

COMBATING SUGARCANE PESTS IN SOUTH AFRICA: FROM RESEARCHING BIOTIC INTERACTIONS TO BIO-INTENSIVE INTEGRATED PEST MANAGEMENT IN THE FIELD

By

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KEYWORDS: Chilo, Eldana, IPM, Induced Resistance, Direct and Indirect Resistance.

Abstract

THE MOST common definition of conventional Integrated Pest Management (IPM) is ‘a decision-making process using multiple pest management tactics to prevent economically damaging out-breaks while reducing risks to human health and the environment’. Low-level IPM is the most often employed form, consisting of the most basic of IPM practices—scouting and insecticide applications according to economic thresholds. Some growers have progressed to medium-level IPM, the adoption of a few additional preventive measures, e.g. cultural controls and plant resistance, coupled with efforts to cut back on broad spectrum pesticide use in order to protect beneficial organisms. These IPM strategies are mainly targeted towards single pest species and do not consider all of the pests in a specific agro-ecosystem. High-level, or Bio-intensive IPM, is where multiple interventions are integrated in a bio-intensive approach targeting multiple pests. Bio-intensive IPM is based on holistic agro-ecosystem interactions, in which knowledge about insects, their symbionts, pathogens, natural enemies, plants, endophytes and interactions between all of these are combined to develop IPM in an area-wide, environmentally friendly manner. Reviewed here are advances in knowledge of, and of biotic interactions between direct, indirect and induced plant resistance, plant nutrition, habitat management, chemical ecology, natural enemies, soil-health, micro-organisms such as endophytic fungi and *Wolbachia* and phylogenetics and phylogeography. All of these are potential building blocks of a bio-intensive IPM system under-construction at SASRI. Also discussed are opportunities and challenges in these areas of research, taking into account bio-security threats to the South African sugar industry and possible limitations in current sugarcane plant breeding material.

Introduction

SASRI has been working to improve control of the African sugarcane stalk borer *Eldana saccharina* Walker (Lepidoptera: Pyralidae) since the early 1970s (Carnegie, 1974). A few cultural control measures (Carnegie, 1981; Carnegie and Smaill, 1982) and several less susceptible varieties have been developed against it (Keeping, 2006).

However, it still remains a pest throughout the sugar industry (Webster *et al.* 2005, 2009).

In order to build resilience into the sugarcane agro-ecosystem, a refocusing of control efforts into a bio-intensive area-wide integrated pest management approach is necessary (Klassen, 2005). Such an approach marries conventional control options with ecologically based new technologies

such as delineation of within species populations, chemical ecology, stimulo-deterrent diversion (push-pull) and enhancement of natural enemies through habitat management and good soil health practices, to produce sustainable IPM strategies applicable across large areas involving multiple stakeholders (Conlong and Rutherford, 2009).

There is also a need to refocus bio-security to again build resilience to invasion into agro-ecosystems, rather than building walls around them (Waage and Mumford, 2008). One such regional threat is the spotted sugarcane stem-borer, *Chilo sacchariphagus* (Bojer) (Lepidoptera: Crambidae).

This pest originates in South-East Asia and is largely restricted to *Saccharum* as host plants (Bleszynski, 1970). *C. sacchariphagus* is now present in Mozambique and is an imminent bio-security threat to the South African, Malawian, Tanzanian and Swazi sugar industries (Way and Turner, 1999).

IPM–From the bottom up

Plant resistance to pests and diseases can be linked to optimal physical, chemical and, biological properties of soil (Altieri and Nicholls 2003; Zehnder *et al.*, 2007). ‘Healthy’ soil is described as having sufficient organic matter to support a high diversity of animal (arthropods, nematodes etc.) and microbial life. Soils can act as important reservoirs for a diversity of entomopathogenic fungi and nematodes, as well as predaceous arthropods, which can contribute significantly to the regulation of pest populations (Keller and Zimmerman, 1989).

Ninety percent of insect pest species spend at least part of their life cycle in soil (Villani and Wright, 1990; Kaya and Gaugler, 1993). In addition, pests that occasionally come into contact with soil can be attacked by predators or become infected by entomopathogens (Klingen *et al.*, 2002). After the harvest of heavily infested sugarcane, the residual *E. saccharina* population from which infestation of the following ratoon crop can be expected is found in the sugarcane stubble at soil level and in the stool below ground.

By minimising compaction and tillage, and by mulching and increasing organic matter, soils can support increased populations of entomopathogenic fungi, entomopathogenic nematodes and predaceous arthropods such that these natural enemies of insects can be included in the suppression of pests in a conservation biological control strategy (Landis *et al.*, 2000; Meyling and Eilenberg, 2007).

Direct and indirect host-plant resistance

Insect resistance in grasses is the result of many defence mechanisms that act in parallel to limit the damage of herbivore attacks. Many of these defence mechanisms are based on plant secondary metabolites, or defensive proteins that directly affect the herbivore due to their toxic, deterring or anti-nutritional properties.

Structural resistance also occurs. Keeping and Meyer (2002) have shown that resistance to *E. saccharina* can be enhanced using soil-applied silicon, which becomes incorporated into the plant alongside lignin and fibre increasing resistance to penetration. These authors emphasise a relationship between nitrogen and silicon nutrition whereby the ratio of these elements determined in leaf analyses can be used as an indicator of *E. saccharina* infestation risk. Keeping and Rutherford (2004) have reviewed mechanisms of direct resistance to *E. saccharina*.

