Technical Guidelines for Development of Pest Specific Response Plans

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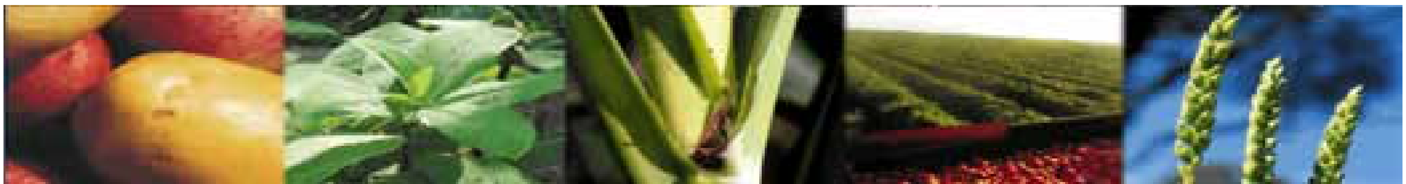

Plant Health Australia is a peak national coordinating body for plant health in Australia. We commission projects and work with members to coordinate the development of national policy and capability to enhance the ability of Australian agriculture to respond effectively to plant pests.

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Acronyms

APVMA	Australian Pesticides and Veterinary Medicines Authority
BA	Biosecurity Australia
CCEPP	Consultative Committee on Emergency Plant Pests
CPHM	Chief Plant Health Manager
DAFF	Department of Agriculture, Fisheries and Forestry
DQMAWG	Domestic Quarantine Market Access Working Group
ELISA	Enzyme-Linked Immunosorbent Assay
EPPRD	Emergency Plant Pest Response Deed
ICA	Interstate Certification Assurance
IPM	Integrated Pest Management
MCS	Manager of Chemical Standards
MRL	Minimum Residue Limit
NMG	National Management Group
OCPPO	Office of the Chief Plant Protection Officer
OGTR	Office of the Gene Technology Regulator
PCR	Polymerase Chain Reaction
PEQ	Post entry quarantine
PHA	Plant Health Australia
PHC	Plant Health Committee
PHER	Plant Health Expertise Register
R&D	Research and Development
SOP	Standard Operating Procedure
SPHDS	Subcommittee on Plant Health Diagnostic Standards
STMPP	State Technical Manager Plant Protection
TAG	Technical Advisory Group
WTO	World Trade Organisation

Executive Summary

This document provides technical guidelines to assist scientists and regulators develop response strategies for emergency plant pests (either pre-emptively or reactively) and provide technical advice during an incursion.

This guideline is built around the four phases of incursion response in PLANTPLAN – investigation, alert, operational and stand down – although the content differs from PLANTPLAN. It focuses more on the specific responsibilities of experts in developing incursion response strategies, and provides a guide for developing response strategies aligned to the biology, epidemiology and control of different pest types.

The document has particular relevance for entomologists, plant pathologists and other discipline specialists who become involved and provide advice during incursion responses. These can include modellers, biometricians, plant ecologists, breeders and economists.

The document is comprised of three sections:

Section 1 identifies the general roles, responsibilities, skills and knowledge requirements of technical specialists during an incursion response (page 9).

Section 2 considers the impact of different methods of pest dispersal on incursion management. Categories have been identified which are independent of types, genera and species, but which associate organisms on common methods of dispersal. This approach has been used because the variety of methods of dispersal of pests and pathogens are important determinants of quarantine decisions. They influence the way surveys are conducted, the establishment of quarantine zones and movement controls, the decisions and approaches to eradication.
Four groups have been identified all of which are considered to require significantly different methods of incursion response. They are active flight, wind borne, mechanical (includes soil and seed) and water borne (page 15).

Section 3 presents technical checklists for use by experts in planning for diagnosis, impact assessment, selection of emergency control treatments, surveys, quarantine and movement controls, eradication and stand down (page 23).

The guidelines should be used either in planning response to incursions of pests for which no pre-emptive contingency plans exist, or in the development of specific incursion management plans (contingency plans) for high risk pests identified in the Industry Biosecurity Planning process. They should be used in conjunction with the relevant parts of PLANTPLAN, particularly the Appendices. Attention to the detailed technical issues in the development of plans for incursion response will improve the quality of decisions and ensure more effective use of cost shared funds.

Introduction

Diversity in plant production systems is a unique feature of Australian agriculture. It covers tropical, sub tropical and temperate climatic zones. Within these, an extensive range of monocotyledonous and dicotyledonous plants are grown for food, fibre and amenity. Most plants used in primary industries have been imported over the last 150 years but, surprisingly, not all of the pests[1] which affect these hosts in their native habitats, have arrived in Australia. There are many hundreds of exotic pest and it is impractical to develop response plans for every pest:host combination. Alternative strategies are required.

Plant Health Australia is currently developing national programs, with industries and government, which enhance levels of preparedness for managing incursions of emergency plant pests (pests covering both invertebrates and pathogens).

Three approaches are being developed to enhance effectiveness of incursion management.

1. Overall operational, organisational protocols and responsibilities in incursion management are defined in PLANTPLAN which is the reference document for use by industry and government stakeholders.
2. The Industry Biosecurity Planning process, coordinated by Plant Health Australia (PHA), identifies threats from specific high risk emergency pests and develops biosecurity strategies for farms to reduce risk of incursions, their economic and social consequences.
3. The development of selected incursion response plans for specific pests identified by the industry biosecurity planning process. Examples include Karnal bunt, fire blight, melon fly, banana black sigatoka and Dutch elm disease.

Entomologists, plant pathologists, quarantine agencies and industry can use the technical guidelines in this document to assist in planning and implementing incursion response.

It is essential that these guidelines should be used in conjunction with PLANTPLAN and the relevant parts of the Emergency Plant Pest Response Deed (EPPRD) to ensure response strategies are consistent with nationally agreed processes and protocols.

[1] The International Plant Protection Convention definition of a "pest" is used here, unless otherwise stated, which is "any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products".

Section 1

Roles and responsibilities of technical experts in incursion response

Introduction

Many of the decisions which are made during incursion response usually are a result of a combination of technical and regulatory inputs, backed by detailed planning and logistical support.

Quarantine managers rely heavily on technical advice from experts for diagnosis, surveys, identifying zones, destruction and confirming eradication. A critical factor for success is the ability to identify the pest and predict its biology, dispersal and impact in the Australian environment.

Identification and predictive analysis of pests which have not yet arrived in Australia is challenging and has been imprecise. However recent advances in diagnostic science, modelling and computer access to accurate overseas scientific data mean that experts can now begin to accurately identify pests and interpret their distribution and impact across Australia's diverse ecosystems.

