IPM STRATEGIES FOR PEST AND DISEASE CONTROL IN INDONESIA: PROJECT OVERVIEW AND OUTCOMES FROM RECENT ACIAR-FUNDED RESEARCH

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Abstract

ACIAR is funding research and extension activities in Indonesia to assist with the development of IPM strategies for Indonesian pests and diseases. Various borer species provide some of the greatest threats to Australia’s sugarcane production system; research in Indonesia will lead to the development of Australian expertise in symptom recognition and an understanding of how to control these pests. Research is also being conducted into the various forms of sugarcane mosaic present not just in Indonesia but elsewhere in South East Asia. Incursion management plans will be updated as control measures are further refined during the course of these studies. General surveys conducted in over 930 individual Indonesian sugarcane crops highlighted the incidence of pests and diseases of significance. Further research is being conducted into the vectors transmitting mosaic and yield losses associated with this disease. Research is also being conducted into biological control measures for borers (Chilo or Scirpophaga species) using a range of either egg, larval or pupal parasitoids. Extension activities include demonstration plots, champion farmers, an Indonesian pest and disease field guide and various training days for farmers and factory field staff. This paper describes the work being undertaken and some of the latest outputs.

Introduction

Exotic pests and diseases continue to pose a serious threat to the Australian sugarcane industry. The recent smut incursion and the subsequent elimination of many approved commercial varieties in all districts illustrate how an incursion of an exotic disease can lead to very serious consequences. There are many other examples of devastating pests and diseases that occur in countries neighbouring Australia. One pest group that is largely absent from Australia, but constitute major pests in Indonesia and Papua New Guinea, are moth borers (top, shoot and stem borers from
the genera *Chilo, Sesamia* or *Scirpophaga*). Larvae of these pests bore into either the shoots or stalks of sugarcane crops, severely reducing both yield and sugar content (Magarey *et al.*, 2002; Sallam *et al.*, 2010). Almost all sugarcane-producing industries are affected by borers of various types. Freedom from these pests in Australia means higher productivity and reduced costs compared to most industries around the world.

Sugarcane smut has reminded us again that as an industry we cannot afford to relax our efforts in preparing for an exotic pest or disease incursion. Many exotic pests or diseases would render our very best varieties unprofitable, or would require costly management programs, should they enter the country. With this in mind, a funding application was prepared and submitted to the Australian Centre for International Agricultural Research (ACIAR) so that collaborative work with the Indonesian Sugar Research Institute (ISRI) could be undertaken into Integrated Pest Management (IPM) for borers, other significant pests, and for the various forms of mosaic found in South East Asia and Indonesia in particular. A successful result has enabled significant work with the most important Indonesian pests and diseases. In this paper we describe the project activities and the results obtained to date. A separate paper describes pest monitoring research in more detail (Sallam *et al.*, 2010).

### Indonesian sugarcane industry

#### General outline

Sugarcane production contributes Rupiah 11 500 billion (AUD$1.57 billion) to the Indonesian rural economy. Sugarcane is grown by over 140 000 farmers and supports over 1.3 m workers in associated industries. The Indonesian sugarcane industry traditionally was centred on the island of Java but in more recent years has expanded into Sulawesi, Sumatra, and West Papua. There are 58 sugarcane factories in Indonesia processing 30 m tonnes of sugarcane from 380 000–400 000 ha of land. Over three-quarters of the sugarcane production still occurs on the island of Java, mostly in east Java. Javan farm sizes are small (average around 1 ha); very little mechanical cultivation or harvesting is undertaken compared to the Australian sugarcane industry. Sugarcane is rotated with a range of other crops.

