

**Build capacity of greenhouse
growers to reduce crop loss
through adoption of
preventative disease
management practices**

Jeremy Badgery-Parker
NSW Department of Industry and
Investment

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Know-how for Horticulture™

Build capacity of greenhouse growers to reduce crop loss through adoption of preventative disease management practices

VG07118 (Dec 2009)



“The message is getting around”

Street Art, NSW north coast, 2009

Jeremy Badgery-Parker

VG07118

Build capacity of greenhouse growers to reduce crop loss through adoption of preventative disease management practices

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Purpose of report

This report describes the significant outputs and project outcomes from an intensive industry development project addressing the obstacles and challenges for greenhouse growers in implementing preventative pest and disease management practices. Effective and practical strategies and tactics focussing on prevention are a fundamental requirement for successful IPM and have been largely overlooked until now.

This report is not intended to reproduce the extensive material published as the major output of this project in the manual *Keep it Clean – Reducing the costs and losses in the management of pests and diseases in the greenhouse*. A copy of the manual can be obtained from the project leader.

18th December, 2009

Cover Image: Photo taken by Phil Wilk

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CONTENTS

MEDIA SUMMARY	2
INTRODUCTION	3
TECHNOLOGY TRANSFER STRATEGY AND ACTIVITIES	5
EVALUATION AND MEASUREMENT OF OUTCOMES – IMPACT AND ADOPTION	14
DISCUSSION	21
RECOMMENDATIONS	23
ACKNOWLEDGEMENTS	24
BIBLIOGRAPHY	24
APPENDIX 1: FACTSHEETS ON THE 10 ESSENTIAL MANAGEMENT PRACTICES	25
APPENDIX 2: FARM REVIEW WORKBOOK	37
APPENDIX 3: <i>KEEP IT CLEAN</i> COVER IMAGE AND PUBLICATION DETAILS	57

Media summary

Mr Jeremy Badgery-Parker, Extension horticulturist and greenhouse industry specialist with Industry and Investment NSW (formerly NSW DPI) has continued to deliver significant practical resources and skills development to greenhouse vegetable growers.

“Keeping the greenhouse clean is one of the most cost effective and important ways to manage pests and diseases”, Mr Badgery-Parker explains. “Effective and practical strategies and tactics focussing on prevention are a fundamental requirement for successful IPM and had been largely overlooked until now.”

“Our recently completed HAL project on reducing crop losses through adoption of preventative pest and disease management practices set out to bridge this gap and has produced invaluable resources for growers looking for cost effective pest and disease management.”

“Plant diseases in a typical greenhouse enterprise may be costing a grower as much as 15% of potential income. In some greenhouse crops, the average loss from disease can be as high as 30%. When a couple of pest incursions are included as well, the costs and losses from pests and diseases can really escalate.”

Tony Burfield, Extension officer with SARDI, was employed part-time on the project. Mr Burfield said “The key to cost effective pest and disease management is through preventative and integrated strategies. There are 3 important rules to follow. Firstly, sanitation - everything needs to be cleaned and kept clean.”

“Secondly, quarantine is very important. Greenhouse growers need to strive to stop or at least delay pests and diseases getting into the crop”

“And thirdly, every grower has to regularly monitor their crops. Early detection and knowing which and how many pests or diseases are present is the difference between making good decisions or making poor decisions.”

Jeremy added “It sounds simple, but many growers agree, putting it into practice can be more of a challenge.”

Through this project, we identified 77 preventative pest and disease management practices that can be used to reduce the costs and losses associated with pests and diseases. These are described in an all-inclusive guide; *Keep it Clean – Reducing the costs and losses in the management of pests and diseases in the greenhouse*.

Keep it Clean also includes;

- prompt questions for readers,
- information on a simple monitoring plan,
- sample record sheets,
- a pest and disease risk assessment tool,
- a template for developing action plans and
- a substantial reference section on key greenhouse pests and diseases.

The full colour book is available free of charge to all levy paying greenhouse growers and I&I NSW has set up an online request form (<http://www.dpi.nsw.gov.au/agriculture/horticulture/greenhouse>). There are also a number of other downloadable resources.

A workshop and farm review program was developed and run to guide growers through the book, to explain the many resources and to provide skills development where needed. To date 115 greenhouse growers in 3 states have participated. Growers completing the farm reviews during the project period received a free footbath and bilingual gate sign to help get started with simple quarantine practices around their farm. A significant number of resellers and allied trades and industry consultants also attended meetings ensuring that there is good post-project awareness and ongoing development in the industry.

This project has enabled growers to overcome adoption barriers and implement real practice change on farm. Of the participating growers, 86% have implemented a new preventative pest and disease management practice as a result of this project.

Introduction

This project has improved on-farm implementation of preventative pest and disease management practices in the greenhouse industry. It was a two year project designed with a focus on the lower technology end of the industry, predominantly in NSW and SA. The project team was split between NSW (Sydney Basin) and SA (North Adelaide Plains). These two regions account for around 900 growers. The total greenhouse industry is estimated to have up to approximately 1350 growers (Biggs, 2004).

