VIth ISSCT ENTOMOLOGY WORKSHOP

Advances and Challenges in Sugar Cane Pest Management
Cairns, AUSTRALIA
14-20 May 2006

LIST OF ABSTRACTS

Sugarcane Biosecurity in Australia; Preparedness for a Possible Pest Incursion

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Australia is fortunate that it does not harbour major gramineous moth borer species. However, several destructive lepidopterous borers are widely distributed in neighbouring Asian countries. The incursion by any of these pests into Australia may have severe consequences on the sugarcane industry, and perhaps other industries such as maize and rice. BSES Limited, which is the main sugarcane research provider in Australia, has developed Pest Incursion Management Plans for each of these major borer species. These plans are aimed at improving our preparedness to deal with a sudden incursion mainly by a moth borer pest species, but the principles are also applicable to any incursion by other cane pests or diseases. All borer species in the world have been categorized based on their economic importance, geographical distribution and proximity to Australia. Exotic Pest Categorization is an important action that forms the basis of any cost-sharing agreement between the federal government, state government and the affected industry. A Pest Category determines a Cost Sharing Category, and therefore determines grower's compensation in case of crop destruction. A detailed generic incursion plan has been agreed upon by the Australian government, and signed by the Queensland Department of Primary Industries and Fisheries (QDPI&F) and CANEGROWERS, which is the representative of sugarcane growers in Australia. We believe that Australia is now well prepared to efficiently deal with a sudden exotic incursion and quickly minimize its impact on the sugarcane industry.

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A Proposed Plan for the Improvement of Sugarcane Biosecurity in Louisiana

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Two species of moth borers attack sugarcane in southern USA, and these are the sugarcane borer Diatraea saccharalis, which has been the major pest problem since its introduction into Louisiana in the 1800s, and the Mexican rice borer (Eoreuma loftini) which invaded the United States in 1980 from Mexico. The Mexican rice borer (MRB) has expanded its geographical range through out the Lower Rio Grande valley of Texas and is currently approaching Louisiana. The rate of spread towards Louisiana was estimated at 15 miles/year, which means that, unless aided (or hampered) by human factors, E. loftini is likely to cross the Texas-Louisiana borders in the next 2 years, and will invade the first cane field 3 years later. The invasion of MRB into Louisiana is expected to have a severe negative impact on both sugarcane and rice industries. A joint endeavour was initiated between BSES Limited and the Louisiana State University Agricultural Centre to establish a contingency plan detailing the steps to take following an incursion in Louisiana. The plan followed similar principals as the Pest Incursion Management Plans developed by BSES for the cane industry in Australia. The contingency plan highlights the need for a large-scale awareness campaign to take place on pest recognition, quarantine measurements and Emergency Response Planning. The plan also highlights the importance of establishing quarantine boundaries between sugarcane areas in Louisiana and Texas, where cane transporting should be prohibited. In addition, close collaboration between United States Department of Agricultural (USDA), Agricultural Research Service (ARS) and the Louisiana Department of Agriculture and Forestry (LDAF) is also highlighted.

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Concepts of Managing an Invasive Species and the Plant-Stress Hypothesis

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The Mexican rice borer, Eoreuma loftini Dyar (Lepidoptera: Crambidae), entered the Lower Rio Grande Valley of the United States from Mexico in 1980. It immediately became a devastating pest of sugarcane causing some farmers to forgo harvesting of fields. As it has moved through the Texas rice industry of the Gulf Coast, farmers have experienced 50% yield loss; insecticide applications have increased from less than one per field to an average of between two and three annually in many areas. Texas Gulf Coast studies have also shown that the common Louisiana cultivated varieties of sugarcane could experience E. loftini losses as much as US$4250 per ha.

In 2001, a multi-disciplinary team of research scientists from state and federal agencies combined with extension and regulatory personnel to initiate a proactive program to solve invasive pest problems before E. loftini could threaten the Louisiana sugar and rice industries. Management practices were identified to minimize insect damage, reduce area wide pest populations, and determine important insect-plant interactive mechanisms that could impact on pest population dynamics involving both the sugarcane and rice ecosystems.

Oviposition preference studies have helped to identify the role that drought stress and several free amino acids essential for growth and development could have on enhancing or suppressing pest problems. The proportion of various phonological stages in the graminaceous crop system will have substantial impact on IPM success. In addition to cultivar selection, modifying the suitability of the crop by reducing water deficit stress is shown to make rational irrigation input a key component in the integrated pest management of E. loftini. From an ecological perspective, a more extensive exploitation of the stressed habitat may allow this invasive pest to achieve greater r-strategist capabilities. These studies have involved extensive funding by several US Department of Agriculture competitive grants, and were supplemented by sugar and rice commodity groups.

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How Best To Control *Chilo sccharriphagus* Bojer (Lepidoptera: Crambidae) in Mozambican Sugarcane - Classical Biocontrol, Augmentation, or Both?

