RECENT ADVANCES AND NEW CHALLENGES FOR SUGARCANE PEST MANAGEMENT: A REVIEW OF THE 2011 ENTOMOLOGY WORKSHOP

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Abstract

The 8th International Society of Sugar Cane Technologists (ISSCT) Entomology workshop was held from 27 March to 1 April 2011 in Peyrebere, Mauritius. Fifty-one participants from 11 countries attended. Technical sessions held over three days were grouped into six subject headings: Pest Management; Varietal Resistance; Biological Control; Biosecurity, Genetic Diversity and Population Distribution; Pest Damage and Crop Loss, including the use of new technologies such as barcoding of species and Geographic Information Systems (GIS). Field trips offered the opportunity for delegates to view important insect pests of the Mauritian sugarcane industry in the field, and to visit the Mauritius Sugar Industry Research Institute, as well as visit other sites. The Entomology Section concluded that climate change, globalization and development of new sugarcane areas will threaten the world's sugarcane industries and require the implementation of new tools and strong biosecurity measures to protect these industries from major outbreaks and losses. The ISSCT Entomology Workshops will, therefore, continue to be an important venue for entomologists to stay abreast of impending insect threats to their industries, and also help them keep current with new technologies that will be vital in managing potential new invaders as well as maintaining sustainability.

Introduction

The 8th ISSCT Entomology Workshop was held from 27 March to 1 April 2011 in Peyrebere, Mauritius. The Mauritius Sugar Industry Research Institute (MSIRI) hosted the workshop that welcomed entomologists from 11 countries to share research findings under the theme: Recent Advances and New Challenges for Sugarcane Pest Management. Twenty-five

technical presentations were made during the first three days of the workshop. For the first time in the history of the entomology workshops, three new countries, namely Iran (3), Zimbabwe (1) and China (3), participated in the meeting. There were 51 participants, a number which was never seen before. The presentations covered the topics of biological control of sugarcane pests, biosecurity, pest management, pest damage and crop loss, genetic diversity and population distribution, and new technologies such as taxonomy through barcoding of species and Geographic Information Systems (GIS). As always, active discussion panels were held at the end of each session.

A series of field trips was provided to complement the technical sessions. The first stop at Belle Vue Sugar Estate highlighted the problem caused by *Pulvinaria iceryi*. At the second site (Mount Sugar Estate), delegates were able to view damage caused by the stem borer *Chilo sacchariphagus* and different stages of the pest. The afternoon was dedicated to a tour of research laboratories and activities of the MSIRI. On the last day (Friday 1 April), a visit was organised to the Ile aux Aigrette Nature Reserve, an interesting conservation site.

Opening

The Director of The Mauritius Sugar Industry Research Institute, Dr René Ng Kee Kwong, opened the meeting by stressing the importance of the ISSCT workshops as venues for scientific exchange and the establishment of scientific contacts. The Minister of Agro Industry, Food Production & Security, Honourable Satya Veyash Faugoo, in a vibrant speech, insisted on the importance of biosecurity and the preservation of biodiversity in integrated pest management, and expressed his desire for a successful meeting. The General Secretary of the ISSCT, Dr Jean Claude Autrey, gave an overview of the different ISSCT activities, and welcomed the attendees. Dr François-Régis Goebel, Entomology Section Committee Chairman, presented an historical review of the Entomology Workshops, beginning with the first workshop in 1991. The chairman also encouraged everyone to actively participate in the discussions, as all could contribute to the workshop, and their participation was important to group synergism.

Keynote address

Professor Johnnie van den Berg (North-West University, Potchefstroom, South Africa) gave an outstanding talk on habitat management for the management of stemborers. He stressed the importance of understanding holistic agro-ecosystem interactions in which increased knowledge about the environment, plants, pathogens and insects are all combined to provide effective crop protection in an environmentally friendly manner. For example, increased vegetational biodiversity in these agro-ecosystems generally leads to natural control of pests and diseases. In East and Southern Africa, moth borers of maize are managed by using the push-pull approach. This approach requires a better understanding of chemical ecology, as insect behaviour is mainly driven by a world of smell! As an example, the sugarcane stalk borer *Eldana saccharina* is currently the subject of intensive research on chemical ecology and habitat management at the South African Sugarcane Research Institute (SASRI).