Two decades ago, a new type of defence mechanism, termed indirect defence, was first described in maize (Turlings *et al.*, 1990). Central to this type of defence is the release of a volatile plant SOS signal, a mixture of volatile secondary metabolites.

Plant volatiles are derived from complex biochemical processes and include fatty-acid-derived products [methyl-jasmonate, cis-jasmone, and green leaf volatiles (GLV) like hexenal and hexenyl-acetate], monoterpenes, sesquiterpenes, and shikimic acid-derived products [e.g. methyl-

salicylate and indole] (Turlings *et al.*, 1998; Ferry *et al.*, 2004). These can serve as signals, not only to attract predators and parasites of attacking herbivores, but they can also repel the herbivore itself, and they can elicit responses in neighbouring undamaged plants (Bruin *et al.*, 1995; De Moraes *et al.*, 2001). The use of elicitors to directly activate or prime resistance shows much promise as an IPM tool (Zehnder *et al.*, 2007).

Habitat management

Therefore, it is very important to understand the role of plants in managing insect populations. An example comes from our experience in trying to control *E. saccharina* with indigenous and new association biological control agents.

Conlong *et al.* (2007) found that female *E. saccharina* moths will accept *Cyperus papyrus* and *Cyperus dives* as host plants in preference to the indigenous grass *Pennisetum purpureum*, with sugarcane being least preferred.

A preference was again demonstrated by Keeping *et al.* (2007), who showed that, if given the choice between older sugarcane and maize, *E. saccharina* would oviposit on the maize, even if it were Bt maize.

Keeping *et al.* (2007) further showed that larval survival on this Bt maize was zero. A hierarchical oviposition preference (Thompson and Pellmyr, 1991) is suggested in Southern African *E. saccharina* females, with most oviposition found on or close to its indigenous sedge hosts, followed by indigenous grasses, and then sugarcane.

However, a large proportion of these eggs were not laid directly on the plants, but in cryptic oviposition sites in the vicinity of potential host plants (Kasl, 2004; Barker, 2008).

Thompson and Pellmyr (1991) suggest that egg dumping is behaviour of highly polyphagous species (*E. saccharina* attacks species of the Cyperaceae, Typhaceae, Juncaceae and Gramineae (Atkinson, 1980; Conlong, 2001; Mazodze and Conlong, 2003)), or in species associated with superabundant host plants.

These are both possibilities with *E. saccharina* in sugarcane and its cyperaceous hosts, as both hosts occur in large essentially mono-specific stands. Adult females therefore may not be particularly attracted by host or 'pull' plants in an IPM system and conversely they may be more strongly repelled by non-host or 'push' plants, since the presence of these could indicate that the insect had reached the edge of the preferred mono-specific host plant stand.

Nevertheless, *E. saccharina* seems to have a hierarchical preference in choosing a host plant habitat to oviposit in, i.e. Cyperaceae and maize, both of which have *E. saccharina* population controls in place; natural enemies in the Cyperaceae (Conlong, 1990, 1997, 2000) and genetically engineered Bt toxin in maize (Keeping *et al.*, 2007).

Further evidence to promote habitat management as a control option was provided by Khan *et al.* (1997a, 2001) who demonstrated the repellent 'push' properties of the indigenous grass *Melinis minutiflora* Beauv. to cereal stemborers, and also its attractant properties to their parasitoids (Khan *et al.*, 1997b). *M. minutiflora* produces volatiles similar to damaged maize, even in the absence of pest damage to itself (Gohole *et al.*, 2003).

Stimulo-deterrent diversion using *M. minutiflora* has been successfully deployed against the spotted stemborer, *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae), in Central African maize (Cook *et al.*, 2007; Khan *et al.*, 1997a,b).

In a glasshouse experiment at SASRI, *Xanthopimpla stemmator* (Thunberg) (Hymenoptera: Ichneumonidae) parasitised more *E. saccharina* pupae in sugarcane in close proximity to this grass, than in sugarcane only (Figure 1) (Kasl, 2004). This suggests that the searching behaviour of the parasitoid was increased by *Melinis* volatiles.