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In 1999, Chilo sacchariphagus Bojer (Lepidoptera: Crambidae) was identified from sugarcane in Mozambique - its first record in mainland Africa. This Southeast Asian borer is a major sugarcane pest in Mauritius, Madagascar and Reunion, and could pose similar threats to sugar industries in Mozambique and surrounding countries.

In 2000, the affected estates initiated biological control programs against it. Regular surveys determined levels of infestation, seasonal occurrence and presence of any indigenous parasitoids attacking life stages of C. sacchariphagus. Less than 1% of larvae were attacked by the parasitoids Stenobracon sp. (Hymenoptera: Braconidae) and Cotesia sesamiae Cameron (Hymenoptera: Braconidae). No pupal parasitism was recorded. In contrast, greater than 90% of C. sacchariphagus egg batches were parasitised by Trichogramma bournieri Pintureau and Babault (Hymenoptera: Trichogrammatidae).

In 2001, releases of Xanthopimpla stemmator Thunberg (Hymenoptera: Ichneumonidae) commenced, as an empty niche existed for an effective pupal parasitoid. In addition, SASRI had a strong laboratory colony available. 60% reductions of C. sacchariphagus populations were measured in release fields within a year of releases commencing. Two years after releases ended, X. stemmator adults were collected from surrounding fields, as were parasitised pupae. Xanthopimpla stemmator is thus established on its aboriginal host at both sugar estates.

Should further classical biocontrol be pursued? A larval parasitoid, Cotesia flavipes Cameron (Hymenoptera: Braconidae), has been reported as effective against C. sacchariphagus. A collection of this parasitoid from a closely related population of C. sacchariphagus in Southeast Asia could be imported into Mozambique in order to fill the empty larval parasitoid niche and increase parasitoid biodiversity. Alternatively, T. bournieri could be reared for release at times when its population is low, to augment field populations then, to make them more effective.

In the light of information gained on population dynamics of C. sacchariphagus and its parasitoid complex in Mozambique, arguments for the single use of both approaches will be presented and discussed, as well as a case for the complementary use of both approaches together.

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Preventive Measures Against the Whitegrub Hoplochelus marginalis in Mauritius

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Hoplochelus marginalis Fairmaire (Coleoptera: Melolonthidae) is indigenous to Madagascar and had not been found elsewhere prior to its discovery in Reunion Island in June 1981 when about 4000 ha of sugar cane, uncultivated land, ravines and other crops were already infested. Infestation started near the port area and spread along two fronts, clockwise and anticlockwise, and by 1995 the whole island was infested. Due to the proximity of Reunion Island and the potential threat of this pest to Mauritian agriculture, a Protocol was signed by the Mauritian and French Authorities defining agreed measures that both countries would enforce to minimize the risks of introducing white grubs from one country to the other. The measures include rescheduling of plane flights, treatment of luggage holds, and restriction on movement of ships. Every year, during the beetle flight period, light traps are operated in Reunion Island, at the Ports and Airports, and results are communicated to Mauritius. In addition to the measures listed in the protocol, preventive measures are also taken in Mauritius. These include preventive insecticide treatment around the airport, public awareness campaigns and regular meetings with economic operators. Soil samplings and light trappings are carried for early detection of the insect in Mauritius. The insect has not been detected up to now in Mauritius, although live beetles have been intercepted on board planes and ships from Reunion Island.

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Use of Phylogenetics and Phylogeography of Sugarcane Insect Pests to Direct Control Measures

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In developing integrated pest management strategies for insect pests, the correct identity of the pest and its natural enemies is essential to develop efficient control strategies. Once its true identity is known, then information on its behaviour, biology and ecology becomes easier to attain, leading to informed decisions on types of control tactics to employ, and when best to employ these.

During natural enemy explorations in Africa, behavioural differences in Eldana saccharina Walker (Lepidoptera: Pyralidae) infesting sugarcane in Uganda and west Africa compared to southern Africa were found. In addition, parasitoid complexes attacking E. saccharina in west Africa compared to those in southern and eastern Africa were different. This led to the hypothesis of there being 'biotypes' of E. saccharina in Africa. Phylogeographic techniques and analyses were used to investigate this, and revealed populations of E. saccharina with genetic distances between them greater than that between species in the same genera of other insects. These results will be presented and discussed in the context of choosing biological control agents for use in different regions of Africa. In addition, populations of the parasitoid Sturmiopsis parasitica Curren (Diptera: Tachinidae) were collected from E. saccharina in maize in coastal Benin, and from Busseola fusca Fuller (Lepidoptera: Noctuidae) in maize in highland Zimbabwe. These are morphologically similar, but when subjected to phylogenetic analyses, two distinct populations were identified, also with large genetic distances between them. These results will be discussed in the context of collecting the 'best' parasitoid population, and the implications of this.

Phylogenetic techniques are also very useful when there is large morphological differences between different life stages of the same species of insects, as occurs in white grubs (Coleoptera: Scarabaeidae) infesting sugarcane, especially when the different life stages do not occur together. In the past, life stages had to be reared through to a stage that could be identified, which if successful could take up to a year with this group of insects. The use of phylogenetics to overcome this barrier at SASRI are presented and discussed.

