae (27.7% parasitism) and in Pouncey's (not a release site) 24 *C. plutellae* emerged from 30 DBM larvae (80% parasitism).

DBM pupae were sampled in 14 farms and samples from five farms, of which one has not been a release site, yielded *Diadromus collaris.* The proportion of parasitized pupae ranged between 0% and 55%. In one site, Nr Half Way, 11 *D. collaris* emerged from 20 collected pupae (55% parasitism). The results from this early survey indicated that the two parasitoids had survived in the release sites, had found and parasitized the pest and were dispersing.

As the insect rearing facility of the IPM Project on St Helena was needed for other projects, the rearing of DBM and its parasitoids was terminated shortly after the last parasitoid release in September 2000.

The IPM Project personnel conducted another field survey early in 2001 but it was called off because of extremely low infestation levels by DBM. However, cocoons of *C. plutellae* were present in most farms, which is an indication that the parasitoid could have been the cause for the decline in DBM population levels. Spring (September-October) is normally when DBM outbreaks occur on St Helena but local farmers have commented that DBM infestations have not been recorded this year and no chemical or *Bt* treatments have been requested by farmers since March 2001.

By: Rami Kfir,
Plant Protection Research Institute,
Pretoria 0001, South Africa
Email: rietrk@plant2.agric.za
and
Jason Thomas,
Agriculture & Natural Resources Department,
St Helena Island, South Atlantic Ocean

This article also appears in the ARC-PPRI Bulletin, Plant Protection News *No. 59 (Spring/Summer 2001), with agreement of the author and PPRI.*

❑

Coconut Mite in India: Biopesticide Breakthrough

Aceria guerreronis, the only eriophyid mite considered to be serious on coconuts, has been a big problem to coconut cultivation in Central and South America, the Caribbean and West Africa. The mite was first reported from Mexico in 1960 and was described by Keifer in 1965. Recently, the pest has assumed serious proportions in India and Sri Lanka and experts have not ruled out its further spread to other coconut economies in the east. [See also: Moore, D. (2000) *BNI* **21(3)** (September), 83N-88N. Non-chemical control of *Aceria guerreronis* on coconuts.]

In India, *A. guerreronis* was first observed to be causing severe damage to coconuts in the southern state of Kerala in the late 1990s. The pest has now spread to almost all the districts of Kerala and the major coconut-growing districts of its neighbouring states including Tamil Nadu, Karnataka, Andhra Pradesh, Pondicherry and Goa in mainland India and the Lakshadweep Islands in the Arabian Sea. Losses of 25-30% in copra yield have been recorded. With its high reproductive rate, the mite is increasing in great numbers and spreading fast as well.

The first symptoms of mite infestation are white streaks, which originate from the perianth and go downwards along the nut surface. Later, white to cream-coloured triangular patches are formed along the edge of the perianth. As the fruit increases in size, the older patches turn brown and acquire a corky appearance. And at the same time, new patches start appearing owing to the shifting or formation of new colonies of the mite. Because of the formation of cracks, the exocarp splits and the fissures can reach deep into the mesocarp.

Until the advent of the mite, probably no other pest in India created such an unprecedented panic among farmers, agricultural scientists, politicians and bureaucrats alike. Even ordinary people, who have one to a few trees around their residence, became panicky when they first realised that mites were attacking their coconuts.

The ensuing hue and cry resulted in the prescription of a variety of chemicals by scientists and officers of central institutes, universities and the departments of agriculture in different states. The chemicals that found favour with the farmers during the initial years were monocrotophos (root feeding or stem injection), dicofol, endosulfan and ethion. Later triazophos and carbosulfan entered the list of recommended chemicals. In addition, micronized wettable powder formulation of sulphur at 0.4 % and azadirachtin at 0.004% concentration are also recommended for spraying. A homemade 2% neem oil-garlic soap mixture has also been very popular among Kerala farmers. Nevertheless, none of the methods could bring the pest under sufficient control. Environment and health have been the ultimate casualties.

The results from experiments in many countries indicate that chemical control is possible, but the many treatments and the quantities of chemicals required make it not only uneconomical but also dangerous to the environment and various life forms. Resistance to chemicals is also feared. With the passing of time the problem has been becoming a political issue as many of the farmers and politicians have come to the conclusion that there is no effective control measure in sight.

A recent study in Kerala is an eye-opener. In the Alappuzha district of Kerala, more than 70% of coconut growers expressed their reservations about the extensive use of chemicals against the mite, citing the inimical nature of pesticides to natural enemies. They preferred the use of biopesticides to toxic chemicals. And surprisingly, many coconut farmers that we came across in the affected states were unanimous in their view that chemicals bring about havoc in the long term. Yet in spite of the growing alertness of the public, when it comes to the ground reality, chemicals still have a large customer base.

Concentrated surveys since early 1999 for pathogens of the coconut mite in the southern states had indicated the natural regulatory role played by many entomopathogens, especially *Hirsutella thompsonii*, the well-known eriophyid mite-specific fungus. We isolated and investigated the potential of many strains of the fungus against the mite and uncovered the immense potential of the pathogen. That resulted in the development of a mycoacaricide named 'Mycohit' based exclusively on *H. thompsonii*, the first Indian mycoacaricide based exclusively on this species.

The product is based on the strain MF(Ag)5 [ITCC 4962; IMI 385470] originating from Tamil Nadu. The product has a potency of 2.5×10^8 CFU/g (colony-forming units/g) with a moisture content of about 12%. Mycohit is generally recommended for use as a spray when the weather is dry. It should be used at 1% concentration and about 2 litres of the spray solution is needed per tree. Up to 50 trees (about 1 acre/~0.4 ha) can be treated with 1 kg of the product. In certain situations such as after a heavy rain, just dusting of the product on the bunches is enough because of the wet microclimate within the crown.

Field investigations have been conducted in more than 15 locations to evaluate the performance of Mycohit. In several places, by the 70th day of the experiment more than 70% and 90% mortality of the mite was observed in nuts sprayed once and twice (at 2-week intervals), respectively.

Then our immediate concern was to make available the required quantity of the mycoacaricide, which runs into several thousand tonnes, to the affected planters. Therefore, towards the objective of commercializing Mycohit, help has been sought from the Research & Development Division of the Hindustan Antibiotics Limited (HAL), Pimpri, Pune. We have given the fungal culture and know-how to HAL for pilot-scale production of the mycoacaricide. HAL in turn produced two different variants of Mycohit, namely, Formulation-T (talc-based and similar to the original) and Formulation-W (wettable powder), using our strain and know-how for preliminary bioefficacy investigations. The field trials conducted by us indicated that the former preformed the better and so we chose the talc-based formulation for further work. Subsequently-produced batches of the talc-based formulation ('Mycohit-T') performed consistently well in the field and produced results on a par with our original version of the mycoacaricide.

In an ongoing trial (started in June 2001, at the beginning of the southwest monsoon), both versions of Mycohit showed highest mortality of 98.80% (ours) and 96.62% (HAL's) by the end of the third week, i.e. a week after the second application of the product.

The Government of India has recently (February 2001) included *Hirsutella* in the Schedule to the Insecticides Act (1968) because of our efforts. This has enabled the registration of products based on the fungus with the Central Insecticides Board (CIB). HAL has been testing the biosafety of *H. thompsonii* and the product separately for us thus paving the way for registration of Mycohit in the coming months.

The mite has recently been found to be infesting the palmyrah palm (*Borassus flabellifer*) in Tamil Nadu State, where the tree is an important source of toddy. Farmers are also apprehensive of its spread to the arecanut (*Areca catechu*), which has become one of the most remunerative plantation crops in the south, especially in Karnataka. Therefore, *H. thompsonii* has a very significant role to play through its natural presence as well as in the form of a product.

We have also isolated *Sporothrix fungorum*, which is also widely found associated with the coconut mite in south India. Preliminary trials with the fungus have given encouraging results. Similarly, we have also tried *Verticillium lecanii* with considerable success.

By: P. Sreerama Kumar & S. P. Singh,
Project Directorate of Biological Control (ICAR),
P. B. No. 2491, H. A. Farm Post,
Hebbal, Bellary Road,
Bangalore 560 024,

Karnataka, India
Email: pdblc@kar.nic.in
Fax: +91 80 341 1961

❑

Building Stem Borer Management Capacity

Some 20 moth species constitute the most important cereal pests in many parts of Africa. Their caterpillars, commonly known as stem or stalk borers, bore into the stems of maize, sorghum, millet and rice, often killing the plant. The cereals attacked are grown on small farms to feed the farmers and their families and are of great importance as the staple food for the population in most parts of Africa. Complex control measures, including the use of chemicals, are often inappropriate, and the development of specific regional strategies for environmentally sustainable stem borer management is therefore a priority.

A 2-year collaborative cereal stem borer management initiative in southern Africa plans to bring this goal closer. Funded by USAID (US Agency for International Development), this venture involves ICIPE (International Centre for Insect Physiology and Ecology), Kenya and two South African ARC (Agricultural Research Council) institutions, PPRI (Plant Protection Research Institute) and GCI (Grain Crops Institute). The aim is to increase the capacity of national institutions in southern Africa to manage maize and sorghum stem borers using environmentally sustainable methods. To this end, the project is engaging national programme scientists in Mozambique, Angola, Swaziland, Lesotho, Malawi and Botswana.

The project began with a planning workshop and training course, held in South Africa in September 2000. The training course for 15 participants developed skills in stem borer and natural enemy identification, their collection and rearing (including mass rearing) and host plant resistance screening. Participants also learnt techniques for biological control and habitat management, and were given an introduction to biological and transgenic plant resistance. The planning workshop developed work plans for country-wide surveys of stem borers and their natural enemies.

In July 2001, progress was discussed during a special symposium held during the 13th Congress of the Entomological Society of Southern Africa. Representatives from the participating countries reported on the progress of their work, and proposed activities for the future. The proceedings of the workshop are being compiled and will be published shortly.

Much baseline information on the biology, natural enemies and control of cereal stem borers in Africa can be found in:
Polaszek, A. (*ed*) (1998) African cereal stem borers: economic importance, taxonomy, natural enemies and control. Wallingford, UK, CABI *Publishing*, 556 pp. ISBN 0 85199 175 0

Source: Breytenbach, E. (2001) Collaborative cereal stem borer management initiative.
ARC-PPRI Bulletin, *Plant Protection News*, No. 58 (Autumn/Winter 2001), pp. 2-4.

For project information contact: Rami Kfir,
Insect Ecology Division,
ARC-Plant Protection Research Institute,
Private Bag X134,
Pretoria 0001, South Africa
Email: rietrk@plant2.agric.za
Fax: +27 12 329 3278
Or: Bill Overholt,
International Centre of Insect Physiology and Ecology,
P.O. Box 30772,
Nairobi, Kenya
Email: woverholt@icipe.org

❑

Biocontrol Progress in India

Once again, the Project Directorate of Biological Control (PDBC) based in Bangalore has been a hive of biocontrol activity. Major highlights of work in the last year[1] included the introduction of two parasitoids of the coffee berry borer (*Hypothenemus hampei*; CBB). *Prorops nasuta* and *Phymastichus coffea* were imported from Colombia and were established in the field, thus contributing two new country records.

The maintenance and supply of host insects and natural enemies from PDBC, together with the basic research that supports this, continues to be a priority activity to which much energy and expertise is devoted. Biosystematic studies were conducted on Indian predatory coccinellids, with *Diomus* recorded from India for the first time. Rearing techniques were standardized for a number of natural enemies, and biological and behavioural studies were conducted. Artificial diets were devised for host insects including *Spodoptera litura* and a number of natural enemies. More progress was made in the development of temperature- and multiple pesticide-resistant strains of trichogrammatid parasitoid wasps. Advances were also made on the production and use of insect viruses and fungi, fungal and bacterial antagonists, entomopathogenic nematodes, and fungal biocontrol agents of plant parasitic nematodes and weed pathogens.

On the information side, a CD version of the expert system BIORICE is now available, and a system for pest control in oilseeds and pulses is in preparation.

The success of PDBC in conducting necessary basic research, and developing this through lab studies and field trials to effective pest control solutions for farmers is illustrated by the many and varied field tests of modules they are developing for the biological management of pests in many crops. In the past year a vast number of field trials have been conducted in sugarcane, cotton, tobacco, pulses, rice, coconut, fruit and vegetable crops and potatoes in different states. A striking success this year has been the development of a biopesticide for coconut mite (*Aceria guerreronis*) [see 'Coconut mite in India: biopesticide breakthrough', General News, this issue]. Monitoring and evaluation of weed control agents against water hyacinth (*Eichhornia crassipes*) is also highlighted.

The Annual Report[2] provides details of these and other research efforts by PDBC in Bangalore and in its coordinating centres spread over different parts of India. The work at PDBC included biosystematic studies on Indian predatory Coccinellidae. Progress in rearing work included multiplication of *Harmonia octomaculata* on *Ferrisia virgata* and *Aphis craccivora* in the lab. It was also shown that higher parasitization rates of *Helicoverpa armigera* eggs by *Trichogramma chilonis* could be achieved with the aid of synomones (herbivore-induced plant chemicals). Artificial diets were synthesized for rearing *Cheilomenes sexmaculata*, *Coccinella septempunctata*, *Chilocorus nigrita* and *Cryptolaemus montrouzieri*. Endosulfan-resistant *T. chilonis* was utilized for developing a multiple-resistant pesticide strain. Fungal pathogens were isolated from *Helicoverpa armigera*, *Plutella xylostella,* and *Chilo partellus*. *Nomuraea rileyi* was cultured and a water dispersible powder formulation of *Bacillus thuringiensis* (Pusa *Bt*) developed and bioassayed. *Trichoderma harzianum* PDBCTH10 and *T. viride* PDBCTV23 as powder formulation were tested for control of fusarial wilt and *Rhizoctonia* wet root rot of chickpea. The entomopathogenic nematodes (EPNs) *Steinernema carpocapsae*, *S. bicornutum* and *Heterorhabditis indica* isolates were successfully used for control of *Leucinodes orbonalis* on brinjal [aubergine] in field trials. A talc-base formulation of EPN isolates showed a shelf-life of more than 3 months. The mycoherbicidal potential of *Lasiodiplodia theobromae*, *Nigrospora oryzae, Phoma chrysanthemicola* and *P. eupyrena* was tested against *Parthenium hysterophorus.*

In Punjab, a BIPM (biocontrol-based IPM) module proved effective for cotton pest control. In Gujarat, Andhra Pradesh, Tamil Nadu, Maharashtra and Punjab, cotton bud and boll damage and populations of sucking pests were lower with the BIPM module than with insecticide treatments. *Bt* products gave effective control in cotton in Gujarat. In Andhra Pradesh, the use of the EPN *Steinernema carpocapsae* was found superior to *Sl*NPV against *Spodoptera litura* in tobacco nurseries. In Tamil Nadu, the pod borer (*H. armigera*) complex in pigeon pea was controlled with *Bt-Ha*NPV application. In Andhra Pradesh, *Heterorhabditis indica* sprays were successful against *Helicoverpa armigera* in pigeon pea. In Assam, Punjab, Gujarat and Tamil Nadu, integrated use of biocontrol agents and *Bt* was effective in reducing rice stem borer (*Scirpophaga incertulas*) populations. BIPM modules at different crop stages were useful in management of rice stem borer and leaf folder (*Cnaphalocrocis medinalis*) in Kerala and Punjab. In Karnataka, as noted above, control of coconut mite was successfully achieved with the mycoacaricide formulation 'Mycohit' containing *Hirsutella thompsonii*. In Himachal Pradesh and Karnataka, fruit damage due to pomegranate fruit borer (*Deudorix isocrates*) was controlled with parasitoid (*Trichogramma chilotraeae*) releases. In Kerala and Assam, the weevils *Neochetina eichhorniae*, *N. bruchi* and the mite *Orthogalumna terebrantis* gave successful control of water hyacinth.

By: Dr. S. P. Singh

[1]Singh, S.P.; Rao, N.S.; Ramani, S.; Poorani, J. (*eds*) (2001) Research highlights – 2000-01. Bangalore, India; PDBC, 21 pp.

[2]Singh, S.P.; Rao, N.S.; Ramani, S.; Poorani, J. (*eds*) (2001) Annual Report 2000-01, Project Directorate of Biological Control, Bangalore. Bangalore, India; PDBC, 218 pp.

Copies can be obtained from:
Project Directorate of Biological Control (ICAR),
P.B. No. 2491, H. A. Farm Post,
Hebbal, Bellary Road,
Bangalore 560 024,
Karnataka, India
Email: pdblc@kar.nic.in / drspsingh@valise.com
Fax: +91 80 3411961

❑

IOBC-Africa: Helm Changes Hands

This year saw the retirement from the Presidency of the International Organization For Biological Control of Noxious Animals and Plants – Afro-Tropical Regional Section (IOBC-ATRS) of one of the great figures in weed biological control, Dr Helmuth Zimmermann. As Division Manager of the Weeds Division at PPRI, he oversees the integrated and biological control of invading alien plant species in South Africa in four laboratories spread through South Africa. His own main research focus is the biological control of cacti, and he is currently involved in numerous projects throughout the world on the biological and integrated control of cacti, and their utilization.

Helmuth had been President of IOBC-ATRS since 1996, and his most enduring legacy is the IOBC Global Working Group on Biological and Integrated Control of Water Hyacinth. This was set up in 1997 and held its first workshop in Harare, Zimbabwe in 1998. It is fitting, then, that a key figure in the well-publicized success of biological control against water hyacinth (*Eichhornia crassipes*) in Lake Victoria is succeeding him The Global IOBC Executive Committee appointed James Ogwang as President of IOBC-ATRS following Helmuth's recommendation.

James Ogwang was born in Uganda, and obtained his BSc Degree (Botany and Zoology) from Makerere University in 1979. He continued his studies in the UK, where he gained an MSc. and a DIC (Diploma of Imperial College) from Imperial College, University of London in 1984. Moving back to Africa, he was awarded a PhD from Rivers State University of Science and Technology, Nigeria in 1991. He was employed as a Scientific Officer at Uganda's Ministry of Agriculture before a spell (1991-1992) at ICIPE (International Centre for Insect Physiology and Ecology) in Nairobi as a Post-Doctoral Fellow. Upon his return to Uganda from ICIPE in 1992, he was employed as Senior Research Officer in the National Agricultural Research Organization (NARO), and was assigned to develop a Biological Control Unit to integrate use of natural enemies in Uganda's crop protection policy.

James has worked mainly in the field of biological control and he was instrumental in promoting its adoption in Uganda, where it has been used successfully to combat such devastating pests as the cassava mealybug (*Phenacoccus manihoti*) and, more recently, in the successful biological control of water hyacinth in Uganda. He is currently the Head of Biological Control Unit of NARO.

