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Final Report - SRDC Project BSS175, Risk to the Australian Sugar Industry from Exotic Pests

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FINAL REPORT - SRDC PROJECT BSS175
RISK TO THE AUSTRALIAN SUGAR INDUSTRY FROM EXOTIC PESTS
by
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SD98015

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SUMMARY

The Australian sugar industry has few introduced pests, but risks the introduction of pests from other sugar-growing areas. A new exotic pest could devastate the Australian industry. The industry has been unprepared to cope with such an introduction. This project developed three tools to predict and deal with introduced insects and mites.

A Pest Risk Analysis identified 1286 species of insects and mites affecting sugarcane worldwide. Dossiers were prepared on each species and detail taxonomic information (the order, family, subfamily and authority), common names, synonyms, hosts, distribution, entry, colonisation, spread and establishment potentials, plant part affected and the physical damage and symptoms that may aid detection, general biology, pre- and post-incursion management options, the potential for economic damage to sugarcane, the estimated risk of incursion, quarantine assessment and the name of a contact person who could provide additional information. This has been published as an Access™ database and distributed to all appropriate agencies. We recommend that the analysis be updated in 5 years time to ensure its continued relevance.

A Pest Incursion Management Plan was prepared. This details actions and responsibilities of governmental and industry organizations in the event of an incursion of an exotic pest. This was prepared after consultation with a wide range of stakeholder organizations and has been distributed to all appropriate organizations. The plan should be updated in conjunction with the Pest Risk Analysis. A revised version should take into account developments following any incursion of a pest or disease in both sugarcane and other crops.

The CLIMEX climate-matching program was used to evaluate the potential for establishment in Australia of exotic pests of sugarcane. Because of the large number of potential pests (1286), an absence of data on growth and stress parameters for most of these species, and poor knowledge of most species’ current distribution, the ‘Match Climates’ mode was used to match the climates of 60 non-Australian sugarcane-growing localities with 11 locations representative of the Australian sugar industry. The matches discriminate between Australian locations and show their suitability for a potential introduced species.

A centralized collection of specimens of exotic pests of sugarcane should be developed within an Australian institution. This would allow rapid identification of an incursion. Any collection needs ongoing financial support for development and maintenance.

The Australian sugar industry should also consider development of further monitoring capabilities through northern Australia and in southern Papua New Guinea and Indonesia to allow early detection of potential and actual incursions.

Development of the Pest Risk Analysis and the Pest Incursion Management Plan will help ensure the continued protection of the productivity and profitability of the Australian sugar industry.
1. BACKGROUND

The Australian sugarcane industry has traditionally maintained a strict quarantine system concerning the movement of cane into Australia from other countries and between the cane growing regions within Australia (Croft et al. 1996). No plant material is allowed into the country without first going through these quarantine channels. Until recently, because the trade in sugarcane products was largely restricted to processed sugar and molasses rather than plant material, there was a negligible quarantine risk. Recently, however, there has been an increased interest in the trade of used sugarcane machinery, use of sugarcane in traditional cooking, and the importation of germplasm for breeding purposes. These factors combined with the increase in sugarcane production in Irian Jaya and Timor to the north of Australia and the Ord River District of northern Western Australia have lead to increased concerns about the accidental introduction of sugarcane pests.

Over the last few years, more than 10 insect pests known to cause serious economic damage to crops have been introduced into Australia. The response to each has been first to determine the extent of the introduction, the crops most at risk, the biology and control measures for the pest, the damage caused, the likely economic losses, and the useful control options. This information is essential for the development of containment and management strategies. However, the collection and assessment of these data takes time and invariably leads to delays in implementation of the appropriate responses. These delays allow pests valuable time in which to become established and spread.

The Australian sugar industry has had no formal strategies in place to deal with the introduction of exotic pests. This is despite the real threat of incursions from near neighbours such as Papua New Guinea and Indonesia. Each incursion places additional burdens on the industry. The recent incursion of sugarcane smut into northwestern Australia has demonstrated the usefulness of preemptive preparation and development of contingency plans for exotic diseases. Much of the information needed to prepare similar responses for pests exists in the literature, but this needs to be accessed and converted to responses appropriate for Australia. Other data on geographic distribution and biology can be used to predict where in Australia particular exotic pests will establish or spread. Compilation and analysis of this information can lead to useful contingency plans.

The project aimed to develop a pest risk analysis on likely sugarcane-pest introductions and a pest incursion management plan. Assessments in the risk analysis detail the likely sources of introduction and the best strategies for minimising their impact once they become established. The management plan sets out the activities and responsibilities for dealing with an incursion. These will allow the best use of limited resources and will maximize the early success in treating new introductions.
2. **OBJECTIVES**

- Review literature on exotic pests of sugarcane to:
  - determine pests most likely to be introduced;
  - determine the sources of introduction;
  - determine where in Australia they are likely to cause economic loss;
  - determine the extent of such loss;
  - determine what preemptive work can be done to prepare responses for introductions;
  - determine the appropriate postintroduction responses;
  - determine if other crops will be affected.

- Prepare contingency plans to minimize the possibility of successful pest introductions and to minimize the impact of pests once they become established.

3. **OUTCOMES/OUTPUTS**

- Pest Risk Analysis performed on 1286 species of insects and mites affecting sugarcane worldwide. Dossiers on each species detail taxonomic information (the order, family, subfamily and authority), common names, synonyms, hosts, distribution, entry, colonisation, spread and establishment potentials, plant part affected and the physical damage and symptoms that may aid detection, general biology, pre- and post-incursion management options, the potential for economic damage to sugarcane, the estimated risk of incursion, quarantine assessment and the name of a contact person who could provide additional information. This has been published as an Access™ database and distributed to all appropriate agencies.

- Pest Risk Analysis performed on pests of sugarcane in Indonesia and Papua New Guinea as a report to the Northern Australia Quarantine Strategy, Australian Quarantine and Inspection Service. Dossiers were similar to those above.

- A Pest Incursion Management Plan prepared which details actions and responsibilities of governmental and industry organizations in the event of an incursion of an exotic pest. This was prepared after consultation with a wide range of stakeholder organizations and has been distributed to all appropriate organizations.