Access to practical information and the skills to implement changes on farm remain two of the critical development hurdles in managing pests and diseases and are a key constraint to the effective adoption of integrated pest and disease management in the Australian greenhouse industry. This project was developed by I&I NSW and supported as a subcomponent of the HAL pathology program to address these significant industry development barriers.

To initiate participation and adoption by growers in the short project timeframe, the project used participatory grower groups to develop the general content and format of the manual and activities were conducted within the context of a greenhouse hygiene consultancy program to establish a commercial value for the information.

The project was centred on the development and publication of a comprehensive preventative pest and disease management manual and associated management protocols. A series of participatory grower workshops leading to individual farm practice reviews and the development of actions plans were facilitated by the project team. To further explain key practices, a factsheet series was developed to highlight the ten (10) essential management practices described in the manual.

This comprehensive strategy was used to serve two critical needs. Firstly, to gain early grower participation and establish a degree of ownership of the adoption process and secondly, to create a framework for on-going industry improvement post-project.

Key activities undertaken as part of this project include identification of knowledge gaps and mapping of the farm hygiene review program. The material for the manual was collated, drafted and the farm review protocol was developed.

A key output of this project is the guide to preventative pest and disease management practices for greenhouse growers – *Keep it Clean* – and a corresponding farm review protocol. The content of the manual was developed by the project team in close consultation with a number of participating greenhouse growers and technical experts. The 147 page document provides comprehensive, yet easy to read information for growers on the key sources of pests and diseases in and around the greenhouse and specific practical information on how to mitigate these sources and quarantine the greenhouse from pests and diseases. Extensive field assessment of existing pest and disease problems and practical management strategies was undertaken to define the 77 preventative management practices described in the manual.

The participating growers also requested more basic information on pests and diseases, life cycles and control strategies. This has been provided without unnecessarily duplicating existing resources by compiling general information of key pests and diseases in the context of a risk assessment and prioritising the recommended preventative management strategies.

A large number of illustrations were prepared for the manual to enhance the communication value of the publication to the broad industry readership.

Integrated with the manual is a farm review protocol. This was developed to provide a consistent process when undertaking the farm reviews and preparing individual farm action plans so that consultants and other industry stakeholders have access to a clear process and resources that have been professionally developed and tested with industry. The farm review, as well as being included in the manual, has also been produced as a stand alone document for all growers and consultants to use as a planning resource.

This project has explored and illustrated a simple, yet demonstrably effective methodology to assisting growers in implementation of recommended practices. The implications for industry are two fold. In the first instance, this project (with the user-friendly resources produced), is enabling growers to review their operations, develop action plans and make real on-ground changes in what can be a complex and potentially expensive area of practical business development.

The second implication of this project is that it has demonstrated that not only is a focus on fundamental practices required to initiate and sustain practice change, but ensuring all research and practice recommendations in all areas of production need to be (and can be) delivered in formats that do not overwhelm or confuse growers eager to make lasting improvements.

The key impact of this project is a more deliberate move towards effective, integrated pest and disease management strategies through adoption of the fundamental practices that have previously been assumed to already be in place. This impact is strongly influenced by the capacity for growers to break down a long list of recommendations and demands on their time and resources and prioritise their implementation for a cost effective outcome.

In the short term (the next few years) this project will result in broader adoption of key preventative management practices that reduce the costs and losses associated with pest and disease management. The majority of growers who participated in this project were already aware of many of these practices, at least in concept, but the importance of small changes in farm management was not readily understood. In addition to this, the capacity for many growers to plan, resource and implement changes was limited but has been enhanced by this work.

Providing a clear list of practices and tools with which to prioritise and plan for implementation has been shown to build the capacity of greenhouse growers to adopt feasible and effective changes.

Technology transfer strategy and activities

This project targeted a significant yet relatively simple problem, that is, the adoption of preventative pest and disease management practices is not adequate in the greenhouse industry. Adoption barriers can be quite diverse between individuals. The more common obstacles include economic constraints, knowledge gaps and time or labour limitations.

This project was designed to develop and provide practical solutions and in doing so, build the capacity of greenhouse growers to reduce the costs and losses of pests and diseases. Implementation is rarely as simple as having information at hand. There are many obstacles that growers face when trying to adopt improvements. Barriers to adoption are widely recognised in the field of extension, though their significance can often be understated in research and education programs.

This project encompassed a combined strategy of providing clear, concise information with grower participation, group workshops, individual risk assessments and tailored actions plans to assist growers to identify needs, overcome adoption barriers and implement appropriate practices.

Extension strategy

The overall aim of this project was to address two key problems encountered in the greenhouse and hydroponic industries. Firstly, the limited access to appropriate information resources on pest and disease prevention and secondly, the barriers to adoption of preventative pest and disease management practices.

The objective was to assist growers, through a participatory program, to implement preventative disease management practices, and in this way, build the capacity of greenhouse growers to reduce the costs and losses in the management of pests and diseases.