James brings experience, enthusiasm and energy to meet the challenge of following in Helmuth's footsteps. One of his first initiatives is to organize (together with Martin Hill, PPRI) the next water hyacinth Global Working Group meeting (see Announcements section, this issue).

❑

All About Biocontrol

Trawling the Internet for news and background information occasionally throws up a real gem. This quarter it led to the University of California, Riverside website, which hosts a biocontrol goldmine in Professor Legner's Faculty Homepage at:
http://www.faculty.ucr.edu/~legneref/

Innocuously called 'Discoveries in Natural History & Exploration', the site includes a biocontrol database, and this incorporates lecture notes and a biocontrol text developed over many years as teaching materials for courses at UC Riverside. The database, which is for educational purposes only, is almost a 'one-stop shop' for the student of biological control, and especially the history and theory of classical biological control. The Biocontrol Database has a long and distinguished history. It began as a course taught by the founder of the Department of Biocontrol, Harry Scott Smith. Later Paul DeBach, Charles Fleschner and Ernest Bay developed the course further, with Fred Legner teaching the final version, which comprises most of the Database on the Internet today. Now retired from the University of California at Riverside, Prof. Legner is devoting time to developing an unparalleled Internet resource.

Exhaustive coverage of the theory and practice of biocontrol – everything from ecological theory to implementation and evaluation methods, is backed up by sections covering biocontrol on a group-by-group basis, and also on a regional basis. Some 'new' topics, such as nontarget effects are not yet given up-to-date coverage, but as Prof. Legner makes clear below, the database is very much in development, and is building on its solid base. The extensive coverage afforded by a database allows inclusion of many topics often given scant space in printed texts, and for which summarized information can be hard to find. There is, for example, an in-depth discussion in the section, 'Economic gains from biological control' of not only the measurable monetary costs and benefits of biological control, but also less-easily quantifiable economic gains from increased food security and reduced pesticide use. Prof Legner has considerably enlarged the database, too, to include peripheral aspects of biocontrol, such as insect morphology, taxonomy and integrated control. Other links developed naturally from the numerous travels that he made to secure natural enemies of insects from many lands.

There is a depressing endnote, though. The University of California, Riverside used to have a Department of Biological Control of international renown. In 1962, when Fred Legner joined the Department, there were about 45 full-time faculty and staff devoted to the deployment of natural biological control (a branch of the Department resided at Albany, California). Most efforts involved the importation of natural enemies to combat alien pest insects and mites. There cannot be many readers of this journal who have not benefited either directly or indirectly from the work and research of this department, yet today only remnants remain.

An enduring legacy of the people who worked there, though will be this authoritative Biocontrol Database. There are no restrictions on the use and dissemination of information, as long as it is for nonprofit educational purposes. Fred Legner says he is still developing the site, and is in the process of obtaining feedback from colleagues; parts of it are in a progressive state of change, with new or revised material appearing often daily.

It is impossible to give more than a flavour of what the site contains here, so readers are encouraged to take a look for themselves.

Contact: Professor Fred Legner
Email: legneref@hotmail.co

❑

IPM Systems

This section covers integrated pest management (IPM) including biological control, and techniques that are compatible with the use of biological control or minimize negative impact on natural enemies.

Pesticide Use Figures in IPM

The report of the General Accounting Office[1] (GAO), the US Congress's 'watchdog' agency, 'Management improvements needed to further promote integrated pest management' makes rather uncomfortable if not unfamiliar reading. According to the report, the US Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) initiative to achieve implementation of IPM on 75% of total crop acreage in the USA by 2000 fell far short of its target. This is at odds with USDA estimates, which showed that IPM was being implemented on 70% of national crop acreage by the target date, laudably close to the ambitious target. The discrepancy centres on what overall pesticide reduction figures mean, and what the IPM initiative achieved, or was meant to achieve.

At its outset in 1993, USDA and EPA expected the initiative to lead to a reduction in pesticide use and associated risks while maintaining adequate crop protection. The goal was to be achieved through research, outreach and education. A GAO review of policy implementation was requested by a US Senator after he learnt that annual pesticide use had risen by more than 18 million kg since 1992, although crop acreage had fallen. The GAO report says while IPM has led to significant benefits in some crops and locations in terms of reduced pesticide and management costs, [see following articles, for example], it does not appear to have quantifiably reduced national chemical pesticide use. The report notes, though, that the proportion and total use of most-toxic chemicals (in human terms) have both declined, although these still represent more than 40% of total agricultural pesticide use. Quite how this relates to the original expectation of reducing pesticides *and related risks* is therefore not clear.

An earlier report by the National Center for Food and Agricultural Policy[2] (NCFAP) sheds more light on this. This NGO is supported by government agencies, agrochemical companies and commodity organizations. The detailed analysis conducted under its Pesticide Use Program showed that although a broad-brush summary showed an overall increase in pesticide use in agriculture, this glossed over a multitude of detail. The analysis, which compared figures for 1992 and 1997, was based on a database that recorded use of 200 active ingredients in 87 crops in the 48 mainland states. This report pointed out that the overall upward trend hid a complex of hundreds of increased and decreased uses for different chemicals, crops and states. These varied changes were themselves a reflection of many interacting factors including weather, pest populations, economic factors, shifts in crop acreage and altered agronomic practices, as well as new cost-effective pesticides, introduction of effective non-chemical methods, changes in regulations and voluntary changes to reduce crop residues.

The NCFAP report argued that natural and economic forces resulted in some major increases in usage that hid reductions for more than a half of the comparisons made (including those resulting from the introduction of more effective and less hazardous new products). For example, the arrival of a new and virulent strain of potato blight caused almost 17 million kg more pesticides to be used in this crop annually, while reduced tillage (encouraged by federal farm policies to reduce erosion) is attributed with increasing herbicide use by over 250,000 kg annually; overall fungicide and herbicide usage increased 2%. Most notably, though, a fall in citrus prices led Florida growers to switch to cheaper, less-effective oil products, which single-handedly increased annual insecticide use by over 21.7 million kg. In contrast, overall annual insecticide use rose by 15.1 million kg between 1992 and 1997, while overall pesticide use rose by 42.6 million kg according to this study.

The GAO report, however, also suggests that a lack of clear objectives is one reason for the disparity between IPM adoption and pesticide reduction figures. Although the initiative began in 1993, the definition of IPM and a method for measuring its implementation were not finalized until 1997. In this context, IPM farming practices were grouped into four categories: prevention, avoidance, monitoring and suppression (PAMS). Farmers had to demonstrate adoption of at least one practice in at least three categories for acreage to be included in the IPM goal. However, the GAO analysis focused on biologically based practices as the basis for pesticide reduction. It showed that each category included biologically based methods (such as conserving natural enemies and mating disruption), which tended to reduce pesticide use, and others (such as monitoring pests and cleaning implements), which might not. The GAO report argues that acreage could be classified as IPM acreage without any measures that led to pesticide-reduction being implemented. The report says that although USDA and EPA recognised the key importance of biologically based IPM technologies in reducing pesticide use, and have encouraged growers to adopt these, their definition of IPM did not reflect this, and their analysis did not distinguish biologically based practices. However, in many systems cultural control (healthy seed, crop sanitation, prevention of spread, tillage, etc.) can have substantial impact on control and hence pesticide use, particularly in weeds. Indeed, we have already noted how the NCFAP report attributed an increase in herbicide use to the introduction of reduced tillage. However, the GAO report argues that the USDA implementation rate estimated from their criteria does not reflect "meaningful outcomes in terms of the original goal of pesticide reduction". For example, USDA estimated that 76% of maize acreage nationally was under IPM by the end of 2000, while the GAO report says that biologically based IPM practices that could reduce pesticide use were implemented on no more than 18%. The NCFAP, on the other hand, estimated that between 1992 and 1997, reductions were achieved in insecticide and fungicide use in maize through the introduction of new active ingredients (including soil applied insecticides, which led to a 2.6 million kg reduction, and *Bt* maize), although herbicide use increased (with atrazine still widely applied).

The GAO report found the situation in cotton (where USDA estimated the highest IPM adoption rate of 86%) to be markedly different. The National Academy of Sciences cites this as an example of IPM providing better long-term control than pesticides. The cotton pesticide treadmill story is familiar. Beneficial insects had been effectively eliminated from the agro-ecosystem by years of widespread chemical use, and development of pesticide resistance meant that pest populations increased despite more pesticide applications. Cotton acreages were falling dramatically when an IPM programme was introduced which combined reduced pesticide application with pheromone-based mating disruption and other IPM practices. This brought the pests under control and helped restore cotton production through reduced pest control costs, and increased yields, land values and area planted to the crop. The NCFAP report recorded a reduction of more than 900,000 kg in pesticides used annually (between 1992 and 1997) from the introduction of *Bt* cotton alone, and while insecticide use against boll weevil increased, this was as part of a strategy to eradicate the pest.

According to the GAO report, this is a relatively rare example of widespread IPM implementation, although there have been numerous small successes. It says that although USDA researchers, growers' associations and major food processors have all demonstrated IPM's significant environmental benefits, farmer uptake has been poor or patchy. The report cites farm-level impediments, such as poor communication of IPM information to farmers, farmers' perceptions of financial risks of adopting IPM practices, and the higher costs of IPM products and practices in some cases. However, this also reflects a worldwide trend of poor uptake of IPM technologies. Despite massive financial and research inputs the message has largely not got through to farmers and carefully researched IPM methods have been discarded or ignored altogether. International and national agricultural organizations are now working to change this by focusing on engaging farmers in concerted attempts to develop and deliver appropriate IPM technologies.

Even the GAO report, though, admits that the USA has some remarkable success stories to build on, and we focus on two of these below (apple IPM in the Pacific Northwest and potato IPM in Wisconsin).

USDA, commenting on the report, affirms its determination to improve implementation and coordination of US national IPM programmes. The GAO report calls for 'meaningful outcomes', but what are these? Scientists involved in the areawide apple IPM programme, discussed next, argue that while the GAO report focuses on pesticide reduction in purely tonnage terms, a more useful measure is reduction in *risk* from pesticides, together with other measures to build greater biological stability into the system. IPM includes a basket of technologies, and best solutions use a combination of methods developed on a case-specific basis. In particular, they point out, a focus on purely 'biologically based' IPM together with an insistence on pesticide reduction as the yardstick by which to measure success may leave farmers with very restricted or even no effective choices in many circumstances.

Sources:
[1]US General Accounting Office (2001) Management improvements needed to further promote integrated pest management. Website: http://www.gao.gov/ [listed under September 28, 2001]

[2]Gianessi, L.P.; Silvers, C.S. (2000) Trends in pesticide use: comparing 1992 and 1997. Washington DC; National Center for Food and Agricultural Policy, 165 pp. Website: http://www.ncfap.org/

❑

Apple of Their Eye

Codling moth (*Cydia pomonella*) is the key pest of pome fruit in the western USA. Codling moth control historically relied almost entirely on broad-spectrum organophosphate insecticides, especially azinphosmethyl. The 5-year Areawide Program for Suppression of Codling Moth in the Western United States, which implemented a biologically based IPM strategy that led to an overall reduction of some 60% in organophosphate pesticides directed at codling moth control, together with a similar reduction in codling moth damage in pilot sites, is highlighted as a success story by the GAO report ('Pesticide use figures in IPM', above).

However, one of the architects of this programme, the US Pacific Northwest tree fruit industry, has reservations about the GAO approach and conclusions. It is anxious that the programme's success, of which the participants are justly proud, should not be overstated, nor that oversimplification or generalization from the results should contribute to inappropriate restrictions being placed on pesticide use. Above all it argues that reductions in pesticide use should not be the litmus test for IPM adoption. Such a short-sighted and narrow interpretation could have disastrous consequences for IPM, and place a burden on crop management that would make pome fruit production economically unviable in some circumstances. In the case of the Areawide Program, mating disruption as an IPM tactic is not an adequate 'stand-alone' method when codling moth populations are high and conventional pesticides are needed as a back-up.

The centrepiece of the Areawide Program was codling moth mating disruption based on pheromone dispensers and sterile male releases, which replaced most or, in a few cases, all of the insecticide azinphosmethyl otherwise used for its control. However, control of codling moth with reductions in organophosphate insecticides allowed other secondary pests such as leafrollers

(*Pandemis pyrusana* and *Choristoneura rosaceana)* to emerge, and these were controlled by combinations of organophosphate insecticides used prior to bloom and non-organophosphate insecticides and *Bt* sprays used during the summer period. In most western orchards, some key natural enemies (predatory mites and some leafminer parasitoids) have developed tolerance to organophosphate insecticides, so good biological control of spider mites (*Panonychus ulmi* and *Tetranychus urticae*) and leafminer (*Phyllonorycter elmaella*) existed in most orchards. A reduction in use of azinphosmethyl, however, allowed generalist predators to recover, which helped to suppress such pests as aphids and the pear psylla (*Cacopsylla pyricola*).

This industry is a strong supporter of IPM and has one of the longest histories of IPM implementation in the country (using both biologically based and practice-based IPM tactics). It approves of the GAO focusing on IPM but, despite the resounding success of the Areawide Program, questions pesticide reduction *per se* as an accounting tool. IPM in perennial tree crops is complicated. Many factors, such as the mode of action of a given control tool, overall pest pressure, the weather and the availability of effective alternatives to broad-spectrum pesticides, play a role in the total amount of pesticide used on a crop. While the US Pacific Northwest tree fruit industry continues to support higher visibility and increased funding for IPM programmes at the state and regional level, it stresses that IPM research and implementation priorities must reflect the needs of the growers. Successful strategies are always based on local conditions and the realities of the cropping system community, the pest complex and the economics of the commodity.

The USDA-ARS Agricultural Research Service (ARS), Washington State University, Oregon State University, the University of California, Berkeley and many private companies collaborated to develop the Areawide Program's four components:

- establishing implementation sites in Washington, Oregon and California
- researching questions and problems relating to implementation
- continuously assessing progress
- communicating how the strategy works and how the programme progresses to growers

A significant factor in the success of the programme was getting orchards in a large area to implement the IPM strategy, so that they could begin to function as a complex sustainable system. Given the GAO's criticism of the level of IPM adoption countrywide, this Areawide Program provides interesting lessons on how it promoted successful large-scale adoption by growers in Washington, Oregon, and California (and with some effect in Colorado).

To begin with, the industry has a long history of integrating chemical and biological control in this area – growers are accustomed to the principles of IPM and, for example, considering nontarget effects of pesticides and resistance issues in decision making. Initially, five pilot sites were established in which partial costs (50%) of mating disruption were covered for participating growers for the first 3 years. Further sites were financed for one year only with 'seed money grant', after which growers had to bear all the programme costs. Growers and scientists worked as partners, electing management boards with representatives of both, and hiring project coordinators to monitor codling moth and collate information. Results were made available to participants and the industry via newsletters, news releases and newspaper articles.

Word-of-mouth, though, proved the most effective tool in increasing acceptance and uptake. At first, according to the programme team, most growers were sceptical. Although some asked to be part of the pilot, many adopted a wait-and-see attitude. At the end of the first year participating growers were happy with progress, and at the end of the second more were asking to join the programme. By the end of the third year, growers were clamouring to be included – even those outside the programme's area. In 1995, some 8800 ha of pome fruit were treated with mating disruption products (the pilot sites represented less than 10% of this area), and by 2000 this had increased to more than 38,000 ha. An IPM strategy that farmers could see worked and reduced pest management costs was a carrot to encourage adoption. Thus, the Areawide Program worked because it showed growers that they could successfully use mating disruption as a control for codling moth, and these growers were able to convince other growers that it was neither a difficult nor an expensive method when supplemented with insecticides.

The programme notes, however, that IPM was not necessarily implemented with the level of success achieved in the pilot sites. For example, only 50% of the total apple and pear orchard acreage in Washington even used the technologies employed in the pilot sites by the year 2000. Most of these sites were using reduced rates of mating disruption in combination with pesticides so the same level of pesticide reduction noted in the Areawide Program was not achieved. A full 50% of growers still do not practise use of mating disruption for codling moth, in part because of the difficult economic times which have left growers strapped for cash to pay for pest control activities.

A second identifiable reason for good adoption was more fortuitous, and more of a stick. The Food Quality Protection Act, 1996 (FQPA) set the stage for radical change in pest management programmes in the USA by establishing a new standard for assessing the impact of pesticides, that there would be "a reasonable certainty that no harm will result from exposure". It required re-registration of all pesticides (including organophosphates) according to more rigorous safety standards. This eliminated or restricted the use of most broad-spectrum pesticides, especially on crops that are important foods for infants or children in the USA, including apples and pears. However, the Areawide Program was underway and the usefulness of mating disruption as an IPM technology was being demonstrated concurrently with the implementation of these new regulations. The IPM strategy thus furnished a tool for growers to control codling moth and reduce the use of chemical pesticides just when regulatory pressures were encouraging them to consider alternatives.

However, one drawback to the sustainability of a pheromone-based strategy is that codling moth populations must remain low in the region for continued success. Currently, owing to low or negative returns to apple growers, many orchards in the region have been abandoned or are poorly farmed. This has led to rising codling moth populations and reduced success with sole reliance on mating disruption. Is good IPM still going on? Yes, but there has been a change in the virulence of the pest complex. The message from this is that IPM, whatever technologies this comprises, has to be part of an economically sustainable production system. The next article suggests that this might be achievable – but not just at the farmers' expense.

Sources:
Brunner, J; Welter, S.; Calkins, C.; Hilton, R.; Beers, E.; Dunley, J.; Unruh, T.; Knight, A.; Van Steenwyk, R.; Van Buskirk, P. (2001) Mating disruption of codling moth: a perspective from the western United States.
IOBC wprs Bulletin **25(1)**, 207-215.

Calkins, C.O. (2001) Areawide Program for Suppression of Codling Moth in the Western United States.
Wapato, WA, USA; Yakima Agricultural Research Laboratory, 4 pp.

Contacts: Michael J. Willett,
Northwest Horticultural Council,
Room 600, 6 South 2nd St.,Yakima,
WA 98901, USA
Email: willett@NWHORT.ORG
Fax: +1 509 457 7615
Website: http://www.nwhort.org

Jay F. Brunner,
Washington State University Tree Fruit Research and Extension Center,
1100 N. Western Ave., Wenatchee,
WA 98801, USA
Email: jfb@wsu.edu
Fax: +1 509 662 8714

❑

More Than Just Good Taste

The pressure to move away from the pesticide reliance of conventional agriculture stems at least in part from the perceived poor environmental sustainability of this approach. However, often the economic and environmental sustainability of alternative strategies is unproven. This makes a recent study of apple production systems particularly interesting, as it provides evidence in support of the superior environmental and economic sustainability of organic and integrated systems over conventional approaches in this crop.

