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General News

IOBC Continues Its Mission on Access and Benefit Sharing

Under its new chair, Dr Peter G. Mason of Agriculture and Agrifood Canada, the IOBC (International Organization for Biological Control) Global Commission on Biological Control and Access and Benefit Sharing has continued its mission to provide scientific advice to encourage the implementation of practical and effective arrangements acceptable to all parties for the collection and use of biological control agents under the access and benefit sharing (ABS) regime. On 12 October 2014, the Nagoya Protocol came into force, three months after the 50th country ratified it (www.cbd.int/abs/nagoya-protocol/signatories/default.shtml). Each country that ratified the Protocol will prepare its own legislation and regulations. Countries that choose to accede to the Protocol at a later date will be bound to its provisions. Relevant to biological control is Article 8 'Special Considerations' of the Nagoya Protocol which states:

In the development and implementation of its access and benefit-sharing legislation or regulatory requirements, each Party shall: (a) Create conditions to promote and encourage research which contributes to the conservation and sustainable use of biological diversity, particularly in developing countries, including through simplified measures on access for non-commercial research purposes, taking into account the need to address a change of intent for such research; (b) Pay due regard to cases of present or imminent emergencies that threaten or damage human, animal or plant health, as determined nationally or internationally. Parties may take into consideration the need for expeditious access to genetic resources and expeditious fair and equitable sharing of benefits arising out of the use of such genetic resources, including access to affordable treatments by those in need, especially in developing countries; (c) Consider the importance of genetic resources for food and agriculture and their special role for food security.[1]

Earlier in 2014, the Commission drafted a *Best Practices for the Use and Exchange of Biological Control Genetic Resources Relevant for Food and Agriculture* document that was submitted to the Food and Agriculture Organization (FAO) Commission on Genetic Resources for Food and Agriculture, in response to their call to report on voluntary codes of conduct, guidelines and best practices, and/or standards in relation to ABS for all subsectors of genetic resources for food and agriculture. This action was the follow-up to Recommendation 5 of the Background Study Paper No. 47 on *The Use and Exchange of Biological Control Agents for Food and Agriculture* submitted by the IOBC Commission to the FAO Commission on Genetic Resources for Food and Agriculture[2] (also see *BNI* December 2009[3]). The Best Practices document is intended to inform policy makers and biological control practitioners and emphasizes that "The existing multilateral free exchange ethos and effective global networking of BC [biocontrol] practitioners are foundations that deserve special consideration with regards to ABS." The document includes two appendices, an ABS Draft Agreement and a Best Practices Policy.

The IOBC Commission has also begun to gather information on experiences of researchers working in countries where ABS legislation has been implemented. The goal is to share the information among the global biological control community to help practitioners understand what needs to be done to gain access to species of importance for research and development.

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Web: www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf

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Web: ftp://ftp.fao.org/docrep/fao/meeting/017/ak569e.pdf

[3]van Lenteren, J.C. and Cock, M.J.W. (2009) IOBC reports to FAO on access and benefit sharing. *Biocontrol News and Information* 30(4), 67N–87N.

By: Peter G. Mason and Matthew J.W. Cock (on behalf of the IOBC Commission on Biological Control and Access and Benefit Sharing).

Fungus to Control the Larger Grain Borer in sub-Saharan Africa

An additional tool may soon be available for farmers in sub-Saharan Africa who suffer heavy losses in stored maize from an invasive beetle pest. The larger grain borer (LGB), *Prostephanus truncatus*, was accidentally introduced into Tanzania and Togo in the late 1970s and spread to other East and West African countries including Ghana[1]. It can cause stored maize losses of up to 60%[2], making it one of the major storage pests in the region. The presence of LGB alongside other pests such as the maize weevil, *Sitophilus zeamais*, can make the total pest burden overwhelming.

Protecting food from post-harvest loss in sub-Saharan Africa is essential to address the challenge of food security. Substantial amounts of grain are lost from the food supply chain during post-harvest handling and storage. Subsistence farmers are worst affected by such losses as a high proportion of their disposable income and agricultural output is devoted to staple foods. Maize accounts for 25% of starchy staple consumption in Africa, which equates to 36% of daily calorific intake[3].

In the 1980s, surveys were conducted in Mexico, Honduras and Costa Rica to look for natural enemies of LGB that could be introduced as classical biological control agents[4]. *Teretrius nigrescens*, a predatory histerid beetle, was discovered to have a very narrow host range and was strongly attracted to LGB's aggregation pheromone. It was first released in Togo and later in Ghana, Kenya and Benin in the 1990s, where it was shown to reduce the number of LGB[5,6,7]. However, it proved more susceptible to chemical pesticides than LGB[8], making it less effective in storage conditions where insecticides are used.