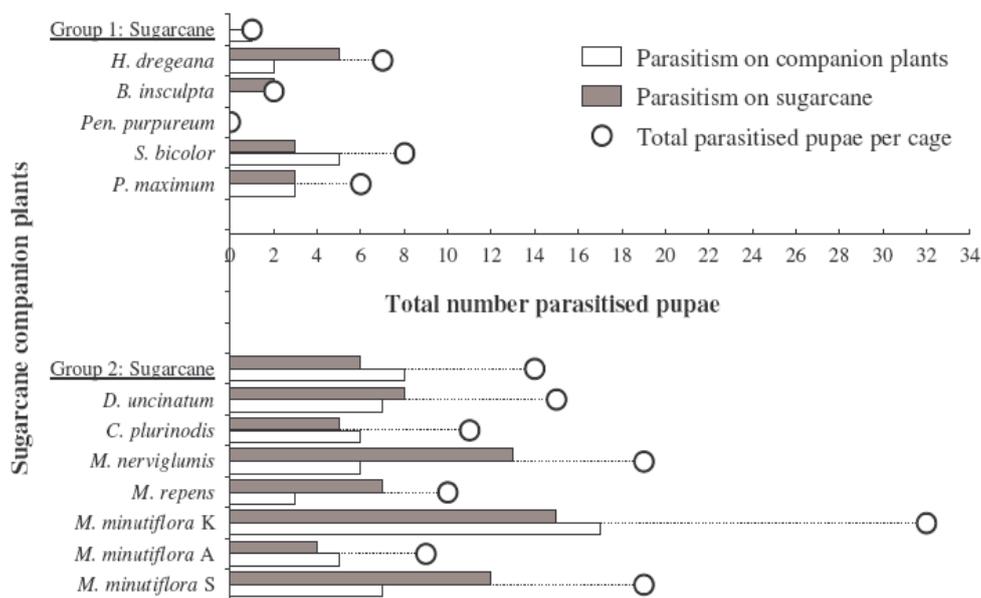


Fig. 1—Total *Eldana saccharina* pupae parasitised by *Xanthopimpla stemmator* when offered on companion plants (unshaded bars) and on sugarcane (shaded bars). Total number of parasitised pupae, from 100 pupae offered per experiment, indicated by circular points. Plants were tested in two groups. (K—Kenyan; S—South African; A—Australian) (from Kasl, 2004).

The next phase in developing this habitat management approach for *E. saccharina* was to set up field trials using rows of *M. minutiflora* along either in irrigation or contour breaks as a repellent or ‘push’ plant. *E. saccharina* populations and damage were halved in field plots planted next to strips of *M. minutiflora* compared to control plots, suggesting that the pest was repelled by *Melinis* volatiles (Figure 2) (Barker *et al.*, 2006). Planting *Cyperus papyrus* as a trap, or ‘pull’ plant along drainage lines of selected sugarcane fields resulted in significantly reduced damage in the cane associated with it (Figure 3) (Kasl, 2004).

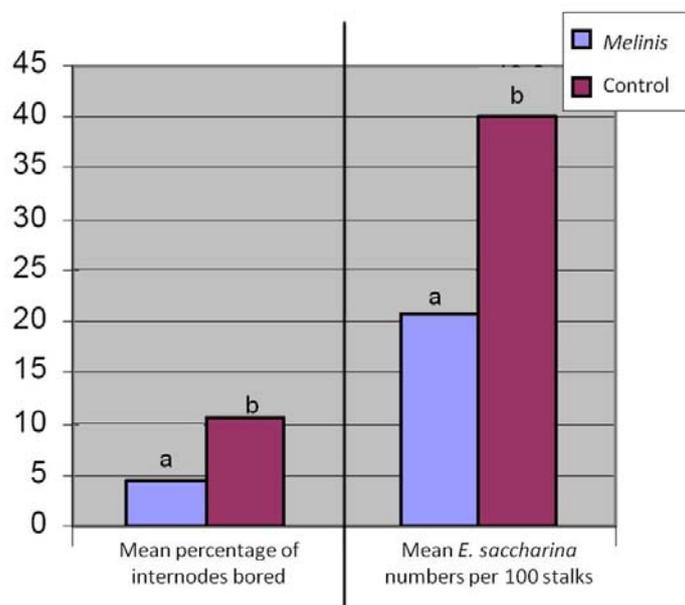


Fig. 2—Mean percent internodes damaged and *E. saccharina* numbers in cane planted with (at 20 row intervals) and without *Melinis minutiflora* (differences significant at $p < 0.001$ within each measure) (from Barker *et al.*, 2006).

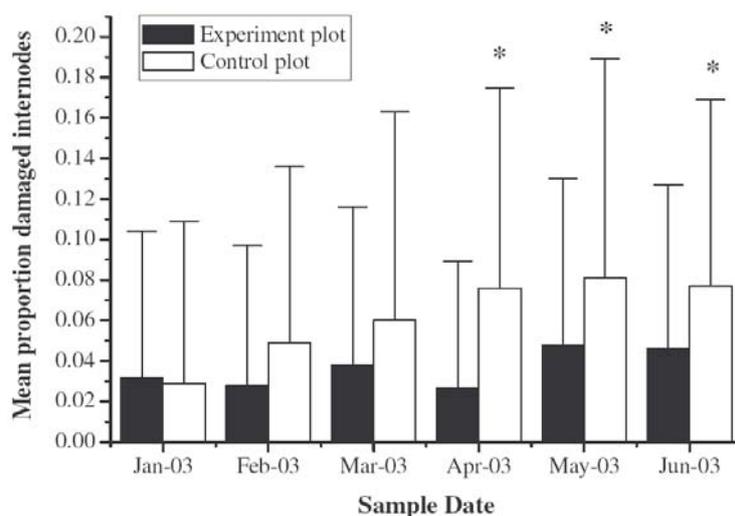


Fig. 3—Monthly damage levels in sugarcane (var. NCo376) adjacent to *Cyperus papyrus* stands (shaded bars), and in control sugarcane not associated with *C. papyrus* (unshaded bars). * Means (+1 SD) significantly higher in paired tests at $\mu = 0.05$ (from Kasl, 2004).