The study compared the sustainability of conventional, organic and integrated 'Golden Delicious' apple production systems in an orchard in Yakima, Washington, USA in 1994-99. The integrated system included soil improvement, and is distinct from the IPM system promoted by the Areawide Program, described above.

Ecological and economic factors were used to assess sustainability, and a sustainable farm was argued to need to produce adequate high-quality yields, be profitable, protect the environment, conserve resources and be socially responsible in the long term. Indicators of sustainability used in the study were soil quality, horticultural performance, orchard profitability, environmental quality and energy efficiency (the amount of total inputs in relation to output or yield).

Organic interventions included compost and foliar sprays; mulches, cultivation and mowing to control weeds; pheromone-mating disruption (PMD) and *Bacillus thuringiensis* (*Bt*) sprays for insect control; and fruit thinning by hand. The integrated treatment included compost, foliar sprays, and synthetic fertilizers; mulch and herbicides for weeds; PMD and insecticides for insect control; and chemical fruit thinner. Conventional system interventions included foliar sprays and synthetic fertilizers; herbicides for weed control; PMD and insecticides for insect control; and chemical fruit thinner.

All three systems gave similar cumulative apple yields, and there were no observable differences in tree growth, physiological disorders, or pest and disease damage across the types of production system. However, the integrated and organic systems had higher soil quality and potentially lower negative environmental impact than the conventional system. Organic apples rated highest in profitability, energy efficiency and taste appeal.

The authors conclude that organic and integrated apple production systems in Washington State are not only better for the soil and environment than the conventional system, but have comparable yields and, for the organic system, higher profits and greater energy efficiency. They note that, although crop yield and quality are important products of a farming system, the benefits of better soil and environmental quality provided by the organic and integrated systems are as valuable. Currently they tend to be overlooked in the marketplace, but come at a financial cost to the grower. The challenge facing policy-makers, the authors argue, is to incorporate the value of ecosystem processes into the traditional marketplace, and so support producers trying to implement economically and environmentally sound practices.

Overall in this study, the organic system ranked first in environmental and economic sustainability, the integrated system second, and the conventional system last. Organic apples were the most profitable owing to price premiums and quicker investment return or break-even point. Were the premiums paid for organic apples removed, though, the conventional system would have broken even first, and organic last. The price premiums reflect consumer willingness to pay extra for organically grown produce. Similar premiums could be applied to integrated products, but for this 'integrated' needs to be certifiable. This is one of the issues addressed by a potato project in Wisconsin, USA, which we look at next.

Source:
Reganold, J.P.; Glover, J.D.; Andrews, P.K.; Hinman, H.R. (2001) Sustainability of three apple production systems.
Nature **410**, 926-930.

❑

Wisconsin Measures Aid Branding

Since 1996, the US Wisconsin Potato and Vegetable Growers Association (WPVGA) and the WWF (World Wildlife Fund) have pioneered an initiative to reduce pesticide reliance and risk through the adoption of biologically-based IPM. The University of Wisconsin potato IPM research and extension team officially joined this collaboration in 1999. This project's success was highlighted by the GAO report ('Pesticide use figures in IPM', above). An outstanding feature, particularly in the context of the report, has been the development of measurement systems to monitor both progress in the transition to biologically based IPM, and the linkage between IPM adoption and significantly reduced reliance on high-risk pesticides. From the outset, the importance of credible methods to track potato growers' progress in meeting pesticide reduction and IPM adoption targets was recognised.

The 180 WPVGA members grow some 32,000 ha of potatoes annually. IPM education and outreach was conducted through an integrated set of grower education meetings, field days, magazine articles, a web site (http://ipcm.wisc.edu/bioipm/) and grower-to-grower neighbourhood meetings. The biologically based IPM strategy included scouting, and field, weed, insect and disease management, and addressed issues of soil and water quality and crop storage. At its core were implementing practices to minimise pest problems and collecting data necessary for making informed and knowledgeable decisions. Adoption was measured on a positive 'points' system: the more and better the IPM practices, the more points. Crop rotation, for example, and scouting, record keeping and decision-making practices earned high points. Overall, IPM measures enhanced the crop's ability to resist pests, and encouraged a switch to reduced-risk pesticides with less impact on beneficial insects.

WWF helped to develop a measure for the toxicity of the chemicals, based on the acute and chronic risk to humans and other organisms, and the impact on the environment (including effects on the viability of the IPM system). In practice, a rating system scores each pesticide for 'toxicity units' per application.

As a result of applying the IPM measures, growers reduced use of potentially toxic compounds by nearly 250,000 kg between 1997 and 2000, and many found that profits increased as a consequence of reduced chemical use.

In the last year, though, the project has moved into a new phase. Growers are hoping to capitalize on the fact that US consumers consider pesticide use in food crops a serious issue, and are promoting their potatoes under an 'eco-label' to gain market-based rewards for their environmental stewardship. This has entailed the creation of a new label, 'Protected Harvest', and a new brand, 'Healthy Grown', for the IPM potatoes. The Healthy Grown brand focuses on marketing certified potatoes and is a separate legal entity from the independent nonprofit Protected Harvest. Protected Harvest is responsible for maintaining high standards, and insuring the integrity of the certification and chain of custody procedures, and conducting consumer outreach. The collaboration's success was instrumental in World Wildlife Fund's decision to allow the use of its logo on bags of certified potatoes.

To make the label credible, the IPM certification process is being undertaken by an internationally recognised certifier, Scientific Certification Systems, with Protected Harvest giving final approval. Some of the recommended IPM measures, such as scouting and recording, rotations with non-potato seasons, and removing/ destroying discarded potatoes are mandatory to meet the IPM standard. There are also ceilings on the number of pesticide toxicity units that can be applied to certifiable short- and long-season crops. Some other chemicals can be used with restrictions, and some pesticides are excluded from use altogether under the certification standard.

The key issue now is to persuade retailers to stock 'Healthy Grown' potatoes in the shops, and encourage consumers to buy them. A marketing campaign directed at retailers and a consumer outreach campaign are underway.

This project has successfully addressed the IPM adoption/pesticide reduction conundrum that the GAO report highlighted. Challenges ahead, as Jeff Dlott (President of Board of Directors of Protected Harvest) said in an interview with the WPVGA newsletter 'Badger Common 'Tater', include strengthening programme standards (on soil and water quality, for example). He also cites a long-term objective of the project, to develop meaningful standards for improving ecosystem function in and around farmland.

Sources:
Pest Management at the Crossroads / Topics / IPM in the Marketplace:
Website: http://www.pmac.net/potatipm.htm

Protected Harvest:
Email: Info@protectedharvest.org
Website: http://www.protectedharvest.org

WWF/WPVGA/UW Collaboration:
Website: http://ipcm.wisc.edu/bioIPM

Scientific Certification Systems:
Website: http://www.scs1.com

Wisconsin Potato and Vegetable Growers Association (WPVGA):
Website: http://www.potatowis.org/

Healthy Grown:
Website: http://www.healthygrown.com

Contact: Deana Sexson,
Biointensive IPM Field Coordinator,
WWF/WPVGA/UW Collaboration Project,
1575 Linden Drive, Madison,
WI 53706, USA
Fax: +1 608 262 7743
Email: dlsexson@facstaff.wisc.edu

❑

Potato IPM Should Focus on Pesticide Reduction

This is the conclusion of a study[1,2] of potato production in the Province of Carchi in northern Ecuador, one of the most productive potato-growing areas in the country. It argues that IPM is an abstract concept that can be difficult to measure, while pesticide reduction is relatively easy to quantify and analyse.

Potatoes have been a staple crop in the Andes since time immemorial. But with agricultural intensification and its concomitant adverse ecological consequences, farmers have come to view pesticides as essential to their economic survival. It is quite clear that pesticides have played a vital role in sustaining potato production in Carchi, particularly against late blight (*Phytophthora infestans*) and Andean potato weevil (*Premnotrypes vorax*). While the impact of systematic pesticide overuse on the environment and human health means that alternatives needed to be found, farmers' faith in pesticides made achieving pesticide reduction a socially complex and politically challenging goal.

In Carchi, potato farmers have taken advantage of the favourable climate and soils, and combined fertilizers and agrochemicals with their knowledge of crop management to produce potato yields well above the national average. Farmers have shifted from subsistence towards commercial production, in a step that potato farmers in other parts of the country may also follow. This shift, however, has increased the exposure of families to pesticides, and most notably the highly toxic insecticides carbofuran and methamidophos. An escalating economic crisis in the 1990s threatened the profitability of potato production, and made it increasingly difficult for communities to address long-term health and environmental concerns.

For more than 10 years a number of organizations including INIAP (Instituto Nacional Autónomo de Investigaciones Agropecuarios, Ecuador), CIP (International Potato Center), Montana State University (USA), McMaster Institute of Environment and Health (Canada) and Wageningen University (the Netherlands) have been working with communities in Carchi on a variety of projects to assess the role and impact of pesticide use in potato production and how the latter may be ameliorated. These projects have both provided quantitative assessments of community-wide pesticide effects, and shown ways that may allow pesticide use to be lessened.

Hidden Costs

Pesticides play a dual role in Carchi. On one side is the positive role where pesticides contribute to improved productivity. Potatoes can be planted more frequently and yields are higher as result of their use. Undoubtedly, pesticides have helped residents of rural Carchi improve their incomes. At the same time, almost all farm families know of or have experienced pesticide poisoning to some degree. Nevertheless, the local attitude is that pesticides can be tolerated by the 'strong.' This rationalization, based on ignorance, highlights the other finding: despite their central role in the economic life of the community, most know startlingly little about pesticides, how to recognize dangerous products, how exposure can occur, and how to prevent intoxication.

Farmers' conventional production technology is dependent on the fungicide mancozeb and the insecticides carbofuran and methamidophos. Pesticides, though, are not as widespread in the Carchi environment as might be expected. Carbofuran, for example, is present in groundwater but at levels well below contamination standards used by the US Environmental Protection Agency (EPA). In the environmental and soil conditions in Carchi, carbofuran is relatively short lived and likely to bond to soil and degrade before entering water supplies. Contamination is most likely from accidental or intentional dumping of pesticides in streams. Another potential danger, uncooked and unpeeled potatoes, showed no significant presence of carbofuran. Presumably, any reaching the tuber degrades before it is harvested.

There is, however, a pervasive presence of pesticides in the workplace and at home. Trials showed that most user exposure occurs during mixing and spraying, with hands, arms, backs and legs the most exposed body parts. A trial using phosphorescent powder demonstrated to the communities that poor handling practices and skimpy personal hygiene led to pesticide contamination both inside and outside the home.

The health impacts of pesticide use in Carchi are widespread and serious. An active pesticide poisoning vigilance system established the number of pesticide poisonings in the province is 171 per 100,000 inhabitants (with results about twice as high in rural areas), a figure among the highest reported in the world. The treatment costs and work days lost impose a significant financial burden on the public health system and the individual.

Fungicide use, dominated by mancozeb, causes a variety of eye and skin problems. Carbofuran and methamidofos are neurotoxins and exposure affects the peripheral and central nervous systems. Research to measure adverse neurobehavioural effects in at-risk and control samples of families in Carchi produced startling results. They showed that the entire family unit of potato farming enterprises was at risk, not just the farmer who applied products. Thus in Carchi, the at-risk population is the majority of rural dwellers or urban dwellers that for farming or other reasons handle neurotoxic insecticides. A battery of World Health Organization tests found that nearly 60% of the at-risk sample, and by implication 60% of the at-risk population were affected.

Putting Pesticides in their Place

Agricultural research financed by the government and external donors has developed viable technological alternatives based on IPM. These options, which reduce but do not eliminate pesticide dependence, and the identified knowledge gaps outlined above point the way to possible solutions.

Unexpectedly, an economic analysis indicated that taxing pesticides could improve both health and crop production, without any other technology changes. Farmers with lower neurobehavioral status, as measured by health tests, were generally the less productive ones, who made less efficient use of their production inputs. If carbofuran use were reduced by taxing it, results showed that improved farming due to improved neurobehavioral status would more than offset the losses from reduced carbofuran use. Simply ‘punishing’ carbofuran use through taxation created a situation where both rural health and productivity of potato growing could gain.

A combination of taxes and changes in technology and pesticide handling practices also showed positive results. Economic analysis showed that either changes in technology or practices or a combination of both could achieve public health goals while at least preserving the agricultural income in the region. At their most fundamental level, the policy solutions rest on strengthening farmer capacity to change farming practice and to change pesticide-handling practices. Solutions also rest on establishing external conditions, such as regulatory policies and market incentives, to promote pesticide reduction and safer use. This was demonstrated in practice in the Eco-Salud project.

The multi-institutional broad-based Eco-Salud project in Carchi was established in 1997 to promote change, and particularly pesticide reduction, through participatory learning and action with farmer households. It was directed at a three-faceted goal of better human health, improved economic welfare and greater environmental integrity. The project began with public forums to discuss outputs of previous research in order to (a) raise awareness and (b) begin to develop possible interventions. Cross-cutting themes of the project were pesticide safety and IPM.

It developed mechanisms for informing the public of pesticide safety concerns from the results of research and community led-activities in Carchi (such as the contamination pathway outlined above). In a ‘Safe Use of Pesticides’ (SUP) approach, the project sought to increase understanding and awareness of product labelling. Project staff discussed pesticide safety strategies with participating families, especially storage and safety equipment. More than two-thirds of families took advantage of interest-free 2-month credit towards purchase of high-quality protective equipment, which cost the equivalent of a week’s labour. Some rented the equipment out to recover costs.

Eco-Salud also worked with provincial government officials to influence public policies. In one innovative move, INIAP and CIP, encouraged by the Food and Agriculture Organization of the UN (FAO) Global IPM Facility, led a stakeholder meeting in Carchi on ‘the impacts of pesticides on health, production and the environment’. The aim was to bring together scientific, government and farming communities and to encourage them to work together for more rational and effective pest management. As a result, stakeholders in Carchi have called for:

- better control of agrochemicals (and for the most toxic compounds to be prohibited)
- increased funding for IPM
- provision of school-level education on pesticide impacts
- inclusion of IPM in university-level agricultural training
- promotion of awareness of collateral impacts of agricultural practices in rural communities
- direct financial support of the agrochemical industry in implementing the resolutions.

IPM Depends on Farmers

Educational campaigns and capacity-building interventions by projects in Carchi have been largely based on existing IPM alternatives. Eco-Salud disseminated IPM information (e.g. pest ecology, pesticide effects on beneficials, and specific IPM technologies). Together with its collaborating projects (including the Swiss-funded national potato programme FORTIPAPA, the US Agency for International Development (USAID) funded IPM/CRSP (Collaborative Research Support Program) and an FAO Global IPM Facility initiative), Eco-Salud viewed IPM not merely as a suite of technologies, but one whose adoption was dependent on good farmer decision-making, motivation and confidence. Beyond merely 'disseminating' information, Eco-Salud and others have been working to increase farmer innovative capacity through empowerment and environmental education, in particular regarding the management of the agricultural ecology for greater productivity and sustainability.

At the heart of the Eco-Salud strategy was the farmer field school (FFS) approach. IPM was promoted through building and strengthening farmer capacity in decision-making through new information and enhanced agroecosystem analysis. With leadership of INIAP, the Ministry of Agriculture and CIP, Eco-Salud established FFS in three communities in Carchi in 1999. FFS participants conducted experiments on conventionally managed and IPM plots of about 2500 m^2. They experimented with use of technologies such as adult weevil traps, late blight-resistant potatoes, specific and low-toxicity pesticides, and pre-spray monitoring.

Late blight poses a particular problem for potato IPM. However, previous participatory research by farmer groups in Montufar and Tulcan with INIAP researchers significantly decreased the time taken to develop new resistant varieties from about 15 years to 5 by the end of the 1990s. Acceptance of new varieties, and particularly 'Fripapa', has consequently been increased in Carchi.

After two seasons, the application of IPM techniques had led to a reduction of pesticide applications from 12 (in conventional plots) to 7 in IPM plots, while production was maintained or increased. The amount (of active ingredient) of fungicide for late blight was decreased 50%, and insecticides for Andean weevil and leafminer (*Liriomyza* sp.) by 75% and 40%, respectively. FFS participants had not only reduced pesticide use. They had identified how to maintain production with considerably less financial outlay; production costs were decreased from US$104 (in conventional plots) to $80/t in plots under IPM.

The real test for an FFS is whether the practices learnt are adopted and work for the farmers in their own fields, year on year. Early evidence in Carchi is promising with farmers appearing highly motivated. FFS graduates are showing a willingness to experiment and adapt the IPM technologies they learnt in the FFS. Farmers explained how they had experimented with 'traps' for Andean weevil.

Potato weevils are the most serious insect pests of potatoes cultivated in the high Andes. Female weevils lay eggs inside straw debris near potato plants, and the emerging larvae dig into the soil and bore into the tubers. Tuber damage from weevils can exceed 50%. Full-grown larvae abandon the tuber and pupate in the soil, and the adults emerge during the rainy season to infest new potato fields. Earlier CIP research developed a suite of IPM technologies for this pest. See *BNI* **19(3)** (September 1998), 76N-77N, 'Teaching success in Andean communities'; also see: http://www.solutions-site.org/cat11_sol98.htm

Adult weevils hide in the shade during the day. One control option is to create traps by treating potential shelters (such as straw debris or cut potato foliage) with insecticide. Plant material is replaced and weevil counts are made at intervals. These 'shelter traps' are particularly effective just prior to the emergence of main crop potato plants in new fields.

Traps introduced to farmers in Carchi through the FFS were subsequently improved through experimentation. One farmer described how he planted a small number of potatoes in newly prepared land immediately after ploughing. Once adequate foliage was in place (2 weeks after emergence), the plants were sprayed with insecticide and left in the ground as shelter traps while the main crop emerged. Another farmer described how he found he could transfer live potatoes from another field after ploughing, and treat these with insecticide. Both modifications meant treated foliage did not need replenishing. Yet another farmer says he is planning to put treated potato foliage into a container full of water in each shelter to keep it fresh, while he expects dead weevils to collect in the water and be easy to count.

Farmers have thus demonstrated that they can eliminate highly toxic compounds from their production system and substantially reduce pesticide use and production costs while not adversely affecting production per area. Complementary projects support follow-up activities, including the transition of FFS to small-production enterprise groups, the development of local FFS facilitators, and establishment of farmer-to-farmer extension. Early evaluations by the IPM/CRSP project suggest that the Carchi experience of FFS reflects the positive findings elsewhere.