- The CLIMEX climate-matching program was used to evaluate the potential for establishment in Australia of exotic pests of sugarcane. Because of the large number of potential pests (>1280), an absence of data on growth and stress parameters for most of these species, and poor knowledge of most species’ current distribution, the ‘Match Climates’ mode was used to match the climates of 60 non-Australian sugarcane-growing localities with 11 locations representative of the Australian sugar industry. The matches discriminate between Australian locations and show their suitability for a potential introduced species.
4. RESEARCH METHODOLOGY, RESULTS AND DISCUSSION

4.1 Pest Risk Analysis

4.1.1 Introduction

The purpose of a pest risk analysis (PRA) is, firstly to identify quarantine pests and pathogens that pose a threat to sugarcane and that may enter Australia, and secondly, to identify measures that could be taken by various agencies to reduce the risks of entry or to minimize the impact of such pests should they arrive. This includes insects that can be introduced by natural means (such as wind currents), illegal movement of sugarcane plants, and authorized movement of sugarcane products.

The PRA was conducted as outlined in the FAO Standard Guidelines for Pest Risk Analysis (FAO 1996). The main sources of information were CAB abstracts, Agricola and Zoological Records. The occurrence of a pest in Australia was based on the world catalogues of each group and where available catalogues of Australian insects. Experts within the Australian National Insect Collection, BSES, The Australian National University, the Agricultural Scientific Collections Trust, Ramu Sugar and Indonesian universities were consulted as appropriate. It must be stressed that the low rating of an insect in the accompanying dossiers does not mean that it will not be of economic concern within Australia, it simply means that it is not a pest in its home range. What may happen in Australia in the absence of its natural enemies and diseases and in a different climate is unknown and difficult to anticipate.

Despite the high economic importance of some of these insects there are often few publications shedding any information on their biology, ecology or related natural enemies. For workers in Australia, the problem is confounded by the possibility of not knowing what the insect looks like. This could be redressed if a collection of the target pests could be established and housed at an institution such as the Australian National Insect Collection. This collection could then be used as reference material to build within Australia the capacity to identify potential threats quickly.

Disclaimer. The lists of pests and the information within the dossiers have been compiled using the available literature and are as current as possible. The information, advice and/or procedures contained in this report are provided for the sole purpose of disseminating information relating to scientific and technical matters in accordance with the functions of CSIRO under the Science and Industry Research Act 1949. To the extent permitted by law, CSIRO or BSES shall not be held liable in relation to any loss or damage incurred by the use and/or reliance upon any information advice and/or procedures contained in the report. Mention of any product in the report is for information purposes only and does not constitute a recommendation of any such product either expressed or implied by CSIRO or BSES.
4.1.2 Data base and its use

This Pest Risk Analysis (PRA) was initiated to accomplish three aims. Firstly, a list of all insects and mites associated with sugarcane around the world was to be compiled. Secondly, the literature was to be reviewed to determine the level of risk to the Australian sugar industry in terms of the threat of incursion and potential damage. Finally, a contingency plan was to be developed to minimize the possibility of invasion and the impact of any new pest should it become established. The review of the literature also indicated potential avenues of introduction that could aid in the development of preemptive strategies, appropriate post-introduction responses and other crops that may be affected. While much of the information in this PRA is available in the literature, accessing it was often difficult and time consuming. By compiling the relevant data into a single resource, accessing the information is thereby simplified, reducing response times during the critical decision-making weeks following the detection of an incursion.

We list 1286 pests assembled by searching the literature abstracted from 1972 in all available databases (CABI, AGRICOLA, Zoological Records) and numerous unpublished sources such as conference proceedings and research station reports. This includes information on the biology, management and incidence of insects as well as information on the economic impact of pest species. A bibliography of over 3300 references has been compiled and is in a bibliographic database (Reference Manager™ v7.0 for Windows).

Some of the difficulties encountered in preparing the list were the use of incorrect scientific names, the use of outdated synonyms and the incorrect spelling of species and/or genera.

Two of the most confused groups are those in the *Chilo* and *Scirpophaga*-*Schoenobius*- *Tryporyza* complexes. Many of these insects have been placed, taxonomically in almost all of these genera and this has resulted in some workers using several names, outdated names or incorrect names to describe the same insect. For example, *Scirpophaga nivella* is commonly referred to as a sugarcane pest under the genus *Tryporyza*. However, according to Lewvanich (1981) *Scirpophaga nivella* (the correct name) is not a sugarcane pest but a rice pest that has been confused with *Scirpophaga excerptalis*. These two borers are very similar in appearance, both to each other and to a third borer, *Scirpophaga incertulas*, another rice pest. This confusion is an ongoing problem (for example, Cheng 1994) and is further complicated by the use of the common name, top borer, which can refer to individual species from each genus. This confusion highlights the need for samples from potential incursions to be identified correctly by a taxonomist familiar with the genus. Another example is *Chilo sacchariphagus*, which has been referred to in the literature as *Chilo venosatus*, *Diatraea venosatus*, *Proceras sacchariphagus* and *Proceras venosatus* (Bleszynski 1970). Again, correct identification is critical, especially if the introduction of a biological control agent is to be considered.

A second point that became clear from the literature was that the definition of a pest of sugarcane varied from country to country and author to author. Often it appeared that any insect caught in a cane field was considered a pest. Two notable examples were a species
of dung beetle and a parasitoid of a sugarcane pest that were listed as pests, despite the unlikely nature of this observation. Therefore, when browsing the database you will notice that there are records that do not list sugarcane as a host. This is because the species is not noted as feeding or developing on sugarcane in reliable taxonomic descriptions or catalogues. However, it has been mentioned as a pest in less reliable sources. Its listing in these sources may be genuine, but is considered more likely to have been either a misidentification or an incorrect interpretation of the insect presence in the cane field.