A previous project at CABI's centre in the UK successfully used an isolate of *Beauveria bassiana* to develop a product for controlling grain store pests, such as the saw-toothed grain beetle, *Oryzaephilus surinamensis*, in the UK. The product is currently in the process of being registered in Europe.

Following on from this success, a two-year proof of concept project, funded by the Bill and Melinda Gates Foundation, aims to adapt the European *B. bassiana* technology to the African market for the control of LGB and other maize storage pests. The key question we are seeking to answer is whether the UK *B. bassiana* isolate can control LGB in African maize stores. The consortium CABI, Exosect Ltd and Agrauxine is working closely with collaborators in Ghana and Tanzania to carry out laboratory and semi-field trials.

The laboratory pathogenicity studies have already been concluded and show that *B. bassiana* can cause 90–100 % kill of LGB. Now the the first set of semi-field trial data have been collected, which show that formulated *B. bassiana*, when applied to maize then stored in a crib for 3 months, can result in over 90% kill of LGB, compared with only 10% mortality in the untreated control. There was also an over 50% reduction in the amount of maize powder – the dust formed when LGB eats stored maize. Further field trials are still in progress in different climatic regions of Ghana and Tanzania with full results expected by December 2014.

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Biopesticide Consolidates Position in the Mexican Market

The development and launch of the first Mexican biofungicide, Fungifree AB®, reported in the *Electronic*

Journal of Biotechnology, was previously reviewed in *BNI* in September 2013. Fungifree AB® is produced by Agro&Biotecnia S. de R.L. MI, a spin-off company of the Institute of Biotechnology – UNAM (Universidad Nacional Autónoma de México), and was developed by the scientists Enrique Galindo and Leobardo Serrano-Carreón, together with Carlos Roberto Gutiérrez.

Fungifree AB® was launched onto the market in November 2012, as an alternative to chemical fungicides, to control mango anthracnose caused by the fungal pathogen *Colletotrichium gloeosporioides.* The biofungicide is formulated with a specific strain of *Bacillus subtilis* (83) spores, which was isolated from the mango canopy. The commercial launch was possible thanks to the participation of FMC Agroquímica de México, the exclusive distributor in Mexico, which has also actively participated in widening the use of this product in several other crops, following authorization by the Mexican authorities.

To date, the biofungicide has been registered for anthracnose control in mango, papaya, avocado and citrus fruits, as well as for the control of powdery mildew (caused by *Leveillula taurica* and *Erysiphe cichoracearum*) in Solanaceae (aubergine/eggplant, chilli pepper, red and green tomato) and Cucurbitaceae (courgette/zucchini, squash, melon, cucumber, watermelon), and to control *Sphaerotheca* sp. in strawberry and raspberry. This makes Fungifree AB® the biological control product with the widest spectrum against foliar diseases in Mexico.

Besides these commercial achievements, Fungifree AB® has been given recognition by several organizations. In 2013, the Innovation for Productivity and Competitiveness Program of the Inter-American Institute for Cooperation on Agriculture (IICA) recognized Fungifree AB® as one of the three most important achievements in Latin American biotechnology in 2012. In April 2014, the Mexican Association for Applied Research and Technological Development Executives (ADIAT) awarded Agro&Biotecnia the ADIAT Prize in Technological Innovation for small companies. This is the most prestigious award that a company can receive in Mexico for innovation. Most recently, in July, Agro&Biotecnia was awarded the 2014 prize 'Innovators of America', in the Enterprise and Industry category, by Innovamerica, a Latin American platform for the promotion of innovation and creative ideas as a tool for regional development based on new models and values. Fungifree AB® was selected from 122 candidate projects from all over Latin America in this category.

Taken together, these achievements and accolades have facilitated the consolidation of Fungifree AB® and Agro&Biotecnia in the Mexican market. Currently, Agro&Biotecnia and FMC Agroquímica de México are in the process of obtaining certification by the Organic Materials Review Institute (OMRI), an independent American organization that assesses and certifies products suitable for organic production, in order to increase the potential market of the biofungicide. Future plans include the registration of Fungifree AB® in Central and South American countries, the development of new formulations based on *B. subtilis* strain 83 for use as plant growth promoters, and the development of new biological control products for other phytopathogens.

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Fungal Formulation Shows Promise for Controlling Africa's Worst Cocoa Disease

The development of an oil-based formulation of a fungal biocontrol agent may lead to a new control option for smallholder cocoa farmers currently suffering the depredations of Africa's worst cocoa disease[1].