The extension strategy pursued in this project consists of two specific components:

1. Development and delivery of information to the target audience in a format that they find valuable, useful and interesting.

The target audience was engaged in the development of information resources from the start. This participatory approach enabled direct identification of needs. This industry experience and target audience input was coupled throughout the project with extension and adult education expertise and resulted in a comprehensive decision support tool for greenhouse growers. To develop the practices list, real practices that are known to work were identified and described, practices that ought to work but there were no local practitioners were assessed and trialled, and experts were consulted as to what they think is most important. The integration of this information in the context of the experience and knowledge of the participating growers generated a full and helpful list of preventative management practices.

To further improve the readability and interest in the information, illustrations were used. Where possible without adversely impacting on the quality of the information, technical or expert material was simplified. For example, the term 'pathogen' was removed from the text and 'disease' was used instead to describe both pathogens and diseases. This minimises the confusion that interchanging terms can cause without affecting the quality or value of the information for the end user. Another example of this simplification was the grouping of diseases on the basis of risk factors and basic management practices. While small technical compromises are made, it avoided large amounts of repetition and simplified the basic management concepts that are being promoted.

2. Support information with hands-on practical advice and tools to assist users in implementing recommendations that have a real, on-going benefit.

To avoid having valuable information sitting unused on shelves, it is important to ensure that the target audience possesses and can practice the skills and use the necessary tools to make use of the information.

Three significant skill gaps were identified in this project.

- a) Allocating priorities.

While almost everyone allocates priorities to a range of activities every day, making the same decisions in the context of a greenhouse business is not always straightforward. To overcome

this problem, a risk assessment tool was included in the manual and growers were given practice in using it in the workshops. This gave the participants confidence in being able to separate pests and diseases into priority groups instead of struggling to try to address all pests and diseases in one go.

In conjunction to this tool, sources of pests and diseases are described in the guidebook. During the extension activities (workshops and farm reviews), growers are given the opportunity to identify and list sources of problems around the farm.

Within the manual too, practices are presented in a number of ways. The main format is a series of prompt questions with each section of text and two key additions were made in the manual. The first was to extract the 10 most important practices which need to be implemented by every grower. These are the Essential Management Practices. They are listed at the start and individually highlighted as they are discussed throughout the manual. The second addition in the manual is the separate listing of the 10 best practices for preventing each key pest and disease group, described as Critical Management Practices.

The integration of the risk assessment tool, the identification of sources of pests and diseases and the listing of relevant practices enables a grower to effectively develop clear priorities as to which practices should be implemented first. In effect, this combination of information and tools creates a basic decision support system for growers.

b) Pest and disease check (monitoring).

Monitoring the crop regularly and routinely is a fundamental component of effective pest and disease management. Despite many years of promotion of this concept through IPM research, adoption of monitoring practices is sparse in the industry. In this project, all participants intuitively recognised the value of monitoring. Monitoring and the correct identification of pests and diseases is designated as one of the Essential Management Practices.

The most significant barriers to this practice were identified as being the lack of knowledge of a simple method of greenhouse crop monitoring and a perceived lack of time. To address these, the project team developed a simplified monitoring system – the pest and disease check. Key features of this system are:

- i) The greenhouse is marked up with zones at the beginning of the season/crop
- ii) A routine process assists the growers to follow the zones
- iii) Record charts are used to make record keeping almost effortless

Pre-marking the greenhouse creates boundaries and effectively a map which gives growers a structure to work within. This removes some of the uncertainty and enables growers to focus on the crop inspection aspect with more confidence. The use of charts with which to make records streamlines the record keeping component and helps growers get immediate value from the information they collect.

c) Action plans.

Allocating resources and developing action plans often tend to be intuitive for many in business rather than being planned management activities. Problems can often go unnoticed or as time and resources become overwhelmed, the manager resorts to addressing 'urgent' operational matters only. While this gives the impression that problems are being resolved and the business is moving forward, strategic management is the casualty and with this, businesses inevitably spiral downwards, unable to stay ahead of seemingly increasing problems.

Money, time and resources are often the most cited reasons for failing to adopt what are known to be improved practices. Developing action plans which set out clear objectives and allocated resources over a specified period of time enables growers to make changes which reduce on-going problems rather than just manage them, or more accurately, manage their consequences.

The use of a template for drawing up action plans provided participants with a simple structure and process to follow. This allowed growers, particularly those without business management

training, to implement some simple, low cost changes despite their busy schedules and cost constraints which have on-going benefits in other parts of the greenhouse business.

The two simplest strategies adopted by most participants to date have been the setting out of a clean zone in the farm and implementing basic check and control points to manage the risk of pests and diseases getting in. Associated with this has been the use of a gate sign and farm management policies to stop people entering the clean zone or greenhouse without permission. These two practices have cost almost nothing and only required a change of attitude and management policy. Some growers have reported that reduced pest levels and/or disease spread were already being observed. This confidence in the participating growers is a substantial gain from the project.