However, moving farmers from thinking in terms of single-element ('silver bullet') solutions to multiple tactics based on understanding of ecological principles is quite some undertaking. Farmers in Carchi, for example, have accepted late blight-resistant potatoes, but inducing them to try other cultural controls was a challenge. An approach is required that focuses on environment-pest interactions, localized technology development and farmer/community decision-making capacity with an emphasis on the integrated management of practices.

A call is also made for a more balanced research agenda, and for past neglect of biological approaches to pest control, in particular disease and weed management, to be remedied. Better understanding is needed of naturally occurring antagonists in agro-ecosystems; for example, the impact of fungicides on entomopathogenic organisms. There is a need to begin to deal with the complex interactions among the multitude of organisms in the agro-ecosystem and work toward integrating pest management approaches.

Inter-institutional partnerships and collaborations for IPM and pesticide reduction are also seen as key. These would include involving scientists and even the pesticide industry in the solution-finding and implementation process. In particular, scientists' expertise and farmers' practical orientation are important for formulating policies that will work. These can have an important impact on the thinking of decision-makers, public opinion, and policy outcomes.

IPM also needs to face the heterogeneity of communities and farming styles. The projects in Carchi have led partners to conclude that while the FFS approach works in some contexts other IPM intervention strategies may be needed in others. An analysis of farmers by social grouping, farming style and social and economic resource management strategies indicated that FFS was most attractive to farmers with a low-risk approach.

Intervention Strategies: a Way Forward

Interventions can be broadened along three axes: pesticide substitution, market changes and community capacity building by:

- Involving all stakeholders in eliminating most-toxic pesticides and substituting less toxic compounds. Less toxic compounds are currently more expensive and costs would need to be ameliorated through alternative FFS-generated technologies, but also financial incentives for implementing IPM. Scientists' involvement in decision support and policy development is highlighted as vital.
- Promoting market-based supports for movements towards sustainable production, through such avenues as post-marketing surveillance for pesticide adverse effects, distribution networks for personal protection equipment, and labelling, certification or preferential pricing for IPM products.
- Developing capacity in highly diverse rural communities through collaborative community-led and community-based activities, with the focus on user-centred farming interventions.

This study was originally financed by the Rockefeller Foundation. Subsequent investigations were conducted with the support of the USAID Soil Management and IPM Collaborative Research Programs as well as the FAO, the Ecosystem Health Program of the Canadian International Development Research Council, and the Dutch/Swiss Fund for Eco-Regional Research.

[1] Crissman, C. C.; Antle, J.M.; Capalbo, S.M. (*eds*) (1998) Economic, environmental, and health tradeoffs in agriculture: pesticides and the sustainability of Andean potato production.
Netherlands; Kluwer, 281 pp.

[2] Crissman, C.C.; Espinosa P. (*eds*) (2001) Impactos del uso de plaguicidas en la producción, salud y medioambiente en Carchi: un compendio de investigaciones y respuestas multidisciplinarias [The impact of pesticide use on production, health and environment in Carchi: a compendium of multidisciplinary research and responses]. Quito, Ecuador; CIP, 300 pages.

Contact: Stephen Sherwood,
Centro Internacional de la Papa (CIP),
Apartado Postal 17-21-1977,
Quito, Ecuador
Email: s.sherwood@cgiar.org
Fax: +593 2 269 2604

❑

Nursery System Improves Potato Seed

Potato is an increasingly important and popular staple component of sub-Saharan African diets. In East Africa, potato-producing areas are characteristically the populous highland regions, dominated by smallholder farmers who operate intensive low-input agriculture. Emerging markets for chips and crisps are making potato an increasingly attractive cash crop, although home consumption remains important for local food security. This situation contrasts with South Africa, the largest potato-producer in Africa. Here, large, highly mechanized commercial farms dominate production, but as in East Africa, smallholders value potatoes for both income generation and home consumption, and stimulation of smallholder potato production is a priority for the South Africa Government.

Smallholders rarely achieve the potato productivity known to be possible when planting healthy seed-tuber on well managed, fertile land. In Kenya, for example, average on-farm yields of less than 10 t/ha contrast markedly with research station yields of over 40 t/ha. Such low yields have been attributed to near-continuous potato production on the same land, which leads to increased incidence of diseases and pests, (linked to) a shortage of disease-free seed, and a decline in soil fertility. Diseases, in particular, are rife with potato blight (*Phytophthora infestans*), bacterial wilt (*Ralstonia solanacearum*) and viruses recognised as primary constraints to production.

Smallholders are frequently unable to obtain good seed owing to the capacity and/or linkage constraints of certified seed production. Yet bacterial wilt and viruses are primarily seed-borne, and hence disease-free seed is of paramount importance. Certified seed production in Uganda and Kenya is vastly insufficient to meet national demand. In South Africa, where certified seed is not a constraint, marketing is oriented to large enterprises, which limits the availability to smallholders of certified seed of both new and old varieties. Smallholder farmers in all three countries therefore use potato tubers from their previous harvest as seed tubers. But in the traditional ware-to-ware production system, this seed-tuber selection is an afterthought, made from what is left following selection of ware potatoes for market and home consumption. This process biases seed-tuber selection towards leftover, undersized, damaged and unhealthy tubers that will inevitably be low yielding. Although farmers can discard the smallest tubers, latent infection (such as bacterial wilt) is less apparent. A downward spiral of increased disease incidence and falling productivity is thus almost inevitable.

Control practices for baterial wilt have centred on plant breeding, field sanitation, crop rotation and bactericides, but have had only limited success. Alternatives, such as biological control, involving appropriate technologies and low costs to the farmer are urgently needed. We describe two initiatives here. The first, in this article, deals with on-farm production of disease-free seed-tubers. The second, in the article below, discusses a novel GM approach to biological control.

In Kenya, the challenge of improving potato seed health is being addressed by researchers at CABI *Bioscience*, the Kenya Agriculture Research Institute (KARI), the International Potato Centre (CIP) and the farming community of Njabini. They have been developing a small-scale seed-tuber production system (SSPS) to replenish current farmer seed-tuber material with new disease-free material whose quality can be maintained over a number of on-farm generations.

The SSPS separates ware and seed-tuber production on each farm by the establishment of a seed-tuber nursery bed (a flatbed strip of land planted at high density). This provides the seed-tubers for both the next ware planting and for the seed-tuber nursery bed for the next season (selected on an optimal yield basis). The SSPS system also incorporates IPM of seed-borne diseases through improved land management practices, taking advantage of the 'window of opportunity' for intensive management afforded by the nursery bed.

Six farmer-field sites were selected in 1997 for the evaluation of the SSPS against the traditional ware-to-ware system and certified seed-tubers from KARI National Potato Research Centre (NPRC). Two varieties are under assessment, traditional Roslin Tana and new Tigoni. From the results of five seasons' trials, seed-tuber production per unit area of land has been shown to be some 2-3 times greater under the SSPS, with a concomitant reduction in land required to meet on-farm seed-tuber needs. Disease and pest incidence has not been significant under any system during the period of the trial. Ware productivity has not been shown to be significantly different during the early phases. The latest harvest, however, has shown a strong trend towards greater productivity under the SSPS.

A facet of working across six farms is that the data tend to be very variable. This has highlighted the importance of soil factors and has also revealed an unexpected strength of the SSPS nursery bed: its buffering capability against extremes of drought and frost. The practical significance of this is that farmers, following a poor season, are less likely to need to source seed-tubers from outside their farm (uncertified market material), thus reducing the risk of introducing diseases such as bacterial wilt to the farm. Furthermore, the reduction in land planted for seed-tuber production makes available a near-equal area of land for a non-solanaceous crop without a notable reduction in ware production, which presents a largely new opportunity for crop rotation.

The initial goals of the SSPS have been realized, although robust conclusions on the benefits to smallholders require addition trial seasons at Njabini, wider testing under varying environments (as is happening under analogous research at Meru in Kenya and in Uganda) and promotion at the farmer community level. In addition, the SSPS provides a window for application of biocontrol agents to control seed pests and diseases at the nursery bed stage. Development of a possible agent for bacterial wilt is described below.

Contact: Julian Smith,
CABI *Bioscience*,
Bakeham Lane, Egham,
Surrey TW20 9TY, UK
Email: j.smith@cabi.org
Fax: +44 1491 829100

❑

Bacterial Wilt Faces GM Competition

In comparison to investment in the development and deployment of genetically manipulated (GM) crops for pest management, the use of biotechnology to enhance the capacity of natural enemies to act as biological control agents (BCAs) is largely unexplored and unexploited. IOBC (the International Organisation for Biological Control of Noxious Animals and Plants) has the topic up for discussion at its next Symposium [See Announcements section, this issue]. One avenue exciting interest is the potential for biological control of bacterial plant diseases by using antagonistic or competitive bacteria, including non-pathogenic mutants of the pathogen.

In line with CABI's open and objective policy on crop-related GM technologies, CABI *Bioscience* is providing technical support and training to countries for the development and evaluation (including biosafety) of, and informed decision making on crop-related GM technologies. In this context, and as an adjunct to the SSPS project described above, CABI *Bioscience* and partners are researching whether biotechnology can contribute to the biocontrol of bacterial wilt disease on potato in Africa. Specifically, they are investigating the potential of using a non-pathogenic mutant of the causal organism of bacterial wilt, *Ralstonia solanacearum*, as the biological control agent. The application for the BCA in the first instance is the smallholder potato cropping systems of Kenya where the BCA is envisaged as an ICM (integrated crop management) component of the SSPS. This research has been funded by the UK Department for International Development (DFID).

The technology used in the induction of the non-pathogenic mutation was developed by the Institute National de la Recherche Agronomique, France (INRA) on *R. solanacearum* of tomato, and it has proven relatively straightforward to apply the technology to the potato isolates of Kenya. Accordingly, a representative number of ecologically fit *R. solanacearum* isolates of Kenya have been identified by genomic population characterization and developed as non-pathogenic mutants. Confirmatory tests have confirmed the dysfunction of the pathogenicity genes in *R. solanacearum* and the creation of a defined GM non-pathogenic strain of the bacterium.

Efficacy assessments of the non-pathogenic bacterium as a BCA against the wild-type (WT) disease-causing bacterium have since been undertaken that have produced statistically significant ($P<0.001$) data in support of its potential against *R. solanacearum* populations of Kenya and other countries, and also with diverse potato varieties. The mechanism by which the GM strain protects potato from disease infection is not yet understood, although induction of host resistance or competitive exclusion of the pathogen have been suggested. These assessments have to date been conducted under contained-use conditions only (CABI *Bioscience*, UK and the Agricultural Research Council – Vegetable and Ornamental Plant Institute (ARC-VOPI), Republic of South Africa) and require the satisfactory fulfilment of biosafety assessments before progressing to a field release phase.

Preliminary biosafety assessments have focused on method development that enables the tracking of the BCA and WT populations in soil. These studies have focused on antibiotic marker-based systems for numeric isolations on selective media and molecular approaches in the study of microbial community dynamics, and have shown the GM bacterial populations to decline in soils independently of the crop imposed, including potato. From this it was concluded that soil GM BCA populations are unlikely to persist in agricultural soils beyond the timeframe expected of natural populations. No evidence of gene transfer between GM and WT populations has been observed. These data have been used in support of testing the GM BCA in-country.

The transition to in-country assessments of a GM and the introduction of a BCA requires compliance under the International Plant Protection Convention's (IPPC's) 'Code of Conduct for the Import and Release of Exotic Biological Control Agents' (ISPM No. 3). While genetically modified BCAs will continue to fall under the Code of Conduct, it is recognized that additional screening may be required. International agreements on these requirements are generally not yet implemented, although some countries have enacted national measures independently. The Cartagena Protocol on Biosafety to the Convention on Biological Diversity (CBD) addresses transboundary movement of GM organisms, or "living modified organisms" (LMOs) as defined in that text. While over 100 countries are signatories to this Protocol since January 2000, only five have taken the steps of national adherence in order to become contracting parties. The Protocol itself does not enter into force until the 50th party to the CBD ratifies or approves it through the national procedures. All GM organisms that could cause injury to plants may soon be subjected to an additional process under the IPPC. Fortunately, there are efforts to coordinate this risk assessment process with the requirements of the Cartagena Protocol. Following two years of technical discussions, the new standard on risk assessment of LMOs is slated for development under the IPPC in 2002. These international efforts to harmonize methodologies and criteria for assessment of GM organisms are aimed at reducing the burden of disparate requirements or restrictions by various trading partners.

Against this background, CABI and KARI have worked closely with the emerging biosafety framework of Kenya. The procedure and formulation of an application to allow testing of this potential BCA in Kenya and the subsequent review of that application has provided a useful test case. This reached the final stages of review by the National Biosafety Committee, and the framework for testing the GM BCA in Kenya is now in place. In addition, counterparts at KARI received instruction in bacteriology and GM working practices in preparation for in-country testing. In Republic of South Africa, approval for testing under contained-use has been gained by ARC-VOPI.

Project partners are current actively engaging donors to secure the additional funds necessary to realise the potential of this innovative technology.

Contact: Julian Smith,
CABI *Bioscience*,
Bakeham Lane,
Egham,
Surrey TW20 9TY, UK
Email: j.smith@cabi.org
Fax: +44 1491 829100

❑

Control Menu for Potato Aphids

In the Pacific Northwest region of the USA, the biggest insect-related threat to potatoes comes from viruses, and particularly the leafroll virus transmitted by the green peach aphid, *Myzus persicae*. The potato leafroll virus is responsible for huge losses worldwide, and in the warm production zones of this part of the USA a long season provides extensive opportunity for infection.

Biocontrol Buffet

Aphids are attacked by a broad diversity of predators and parasitoids, and the Homoptera as a whole are very amenable to biological control. Encouragingly, two

Aphidius species (*A. colemani* and *A. matricariae*) that parasitize *M. persicae* are already established in parts of the Northwest. *Aphidius matricariae* appears to have a high preference for *M. persicae* and is rapidly becoming common in collections made in potato fields in Washington State. Another Old World parasitoid, *Praon galicum,* was recorded from the State for the first time in 2000 and has been mass-reared for augmentative releases in 2001.

The aphid parasitoids are relatively easy to mass rear, making mass releases a viable option. However, how far early-season augmentative releases might suppress population build up has not yet been adequately studied. Neither has a systematic study been conducted on the possible role of wild plants that harbour early season aphids to serve as a breeding ground to enhance early season parasitoid abundance.

But could parasitoids provide a complete answer to aphid-vectored viruses in potato? Unfortunately, the answer is 'no'. Aphid parasitoids reduce aphid populations, and often below a level where they cause direct damage, but the key point about insect-vectored viruses is that you do not need many vectors to cause economically damaging levels of disease in your crop. There is little evidence that aphids become abundant enough to cause yield reduction or damage in cultivated potatoes, yet they cause major virus disease outbreaks. Because of this, the economic threshold for aphids is far lower than the population levels associated with even high levels of parasitism. Thus parasitoid-based bio-control has to be just one course in a menu of options for a successful IPM strategy.

What else could be on the menu? Each option needs to form part of a winning team. Creating a menu of appropriate options, however, is not straightforward.

One potentially compatible option is the use of microbial controls, but will these have an additive effect? A promising candidate is *Verticillium lecanii,* which has been shown to have excellent activity against *M. persicae* in humid environ-ments. Its activity against *M. persicae* in the potato agroecosystem has yet to be assessed, however, as is its ability to instigate effective epizootics in the irrigated desert regions of the Pacific Northwest. Significantly, too, there is another possible fly in the ointment. Research on Russian wheat aphid (*Diuraphis noxia*), its common parasitoid, *Aphelinus asychis*, and the fungus *Paecilomyces fumosoroseus* showed that parasitoids avoided fungi-infected aphids, and conversely fungi were less likely to establish in parasitized aphids. Although they did not enhance each other's actions, neither did they dampen them. The mechanisms that decreased antagonistic behaviour allowed each to co-exist with minimal negative impact on the other. Current research by USDA-ARS (US Department of Agriculture – Agricultural Research Service) is aimed at evaluating interactions between *V. lecanii* and the parasitoid *A. colemani* in the *M. persicae*–potato system.

Pièce de Résistance

Another approach compatible with biocontrol is to decrease susceptibility to viral infection by engaging host plant resistance. Virus-resistant cultivars can be developed by conventional and bio-engineering techniques. It has long been realised that there is a high degree of resistance to the leafroll virus in potato breeding materials. This resistance is also highly heritable, which means that the genes that control resistance are transmitted from the parent to the offspring in such a way that a high proportion of the progeny have high resistance too. Results from conventional breeding suggested that just one or two genes had a major influence on this resistance. Since then, advances in biotechnology have confirmed this. Monsanto has successfully taken a gene from the potato leaf roll virus (the *orf1/orf2* gene) and inserted it into potato to create a leafroll-resistant GM variety. The mech-anism of resistance is not yet understood, but the presence of the viral gene in the GM strain of potato prevents the potato leaf roll virus from reproducing in the potato plant. This technology has been given EPA (US Environmental Protection Agency) approval and have been included in GM potato varieties, although there has been apparently limited uptake so far.

Insecticide Role

Aphid-selective insecticides are also being assessed, with imidacloprid one candidate. This one of the neonicotinyl insecticides, analogues of naturally occurring nicotine, which specifically bind to an insect's nicotinic receptor. When first introduced to the market 8 years ago, imidacloprid was argued to be natural enemy-friendly because of its low nontarget toxicity and systemic action. Now it seems the story is more complicated. A number of different studies have provided evidence to variously support or disprove the claim. Imidacloprid is not universally compatible with IPM, but because it can be used as a systemic soil or seed treatment it should have definite benefits in protecting predators and parasitoids. Internal plant residues should not be accessible to insects probing along the leaf surface or scraping the epidermis, but directly sprayed predators could be at risk, and the effects on natural enemies walking on dried deposits on leaf surfaces have yet to be assessed. Imidacloprid seems to have a persistence measured in a small number of days on some leaf surfaces.

Another aspect of compatibility with IPM systems is the rapidity with which a pest is likely to develop resistance and whether a pesticide is likely to be compatible in chemical rotation schemes designed to delay resistance development. During the development of imidacloprid, more than 90 generations of *M. persicae* were repeatedly treated with different concentrations of imidacloprid and resistance did not develop. One study, though, has found wide variation in susceptibility among different populations of the Colorado potato beetle (*Leptinotarsa decemlineata*), and this tolerance seems to be linked to pre-existing resistance to the carbamate insecticide carbofuran, which suggests the possibility of cross-resistance and makes resistance management is a priority.