This information is used by quarantine managers in formulating decisions within a framework defined by state and territory and Commonwealth legislation, PLANTPLAN and the Emergency Plant Pest Response Deed (EPPRD). The quality and effectiveness of decisions usually relies heavily upon the accuracy of technical advice.

Experts such as entomologists, plant pathologists, economists, biometricians, modellers and ecologists are usually unfamiliar with the requirements of incursion response. Their careers usually are developed within R&D organisations which are different from the more regulated environment of quarantine and emergency response. It is important that these groups have a shared understanding of roles and responsibilities when involved as members of incident management teams dealing with incursion response.

This section presents the general roles and responsibilities for technical personnel in an incursion response. The role of such experts is usually performed through a Technical Advisory Group (TAG) over the four phases of incursion response specified in PLANTPLAN. Note that the concept of a TAG has not been formally ratified to date, but has been used on an *ad hoc* basis by the CCEPP during and incursion response. Pending agreement by PHA members this would be included in a future version of PLANTPLAN. The members of any TAG could be primarily identified from PHA's Plant Health Expertise Register (PHER).

Note also that the State Technical Manager of Plant Protection (STMPP) (described below) in not currently a formal role in PLANTPLAN. This position would likely be a technical delegate of the CPHM, depending on the structure of the agency.

Table 1. **Summary of roles, responsibilities and skill/knowledge requirements for experts involved in a Technical Advisory Group**

ROLE	SKILLS/KNOWLEDGE
Applicable for all:	
Responsibility for technical advice: Primary responsibility for provision of technical advice in specialist areas of entomology, plant pathology, biometrics, ecology, modelling and economics which is used by CPHM and CCEPP to formulate important recommendations on incursion response	Recognised national and international research scientist with extensive expertise on specific emergency plant pests and experience in applied industry R&D; experts in biometrics, ecology, modelling and economics with specific understanding of the applications for incursion response operations; detailed knowledge of technical and organisational protocols and processes required for effective incursion response. Knowledge of WTO requirements, trade/political issues and legislation
Entomologists and plant pathologists:	
Maintenance of pest knowledge: Maintain an understanding of the diagnostic features, biology, epidemiology impact and control of key emergency plant pests identified by industry biosecurity plans	Capability to use science, industry literature and international networks to maintain an awareness of existing and emerging pest threats; ability to analyse and selectively apply knowledge for decisions in diagnosis, impact assessment, survey, quarantine and eradication
Selection of diagnostic protocol: Assist State Technical Manager Plant Protection (STMPP) and Manager Diagnostics to select and implement diagnostic protocols to confirm identity; liaise with CPHM to engage international experts to accelerate identification, and to select second national laboratory	Ability to recognise the emergency plant pests identified in Industry Biosecurity Plans. Ability to identify robust diagnostic tests and develop Standard Operating Plans (SOP) under tight deadlines; high level technical communication skills with international scientists; knowledge of Australian expertise and diagnostic resources
Advise on identification of pest: Provide advice to STMPP and CPHM on the putative identity of the suspect pest, interpret results from diagnostic tests to confirm the identity of the pest and its vectors; communicate recommendations to CPHM through STMP	Ability to progressively interpret and communicate the results of complex technical tests to senior quarantine managers and maintain confidentiality
Availability of control measures: Analyse whether any chemical, biological or genetic controls exist in Australia and/or justify the need for importation and use as emergency treatments; liaise and advise MCS, CPHM and CCEPP on immediate needs	Networking with international experts to identify the most cost effective control treatments for introduction and emergency use
Secure destruction: Assist quarantine managers to plan for the safe removal and destruction of affected plants and plants in buffer zones, including specific disinfestation treatments of soils and equipment	Ability to apply knowledge of the biology, dispersal of the pest (including vectors) and of disinfestation treatments in planning practical strategies to reduce the risks of escape of the during removal and destruction programs

Entomologists, plant pathologists and biometricians:

Establishment of quarantine zones: Assist quarantine managers establish zones and movement controls, specify disinfestation treatments and estimate the extent of buffer zones	Knowledge of the natural and mechanical pathways for spread of the pest and of disinfestation strategies for minimising risks of escape and spread; understanding of the legislative requirements of plant quarantine
Survey design: Liaise with industry experts and quarantine managers to design delimiting and area wide surveys and surveys to confirm pest free areas	Knowledge of the expected ecology, predicted distribution and survey methods for the pest on host plants; ability to work under tight deadlines within teams
Survey implementation: Provide technical advice to CPHM, CCEPP, DQMAWG, on the implementation of survey to confirm affected and pest free areas; assist in the development of illustrated field guides and train teams	Ability to communicate the output from predictive analysis to senior managers and industry including confidence limits of detection; knowledge of reference literature and images for creating field guides for survey teams
Survey interpretation: Assist CPHM, CCEPP, DQMAWG and Biosecurity Australia (BA) in interpretation of survey data for use in negotiations on trade in host plants, plant products and in movement controls	Ability to interpret complex technical issues from survey relating to pest presence and absence, and risk management protocols for trade and movement controls
Pest Free Area determination: Provide technical advice to CPHM and CCEPP on the methods for confirming eradication of the pest from the affected area; assist in training survey teams	Ability to design sensitive sampling strategies which can detect low levels of the pest (includes the sampling of soils and the deployment of sentinel plants) ability to communicate to CPHM and CCEPP and train teams
Post-incursion report: Provide the necessary technical input required by CPHM and CCEPP in preparing the post incursion report for communication to stakeholders	Ability to summarise and incorporate technical outputs from incursion response into a final generic report targeted for a range of stakeholders, including markets, industry, the community, government

Entomologists, plant pathologists, modellers, plant ecologists, economists and biometricians:

Prediction of impact: Assist in the preparation of a national report for CCEPP which predicts and reports the economic and environmental impact of the establishment of the pest in agricultural and native ecosystems	Ability to work in teams and meet tight deadlines for development of predictive impact and cost benefit analyses. Ability to prepare cost benefit analysis reports and communicate complex technical issues to CPHM and CCEPP

Entomologists, plant pathologists, biometricians and plant ecologists:

Feasibility of eradication: Analyse and recommend the technical feasibility of eradication to CPHM and CCEPP	Knowledge of the survival, rates of multiplication, host range and methods of dispersal within the Australian agricultural and natural landscape; ability to interpret survey and cost benefit analyses in the context of the eradication or containment decision
Development of response plan: Assist CPHM in the development of a response plan for the Emergency Plant Pest	Detailed technical knowledge of the biology of the pest; of PLANTPLAN and how to integrate these into a specific response plan

Section 2

Pest dispersal methods

Introduction

This section present information to assist entomologists and plant pathologists develop response procedures for categories of organisms based on their dispersal characteristics.