Black pod disease of cocoa in West and Central Africa caused by *Phytophthora megakarya* threatens the global cocoa industry because Africa supplies over 70% of beans for the world market. Although disease caused by *Phytophthora* spp. occurs in all cocoa producing regions, it was generally not a serious problem in Africa until the emergence and spread of *Phytophthora megakarya,* which is thought to have originated in the Cameroon/Nigeria border region. Since, as a new disease, it was first reported to be causing 60–80% yield losses in Ghana in 1985, it has become widespread in Cameroon, Equatorial Guinea, Gabon, Ghana, Guinea, Nigeria and Togo, and is present in Côte d'Ivoire. In untreated cocoa, losses can be 80–100%. Current management measures include cultural and chemical control and there is also promise in breeding for plant resistance but, for many farmers, fungicides are the principal control method. Biological control would be a useful addition to control options, especially to reduce dependence on pesticides. The potential of antagonistic fungi in the genus *Trichoderma* have been investigated for some years and have shown promising impact, but the stumbling block has been how to make them accessible to farmers.

Research at the Institut de Recherche Agricole pour le Développement (IRAD) in Cameroon on *Trichoderma asperellum* conidia formulated as a wettable powder, with cassava flour as the carrier, showed promise against *P. megakarya*, but also the limitations of the formulation, which had a limited shelf-life and poor persistence in the field; it was susceptible to wash-off by rain, and the conidia desiccated rapidly after application to cocoa pods.

Trichoderma spp. are the basis of some 90% of formulations of antagonistic fungi used to control plant diseases, and most of them are granular or wettable powder formulations. Yet oil-based formulations are more suitable for conidia because they facilitate better adherence to the target and slower desiccation of the conidia in conditions of fluctuating temperature and relative humidity.

The IRAD team therefore assessed palm oil and soybean oil as carriers using combinations of five emulsifying–dispersing agents and a structural agent, with glucose as a carbon source. These initial experiments confirmed that only the emulsifier Tensiofix NTM with structural agent Tensiofix 869 plus glucose produced a stable, homogenous emulsion, but the palm oil emulsion was very viscose, so soybean oil was selected as the carrier. Assessment of the viability of conidia in the selected formulation indicated a half-life of 22.5 weeks compared with 6 weeks in aqueous solution. The longer viability is thought to be related to the soybean oil and glucose providing food as well as regulating water availability.

A short-term experiment with detached pods indicated that the conidia–soybean oil formulation outperformed a commonly used copper hydroxide-based fungicide, Kocide 2000. Pods from trees of three clones (sensitive, moderately sensitive and tolerant to *P. megakarya*) were inoculated with *P. megakarya* following protective treatment. With the conidia–soybean oil formulation, all pods were still free of disease at the end of a 4-day observation period, while lesions of varying severity were recorded on pods treated with water, the formulation alone, and conidia in aqueous suspension; Kocide 2000 gave only 88% protection of pods from the susceptible clone but completely protected pods of the other two clones. Interestingly, the formulation alone delayed and gave some protection from disease and, although supposedly inert, may present a physical barrier to the pathogen.

In September 2013, a seven-week trial was set up at the IRAD Nkolbisson station to assess the performance of the conidia–soybean oil formulation in protecting cocoa of the highly susceptible clone SNK10 from *P. megakarya* in the field. Results indicated 90% protection after one week, and 50% protection was maintained equally well by the conidia–soybean oil formulation and the fungicide up to 3.2 and 3.0 weeks post-spraying, respectively. The experimental formulation maintained a measurable effect up to 7 weeks, compared with 2 weeks for an aqueous suspension and 5 weeks for Kocide 2000.

Apart from its efficacy against *P. megakarya*, the oil-dispersion formulation has been developed with smallholder cocoa producers in mind. Other currently available oil-based *Trichoderma* formulations are based on invert or reverse (water-in-oil) emulsions, which work well in ultra-low volume spray equipment such as misters or foggers. Knapsack sprayers are, however, by far the most common application equipment used by smallholder farmers in Africa, and for these the conidia–soybean oil formulation, with its water miscibility and stability, is far better suited, giving uniform conidial distribution in the tank and potentially improving colonization of the pods.

To assess the performance of the conidia–soybean formulation plus the persistence and viability of *T. asperellum* under farmer-field conditions, a two-year field trial was set up. Tragically, the lead author of the study described here, Joseph Bienvenue Mbarga, who was instrumental in conducting the farmer-field trial, was killed in a car crash in June 2014 just after it was completed.

At IRAD work on testing and improving this oil-based biological fungicide continues. The aim is to provide smallholder cocoa farmers with a viable alternative to conventional fungicides for controlling black pod disease in cocoa and so also to honour the work of Joseph Mbarga.

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Bernard Blum 1938–2014

It was with great sadness that we learnt of the sudden death in August of Bernard Blum, aged 76, a pioneer in the modern biocontrol industry.