To maximize the use of the collated information, a simple database (Access™ version 7.0) was created to store the data. For each insect species, taxonomic information (the order, family, subfamily and authority), and the common names, synonyms, hosts, and distribution were included where ever possible. For key pests species or species where the information was readily available the following information was also included - the entry, colonisation, spread and establishment potential, the plant part affected and the physical damage and symptoms that may aid detection. General biology, pre- and post-incursion management options, the potential for economic damage to sugarcane, the estimated risk of incursion, quarantine assessment and the name of a contact person who could provide additional information are also given. Decision making in terms of the potential for incursion, likelihood of establishment and spread, the potential for economic damage and the risk posed was based on the advice from research staff in CSIRO, BSES, NSW Agriculture, Ramu Sugar and The Australian National University. Information for each of these is given in broad terms only as it is extremely difficult given the lack of scientific rigour of many of the claims, to make more detailed estimates. Similarly, the decision to include a species as a key pest was based on advice and estimation based on past experience with similar pests either in Australia or in countries where the quality of the data is reliable.

It is clear from the assembled literature that there is no single world-wide pest species or pest genus of sugarcane. Each region, even those that are geographically close, has its own suite of key pests. This increased the difficulty in making a list of potential threats to the Australian sugar industry. The pests included were those which either caused economic damage elsewhere or belonged to a genus containing species of known damage potential or had the potential to transmit economically damaging plant viruses. This does not mean that other species pose no threat as it is not possible, given the lack of data to assess the threat potential of an innocuous pest when introduced to Australia in the absence of its natural enemies and diseases and forced to adapt to a different climate.

There are inherent drawbacks in the database that have not been overcome. This is evident in the reports that can be generated. Access does not allow the mixing of font style. For example, the names of the insects or their host plants could not be italicized, and the reports cannot be printed in a Word document without losing some of the formatting. We considered it more important to have the information in a form that could be manipulated to suit the users’ needs than to follow normal style conventions. With some work, the reports can be reformatted into a Word document if this is desired. It may be possible that the future versions of Access will redress these anomalies.

4.1.3 Sample dossier
A sample dossier is included as Appendix 1. Information included comprises species scientific and common names (including alternative scientific names), order and family, hosts, distribution including nearest known location to Australia, an assessment of the entry, colonisation, spread and establishment potentials, plant part affected and physical damage, methods for detection, options for response to detection, a summary of the pest’s biology and management options (including a list of known parasites), an assessment of potential economic damage, estimated risk and quarantine status, contacts for further information, and key references. All are presented in the standard FAO format.

4.2 Predicting establishment and range

4.2.1 Introduction

To provide a logical rationale for the implementation of quarantine, monitoring and eradication measures for an exotic pest, two questions need to be answered (Worner 1988). Once an exotic pest is introduced, is it likely to become established? Once established, how widely will the infestation spread? We used the CLIMEX for Windows 1.1 computer program (Sutherst and Maywald 1985; Sutherst et al. 1998) to evaluate the potential for establishment in Australia of exotic pests of sugarcane.

4.2.2 Methods

CLIMEX enables the prediction of an organism’s potential relative abundance and geographical distribution as determined by climate. It can be used in two ways. The first uses the species’ temperature and moisture growth and stress parameters together with long-term weather data to determine the average responses of the species to climate in the specific locations to be compared. We rejected this mode as a method for determining the potential distribution of exotic sugarcane pests in Australia for three reasons. Firstly, the analysis would have to be done for each potential pest; the sheer number of these species (>1280) makes this impractical. Secondly, when data on growth and stress parameters are available, these can be used as a basis for developing potential distributions; these data do not exist for most potential introductions. Thirdly, where data on parameters are not available, a reasonable knowledge of the species’ current distribution is required to develop estimates of the growth and stress parameters; this does not exist for most potential pests, e.g. many published distributions are either a few sites or unspecified localities in a country. These last two points lead to predicted distributions that are very extensive, have little discrimination between different target localities, and give poor estimation of the potential distribution of the pests.

The second way of using CLIMEX is to compare the climate of potential locations with that of the known range of the species. It has been used to predict the ranges of introduced weeds and insects (Scott 1991; Csurhes and Kriticos 1994; Allsopp 1996). Again, this would be impractical to do for each potential introduction, so we used this mode to compare the climate in 60 representative overseas cane-growing locations (Fig. 1) with that of 11 representative Australian canegrowing locations; Kununurra, Cairns, Mareeba, Innisfail, Ingham, Ayr, Mackay, Bundaberg, Nambour, Murwillumbah and Grafton (Fig.
2). In CLIMEX, the level of similarity between climates is given by the Match Index, which is derived from up to four component indices indicating similarity in maximum temperature, minimum temperature, total rainfall and rainfall pattern. As most Australian sugarcane is grown under supplementary irrigation or in areas of overabundant rainfall, we omitted the two rainfall indices. We also decided that maximum temperature is more important than minimum temperature, especially where insects are subterranean, within plants and/or with long lifecycles. Therefore, we assigned a Match Index Weight of 1 to the maximum temperature index and 0.5 to the minimum temperature index. We considered that a Match Index (range 0-100) of 50 or greater indicated that the climate in the target location was favorable for an introduction from the source location to establish. A match of 70 generally provides an indication of a high degree of climatic similarity (Maywald and Sutherst 1991; Scott 1991). However, the critical value may be species specific and Csurhes and Kriticos (1994) and Allsopp (1996) used a threshold of 50 for a weed and a beetle.

Figure 1. World map showing the location of the 60 exotic cane-growing locations selected as representative.

Figure 2. Map of Australia showing the location of the 11 representative locations.

To summarize the above data, we used principal components analysis. This analysis created a reduced number of variables for each Australian location and shows general similarities between Australian locations in how their climates match with overseas locations.

4.2.3 Results and discussion
The Match Indexes for the 60 exotic locations are given in Appendix 2. The highest match is 88.6 for Cairns and Habana, Cuba, and the lowest is 7.0 for Kununurra and Chengdu, China. The matches discriminate between Australian locations and show their suitability for a potential introduced species. For example, an insect from Brownsville, USA, would find Mackay, Ayr and Ingham to be favorable locations, whilst Murwillumbah, Nambour and Grafton would be marginal, and Kununurra would be highly unfavorable. Any introduction from Luxor, Egypt, would find all Australian locations unfavorable. No exotic location provides good matches to all Australian locations.