Based on the success of these trials, a farm based habitat management plan has been devised, incorporating indigenous host plants and Bt maize as ‘pull’ plants for *E. saccharina* and *M. minutiflora* as the ‘push’ component. This bio-intensive approach has been expanded into a Bio-intensive-IPM plan, incorporating plant nutrition, soil health and the use of less susceptible sugarcane varieties (Figures 4 and 5).



Fig. 4—A habitat managed field of sugarcane. The grass with the purple flower heads is *Melinis minutiflora* (From Conlong and Rutherford, 2009).

An added aspect to the plan is to plant buckwheat at the time of sugarcane planting. This is to attract adult parasitoids and predators into the sugarcane environment by providing a pollen and nectar source for their survival during periods of low host availability, much the same as advocated

by Wäckers *et al.* (2005) and Zehnder *et al.* (2007) in their conservation biological control approach to enhance the activity of indigenous natural enemies.

Does sugarcane emit SOS volatiles when attacked by *E. saccharina*?

In contrast to the situation in the natural hosts of *E. saccharina*, negligible parasitism has been recorded in sugarcane, even when this crop was planted adjacent to infested indigenous host plants with abundant parasitoids present (Conlong and Hastings, 1984). Many introduced parasitoids have also failed to colonise the sugarcane habitat (Conlong, 1997).

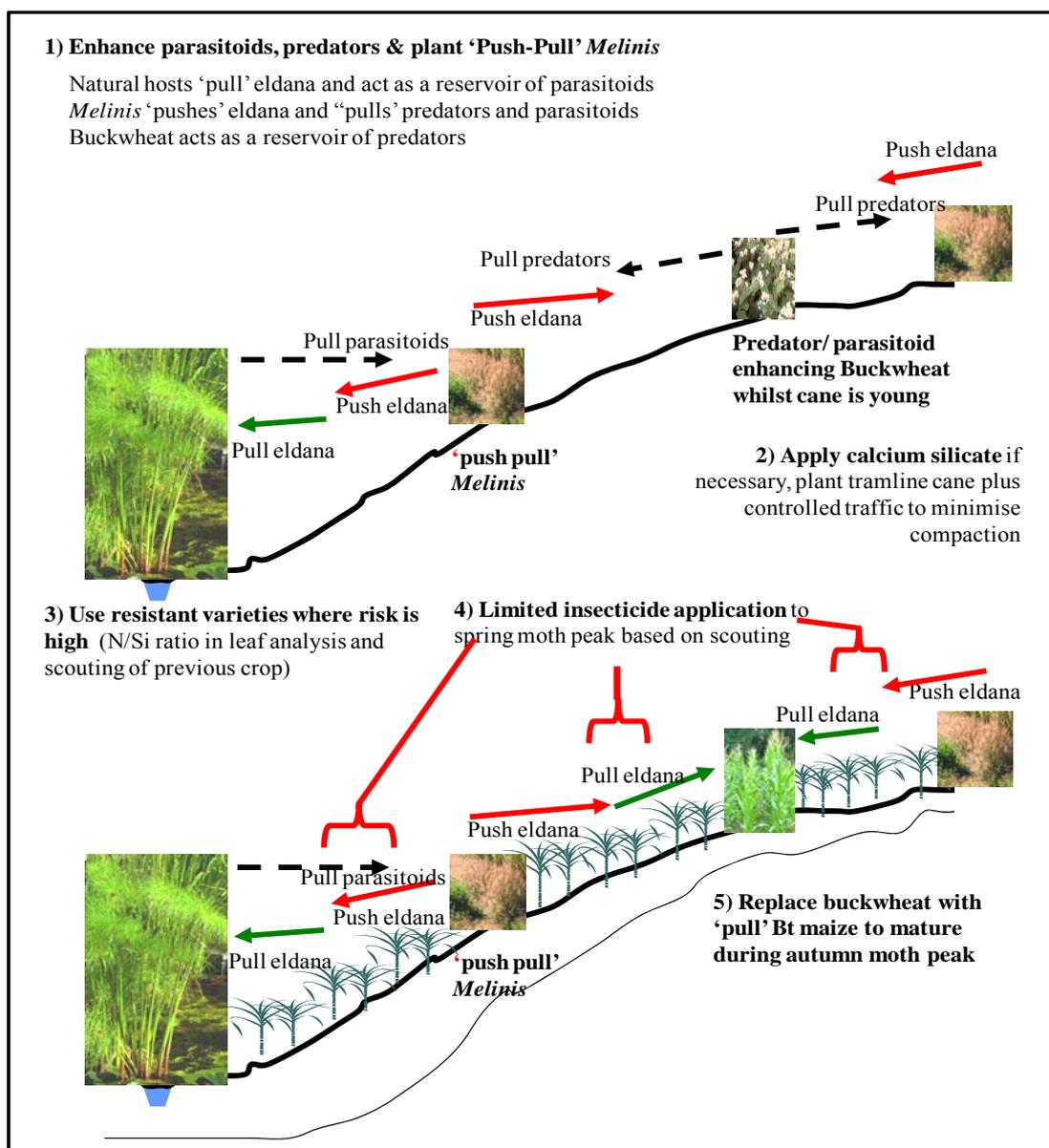


Fig. 5—Conceptual diagram for a bio-intensive habitat management based IPM approach (Modified from Conlong and Rutherford, 2009.)