#### Pests and diseases

Attention to pest and disease control varies with sugar factory area; some focus considerable attention on crop protection while, in other factory areas, pest and disease control is neglected. Pests and diseases are major contributors to a production slide that has been occurring over the last 40 years. Borers in particular are significantly affecting crop yields in Javan canefields. Major borer pests include *Chilo auricilius* and *C. sacchariphagus*; losses are estimated at 0.5% loss in tonnes cane/ha for every 1% bored internodes. Other stem borers include *C. infuscatellus, Scirpophaga excerptalis* and *Sesamia inferens* (Sallam *et al.*, 2010). The potential for borers to affect crop yields has been observed in Sumatra. BSES entomologists estimated a 50% loss in sugar production on a 20 000 ha estate in southern Sumatra caused by combined infestations of *C. auricilius* (stalk borer) and *Scirpophaga*
excerptalis (top borer). In the 2002–2003 season, income on the same estate was reduced by 40% because of borer infestations. Overall financial losses for a three year period were estimated at AUD$20 m (BSES Limited internal report). Previous observations suggest borer infestations in commercial sugarcane fields in Java have been > 10%. Previous research by ISRI has led to the implementation of IPM strategies, particularly the operation of some biological control laboratories and associated release of parasitoids for borer control.

Diseases of note in Java include several forms of mosaic (streak mosaic / sugarcane mosaic / sorghum mosaic). These viruses are widespread through S.E. Asia and Indonesia, and cause significant losses. Disease infestations in commercial Javan fields have been estimated at 30–50% of crops infested and yield losses are estimated at 10% or greater. Known mosaic vectors around the world are various aphids, including Rhopalosiphum maidis, Hysteroneura setariae, Schizaphis graminum and Dactynotus ambrosiae (Homoptera, Aphididae). It is unknown how many of these vectors are present in Indonesia.

Other significant diseases present include smut, chlorotic streak, leaf scorch, ratoon stunting disease (RSD), leaf scald and several leaf diseases (yellow spot and orange rust). Some of these diseases (such as leaf scorch and streak mosaic) do not occur in Australia.

Research facilities

The Dutch had a significant input into the Indonesian sugarcane industry and established research facilities at Pasuruan in the 1860s. As a result, the Indonesian Sugar Research Institute (ISRI) is an old research institute by world standards with a noteworthy history. Many significant sugarcane research achievements have occurred at ISRI, especially in the areas of breeding and disease control.

It was in Indonesia that observation of natural crosses in the field led to the realisation that Saccharum officinarum and S. spontaneum could be crossed to produce inter-specific hybrids. Artificial crossing of these species in Indonesia led to the first deliberate hybrid canes; in essence sugarcane plant breeding began in Indonesia. It was not long before the first ‘wonder cane’, POJ2878, was produced in Java and this hybrid variety was grown in many countries around the world (including Australia) leading to improved productivity, longer ratooning and disease resistance.

Main project components

Since pests and diseases are causing large losses in Indonesia, and the Australian industry needs to prepare for potential pest incursions, very significant benefit will accrue for both countries with the development of effective control programs.

The emphasis in this project is on the implementation of effective IPM strategies in Javan canefields. The project seeks to improve sugarcane productivity by reducing losses from the borers and diseases causing the greatest economic effects.
The following objectives are being pursued:

1. determine the distribution and incidence of moth borers, insect vectors and natural enemies in Java
2. identify known insect vectors of mosaic viruses and their frequency in Java; the transmission of mosaic by some potential vectors may be assessed
3. develop IPM programs, particularly for borers
4. transfer new technologies using appropriate extension methods to the farming, scientific and quarantine community.

Project activities

General surveys

Initial project activities have sought to gain more information about pest and disease incidence in Java and the highest priority areas for research and extension. Accordingly, a survey of over 930 sugarcane fields has occurred from March 2008 to April 2009 in over 30 sugar factories distributed around Java. In these sugarcane fields, the incidence of the major pests and diseases has been quantified through systematic pest and disease observations in multiple plots within each monitored crop. Samples of mosaic-infected leaves were collected for molecular analysis to determine the pathogen involved, while borers and their parasitoids were also collected for identification at the Pasuruan laboratory. The pest aspects of this general survey have been described elsewhere (Sallam et al., 2010).

Research

Pest research is aimed at a review of previous research, field observations to determine the borer species causing significant yield losses, understanding the ecology of both the borers and their parasitoids, and assessment of the current biological control laboratories operating in many sugar factory areas and potential improvements in laboratory operations. Research was conducted into three aspects of sugarcane mosaic during the last 12 months: i. transmission by potential insect vectors in cage trials at Pasuruan, ii. hot water treatment to eliminate the virus from planting material, and iii. the effect of mosaic on sugarcane yield.