Pest Management

Sterile Insect Technique (SIT) is studied in South Africa as a potentially important component of pest management systems. SASRI teams are currently studying the technique on the sugarcane stalk borer *E. saccharina*. Radiation biology studies on this pest showed that complete female sterility is attained at a radiation dose of 200 Gy, and complete F1 sterility of males irradiated is attained at 250 Gy. These doses compare well with other Lepidoptera being mass-reared for SIT programs in various crops in South Africa and worldwide. It was also shown that *E. saccharina* adults can be marked with a fat soluble dye (Calco red), without ill effects. Laboratory-reared moths can thus be distinguished from field moths and this will advance pilot field releases. However, it was not certain how these radiation doses will affect the field survival of radiated compared to field moths, nor how irradiation would affect the complicated lek-driven male moth pheromone calling.

In Zimbabwe, where *E. saccharina* is also a problem, the Sugar Association Experiment Station tested from 2006 to 2009 a set of agronomic and cultural strategies to be implemented after harvest in fields infested with the stalk borer. Different plots were then compared: (1) standard cane harvesting methods and trash management practices, (2) cane cut flush to the ground, (3) cane stubble covered with soil, and (4) plots treated with insecticides (alpha-cypermethrin, imidacloprid and chlorpyrifos). Results showed that there was a general increase in the average tiller numbers/m over the four-year period. Borer infestation levels (dead hearts) decreased significantly from 5% at the start of the trial to less than 1% in all treatments over the 4-year period, particularly in plots sprayed with alpha-cypermethrin, plots with cane cut flush to the ground and in plots where cane stubble was covered with soil. At harvest of these plots, there was a significant decrease ($p < 0.001$) in infestation levels (bored stalks) from more than 15% in 2007 to less than 5% in 2010. These results confirmed the influence of sugarcane agronomic practices on *E. saccharina* biology and ecology.

In Mauritius, the soft scale *Pulvinaria iceryi* (Hemiptera: Coccidae) continues to cause localised infestations every year, leading to significant crop losses in extreme cases. Ways of managing this pest via silicon soil amendments, which have been proved effective in South Africa on the stalk borer *E. saccharina*, are being studied. Promising results were obtained with foliar sprays of Orymax (liquid silica), leading to 50% mortality of larval stages of the soft scale. The effect of abiotic factors and environmental stresses on these silicon treatments is being researched. Non-traditional chemicals, such as detergent and the botanical insecticide (Vegol), are also being tested in laboratory and field, as well as promotion of biological control of *P. iceryi* using coccinellid predators. This integrated approach points out the importance of understanding all factors that can contribute to damage reduction, including chemical ecology.

Varietal Resistance

Together with biological control, the use of resistant varieties remains an essential component of sugarcane pest management. This is particularly true for moth borers, where important research programs are ongoing.

In Papua New Guinea**,** a collaborative project between BSES Limited and Ramu Agri-Industries is being implemented on varietal resistance to key moth borers such as *Sesamia grisescens*, *Chilo terrenellus* and *Scirpophaga excerptalis*, as well as the weevil borer *Rhabdoscelus obscurus.* The moth borers present biosecurity risks for Australia and the

screening of Australian commercial varieties for resistance is important as a precaution against future pest incursion. Preliminary observations on variety trials confirm that *S. grisescens* is the dominant species and there is evidence of resistance to this pest among sugarcane clones.

The Agricultural Research Station at Andhra Pradesh (India) is currently screening sugarcane varieties against a complex of borers. None of varieties was observed to be immune to borer attack, but there was significant variation among the different cultivars. Of 28 clones, 16 were resistant, 6 were moderately resistant and 6 moderately susceptible (based on dead hearts; 4.3% average). Based on bored internodes (4.5% average), 19 were resistant, 8 moderately resistant and 1 moderately susceptible. Medium/late maturing varieties had comparatively more borer infestation than early maturing varieties in the spring season and required proper plant protection measures for borer control to enhance cane and sugar productivity.

This research station also conducted screening against sugarcane wooly aphid, *Ceratovacuna lanigera*. In 2002, an outbreak of this pest in the state of Andhra Pradesh was observed on more than 40 000 ha and resulted in serious economic losses of 15-25 t cane/ha and sugar loss of 0.5-2 units. Twelve sugarcane genotypes were assessed, each of them with susceptible and local varieties. Results revealed that only one genotype, CoCV-2003-165, was completely free from infestation. Resistance was due to antibiosis and/or non-preference mechanisms impacting adversely on the pest and arresting further colonisation and spread. The control variety Co-8371 was colonised by aphids within 24 hours after insect release.