Using gas chromatography, Smith *et al.* (2006) showed different volatile emission patterns between *Cyperus papyrus* infested by *E. saccharina* and uninfested *C. papyrus*. Infested sugarcane was neither qualitatively or quantitatively different from uninfested sugarcane and both were different from *C. papyrus* (Figure 6). In addition, these authors showed that the parasitoid *Goniozus indicus* (Ashmead) (Hymenoptera: Bethyridae) was attracted to frass from *E. saccharina* that had

fed on *C. papyrus*, and was not attracted to frass from *E. saccharina* that had fed on sugarcane. Adding this to the lack of parasitism recorded in sugarcane, even in the vicinity of natural host plants harbouring parasitoids, suggests that modern sugarcane genotypes may not attract natural enemies through the release of herbivore induced SOS volatiles, or that they may differ in the ability to do so.

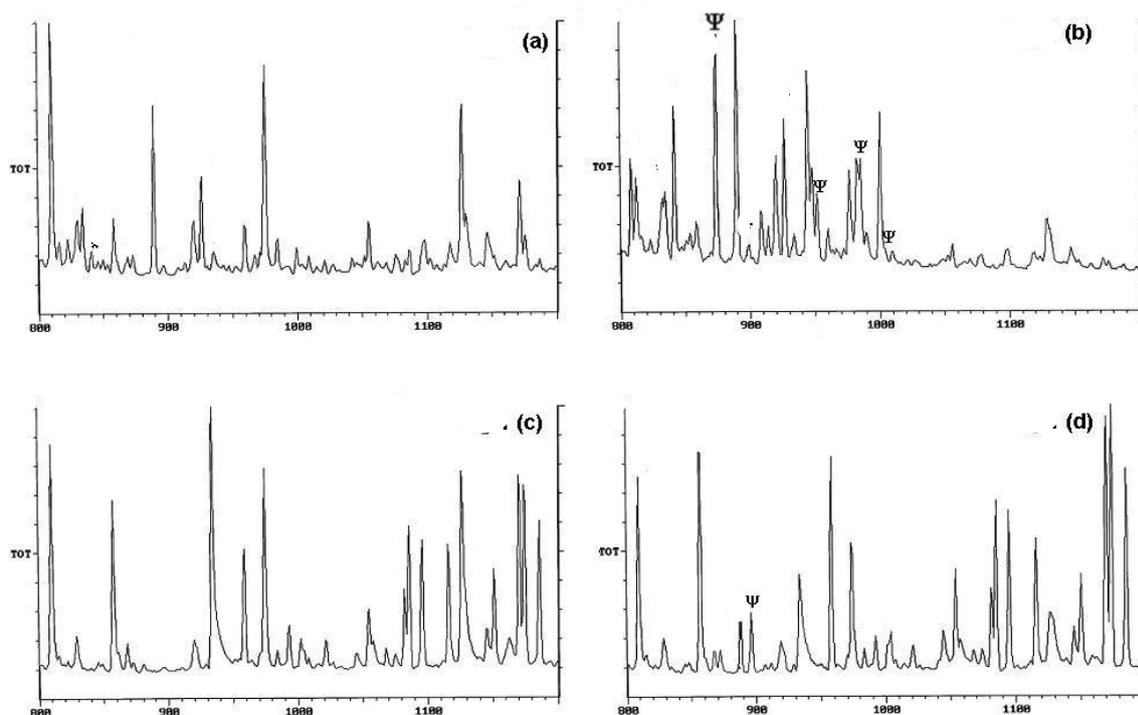


Fig. 6—Gas chromatograms of volatiles released by (a) uninfested *C. papyrus*, (b) infested *C. papyrus*, (c) uninfested sugarcane variety N11 and (d) infested sugarcane variety N11 (Ψ = compounds showing major differences—volatiles were not identified) (from Smith *et al.*, 2006).

Genotypic differences in plant volatile emission

The ability to mount indirect defence against *E. saccharina* may have been lost in sugarcane as a result of inadvertently concentrating on direct resistance in a monoculture oriented plant breeding selection program. Besides this possibility, the release of plant volatiles is characterised by a large degree of genotypic variation within plant species, for example, maize genotypes and their closest wild relatives, *Zea mays* ssp. *parviglumis* and *mexicana* (collectively known as teosinte), show significant differences in emissions when attacked (Gouinguene *et al.*, 2001; Degen *et al.*, 2004).

An example of loss of indirect defence has been found below ground in maize. In response to feeding by the western corn rootworm, *Diabrotica virgifera virgifera* (LeConte) (Coleoptera: Chrysomelidae), maize roots release (E)-b-caryophyllene that attracts the entomopathogenic nematode *Heterorhabditis megidis* (Rasmann *et al.*, 2005). Most North American maize lines do not release (E)-b-caryophyllene in response to rootworm attack, whereas many European lines and teosinte accessions do (Kollner *et al.*, 2008).