Information in this section comes from articles focusing on imidacloprid in the October issue of *Agrichemical & Environ-mental News* (*AENews*), a publication from the Pesticide Information Center, Wash-ington State University, USA at:
http://aenews.wsu.edu/Oct01AENews/Oct01AENews.htm

Single printed copies of issues of *AENews* are available while supplies last. Once supplies are diminished, individual photo-copies of articles or issues are available. (From January 2002, the journal will be published in electronic form only, but printed copies will still be available on request.)

Contact: Sally O'Neal Coates,
Editor of Research Publications,
Pesticide Information Center,
Washington State University,
2710 University Drive, Richland,
WA 99352, USA
Email: scoates@tricity.wsu.edu
Fax +1 509 372 7491

Clearing the Leftovers

Selective control of one pest, however, opens the door for secondary pests. In the case of the Pacific Northwest potato crops, one such pest is the Colorado potato beetle, *L. decemlineata.* Similarly, frequent use of fungicides for late blight control in some areas has resulted in exploding *M. persicae* populations because the fungicides also kill naturally-occurring fungi that attack the aphid.

Selective and effective control of *L. decemlineata* has been achieved with *Bacillus thuringiensis* var. *tenebrionis*. This was discovered and developed as a selective larval bioinsecticide for a number of chrysomelid beetles in Germany. Fungal pathogens are also important naturally occurring agents, and *Beauveria bassiana* has been shown to be the most effective against *L. decemlineata*, although results have been highly variable. Lacey has now shown that in the Northwest situation, *L. decemlineata* can be kept under good control by a mixture of *B. bassiana* and *Bacillus thuringiensis* var. *tenebrionis*. The fungus can persist in the soil by infecting overwintering adults.

Leptinotarsa decemlineata control, though, provides another angle on the neonicotinide story, as history repeated itself with promising biocontrol technologies being side-lined following to the introduction of this new chemical insecticide group. Just before the neonicotinyl insecticides came on the market, considerable progress was being made with developing biopesticides for *L. decemlineata* control. Promising results were obtained from research centered on inserting delta endotoxin from *B. thuringiensis* var. *kurstakii* into *Pseudomonas fluorescens*. However, continued product development was not economically viable in the face of competition from the neonicotinides, so work was shelved.

On the positive side, as we discussed above, neonicotinides constitute an important group of efficaceous systemic compounds that have provided viable substitutes for more (human) toxic insecticides such as organophosphates.

What the issues discussed in this article highlight above all, however, is Lacey and his colleagues' assertion that an effective solution to pest management in potatoes will need a truly integrated approach of all agricultural practices.

Light at the End of the Tunnel?

To end on a bright note, USDA researchers at the ARS Insect Biocontrol Laboratory, Beltsville (Maryland) have reported finding a strain of *Photorhabdus luminescens* that outshines the competition. Many strains have been found of this widely-dispersed multiple strain bacterium that lives in the gut of, and in symbiosis with, soil-dwelling nematodes that invade insects. The bacteria produce a variety of insecticidal toxins as well as luminescent proteins that make the corpses of infected insects glow in the dark. One strain tested in laboratory studies against *Leptinotarsa decemlineata* gave 100% control, making it a prime biocontrol candidate. Researchers are now investigating some of the toxins it produces, as well as the whole bacteria for their potential as a biocontrol for the beetle.

The *P. luminescens* strain tested by ARS caused the beetles to stop eating, although the mechanism for this is not understood. Bacterial testing in the beetles is difficult, though, because feeding is affected by ambient conditions. They stop, for example, if temperature margins present in the field are exceeded. An artificial diet has been developed to help study the pest, and scientists will conduct more tests to determine the mechanism of control and whether *P. luminescens* can successfully be transferred from the laboratory to the field.

USDA-ARS Insect Biocontrol Laboratory website:
http://www.barc.usda.gov/psi/ibl/ibl.htm

Main sources:
Lacey, L.A.; Horton, D.R. (2001) New ways to foil potato pests.
Agricultural Research, May 2001.
See: http://www.ars.usda.gov/is/AR/archive/may01/foil0501.htm
Lacey, L.A.; Horton, D.R. Unruh, T.R.; Pike, K.; Márquez, M. (2001) Biological control of insect pests of potato in North America.
Presented at: 2001 Washington State Potato Conference and Trade Show, 'Taller en Espanõl sobre la Producción de Papas' [in English and Spanish].
See: http://www.aenews.wsu.edu/May01AENews/May01AENews.htm

❑

Waking the Worm: Potato Cyst Nematode

The potential of soil as a long-term source of viable inoculum is a common problem in crop diseases, insects and weeds. The challenge is how to remove the inoculum source effectively and safely. A promising approach is to interfere with the life cycle of the pest so that it emerges, hatches or germinates when conditions are not suitable for further development because of adverse environmental conditions or lack of hosts.

In the case of diseases with soil dormancy, one approach is to stimulate this to break when there is no host for it to infect. Understanding what is involved in natural breaking of dormancy, and being able to simulate the same conditions artificially are essential elements. Research on potato cyst nematodes (*Globodera rostochiensis* and *G. pallida*) in the Netherlands, funded by NWO (Netherlands Organization for Scientific Research) and STW (Netherlands Technology Foundation) has made promising advances in this field.

The nematodes, which cause serious damage to potato crops throughout the world, normally hatch from their protective cysts in spring in response to a substance excreted by potato plants. This neat mechanism means that infective nematodes emerge only when host plants at a suitable growth stage are nearby. Each cyst is formed from the swollen remains of a mature female and contains several hundred fertilized egg cells. The hatched nematodes make their way to the growing roots of the plant, which they penetrate. From then on they live as parasites on the plant. As a result, plant growth is impeded and productivity falls.

Researchers at NWO have produced a substance in the laboratory that breaks potato cyst nematode hibernation. In field trials, this caused the nematodes to break hibernation prematurely, when there was no crop in the field, and they subsequently died from starvation.

The substance responsible for stimulating nematode emergence was identified by chemists at Amsterdam University as solano-eclepin A, which young potato plants excrete via their roots. Solano-eclepin A is, however, a complex chemical compound whose molecular structure was only identified in 1992. Since then, researchers have tried to reconstruct the complex natural product, and successfully synthesized the tetracyclic left-hand substructure of the compound in the configuration of solano-eclepin A. In subsequent laboratory and field tests, two derivatives showed a promising ability to hatch juvenile nematodes.

The team intend doing further research on a wide range of substances derived from solano-eclepin A with the aim of producing a biologically active substance that can be simply prepared on an industrial scale and which will provide an environmentally-friendly means of protecting potato crops against potato cyst nematode infestation.

Such a product would allow farmers to treat fallow fields in order to activate the dormant nematode cysts in the ground. These would die because there would be no potatoes to feed on, and potatoes could be planted the following season without any danger of infection. If the success so far can be translated into an effective product, potatoes will be able to be planted in the same field every 2 years instead of every 5 as at present.

Contact: Jorg Benningshof,
Amsterdam University,
Institute of Molecular Chemistry,
Nieuwe Achtergracht 129,
1018 WS Amsterdam, The Netherlands
Email: jorg@org.chem.uva.nl
Fax: +31 20 545 5670
Website: http://www.science.uva.nl/research/imc/hiemstra/index.html

❑

Fungus From Fuzzy Wireworms

Finally on the potato scene for this section, a new strain of *Metarhizium anisopliae* isolated from a wireworm (*Agriotis obscurus*) in potatoes in British Columbia, Canada may herald a new biocontrol solution for wireworms (elaterid beetle larvae), one of British Columbia and eastern Canada's most devastating pests of potatoes and other crops.

The new strain was found during field trials by Agriculture and Agri-Food Canada's Pacific Agri-Food Research Centre in Agassiz in 1999. Wireworms found with a 'fuzzy' appearance proved to be fatally infected with the fungus. Further laboratory tests conducted in collaboration with Lethbridge Research Centre and other agriculture associations investigated the relationship between fungal dose and infection/mortality under different soil exposure conditions, and compared the new isolate with other *M. anisopliae* strains. Assays indicated the new strain to be more lethal to *A. obscurus* than the other isolates tested. Further work is needed, however, to determine the conditions in which it works well and not so well, so predictions about efficacy can be made. However, with the results of field trials showing 65% mortality (55% associated with *M. anisopliae* infection), the prospects for a new 3-year research programme appear promising.

Contact: Todd Kabaluk,
PARC Agassiz,
P.O. Box 1000, Agassiz,
B.C., Canada, V0M 1A0
Email: kabalukt@em.agr.ca
Fax: +1 604 796 0359

❑

Training News

In this section we welcome all your experiences in working directly with the end-users of arthropod and microbial biocontrol agents or in educational activities on natural enemies aimed at students, farmers, extension staff or policymakers.

Natural Enemies and Farmer Decision-making

Understanding farmers' decision-making processes is important if outside interventions are to enable farmers to make more informed pest management decisions, and especially if interventions are to result in farmers deciding to adopt IPM practices which are better for farm family welfare and for the environment[1]. In order to gain a better understanding of farmers' decision-making in pest management, fieldwork was carried out in 1999-2000 in smallholder vegetable systems in Kenya and cotton systems in India, both characterized by relatively high levels of external inputs, increasing production costs, and pesticide misuse problems. A further objective was to explore the impact of training interventions on farmers' decision-making and the study therefore compared trained and untrained farmers at three sites where IPM training projects were underway or had recently taken place. These were:

- the Insecticide Resistance Management (IRM) project of the Natural Resources Institute and the Central Institute for Cotton Research (CICR) in Maharashtra State, India
- the Farmer Field School (FFS) cotton IPM project run by Voice Trust and Agriculture Man Ecology (AME) in Tamil Nadu State, India
- the Farmer Field School vegetable IPM project managed by CABI *Bioscience* in collaboration with Kenyan research, extension and NGOs in Central Province, Kenya

Fieldwork was done by a multidisciplinary team in collaboration with training project staff and involved semi-structured individual interviews with men and women farmers, and farmer group analysis and discussion using partial participatory farm management budgets and causal diagrams. Details of methodology are given in the project report[2]. The use of discovery-learning exercises in FFS programmes to help farmers appreciate the role of natural enemies forms a key pillar of the IPM training curriculum[3] and the effectiveness of such training in encouraging the conservation of natural enemies has been reviewed[4]. Farmers' awareness of natural enemies was therefore studied in this fieldwork, with attention to how such knowledge might be used in pest management decision-making. Farmers were also asked how they would deal with a hypothetical example of an unfamiliar insect appearing in their crop, in order to explore how training and other information sources influence subsequent problem analysis and decision-making.

Putting Training into Practice

Table 1 summarizes the awareness of natural enemies and recognition capability among the different trained and untrained farmer groups interviewed and their use of natural enemies in decision-making. Trained farmers were consistently more aware of natural control mechanisms than their untrained counterparts and could identify several key groups of important arthropod predators and parasitoids, as a direct result of the training activities. In terms of their use in decision-making, FFS farmers appeared to make much more active use of natural enemy incidence and levels as decision tools than did farmers from the IRM programme.

IRM programme staff explained that previously many cotton farmers would spray indiscriminately against any insects in their fields, including beneficials, and the training had helped them to distinguish between good and bad insects. Decision-making on the need for pesticide applications and timing and product selection by IRM trained farmers was mainly based on scouting for specific pests, observation of spray thresholds (e.g. *Helicoverpa armigera* eggs present on 10 out of 20 plants sampled) and project recommendations. These recommendations were validated with farmers through demonstrations in their field, evaluating particular products for specific pests, pest stages or crop growth stages. Untrained farmers in the same area relied mainly on pesticide dealers for advice, often spraying insecticides on a calendar basis every 8-15 days. They tended to select products such as monocrotophos which they perceived as 'powerful', i.e. fast-acting, or to use up chemicals left over from earlier applications. Untrained cotton farmers in

Table 1. Farmers' knowledge and use of natural enemies (NE) in decision-making

Farmer group	Knowledge of NE	Use of NE in decision-making
IRM cotton farmers, Maharashtra, India	Learnt about biological control as part of their training and aware of insect natural enemies. Able to recognise certain groups (ladybirds, lacewings).	No longer spray against "any insect" but otherwise NE levels did not appear to play a significant role in their decision-making process.
Untrained cotton farmers, Maharashtra	Low awareness of natural enemies, only 2/6 interviewed had heard of "pests that eat other pests."	None.
FFS cotton farmers, Tamil Nadu, India	Learnt about biological control during training and all aware of natural enemies. Could recognise a range (ladybirds, hoverflies, lacewings, spiders, egg and larval parasitoids).	NE population levels, in both main crop and intercrop rows, important in deciding whether or not to spray. Final decision made on basis of pest and natural enemy levels in each field.
Untrained cotton farmers, Tamil Nadu	Concept not totally new but they had either not observed any in their fields, or said they would not be able to recognise them.	None.
FFS vegetable farmers, Kenya	Acquired a detailed understanding and appreciation of natural enemies via training (lacewings, hoverflies and ladybirds (larvae and adults) parasitic wasps, chameleons). Farmers invented their own names for natural enemies that did not have names in the local language.	Pest control decisions on action and methods partly made with respect to NE levels via AESA[1]. Avoided spraying synthetic insecticides to conserve natural enemies. Pegging rather than ash preferred for cutworm control as it "leaves pests alive for natural enemies to eat."
Untrained vegetable farmers, Kenya	Aware that natural enemy insect species existed, but said they would not be able to identify them.	None. One respondent aware that chameleons were beneficial in coffee but did not want them in her vegetable plot in case they got diseased and contaminated the crop.

[1] Agro-ecosystem analysis.

Tamil Nadu also made very similar decisions.

In contrast, cotton FFS graduates in Tamil Nadu observed natural enemies and used them in deciding whether the balance between pests and beneficials merited any control action, in addition to making augmentative releases of *Trichogramma* spp. for bollworm control. They also used pheromone and light traps to monitor adult•bollworm populations and time parasitoid releases, and erected bird perches to encourage predation. Farmers recounted how they used regular field observation and agro-ecosystem analysis (AESA), rather than specific thresholds, to make decisions, building on their group experience gained during and after training. All FFS farmers we met grew cotton as part of an intercropping system, with various combinations of pigeonpea, cowpea, maize, sunflower and castor. The majority viewed intercropping as a valuable pest management technique by maintaining or increasing natural enemy numbers, although one or two farmers expressed concern that pests might 'jump' from cowpea to the cotton plants. Some FFS farmers explained that insecticides exacerbate bollworm infestations by killing off natural enemies, while others were not sure why insecticides failed to control bollworm when they quickly killed other pests.

In Kenya, untrained vegetable farmers relied on extension services and other farmers for their pest management information. They applied insecticides on a preventative basis for aphids in kale and beans, either by calendar or crop stage. Preventative weekly sprays of contact fungicides were applied for late blight (*Phytophthora infestans*) in tomato, plus curative products if preventative control broke down. These farmers mainly used synthetic insecticides but one or two had used home-made botanical preparations or wood ash. Inexperienced vegetable farmers admitted that they watched to see what their neighbours were doing and were not confident in making their own decisions. Kenyan FFS graduates growing vegetables also relied on preventative and curative fungicide application for blight, in the absence of effective, proven alternatives for this key production constraint. However, several also used diluted milk solution to delay the onset of blight, a practice which they had learnt via farmer exchange visits during FFS training, with variable success. For other disease control, FFS and untrained farmers alike would rogue out wilt-infected plants when spotted in their fields.

Where Kenyan FFS graduates differed from their untrained counterparts was in the use of a much wider range of pest and disease management options, careful field observation and specific decision-making tools. They used home-made chilli extracts as their first choice against a variety of insect pests, a traditional practice which they had also learnt via farmer exchange visits. Farmers explained that this choice was influenced by their desire to avoid the use of synthetic pesticides where possible and conserve natural enemies but it also had the advantage of being much cheaper and not requiring observance of post-harvest intervals. They demonstrated knowledge of root-knot nematode *Meloidogyne* spp. and burned plant trash on nursery beds to prevent this and other soil-borne problems. For insect control they also used ash and they pegged thin sticks against seedling stems to prevent cutworms (*Agrotis* spp.) encircling and chewing through the stalk. This was another farmer practice acquired via exchange visits and tested during training and FFS farmers opted for pegging over ash as it "left pests alive for natural enemies to eat".

Experimenting and Adapting

Farmers' responses to the hypothetical question on what they would do on

Table 2. Farmers' responses to a hypothetical new insect appearing in their crop

Farmer group	Response on observing a new insect
IRM cotton farmers, Maharashtra, India	*4/5 respondents*: would consult CICR[1] for advice. *1/5 respondents*: would spray, but not sure which pesticide to use.
Untrained cotton farmers, Maharashtra	*4/6 respondents*: would either consult agricultural officer or pesticide dealer. *2/6 respondents*: would spray immediately.
FFS cotton farmers, Tamil Nadu, India	*5/6 respondents*: would ask the Voice Trust for advice, and discuss with neighbours or extensionist. *1/6 respondents*: would set up an insect zoo (an observation exercise from FFS) to find out if it caused damage.
Untrained cotton farmers, Tamil Nadu	*2/3 respondents:* would spray immediately. *1/3 respondents*: would see if it is doing damage before spraying.
FFS vegetable farmers, Kenya	*Group response*: (1) would catch insect, place it in a jar and observe its feeding behaviour to determine whether it was a natural enemy or a pest, (2) discuss outcome with rest of group and extension and research staff and share information with neighbours who had not been trained, and (3) if it proved to be a pest and spraying was required, chilli would be first choice.
Untrained vegetable farmers, Kenya	*Experienced respondents*: would handpick it if there were only a few, or if there were many, spray and send a sample to extension services. *Less experienced respondents*: would ask their neighbours for advice.

[1] Central Institute for Cotton Research.

encountering an unfamiliar insect in their crop were varied, yet indicated that the majority of trained farmers would not spray immediately on sight but seek advice or conduct their own experiments (Table 2). Regular field observation is key to effective decision-making in pest management and all the training programmes studied had succeeded in persuading farmers of the need to check what is happening in the field before deciding what action to take. Most of the trained farmers appeared to be much more confident in their pest management capability than the untrained farmers. The FFS farmers, especially in Kenya, described how they now relied more on their own knowledge or on their group to solve problems than they had before. FFS training certainly appeared to have provided farmers with new decision tools and useful knowledge on pest and natural enemy biology to assist decision-making. The value of these tools was demonstrated in the Kenyan farmers' answers on how they would deal with an unfamiliar insect: they would catch it, place it in a jar and study its feeding behaviour to find out whether it was a pest or beneficial. This experiment is called an 'insect zoo' and is practised as part of the FFS curriculum[3]. These decision tools and new agro-ecological understanding appeared to have enhanced farmers' analytical capacity, via an ordered framework for observation and decision-making and more criteria for selection of pest control methods. Trained farmers in this study, from both FFS and IRM programmes, also stated how much they had enjoyed learning about pests and natural enemies, a finding common to most evaluations of discovery-learning based IPM training[5]. The discussions also showed that trained farmers were willing to invest considerable time and effort in detailed field observation of arthropods, contrary to the popular perception of many researchers and extensionists.