The first two vectors from the principal components’ analysis accounted for 64.1% and 29.8%, respectively, of the total variance in Match Indexes. Vector 1 contrasts Kununurra with the eastern localities, whereas vector 2 appears to be mainly related to latitude (Fig. 3). This plot indicates the climatic peculiarity of Kununurra (much drier and hotter), and in eastern Australia three groups, southern (Grafton, Murwillumbah, Nambour and to a lesser extent Bundaberg), central (Mackay), and northern (remaining eastern localities). A similar relationship between areas is evident in the sugarcane cultivars grown: Q124 is grown extensively in the Mackay area and less so in the south and the north; Q96 and Q117 are grown virtually only in the Ayr region; Q115, Q120 and Q152 are restricted to northern Queensland; Q141, Q146, Q151 and CP51-21 are grown only in southern Queensland (Bureau of Sugar Experiment Stations 1997).

Figure 3. Plot of first two principal components for the 11 Australian locations.

Where data on species’ growth and stress parameters do not exist and/or there is not a reasonable knowledge of a species’ current distribution, then CLIMEX can not be used with confidence to make extensive predictions of the species’ potential geographic distribution. For sugarcane, the fact that most pests are endemic species which feed on a wide variety of grasses and which have colonized sugarcane (Strong et al. 1977; Pest Risk
Analysis) complicates this further. This means that the distribution of a pest species could be much wider and that the species could be adapted to more extreme climates than that indicated by its pest status in sugarcane. However, for sugarcane-growing areas, the Match Index function of CLIMEX can give useful predictions of the potential ranges of species in non-endemic areas. These predictions could be improved with better knowledge of the biology of major pests.

4.3 Pest Incursion Management Plan

4.3.1 Introduction

In response to the risk of entry of animal diseases, which could not only affect animal industries but also human health, the AUSTVETPLAN has been developed and refined over many years. This plan is a detailed contingency plan for the response to an incursion of a serious animal disease. Detailed agreements on the cost sharing arrangements for eradication programs are included for some of the diseases.

Plant industries are faced with a much wider range of species that need protection and exotic pest species that could cause serious economic losses. The Federal Government Standing Committee on Agriculture and Resource Management (SCARM) has developed a general, non-specific, incursion management strategy (SIMS). This strategy outlines the broad areas of an incursion management plan and the appropriate authorities involved. The key feature of the strategy is the operation of a Consultative Committee that is convened by the Plant Health Committee after an incursion occurs. Recently, the SCARM Task Force on Incursion Management (STF) has developed a generic incursion management plan (GIMP) for plant industries. This plan outlines the four steps to incursion management: prevention, preparedness, response and recovery. These plans give a good basis for development of specific management plans.

Recently, some plant industries have seen the need for specific contingency plans for pests and diseases that stand out as being of major economic importance and also which have a high risk of entering Australia. Specific contingency plans have been prepared for black sigatoka of bananas, 1996, fireblight of pome fruit, 1996, dutch elm disease, 1994 and sugarcane smut, 1997 (Croft and Magarey 1997). Incursions of black sigatoka, fireblight and sugarcane smut have occurred in the 1996/98 period. The contingency plans were useful in assisting with eradication programs. These plans have been used as models in the development of this incursion plan for sugarcane pests. The other notable example is the preparation of contingency plans for exotic fruit flies following the incursion of papaya fruit fly (Bactrocera papayae) in 1995. This incursion has been controlled and formal declaration of eradication of papaya fruit fly from Queensland occurred on 30 April 1999.
4.3.2 The plan

This plan covers both incursions into commercial cropping areas and into back-yard plots of sugarcane in non-commercial cropping situations such as the Torres Strait, Cape York Peninsula or urban areas. The first edition of the contingency plan has been developed after consultation with industry groups and should be revised with further developments in the sugar industry and with developments in the pest situation outside Australia.

A summary of the plan is presented in Appendix 3. A more detailed version can be found in Allsopp et al. (1999).

4.4 Technology transfer

The Pest Risk Analysis database has been distributed to Queensland Department of Primary Industries, NSW Agriculture, Agriculture WA, all CPPBs, AQIS, Department of Agriculture, Fisheries and Forests, CANEGROWERS, Sugar Research Institute, Department of Natural Resources and all major BSES centers. The Queensland Minister for Primary Industries officially launched the CD package on 9 December 1998.

The Pest Incursion Management Plan was developed in consultation with industry and government organizations. It has been distributed to Queensland Department of Primary Industries, NSW Agriculture, Agriculture WA, all CPPBs, AQIS, Commonwealth Department of Agriculture, Fisheries and Forests, CANEGROWERS and all BSES offices.

5. RECOMMENDATIONS

- The Pest Risk Analysis should be a ‘living’ document. We recommend that it be updated in 5 years time to ensure its continued relevance.

- The Pest Incursion Management Plan should be updated in conjunction with the Pest Risk Analysis. A revised version should take into account developments following any incursion of a pest or disease in both sugarcane and other crops.

- A centralised collection of specimens of exotic pests of sugarcane should be developed within an Australian institution - the Australian National Insect Collection may be suitable. Any collection would need ongoing financial support to maintain and develop such a collection.
- The Australian sugar industry should consider development of further monitoring capabilities through northern Australia and in southern Papua New Guinea and Indonesia to allow early detection of potential and actual incursions.