Extension

The project has a strong extension component focusing on the following activities: i. factory staff training: the staging of five workshops to train factory field staff in the identification and management of pests and diseases. This training will also include a focus on the production of disease-free planting material. ii. champion farmers: one champion farmer per region will be established to demonstrate the best IPM strategies for pest and disease control. Mini-field days and farm walks will be held at each farm. iii. demonstration plots: these will be used to demonstrate disease-free propagation and borer control measures; losses from ratoon stunting disease and mosaic may also be demonstrated. iv. field guide and other printed materials: a pests
and diseases field guide is being prepared to extend important information on pests and diseases to key industry staff. Written in Indonesian, it is intended to translate the pest section into English to provide up-to-date information on exotic pests to the Australian industry. v. training workshop on biological control: staff at selected factories will be updated towards the end of the project on improvements to biological control systems.

Results

Moth borers

Pest data suggest a lower severity of stem borers (Chilo species) and the top shoot borer (Scirpophaga excerptalis) than anticipated (Sallam et al., 2010). However, additional analyses are needed to examine the influence of crop age at inspection on recorded severity, as not all crops could be inspected when borer infestations were peaking. Identification of potential mitigating factors will be an important aspect of further data analyses.

Diseases

The timing of disease assessments in some crops did not coincide with maximum severity either and this particularly applied to leaf diseases. This resulted in an under-estimate of their severity. Some of the most important diseases in Java, and in S.E. Asia generally, are various forms of sugarcane mosaic. Symptoms of these diseases are evident through the season and survey results provide a reasonable assessment of their likely severity and affected areas. Leaf samples collected from the survey are subject to molecular assay in BSES laboratories; these are yet to be completed. The results will provide a lot more detail on the incidence of streak mosaic virus compared with sugarcane mosaic virus.

Mosaic

The incidence of mosaic in crops in the different sugar factories and in the infestation levels in individual crops are detailed in Figure 1.

Important points: Outcomes from the general survey included: i. mosaic is one of the most widely distributed diseases in Javan sugarcane fields, ii. other data suggests there are several different pathogens causing mosaic (sugarcane streak mosaic virus and sugarcane mosaic virus); assays for these pathogens in survey specimens are pending. The results will provide further insight into causal agents infecting Javan crops, iii. mosaic severity varied widely (a few crops had 90–100% diseased stools while many had low infestation levels), iv. incidence in Java suggests some areas were more heavily diseased; the reasons for this distribution require further investigation. Varietal susceptibility is likely to be one of the controlling factors.

Chlorotic streak

The survey highlighted the incidence of chlorotic streak in Java. Previously, the disease had not been the focus of pest and disease observations and was not widely acknowledged as a disease of importance (Figure 2).
Fig. 1—The frequency of mosaic-affected crops in each surveyed sugar factory area in Indonesia (top), expressed as a percentage of number of sampled crops infested, and the incidence of mosaic in individual crops expressed as the percentage of stools infested (bottom); most crops were not infested in this survey.

Fig. 2—The incidence of chlorotic streak in individual crops expressed as a percentage of stools infested.
Important points:  i. chlorotic streak was found for the first time in parts of central Java ii. there were a number of crops (274) where chlorotic streak was recorded; the disease is obviously widely distributed and may be causing significant yield losses in some crops iii. further information is needed on the distribution and severity of chlorotic streak.

Yellow spot

Yellow spot incidence was probably under-estimated from the general survey since some crops were observed when they were too young or when environmental conditions did not favour disease development (wrong time of the year; Figure 3).

![Chart showing frequency of yellow spot in individual crops](image)

Fig. 3—The frequency of yellow spot in individual crops with severity expressed as a percentage of leaf area affected by the disease.

Important points:  i. records for leaf diseases need to be treated with some caution since some data were collected at an inappropriate crop growth stage; yellow spot usually occurs in older crops during and just after the wet season. The data presented can therefore be assumed to be an under-estimate of the actual incidence of yellow spot in Java, ii. further analyses of disease incidence by crop age, and the use of climate data to ascertain the underlying factors (besides variety) that may be influencing disease severity, are required.