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Bugs, Genes, Islands and Invasions: *Eumetopina flavipes Muir* (Hemiptera: Delphacidae) in the Torres Strait

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The Torres Strait Islands form a unique archipelago between Papua New Guinea (PNG) and northern Queensland. Islands are vulnerable to the effects of invasive organisms - the Torres Strait Islands are particularly vital as an Australian quarantine frontline. Ramu Stunt is a major disease of sugarcane in PNG. If it entered Australia, it could devastate the billion-dollar sugarcane industry. The insect vector of Ramu Stunt, Eumetopina flavipes, occurs in PNG, the Torres Strait and at Bamaga on Cape York. Detailed studies of the geographic distribution, hostuse and inter-population movement of E. flavipes will enable the development of an innovative predictive model for potential Ramu Stunt incursions through the Torres Strait. The model will enable critical assessment of threat and aid in the application of an appropriate response. This research will also provide information on the role of the Torres Strait archipelago in facilitating invasions.

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Is the Distribution of Fiji Leaf Gall in Australian Sugarcane Explained by Variation in the Vector *Perkinsiella saccharicida*?

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Fiji leaf gall (FLG) is an important virally induced disease of Australian sugarcane. It is confined to southern canegrowing areas, despite its vector, the delphacid Perkinsiella saccharicida, occurring in all canegrowing areas of Queensland and New South Wales. This disparity between distributions could be a result of successful containment of the disease through quarantine and/or geographical barriers, or because northern populations of P. saccharicida may be poorer vectors of the disease. These hypotheses were first tested by investigating variation in the ITS2 region of the rDNA fragment among eastern Australian populations of Perkinsiella. The ITS2 sequences of the Western Australian P. thompsoni and the Fijian P. vitiensis were distinguishable from those of P. saccharicida and there was no significant variation among the 26 P. saccharicida populations. Reciprocal crosses of a northern Queensland and a southern Queensland population of P. saccharicida were fertile, so they may well be conspecific. Single vector transmission experiments showed that a population of P. saccharicida from northern Queensland had a higher vector competency than either of two southern Queensland populations. The frequency of virus acquisition in the vector populations was demonstrated to be important in the vector competency of the planthopper. The proportion of infected vectors that transmitted the virus to test plants was not significantly different among the populations tested. This study shows that the absence of FLG from northern Queensland is not due to a lack of vector competency of the northern population of P. saccharicida.

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Maximizing Returns from Greyback Canegrub (*Dermolepida albohirtum*) Control in Sugarcane in Queensland, Australia

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During the development of suSCon Maxi, Crop Care's controlled release (CR) imidacloprid insecticide using suSCon® technology, a large number of research trials were conducted by Crop Care and BSES. Field testing of CR imidacloprid formulations commenced in 1996, and eventually led to the registration of suSCon Maxi in 2004. There is now a greater range of insecticides available for control of greyback canegrub. Crop Care and BSES have evaluated a range of these options in trials in the Burdekin and North Queensland, so that recommendations can be made according to individual growers grub damage risk and length of control required. Treatments evaluated were suSCon Maxi at 10 and 15 kg/ha, suSCon Blue (not in the Burdekin), suSCon Plus and

Confidor® Guard, applied to the plant crop at the drill fill-in stage.

This paper contains the results of three field trials that represent a range of greyback grub infestations in the Burdekin and North Queensland, which were monitored in detail in the plant, first- and second-ratoon crops. Where suSCon Maxi, suSCon Plus or Confidor Guard are applied to plant cane and greyback canegrubs only attack the plant crop, yield increases will occur in both plant and first ratoon crops.

Without further infestations from greyback canegrub in subsequent ratoon crops, there will be a positive net economic return from these insecticide treatments over a three-year crop cycle. In this situation all products provided similar net economic returns of around $2000/ha in the Burdekin.

Where infestation from greyback canegrubs occur in both the plant and first-ratoon crops, suSCon Maxi, suSCon Plus, suSCon Blue (in soils with pH below 6) and Confidor® Guard will provide yield increases and very positive net economic returns in both the plant and first ratoon crops. However in the first- and second-ratoon crops, suSCon Maxi and suSCon Blue (in soils with pH below 6) provided much higher net returns than suSCon Plus or Confidor Guard. In this situation in North Queensland the net economic returns for suSCon Maxi (15 kg/ha) and suSCon Blue were around AU$2000/ha, whereas they were around AU$1000/ha for suSCon Plus and Confidor Guard over the three crop cycle.

Where there is an ongoing moderate to heavy infestation from greyback canegrubs in the plant, first- and second-ratoon crops, substantial yield increases and positive net returns have been measured from the use of suSCon Maxi at 10 and 15 kg/ha, suSCon Plus and Confidor Guard. However, in this situation suSCon Maxi (at both the 10 and 15 kg/ha rates) provided much greater net returns (AU$6,742-$7,396/ha) than either suSCon Plus (AU$3,036/ha) or Confidor Guard (AU$4,385/ha).