6. PUBLICATIONS


FitzGibbon, F, Allsopp, P G and De Barro, P J Suitability of Australian sugarcane areas for the establishment of exotic pests. Biological Invasions (submitted for publication)

7. REFERENCES


8. ACKNOWLEDGEMENTS

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9. APPENDICES

Appendix 1 – Sample Pest Risk Analysis dossier

Appendix 2 – Match indexes for 60 non-Australian sugarcane-growing areas with 11 Australian localities

Appendix 3 – Summary of Pest Incursion Management Plan
Appendix 1 – Sample pest risk analysis dossier

Species: *Diatraea saccharalis*

Author: (Fabricius)

Order: Lepidoptera

Family: Pyralidae

Type: moth borer

Common Name(s):
- Small moth borer
- Sugar cane stalk borer
- Shoot borer
- Internode borer
- Sugar cane borer
- Sugar cane moth borer
- Sugar cane moth stalk borer

Synonym(s):
- *Phalaena saccharalis*;
- *Crambus sacchari*;
- *Crambus leucaniellus*;
- *Crambus lineosellus*;
- *Chilo obliteratellus*;
- *Diatraea obliteratellus*;
- *Diatraea sacchari*;
- *Diatraea saccharalis var grenadensis*;
- *Diatraea pediota*;
- *Diatraea continens*;
- *Diatraea sacchari f. brasiliensis*;
- *Diatraea incomparella*.

Hosts:
- Saccharum spp. (sugarcane);
- Zea mays (maize);
- Oryza sativa (rice);
- Pennisetum latifolium;
- Sorghum bicolor (sorghum);
- Cortaderia selloana (pampas grass);
- Cymbopogon citratus;
- Cymbopogon nardus.

Distribution:
- Delaware (USA), Kansas (USA), Louisiana (USA), South Carolina (USA), Ohio (USA), Florida (USA), Texas (USA), Cuba, Mexico, North Carolina (USA), Central America, Costa Rica, Puerto Rico, Barbados, Trinidad & Tobago, Dominican Republic, Virgin Islands, St. Kitts and Nevis, Guadeloupe, Jamaica, Guyana, Colombia, Brazil, Argentina, Ecuador, Peru, Bolivia, Uruguay, Venezuela, Thailand.

Nearest known location to Australia: Thailand - this may be an incorrect identification

Entry potential: Low - infested plant material  
Colonisation potential: High
Spread potential: High  
Establishment potential: High

Plant part affected: stem

Physical damage:
- Shoots are killed when the insect bores into the joints and this produces dead hearts. Often the plant dies when there is damage to the young primary shoots. The dead inner whorl is often a clear indication of the presence of this borer.

Detection/diagnosis:
- Visual checks of the young cane, especially the whorl or spindle. Adults are not attracted to light traps therefore this cannot be used as a method of monitoring populations.

Options for response to detection:
- Offshore: Monitor the importation (commercial and incidental) of cane into Australia. All cane material should be carefully checked for larvae inside the stalk. This cane should be destroyed. Raise public awareness of the seriousness of this pest.
- Onshore: Monitor all cane material entering Australia, especially material entering via pleasure craft. Investigate the use of pheromone traps for monitoring the adult population and determine which insecticides may be used against this pest. A screening program for varieties that are resistant to moth borer would be advantageous as well as determining suitable natural enemies that may be in Australia or can be imported.

Biology:
- *Diatraea saccharalis* (sugarcane borer) is native to the Caribbean. Prior to the introduction of sugarcane it was found on wild grasses (Baker et al. 1991). Some of its natural enemies made the transition to sugarcane with the borer, however, there were many that did not and this, in part, has lead to outbreaks in sugarcane of economic importance. It remains one of
the most important pests of sugarcane in the region. In some areas the climate is sufficiently warm to allow overlapping generations throughout the year. In countries with a cooler winter the number of generations per year is reduced.

The SCB lays clusters of about 25 eggs (though egg masses of 50 have been recorded) on the upper or lower surfaces of leaf blades. Oviposition usually takes place around dusk and continues throughout the adult emergence of 3 or 4 nights. The clusters are flat and the eggs themselves are flattened, oval and cream coloured. The eggs hatch in 4-9 days depending on the season. The larvae are yellowish-white and have brown spots which may be absent in the winter larvae. During the first few days feeding takes place within the leaf sheath or between the sheath and the stem. There are 6-7 larval instars which tunnel vertically into the cane stalks near the joints and internode. These tunnels can be the entry for red rot fungus. The larvae feed for 20-30 days before pupating. The adult emerges after 9 days and is a straw colour with a characteristic V of dark dots on the wings. The life cycle is about 43 days under laboratory conditions (28°C) and 30-45 in the field with 4 or 5 generations per year. In tropical areas where conditions are favourable for continuous development there can be up to 7 generations per year. In the cooler parts of its range D. saccharalis diapause during the winter and carry over to the next year in crop residues (Legaspi et al. 1997; Harris 1989).

Management:

- Apanteles diatraeae (Braconidae) - Mexico, Cuba, Trinidad
- Apanteles flavipes (Braconidae) - Barbados, Brazil (larva)
- Apanteles impunctatus (Braconidae) - Louisiana
- Apanteles xanthopus (Braconidae) - Brazil, Argentina
- Agathis stigmaterus (Braconidae) - Peru, Florida (larva)
- Agathis sacchari (Braconidae) - Trinidad, Venezuela, Puerto Rico, Guyana
- Agathis parvispectrata (Braconidae) - Guyana
- Agathis stigmatera (Braconidae) - Florida, Cuba, Jamaica, Haiti, Dominican Republic, St. Kitts, Montserrat, St. Lucia, St. Vincent, Grenada, Barbados, Trinidad, Venezuela, Guyana, Brazil, Peru, Argentina
- Agathis sp. (Braconidae) - Brazil
- Ipomobracon (Iphiala lux) abancay (Braconidae) - Peru (larva)
- Ipomobracon (Iphiala lux) amabilis (Braconidae) - Brazil (larva)
- Ipomobracon (Iphiala lux) dolens (Braconidae) - Trinidad, Guyana (larva)
- Ipomobracon (Iphiala lux) pennipes (Braconidae) - Guyana (larva)
- Ipomobracon (Iphiala lux) rimac (Braconidae) - Colombia, Peru, Florida (larva)
- Ipomabracon (Iphiala lux) saccharalis (Braconidae) - Guyana (larva)
- Ipomabracon (Iphiala lux) tucumanus (Braconidae) - Argentina (larva)
- Ipomabracon (Iphiala lux) sp. (Braconidae) - Grenada, Trinidad, Venezuela, Suriname, Guyana, Puerto Rico, Cuba, Brazil (larva)
- Microdus sp. (Braconidae) - Venezuela, Barbados (larva)
- Spiloccalis dux (Chalcididae) - Mexico, Guyana
- Eremotylus flavofuscus (Ichneumonidae) - Peru
- Mesostenoides sp. (Ichneumonidae) - Guyana
- Trichogramma minutum (fasciatum) (Trichogrammatidae) - USA, Mexico, Central America, Greater and Lesser Antilles, South America
- Ufens niger (Trichogrammatidae) - Texas
- Telenomus alecto (Scelionidae) - Barbados, Puerto Rico, Guyana, Colombia, Brazil, Argentina. St. Lucia, St. Vincent, Grenada, Peru
- Telenomus sp. (Scelionidae) - Venezuela
- Jaynesleksia (Leskiomima) jaynesi (Tachinidae) - Colombia, Peru, Argentina, Brazil
- Leskiopalpus (Stomatodexia) diadema (Tachinidae) - Venezuela, Trinidad, Guyana, Brazil
- Lixophaga diatraeae (Tachinidae) - Cuba, Jamaica, Haiti, Dominican Republic, Puerto Rico, Florida, Louisiana, U.S. Virgin Is., St. Croix, St. Kitts, Antigua, Guadalupe, Dominica, St. Lucia, Barbados, Venezuela, Guyana, Peru
Metagonistylum minense (Tachinidae) - Brazil, Peru, Puerto Rico, Guadaloupe, Dominica, Barbados, USA, Cuba, St. Lucia, Venezuela, Guyana
Palpozenillia diatraeae (Tachinidae) - Brazil, Bolivia
Paratheresia claripalpis (Tachinidae) - Florida, Mexico, Guatemala, Panama, Dominica, Guadaloupe, Trinidad, Venezuela, Guyana, Brazil, Colombia, Peru, Argentina, Bolivia
Parkerella parva (Tachinidae) - Brazil
Parthenoleksia parkeri (Tachinidae) - Brazil
Prosochaeta sp. (Tachinidae) - Brazil
Zenilia sp. nr. ochracea (Tachinidae) - Venezuela
Leptotrichelus dorsalis (Carabidae) - Louisiana (egg)
Chlaenius pusillus (Carabidae) - Louisiana (egg)
Harpalus sp. (Carabidae) - Louisiana (larva)
Conoderus vespertinus (Elateridae) - Louisiana (egg/larva)
Conoderus rudis (Elateridae) - Louisiana (egg)
Drasterius scutellatus (Elateridae) - Louisiana (egg)
Chrysopa sp. (Chrysopidae) - Louisiana (egg)
Doru aculeatum (Forficulidae) - Louisiana (egg)
Anisolabis annullipes (Labiduridae) - Louisiana (larva)
Eperigone tridentata (Araneida) - Louisiana (egg)
Paradosa milvina (Araneida) - Louisiana (egg)
Singa variabilis (Araneida) - Louisiana (egg/larva)
Achaeaeranea index (Araneida) - Louisiana (egg)
Colesosoma acutiventer (Araneida) - Louisiana (egg)
Paratheridula quadriraculatus (Araneida) - Louisiana (egg)
Clubiona abotti (Araneida) - Louisiana (egg/larva)
Lycosa helluo (Araneida) - Louisiana (adult)
Habronattus coronatus (Araneida) - Louisiana (egg)
Sarcodexia lambens (Sarcophagidae) - Brazil
Sarcodexia sternodontis (Sarcophagidae) - Cuba, Venezuela
Sarcophaga pedata (Sarcophagidae) - Cuba
Sarcophaga rapax (Sarcophagidae) - Cuba
Sarcophaga surrubea (Sarcophagidae) - Cuba
Sarcophaga sp. (Sarcophagidae) - Cuba
Solenopsis invicta (Formicidae) - Louisiana
Solenopsis saevissima richteri (Formicidae) - Louisiana (egg/larva/pupa)
(Bennett 1968; Bin & Johnson 1982; Simmonds 1968; Box 1953; Ali & Reagan 1985; Alam 1980; Negm & Hensley 1971; Botelho et al. 1986)

The most successful natural enemies were those in the Tachinidae family. Attempts to introduce Braconids into Florida, Barbados and Puerto Rico were unsuccessful in spite of providing flowering shrubs around the perimeters of the cane fields (Simmonds 1968). Since the introduction of L. diatraeae, M. minense and P. claripalpis into these sugarcane growing regions, D. saccharalis has not been a serious problem in the Caribbean, however it still causes damage in Louisiana, Barbados, Puerto Rico and Brazil (Simmonds 1968).
In Barbados the introduction of Apanteles flavipes and Lixophaga diatraeae, combined with changes in cultural practises and cane varieties, appeared to reduce, substantially, the number of joints damaged (Alam 1980). It also appeared that the Barbados strain of Lixophaga is heat tolerant and has a greater fecundity than the Louisiana strain which is cold tolerant. The apparent success of these two parasitoids in combination seemed to be that they were most effective under different conditions - i.e: Lixophaga is not density dependent, however its population fluctuates according to the cane height throughout the season, whereas Apanteles flavipes is density dependent and therefore, the population fluctuations can be correlated with the number of damaged cane joints (Alam 1980).
In Louisiana, a sampling plan has been devised that has enabled the growers to reduce the
number of insecticide applications per year and concentrate on the most destructive phase of the pest (Hensley 1971). Surveys are conducted for about 2.5 months starting in the later part of June (mid-summer), just prior to the emergence of the second generation. At weekly intervals, 50 stalks, at least 3 feet apart and at 6 locations in the field (field size ranges between 40-100 acres), are examined for live small larvae in the leaf sheaths. Control is initiated after the internodes are visible and infestation reaches 5% (the economic threshold determined for this pest in Louisiana). Retreatment is done when 5% reinfestation occurs and only if this level is reached before the middle of September (Hensley 1971). Azinphos methyl was the insecticide registered for use on sugarcane in Louisiana in the early 1970s and gave good control (80-90%) and had a residual effect of 2-3 weeks. Monocrotophos and endosulphan were also used. None of these insecticides are registered for use on sugarcane in Australia and before their use could be contemplated an Emergency Use Permit would have to be obtained from the National Registration Authority.