The existence of genotypic differences in the emission pattern of volatile compounds for Kenyan *M. minutiflora* cultivars has also been demonstrated (Gohole *et al.*, 2003). The lack of response by *X. stemmator* in the presence of Australian *M. minutiflora* again points to variability within this species (Figure 1). Australian *M. minutiflora* is extensively used for cattle fodder. The strong odour of the plant can be carried through to milk and, because of this, there has been an

extensive program to breed a less volatile variety with similar nutritional quality. The volatile(s) that the parasitoid responded to in the African variety could have been bred out of the Australian variety, as explained by Pickett and Woodcock (1993).

Breeding for artificially primed and induced resistance

The loss of the ability to produce an SOS volatile and the observed genotypic variability in their production by maize points towards the exploitation of the phenomenon in sugarcane, by breeding varieties for enhanced attractiveness to natural enemies (Bottrell *et al.*, 1998). This could be achieved through the application of an artificial elicitor followed by selection for enhanced direct and indirect resistance in a system that includes natural enemies.

Experimental application of elicitors is fairly simple and it is worth trying to make selections among plant breeding lines grown under the influence of plant defence elicitors, aiming for new cultivars optimised for artificially inducible resistance traits without significant yield penalty (Agrawal *et al.*, 2002; Ahman, 2006). Historically, induced resistance research has mostly concentrated on direct activation where resistance is expressed in advance of challenge by the pest. The possibility of priming as a mechanism of protection has often been overlooked because it only becomes apparent in challenged plants. Priming equates to a 'heightened state of readiness', in that in the event of damage to a primed plant, resistance responses are faster and more intense (Conrath *et al.*, 2006).

Direct activation of resistance might best be employed where the target pest is widespread and has predictable outbreaks. An example is the sugarcane thrips, *Fulmekiola serrata* (Kobus) (Thysanoptera: Thripidae) that affects more than two thirds of sugarcane plants in a particular field at the same time. Outbreaks occur in summer with numbers peaking every January since the pest was first discovered on the African continent in 2004 (Way *et al.*, 2006). Primed resistance would, however, be more suitable for *E. saccharina*, since a much lower proportion of plants is attacked and infestations tend to be patchy.

Ecology and phylogeography

The basic building block of IPM is still regarded as ecology (Gurr *et al.*, 2003). In a study of *E. saccharina*, Conlong (2001) found behavioural, host plant and natural enemy differences in populations occurring between South, Central and West Africa, with them seemingly coming together in Uganda.

These confusing factors between different populations of what is otherwise a morphologically similar species made it an ideal candidate for molecular systematic analyses. Assefa *et al.* (2006), using the cytochrome oxidase subunit 1 (CO1) region of the mitochondrial genome, separated *E. saccharina* into three distinct groups (west, south and Ethiopian). Two of these groups (west and south) were found in Uganda.

The CO1 genetic diversity between these groups was larger than that between recognised species within the genus *Ostrinia* (Lepidoptera: Crambidae) (Coates *et al.*, 2005). In other insects, unexpected mtDNA CO1 patterns have led to the discovery of cryptic species (Hebert *et al.*, 2004; Smith *et al.*, 2007). Such diversity should encourage us to confirm covarying genetic, behavioural and ecological characteristics which would lend support to the notion that cryptic species exist within the *E. saccharina* complex.

In IPM programs which use classical biocontrol as one of their management options, or translocation of natural enemies (Schulthess *et al.*, 1997), these aspects can be enhanced by using such techniques to identify cryptic species, or populations of species most closely related to each other, so that more informed decisions can be made regarding natural enemy selection for use against pests. This applies not only to pest species, but also to parasitoids (Dittrich *et al.*, 2006; Muirhead *et al.*, 2006; Ngi-Song *et al.*, 1998).

Since 1992, surveys for indigenous parasitoids of *E. saccharina* in a variety of African habitats have been completed. Thirty species of larval parasitoids have been found in eight countries (Conlong, 2000). Several of these have failed to parasitise *E. saccharina* from South Africa due to incompatibility. For example, from West Africa, *Descampsina sesamiae* (Diptera: Tachinidae) larvae are encapsulated by *E. saccharina* (Conlong, 1997). *Cotesia sesamiae* (Cameron) (Hymenoptera: Braconidae) from South Africa is also unsuccessful as eggs are encapsulated (Potting *et al.*, 1999). Further collections of parasitoids from Central Africa, where southern and western populations of *E. saccharina* co-exist, could reveal biotypes of parasitoids that could be effective against this pest (Muirhead *et al.*, 2006; Ngi-Song *et al.*, 1998).

Wolbachia

These obligate intracellular bacteria (Phylum α -Proteobacteria: Family Rickettsiaceae) are commonly found in diverse insect taxa and can profoundly alter their host's reproduction. They are maternally inherited, residing mostly in the reproductive tissues of their hosts and it has been suggested that they may infect over 70% of arthropod species worldwide (Jeyaprakash and Hoy, 2000).

In their reviews on the biology of *Wolbachia*, Werren (1997), Floate *et al.* (2007) and Bourtzis (2007) all regard the symptoms of infection such as feminisation of genetic males, male embryo killing and cytoplasmic incompatibility (CI) as potentially useful characters for insect population regulation. Attempts have been made to exploit CI as a method to suppress natural populations of pests in a way analogous to the sterile insect technique through the release of incompatible infected male insects (Brower, 1980). Alternatively *Wolbachia* could be introduced into South African *E. saccharina* (populations of which are currently free of infection) using hybrid introgression and field release. *Wolbachia* have potential as a new type of biological control agent by altering the reproductive success of their hosts and probably also that of parasitoids (Fytrou *et al.*, 2006).