Despite the 50% increase in cost of the higher rate (15kg/ha) of suSCon Maxi compared to the lower rate (10kg/ha), there was a greater net return provided by the higher rate of application in this situation of ongoing heavy greyback grub infestation.

These results show that growers have a good range of insecticide options for application in the plant crop for protection against greyback canegrubs that will provide very positive net returns, but suSCon Maxi will provide the greatest economic returns if there is high risk of ongoing infestation in plant and ratoon crops. The costs of the insecticides are relatively small compared to the economic returns that are achieved from greyback canegrub control.

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Canegrub Management with Insecticides in New Planting Systems

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There is considerable interest in Australia in the adoption of new farming systems for sugarcane, including controlled traffic and minimum tillage. Both of these are likely to have consequences for canegrub control using insecticides.

Controlled traffic, which aims to avoid compaction of the soil around the cane roots, is achieved by matching the spacing of the planting beds with the wheel tracks of machinery. The current conventional bed spacing is 1.5 m; in a controlled-traffic system this is increased to at least 1.8 m. At this spacing, crop yields may fall unless cane is planted in the beds in dual rows, often 500 mm apart on beds 1.8 m centre-to-centre. There are 11,111 row metres of cane in such a dual row system, compared with 6,667 row metres in a conventional single row 1.5 m configuration. Growers want to know what rate of insecticide should be used in such a system; is the current per hectare rate adequate, or should rates be increased to maintain a constant amount of insecticide per metre of each individual dual row?

Some growers are adopting minimum-tillage planters, which open a narrow planting slot using double discs. This potentially creates a problem with some insecticides. Controlled-release granules such as suSCon® Blue are registered for application in a band 150-200 mm wide, to maximise the chance of contact between canegrubs and the granules. This distribution is readily achieved with conventional planters but not so readily with disc-opener planters, where granules dropped between the discs end up in a band only 60-70 mm wide. Growers are asking if these products will work with a new planting system, or whether other products such as liquid imidacloprid might be more suitable?

We are currently testing different insecticides and application rates in these new systems, and have designed suitable equipment to allow us to establish realistic trials.

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What Criteria could Model Trends in the Risk of Greyback Canegrub Damage?

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Larval Dermolepida albohirtum (Coleoptera: Melolonthinae) - soil-inhabiting whitegrubs known as greyback canegrubs - constrain sugarcane production on about 50,000 ha in Australia. Larvae rapidly eat cane-roots during summer and autumn, causing loss of growth, and subsequent failure to ratoon.

Greybacks have a one-year life cycle. Each year, control tactics or alternative operations for greyback grub management should be in place in advance of the next generation. Unsuitable crop growth and/or weather conditions may prevent field operations by the time beetles fly in late spring or early summer, and usually prevent operations later than early summer.

We are attempting to develop systems to predict specifically when and where greyback infestations are likely, so that strategic grub control or management plans for the next year can be made before late winter and/or the next round of planting, harvesting, and ratooning.

There is good potential for a prediction-based approach to managing greyback grub. First, outbreaks tend to be sporadic and cover several years. Second, almost all instances trace back to progressively increasing populations or other predisposing conditions, either in the same field or in its locality.

Thus, we proposed that if appropriate awareness and risk-assessment systems were in place, sugarcane producers could respond in advance and avoid sporadic, disastrous outbreaks, and increase the level of control with less reliance on routine, widespread, prophylactic application of pesticide than at present. Production could be more consistent, cost-effective and sustainable, with discrete pesticide use, despite the greyback threat.

We outline indicators that may be suitable to monitor local and district-wide greyback population trends and will also outline predisposing conditions that should possibly be included in riskassessment and decisions on management strategy and tactical options.

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Successful Biological Control of Hoplochelus marginalis (Col.: Melolonthidae) by Beauveria sp. in Reunion Island

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Hoplochelus marginalis (Col.: Melolonthidae) was introduced accidentally from Madagascar to Réunion Island probably in 1973 and has become a major sugarcane pest since the 1980s. Current control measures evolved after several phases. First, a chemical control was used namely with application of granules of chlorpyriphos-ethyl (14% a.i, at the rate of 28 kg/ha). Next, biological control was developed using an entomophathogenic fungus: Beauveria sp. (Hyphomycete: Deuteromycotina), discovered in 1987 during surveys in the country of its origin. In 1993, its registration was obtained after an agronomic tests phase (1988-1992) that showed the exceptional biological capacity of this pathogen (intrinsic virulence, fast and natural colonisation of fields). Between 1993 and 1999, a mixed treatment of insecticide+biocide was recommended [7.5-15 kg of chlorphyriphos-ethyl 14% + 25-40 kg of granules containing Beauveria (2.107 spores/g dry matter)]; the dosage rates were varied according to the infestation pressure by the grub. In 1999, some growers complained about poor control in the south of the island. Between 2001 and 2005, new studies were undertaken to evaluate the situation and to make adjustments, technically and administratively, to improve the effectiveness of control. The results are discussed in this presentation.