Categories have been identified which are independent of bio-types, genera and species, but are based on common methods of dispersal.

This approach has been used because the variety of methods of dispersal of pests and pathogens are important determinants of quarantine decisions. They influence the way surveys are conducted, the establishment of quarantine zones and movement controls, the decisions and approaches to eradication.

Four categories of dispersal have been identified, each of which involves different approaches to incursion management. The categories are intended as a guide and do not cover all of the issues associated with specific organisms.

- ***active flight*** (covering invertebrates pests with an ability to sustain active flight enabling dispersal over considerable distances)
- ***wind*** (includes spores, certain insect groups and any seed borne pathogens of wind borne seeds)
- ***mechanical***
- ***water***

Natural methods of movement of pests (crawling insects, nematodes, zoospores) in soil have been omitted because this occurs over relatively short distances, usually metres or less, and is not critical for quarantine decisions. On the other hand long distance transport of soil and seed borne pests by farming practices is significant and considered under the categories of mechanical and water.

The categories are also applicable for certain viruses and virus-like organisms, many of which are spread by vectors. These are commonly invertebrate species, but sometimes fungi. The vectors may be exotic to Australia or introduced. Other viruses can be transmitted, and dispersed by mechanical means. Of the four categories, those on active flight, wind borne and mechanical (including seed) are the most relevant for incursion management of vectored viruses.

Active Flight

Types of organism

Invertebrate pests that can sustain protracted flight, and have the capability to travel from a few to several hundred kilometres. These organisms also use wind and air currents to assist dispersal but are also capable of independent flight.

> **Examples include:**
> Moths, beetles, weevils, locusts

Issues for incursion management

Incursions of pests which are active fliers are regarded as high risk. They can create significant problems for incursion management either for the damage they cause or as vectors of pathogens which are the cause of significant losses. Incursions of some active fliers such as fruit flies have substantial impact on Australia's international trade in horticultural produce. Others such as the sharp shooter group are vectors of important pathogens which can affect several different commodity groups.

Active fliers are considered a serious risk because of their rapid methods of spread. Not all incursions will be detected at an early stage and consequently eradication may be difficult to achieve. In many instances infected areas can be extensive which makes justification of eradication difficult. Exceptions to this are those pest species that are attracted to lures (fruit flies and moths) which provides a management tool for incursion response.

Predictive analytical tools are essential for effective incursion response and this is particularly relevant for active fliers. The use of models to predict breeding cycles on host plants and variations in the rates of population increase are critical for effective eradication or containment response. It requires an understanding of the biology of the pest which is applied to the climatic variables and host plant systems across the Australia's agricultural landscape.

Similarly predicting migration patterns is equally important and dependent on analysis of weather variables.

Wind borne

Types of organism

Wind borne spores of plant pathogens, alate and non-alate invertebrate pests. Note that:

- the alate, or winged forms, cover those genera and species which are known as trivial flyers. These have the capacity to fly and maintain their position in air currents, but it is the currents which are the primary means of transport
- also included are wind borne non-alate invertebrates that are usually very small and easily transported by air currents

> **Examples include:**
> Mildews, rusts, smuts, certain aphids, mites and thrips

Issues for incursion management

Wind borne organisms are regarded as high risk. They create significant problems for incursion management because of rapid and extensive means of dispersal. Detection of the early stages of infestation can be difficult because of their microscopic and cryptic nature. Not all infestations will be detected at an early stage, consequently by the time their presence is confirmed, affected areas can be extensive and justifying eradication and containment will be difficult.

"Dangerous" features of many of the pathogens are short regeneration times and explosive rates of asexual reproduction. In reality this means fewer generations are required to start an epidemic.

Major determinants of the rates of population increase and of distribution are weather and availability of host plants. It is essential to develop accurate models which can be used to predict the distribution and population size.

Mechanical

Types of organism

Seed and soil-borne pests that colonise seed or root systems and other vegetative organs such as tubers, bulbs and corms. The major consideration is long distance mechanical methods of spread of either contaminated seed or infested soil. The latter usually occurs on vehicles, machinery and containers.

The distances these organisms move within soil habitats are usually less than one metre and are not considered significant for incursion management.

> **Examples include:**
> *Soil-borne organisms:* Fusarium and Verticillium wilt fungi, Cyst, Lesion and Root Knot Nematodes, Corn Root Worm, Cabbage Flea Beetle, Pea Leaf Weevil, Wire Worms
>
> *Seed-borne organisms:* this primarily concerns plant pathogens including viruses, smuts, and certain fungi. Note that there are very few pest species which are truly seed-borne

Issues for incursion management

Soil-Borne Pests*:* From a natural or biological standpoint soil-borne organisms do not disperse over long distances. However most are considered a significant risk for incursion management primarily because of farming practices (mechanical issues) which can spread infested soil over substantial distances.

Containment is feasible because, in contrast to the situations with wind and active flight, secondary spread is usually quite slow.

Eradication is also a possibility but this usually is a long term program involving strategies which adversely affect survival of the pest in soil. The duration for implementing and confirming eradication can take from three to ten years depending on the nature of the life stage.

<u>Seed-Borne Pests</u>*:* Specific problems associated with incursion management of seed-borne pests concern:

- tracing of contaminated seed lots
- the problem of killing contaminated seed which may have fallen from plants and lie dormant in soils
- minimising the risk of spread to alternative hosts particularly weeds where contaminated seed creates an inoculum source for reinfection of commercial crops.

Successful incursion management for seed and soil-borne organisms depends on two important strategies:

1. effective quarantine and containment at affected sites
2. strategies which identify and "close" all pathways of mechanical dispersal and minimise risk of secondary spread.

Water

Types of organism

In most instances organisms which are transported by water usually originate from soil infestations. The exceptions are those pests which may dropout from wind currents into water storages or water courses.

Not all of the pests are adapted to immersion in water and usually only those with dormant, resistant life stages can survive prolonged periods of immersion.

Examples include:
Resistant spore types of fungal pathogens such as chlamydospores and cysts of some nematode species.
Eggs and juvenile stages of certain pest species.

Issues for incursion management

For many dry land production areas in Australia, dispersal of organisms by water is considered low risk. Exceptions occur during periods of intense rainfall and flooding when organism can be carried in run-off water. Development of containment strategies for flooding events is unlikely to be feasible.

Dispersal of water-borne pests is considered high risk in irrigated crops and crops grown under hydroponic systems.

Water storages, channels and field irrigation systems used for irrigated crops present significant problems. Difficulties exist in identifying and treating the source water and in preventing distribution of the pest throughout irrigation systems.