Biological Control

Research on biological control continues in many research organisations and significant progress has been made to ensure better efficacy of biocontrol agents in the field. While this efficacy is well documented, there is a need to reduce the cost of production and for releases of beneficial insects in the fields to be generally adopted.

Thailand is unique among the world sugarcane industries in having five important species of stem borers: *Chilo tumidicostalis, C. infuscatellus, C. sacchariphagus, Sesamia inferens* and *Scirpophaga excerptalis*. Sugarcane fields are also infested by a longhorn beetle stem borer, *Dorysthenes buqueti*. Fortunately, a number of beneficial insects and fungi are present and they have been mass produced and released in fields with success. The role of natural enemies of moth borers was studied in 2008-2009 to estimate their impact and develop a sustainable control strategy for the sugar industry. Quantitative and qualitative analyses of cane yield showed that the utilization of parasitoids (such as *Cotesia flavipes*), predators (earwigs, green lacewings) and green muscardine fungus (*Metarhizium anisopliae*) caused a significant reduction in damage by pests and resulting yield losses compared to untreated plots. In addition, an increase in field establishment of these natural enemies was noted. All the experiments confirmed that biological control can play a substantial role in improving sugarcane production in Thailand. The economic impact of this biocontrol was also assessed on 52 sugarcane farms and it was shown that in some cases there was an increase in yield of 11.82 tonnes per ha worth US$202 million in total. Biological control adopted by the sugarcane farmers has resulted in the spectacular control of several pests. For example, the use of the larval parasitoid *C. flavipes* to control stemborers has generated benefits to farmers of 22.58% of the Net Present Value (NPV) in 2008.

Indonesia is another country where moth borers are numerous. Monitoring and pest management strategies are being implemented through collaboration with Australian-based researchers in an ACIAR-funded project. First results on biocontrol of *Chilo* spp. (stem borers)

and *Scirpophaga excerptalis* (top borer) were presented. The experiment tested the factory-recommended dose of *Trichogramma* egg parasitoid (10 000 released in total between 1.5-4 months crop age) compared to a 10-times increased application dose (100 000 *Trichogramma*/week/ha for the first 4 months), a pesticide application, and a control with no treatment (natural damage). Top and stem borer pressure increased at 3, 6 and 9 months and at 12 months, before harvest, the infestation level reached 15.8% stalks damaged for the top borer and 84.8% (14.5% internodes bored) in the unprotected plots. The 'factory' treatment did not reduce borer infestation and was similar to the 'no treatment' plots. In comparison, the best treatment using insecticide had only 4.6% and 3.8% damage levels, followed by plots treated with the higher release rate of *Trichogramma*. The untreated plots had lower sucrose yield, higher fibre content and lower cane yield than all treated plots, representing a loss in cane yield of 46.2 t/ha (–34.5%). Stalk height and other parameters were also affected, particularly when attacked by *S. excerptalis*. The ineffectiveness of factory releases is explained by the low number of *Trichogramma* per hectare.

French researchers from INRA, FDGDON and CIRAD have developed an effective program of controlling the stem borer *C. sacchariphagus* in Reunion Island with the egg parasitoid *Trichogramma chilonis*. Now, ways to improve efficiency of mass production and release of the parasitoid to reduce overall costs are being studied. Results presented at the workshop focussed on the development of cold storage technology of *T. chilonis*. The results indicate that successful cold storage was obtained for up to 2 months without loss of physiological performance (emergence, fecundity, survival during seven days). The team from Réunion (FDGDON) also confirmed the effectiveness of cold-stored egg parasitoids in field trials, which was similar to unstored parasitoids. Cold storage did not affect fecundity, longevity or emergence. This augurs well for further development of the technique.

In South Iran, the stemborers *Sesamia nonagrioides* and *S. cretica* are key pests of sugarcane and biological control is one option considered by the researchers to reduce infestation. The phenology and the efficiency of egg parasitism by the wasp *Telenomus busseolae* were studied on different cultivars and in two locations (South and Southwest of Iran). In 2007 and 2008, results showed that *Sesamia* eggs were parasitised at high levels (35-100% of egg batches and 41.2-87.3% of eggs). Parasitism rates were 91.7% the first year and 87.2% the following year. It was also concluded that the cultivar CP48-103 had the highest egg batch density, recovery efficiency and % parasitism.