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Cophylogeny of the Cotesia flavipes Complex and Their Polydnavirus Symbionts:
Towards the Effective Biological Control of Stemborer Pests in Australia

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The Cotesia flavipes species complex of parasitic wasps are economically important worldwide for the biological control of lepidopteran stemborer species associated with gramineous crops. The complex currently comprises three species: C. flavipes Cameron, C. sesamiae (Cameron) and C. chilonis (Matsumura), which are morphologically similar. The absence of clear diagnostic characters to separate the species and inaccurate identification have confounded past efforts to assess the impact of specific introductions. Moreover, small- and large-scale geographic populations have exhibited differences in host/habitat preference and host range. Founder effects, genetic drift, inbreeding and adaptation to new environments can occur during the introduction and establishment of biological control agents and may promote the genetic divergence of populations. In addition, C. flavipes and C. sesamiae are found to carry different polydnaviruses (PDV). These PDVs are integrated in the wasp genome and play an important role in host immune suppression and, inturn successful parasitism. Differences in PDV symbionts between populations may have potentially important implications for host utilisation and thus, the diagnosis of appropriate strains for biological control against specific host species. Molecular markers are being developed to investigate genetic variation among worldwide populations of the C. flavipes complex and phylogenetic congruence between wasps and their PDVs. The status of the C. flavipes-like species and its PDV in Australia will be determined for the preparedness of stemborer incursion into Australia.

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Ten Years of Utilizing Cotesia flavipes (Cameron) for Augmentative Biological Control of Sugarcane Moth Borers in Thailand

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Preliminary investigations on the utilization of Cotesia flavipes for augmentative biological control of the sugarcane moth-borer complex in Thailand were conducted in 1994. About 100,000 - 500,000 adults of C. flavipes were produced monthly at National Biological Control Research Center (NBCRC), Central Regional Center (CRC), Kamphaeng Saen, Nakhon Pathom Province. Field releases were made, of C. flavipes on monthly intervals in 10-acre sites at rates of about 4,000, 2000 and 1,000 adults in Nakhon Pathom, Suphanburi and Kanchanaburi Provinces, respectively. The investigation revealed that the parasite population and percent parasitization increased to levels higher than those of the control plot at all locations. The study was repeated during the period from 1995 - 1997. Approximately 2000 adults of C. flavipes were released in 10-acre sites every 2 weeks during the first 3 months of plant growth. Subsequent releases were made every 2 months until 2 months before harvesting at Nakhon Pathom and Suphanburi Province. The investigation during these period showed that the parasite population and percent parasitization in the release plots were higher than those in control plots at all locations in every year and the percent infestation by sugarcane moth borers in release plots was lower than in the control plots at every locations. In 1999 and 2000, outbreaks of the sugarcane moth borer Chilo tumidicostalis were detected in Thailand. Augmentative releases of C. flavipes were made of about 200 adults per acre. The releases were repeated again in 2004 and 2005 for control of this sugarcane stem borer. The results obtained from these studies indicated successful use of C. flavipes for augmentative biological control of the sugarcane moth-borer complex in Thailand.

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Biocontrol of the Sugarcane Stemborer Chilo sacchariphagus (Lepidoptera: Crambidae) in Reunion Island: Optimization of the Technique for a Wider Use in Infested Sugarcane Areas

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From 2000 to 2003, successful biocontrol of a sugarcane stemborer using releases of Trichogramma chilonis Ishii (Hym.: Trichogrammatidae) has been developed through a partnership between research and development. The good results obtained in 2002 and 2003 field trials justified us starting research to optimize the technique. In 2004/05, a new set of experiments was conducted on the susceptible variety R579 in the most infested area, Sainte-Marie (northern part of the island). A weekly dose of 80,000 T. chilonis per hectare released during 4 months was compared to the reference dose of 100,000 T. chilonis/ha. From these treated plots, gains of 17 tonnes cane /ha (+15%) and 35 tonnes cane /ha (+30%), respectively, were obtained when compared to untreated plots, thus confirming the trends observed in 2003. Moreover, in 2005, a density of 100 release points per hectare gave similar results to the one obtained in 2003 with 200 release points/ha. Other results, briefly presented, give basis to define and set up the improvements expected for 2005-2006 trials. The final objective is to propose a sustainable pest management strategy to sugarcane farmers facing high Chilo infestation in some areas of Reunion Island.