Some work has been done on using entomopathogenic nematodes against D. saccharalis in Florida, however, while the laboratory trials were encouraging, the field trials were less so (Sosa et al. 1993). Further work into this area would be valuable. Ali and Reagan (1985) found that the fire ant, Solenopsis invicta, was a main predator of D. saccharalis and that weed removal within or near the cane field reduced ant populations resulting in a reduction of control. The weeds provided a secondary source of prey for the ants, allowing populations to build up, resulting in more efficient control of SCB later in the season. Other management practices such as stubbling and only moderate weed control enhanced predator populations in general which lead to the decreased need for reliance on insecticidal control. In Louisiana, azinphos methyl is usually applied 4 times a year to control SCB. This tended to reduce the number of predators as well as their prey (other than SCB) found in the weedy areas. Augmentative releases of Trichogramma species did not appear to be successful and were discontinued in 1959 (Hensley 1971). Carabid larvae were considered important predators because they attacked the 1st, 2nd and 3rd stage larvae, thereby causing mortality before the larvae had enough time to develop and damage the cane (Negm and Hensley 1971). They were very active and able to reach the borer larvae behind the leaf sheaths.

As with many of the borers there appears to be differences between cane varieties and the level of damage sustained (Hensley 1971). It was also noted that the populations of parasitoids associated with this pest, specifically Metagonistylus minense, Apanteles flavipes and Paratheresia claripalpis, also varies between cane varieties (Botelho et al. 1986). A screening program would determine the most suitable varieties to use should this pest become a chronic problem.

Cultural control methods include removing portions of cane left in the field after harvesting, not planting corn near the cane fields to reduce late season borer migration and making sure that the cane sets are clean and uninfested.

Some work has been done on developing the sex pheromone of D. saccharalis which could be used in mating disruption and/or trapping out (Hammond & Hensley 1971).

**Economic damage:** High. Damage by this pest has resulted in high economic damage both in sugarcane and corn in the United States, Central and South America.

**Estimated risk:** Medium for entry. High should this pest become established in Australia.

**Quarantine Assessment:** Not in Australia/in pathway/of economic importance/status unknown

**Quarantine status:** Quarantinable

**Further Information**
Mr E. Edwards, CSIRO Entomology, PO Box 1700, Canberra, ACT 2601; Ph. 02 6246 4257; Fax. 02 6246 4000; email: Ted.Edwards@ento.csiro.au

**References:**
Appendix 2 – Match indexes for 60 non-Australian sugarcane-growing areas with 11 Australian localities

- **Brownsville, USA**
  - Match Index: 30
  - Locations: Mackay, Ingham, Innisfail, Mareeba, Bundaberg, Cairns, Murwillumbah, Nambour, Grafton

- **New Orleans, USA**
  - Match Index: 30
  - Locations: Bundaberg, Grafton, Murwillumbah, Mackay, Nambour

- **Miami, USA**
  - Match Index: 20
  - Locations: Ingham, Mackay, Ayr, Cairns, Madden, Bundaberg

- **Culiacan, Mexico**
  - Match Index: 25
  - Locations: Mackay, Innisfail, Cairns, Cairns, Cairns, Cairns

- **Veracruz, Mexico**
  - Match Index: 40
  - Locations: Ingham, Mackay, Ayr, Cairns, Innisfail, Mackay

- **San Salvador, El Salvador**
  - Match Index: 30
  - Locations: Ingham, Mackay, Ayr, Cairns, Innisfail, Mackay

- **San Jose, Cost Rica**
  - Match Index: 16
  - Locations: Ingham, Ayr, Cairns, Cairns, Mackay, Bundaberg

- **Habana, Cuba**
  - Match Index: 40
  - Locations: Ingham, Ayr, Cairns, Mackay, Bundaberg

- **Kingston, Jamaica**
  - Match Index: 30
  - Locations: Ingham, Ayr, Cairns, Mackay, Bundaberg
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### Appendix 3 - Summary of Pest Incursion Management Plan