Manual

The primary output of this project is a comprehensive greenhouse growers' guide describing the range of preventative pest and disease management practices available as well as associated information. A key extension strategy in developing this guide was to work with a small group of greenhouse growers (16) who participated in the development of the management guidelines.

The collation and assessment of management practices was the major objective.

These growers were questioned about their pests and diseases and their management practices. Their farms were audited in respect to pest and disease management to gain an insight into both the practices that were being undertaken and also the various pest and disease problems encountered. The latter, included a broad assessment of the sources of pests and diseases in and around the greenhouse and the farm as a whole.

The second part of the collation and assessment of management practices involved reviewing existing recommendations with respect to farm hygiene and pest and disease management. The main resource was an extension trial program developed by the project leader, Mr Badgery-Parker in 2005. This trial was limited in its original dissemination but provided a format that had been shown to have on-farm impact. The basis of this program was a series of checklists covering important practices in various areas of the greenhouse business.

Draft hygiene protocols were proposed to be developed through existing projects (VG04012 – Effective management of root diseases in hydroponic systems and in particular, VG05084 – Integrated management of greenhouse vegetable diseases: development of microbial controls and biorational products) which provided a pathologists' perspective on what practices contribute best to disease management. Their preliminary protocols formed a partial basis for developing the broader preventative pest and disease management practices list. Subsequently, the draft hygiene protocols were superseded by the development of the more comprehensive extension orientated materials produced in this project.

Other major publications that contain a range of preventative pest and disease management practices that were considered in this project were *Integrated Pest Management in Greenhouse Vegetables* (NSW DPI, 2002), *Integrated Pest Management in Lettuce* (NSW DPI, 2002), *Managing Diseases in Greenhouse Crops* (Jarvis, W, 1997), *Floriculture Production Guide for Commercial Growers* (British Columbia Ministry of Agriculture and Food, 1999), *Greenhouse Vegetable Production Guide* (British Columbia Ministry of Agriculture and Food, 1997).

Much of this information is considered common knowledge in extension and research fields. The goal of the current project was to collate and describe the practices that would have significant and cost effective benefits to greenhouse growers. An underlying strategy of this project has been to create a decision support system for growers that can be followed even if growers have not attained a comprehensive knowledge of certain pests and pathogens.

The third part of the process of identifying practices involved having a number of experts and experienced growers ranking the practices in terms of their usefulness in combating key pests and diseases. A detailed analysis was undertaken to rank and allocate these practices in terms of their efficacy towards specific pests and diseases. A spread sheet was developed for this exercise (Figure 1). Returns were collated and rankings were automatically summed.

This exercise helped to identify the more important practices and ones which influenced a greater number of pests and diseases and also identified practices which were not considered to be particularly beneficial. The ten (10) practices which offer the most benefit for the most pests and diseases have been grouped and labelled

Essential Management Practices. These are listed separately towards the start of the guidebook and are also identified throughout the manual.

Figure 1 Ranking practices in terms of their usefulness in combating key pests and diseases

Please rate each potential practice as either 1, 2 or 3 for the priority in which you'd recommend the practice. Just select a 1, 2 or 3 in corresponding square for practice/pest or leave blank if practice has no value

	no value
1	for first choice
2	for second choice
3	for third choice

Add additional practices if you think of any at the bottom, or additional diseases on the far right



Disease	Alternaria	Anthracnose	Black root rot	Botrytis	Root rots / wilts	Rhizoctonia	Pythium	Fusarium
GENERAL MANAGEMENT AND PRACTICES								
Greenhouse or production area in an established 'clean' zone on farm separate to an 'outside' zone								
A 5-10 metre buffer zone (free of plants, crop waste, rubbish) maintained around greenhouse								
Greenhouse and farm surrounds kept weed free								
Greenhouse floor and other surfaces kept covered for easy cleaning								
Shed floor and other surfaces kept covered for easy cleaning								
Windbreaks established around farm, greenhouse or production area								
Rubbish stored/disposed of away from greenhouse								
Bins located conveniently in or near greenhouse								
Check and control points to control movement of vehicles, people and materials into 'clean' zone								
Parking area for employee and visitor vehicles in 'outside' zone								
Off-farm vehicles always cleaned before entering 'clean' zone								
On-farm vehicles kept free of soil, plant material and rubbish								
Roadways sealed								
Roadways covered with gravel								
Roadways covered with mulch								
Roadways covered with weed matting								
Roadways kept free of soil, mud, plant material and rubbish								
Crop work plan followed where Work done in cleanest, youngest crops first								
Dirty work tasks always done last								
Old crops removed from greenhouse before replanting								
Crop waste disposed of away from greenhouse								
Pruned plant material is put directly into a bin or bag								
UV absorbing covering materials used on greenhouse								
Bins emptied regularly								
SANITATION								
All water used in greenhouse is disinfected								
Disinfected water is stored so that it can not be contaminated								
Appropriate disinfectant used for each task								
Greenhouse always cleaned and disinfected before planting new crop								
Hydroponic (irrigation) system always cleaned and disinfected before planting new crop								
Clean and disinfect all containers before using in greenhouse								
Clean and disinfect all tools before using in greenhouse								
Clean and disinfect all equipment before using in greenhouse								
Cleaning station set up at each entry way or centrally								
Pruning tools are regularly disinfected during the pruning task								
Replace or disinfect twine before planting new crop								
Only clean, pest and pathogen free substrate used for each new crop								
Sheds are regularly cleaned								

A second objective of the manual was the inclusion of relevant information that growers needed to make the most of the preventative practices. The participating growers were asked what information they wanted and also what information they felt they needed in order to prevent pests and diseases. The responses were combined with the existing knowledge of skill gaps and several inclusions for the manual were determined.