Bernard graduated from the National Institute of Agronomy in Paris in 1963. He obtained a PhD in tropical agronomy with ORSTOM (now IRD, the Institute for Development Research) and an MBA at INSEAD at Fontainebleau.

After a brief period (1965–68) at the Tropical Research Institute for Oil Palms, IRHO (now CIRAD, the Centre for International Cooperation in Agronomic Research for Development) in Côte d'Ivoire, he joined Ciba-Geigy (which later became Syngenta) and pursued a brilliant career in the plant protection industry.

From 1993 he was a tireless campaigner for the development of biological control and other alternative methods for modern agriculture. He founded his own company Agrometrix specializing in the development of precision agriculture.

In 1995 he founded IBMA (the International Biocontrol Manufacturers' Association) of which he was President for the first two years and then Vice-President for International Affairs.

In 2008 he was received into the French Academy of Agriculture (AFA) and recently he founded the Academy of Biocontrol together with many top biocontrol experts and scientists.

Over the last 20 years Bernard worked assiduously for the biocontrol industry and helped shape the past, current and future changes in biocontrol protection and production.

During the last five years of his life Bernard published a great number of articles for AFA, and at the same time he led new biocontrol projects in south-western France.

Bernard will always be remembered and sadly missed by his many friends and colleagues throughout the world.

By: Michel Guillon.

Status of *Parthenium hysterophorus* Biological Control in Ethiopia

In the first classical biological control project to be implemented in Ethiopia, the first biocontrol agent has been released against an invasive weed and the release of a second agent is imminent.

The invasive weed parthenium (*Parthenium hysterophorus*) belongs to the family Asteraceae. From its origin in Mexico, it has spread to Australia, Asia, the Pacific and Africa. In the Asia-Pacific region it is found in Bangladesh, southern China, Israel, Nepal, New Caledonia, Pakistan, Papua New Guinea, Sri Lanka, Taiwan, Vanuatu and Vietnam. A survey conducted in eastern and southern Africa showed that parthenium is found in Ethiopia, Kenya, Mozambique, South Africa, Swaziland, Tanzania and Uganda[1]. The climate modelling program, CLIMEX, used in the survey indicated that conditions in other sub-Saharan African countries are optimum for the rapid establishment and further expansion of parthenium in the continent.

Parthenium is a very successful invader because it is a prolific seed producer (a single plant can produce up to 30,000 seeds), can germinate and grow in a wide range of environments, can complete its life cycle in a relatively short time (up to four generations in a single season) and can produce chemicals that can inhibit the growth of other plants. The latter characteristic enables it to displace native plants thereby making it a major threat to biodiversity. It can reduce crop yield and displace pasture species thereby adversely affecting livestock production. It taints meat and milk when animals feed on it. It also causes dermatitis and allergic reactions in humans.

Since this weed occurs on roadsides and in vacant land, fallow fields, nature reserves, pastures and cropped fields, it has become difficult to manage with chemical, cultural and mechanical control methods. However, classical biological control offers an opportunity to tackle it, as it is an exotic plant that has been introduced without its natural enemies. Australia initiated biological control of parthenium in 1977 and, so far, nine species of insects and two rust fungi have been introduced there, of which six insect species and two fungi have been established. The chrysomelid beetle, *Zygogramma bicolorata* of Mexican origin was introduced to Australia in 1980 and India in 1984; it was later fortuitously introduced to Bangladesh, Nepal and Pakistan from India.

In Ethiopia, a biological control programme for parthenium, funded by the United States Agency for International Development (USAID), was started in October 2005. Since this was the first project for classical biological control in Ethiopia, human and institutional capacity building was given high priority. Accordingly, a greenhouse at the Ambo Agricultural Research Station of the Ethiopian Institute of Agricultural Research was converted into a quarantine facility and scientists and technicians were trained in South Africa on quarantine facility operation, host-specificity testing, environmental assessment preparation, field release, post-release monitoring and other associated activities.

Following the establishment of the quarantine facility at Ambo, a culture (300 larvae and 531 adults) of the leaf-feeding beetle, *Z. bicolorata*, was imported into it from South Africa in October 2007 to allow host-specificity tests to be conducted. The importation of the culture went ahead only after obtaining the necessary permits from the Ethiopian Government and USAID. Host-specificity tests on some 24 species of important crops grown in Ethiopia as well as plants related to parthenium were conducted. The tests showed that *Z. bicolorata* feeds only on parthenium and does not harm other plants. Based on the results of the tests, an environmental assessment statement was prepared, which indicated that there was no negative impact on non-target species, and both the Government of Ethiopia and USAID gave permission for the beetle's field release. Adults of *Z. bicolorata* were field-released at Woollenchiti in the Oromiya region of Ethiopia on 16 July 2014. Preparations are underway to send additional shipments to Kobo in Amhara and Haramaya in eastern Oromiya for multiplication and field releases.