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<th>SUGGESTED TIMELINE</th>
<th>ISSUE</th>
<th>RESPONSIBLE PERSONS</th>
<th>ACTION</th>
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<tr>
<td><strong>Day 1</strong></td>
<td>INVESTIGATION</td>
<td>BSES, State Department or AQIS Officer, Grower, Member of the Public</td>
<td>Immediately contact BSES or other Entomologist. Hold specimens under secure conditions.</td>
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<tr>
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<td>Notification of suspect pest detection</td>
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<td>DO NOT REMOVE PLANTS FROM FIELD</td>
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<td></td>
<td>Keith Chandler (Cairns) 07 40561255</td>
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<td>Mohamed Sallam (Tully) 07 4068 1488</td>
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<td>David Logan (Ayr) 07 4782 5455</td>
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<td>Peter Samson (Mackay) 07 4954 5100</td>
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<td>Peter Allsopp (Bundaberg) 07 4159 3228</td>
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<td>Agriculture WA (Ord) 08 9166 4000</td>
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<td>Murray Fletcher (NSW) 02 6391 3800</td>
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<td></td>
<td></td>
<td>or Director BSES 07 3331 3333</td>
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<td></td>
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<td>Notify BSES &amp; State/Territory Chief Quarantine Officer, Plants, prepare initial report. State/Territory Chief Quarantine Officer or Director BSES to notify State/Territory Minister and Chief Plant Protection Officer, AFFA. CPPO to notify Federal Minister, other States and Territories and key industry representatives on a confidential basis.</td>
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<tr>
<td><strong>Day 1-2</strong></td>
<td>Identification of pest</td>
<td>BSES/other Entomologist</td>
<td>Travel to site, inspect suspect plants and specimens</td>
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<td></td>
<td>Not a new pest</td>
<td>BSES/other Entomologist</td>
<td>Suspend operations</td>
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<td></td>
<td>Uncertain identification</td>
<td>BSES/other Entomologist</td>
<td>Collect specimens, return to laboratory and inspect microscopically, also dispatch specimens by express courier to:</td>
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<td>CSIRO Entomology Australian National Insect Collection(ANIC) Attn: Kim Pullen Clunies Ross Street, Acton, Canberra, 2601 GPO Box 1700, Canberra, ACT, 2601 ☏: 02 6246 4263 Fax: 02 6246 4364 Email: <a href="mailto:kimp@ento.csiro.au">kimp@ento.csiro.au</a></td>
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<td>John Donaldson QDPI, 80 Meiers Road Indooroopilly Qld 4068 ☏: 07 3896 9419 Fax: 07 3896 9446 Email: <a href="mailto:donaldj@dpi.qld.gov.au">donaldj@dpi.qld.gov.au</a></td>
</tr>
<tr>
<td><strong>ALERT</strong></td>
<td>Positive identification of new pest</td>
<td>BSES/other Entomologist</td>
<td>Place infested premises under quarantine - State departments.</td>
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<tr>
<td>SUGGESTED TIMELINE</td>
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<td>RESPONSIBLE PERSONS</td>
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<tr>
<td>Day 2-3</td>
<td>OPERATIONAL Implementation of response action</td>
<td>Director BSES, State/Territory Chief Quarantine Officer, Plants</td>
<td>Establish State/Territory Strategic Management Group and Local Operations Centres. Quarantine alert teams formed and instructed in pest identification, survey/trace-back methods and disinfestation techniques. Survey and trace-back commenced. Collection and destruction of infested plants on infested premises if appropriate.</td>
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<tr>
<td>Day 2-3</td>
<td>Convene Consultative Committee</td>
<td>CPPO in collaboration with State/Territory Chief Quarantine Officer, Plants</td>
<td>Committee is convened and briefed on incursion and recommends further action. Press Release is prepared and circulated to Government and Industry. Chairman of Committee negotiates with Federal and State Ministers on release of Press Release to media and statement by Minister or their nominee. Seek approval from NRA for use of pesticides needed in eradication or containment.</td>
</tr>
<tr>
<td>Day 6-9</td>
<td>Survey and trace-back</td>
<td>Operations Managers</td>
<td>Collect, compile and interpret survey data. Prepare report for Consultative Committee. Second meeting of Consultative Committee</td>
</tr>
<tr>
<td>Day 6-9</td>
<td>Second meeting of Consultative Committee</td>
<td>Consultative Committee, State/Territory Strategic Management Group</td>
<td>Consultative Committee to meet in district of outbreak (if commercial cane area) and meet with BSES Entomologist and Operations Managers. Review survey data and report on identification from CSIRO Entomology (ANIC) and QDPI and recommend: (a) eradication (b) more information - continue alert (c) eradication not possible, move to active containment.</td>
</tr>
<tr>
<td>SUGGESTED TIMELINE</td>
<td>ISSUE</td>
<td>RESPONSIBLE PERSONS</td>
<td>ACTION</td>
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<tr>
<td>Day 6-9</td>
<td>(a) <strong>Eradication</strong></td>
<td>CPPO and affected State/Territory Strategic Management Group, Consultative Committee</td>
<td>Prepare recommendation for eradication including cost/benefit analysis and a budget. Submit recommendation and budget to SCARM through the Plant Health Committee. Discuss compensation with industry and governments. Prepare State legislation if required to restrict movement of plants and machinery and enforce plough-outs.</td>
</tr>
<tr>
<td>Decision to eradicate made</td>
<td>Operations Managers</td>
<td>Organise destruction of all infested and buffer crops. Re-survey fields surrounding infested crops. Continue wider surveys and trace-back. Organise counselling of affected farmers. Convene Information Meetings for Industry in affected district. Prepare Press Release on decisions of Consultative Committee and SCARM. Inform industry organisations and interstate governments on decisions</td>
<td></td>
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<tr>
<td>1-36 months</td>
<td>Review</td>
<td>Operations Managers, State/Territory Strategic Management Group Consultative Committee</td>
<td>Report monthly on ongoing surveys and eradication. Meet bi-monthly or as required to review eradication program.</td>
</tr>
<tr>
<td>Post-eradication</td>
<td>Surveillance</td>
<td>AQIS</td>
<td>Maintain surveillance and off-shore control programs.</td>
</tr>
<tr>
<td>Day 6-9</td>
<td>(b) <strong>More information</strong></td>
<td>Operations Manager</td>
<td>Surveys and trace-back (ongoing). Report prepared on daily basis.</td>
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<tr>
<td>SUGGESTED TIMELINE</td>
<td>ISSUE</td>
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<tr>
<td>Day 6-20</td>
<td>(c) Eradication not possible</td>
<td>Consultative Committee, State/Territory Strategic Management Group</td>
<td>Consultative Committee ceases to function and Containment Committee formed. Preparation of containment plan. State/Territory Strategic Management Group continues to oversee program until containment plan is fully operational. Prepare State legislation if required to restrict movement of plants and machinery and enforce plough-outs. Report to industry organisations. Discuss industry-wide levy to fund containment with State and Industry bodies.</td>
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<td>Operations Managers</td>
<td>Organise strategic surveys in district outside infested district. Establish road-blocks on major roads out of district to inspect for plants and contaminated machinery. Organise survey teams to monitor pest levels and issue plough-out orders as required to reduce build up. Convene information meetings in affected area.</td>
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<tr>
<td>1-12 months</td>
<td></td>
<td>BSES/other Entomologist/State Plant Improvement Manager</td>
<td>Establish insecticide-screening program. Establish list of potential non-insecticidal controls. Establish propagation areas of resistant varieties initially in affected area but also in other districts. Distribute resistant varieties to affected growers.</td>
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<td>BSES Entomologist/State Plant Improvement Manager</td>
<td>Develop plan for production of pest-free planting material and establish resistance screening for advanced clones in breeding programs if appropriate. Organise visit by overseas Entomologist with expertise in control of particular pest type.</td>
</tr>
</tbody>
</table>