A substantial reference section on key greenhouse pests and diseases was developed. Each key greenhouse pest was described, an illustration is used to mark the likely place on a plant where the pest will be found, the risk factors for it are listed, and a simple table showing the pest's lifecycle is included. For each pest, the ten (10) most important practices for preventing the specific pest are also listed. These are described as *Critical Management Practices* for that pest or disease group. For the disease section, the diseases (pathogens) are grouped roughly in terms of the risk factors and the best preventative management practices.

Throughout the manual, all the practices described are also laid out as prompt questions for readers (Figure 2). This format was used to enable the reader to quickly and simply assess their own operations with respect to what is currently being done or not done. All seventy seven (77) practices are provided as a comprehensive checklist in the appendix of the manual.

Figure 2 Example prompt questions presented in the manual

	<p>Are old crops completely removed from the greenhouse at the end of the crop?</p>	<p>Y <input type="checkbox"/> N <input type="checkbox"/></p>
	<p>Is used substrate completely removed from the greenhouse at the end of the crop?</p>	<p>Y <input type="checkbox"/> N <input type="checkbox"/></p>

Essential practices are specifically highlighted in the prompt questions and in the checklists (Figure 3).

Figure 3 Essential practices are specifically identified throughout the manual

<p>? Essential practice</p> <p>Is crop debris removed and stored/disposed of outside of the 'clean' zone and away from the greenhouse?</p>	<p>Y <input type="checkbox"/> N <input type="checkbox"/></p>
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In order for growers to better prioritise and implement practices, a pest and disease risk assessment tool is included. This is a simple coloured table that can be used to help separate problems out as being high risk, medium risk or lower risk. This information can then be used to prioritise the order in which practices need to be implemented.

A template for developing action plans has also been provided. During the first phase of the project, it was found that a significant number of growers participating in the program were not used to planning and allocating time and resources and this was a common reason why new practices and recommendations were not being implemented. The action plan template is a tool to help growers clarify the problem and what they aim to achieve. It requires the grower to identify which practices from the manual will be used and what will be done in terms of these practices in the greenhouse or elsewhere on the property. The template also calls for what resources will be needed and allows the grower to set a schedule.

Monitoring was distinguished as an essential management practice. It is also apparent that while most growers are aware that monitoring is needed, few are actually skilled up and confident in monitoring their crops. In addition to this, the majority of growers find that time is a significant obstacle to getting started. To gain a start to basic monitoring, a review of monitoring data was used to work back to a minimum level of greenhouse crop monitoring that still provided sufficient quality information for pest and disease management decisions. A simplified greenhouse monitoring plan was developed and tested in the industry.

The process involves presetting the greenhouse with marked zones and then following a minimal plant assessment protocol and recording the findings onto record charts. Information on this simple monitoring plan and sample record sheets have also been included in the guidebook.

These inclusions and the detailed feedback sought and received from participating growers resulted in some delays in the development of the manual. It is an important consideration when drawing extensive feedback from growers that additional preparation and drafting time is allocated.

These activities were conducted over the first 12 months of the project and were used to build a whole of farm picture of pests and diseases and what was being done to manage them and the specific practices and strategies were identified.

Workshops

To engage growers in both the development process and the materials, a number of workshops were organised. During the workshop, growers were walked through the manual, developed skills in risk assessment and in setting up a greenhouse for a pest and disease check. Individual on-farm reviews were also scheduled during this activity. From these site visits, action plans are developed to help growers prioritise the implementation of appropriate preventative practices for their farm.

The first of the workshops were in December 2007 in Rossmore (NSW) and Virginia (SA). Growers were informed of the project and its aim and were invited to share their needs and ideas in a structured program. These facilitated meetings allowed for an expanded audience – from the initial project participants – to growers identified as being interested in better pest and disease management.

A further five (5) meetings were held in the Sydney region during February and March, 2008 with 44 growers and 12 South Australian greenhouse growers attended a meeting over the same period.

An additional series of workshops were run in Sydney in August 2009. Another 13 growers joined the project and 11 of the growers who had participated at the beginning of the program, re-attended.