Table 2: Different response strategies associated with the four categories of pest dispersal

Active Flight	Wind-Borne	Mechanical: Internal Seed and Soil-Borne	Water-Borne
<u>Diagnostics:</u> Example variations in diagnostic protocols			
Lures and traps for adults; feeding damage; larval instars; PCR/ELISA for larvae	Characteristic foliar symptoms; PCR/ELISA for strain differentiation and identifying larval instars	Seed and soil sampling protocols; special nematode, pest and spore isolation and DNA extraction methods	Water and soil sampling; special nematode, pest and spore isolation; PCR/ELISA protocols
<u>Surveys:</u> Different requirements for delimiting survey			
Area wide survey required linked to estimated flight times, wind speed, direction and host plant distribution	Area wide survey linked to prevailing wind speed, direction; and characteristic spatial distribution patterns in crops/orchards	Local survey for restricted areas of poor growth, root symptoms	Local survey for restricted areas of poor growth, foliar symptoms that is linked to either distribution by water courses, channels and run off events
<u>Tracing:</u> Example issues that influence trace back/forward analysis			
Identifying hitch hiking opportunities for adults and larvae	Identifying hitch hiking opportunities for spores, adults and larvae	Tracking pest movement on produce, equipment, containers or in seed/fruit, and soil	Tracking pest movement along water courses, irrigation lines/channels and run off, identifying water sources
<u>Impact assessment:</u> Examples of the different factors which affect impact (other than climate and presence of host plants)			
Identification of controls already present in Australia including: classic biological, resistant germplasm, pesticides; estimating population dynamics and rates of spread	Identification of controls already present in Australia including: classic biological, resistant germplasm, pesticides; estimating population dynamics and rates of spread; resistance to UV and desiccation	Survival characteristics of pests exposed or within seed, plant debris or soil; effects of existing seed treatment and disinfestation practices; adaptation to soil environments and management practices	Estimating risks and times of high soil water over cropping cycles

Active Flight	Wind-Borne	Mechanical: Internal Seed and Soil-Borne	Water-Borne
Quarantine zones: **Special requirements for defining quarantine zones**			
Defining the limits of affected area by survey for feeding damage and life stages; application of pesticides to prevent active flight; identifying extent of buffer zones in relation to risk of flight; application of specific movement controls to reduce the risk of hitch hiking	Defining the limits of affected area by survey for canopy symptoms; application of pesticides to prevent sporulation and trivial flight; identifying the extent of buffer zones in relation to wind dispersal; application of specific movement controls to reduce risks of hitch hiking	Defining the limits of the affected area by sampling root and soil, the inflorescence, fruit, seed heads, application of soil fumigants; application of specific movement controls to reduce risk of seed and soil movement; identifying the extent of buffer zones in relation to the risk of local natural dispersal of seed and soil pests	Defining the limits of the affected area by identifying affected plants and contaminated "water pathways"; application of filters or treatments in irrigation systems and fumigants for affected soils; application of specific movement controls to reduce risks of water borne dispersal; identifying the extent of buffer zones in relation to the risk of local spread in soil and irrigation water
Pest Free Area surveys: **Special issues for pest free area surveys to meet defined confidence limits**			
Network of traps and lures, backed by statistical surveys of known host plants for damage on hosts and larval stages	Statistical surveys of known host plants for symptoms backed by diagnostic tests on selected samples	Statistical field survey for symptoms on seed/fruit/roots; post harvest survey of seed, fruit; statistical soil sampling – all backed by diagnostic tests	Statistical survey of irrigation systems, water sources and associated soil areas – backed by diagnostic tests
Destruction: **Special issues for destruction of affected plants and site treatments (other than general disinfestation treatments)**			
Affected plants sprayed with knockdown pesticide before removal and destruction; vehicles and equipment washed (and treated?); soils fumigated to remove soil life stages	Affected plants treated with knockdown insecticide or curative fungicide before removal and destruction; vehicles and farm machinery washed (and treated?); soils fumigated to remove soil life stages	All plant material removed including seed and subterranean plant parts (tubers, roots, bulbs). Soils fumigated to kill seed and vegetative parts of plants. Treated sites reinspected for regrowth	Similar arrangements for "mechanical" with additional requirement for disinfestation of irrigation equipment and contaminated water sources
Eradication: **Special issues for confirming eradication**			
Statistical deployment and scheduled inspection of traps/ lures or sentinel plants	Statistical deployment and scheduled inspection of sentinel plants	Statistical baiting of soils with host plants combined with diagnostic testing for the pest in soil samples all linked to known survival characteristics	Same arrangements for "mechanical" with additional requirement of bait testing irrigation lines, equipment and water sources

Section 3

Technical checklist for incursion response plans

Introduction

This section provides checklists of technical issues to guide experts preparing and implementing emergency plant pest responses or assisting in this process.

This part of the document can be used when developing pest specific contingency plans (pre-emptive) or for developing an incursion specific response plan (reactive). This should help to ensure that recommendations take into account most of the technical issues, thereby reducing the risk of unanticipated errors and costly mistakes.

These guidelines are complementary to the broad framework of emergency plant pest responses described in PLANTPLAN and it is essential that it is cross referenced and considered. Any pest specific response plans developed using these guidelines should therefore be the level of detail under PLANTPLAN that is specific to the pest concerned and not duplicate and national arrangements in PLANTPLAN.

This section presents seven components that correspond to key response issues:

▪	Diagnosis	page 27
▪	Estimating impacts	page 29
▪	Identification and selection of control treatments	page 31
▪	Technical information for surveys	page 34
▪	Quarantine zones, movement controls and risk mitigation	page 36
▪	Destruction and eradication	page 38
▪	Technical debrief and stand down	page 40

Diagnosis

Introduction

The process of confirming "not seen before" or "this is new" is absolutely critical for effective quarantine management. Diagnosis is not just the science of isolation and identification. It involves the capability to recognise symptoms in the field and an understanding of how to get the situation confirmed as soon as possible.

During incursion response, diagnostic science is used to absolutely confirm the identity of the introduced pest. Selected tests are also applied to samples collected during survey operations and the information is used to back up observations on presence of symptoms of pest damage. This information is used to meet two requirements:

1. for defining the boundaries of pest distribution for the establishment of quarantine zones and movement controls
2. for confirming that the pest is not detected. This "known not to occur" principle is critically important for trading partners.

In addition to the specific technical facilities and equipment required, diagnostic laboratories involved in incursion response require standard operating procedures (SOP) to ensure consistency. This should be based on endorsed National Diagnostic Standard Protocols where these are available. Together with defined recording and reporting protocols this is important in maintaining the chain of evidence (refer to PLANTPLAN for further details). Three technical levels are required:

1. Trained scientists who operate in the diagnostic laboratory and use the diagnostic protocols to test samples.
2. A Manager of the Diagnostic Laboratory whose duties include: checking on SOP's, managing the sample flow, supervising records management, managing the resource and dealing with quarantine and other specific issues.
3. A Senior Technical Manager Plant Protection (STMPP) who assists the Manager Diagnostics and diagnosticians to ensure results are correctly interpreted, and who is responsible for reporting the results to the Chief Plant Health Manager.