Recent results (Rutherford, unpublished) have confirmed the presence of *Wolbachia* in *E. saccharina* from Kenya, Uganda and Tanzania, all close to the probable centre of origin for *E. saccharina*, while it is absent from *E. saccharina* populations in western and southern Africa. This now opens up the potential use of *Wolbachia* in our IPM strategy.

The interaction between *E. saccharina* and *Fusarium*

When *E. saccharina* bores in sugarcane, the tissue surrounding the boring becomes reddish discoloured often affecting a whole internode. Following on from this, and work of Schulthess *et al.* (2002), McFarlane *et al.* (2009) cultured numerous *Fusarium* spp. isolates, from the red tissue surrounding *E. saccharina* borings, as well as from undamaged stalks as endophytes. Most of the isolates from borings were beneficial to *E. saccharina* in artificial diet in terms of larval survival and growth rate, and were attractive to neonates in olfactory choice assays.

A few of the endophytic isolates were antagonistic, with *E. saccharina* neonates repelled and growth retarded. Moths may also be attracted or repelled depending upon isolate. Ako *et al.* (2003) showed that West African *E. saccharina* females laid on average 32 eggs on maize stalks with *F. verticillioides* present as an endophyte, versus nine on stalks grown from fungicide or hot water treated seeds.

In an integrated control approach against *E. saccharina*, seedcane hot water treatment and/or treatment with fungicides could reduce endophytic colonisation by *Fusarium* isolates beneficial to *E. saccharina*, thereby reducing the chance of infestation. Alternatively, the facilitation of endophytic colonisation of sugarcane by *Fusarium* isolates antagonistic to *E. saccharina* could afford more sustainable and environmentally friendly protection from this stalk borer. Another approach could be to exploit the differences in volatiles between repellent and attractive isolates in the development of repellents and lures of use in the field.

Concluding remarks

Khan *et al.* (1997a) described a ‘push–pull’ system effective against cereal stemborers in maize. This system includes the indigenous parasitoid *Cotesia sesamiae* as well as *C. flavipes* which was introduced against the exotic *Chilo partellus* (Overholt *et al.*, 1997). *C. sacchariphagus*, now present in Mozambique, is being parasitised by both *C. flavipes* and *X. stemmator* on larvae and pupae respectively in sugarcane (Conlong, pers.comm). Ngumbi *et al.* (2005) showed that *C. flavipes* females respond to terpenoids and the green leaf volatiles which are released by maize plants damaged by *C. partellus*. This suggests that sugarcane may produce SOS volatiles in response to *C. sacchariphagus*.

There are alternative hypotheses to that of loss of ability to produce SOS volatiles. By boring the tops of stalks and leaf spindles in young cane, volatile emission could be elicited by *C. sacchariphagus*, whereas *E. saccharina* may avoid eliciting volatile emission by boring the bottoms of stalks in older cane. Another hypothesis is that the *Fusarium* associated with *E. saccharina* could interfere with the elicitation of volatile emission or change the composition of emitted volatiles. These possibilities are worthy of further investigation.

Nevertheless, a bio-intensive IPM strategy could be made more effective if the crop itself is capable of releasing appropriate SOS volatiles when attacked. Breeding varieties for enhanced attractiveness to natural enemies has potential if natural enemies are already present in the habitat management system. *Goniozus indicus* parasitises *E. saccharina* in *C. papyrus*. It is also known to parasitise *C. partellus* (Keiji and Overholt, 1996) and has been found doing so in *Sorghum arundinaceum* growing in proximity to *C. papyrus* (Conlong, 1994; 1997). It is therefore possible that *G. indicus* could parasitise both *C. sacchariphagus* and *E. saccharina* in sugarcane. The same applies to the pupal parasite *X. stemmator*.

Conlong *et al.* (2004) showed that some of the varieties with the highest direct resistance to *E. saccharina* were the most susceptible to *C. sacchariphagus* and vice-versa. This has implications for variety choice in an IPM system designed to target both pests simultaneously, should *C. sacchariphagus* invade the South African sugar industry. Given increasing adoption of the ‘push–pull’ habitat management concept even in the absence of parasitoid activity against *E. saccharina* in sugarcane, and its success against *C. partellus* in maize, we are confident that ‘push–pull’ habitat management will also be effective against *C. sacchariphagus*.

The development of IPM strategies depends on a sound understanding of the chemical ecology of pest interactions with sugarcane, natural enemies and the habitat. Modern IPM is not only about insect/plant interactions, it is about holistic agro-ecosystem interactions, in which increased knowledge about the environment, soils, plants, pathogens, endophytes, symbionts and insects are all combined to provide effective crop protection in an environmentally friendly manner.

As knowledge about, and interactions between, induced plant resistance, chemical ecology, micro-organisms such as endophytic fungi and *Wolbachia*, and phylogenetics and phylogeography of arthropods becomes more easily available, it is hypothesised that these will become important components of bio-intensive AW-IPM, thereby minimising the impacts of synthetic pesticides even more (Conlong and Rutherford, 2009).