A workshop was conducted at Chambers Flat, Qld (15 participants) in October 2009 and a final Sydney workshop was held in Glenorie (13 participants) in November, 2009. Additional meetings and farm visits conducted in SA over spring 2009 added another 14 participating enterprises. A planned workshop for Coffs Harbour unfortunately was cancelled on two occasions and consequently has not been completed. A Coffs Harbour workshop is expected to be undertaken post-project some time in 2010. An approach was made to the Perth based growers however; they felt the program was not a high enough priority at this time. Given the generally more sophisticated greenhouses being used in that region, the project did not pursue a workshop in WA.

Farm reviews

Farm reviews were conducted with all growers who participated in the project. A farm review workbook (Appendix 2) has been developed as another output of this project. This enables growers to complete reviews on a regular basis using the *Keep it Clean* manual as an information resource and reference.

The review involves completing the full practices checklist. Firstly, each grower assesses their property in terms of pests and diseases as well as identifying and describing the sources of pests and diseases in and around their greenhouse. Using the risk assessment tool included in the manual, growers allocate a risk level to each of these pests and diseases. This information is used to prioritise the management practices and enable each grower to develop feasible action plans for implementation of preventative management practices on their farm.

Incentives

Encouragement is an important adoption tool. This is especially evident when recommendations are recognised by the grower as being valuable but gathering objective evidence is difficult (at least in the short term) or, as is often the case in preventative management, single practices alone do not always result in measureable change.

Throughout the project, the scope for incentives was constantly assessed. A number of targeted incentives were used as well as broader incentives. For a couple of key farms that were known as “observed farms”, that is, the local industry watch and very often follow practices that are conducted on these properties, specific implementation of preventative practices were undertaken. Growers attended the workshops and participated in the farm review program. From these activities, they were assisted to prepare action plans. These plans included setting up the greenhouses for the pest and disease check (monitoring) and also negotiating minor on-ground works. Weed mat was provided for some early participants needing to improve their greenhouse surrounds and other practices such as use of waste bins and rubbish clean ups were undertaken.

Figure 4 Simple incentives selling the message



Keep it Clean gate signs

Keep it Clean footbaths



Footbaths and gate signs (4 languages) were also provided for growers who participated in the workshops and farm reviews. These incentives (Figure 4) have been very well received. The remaining gate signs will be handed out with copies of the manual over the next 6 months.

Communication and the project message

This project involved a diverse range of communication oriented activities and outputs.

Getting the message out to industry is a key part of building growers' capacity to implement preventative pest and disease management practices and was integral to the project. A multitude of complementary communication avenues were used including printed publications, online resources, media articles, conference presentations, conference posters and a large number of face to face activities including workshops, meetings and farm visits.

A prominent communication strategy that has been used in this project is simple branding. The ultimate practice that can significantly prevent pest and disease problems in any greenhouse is hygiene, thus the slogan adopted by the project has been "Keep it Clean". Not only was this used as the title of the guidebook but both the gate signs and footbaths were similarly badged. This strategy enabled a simple message to be delivered consistently to active participants as well as other growers on the periphery.

Enquiries made by growers illustrate the value of this message packaging, in that growers hearing about and discussing the project or project resources with other growers and allied traders make contact and ask about "keeping it clean". Thirteen (13) direct telephone enquiries and 8 face to face enquiries have been made by NSW growers in the 2009 calendar year. Upon prompting for further information, all enquirers mentioned the project, the book and/or the 'keep it clean footbath and signs' and asked specifically for the project "about how to clean up the farm" and stop pests and diseases. This provides a useful qualitative measure that the concept and message behind the project has been received.

Published materials

Written materials include the growers' manual (*Keep it Clean*), the Farm Review workbook and 11 factsheets. Information about the project and these materials has also been published online on the I&I NSW website (<http://www.dpi.nsw.gov.au/agriculture/horticulture/greenhouse>). The website includes a request form for the manual and downloadable copies of the review workbook and factsheets as well as a number of sample record charts. Some reference and project material has also been published on the SARDI website with a focus on IPM-sustainable farming (http://www.sardi.sa.gov.au/pestsdiseases/horticulture/horticultural_pests/integrated_pest_management/resources)

Factsheets

Eleven hygiene factsheets were prepared as an additional communication tool. These focus on the 10 essential management practices which the project determined were the minimum requirement for all greenhouse growers. The factsheets each cover one practice and there is an introductory factsheet. The factsheets are used to promote the specific practices as well as the project and the guidebook. These are used at meetings, field days and in mail-outs (Appendix 1).

Articles and promotion

The main communication undertaken in this project has been through direct contact with target growers. This approach was used as the growers have been involved in the development of materials throughout the project as well as the field activities. Involvement by NSW growers was strong. To enhance awareness in South Australia where early response was limited and to stimulate involvement in the workshops and farm reviews, an article, "Grower workshops help reduce greenhouse losses" was published in the February 2009 issue of the *SA Grower*. The project was also linked with a virus education workshop held in Virginia and project contacts were reported in a second *SA Grower* article, "Capsicum virus threat needs grower action" was published in the November 2009.