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Integration of Insecticides in the Management of Sesamia grisescens Warren Lepidoptera: Noctuidae) in Sugarcane at Ramu, Papua New Guinea

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The larva of the noctuid moth borer, Sesamia grisescens Warren is a serious pest of sugarcane and has become one of the major constraints to sugar production at Ramu Sugar plantation, Papua New Guinea. Recent developments in the management of S. grisescens using insecticides are discussed in this paper, particularly the use of a pheromone trapping/monitoring system to schedule insecticide spraying. It has been found that spraying carried out during the moth flight period is effective in controlling young larvae before they bore into the stems, thus minimizing damage to sugarcane. Strategies to minimize the use of insecticides and the management of potential insecticides resistance are also discussed.

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Importance of Chemical Ecology in Successful Habitat Management Strategies for Sugarcane Stalk Borers

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In subtropical eastern South Africa, sugarcane is a major crop. In this area are numerous wetlands dominated by sedges (Cyperaceae), especially Cyperus papyrus L. and C. dives deLile. Because of very productive wetland soils, many areas have been drained and used for sugarcane production. Sugarcane has thus encroached into a wetland habitat, of which an indigenous borer, Eldana saccharina Walker (Lepidoptera: Pyralidae) and its parasitoids are an integral part. Eldana saccharina found the copious trash produced by sugarcane an ideal oviposition substrate. Its neonate larvae chew into, eat and survive on the sugarcane stalk. As a result, since 1970, this borer has become the biggest threat to sugarcane production in South Africa.

In 1980, a biocontrol program against it commenced, using a new association approach with egg parasitoids, followed by larval and pupal parasitoids. Although very productive laboratory colonies of these parasitoids were initiated and maintained, no field establishment of any after releases ceased was recorded. In the 1990s, more emphasis was placed on collecting indigenous parasitoids of E. saccharina from within Africa. Many were, and still are, being found even in South Africa, where 'text-book' pest/parasitoid interactions were recorded. However, when these parasitoids were released into sugarcane, no establishment was recorded following cessation of releases. Even where sugarcane and C. papyrus and/or C. dives were growing adjacent to each other, with populations of E. saccharina in both, the parasitoids present in the wetlands did not make the transition into the healthy host population in sugarcane. This led to the hypothesis that sugarcane, because of intensive breeding for higher sucrose, no longer produced volatiles that parasitoids used to locate their hosts.

This presentation outlines hypothesis development, presents recent developments in our 'young' chemical ecology program and shows novel habitat management approaches using non-host plants known to produce these 'SOS' plant volatiles, and their impact on E. saccharina populations in sugarcane.

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Cross Resistance in Sugarcane to the Mexican Rice Borer and the Sugarcane Borer (Lepidoptera: Crambidae)

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The sugarcane borer, Diatraea saccharalis (F.), has been the dominant stemborer of sugarcane in the United States. However, in 1980, the Mexican rice borer, Eoreuma loftini (Dyar), became established in the Lower Rio Grande Valley of Texas and has since supplanted the sugarcane borer as the dominant insect pest of that industry. The Mexican rice borer has since expanded its range and now threatens the sugarcane industry in Louisiana. Although dissimilar in several aspects of their biology, there are sufficient similarities that it seems likely that a high degree of cross-resistance for the two species exists in sugarcane. While researching a molecular approach to breeding for stemborer resistance, we were presented with the opportunity to evaluate sugarcane varieties from both Louisiana and Texas in the presence of both stemborer species.

In 2004 we planted 80 sugarcane varieties in a randomized complete-block design with four replications. Individual plots were 6 m in length. Random 10-stalk samples were collected from each plot in 2005 for damage evaluation. Damage was measured as percent damaged internodes. Mexican rice borer was the dominate borer species and responsible for 23% (±0.62) bored internodes verses 7% (±0.33) bored internodes for the sugarcane borer. Texas varieties averaged 22% (±0.73) damage internodes by the Mexican rice borer, while Louisiana varieties averaged 25% (±1.09). For the sugarcane borer, damaged internodes averaged 8% (±0.46) for Texas varieties and 5% (±0.42) for Louisiana varieties. We found strong statistical evidence for cross-resistance among the Louisiana varieties, but no evidence among the Texas varieties. We have ratooned the study with plans to collect another year of data in 2006. Meanwhile, molecular markers are being applied to these genotypes in an attempt to tag major resistance genes involved in stemborer resistance.

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Bioecology of the Yellow Aphid, Sipha flava Forbes, in Sugarcane in Ecuador