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LA LUTTE CONTRE LES RAVAGEURS DE LA CANNE À SUCRE EN AFRIQUE DU SUD: DE LA RECHERCHE DES INTÉRACTIONS BIOTIQUES À LA LUTTE INTÉGRÉE BIO-INTENSIVE

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**MOTS CLÉS: Chilo, Eldana, Lutte Intégrée, Induction de la Résistance,
Résistance Directe et Indirecte.**

Résumé

LA DEFINITION la plus courante de la lutte intégrée contre les ravageurs (IPM) est « le processus décisionnel de gestion des ravageurs sur la base de stratégies multiples afin de prévenir les attaques avec des conséquences économiques, tout en réduisant les risques à la santé humaine et à l'environnement ». L'IPM de faible niveau est la forme la plus couramment utilisée, comprenant les pratiques de base de l'IPM – prospections et applications des insecticides en conformité avec les seuils économiques. Certains planteurs ont progressé jusqu'au niveau intermédiaire de L'IPM en adoptant quelques pratiques préventives additionnelles, comme les pratiques culturales et les variétés résistantes, en plus des efforts visant à diminuer les applications de pesticides à large spectre dans le but de protéger les organismes bénéfiques. Ces stratégies de l'IPM se focalisent principalement à une espèce de ravageur et ne considèrent pas l'ensemble des ravageurs d'un agro-écosystème spécifique. Par contre, l'IPM de haut niveau ou bio-intensive comprend des interventions multiples qui sont intégrées dans une approche ciblant plusieurs ravageurs. L'IPM bio-intensif est basé sur les interactions holistique de l'agro-écosystème, dans lequel la connaissance des insectes, leurs symbiotes, les pathogènes, les ennemis naturels, les plantes, les endophytes ainsi que leurs interactions, sont combinés pour développer un IPM adéquat tout en étant respectueux de l'environnement. Les avancées de nos connaissances sur les interactions biotiques directes et indirectes, l'induction de la résistance, la nutrition de la plante, la gestion de l'habitat, l'écologie chimique, les ennemis naturels, la qualité biologique du sol, les microorganismes comme les champignons endophytes, la bactérie *Wolbachia*, la phylogénétique et la phylogéographie sont passés en revue ici. Tous ces thèmes sont des composantes potentielles d'un système IPM bio-intensif en développement au SASRI. Les opportunités et défis dans ces thématiques de recherche sont aussi élaborées, en tenant compte des menaces de biosécurité à l'industrie sucrière d'Afrique du Sud et les limitations possibles du matériel génétique pour l'amélioration de la canne à sucre.

**EL COMBATE DE LAS PLAGAS DE LA CAÑA DE AZÚCAR EN SUDAFRICA:
INVESTIGACIÓN DESDE LAS INTERACCIONES DE BIOTICOS HASTA
EL MANEJO INTEGRAL BIO-INTENSIVO EN EL CAMPO**

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PALABRAS CLAVE: *Chilo*, Eldana, MIP, Resistencia Inducida,
Resistencia Directa e Indirecta.

Resumen

LA DEFINICIÓN convencional más común de Manejo Integral de Plagas (MIP) es ‘un proceso de toma de decisiones usando tácticas de manejo múltiples para prevenir brotes de insectos que causen daño económico mientras se reducen los riesgos a la salud humana y al ambiente’. El MIP de bajo nivel es la forma más común empleada, y consiste en el uso de las practicas básicas de monitoreo y aplicaciones de insecticidas de acuerdo con umbrales económicos. Algunos cultivadores han progresado a un nivel medio de MIP, la adopción de unas pocas medidas preventivas adicionales, p. e., control cultural y resistencia de plantas, acopladas con esfuerzos de reducir el uso de plaguicidas de amplio espectro con el fin de proteger organismos benéficos. Estas estrategias de MIP son principalmente dirigidas hacia una sola especie de insecto y sin considerar todas las plagas de un agro ecosistema en particular. Alto – nivel o MIP Bio – intensivo, en donde muchas intervenciones se integran en un enfoque Bio- intensivo enfocándose a muchas plagas. MIP Bio – intensivo se basa en interacciones holísticas del agro ecosistema, en las cuales el conocimiento de los insectos, sus simbioses, patógenos, enemigos naturales, plantas, endofíticos e interacciones entre todos estos enfoques se combinan para desarrollar el MIP en un área amplia, de una manera amigable con el ambiente. Por tanto, aquí se revisan los avances en el conocimiento de y de las interacciones bióticas entre directas, indirectas y resistencia inducida en plantas, nutrición de las plantas, manejo del hábitat, ecología química, enemigos naturales, sanidad del suelo, microorganismos tales como hongos endofíticos, *Wolbachia*, la filogenia y filogeografía. Todos estos son componentes potenciales para construir un sistema de MIP Bio – intensivo en SASRI. También se discuten las oportunidades y desafíos en estas áreas de investigación, tomando en consideración amenazas de bio seguridad a la industria azucarera de Sur África y las posibles limitaciones a los actuales materiales de mejoramiento de plantas de caña de azúcar.