Checklist for diagnostic scientists and technical managers:

- Describe symptoms and damage on all plant parts. This should include variations in symptoms/damage on other cultivars, host plants and weeds.
  - For pathogens describe characteristic visual disease symptoms and any obvious morphological characteristics of the disease/pathogen.
  - For invertebrates (including vectors of pathogens) describe damage characteristics, and any morphological characteristics of egg, juvenile and adult stages, of frass, and the presence of predators, parasitiods and parasitised life stages.

- Sampling procedure: Specify sampling procedures to be used, any special methods of disinfestation and decontamination and special packaging methods for live organisms.

- Specify diagnostic laboratory: Specify to CPHM, or nominee, the preferred Australian diagnostic laboratory where organism specific expertise exists, a second national diagnostic laboratory for independent diagnosis; and recommend an international expert(s) who can be used and is acceptable to stakeholders. This should be consistent with the National Diagnostic Network specifications.

- Communicate consignment details: Ensure consignee communicates with the recipient diagnostician advanced detail of special alerts associated with the organism and risks of escape – spores, alate insects[2].

- National Diagnostic Standards: Check whether approved National Diagnostic Standard Protocols already exist[3], otherwise specify best practice diagnostic protocols for the isolation and identification of the organism including details of consistent methods and ingredients which are to be used nationwide to confirm presence or not in samples from survey, the agreed method of interpreting and recording results, and estimates of the time taken for completion of each test.

- DNA based diagnosis: Where possible use GENEBANK to verify the identity of the pest by comparison of DNA sequence data between test samples with that from either "type" specimens from reference collections or sequences published in refereed papers from reputable scientific journals.

- Juvenile invertebrates: For eggs and juveniles of invertebrates specify unique morphological characters and biochemical methods (including DNA analysis) where available to assist with identification; and methods for rearing to adult with anticipated time frames.

- Containment of organisms: Specify containment levels for pest organisms. For Koch's postulates with non-obligate pathogens specify minimum containment levels for laboratories, glasshouses and growth rooms. Handling and disinfection protocols which are consistent with the risk category of the organism need to be in place; and also containment facilities for use in rearing pests. Specify anticipated time frames for completion of Koch's postulates.

- Problems with interpretation: Identify any problems over interpretation of results which need to be communicated to STMPP and CPHM.

- Field guide preparation: Identify and assist in the preparation of specific field guides which illustrate characteristic symptoms and damage on hosts and weeds.

[2] CPHM to deal with any specific regulatory requirements associated with consignment.

[3] Information on National Diagnostic Standards will be available through the recently formed Sub-Committee on Plant Health Diagnostic Standards. Prior to the SPHDS website, PHA can be contacted for details of available standards.

Estimating impact on production, trade, allied industries and native ecosystems

Introduction

Understanding the relative risks that emergency plant pests pose to plant industries requires an evaluation which predicts their impact on Australia's agricultural and natural ecosystems. Data from this analysis is used to assess whether the economic benefits of eradication can be justified. The process usually requires inputs from plant protection experts, modellers, ecologists and economists.

The analysis is based on industry statistics, phytosanitary regulations of trading partners, estimates of the impact of the introduced organism on the pre and post farm gate productivity and any unanticipated environmental losses.

Examination of the phytosanitary regulations of trading partners provides an indication of the likely trade embargoes which can be introduced following the report of a pest incursion in Australia. For some industries these can be insignificant, but in other cases the value of "at risk" trade is substantial.

Science literature and web sites provide information on the biology of the organism, its spread, the predicted losses to host plants (including Australian plant species) and on the nature of control treatments. Models then use this data, together with the value of pre and post farm gate production, to estimate impact on host plants in the various climatic zones across Australia.

There are also indirect costs that should also be incorporated into calculations of impact. Examples are the spill over effects where a pest may affect post harvest quality which, in turn, may complicate value adding operations.

Significant difficulties can be encountered in estimating effects on native plants because in many instances there is no host range data for these genera and species. In this instance the only options are to consider any evidence on pest damage to Australian plants grown o/s and the nature of the organism (host specific or not) which can be used to indicate risk to native plants.

Presented below are four sections which can be used as a guide for estimating impact.

Checklist for entomologists, plant pathologists, modellers, ecologists and economists

Identification of endemic pest controls that would prevent/limit establishment

- Resistant varieties: Liaise with plant breeders to check whether resistance genes for the specific emergency plant pest are present in Australian cultivars of the host plant.
- Pesticides: Check whether pesticides currently approved in Australia also have activity against the introduced emergency plant pest (see APVMA website).
- Biological controls: Check whether naturally occurring biological controls are present in Australia.

Estimating impact on plant production, yield, quality and post harvest quality

- Impact on production[4]: Extrapolate from overseas data (and information on "unintended" controls in Australia) to estimate yield loss in plant production systems in various climatic zones in Australia. If possible two estimates are valuable: 1) unrestricted losses on susceptible cultivars without application of controls; and 2) expected losses when controls are applied. If necessary provide estimates of the range of losses.
- Effect of land contamination: Estimate any additional effects on the long term contamination of productive land.
- Cost of extra treatments: Estimate the additional cost of field control treatments.
- Post harvest impacts: Identify post harvest effects on product quality such as toxins, processing and shelf life issues.
- Impacts to allied industries: Identify allied industries which are dependant on the commodity and estimate impact of yield loss and quality on value adding operations.
- Impacts of a vector: Liaise with other experts to assess additional losses through the introduction of pest species which also can act as vectors for other pests.

Estimating impact on trade

- Market access implications: Liaise with Biosecurity Australia (Department of Agriculture, Fisheries and Forestry) and the Domestic Quarantine and Market Access Working Group, to identify existing trade (domestic and international) and trading partners likely to deny access to the commodity due to pest presence.
- Protocols to retain market access: Predict the type of post harvest treatments and pest free area protocols required by the market to retrieve access and estimate costs of implementation.
- Issues to agree pre-emptively:
  - Prepare/obtain a referenced host list for agreement by relevant jurisdictions.
  - Identify the commodity/plant parts that the pest can/could move on and the likelihood of transport and survival.
  - Describe the most efficacious and cost effective potential treatments that would allow commodity movement with minimal risk of pest spread.

Impact on native vegetation, weed hosts and home garden plants:

- Use available information on host range to estimate the risks of damage to native flora and fauna and any possible long term effects on associated ecosystems[5]
- Identify any possible beneficial effects on control of noxious weed species
- Estimate the significance of damage to Australian home gardens.