A second natural enemy, the stem-boring curculionid weevil *Listronotus setosipennis*, was brought to the Ambo quarantine facility from South Africa in 2009. Host-specificity tests were conducted on 30 crops and other native species plants under quarantine conditions. These tests showed that *L. setosipennis* can only feed and complete its life cycle on parthenium. An environmental assessment statement has been approved by the Government of Ethiopia and USAID. Currently this organism is being multiplied in the quarantine facility for field release.

Acknowledgement: This project was funded by USAID Cooperative Agreement No. EPP-A-00-0400016-00.

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Biological Control of Woolly Nightshade: Progress in Two Countries

Solanum mauritianum (bugweed or woolly nightshade), an evergreen shrub or small tree native to South America, is one of New Zealand's newer targets for classical biological control. The tingid sap-sucking lace bug *Gargaphia decoris* was introduced in 2010 using material supplied from South Africa and has now been widely released. In 2014, its first impacts were seen when populations reached outbreak proportions in an *S. mauritianum*-infested pine plantation in the Bay of Plenty area of North Island. While this is potentially good news for New Zealand, it is also interesting to South African collaborators in the programme. The Landcare Research team leading the New Zealand programme has been working with Terry Olckers and his team at the University of KwaZulu-Natal (UKZN) in South Africa, where the lace bug was first released some 15 years ago, and drawing on the South Africans' extensive research on *S. mauritianum* biological control, initially when Olckers was at the ARC-PPRI (Agricultural Research Council – Plant Protection Research Institute) and later at UKZN.

Identifying a biocontrol agent for *S. mauritianum* that met host-specificity and regulatory requirements was a challenge because of the relatedness of native *Solanum* species and important *Solanum* crops. Although surveys for potential biocontrol agents by South African researchers began some 30 years ago (and a dedicated programme was initiated in 1994), almost all of the many arthropod species found on the plant in its native range were later discarded. Just two species have so far been shown to have acceptable host specificity for approval and release in South Africa. The lace bug, found in north-eastern Argentina and southern Brazil, was released by the ARC-PPRI and latterly the Working for Water programme and Sappi Forests between 1999 and 2007. Although initially establishment was thought to be patchy, it has now been confirmed to be established at many sites across three provinces. A second agent, the flowerbud-feeding weevil *Anthonomus santacruzi* from Argentina, was first released in 2009 and is now well established in KwaZulu-Natal Province following mass rearing and releases by the South African Sugarcane Research Institute. This agent was rejected by New Zealand, however, because of concerns about its potential impact on a native *Solanum* species of ecological/cultural importance.

Solanum mauritianum has a number of attributes contributing to its invasive status in the introduced range, notably a fast growth rate and an excessive fruit production whose dispersal is aided by birds. An agent such as the lace bug that reduces photosynthesis could be a useful agent, especially if complemented by an agent that attacks reproductive output, like the flower-feeding *Anthonumus* weevil, but the lace bug has so far had modest impact in South Africa. Field observations and research indicate that several factors are implicated. Lace bug populations decline during the South African winter, probably owing to poor plant quality as a result of low rainfall since temperature as a factor has been ruled out. They are slow to recover in spring, at least partly because of predation of the immature stages especially, and maximum populations are not reached until autumn. Observations in New Zealand indicate that predation is occurring there too.

There have been sporadic lace bug population peaks and outbreaks in South Africa, similar to the one seen in New Zealand this year. The first and largest was a massive outbreak in the understorey of a pine plantation in Mpumalanga Province in 2007, which caused extensive defoliation, reduced flowering/fruiting, and seedling and even tree death. Other, smaller outbreaks were reported nearby but widespread fires destroyed all these sites and the opportunity for follow-up. The occurrence of outbreaks in pine plantations in both countries may not have been a coincidence.

Solanum mauritianum thrives in a variety of habitats, from sunny, exposed locations to partially and fully shaded sites, while field observations suggest that the lace bug might be doing better in shade. Olckers' team has been disentangling the effects of plant quality, shade and predation on its performance. In one experiment, monitoring of shade-house grown *S. mauritianum* potted plants infested with immature or adult lace bugs and then moved to unshaded, semi-shaded and shaded locations indicated that both immature and adult lace bugs persisted best in semi-shaded conditions and these sites had fewest predators. Both adults and immatures persisted poorly in fully shaded sites, where spiders were abundant, and immatures also fared badly in unshaded sites, where ants were abundant, with none reaching the adult stage. It may be that the pine plantations that hosted lace bug outbreaks provided a level of shading that minimized predation and allowed populations to expand.