While only one of the Indian FFS farmers said they would carry out an insect zoo experiment, case study work from other cotton FFS groups facilitated by AME in Tamil Nadu reveals how trained farmers actively experiment with pest and natural enemy manipulation[6]. Cotton farmers in Tiruchirapalli had learnt about agro-ecological functions of intercropping as part of their FFS training, observing how an intercrop of cowpea served as an alternate host to cotton aphids, *Aphis gossypii,* which then attracted populations of ladybirds and syrphids. The farmers agreed that cowpea provided a useful build-up of natural enemies to help control aphids in their cotton crop but pointed out that this benefit only lasted for the 60-day cropping period of cowpea, whereas natural enemies are needed throughout cotton's 150 days in the field. They decided to adapt AME's recommended intercrop design by planting cowpea every 10-15 days during the cotton season, to ensure that there would always be food for ladybird predators. This example demonstrates farmers' ability to make in-depth observations regarding a problem and how participatory training and research methods can encourage further experimentation and build individual analysis and decision-making skills. The issue of how to encourage season-long natural enemy populations in cotton has now been taken up by AME and partners for further research and validation.

Perceptions that pesticides are essential to obtain good yields and that fields must be kept insect-free were expressed by all the untrained farmers in this study. For the Indian cotton farmers, their decision making had traditionally been strongly influenced by the advice and opinions of local input supply providers, in terms of choice of product and timing of application. Independent decision making was more difficult under these circumstances, even for trained farmers, especially those who wished to change from dependency on synthetic pesticides. Despite these pervasive influences, all three training projects studied had managed to alter participating farmers' perceptions about pests and their dependency on pesticides, demonstrating the importance of effective training in bringing about attitudinal and behavioural change at farmer-level. Season-long training, where farmers observe field ecology and compare different pest management regimes, as opposed to conventional extension methods, is critical in achieving such change and discovery-learning about biological control should form an essential element in these training programmes.

This publication is an output of a research project (CPP/R7500) funded by the United Kingdom Department for International Development (DfID), for the benefit of developing countries. The views expressed are not necessarily those of DfID.

References

[1] Meir, C.; Williamson, S.; Little, T. (2000) Literature review of farmer decision-making in pest management.
Report for DFID CPP project ZA0352 Analysis of farmers' decision making in pest management.
CABI *Bioscience*, Ascot, UK, 48 pp.

[2] Little, T.; Ali, A.; Kimani, M.; Oruko, L.; Williamson, S. (2000) Analysis of farmers' decision making in pest management DFID/CPP Project ZA0352 (R7500).
A report on fieldwork carried out in Kenya and India, December 1999 – February 2000.
CABI *Bioscience*, Ascot, UK, 54 pp.

[3] Vos, J. (1998) Development of decision-making tools for vegetable farmers in South East Asia.
In: Haskell P.; McEwen, P. (*eds*) Ecotoxicology; pesticides and beneficial organisms.
Dordrecht, Netherlands; Kluwer Academic Publishers, pp. 404-409.

[4] Williamson, S.F.J. (1998) Understanding natural enemies: a review of training and information in the practical use of biological control.
BNI **19**, 117N-125N.

[5] Meir, C. (2000) Learning and changing: helping farmers move to natural pest control.
In: Stoll, G. (*ed*) Natural crop protection in the tropics. Letting information come to life.
Weikersheim, Germany; Margraf Verlag, pp. 265-279.

[6] Anand Raj, D.; Suresh, C. (2000) Farmers' research on natural crop protection.
In: Stoll, G. (*ed*) Natural crop protection in the tropics. Letting information come to life.
Weikersheim, Germany; Margraf Verlag, pp. 291-296.

By: Stephanie Williamson,
International Project Officer,
Pesticide Action Network-UK Eurolink Centre,
49 Effra Road,
London SW2 1BZ, UK
Email: stephaniewilliamson@pan-uk.org

❑

Announcements

Are you producing a newsletter, holding a meeting, running an organization or rearing a natural enemy that you want other biocontrol workers to know about? Send us the details and we will announce it in BNI.

International Arthropod Biocontrol Symposium

The 1st International Symposium on Biological Control of Arthropods [see *BNI* **22(1)**, 14N (March 2001)] has been rescheduled for 13-18 January 2002, and will be held at the same venue as planned for last September. At the time of preparing this issue (October 2001), re-registration was well advanced, with the majority of registered participants planning to attend. The organizers have made every effort to contact all of these, and extend their thanks to all for their patience and understanding. *BNI* will include a report from the meeting in a future issue.

Contact: Roy Van Driesche
Email: vandries@fnr.umass.edu
Website: http://www.isbca.ucr.edu/

❑

International Weed Biocontrol Congress

The XI Symposium on Biological Control of Weeds, the next in this pivotal meetings series, will be held in Canberra, Australia on 27 April – 2 May 2003, with an emphasis on the importance of ecology as the underpinning discipline for biological control

Proposed themes, which will have a keynote speaker and several oral contributions together with poster presentations, are:

1 Biological theory and new approaches.
2 Target and agent selection: ecology in target selection, and ecology in exploration and agent selection.
3 Risk analysis: host-specificity procedures, non-target effects (including food-web and downstream impacts) and risk assessment, decision-making and risk management.
4 Evaluation: population ecology in the measurement of biocontrol impact, community and landscape scale approaches to evaluating biocontrol effectiveness, and economic and social indicators of biocontrol impact.
5 Integration and management: release and redistribution tactics and strategies, integration with other control methods, and technology transfer (national and international).

The Congress Committee is chaired by Mark Lonsdale, with David Briese as Treasurer.

Contact: Congress Secretary,
CSIRO Entomology,
GPO Box 1700,
Canberra ACT 2601 Australia
Email: weeds2003@ento.csiro.au
Fax: +61 2 6246 4177
Website: http://www.ento.csiro.au/weeds2003/index.html

❑

3rd IOBC International Symposium

The Role of Genetics and Evolution in Biological Control is the title of the 3rd International Symposium of the International Organization for Biological Control of Noxious Animals and Plants (IOBC). Co-organized with CILBA (Complexe International de Lutte Biologique Agropolis), it will be held on 14-16 October 2002 in Montpellier, France.

The last decade of the 20th century brought major change, with revolutionary advances in molecular biology that opened vast new areas for basic and applied research. This has provided new issues for classical, augmentative and conservation approaches to biological control. For example: (1) How and when can molecular genetics be used to trace the origin of target pests in classical biological control? (2) What will be the genetic consequences of releasing transgenic or non-transgenic biological control agents? (3) How compatible are transgenic crops and natural enemies in conservation biological control?

The Symposium will address recent developments in genetics and evolutionary biology, and their relevance to biological control, and the organizers have invited leading genetic ecologists and biological control researchers to speak on these topics. The Symposium's aims are to acquaint biological control workers with the latest advances in genomics and molecular biology and to explore ways in which these advances can be put to practical use in biological control. The aims will be addressed under the following themes:

1 Genetic variation in pests and natural enemies.
2 Genetic diagnostic tools in biological control.
4 Tracing the origin of pests and natural enemies.
5 Predicting evolutionary change in pests and natural enemies.
6 Compatibility of transgenic crops and natural enemies.
7 Transgenic biological control agents.

Contact: Mireille Montes de Oca,
IOBC International Symposium,
AGROPOLIS, Avenue Agropolis,
34394 Montpellier,
Cedex 5, France
Email: iobc.symp@agropolis.fr
Fax: +33 4 67 04 75 99
Website: http://www.iobc.agropolis.fr/symposium2002/

❑

IOBC Water Hyacinth Meeting

The 3rd IOBC Global Working Group Meeting for the Biological and Integrated Control of Water Hyacinth will take place in Entebbe, Uganda on 27-29 August 2002, organized by the Biological Control Unit of the Namulonge Agricultural and Animal Production Research Institute (NAARI) of Uganda. This workshop proposes to facilitate the dissemination of recent research into the biological and integrated control of water hyacinth and to identify areas that may lead to improved control. It also aims to establish closer links between researchers and water hyacinth managers.

Contacts: Dr James Ogwang,
Biological Control Unit,
Namulonge Agricultural and Animal Production Research Institute,
P.O. Box 7084, Kampala,
Uganda
Email: jamesogwang@hotmail.com

Dr Martin Hill,
PPRI,
Private Bag X 134,
Pretoria, South Africa, 0001
Email: rietmh@plant2.agric.za

❑

Newsletter from Bangalore

The newsletter from the Project Directorate of Biological Control Bangalore gives a brief update on activities and highlights research activities and achievements. In the latest issue*, a short report is given on planning for international collaboration on biological control. A report on training conducted, publications issued, and workshops, seminars and exhibitions organized is included, together with a list of distinguished visitors to PDBC.

*Biocontrol Newsletter 2001. Vol. XI, No. 1. PDBC, Bangalore, India, 4 pp.

Copies can be obtained from the publisher:
Project Directorate of Biological Control (ICAR),
P.B. No. 2491, H. A. Farm Post,
Hebbal, Bellary Road,
Bangalore 560 024, Karnataka, India
Email: pdblc@kar.nic.in /
drspsingh@valise.com
Fax: +91 80 3411961

❑

Indian Potato Biocontrol Bibliography

Among the world's food crops, potatoes rank fifth in tonnage. In 1996-7, India emerged as the third largest producer of potatoes in the world with a total production of 25 million tonnes and an average yield of 19.2 t/ha. A number of pests, both in fields and stores, attack potato and are responsible for reducing yield. Of these, about 80 pests have been reported from India. The current plant protection techniques are mainly pesticide-based, which, in spite of their indisputable merits in increasing crop production, have a number of adverse side effects. In the changing scenario of pest management, an integrated approach is advocated, where predators, parasitoids and diseases of pests along with other safe and environmentally sound methods of pest control play a dominant role. It was, therefore, felt imperative to consolidate the entire work done on biocontrol of potato pests in India. This bibliography* will be of interest to scientists, students and research workers, project funding agencies and others.

*Singh, S.P.; Joshi, S. (*eds*) (2001)
Annotated bibliography of biological control of potato pests in India (1914-2000).
Bangalore, India;
Project Directorate of Biological Control Technical Bulletin No. 28, 92 pp.

Copies of can be obtained from:
Project Director, Project Directorate of Biological Control (ICAR),
P.B. No. 2491, H. A. Farm Post,
Hebbal, Bellary Road,
Bangalore 560 024, Karnataka, India
Email: pdblc@kar.nic.in /
drspsingh@valise.com
Fax: +91 80 3411961

❑

Biocontrol in Hindi

The Project Directorate of Biological Control, Bangalore organized scientific seminars in Hindi on the 14th of every month from September 1999 to September 2000 in connection with the National Language ('Raj Bhasha – Hindi) Golden Jubilee Celebrations. The seminars covered many aspects of the biological control of crop pests and weeds. A book* comprising 14 chapters has now been published based on the seminars, and will be of immense help on the specialized topic of biological control to readers of Hindi.

Singh, S.P. (2001)
Jaivik Niyantran [Biological control]
Bangalore, India, PDBC, 127 pp.

Copies can be obtained from:
Project Director,
Project Directorate of Biological Control (ICAR),
P.B. No. 2491, H. A. Farm Post,
Hebbal, Bellary Road,
Bangalore 560 024, Karnataka, India
Email: pdblc@kar.nic.in /
drspsingh@valise.com
Fax: +91 80 3411961

❑

New Leafminer Website

A new Philippines-based leafminer webpage has been launched to assist local technicians and farmers, and enhance interactions between scientists around the globe. Please browse through the site at:
http://www.bsu.edu.ph/leafminers/
and send comments and suggestions via the guestbook or directly to Dr Joshi at the address below.

Although developed as a primer focusing on leafminers of vegetables in the Cordillera Region, and dealing with species identified from there, much of the information has a wider relevance. It covers reasons for the increased importance of these pests, life cycles, host plants and damage caused, together with management options. There is also an international directory of relevant expert individuals and organizations and a bibliography. A science comic on leafminer for farmers and technicians and a video film on leafminer can be opened in Microsoft PowerPoint.

Contact: Dr R.C. Joshi,
Crop Protection Specialist,
c/o Department of Agriculture,
Regional Field Unit,

Cordillera Administrative Region,
Baguio City, Philippines
Email: joshiraviph@yahoo.com /
joshiravi@hotmail.com /
rcjoshi@philrice.gov.ph

❑

New IPM Website

The new 'sp-IPM 2001' website of the CGIAR (Consultative Group on International Agricultural Research) Systemwide Program on Integrated Pest Management is up and running at:
http://www.cgiar.org/spipm/

The sp-IPM is a complex multi-centre, multi-stakeholder initiative, so this well-designed site is particularly useful for explaining how the programme operates and the involvement of its different stakeholders. Also invaluable are the project pages themselves, which provide a wealth of well-organized detail covering the rationale for the work, partner involvement, activities undertaken and progress so far – and lots of pictures!

❑

Hot Potato Research On-line

The new Global Potato News website at:
http://www.potatonews.com
has developed out of a homegrown-site, which grew and grew. Lukie Pieterse, who founded it in 1997, aims to give potato growers, processors, retailers and researchers around the world instant and free access to the latest business and crop management information. He sees communication and information exchange between growers, processors and researchers as key to the potato sector's success. Since last year, the site has been sponsored by Syngenta (and there are links to their business and crop management tools). The site combines up-to-the-minute international potato news, market information, trends and statistics with access to a large reference database.

It hosts also Potato Research Online, which provides email alerts of key potato research news. The latest development is a bi-monthly emailed research-focused newsletter, the first appearing in November 2001 with some 40 articles on all aspects of potato research. A veritable feast!

Contact: Lukie Pieterse,
Content Manager, Global Potato News, Charlottetown, Prince Edward Island, Canada
Email: info@potatonews.com

❑

EPPO Potato Guidelines

Given all the articles on potatoes in this issue, it seems a good time to include a note about the new EPPO (European and Mediterranean Plant Protection Organization) Guidelines On Good Plant Protection Practice for potatoes*. Published in English and French, they cover methods for controlling pests (including pathogens and weeds) of primarily ware potatoes. Each pest problem is outlined, and the strategy for dealing with it is described, including details, where applicable, of control methods and timing of interventions, together with constraints such as pesticide resistance. Pests covered include: *Phytophthora infestans* (late blight), *Alternaria solani* (early blight), *Thanatephorus cucumeris* (black scurf and stem canker), *Verticillium dahliae* (verticillium wilt), storage diseases, *Leptinotarsa decemlineata* (Colorado beetle), aphids, *Phthorimaea opercullela* (potato tuber moth), soil Coleoptera (*Agriotis* spp. wireworms and *Melolontha* spp. whitegrubs), noctuids (cutworms), the mirid *Lygoris pabulinus*, leafhoppers (*Empoasca vitis, E. solani* and *Eupteryx atropunctata), Globodera* spp. (potato cyst nematodes), slugs and weeds. The use of desiccants as haulm killers and sprout suppressants is also covered. The guidelines, part of an EPPO programme to prepare such guidelines for all major crops of the EPPO region, should be read in conjunction with EPPO Standard PP 2/1(1) Principles of Good Plant Protection Practice.

*OEPP/EPPO (2001) *Bulletin OEPP/ EPPO Bulletin* **31**, 183-199.

❑

Conference Reports

Have you held or attended a meeting that you want other biocontrol workers to know about? Send us a report and we will include it in BNI.

VII Siconbiol

The VII Symposium on Biological Control (VII Siconbiol) was held in Poços de Caldas, State of Minas Gerais, Brazil on 3-7 June 2001. The meeting was attended by 530 registered participants and invited speakers.

The Symposium benefited from the participation of specialists from Belgium, Canada, Chile, Colombia, Cuba, the USA, Finland, France, Holland, the UK, Israel and Italy who contributed with Brazilian experts to the success of the event, demonstrating once more that the symposia on biological control are recognized by the scientific community as the best forum for discussion of the many aspects of biological control.

There were eight conferences, and 24 plenary sections organized within the established themes:

1 Ecology and biological control (tri-trophic interactions, plant diversity and biological control, weeds and insecticides, endophytic microorganisms).

Strategies used to preserve native and/ or introduced natural enemies in agroecosystems were discussed. Supplementary food sources, refuges and/or adoption of crop management tactics which guarantee more ecological stability in the crop area are considered key factors in biological control programmes and for the preservation of biocontrol agents.

2. Taxonomic identification and selection of natural enemies (predators, parasitoids and insect pathogens).

The correct taxonomic identification of a biocontrol agent is of great importance since its scientific name is key to providing correct information on its morphology, biology, behaviour and potential harm for human health. Improving identification techniques and developing methods based on phylogenetic studies and direct analysis of DNA will lead to better precision in identifications, increasing the prob-ability of success in efficient natural enemy selection.

3 Attributes of a good natural enemy (predators, parasitoids and insect pathogens).

Specific attributes are of great importance for using entomophagous and pathogenic organisms in an economic and efficient way, and similarly as biocontrol agents for weeds and as antagonists for the biological control of plant diseases. Biocontrol of human and domestic animal diseases requires agents with special characteristics, given the nature of the problem. New knowledge on the ecology and biology of these organisms will allow the identification of new desirable characteristics for a good biological control agent.

4 Improving the efficiency of natural enemies (increment factors in biological control, insect pathogens in agriculture and in vector insect control).

Natural enemies (predators, parasitoids, insect pathogens or antagonists) have characteristics which make them specific or generalist, enzootic or epizootic agents of control, which indicates strategies for their use in inoculative or inundative releases, and conservation and augmentation among other uses. These characteristics can be manipulated to favour their utilization as biocontrol agents. Techniques for breeding better natural enemies were discussed, covering more conventional to more advanced techniques, such as the use of the rDNA.

5 Commercial production of biocontrol agents (entomophages, biological control and pheromones in agribusiness, insect pathogens).

Modern agriculture causes severe problems in environmental and human health and leads to a dramatic reduction in biodiversity, as a result of intense and frequent utilization of pesticides. In this section, analyses were presented of incentives and perspectives for the commercialization of biological control in Brazil in the light of similar initiatives in other countries.

6 Quality control of natural enemies (entomophages and insect pathogens)

Rearing and producing natural enemies under laboratory conditions can alter the performance of such organisms, resulting in failures in biological control. Care in selection criteria and attention to rearing methodologies are important to guarantee the quality of the product. Quality control is of great importance for assuring the performance of predators, parasitoids and pathogenic organisms, and assuring their efficiency in the target organism.