[4] Note that PHA has active research projects with ABARE and Monash University to model economic impacts (particularly regional) of hypothetical pest incursions consistently.

[5] This is usually an extremely difficult area because of lack of information on the interaction of the pest with Australian fauna and flora. Notwithstanding this, it is possible to check for references on effects on Australian plants growing in areas where the pest is endemic and secondly to use knowledge of the host range of the pest.

Guidelines for the identification and selection of control treatments

Introduction

In many instances when new pests arrive in Australia, industry and other stakeholders request urgent information on chemical or biological control strategies, or resistant cultivars which can be used to offset losses.

It is common to find that there are no control treatments or sources of resistance available in Australia which can be used by growers because the organism was not previously known to occur. Consequently specific active ingredients have not been registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA), nor approved for use under relevant State legislation. Biological control agents may not have been imported through the necessary quarantine channels and plant breeding programs may not have incorporated resistant genes into Australian cultivars.

The registration process for pesticides is normally driven through commercial agro-chemical companies who provide evidence of efficacy against targets, rates, methods and frequency of application, toxicological information and data for the establishment of maximum residue limits. Once registration is approved, States then consider specific control of use requirements. These relate to requirements for applicators, methods of application and controls on distribution, points of sale and disposal practices. Processes also exist for importation of biological control agents which involve off shore screening for risks of their possible pest status and importation through post entry quarantine channels.

During an incursion provisions are available for the emergency use permits (EUPs) for specific chemicals. Responsibility for initiating the process usually rests with the agencies in the State where the incursion has been recorded. Approvals for EUPs can be initiated pre-emptively for high priority pests to minimise response times in the event of an incursion. This should be coordinated through the relevant Industry Biosecurity Planning group (contact PHA for further details). Approvals for emergency registration and control of use are usually for defined periods and may require renewal during an extended incursion management campaign.

It should be noted that there are no effective therapeutic treatments for plant viruses. Use of antibiotics as control treatments is not permitted in Australia, although these are used overseas for control of bacteria and some phytoplasmas.

This section summarises issues for emergency use of control treatments not previously available in Australia, and can be used pre-emptively as part of a pest specific contingency plan.

Checklist for entomologists, plant pathologists, plant breeders

Selection of preferred control treatments (in conjunction with industry):

- <u>Advice on controls:</u> Provide technical advice for consideration by industry on the various types of controls available including their feasibility, safety and cost effectiveness.

- Prioritise control strategies: Prioritise and select the strategies which are best suited for the industry/environment and identify options for introduction over short, medium and longer term[6].
- Adverse effects: Ensure any potential adverse effects are identified when selecting control treatments[7].

Identification of chemical controls – immediate

- Identify active/formulation/application: Identify active ingredients of registered pesticides, the preferred formulation, rate and frequency and method of application and any strategies to avoid acquired resistance to chemicals. Note that special rates of application may be required to achieve eradication.
- Documentation for approval: Assist the Manager of Chemical Standards to prepare documentation required for securing approvals for emergency use permits and control of use[8].
- Identify mating disruption and trapping systems which are used as effective control treatments.
- Data on trapping systems: Provide technical data for consideration by AVPMA on proposed importation and use of pheromone and associated products for use mating disruption and trapping programs in Australia.

Other issues for pesticide use

- Identify non-target effects on bio-control agents.
- Identify resistance management strategies.
- Importation of actives: Evaluate chemical company policy on registration of introduced actives in Australia.
- Seek advice on MRLs (Maximum Residue Limits) for active ingredients and any trade market access implications.
- Application method efficacy: Develop specific advice on methods of application which will maximise opportunities for contact with specific target organism.
- Develop methods for assessing effectiveness of kill.

Identification and introduction of resistant germplasm – medium term

- Deployment of available germplasm: Liaise with plant breeders to recommend methods for the deployment of any resistant germplasm which is available in plant breeder's collections in Australia.
- Deployment of exotic germplasm: Develop programs for the introduction, evaluation and multiplication of commercially available resistant germplasm from overseas[9].

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[6] This should include consideration of the immediate introduction of management/hygiene and additional chemical treatments and the longer term requirements for non chemical methods such as resistance breeding and biological treatments

[7] Particular issues include effects on the sustainability of IPM programs and the risks of additional chemical treatments infringing minimum residue limits (MRLs) established by trading partners.

[8] Notes: (1) Commonwealth and state legislation on registration and control of use of Ag & Vet chemicals can be complex and awareness and preparedness of these organisations is essential for effective emergency response. (2) Documentation required for emergency approval and control of use should where possible include detail on efficacy, residues (Codex MRL), use patterns (includes resistance management strategies and minimising risk on non target species), controls on methods of storage and disposal and availability of supply.

- Importation of resistant germplasm: Prepare submissions for the importation of resistant lines for use as parents in pre-emptive breeding programs.
- Introgression of exotic resistance: Consider the possibility introgression of imported resistance genes. Where this involves Genetically Modified material this will need stakeholder approvals and consideration by the Office of the Gene Technology Regulator (OGTR).

Identify potential biological agents for control – medium term

- Identify endemic bio-control agents: Search literature and databases to determine whether species used for bio-control overseas are present in Australia
- Distribution of agent: Pending confirmation of above plan, survey to assess incidence, distribution and link to vegetation/climatic zones
- Culturing agents: For endemic biological agents, evaluate the need for establishing cultures for inundative release and specify requirements
- Identify need to import agents: Consider a recommendation to import additional biological agents from overseas and prepare a submission which describes testing protocols and satisfies regulatory controls

[9] This and the next dot point will need provisions for an application through Department of Agriculture, Fisheries and Forestry for importation into post entry quarantine.

Technical Information for Planning Surveys

Introduction

Survey is an essential activity and has application in each of the phases of incursion response. Various types are used to determine the distribution of the emergency plant pest, to confirm pest free areas and the success of eradication.

Surveys for emergency plant pests depend on the capability to anticipate their likely distribution in Australia. This can be difficult and requires interpretation of overseas research because there is usually no relevant Australian data on the pest. To assist the planning of surveys for incursion response, technical experts are required to analyse and interpret overseas information. Models have been developed which can predict the likely distribution of the pest across the Australian landscape.

Successful application of such models relies on the accuracy of information from overseas research on the biology, epidemiology and host range of the pest. Models align this with Australian climatic (temperature, wind, rainfall) and vegetation data and present predictive distribution maps which are used to plan surveys.

Technical expertise is essential to select relevant data on pest biology and climate, host plant ecology in Australia, and then to run the models. The checklist presented below provides some guidelines for experts on the data requirements for this predictive analysis.