Although results with the lace bug in South Africa have been slow, preliminary results for the flower-feeding weevil *A. santacruzi* weevil are encouraging. Weevils in this genus are found throughout *S. mauritianum*'s native range and credited with suppressing fruit set to the low levels seen there. *Anthonomus santacruzi* and its congener *A. morticinus* are commonly found in Argentina, Brazil and Paraguay. Although *A. santacruzi*, like the lace bug, is experiencing predation in South Africa, field surveys over the course of a year at coastal and inland sites in KwaZulu-Natal to assess the incidence and abundance of potential predators on *S. mauritianum* indicate that their numbers on inflorescences in the field are low so predation is not expected to be a constraint, and the weevil seems to be establishing well, albeit largely in coastal areas.

Following the rejection of *A. santacruzi* for New Zealand, Landcare Research has revisited South Africa's earlier research to identify other candidate agents for New Zealand. In collaboration with Olckers' collaborator in Brazil, Professor Henrique Pedrosa Macedo at the University of Paraná, they have drawn up a plan for host-specificity testing and field trials at Curitiba in Brazil. Amongst species they are testing are the flowerbud-feeding weevil *A. mor-*

ticinus that is found with *A. santacruzi* in the field, and a stem-boring weevil, *Conotrachelus squalidus*.

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The Loss of a Giant in Weed Biological Control

Many colleagues and friends of Dr Peter Harris were saddened to hear of his passing in August of this year. He will be remembered for his many pioneering successes in classical weed biological control, and also for his vision, tenacity and leadership in seeing the science advanced and implemented. Both in Canada and internationally, he was respected as a trail blazer and builder of foundations, and thus acknowledged as a major contributor to the respected institutions and reputation we cherish today within our applied discipline. A more detailed article on Peter's contributions will be appearing in the March issue of *BNI*.

By: Rosemarie De Clerck-Floate

Parasitoids Introduced into Indonesia: Part of a Region-wide Campaign to Tackle Emerging Cassava Pests and Diseases

Cassava (*Manihot esculenta*) is the world's fourth most important agricultural commodity after rice, wheat and maize, and features prominently in the diet of millions of people throughout the tropics. Grown on over 18 million hectares worldwide, cassava cultivation sustains the livelihoods of countless smallholder farmers, many of whom operate in degraded environments. In South and Southeast Asia alone, cassava is grown by more than eight million farmers and is the engine of the rural economy in countries such as Vietnam and Thailand. On the other hand, it is a chief food security crop in Indonesia, where approximately 50% of locally cultivated cassava is directly used for human consumption[1].

Throughout the world, cassava crops are affected by myriad arthropod pests, such as whiteflies, mealybugs and mites (e.g. [2,3]). Until the turn of the century, Southeast Asian cassava was virtually free from limiting pests and diseases. However, the recent appearance of a complex of invasive mealybugs and emerging diseases has greatly altered this situation, and farmers now face difficulties in sustaining their yields and safeguarding harvests. The appearance of these novel plant health threats is directly related to increased global trade and associated movement of infested planting material, deficient quarantine systems, and pervasive crop expansion.

In 2008, the cassava mealybug *Phenacoccus manihoti* was first reported from Thailand and has since spread to Lao People's Democratic Republic (Lao PDR), Vietnam, Cambodia and Indonesia[4,5]. Widely considered to be the foremost pest threat to global cassava production, *Ph. manihoti* historically caused major losses to cassava production and associated livelihoods in the African continent[6]. In Thailand, *Ph. manihoti* led to country-wide yield losses of up to 30% in the first year following its detection. In Indonesia, where *Ph. manihoti* is spreading in key cassava growing areas of central and eastern Java, substantial impacts have been forecast for local food security, welfare and the sound functioning of rural economies.

Similarly, the exotic papaya mealybug, *Paracoccus marginatus*, was reported during 2008–10 in multiple Southeast Asian countries (i.e. Thailand, Cambodia, Vietnam and Indonesia)[4]. Aside from papaya, this pest seriously affects several other agricultural crops, including mulberry and cassava. In 2010, yield losses due to *Pa. marginatus* were estimated at 10–40% in key cassava cropping regions in India[7].

Lastly, exotic long-tailed mealybugs such as *Ferrisia virgata* and *Pseudococcus jackbeardsleyi* have been found on Asian cassava crops for many years, although rarely at high densities. In fact, *F. virgata* was termed a key pest of citrus, guava, custard apple, cashew and coffee, but caused few problems in cassava (e.g. [8,9]). Over the past decade, however, long-tailed mealybug populations have increased dramatically in cassava, with some farmers estimating yield losses up to 80% due to *F. virgata* outbreaks; this possibly occurs in areas with prolonged drought, anaemic soil fertility levels or high incidence of cassava diseases (which debilitate plants)[3]. Factors such as warmer temperatures, a longer dry season, or enhanced use of pesticides are thought to have contributed to this increase of both long-time invaders.