An R&D overview for the project was published in the May/June 2008 issue of *Vegetables Australia* and a brief article about this project was also published in the HAL Vegetable Annual Report 2007/08.

The project has also been publicly promoted through the NSW Agriculture Projects on the Web online forum (<http://www.agric.nsw.gov.au/projectsearch/>).

An article, "Preventative practices – Identifying problems and assessing pest and disease risk", was published in *Australian Flower Industry* magazine, December 2009.

Keep it Clean is also the primary reference provided in the recently drafted I&I NSW Primefact, *Healthy farms: good on-farm hygiene and sanitation*, Forsyth, L. October 2009.

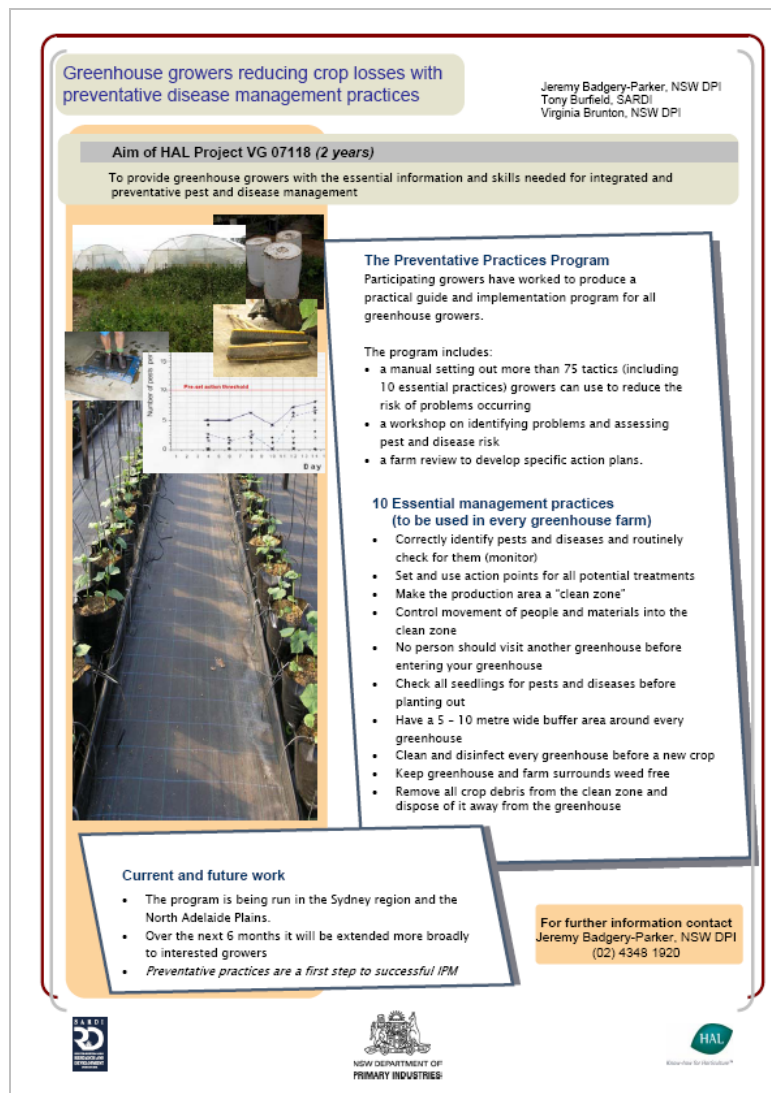
The factsheets and promotion of the manual, *Keep it Clean*, are expected to be published in both *Soilless Australia*, the newsletter of the Australian Hydroponics and Greenhouse Association, as well as in *Practical Hydroponics & Greenhouses* magazine. This has not been finalised, but should result in further promotion of the project and resources, post-project in 2010.

Conferences

As part of the Horticulture Australia Vegetable Pathology Program, the project leader presented the Extension sub-component, including this project, as part of a joint program presentation at the AusVeg conference in Melbourne in May 2009. A poster (Figure 5), printed by the HAL Vegetable Pathology Program, was displayed at the conference and published in a booklet provided to delegates.

A full conference presentation was delivered twice at the Australian Hydroponic and Greenhouse Association conference in Sydney in July 2009. Approximately 75 delegates attended the presentations. A paper was also published in the conference proceedings. The HAL Vegetable Pathology Program poster was again displayed at this widely attended industry event.

Figure 5 Vegetable Pathology Program project conference poster



Meetings

Five (5) project meetings were held with growers and allied traders. These facilitated meetings provided a forum for explaining the project and discussing content and activities. In NSW, 98% of the growers who attended a project meeting also participated in the project workshops.

The hygiene project was explained and promoted at a significant industry forum attended by approximately 90 growers in Penrith in June 2009.

Other meetings

Four meetings were also attended as part of the HAL Vegetable Pathology Program and 5 team meetings were conducted during the course of the project.