Checklist for entomologists, plant pathologists, plant ecologists and modellers

- Survey strategy: Propose a survey strategy that could be used in the event of an incursion.

For invertebrates

- Resistant strains: Identify the risk of introducing strains particularly with resistance to insecticides.
- Generation time: Identify the likely generation time (egg to adult, including number of life stages) under degree day formula.
- Generations per season: For climatic zones, predict the number of generations per season and numbers per generation.
- Preferred environment: Identify preferred environment (plant, seed, soil) for maturation of life stages and known sites of survival over summer and winter.
- Endemic hosts: Analyse the scientific literature to identify the range of cultivated and Australian plants and weeds which are recorded as naturally occurring hosts of the emergency plant pest; identify their significance in Australia.
- Natural dispersal: Identify methods and the likely extent of natural dispersal, including factors which trigger development of alate forms.
- Mechanical dispersal: Identify risks of mechanical dispersal on equipment, plant parts, soil, people.

- Vectoring ability: Identify risks of the emergency plant pest acting as a vector for plant pathogens.
- Predict distribution limits: Predict the limits of the distribution of the organism in Australia as determined by vegetation and climate analysis.

For plant pathogens

- Biotypes: Identify the risk of introducing strains, pathovars, including resistance to fungicides.
- Conditions for infection: Identify the conditions required for infection of the host plant (temperature, moisture).
- Nature of vector: For vectored pathogens, identify the nature of transmission by insects (persistent vs non persistent) mites and nematodes.
- Rate of colonisation: Estimate the rate and extent of colonisation of host plants by systemic organisms under particular environmental conditions.
- Generation time: Estimate the generation time and rate of epidemic development for sporulating pathogens as affected by Australian environmental conditions.
- Persistence: Determine likely methods and sites of survival over summer and winter.
- Soil survival: For soil-borne pathogens estimate the longevity of survival structures and methods of detection in soil.
- Endemic hosts: Analyse the scientific literature to identify the range of cultivated and Australian plants and weeds which are recorded as naturally occurring hosts of the exotic pest or pathogen; identify their significance in Australia.
- Natural dispersal: Assess the methods and extent of natural dispersal - wind, water, vectors, seed.
- Mechanical transmission: Identify the risks of mechanical transmission on equipment, plant products, soil, people.
- Vectoring: Identify risks of pathogen acting as a vector for other plant pathogens.

Predicting the distribution on host plants in Australia

- Use of models: Adapt CSIRO and state agency climate/vegetation analysis models to predict the distribution of the emergency plant pest (previous section) on introduced host plants and weeds in non commercial and commercial plant production; and on Australian hosts in natural ecosystems. Where possible, identify the high, medium and low risk zones.

Quarantine zones, movement controls and risk mitigation measures

Introduction

During incursion response, risk mitigation measures are applied at national, state and farm levels to minimise the spread and establishment of the introduced pest. Activities usually commence following confirmation of the identity of the pest which allows agencies to act under appropriate legislation. At the national level actions are focussed on Australia's border, whereas at the state and local level activities are focussed on the infected and suspect premises. At these sites, quarantine zones and movement controls are introduced to minimise the risk of escape of the pest. For this to be effective the legislative powers must enable effective containment and secondly technical and industry analysis must identify all possible pathways which, if not closed, may allow escape and further spread.

Presented below is a list of essentially technical issues which should be considered at national, state and local levels when developing protocols/measures.

Checklist for entomologists, plant pathologists and quarantine scientists

National

- <u>PEQ protocols:</u> Evaluate possibilities for improvements in PEQ inspection protocols particularly for alternative host species.
- <u>Diagnostic tests:</u> Review and recommend improvements to documented diagnostic tests (including National Diagnostic Standards) used in PEQ to identify emergency plant pests.
- <u>Potential pathways:</u> Identify and evaluate risks from any unusual pathways not identified in quarantine manuals eg risks from dried produce, true seed and vegetative propagating material, farm machinery.
- <u>Import risk mitigation:</u> Review existing risk mitigation protocols for commodity imports including accredited sources, disinfestations, and pest free areas.

State

- <u>Trapping grids:</u> Identify possible weaknesses and recommend improvements in the frequency and intensity of trapping grids for lure responsive pest species particularly with regard to exclusion zones, wholesale markets and ports.
- <u>Quarantine justification:</u> Check that state quarantine zones for organisms under official control can be justified in respect of legislation and technical issues - the biology and spread of the emergency plant pests.
- <u>Inspection arrangements:</u> Review and recommend any improvements for inspecting commodity imports from interstate, including any possible weaknesses in ICA agreements.
- <u>Movement controls:</u> Review movement controls to minimise risk of mechanical spread including protocols for the interstate movement of contract labour, farm machinery and other relevant items particularly from high risk control zones.

- Diagnostic services: Recommend possible improvements to state wide diagnostic service capacity including the use of devitalised type-specimens of quarantine organisms to assist with diagnosis.

On farm

- On-Farm Biosecurity advice: Provide technical advice and guidance to industry with regard to 'on farm biosecurity' plans for particular commodities to ensure appropriate risk mitigation measures are developed for:
  - germplasm imports on farm;
  - on farm contract labour from other production districts – specify treatment of clothing and tools which have been used on other farms;
  - vehicles and farm machinery which have visited or been imported from other properties – specify dedicated wash/steam treatment areas;
  - tools used on farm which can be contaminated – specify methods of cleaning and sterilisation;
  - imported mobile bins and silos – specify methods of cleaning and sterilisation;
  - laundering of clothing worn when visiting or working in off farm crops – specify protocols.

Destruction and eradication

Introduction

The process of eradication is critical for incursion response, if successful it justifies the recommendations and decisions of CCEPP and NMG respectively and the investment of cost shared funds.

There are three parts to the process: planning; removal, destruction and clean up; and confirmation of eradication. In relation to destruction, technical advice is required to maximise the chances of 100% kill of the pest, and minimise the risks of escape. Similarly recommendations from experts should specify the methods to confirm that the affected sites are now pest free.

The methods used depend in part on the type of organism described earlier and technical advice is required for planning and pre-treatment of the affected site, methods of removal and destruction, site clean up and disinfestation, and confirming eradication.

Expertise from entomologists or plant pathologists is essential and advice should be conveyed to either CPHM or DSPCHQ who should consider necessary actions

Checklist for entomologists and plant pathologists:

Planning and pre-treatment of affected site and disinfestation

- Plant removal biosecurity: Analyse the impact of plant removal on pest movement and dispersal and where necessary specify types and methods of application of pesticides which maximise kill before removal.
- Mechanical pathways: Identify the vehicles, equipment, tools and clothing which could be pathways for mechanical transmission and will need disinfestation treatment.
- Effective chemicals: Specify disinfestation chemicals which are known to be effective against relevant life stages of the pest and preferred methods of treatment of equipment.
- Boundary definition: Specify the survey and diagnostic methods the define the boundary of the affected area and for confirming any buffer zone of "non affected" plants which are to be included in the removal program.