Acceptance and suitability of Indonesian borers for the development of the Australian endoparasitoid *Cotesia nonagrioides* is currently being studied by the University of Adelaide, Australia, in collaboration with BSES Limited. This parasitoid attacks larvae of the large moth borer (*Bathytricha truncata*), which is a minor borer species found only in Australia. This study was initiated to test if the Australian parasitoid could attack exotic moth borers. Results show that it is able to attack and develop in two key borer species from Asia (*Sesamia grisescens* and *S. inferens*). This work continues.

Research on biological control against *Chilo infuscatellus* is ongoing at the Guangxi Sugarcane Research Institute (China). Parasitic ability of the Cuban fly, *Lixophaga diatraeae* (Diptera: Tachinidae), was studied on the factitious host *Galleria mellonella*, another pyralid moth. Optimal inoculation proportions between maggots and larvae were defined, as well as effects of different storage temperatures and emergence rate of Cuban fly, which showed good parasitism levels (33-50%). Artificial rearing methods were also improved to release a large number of tachinid flies in the fields.

Another study from the same institute was presented on the interspecific horizontal transfer of *Wolbachia* in *Trichogramma* wasps using the method of synparasitism (sharing one host). Due to the existence of thelytokous parthenogenesis in *Trichogramma*, *Wolbachia* can be vertically or horizontally transferred in new hosts for up to 5 generations. This bacterium has the ability to increase the proportion of female individuals of its host and, therefore, can be used for efficient mass production of *Trichogramma* spp.

A regional project on biopesticides to control sugarcane whitegrubs was presented by the team leaders from MSIRI and SASRI. Research activities include: species composition and identification using morphological and molecular techniques; establishment of a collection of entomopathogens from different regions of southern Africa (SADC); and tests for virulence at the quarantine laboratory of the African Agricultural Research Council-Small Grain Institute. Should any pathogens show a good virulence, they will be produced and formulated via a factory partner and sent back to the country of origin for preliminary field testing.

Studies on entomopathogens such as *Metarhizium anisopliae* and *Paecilomyces* sp. are conducted at MSIRI not only to check their efficacy on different sugarcane insect pests but also to measure their sensitivity to fungicides (metalaxyl, benomyl and mancozeb) and insecticides (cyromazine, deltamethrin and metamidophos) through treated media. As expected, the fungicide-treated media had a major impact on mycelium development, while the insecticides had no effect and growth was comparable to the control.

Biosecurity

Australia grows sugarcane in tropical Queensland and is constantly threatened by exotic pest incursions due to its close proximity to Papua New Guinea and Indonesia, two other sugar-producing countries known for their rich biodiversity. Generally, Australia is known to have one of the best biosecurity and quarantine systems in the world, implemented by the Australian Quarantine and Inspection Service (AQIS). The Australian sugarcane industry so far remains free of any major moth borer pest problems. Pathway analysis showed that 22 of the 36 exotic moth borer species elsewhere in the world have the potential to invade Australia and they are considered to have greatest potential to cause economic harm to the Australian sugar industry. As a result, BSES Limited has developed an Industry Biosecurity Plan (IBP) with the state agency (DEEDI), the office of the federal Chief Plant Protection Officer (OCPPO) and Plant Health Australia (PHA). The resulting risk analysis determines cost-sharing arrangements between government and industry in the event of an incursion and consequent eradication campaign. Biosecurity activities carried out by BSES are breeding for resistant cultivars, pest and disease surveys in neighbouring countries including studies on biology, ecology and management of major pests and disease in these countries, and maintenance of quarantine regulations within Australia.

A major threat for the South African sugarcane industry is the spotted stemborer, *Chilo sacchariphagus*. This country already has a stemborer problem caused by the native species *Eldana saccharina*. The spotted stemborer is a major pest in many Asian countries, Reunion and Mauritius and was introduced into Mozambique in 1999, where it is currently causing economic losses in the Mozambican sugarcane areas near the Zambezi River. Therefore, *C. sacchariphagus* represents today a biosecurity threat for all southern African countries that produce sugar. Because South Africa is particularly exposed to the risk, SASRI established a

regional biosecurity program based on pest surveillance at the border and a planned rapid response using local network systems.

Genetic Diversity and Population Distribution

In Reunion, *Melanaphis sacchari*, an efficient vector of sugarcane yellow leaf virus (SCYLV), is being studied to understand its worldwide genetic diversity. As a first step, a phylogenetic approach, based on morphometric criteria and sequencing of typical loci (COI Cytochrome B), was used to disclose the molecular basis of the distinction of two species, *M. sacchari* and *M. sorghi*. The second step was a population study (clonal diversity) using microsatellite loci. A total of 1748 individuals from 14 distinct geographical regions were genotyped.