7 Risk analysis and environmental impact in the introduction of natural enemies (legislation, biological control and genetically modified organisms, classic biological control)

The introduction of biological control agents in a particular ecosystem alters its composition and has a not well-understood impact. The importance of risk analysis and environmental impact evaluation has been increasingly recognised as an indispensable procedure to assure a sustainable agriculture.

8 Cases of success in biological control (agricultural, urban and forest ecosystems)

Biological control should not be considered a unique and isolated method, but as one tool in a group of strategies of management. The success of the establishment of a native or exotic natural enemy or the efficiency of a pathogen in pest control are therefore dependent on several factors: biotic, abiotic, cultural and social. Biological control programmes established as standard practice in pest control were discussed in this section.

In addition, 430 papers covering established themes were presented in poster sessions over the 4-day event.

Two sets of abstracts were produced:

- Abstracts book/Livro de resumos. VII Simpósio de Controle Biológico, Poços de Caldas, MG, Brazil, 3-7 June 2001, 472pp. This contains abstracts of papers presented in the poster sections, without the texts of the conferences.
- CD-ROM - Simpósio de Controle Biológico. VII Simpósio de Controle Biológico, Poços de Caldas, MG, Brazil, 3-7 June 2001. This contains the abstracts of the papers presented in the poster sections, together with the texts of the conferences.

The success of VII Siconbiol was the result of the united efforts of many people, universities, research institutions, development agencies, scientific societies and private initiative, which in direct or indirect ways contributed for the realization of the event, and to whom the Organizing Committee expresses its gratitude.

By: Vanda Helena Paes Bueno,
President, VII Siconbiol

❑

Practising Biological Control

An international conference, The Practice of Biological Control: Importation and Management of Natural Enemies and Agents, was held on 2-5 August 2001 at Montana State University, in Bozeman, USA. The conference consisted of 11 invitational keynote speaker and panel discussion sessions covering issues of importance to all of the disciplines involved in applied biological control. Afternoon poster sessions were held for specific research posters submitted by attendees. The conference was attended by 140 practitioners from 20 countries, and was co-sponsored by IOBC-NRS (International Organization for Biological Control, Nearctic Regional Section) and the Cooperative States Research, Education and Extension Service Experiment Station Committee on Organization and Policy, Biological Control Working Group (ESCOP-BCWG). The conference was supported largely by registration fees of attendees, with additional funds provided by the National Biological Control Institute (USDA-APHIS-PPQ-NBCI), the USDA Competitive Grants Program (NRI), and the Invasive Species Initiative (USDA-APHIS).

Limited copies of the conference programme, which includes abstracts, are available from the conference organizer.

Contact: Tim Kring,
University of Arkansas - Entomology,
Cralley-Warren Research Laboratories,
2601 N. Young Avenue,
Fayetteville,
AR 72704, USA
Email: Email: tkring@uark.edu
Fax: +1 501 575 3348

❑

Biological Control Meetings in India

Biological Control Symposium

The Society for the Advancement of Biological Control, Bangalore, and the Indian Society for the Advancement of Insect Science organised a Symposium on 'Biocontrol Based Pest Management for Quality Crop Protection in the Current Millennium', which was held at Punjab Agricultural University (PAU), Ludhiana on 18-19 July 2001. [See Proceedings section, this issue.]

Dr S. P. Singh, Project Directorate of Biological Control (PDBC), Bangalore, welcomed the delegates and gave a brief account of advances in biological control in

India. Padma Bhushan Dr Rajindra Singh Paroda, Secretary, Department of Agricultural Research and Education and Director General, Indian Council of Agricultural Research, New Delhi, inaugurated the symposium and delivered the inaugural address: 'Relevance of biocontrol in the current agricultural scenario in India.' Padma Bhushan Professor Virender L. Chopra, National Professor, delivered a special lecture on 'Biotechnological approaches to biological control of crop pests.' Dr Kirpal Singh Aulakh, Vice Chancellor, PAU, Ludhiana, presided over the function. Dr Darshan Singh, Professor and Head, Department of Entomology, PAU, Ludhiana, proposed a vote of thanks.

There were 200 participants from India, Kenya, the UK, Australia, Thailand, the Philippines and Japan. Eighteen invited papers were presented in three different sessions over two days. Lead papers were presented on: Innovations in mass rearing technology and techniques for mass releases, transportation and storage of natural enemies (S. P. Singh); Bio-intensive management of cereal stemborers in Africa: exploiting chemical ecology and natural enemies in a 'push-pull' strategy (Z. R. Khan); New approaches in maximizing the effectiveness of natural enemies (D. N. Yadav); Tritrophic interactions amongst host plants, insect pests and their natural enemies (A. J. Tamhankar & K. Shantharam); Augmentation biocontrol: recent progress and emerging opportunities (S. Sithanantham & N. K. Maniania); Innovations in mass production of microbial agents for the control of insect pests (V. M. Pawar, U. T. Thombre & P. S. Borikar); Biotechnological approaches in increasing effectiveness of microbial agents (R. J. Rabindra, J. S. Kennedy, N. Sathiah & B. Rajasekaran); Biological control of plant pathogens – an application of natural control (A. N. Mukhopadhyay); Integration of biocontrol with chemical and non-chemical methods of pest management (Banpot Napompeth); Transgenics in insect pest management (D. S. Brar & G. S. Khush); Development and use of heat and insecticide tolerant strains of natural enemies in IPM (J. Singh, K. S. Brar & J. P. Singh); Biocontrol of weeds using pathogens: recent advances (Carol A. Ellison & H. C. Evans); *Bt*-cotton to combat bollworms: its development and current status (T. M. Manjunath & K. S. Mohan); Recent developments in biocontrol of weeds using insects (Rachel E. Cruttwell McFadyen); Role of cultural practices in improving the abundance and efficiency of natural enemies (M. V. Potdar & A. K. Kakkar); Development of RAPD PCR (V. K. Dilawari); Importance of quality control in commercial production of biocontrol agents (K. P. Jayanth); and Pheromones as a tool for IPM (Kinya Ogawa & Toshimi Kobayashi).

There were three poster sessions in which more than 170 papers were presented. The papers presented by Dr S. Ramani, Dr S. S. Hussaini and Dr (Mrs) C. R. Ballal, all from PDBC, Bangalore, took the best poster paper awards for the three sessions.

The Symposium came up with 20 recommendations in three areas. Areas recommended for targeting in research were:

1 Strengthening national capacity for utilizing molecular tools together with conventional taxonomic tools in characterizing and mapping the diversity of native biocontrol agents.

2 Intensification of software development for identification and databases.

3 Exploration of additional opportunities for selective deployment of biocontrol agents that perform more effectively in important crop targets.

4 Intensification of work on evolving superior strains of parasitoids and predators which would perform better in field conditions.

5 Identification and utilization of manipulative practices that enhance the efficacy of promising biocontrol agents.

6 Creation of a National Repository for potential bio-agents.

7 Development of inter-disciplinary and international collaboration in selected themes including biosystematics, native diversity characterization, gene banks, habitat management, tritrophic interactions and quality monitoring.

8 Strengthening of research strategies to promote *in vitro* production techniques of biocontrol agents to enhance the capacity to produce and enable the commercial production of these agents.

9 Increased emphasis on genetic improvement, utilization, commercial production and popularization of viral, fungal and bacterial pathogens, fungal and bacterial antagonists and entomopathogenic nematodes in biological control.

10 Establish and standardize quality control parameters for biocontrol agents to enable quality control checks necessary in production, sale and use of biocontrol agents.

11 Development of protocols for non-target risk assessment.

Policy areas recommended for development were:

12 The constitution of focused working groups and experts' panels for visualizing future thrusts and developing appropriate vision documents and concept notes for inter-institutional cooperation including stakeholder participation and popularization of the technology for biocontrol.

13 Initiatives to further promote policy support, encourage private enterprise and simplify the product registration as well as quality control guidelines of bioagents.

14 Enforcement of quality control checks necessary in production, sale and use of biocontrol agents.

15 Registration and licensing of biocontrol producing individuals and organizations in the government and private sectors.

16 Designation of quality control laboratories for biological control.

17 Policy on registration of pesticides that are ecofriendly and safe to natural enemies, including provision of re-registration after evaluating their performance.

18 Strengthening of human resource development (HRD) and transfer of technology mechanisms.

Development issues recommended for addressing were:

19 To intensify awareness programmes among the farmers about the benefits of use of natural enemies and availability of resources.

20 Country-wide networking to disseminate information on biological control.

The above recommendations may be adopted as appropriate by different organizations such as the Ministry of Agriculture, Ministry of Commerce, Ministry of Human Resource Development, Department of Agriculture and Cooperation, Department of Agricultural Research and Education, Indian Council of Agricultural Research, Department of Biotechnology, Department of Science and Technology, Department of Environment and Forests, Directorate of Plant Protection, Quarantine and Storage, University Grants Commission, Council of Scientific and Industrial Research, state agricultural universities, state departments of agriculture, state departments of horticulture, etc.

Indian Biocontrol Workers' Group Meeting

The 10th Biocontrol Workers' Group Meeting was held at Punjab Agricultural University, Ludhiana on 20-21 July 2001 (under the aegis of the Indian Council of Agricultural Research (ICAR), New Delhi). Around 60 delegates representing ICAR, New Delhi, ICAR institutes, state agricultural universities and other invitees participated. The members presented work done in the year 2000-01 on various aspects relating to biological control of crop pests and weeds. The workshop then held technical sessions. The technical programme was formulated for the years 2002-03 and 2003-04 in the final session.

By: Dr S. P. Singh,
Project Director,
Project Directorate of Biological Control (ICAR),
P.B. No. 2491, H. A. Farm Post,
Hebbal, Bellary Road,
Bangalore 560 024,
Karnataka, India
Email: pdblc@kar.nic.in /
drspsingh@valise.com
Fax: +91 80 3411961

❑

Alien Plant Invaders

The 6th EMAPi (Ecology and Management of Alien Plant Invasions) Conference was held at Loughborough University, UK on 12-15 September 2001 and was organised by Dr Lois Child. This was the latest in a series of international conferences which started in Loughborough in 1992 and intervening ones have been held in recent years in Kostelec, Czech Republic; Arizona, USA; Berlin, Germany; and La Maddalena, Sardinia, Italy.

A total of 34 oral papers and 31 posters were presented at the conference under the seven conference themes: Global issues; Mechanisms; Alien floras; Species ecology - congeners; Species ecology - case studies; Impacts; and Control and management.

The conference, which was truly international, was attended by 71 delegates from countries including Australia, New Zealand, South Africa, China, USA, Ecuador, Hungary, Spain, Portugal, Italy, France, Germany, Czech Republic, Slovakia, Poland, Denmark, England, Scotland, Ireland and Wales.

From the European context, the usual suspects still dominated discussions although more Mediterranean species were highlighted than previously. It was pleasing from a biocontrol perspective for there to be American, Australian and New Zealand speakers since classical biocontrol is so commonplace in these cutting edge countries. Due to high demand there was a Japanese knotweed discussion group chaired by Max Wade which spent some time discussing biological control and concluded that it was a good idea. As the problems with invasive plant species grow worse, more and more attention is being paid to practical solutions and sustainable management solutions; this should mean that biocontrol receives the attention it deserves.

The proceedings of the conference will be published by Backhuys Publishers, Leiden, The Netherlands and will continue the 'Plant Invasions' series. The next conference is planned for 2003, with the venue yet to be decided.

For details of previous conferences in the series including abstracts, see:
http://www.lboro.ac.uk/research/cens/invasives/index.htm

By: Lois Child, Loughborough University and Richard Shaw, CABI *Bioscience*

Contact: Lois Child,
Centre for Environmental Studies,
Loughborough University,
Loughborough, LE11 3TU, UK
Email L.E.Child@lboro.ac.uk
Fax: +44 1509 222558

❑

Asia Pacific Entomology

The 4th Asia Pacific Conference of Entomology was held on 14-17 August 2001 in Kuala Lumpur, Malaysia. The theme of this meeting, which was jointly organized by the Malaysian Plant Protection Society (MAPPS) and the Entomological Society of Malaysia (ENTOMA) was 'Entomology for a dynamic and borderless world'. The Conference saw the participation of 273 participants from 22 countries covering various disciplines and vocations. In congruence to the fluid nature of the conference theme, and the varied response from participants, amongst the 34 sessions on different topics, papers dealt with some generic issues in the areas of biological control and IPM, and papers addressed a whole range of basic to applied topics of interests, both for the tropical and temperate situations.

There were 2 oral sessions in biological control, and in IPM there were 3 sessions. The papers presented in the biological control sessions could be broadly classified into those dealing with: (1) Status of natural enemies and their biology including advances in the rearing of selected natural enemies; and (2) Implementation of biological control in crop systems. Some of the papers presented in (1) were: (i) Some native parasitoids and their biological control aspects on aphids of vegetables from Kyushu Island of Japan; (ii) Parasitoids and hyperparasitoids of walnut aphid in Iran; (iii) Multiparasitism between *Eriborus argenteopilosus* and *Microplitis manilae*: its effect on encapsulation and parasitoid survival and (iv) Recent advance in *in vitro* rearing of egg parasitoids in China. Topics presented in (2) included: (i) Cotton aphid management by using a marginal mutual alfalfa zone; (ii) Successful biological control of *Bemisia tabaci* species complex in the United States; (iii) Managing pesticide use on sugarpeas in relation to parasitoid dynamics; (iv) Biological control of the cocoa pod borer using cocoa black ants (CBA) in Malaysia: CBA colony development in artificial pests.

The papers presented in the IPM sessions encompassed areas that dealt with: (1) Status of pests and their IPM programmes in crop systems; (2) Review and assessment of current methodologies and approaches, with emphasis on bio-based technologies, used in IPM programmes; (3) Role of extension in area-wide IPM programmes. A sample of papers presented in (1) includes: (i) Insect infestation of indigenous vegetables in Sarawak; (ii) IPM of *Sesamia nonagriodes*, a sugarcane borer in Iran; in (2): (i) Dispersion of the cocoa pod borer egg population in cocoa-coconut ecosystems; (ii) Sampling of *Xanthogaleruca luteola* on *Ulmus* spp. in urban condition and development of sequential sampling plans; (iii) Bio-based pest management approaches against the diamondback moth, *Plutella xylostella* in brassicas grown within a nethouse; and in (3): (i) Area-wide fruitfly control in Taiwan (1994-2000); (ii) Extension's role in area wide programmes for managing fruit flies in Hawaii.

By: Dr A. Sivapragasam,
MARDI, Malaysia

❑

New Books

Toolkit for Aliens

This new publication* is neither a spaceship repair manual, nor a companion volume to 'The Hitchhiker's Guide to the Galaxy', but a key resource from the Global Invasive Species Programme (GISP). Its publication marks the culmination of a 2½-year consultative process to develop a compilation of best prevention and management practices for invasive alien species (IAS). Over this period, it has become known to those involved as simply 'The GISP Toolkit'.

IAS are familiar territory to biocontrol researchers and practitioners. Water hyacinth, depicted on the toolkit's front cover, is one of the best-publicized cases in recent years. Originating in South America, it has become widely distributed by humans in the Old World tropics because of its attractive flowers. It inflicts significant economic damage by impairing water transport, disrupting hydro-electric power generation, preventing fishing, and blocking irrigation schemes and reservoirs, but it also affects biodiversity by reducing native fish, aquatic invertebrates and plants. Integrated pest management (IPM) has proven to be most efficient in clearing lakes and rivers, using case-specific combinations of mechanical, chemical, and biological control techniques.

The Convention on Biological Diversity (CBD) recognises IAS as the second greatest threat to biodiversity after habitat destruction (and the greatest threat on islands). All signatories to the CBD have an obligation under Article 8(h) to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species." The mechanisms for this were elaborated at COP-5 (the 5th Conference of the Parties to the CBD, held in Nairobi, May 2000). Decision V/8, 'Alien species that threaten ecosystems, habitats or species', urged Parties, other governments and relevant bodies to give priority to the development and implementation of IAS strategies and action plans. It called for case studies by countries, particularly focusing on thematic assessments. It called for information sharing and harmonization of approaches. It suggested priority issues to address, including mechanisms for transboundary cooperation and regional and multilateral cooperation, and including exchange of best practice. It identified bodies to lead in the international arena, and called for a focus on (bio)geographically isolated ecosystems.

GISP was initiated to address these issues of IAS formulated in the CBD. It is coordinated by SCOPE (the Scientific Committee on Problems of the Environment) in conjunction with IUCN (the World Conservation Union), CABI and UNEP (the UN Environment Programme). Its goal is to enable communities and conservation managers to draw on the best available tools to improve prevention and management of biological invasions, and that is the focus of the GISP toolkit.

The toolkit was designed and partially drafted at a workshop held in Kuala Lumpur in March 1999 by a group of experts gathered together from 13 countries around the globe. In addition, these and other internationally renowned experts prepared case studies of successful projects highlighting successes, problems and opportunities for prevention and management of IAS. Continuing from this, Rüdiger Wittenberg and Matthew Cock of CAB International prepared the text of the toolkit, which was then reviewed by the participants of the Kuala Lumpur workshop and their feedback incorporated. Dick Veitch of New Zealand acted as a third editor during this review process. The resultant draft was presented at the GISP Final Synthesis Conference held in Cape Town, South Africa in September 2000, and reviewed in working groups during the conference. Many valuable suggestions made at this time were incorporated in the toolkit text prepared for publication as this book.

Although the toolkit's focus is on IAS affecting biodiversity, many examples are drawn from traditional sectors such as agriculture and forestry, reflecting the diverse problems caused by IAS and the wider knowledge base and experiences with IAS in these commercial sectors. The 102 case studies presented span the globe and cover most regions, although islands are particularly stressed because they are especially vulnerable to the impact of IAS. The immense scope of the issue prohibits a comprehensive description of detailed approaches. Hence, an essential feature of the toolkit is to provide an overview, advice by example, and leads on where to learn more.

The book provides a wealth of information on best management practices for IAS and will assist and direct those involved with biodiversity conservation and land management. The breadth of the management approach and the numerous case studies will also be of interest and an information source for a wider public audience. Management (in a wider sense) of IAS is described: from the establishment of national management plans, to measures to prevent invasions, opportunities for risk analysis processes, early detection systems and methods for management.

Publication of the GISP Toolkit is not the end of the line. The text and case studies will be adapted to form a website, and it is intended that this will become an enduring but dynamic version of the Toolkit, to be updated with new information, Internet links, and case studies as these become available. In particular, the some hundred separate case studies in the published version represent the expertise of the workshop participants, and the people subsequently involved in the preparation of the toolkit, and are therefore not representative of the full range of experience worldwide. Therefore, nationally and regionally focused case studies using local adaptations of the toolkit will be particularly welcomed.