Removal and destruction

- Disposal biosecurity: Identify the biosecurity risks of preferred method of disposal (i.e. burning or burial). Certain types of organisms such as systemic pathogens can remain viable inside plants after pre-treatment and removal, and may also have spore types which are adapted to survival after burial in soil. Controlled burning with necessary permit approvals should be considered for these types of pest.
- Soil treatments: Advise on the need to consider application of specific soil treatments which will kill emergency plant pests either within seed or other vegetative structures or as "exposed life stages" in soils. This will almost certainly involve soil fumigation and alternatives to methyl bromide should be specified where possible. The issue is relevant for invertebrates with juvenile life stages involving a "soil" phase and pathogens which remain in soil either after colonisation of and death of roots or within seeds, tubers, corms and bulbs.

Site clean up and disinfestation

- Confirm destruction: Identify approaches to confirm that plant material and pest life stages have been devitalised, inspections and the diagnostic methods required. Special arrangements should be considered for water-borne pests where there will be requirements for treatment of irrigation lines, equipment and water sources.

Confirming eradication

- Specify the methods which should be used to confirm that eradication has been achieved:
  - for sentinel plants: for many pests confirmation will usually require the establishment of sentinel plants in a biometrically based pattern across the site where eradication treatments have been applied. Specifications should also identify the frequency and methods of inspection including back up diagnostic tests.

  - for pests attracted to lures: for these pests sentinel plants should not be required provided the lure or trap is effective in catching both males and females. Specifications should identify the distribution of traps across the affected area which should relate to the known sensitivity of the attractant chemicals, and also take into account prevailing wind direction.

  - for soil and water-borne organisms: for some soil and water-borne organisms with characteristic morphological features it should be possible to confirm eradication by extraction of the pest from soil or water samples. This will also require the capability to test the viability of any extracted life stages. For other types of organisms with no characteristic morphology, bait plants should be used to detect presence. For either situation the biometric basis for sampling or deployment of baits should be specified.

- Technical reports for confirming eradication should include the methods used to confirm eradication including the number of rounds of testing, the sensitivity of the tests and confidence limits based on sampling intensity.

Technical debrief and analysis for stand down

Introduction

Incursion response and related activities can be terminated for a number of reasons, including:

- the initial identification of an emergency plant pests is proven incorrect;
- the initial decision to eradicate is rescinded on the basis of subsequent technical and economic analysis;
- eradication is confirmed;
- eradication is unsuccessful.

In each of the above cases the decision is made by the National Management Group (NMG) which usually acts on recommendations from CCEPP.

Stand down activities include the requirement to prepare a debriefing report on incursion response, irrespective of its success or failure, and there is usually a requirement for technical input. Section 2.4 of PLANTPLAN describes the stand down phase of the national emergency in more detail.

When incursion response is either not recommended or unsuccessful, the pest is no longer considered an emergency plant pest in that area of Australia. Under these circumstances responsibility for pest containment and management is transferred to state and territory governments, relevant industry organisations and associated funding bodies. Respective agencies then develop strategies for managing the specific pest. These will vary between types of pests and may include state quarantine action for containment and/or the application of a range of control treatments.

There are two areas where a requirement for technical advice is anticipated:

1. a debriefing report on incursion response;
2. technical recommendations on additional containment or control/management activities by industry, states/territories and funding agencies.

Where eradication is unsuccessful technical advice should reflect the change from eradication to a containment and control/management scenario.

Checklist for entomologists, plant pathologists and quarantine scientists

Debrief on incursion response

- STMPP should coordinate the input from technical experts in the debriefing activities – consideration is required on two issues:
    1. Specific Technical Issues*:* recommendations for improvements to specific technical issues such as diagnosis, survey, destruction. Live incursion response operations on specific pests usually expose unanticipated weaknesses in areas of technical response. Examples include false positive reactions in diagnostic tests, incorrect estimates of the extent of spread and previously unknown host plants and methods of survival. There are many others. Each should be identified in the debrief report and recommendations made for improvements to these issues. In some cases this may involve a desktop exercise but others might require further research possibly involving overseas centres of expertise. Once approved the

recommendations should be incorporated into relevant biosecurity documents such as Industry Biosecurity Plans and Contingency Plans.

2. Expert input: opportunities for improving the integration of technical experts in the incursion response. Where problems have arisen with the provision of advice into the response management structure, these should be identified as part of the debriefing or to the CPHM. The analysis should consider line management and reporting relationships, planning and communication processes, human resources, funding and logistical support.

Technical recommendations for ongoing pest management

- Management advice: Where eradication is unsuccessful, government agencies, industry and funding bodies will require technical analysis from experts to guide their decisions on containment and control. Recommendations should reflect the change in emphasis from eradication to containment and control.
- Containment: Technical advice will be required on the question of containment by state quarantine action and movement controls. This will be an issue for production areas of Australia where the emergency plant pest has not yet been detected[10].
- Control/Management: Earlier technical analysis will have identified the most appropriate chemical, biological, genetic and management controls for the particular pest. In most instances, incursion response will have developed time bound emergency approvals for selected treatments. The challenge is to establish long term control strategies. These strategies will need to provide information to growers on:
  - the use of pathogen free plant material and resistant varieties;
  - destruction of crop residues;
  - crop rotation methods to control the pest;
  - control of alternative hosts and weeds;
  - chemical control measures (where they may differ from those used in the eradication phase);
  - tillage practices that reduce the potential spread of the pest;
  - use of dedicated equipment in high risk areas;
  - appropriate warning and information signs;
  - restriction of movement of equipment, people and vehicles;
  - quarantine/biosecurity education of personnel;
  - procedures for reporting the presence of the pest to relevant authorities.
- Control: Technical experts will need to specify the actions required for development of sustainable control strategies, including analysis of the impact of new controls on existing IPM programs and any problems which are anticipated. This usually will require applied research to develop recommendations which are appropriate for Australian industry and the environment.
  - For pesticides, research and development should focus on the generation of data required by APVMA for national registration, and for any control of use activities under state legislation

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[10] Earlier technical advice on establishment of quarantine zones and movement controls should be applicable, providing this is incorporated into relevant state legislation.

- For biological controls studies should define the need for introduction of new agents into Australia, or for inundative releases of endemic agents; and for ecological research and development on how to maximise the effectiveness of the biological control agents
- For genetic controls additional plant breeding research is usually required to incorporate resistance genes into Australian germplasm and adapt this to the requirements of industry.