Leaf scald

The incidence of the important systemic disease leaf scald was highlighted by the general survey (Figure 4).

Important points:  i. leaf scald is restricted in incidence and very few crops are infested. This is a good outcome since leaf scald has the potential to kill crops of susceptible varieties. However, 10% diseased stools in some crops is a serious infestation of this major disease. ii. further analyses are required on the incidence of leaf scald among varieties to determine the influence of resistance on disease records.
Leaf scorch

Previous Indonesian records for leaf scorch have been from Sumatra and it is thought this is where the first disease incursion occurred (leaf scorch originally was not found in Indonesia). It is capable of defoliating the canopy and can significantly reduce the yield of susceptible varieties. The finding of this disease in central Java is of real significance to the Indonesian sugarcane industry as it could spread to affect many more sugarcane crops in Indonesia.

Target blotch

The first record of target blotch in Java was also made during this survey. The disease is found in Papua New Guinea and is generally of minor concern, but individual susceptible varieties could be badly affected by the disease.

Disease research

Sugarcane mosaic

Sugarcane mosaic disease is caused by three different pathogens; sugarcane mosaic virus (SCMV), sugarcane streak mosaic virus (SCSMV) and sorghum mosaic virus (SrMV). The distribution of the three pathogens in Indonesia is not yet clear but will become more evident when survey specimen assays have been completed for each pathogen.

Yield losses: yield loss research suggested that sugarcane mosaic (the causal agent is yet to be identified) reduced total yield by between 15–17%. This is similar to losses described elsewhere (Grisham 2000). There seemed to be no direct relationship between percent diseased planting material and any yield loss parameters.
Vector transmission: three species were investigated, i. ‘brown aphid’, a species feeding on weeds in sugarcane production areas and yet to be identified, ii. *Rhopalosiphum maidis* (corn aphid): a known vector of the disease, iii. a third unidentified insect. The results suggest that the brown aphid is a very effective vector of the disease but further studies are needed to confirm this initial result. No other vector led to plant infection. Crop observations are also needed to assess the presence of the brown aphid in mosaic-infected sugarcane crops in Java.

**Extension**

*Sugar factory extension*

A meeting of over 100 sugar factory staff from many of the 54 sugar factories in Java was organised to coincide with an April 2009 project review meeting. This allowed project staff to provide background information on pests and diseases in Indonesia, to outline the objectives of the project, and to answer queries on project objectives and outcomes. The Indonesian scientists summarised outputs from the general survey. There was very significant interest in the material presented from sugar factory participants and a strong emphasis on the need for further training in both pest and disease recognition and management issues.

**Future on-going project activities**

**Monthly crop monitoring**

Monthly monitoring of selected crops is being conducted and is very important for understanding the biology of sugarcane borers and their parasitoids. The development of an IPM strategy relies on possessing detailed information on pest species development, factors influencing multiplication and the ecology of parasitoids (biocontrols). The monthly monitoring will provide this information and allow project scientists to devise the best IPM strategies.

**Pest research**

There are a number of components to the pest research program (*Sallam et al.*, 2010) and these include the following areas:

i. *Crop loss from stem borers*: there is a need to determine what effect each borer has on yield and how the different parasitoids reduce yield impacts.

ii. *The efficacy of Trichogramma and Cotesia for Chilo species*: Each parasitoid has a different life cycle; *Trichogramma* is an egg parasite while *Cotesia* attacks the larval stage of the borers. Their effectiveness in controlling *Chilo* species and reducing yield losses will be examined in the proposed work.

iii. *Efficacy of Elasmus for control of Scirpophaga*: *Elasmus* is a potential parasitoid for the top borer and will be tested as a biological control agent, *Scirpophaga* – and this species will be tested for control of the borer.
iv. **Soft pesticides for control of borers for use in an IPM strategy:** although some parasitoids have proved effective on stem borers, it may be necessary to use a pesticide at certain stages in the borer development to achieve the best control options. For this reason, ‘soft’ pesticides (those which have minimal effect on non-target species) will be tested to see how well they control moth borers, and to see also how they affect parasitoid populations. This will define whether such a pesticide could be used within an IPM strategy in Indonesia or Australia.

v. **Insecticides for control of cane grubs (*Lepidiota stigma*) in plant cane:** in some factory areas, and on certain soils, white grubs create a problem for sugarcane farmers. It is necessary therefore to test some options for cane grub control.