Initial financial support for the Toolkit came from the Global Environment Facility (GEF), UNEP, UNESCO (UN Educational, Scientific and Cultural Organization), the Norwegian Government, NASA (US National Aeronautics and Space Administration), ICSU (International Council for Science), La Fondation Total, and the John D. and Catharine MacArthur Foundation, while the participating groups have made substantial in-kind contributions. GISP is a component of DIVERSITAS, an international programme on biodiversity science.

*Wittenberg, R.; Cock, M.J.W. (*eds*) (2001) Invasive alien species: a toolkit of best prevention and management practices. Wallingford, Oxon, UK; CABI *Publishing*, 228 pp. Pbk. ISBN 0851995691

The GISP Toolkit is available free of charge to all developing countries while supplies last. Contact: Laurie E. Neville,

Coordinator,
Global Invasive Species Programme,
Department of Biological Sciences,
385 Serra Mall/Herrin Labs 477,
Stanford University, Stanford,
CA 94305-5020, USA
Email: Lneville@stanford.edu
Fax: +1 650 723 9253
Internet: http://jasper.stanford.edu/gisp/

The GISP Toolkit is also available for purchase at UK£27.50 / US$50.00 (+ p&p).
Contact: CABI *Publishing*,
CAB International, Wallingford,
Oxfordshire OX10 8DE, UK
Email: orders@cabi.org
Fax: +44 1491 829292
Internet: http://www.cabi.org/Publishing/
or link directly to the title at
http://www.cabi.org/Bookshop/
book_detail.asp?isbn=0851995691

❑

Organic Opportunities Identified

The world market for organic foods, and particularly for fruit and vegetables, has been expanding strongly and steadily since the mid-1990s. This has created a viable and sometimes value-added niche in the market. Organic production in developed countries is likely to be outstripped by demand, at the very least in the short and medium term, opening the way for the significant organic imports. Tropical and off-season produce, for which many developing countries have comparative advantages, will also continue to provide growth opportunities.

The economies of many developing countries depend on the export of a small number of mostly agricultural commodities. Diversification has been made more crucial than ever by the prospect of further market liberalization in the near future. Expansion into high-value crops can help reduce the vulnerability of many agricultural producers in such countries, especially the small-scale resource-poor farmers. However, owing to a lack of distinction between organic and conventional food products, little information has been available on organic horticultural market development and internationally traded volumes, on which private and public sector decision-makers in developing countries could base decisions about conversion to organic production.

This publication* presents the findings of a recent joint study by the Food and Agriculture Organization of the UN (FAO), the International Trade Centre (ITC) and the Technical Centre for Agricultural and Rural Cooperation (CTA) on international trade in certified organic fresh tropical and temperate fruit and vegetables. It fills the information gap with details of organic market development and global trade in these products.

The study analysed the major global organic markets in Europe (Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Sweden, Switzerland and the UK), Japan and the USA. For each country, it summarizes the development of the organic sector, and gives current production figures for organic fruit and vegetables. It provides data on the organic market, focusing on fruit and vegetables, and covers distribution channels, market trends and market access. It discusses constraints to market development (supplies, price premiums, consumer attitudes). The import market is equally fully analysed, with regulations outlined, and data on current imports of organic fruit and vegetables summarized. Main importers are identified. Import trends and constraints to growth are also considered. This qualitative and quantitative information on demand in the world's largest markets and prospects for growth in the short and medium term is drawn together for each importer country in a discussion that identifies market opportunities for developing countries.

The book then looks at seven case studies, countries that have established, or are developing, organic sectors (Argentina, Cameroon, Chile, the Dominican Republic, Madagascar, Papua New Guinea and Zambia). For each, the history of organic development is outlined, active institutions are identified, and national standards and regulations noted. Current organic production and growth are described, focusing on fruit and vegetables, and types of producers are identified. An economic analysis of organic vs. conventional production is presented, and production supports and constraints are considered. In-country and export markets and marketing chains are described. Lessons to be drawn from each case study are summarized in a discussion that highlights the strengths, weaknesses, opportunities and threats to the country's organic sector, and points out areas for future growth together with any constraints.

The main findings of both the developed market surveys and developing country case studies are synthesized to identify opportunities for developing countries, by highlighting product categories likely to provide market opportunities to them. At the same time, the book gives guidance on requirements for producing and exporting organic products to major markets, and warns of pitfalls and likely constraints.

*Anon (2001) World markets for organic fruits and vegetables. Opportunities for developing countries in the production and export of organic horticultural products. Rome; FAO/ITC/CTA, 312 pp.

❑

Proceedings

Augmentative Biocontrol

The proceedings* have been published of a workshop held in June 2000 at the Project Directorate of Biological Control (PDBC) in Bangalore, India to discuss actual and potential uses of augmentative biocontrol and the factors that constrain its use and adoption. The publication gives the latest information on feasible augmentative biocontrol practices for the management of some major crop pests, and addresses issues such as quality control, regulation and registration, and commercial production of natural enemies.

In the opening dedication, Jeff Waage discusses past and future use of augmentative biocontrol in IPM systems. Chapter 1, Augmentative biocontrol in India (S. P. Singh), examines the feasibility of selection, development of superior strains, mass production, safety requirements, quality control, storage, shipment/transport, marketing, release/application of augmentative agents, and evaluation of important natural enemies or biotic agents in India. Chapter 2, Predators and parasitoids in augmentative biological control – an overview (S. T. Murphy), discusses the genesis of the use of these agents. Hundreds of commercial companies worldwide produce more than 20 species of natural enemies for the control of many pest species in covered cropping situations alone. Augmentative biological control has also been used extensively in the USA and in centrally planned economies (e.g. Cuba, China). This chapter also provides a review of the history and current state of the subject on a global basis, some technical and socioeconomic issues that have been prominent in recent years, and some processes relating to the development of standards and harmonization and their implementation. Chapter 3, Microbial biopesticides in augmentative biocontrol (David Dent & Nina E. Jenkins), details recent advances in the development of biopesticides for inclusion in IPM programmes, and highlights the advantages and value to be obtained through development, exploitation and use of biopesticides in developing countries.

Chapter 4, Augmentative biological control within cotton IPM – Indian scenario (S. Lingappa, K. S. Brar & D. N. Yadav), reflects that continuous use of pesticides in cotton ecosystems has led to the destruction of natural enemies, development of resistance in pests and environmental pollution. The natural enemy fauna in the cotton ecosystem is depicted with the IPM modules for rainfed and irrigated situations at different locations in India. Chapter 5, Augmentation biocontrol within paddy IPM – Indian scenario (S. Pathummal Beevi, L. K. Hazarika & G. S. Katti), gives a picture of the feasibility of augmentative biocontrol in (rice) paddy in India. The insects on paddy and their natural enemies are listed. Chapter 6, Augmentative biocontrol within vegetable IPM – Indian scenario (M. Mani, C. Krishnamoorthy, C. Gopalakrishnan & R.J. Rabindra), describes the classical biocontrol obtained with natural enemies. For control of vegetable pests, indigenous natural enemies such as *Trichogramma* spp., nucleopolyhedroviruses (NPVs), *Bacillus thuringiensis* (*Bt*), *Nomuraea rileyi* and *Paecilomyces farinosis* has given more promising results.

Chapter 7, Quality control parameters in mass produced bio-agents (Chandish R. Ballal, Sunil Joshi, S. K. Jalali & N. S. Rao), describes desirable physiological and behavioural traits in bio-agents. Major components of quality, the methods to be adopted to measure quality, the factors which affect quality, the problems encountered in quality control and possible solutions are detailed. Chapter 8, Registration and quality control of microbial biopesticides (Nina E. Jenkins, David Dent & David Grzywacz), emphasizes the need for clear registration procedures for microbial pest control agents. The regulatory procedures in the USA and EU (European Union) are discussed along with a breakdown of the cost of registering a microbial product in these two regulatory environments. Chapter 9, Regulatory issues and augmentative control (S. T. Murphy), deals with regulatory issues, which are now becoming very prominent in biological control using macrobial agents, with additional information on concerns about the safety of biological control introductions and the need for standardized procedures in the context of inundative releases. Chapter 10, Procedures for registration of biopesticides – Indian perspective (A. D. Pawar), looks at regulatory requirements and framing of rules for manufacture, sale, transport, distribution and utilization of microbials and botanicals. The need for simple registration procedures is highlighted, with emphasis on quality control of biopesticides.

Chapter 11, Commercial production of biocontrol agents (K. P. Jayanth & T. M. Manjunath), discusses a number of constraints commercial biocontrol laboratories face in taking biocontrol technology to the farmers and the available methods for tackling these problems. Chapter 12, Implementation of augmentative biocontrol in support of IPM – NGO perspective (M. S. Chari, P. Humayun, Ch. Anitha & M. Venkateswar Reddy), identifies non-availability of resource material to NGOs and extension agencies as a major bottleneck. Frequently farmers are eliminated from field studies with natural enemies on crop pests by researchers leading to poor perception of biological control. The NGOs have identified that there is a knowledge gap in the effective use of biological control in IPM. Farmer Participatory Development, which gives emphasis to the process rather than product to improve the farmers' analytical and management skills in biological control is suggested. Chapter 13, Extension-related problems in augmentative biological control – Indian perspective (S. C. V. Reddy, S. Balasubramanian & R. V. Usha), details the problems encountered in adopting augmentative biological control at farmer, extension personnel and industry levels. Suggestions are put forward for improvements and reforms, which would lead to popularization of augmentative biocontrol as an integral part of IPM.

This book is expected to be instrumental in expanding the sphere of knowledge on augmentative biocontrol and in inspiring researchers to delve into problems addressed in the different chapters. The book summarizes the experience and identifies the technical, economic and social challenges facing the development of better and cheaper products.

*Singh, S.P.; Murphy, S.T.; Ballal, C.R. (*eds*) (2001)
Augmentative biocontrol. Proceedings of the ICAR-CABI Workshop on Augmentative Biocontrol.
Bangalore, India;
Project Directorate of Biological Control, 250 pp.

Copies can be obtained from:
Dr R. D. Sharma,
CAB *International* – India Office,
National Agricultural Science Centre (NASC), CG Block, Pusa,
New Delhi 110012, India
Email: rds17_2001@yahoo.com

❑

Biocontrol-Based Pest Management

To meet the future challenges of increased food production for the growing human population, there is an urgent requirement for proven technologies, which when adopted will result in sustainable food production. A national symposium, 'Biocontrol Based Pest Management for Quality Crop Protection in the Current Millennium' was jointly organized by the Indian Society for the Advancement of Insect Science, Punjab Agricultural University (PAU), Ludhiana and the Society for Biocontrol Advancement, Bangalore. [See also Conference Reports, this issue] The meeting, held on 18-19 July 2001 at PAU, comprised three technical sessions during which lead papers were presented by invited speakers in the field of biological control from India and other countries including Australia, the UK, Kenya, the Philippines and Thailand. More than 170 research papers were presented as posters.

Lead Papers

The lead papers from this symposium have been published[1]. Chapter 1, Innovations in mass rearing technology and techniques for mass releases, transportation and storage of natural enemies (S. P. Singh, Sunil Joshi & C. R. Ballal), examines various issues relating to the infrastructure required for establishing colonies of natural enemies initially in the laboratory, later leading to successful mass multiplication. Techniques standardized for the production of host insects and natural enemies including parasitoids, plant disease antagonists, predators, pathogens, entomopathogenic nematodes and nematophagous fungi have been included.

Chapter 2, Biointensive management of cereal stemborers in Africa: exploiting chemical ecology and natural enemies in a 'push-pull' strategy (Z. R. Khan), presents a case study of lepidopteran stemborers in subsistence maize production in eastern Africa. Studies have led to the development of a biointensive push-pull' strategy for minimizing stem borer damage in maize-based farming systems in Kenya.

Chapter 3, New approaches in maximising effectiveness of natural enemies (D. N. Yadav), discusses the various methods such as habitat manipulation, use of behavioural chemicals, improvement in biological traits, use of insecticide resistant strains, use of feeding and ovipositional attractants, relay cropping and establishment of entomophage parks, which could be used to maximise the effectiveness of natural enemies.

Chapter 4, Tritrophic interactions amongst host plants, insect pests and their natural enemies (A. J. Tamhankar & K. Shantharam), explains the basic mechanisms that influence the ecosystem population dynamics and govern the interactions between host plants, insect pests and their natural enemies, such as ecosystem energy/resource flow, trophic relationships, role of allelo/info-chemicals, habitat modifications and apparency.

Chapter 5, Augmentation biocontrol: recent progress and emerging opportunities (S. Sithanantham & N. K. Maniania), focuses on the methods for enhancing the numbers and/or activity of natural enemies in agro-ecosystems. It also describes the strategy of multiplying the biocontrol agents in large numbers and deploying them primarily for short-term impact; selective deployment of bio-agents for specific needs and selection and utilization of superior strains.

Chapter 6, Innovations in mass production of microbial agents for the control of insect pests (V. M. Pawar, U. T. Thombre & P. S. Borikar), describes the growth of microbial pesticides, their mass multiplication and their marketability.

Chapter 7, Biotechnological approaches in increasing effectiveness of microbial agents (R. J. Rabindra, J. S. Kennedy, N. Sathiah & B. Rajasekaran), deals with the advances in biotechnology which help in making IPM strategies more sustainable through increasing effectiveness of microbial agents. Approaches such as engineering microbials and plants, recombinant DNA technology and genetic improvement of entomopathogenic fungi are detailed.

Chapter 8, Biological control of plant pathogens – an application of natural control (A. N. Mukhopadhyay), reviews the various strategies of plant disease suppression through antagonists including the methods of application, mass production, mode of action, etc.

Chapter 9, Integration of biological with chemical and non-chemical methods of pest management (Banpot Napompeth), deals with the integration of non-chemical methods with biotic agents, which is ecologically, economically and socially acceptable. Stress has been laid upon the need to make the existing IPM system more practical and practicable.

Chapter 10, Transgenics in insect pest management (D. S. Brar & G. S. Khush), discusses the usefulness of strategies involving gene deployment, pyramiding of genes, targeted expression of transgenes and use of refuges. The need for transgenic technology to be integrated in a total system approach for ecologically friendly and sustainable pest management is highlighted.

Chapter 11, Development and use of heat- and insecticide-tolerant strains of natural enemies in IPM (Joginder Singh, K. S. Brar & J. P. Singh), is about the need to evolve strains which are tolerant to unfavourable temperature regimes and insecticides. The use of these strains can help in developing sustainable bio-intensive strategies in dry tracts of the country.

Chapter 12, Biocontrol of weeds using pathogens: recent advances (Carol E. Ellison & Harry C. Evans), places stress on an interdisciplinary approach to biological weed control, whereby introduced agents can also be applied inundatively. Innovative programmes developed in the use of bioherbicides, such as cut stump treatments, exploitation of niche markets in the leisure industry, and the use of mixtures of pathogens to control complexes of weeds are also discussed.

Chapter 13, *Bt*-cotton to combat boll-worms: its development and current status (M. Manjunath & K. S. Mohan), presents efforts of Monsanto in collaboration with MAHYCO (Maharashtra Hybrid Seed Company) to develop *Bt*-cotton in India. Field experiments to collect data on environmental safety are described.

Chapter 14, Recent developments in biocontrol of weeds using insects (Rachel E. Cruttwell McFadyen), discusses recent successes in the control of parthenium weed (*Parthenium hysterophorus*) in Australia, *Chromolaena odorata* in Indonesia, leafy spurge (*Euphorbia esula* complex) in the USA, and the water fern *Azolla filiculoides* in South Africa.

Chapter 15, Role of cultural practices in improving the abundance and efficiency of natural enemies (M. V. Potdar & A. K. Kakkar), reviews the role of diverse cultural practices on the abundance and efficiency of natural enemies in various agroecosystems. The authors stress the need to promote potential cultural practices using appropriate policy and legislative measures.

[1] Singh, S.P.; Bhumannavar, B.S.; Poorani, J.; Singh, D. (*eds*) (2001) Biological Control (Lead Papers) – Symposium on Biocontrol Based Pest Management for Quality Crop Protection in the Current Millennium (July 18-19, 2001).
Bangalore, India;
Project Directorate of Biological Control, 185 pp.

Copies can be obtained from: Project Director,
Project Directorate of Biological Control (ICAR),
P.B. No. 2491, H. A. Farm Post,
Hebbal, Bellary Road,
Bangalore 560 024, Karnataka, India
Email: pdblc@kar.nic.in /
drspsingh@valise.com
Fax: +91 80 3411961

Extended Abstracts

The extended abstracts of the some 170 research posters presented at the symposium have also been published[2].

[2] Singh, D.;Dilawari, V.K.; Mahal, M.S.; Brar, K.S.; Sohi, A.S.; Singh, S.P. (*eds*) (2001) Biological control (contributed papers). Symposium on Biocontrol Based Pest Management for Quality Crop Protection in the Current Millennium, Ludhiana, Punjab, India, 18-19 July 2001.
Ludhiana, India;
Indian Society for the Advancement of Science, 228 pp.

Copies can be obtained from: Dr V. K. Dilawari,
Indian Society for the Advancement of Science,
Department of Entomology,
Punjab Agricultural University,
Ludhiana – 141004, India

Souvenir Issue

A souvenir issue[3] of Advances in Biological Control was brought out on the occasion of the above symposium. The souvenir contains messages from important dignitaries conveying their wishes for the conduct of the symposium, and the text of the address by Dr R. S. Paroda, Secretary, Department of Agricultural Research and Education, and Director General, ICAR: Relevance of biocontrol in the current agricultural scenario in India.

It also includes a valuable series of articles dealing with biocontrol and related technologies in IPM: Biotechnological approaches to biological control of crop pests (V. L. Chopra); Advances in biological control in India (S. P. Singh); Role of natural enemies in the management of sugarcane pests (Darshan Singh & K. S. Brar); Kairomones' potential in enhancing the efficiency of parasitoids and predators in different crop ecosystems (P. L. Tandon); Scope and potential of microbial control in India (R. J. Rabindra & N. Sathiah); Bio-intensive pest management: a promising approach (O. P. Dubey & O. P. Sharma); Pheromones as a tool for IPM (Kinya Ogawa & Toshima Kobayashi); Importance of quality control in commercial production of biocontrol agents (K. P. Jayanth); Status of biological control of insect pests in Maharashtra (V. M. Pawar, M. B. Sarkate & P. S. Borikar).

[3] Souvenir – Advances in Biological Control, Punjab Agricultural University, Ludhiana, Punjab, India, 71 pp.

Copies can be obtained from Dr V. K. Dilawari (address above).

❑