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The yellow aphid, Sipha flava Forbes (Homoptera: Aphididae) is occasionally an important pest in sugarcane. However, little is known of its ecology and biology, as well as its effects on sugarcane production and sugar recovery. This study, carried out from August 2004 to June, 2005, determined the biology, population dynamics, and the predator complex of the yellow aphid in Ecuador. This species has a gradual metamorphosis (paurometabola) and parthenogenetic, viviparous reproduction. The nymphal period has four instars and is completed in 11-14 days. The adult show polymorphism with apterous and winged forms; and no males are found. All the individuals were reproductive, producing 22-25 offspring per female, at a rate of 1-2 offspring per day. Longevity of adults was 16-25 days. The yellow aphid forms colonies on the lower leaf surface but mainly at the TVD+1, +3, +4, +5, and +6. The highest infestations were found during a dry period from October to December in cane of less than 5 months old. The most common natural enemies are: Scymnus spp, Cycloneda sp, Hippodamia sp and Coleomegilla (Coleóptera: Coccinellidae); Leucochrysa sp and Ceraeochrysa sp (Neuroptera: Chrysopidae); Baccha sp and Mesogramma sp (Díptera: Syrphidae). Several spider species of the families Salticidae and Tetragnathidae were also collected. The population fluctuations of the yellow aphid were related to the presence of the natural enemies, especially Scymnus sp. The research also determined the partial biology partial and predatory capacity of Scymnus sp 1, Cycloneda sp and Ceraeochrysa sp. Many species of graminaceous and cyperaceous weeds have been found to be host plants for the yellow aphid.

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Plant Resistance Studies with the Sugarcane Aphid on Sugarcane in Louisiana

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The sugarcane aphid, Melanaphis sacchari (Zehntner), although a minor pest of sugarcane in Louisiana, is spreading throughout the industry and is the main vector of sugarcane yellow leaf virus. Host-plant resistance is a management option successfully employed against various aphids in different cropping systems. On-going studies are aimed at looking into possible sources of resistance to the sugarcane aphid in the commercial or near-commercial germplasm of sugarcane in Louisiana. Five commercial sugarcane varieties
(L 99-128, LCP 85-384, HoCP 96-540, HoCP 91-555, and Ho 95-988) are being screened in greenhouse pot studies for antixenosis, antibiosis, and tolerance. For antixenosis tests, 50 apterous nymphs were released at the center of a wooden platform that had one leaf from each variety stuck at the margins. The aphids were recovered after 24 hours. There were four replications of each variety in one experiment and the experiments were repeated five times. For antibiosis tests, 2 aphids were confined in a clip-on cage on one leaf of each variety with data collected daily to maturity assessing days in reproduction and number of nymphs produced per aphid. Antixenosis tests did not show difference in aphid preference, but antibiosis tests indicate pronounced variation among varieties. The days in reproduction and number of nymphs produced were highest in L 99-128, while HoCP 91-555 expressed the strongest antibiosis with the least number of days in reproduction and fewest numbers of nymphs produced. Other varieties showed intermediate levels of antibiotic resistance. Tolerance tests and further studies on the qualitative differences in these cultivars and effects of plant stress on aphid performance are also underway. From these studies, an efficient and rapid system of aphid resistance evaluation is being established for the Louisiana varietal development program.

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Basis for the Management of the Colombian Sugarcane Spittlebug, Mahanarva bipars (Hom: Cercopidae)

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The spittlebug, Mahanarva bipars, was recorded for the first time attacking sugarcane fields (1400 masl = meters above the sea level) for panela (=gur) production. These fields were located 25 km away from sugarcane fields of Risaralda Mill. A research project was initiated to develop an IPM program in order to minimize its damage and to prevent its introduction to the Cauca River Valley, the most important sugarcane growing area in Colombia. Its life cycle lasted approximately 100 days (T°: 19 ± 1°C, RH: 85%), which is longer than lifecycles of other species of spittlebugs attacking sugarcane. Eggs are laid in the soil or in the leaf litter at the base of the stalks. Eggs hatch 28.2 days (min.: 18, max.: 41) after they are laid, and there is no evidence of the presence of diapause in this stage, as is common in other species of spittlebugs related to sugarcane. Its distribution in the infested area remained the same after a 6-month period. Changes in its populations are more related to the crop development than to climatic conditions. Up to 4 months after germination, fields are free of spittlebugs, and then their numbers start to increase as the crop matures. Eight insecticides were tested for spittlebug control. Among them, carbaryl and imidaclopril were the most effective. Fifteen sugarcane commercial varieties were evaluated for susceptibility / resistance to M. bipars. MZC 82-11, RD 75-11, MZC 74-275 and MZC 84-04 were the most susceptible as they hosted the highest number of individuals and POJ2878 and POJ2714 were the most resistant. These two varieties are the most important commercial ones grown in the infested area. Removal of the oldest leaves contributes to reducing the number of spittlebugs and fertilization shows a tendency to increase the numbers of nymphs and adults.

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Integrated Management of Sugarcane White Woolly Aphid, Ceratovacuna lanigera (Homoptera: Pemphigidae)

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Sugarcane is one of the important commercial crops in India, and is attacked by more than 250 species of insect and non-insect pests. Recently the outbreak of the white woolly aphid, Ceratovacuna lanigera, was observed in Maharashtra infesting 40,000 ha and resulting in serious economic losses of 5-25 t/ha and sugar loss of 0.5-2 units. During June 2004, it was observed at E.I.D. Parry command area in South India. To prevent the pest spreading and infecting the sugarcane command area of Tamilnadu in general and E.I.D. Parry factories in particular, a detailed survey on the status and the bio ecology of the pest was carried out. Based on the results of our survey, various management measures involving screening of resistant varieties, mass rearing of predators such as Dipha aphidivora (Lepidoptera: Pyralidae), Micromus sp. (Neoroptera: Hemerobiidae) and syrphids were evaluated. In addition, testing of botanical pesticides, such as NEEMAZAL® 5%F, and other agronomic practices were also examined. This paper describes how the combination of different technologies helped to control the white woolly aphid effectively.