DNA barcoding of species is a new exciting tool that allows rapid identification and is an aid to traditional identification using morphological characters. This technique has been applied on six armyworm species causing damage in Mauritius, as their taxonomy is currently confused. The use of a short standardized region at the 5' end of the mitochondrial cytochrome oxidase I (COI) gene allowed the six species to be identified as *Mythimna pseudoloreyi*, *M. loreyi*, *M. insulicola*, *M. phaea*, *M. tincta* and *M. pyrausta*, with sequence divergence values between 6.8 and 11%, except between *M. pseudoloreyi* and *M. loreyi* where the divergence value was 2.3%. All sequences were deposited in Genbank. Further analysis also showed evidence of homologies in the *Mythimna*/*Leucania* complex.

Another tool that is growing rapidly is the use of Geographic Information Systems (GIS) and Geostatistics to understand pest distribution on a large scale. Apart from biological control mentioned earlier, Iran is currently using geostatistical analysis to unravel the spatial distribution of the pink stemborers *Sesamia cretica* and *S. nonagrioides* in sugarcane fields in the Khuzestan Province. Results from geostatistic parameters (semivariogram, kriging) showed a spatial dependence of the pest on 25 ha irrigated fields. The tool is particularly interesting to develop site-specific management and investigate the reasons for such 'high infested areas'.

Pest Damage and Crop Loss

Assessing the losses due to insect feeding is a critical component in pest management. Allocation of research funds, as well as establishing action thresholds and other IPM management decisions, all depend on evaluations of pest losses.

In general, foliar feeding by insects is not considered to cause economic losses in sugarcane. However, in Tucuman, Argentina, the armyworm *Pseudaletia unipuncta* (Lepidoptera: Noctuidae) seems to cause significant losses by eating and killing the shoots. Losses of 15.7-46.9% of shoots were found at 18 locations distributed though the sugarcane areas. Armyworm attacks were observed in early harvested plots and associated with green cane harvest during dry springtime seasons. Chemical control measures (ground applications) allowed damage to be kept at low levels.

In South Africa, the introduction of the thrips *Fulmekiola serrata* (Thysanoptera: Thripidae) in 2004, supposedly from the islands in the Indian Ocean, took the sugar industry by surprise, particularly in the province of KwaZulu-Natal where the bulk of the South African sugarcane crop is grown. Its rapid spread, which was associated with a severe drought, has put the South African Sugarcane Research Institute on alert and research programs are currently

focused on this pest to find a control strategy. In situations of high infestation, this pest is expected to cause yield losses of 18-27% (tonnes cane/ha) and 16-24% (tonnes sucrose/ha).

Conclusions

Global travel, world trade and change in climate conditions increase the risks from pest and disease incursions and outbreaks in many agricultural systems. This emphasises the vital importance of preventive measures to reduce such risks. Sugarcane industries will require their entomologists to react quickly to any negative effects from climatic, agricultural and pest changes by maintaining sustainable protection of sugarcane production. The ISSCT Entomology Workshops continue to be ideal forums to obtain knowledge on the most current control strategies and learn about emerging pest threats and new technologies that help unravel pest distribution, taxonomy, and insect-host relationships. The 8th Entomology Workshop was successful in meeting these objectives and the keynote addressed by the guest speaker was particularly well received.

Maintaining a high level of knowledge transfer remains an important challenge for workshop organizers as travel budgets will remain tight. The Entomology Section committee must also maintain efforts to attract more entomologists from developing and emerging countries through ISSCT grants, as well as give opportunity for a few PhD and/or post-doctoral students to present their project outcomes. For this workshop, we were able to give financial support to Hong Do Thi Khahn, a young researcher working on biological control of stemborers. In addition, it is necessary to provide network and support to the sugarcane entomological community beyond the ISSCT workshops by updating pest compendiums and creating international consortiums on subjects on common interest.

Therefore, during the workshop in Mauritius, it was decided to promote the development of a booklet on sugarcane pests in the world, a project that was already discussed at the last workshop in Argentina. We also stressed the importance of having a consortium on biosecurity and diagnostics, as the demand from sugar industries and research institutions is growing. All biosecurity initiatives currently ongoing in different sugarcane institutions will be listed as the first priority.

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