**Discussion**

Preparations for an exotic pest or disease incursion are essential if the Australian sugarcane industry is to remain both competitive and profitable. The recent smut incursion and resulting epidemic has highlighted the dramatic effect such an incursion may have on the day-to-day operation of industry service groups and operations of sugarcane farmers. Losses from sugarcane smut would have been far higher if detailed preparation for the incursion had not happened well prior to the first smut finding in eastern Australia. BSES is seeking to remain on the ‘front foot’ in preparing the Australian industry for other potential exotic pests or diseases.

The current project addresses a major threat to our industry in the form of moth borers. Sugarcane borers are key pests in most other sugarcane producing nations. Particular pests of note are *Sesamia grisescens* (Papua New Guinea), *Eldana saccharina* (South Africa), *Diatraea saccharalis* (North and South America), various species of *Chilo* (many countries around the world) and *Scirpophaga excerptalis* (Papua New Guinea and Indonesia).

Like sugarcane smut, an incursion of these borer species may be difficult to eradicate and their ongoing management at levels below the economic threshold levels (ETL) could be a key focus for our industry. To address this, the current ACIAR-funded project aims to develop the best IPM strategies using various types of control measures, including parasitoids, varietal resistance or tolerance, cultural techniques and perhaps ‘soft’ pesticides to deliver effective pest control. The involvement of Australian staff in Indonesia is also leading to development of expertise in pest recognition, ability to work with biocontrol organisms and the implementation of in-field IPM strategies. For Indonesia, the project will lead to a refinement in the current control programs utilising Australian expertise in various key areas.

Diseases also pose a threat to both Australian and Indonesian sugarcane crops. There is a range of mosaic viruses present in S.E. Asia; the list of recognised viruses within this group is growing and includes streak mosaic virus, sorghum mosaic virus
and sugarcane mosaic virus (various strains). Magarey et al. (2002) identified sugarcane specimens showing mosaic-like symptoms in New Britain but current molecular assays failed to identify any associated pathogen suggesting another potential causal agent. In Australia, there is only one form of sugarcane mosaic and this is a relatively mild form of the disease. Research in Indonesia aims to gain experience with the other potential pathogens that may invade Australian sugarcane fields, including vectors and the assays that are needed to diagnose the causal agents.

The project to-date has led to a general survey of over 930 individual sugarcane fields providing valuable information on pest and disease incidence in Javan sugarcane fields. Sites have been selected from these crops to undertake more detailed monthly monitoring of sugarcane borers, their parasitoids, mosaic vectors and other pests and diseases so that a better understanding of the ecology of the pests and diseases can be gained. This will be essential for the development of better IPM strategies, particularly for the borers, for immediate use in Indonesia. They will potentially be relevant for use in Australia, if one of these pests or diseases invades our commercial cane fields.

Accompanying research is addressing specific issues related to either parasitoids (hosts and colonisation) as well as vectors that transmit mosaic-type viruses. Extension activities have included BSES and ISRI staff providing key training to factory field staff on the relevant pests and diseases. Already feedback has been obtained that this is increasing the focus of certain factory groups on the control of pests and diseases. Many more extension and training exercises are planned, as well as the production of key pest and disease identification materials for key pests and diseases. These guides will provide the base information for materials that will be released to Australian sugarcane farmers on the important exotic pest threats to our industry.

This ACIAR-funded work again highlights the value of collaborative projects between scientists from neighbouring countries and adds value to that already realised in previous ACIAR-funded work in Papua New Guinea and Indonesia (Magarey et al., 2002, 2003, 2005), and from BSES research conducted through agreements with Ramu Agri-Industries in Papua New Guinea (Kuniata et al., 2010a, b).

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REFERENCES