Aside from this complex of mealybug pests, (novel) plant diseases have equally come to impact on Southeast Asian cassava production. Cassava witches' broom (CWB) is a systemic disease caused by phytoplasmas that was initially reported in the region in 1993. In 2008, severe CWB outbreaks occurred in central Vietnam, bringing 10–15% yield losses and 25–30% reduction in cassava starch content[1]. In early 2014, CWB was reported from all major cassava cropping areas in mainland Southeast Asia, with 80% of fields affected by the disease, and average field-level incidence of 30% in certain countries (authors' unpublished data).

To address this plant health crisis, the International Center for Tropical Agriculture (CIAT) and national partner institutions have joined forces in the implementation of a region-wide integrated pest and disease management (IPDM) programme, through an initiative funded by the European Union (EU) and managed by the International Fund for Agricultural Development (IFAD). This programme is providing almost seamless follow-up to invaluable activities initiated by the Food and Agricultural Organization of the United Nations (FAO) (with support through CIAT and the International Institute for Tropical Agriculture, IITA), in cooperation with public and private institutions in Thailand and elsewhere in the Greater Mekong Subregion. In November 2009, the parasitoid *Anagyrus lopezi* was imported from IITA-Benin and 2000 pairs of the wasp were released in a cassava field in eastern Thailand[10]. FAO subsequently worked together with national institutions to release *A. lopezi* in Lao PDR (2011), Cambodia (2012) and Vietnam (2013). At most release sites in mainland Southeast Asia, *A. lopezi* has established well and is providing relatively good control of *Ph. manihoti* populations[11]. In late March 2014, Bogor Agricultural University teamed up with CIAT, FAO, the Thai Department of Agriculture and Thai Department of Agricultural Extension to introduce the parasitic wasp into Indonesia. In the latest development, 3000 *A. lopezi* wasps were released in a field cage in Bogor in western Java in September 2014 as a first step in what – hopefully – could become a nation-wide mealybug management campaign in Indonesia.

Classical biological control has also become the mainstay of mealybug pest management for *Pa. marginatus*, with recent releases of the (exotic) parasitic wasp *Acerophagus papayae* (in India, Sri Lanka), as promoted through the US Agency for International Development[12]. Following parasitoid releases, papaya mealybug populations have dropped considerably on Indian papaya (and cassava) crops, but much remains to be done to stem the spread and impact of this pest in other countries in Asia[7].

Hence, for both *Pa. marginatus* and *Ph. manihoti* control programmes, follow-up research is needed to carefully document establishment, spread and performance of parasitoids under a range of (climatic, biophysical) settings. Also, eventual interference with or facilitation by local biodiversity should be assessed. Lastly, tactics have yet to be deployed to further boost the efficacy of some of these parasitoids in cassava monocultures. Equally, endemic natural enemies deserve attention as they could provide valuable pest control services, but may lack essential food, host or shelter opportunities in simplified cassava crop ecosystems.

In countries that have been spared from cassava mealybug invasions, such as China and the Philippines, research is urgently needed to build resilience into cassava cropping systems. Tactics such as habitat manipulation can boost the abundance of locally occurring natural enemies and thereby make cassava crops less susceptible to colonization by invasives. Last but not least, it is essential to thoroughly assess (unintended) side-effects of the large-scale adoption of neonicotinoid application for treatment of planting materials, which has accompanied mealybug invasions in some key cassava growing areas.

The current EU-funded, IFAD-managed initiative consists of regional monitoring, applied research, extension and capacity building to further address emerging cassava pest and disease threats. As part of this effort, monitoring in 450 cassava plots (distributed throughout Southeast Asia) has shed light on the geographical distribution and incidence levels of the emerging pests and diseases identified in this article. Applied research has been initiated to develop low-cost and environmentally sound solutions for cassava pest and disease control. While a lot of work remains to be done to ensure long-term pest/disease control, this IPDM programme accentuates the value of and need for collaborative research with national, regional and international partners to safeguard the sustainability and profitability of this important crop for the Asia region.

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New Repository Facilitates Mite Research at NBAIR

Research on agriculturally important mites is part and parcel of the mandate of India's Bangalore-based National Bureau of Agricultural Insect Resources (NBAIR) – the recently renamed National Bureau of Agriculturally Important Insects (NBAII). On 17 July 2014, a new 'Mite Repository' was inaugurated at NBAIR by the Deputy Director-General (Crop Science) of the Indian Council of Agricultural Research (ICAR), Dr Swapan Kumar Datta, in the presence of NBAIR Director, Dr Abraham Verghese. The repository will cater for mite collection, taxonomy and characterization.