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Soft Scale Pulvinaria iceryi Signoret (Homoptera: Coccidae): An Important Pest of Sugarcane in Mauritius

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The soft scale, Pulvinaria iceryi Signoret (Homoptera: Coccidae), has been recorded from Mauritius, Réunion, Agalèga, South Africa, Zimbabwe, Madagascar, Zambia and Uganda. A severe outbreak occurred in Mauritius in 1976-77 when more than 4200 ha were infested causing an estimated loss of about 20000 tonnes of sugar. Many fields were destroyed and had to be replanted during that outbreak. Severe infestation was seldom observed after that. However, since 1997 localised severe infestations have been recurring in many fields every year. In 2005, more than 600 ha were infested leading to an estimated loss of more than 2000 tonnes of sugar. The insect lives on green plant tissues. Infestation in sugarcane causes reduction or stoppage of growth, purple or yellow discolouration of leaves and their premature death. The entire cane stool may also die when infestation is severe. Plants, which survive attack, remain weak and may die later or fail to ratoon after harvest. Up to 69 % reduction in IRSC and 34% in juice purity was noted in severely infested canes. Plant injury is due to the removal of sap and also to the injection of toxic saliva into the plant.

T he insect excretes copious amounts of honeydew, which attract ants and enables a black mould to spread on the foliage. Satisfactory natural control is normally exerted by several species of parasitoids and predators. The vital importance of these is such that use of insecticides against the pest cannot be contemplated. The management of this pest relies essentially on measures that favour development and survival of its natural enemies.

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Sugarcane Longhorn Stem Borer, Dorysthenes buqueti Guerin, and Its Natural Enemies in Thailand

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The sugarcane longhorn stem borer, Dorysthenes buqueti Guerin, is a major soil insect pest of sugarcane on many cane plantations in Thailand. Outbreaks usually occur in sandy loam soils and can spread into larger infected areas than the white grub, Lepidiota stigma (Fabricius). Survey and evaluation of natural enemies of sugarcane longhorn stem borer were conducted and only a mite, Caloglyphus sp., and the pathogen Metarhizium anisopliae were found as natural enemies. Caloglyphus sp. is an ectoparasite of the larva, pupa and adult sugarcane longhorn stem borer, but it is not effective as a biological agent. M. anisopliae is an entomopathogenic fungus in soil and is frequently found infecting D. buqueti in nature. In the laboratory, a symptom of infected larva of sugarcane longhorn stem borer is its slow movement 6 days after inoculation. There was no visible external fungal development on the larva before death. Death of larva occurred 7 days after inoculation. The colour of infected larvae changes from pale yellow to white and then to olive green. The pathogen can infect eggs, larvae, pupae and adults of sugarcane longhorn stem borer. The mortality of larvae was 100% 14 days after inoculation with a conidial suspension of 3x107 conidia/mL. In the greenhouse, data showed that 80-100% of sugarcane longhorn stem borer were killed 20 days after application. T he investigation showed that M. anisopliae is an efficient natural enemy and appropriate for biological control of the sugarcane longhorn stem borer in Thailand.

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Preliminary Investigation Into the Use of Insecticides for the Control of the Sugarcane Thrips Fulmekiola serrata (Kobus) (Thysanoptera:Thripidae) in Sugarcane Cultivated in South Africa

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The recent invasion of the South African sugar industry by the sugarcane thrips, Fulmekiola serrata (Kobus), has necessitated a planned response to the development control measures against this pest. Current efforts are focused on assessing the distribution and intensity of this pest as well as examining host plant resistance and the use of insecticides. Reported here is progress with the use of insecticides for thrips control.

Three insecticide trials were conducted in different regions of the industry - the highlands, the coastal region and the northern region (where the outbreak was first observed). Five insecticides were tested for efficacy in each trial (Vydate, Polytron K, Hunter, Regent and Ethipro). In one trial, Confidor replaced Vydate. Each product was tested at two rates and applied twice, 1 month apart. Surveys conducted 2 weeks after the second treatment application showed that in the highland trial, Vydate, Polytron K and Ethipro were more effective against adults, while no product was shown to be effective against nymphs. In the coastal trial, all products were effective against adults, while only Vydate, Regent and Hunter were effective against nymphs. In the northern trial, only Ethipro was effective against adults, while Ethipro, Confidor and Hunter were effective against nymphs. In subsequent surveys of the trials, conducted 1 month after the second survey, treatment effects were seen to decline and in some instance thrips numbers were greater in treated plots. These results are discussed in relation to the value of using insecticides for the control of this pest in sugarcane.