The number of acarologists with an interest in taxonomy is dwindling in India. Consequently, it is getting tougher for plant protection practitioners to get existing or newly emerging mite pests identified.

More than 25 species of mites are considered serious pests on various agri-horticultural crops in the country. Among the Tetranychoidea, several members of Tetranychidae (spider mites) and Tenuipalpidae (false spider mites) are injurious to vegetables, ornamentals and fruit crops. At least two species of Tarsonemidae (thread-footed mites) cause serious losses on a wide variety of crops. For instance, *Polyphagotarsonemus latus* can acutely damage chilli and potato crops. The panicle mite, *Steneotarsonemus spinki*, is a fairly recent problem on rice in several rice-growing areas. Gall-forming mites and rust mites in the Eriophyoidea are persistent problems on a number of crops such as coconut, litchi, mango and pigeonpea. Phytophagous mites thus continue to pose problems, and in the future populations of other currently innocuous mites may flare up.

With increasing interest in biological control and organic farming, the crucial role of predatory mites is being appreciated. Indeed, some multinational commercial firms are now trying to introduce and market predatory mites in India.

Close to 200 predatory phytoseiid mite species have been recorded in India[1], while species in the Ascidae, Anystidae, Bdellidae, Cheyletidae, Cunaxidae and Stigmaeidae have also been reported[2]. Their exploitation in biological control has largely to be realized, although previous research suggests this should be expanded.

In the 1960s, the predatory mite *Typhlodromus newsami* was imported from Malaysia[3] for trials against several mite species in tea, and research continues today on the use of phytoseiids for control of this important pest group in the crop. There is also potential for mite-based biological control in smallholder crops. Limited field trials have indicated that the exotic predatory mite *Phytoseiulus persimilis* (which has established in India) and the indigenous species *Amblyseius tetranychivorus, Neoseiulus longispinosus* and *N. barkeri* are efficient predatory mites for targeting phytophagous mites. For example, in field trials in Solan (Himachal Pradesh), *N. longispinosus* proved to be a good option for management of *T. urticae* on capsicum, and as effective as acaricide treatment. In addition, it is possible that predatory mites could be used for targeting thrips and whiteflies. The indigenous mite species are amenable to mass rearing and novel and farmer friendly techniques have been developed at NBAIR to mass rear them.

Other categories of interest to Indian acarologists are insect-parasitic mites as well as phoretic mites, which remain poorly investigated.

Mite research in Bangalore has a strong history. For example, the earlier avatar of NBAIR/NBAII, the Project Directorate of Biological Control or PDBC, carried out research on the biological control of the coconut eriophyid mite, *Aceria guerreronis*, utilizing the acaropathogen *Hirsutella thompsonii*[4]. The new Mite Repository at NBAIR will provide a resource for further research at NBAIR and country-wide to promote knowledge of India's mites, which will improve prospects for biological control to be implemented in association with this key arthropod group.

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Role for Weaver Ants in Cashew in Vietnam

Farmer surveys and a field experiment in Vietnam suggest that weaver ants (*Oecophylla* spp.), already promoted in the country as a control option for citrus farmers, could have a valuable role in reducing pesticide reliance in cashew[1]. Cashew is a relatively new commercial crop in Vietnam, but productivity among the over 200,000 farmers that depend on it is low, at least partly because of pests and the costs of trying to manage them. Pesticide use is heavy with many reports of adverse health and environmental impacts from farming families.

Farmer surveys in four cashew growing regions and monitoring in experimental plots indicated the main pests to be the mosquito bug *Helopeltis theivora*, various species of curculionid shoot borers and a fruit-nut borer, *Nephopteryx* sp. Of lesser importance were coreid bugs and leidopteran leaf rollers while a leaf miner, *Acrocercops syngramma*, and an aphid, *Aphis gossypii*, were minor pests.

Because of prevailing pesticide use, no weaver ants were found in orchards during the surveys. For the year-long field experiment, colonies were established in one plot, which was compared with a cypermethrin-treated plot. Regular monitoring indicated that weaver ants provided equivalent or better control than insecticide for most of the above pests during some or all seasons; any concerns that weaver ant attendance might exacerbate aphid problems were allayed.

Not all economically important cashew pests were controlled by the weaver ants, however, notably branch and stem borers and thrips. The authors say that implementing an integrated pest management package in which weaver ants form a major component, and avoiding insecticides to which they are susceptible, could increase net profit for farmers in addition to improving cashew nut quality and enhancing natural enemy diversity in cashew orchards.

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