Consultants

The workshop and farm review program was developed and delivered in a consultancy format though without actual charge to the participants. This was used as a trial to see whether establishing commercial acceptance and value for the information was attainable given that the greenhouse industry has a weak demand for consultants despite skill and knowledge gaps. It was hoped to complement the Western flower thrips extension project which was working to develop the use and availability of consultants in the industry.

The expectation was that this would help develop an improved attitude in the industry to engaging consultants. It is unclear whether this has been successful. There has been very limited effective promotion of consultants in the IPM project. However, while participants have not shown interest in paying for this sort of information, this is partly attributable to their recognition that it comes from an industry funded project.

There is a discernible interest and recognition of the importance of the practices being promoted in this project. This is clearly demonstrated by the better than normal participation (based on over 10 years of experience) and importantly, follow-up participation. The manual, in particular, has been very positively received. The project materials, specifically the manual, the farm review workbook and the factsheets are available for consultants to use.

Evaluation and measurement of outcomes – impact and adoption

Qualitative evaluation of grower needs formed a significant basis for the development of resources in this project. Industry meetings early in the project addressed a range of issues surrounding the content. This feedback was integral to the development process. Workshops and facilitated meetings were conducted regularly in the first half of the project to inform the development of the manual and subsequent extension program. Training and extension workshops and farm visits in the second year of the project focussed on participation in the preventative management practices program.

A number of quantitative measures have been collected to gauge grower participation, project penetration and grower feedback. Two hundred and six (206) manuals have been distributed as well as 90 farm gate signs and 65 footbaths as at December 2009.

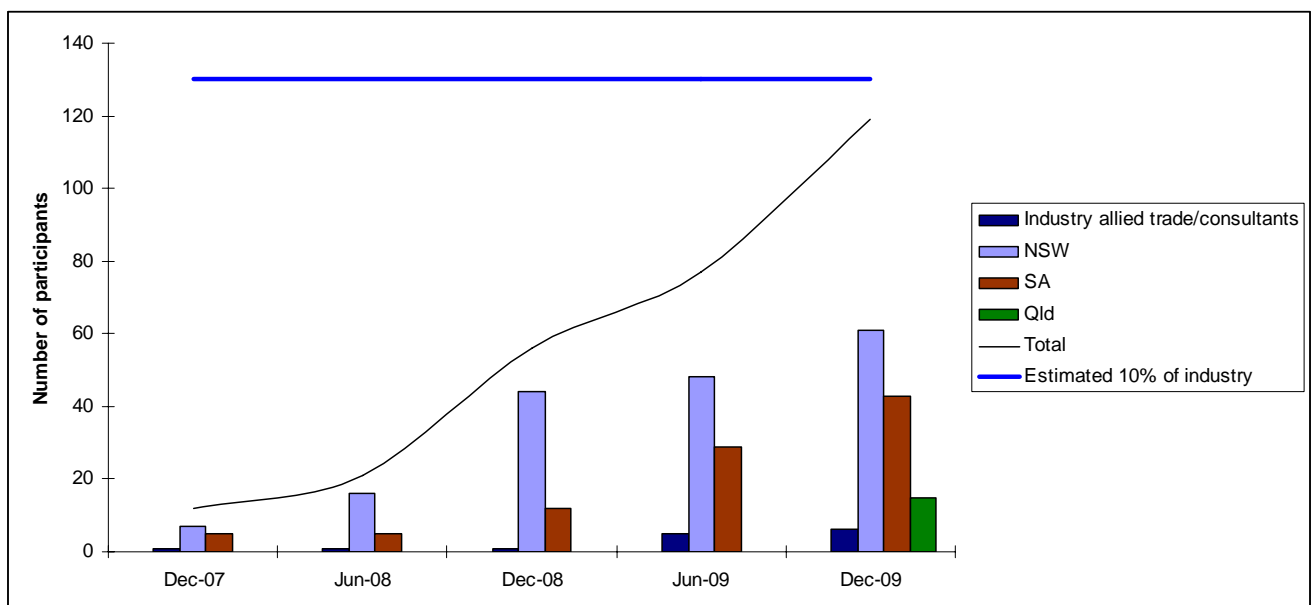
A total of 119 growers in three states have participated in the project workshops up to the time of writing this report. One hundred and nine (109) participants have completed farm reviews so far, which is almost 92%. The preparation of action plans was not a primary focus but was undertaken with growers seeking to use this tool. Twenty nine participants in SA and 18 in NSW developed some action plans for implementing one or more practices.

Project objectives

This project aimed to achieve gains in 3 key result areas. The overall focus was on implementing preventative management practices so as to reduce the adverse impact of pests and diseases on a greenhouse enterprise.

The first benchmark was to have ten percent (10%) of the target greenhouse growers participating directly in the greenhouse hygiene program. The program involved attending a workshop and completing a farm management review. A total of 125 people participated in the workshops with 119 growers involved in the workshop and review program. The final numbers suggest that based on an estimated industry size of 1300 growers (Biggs, 2004), the project has finished extremely close to the target participation rate. The workshop that had been set for the mid north coast of NSW was expected to have over 30 participants which would have easily seen the target exceeded.

Figure 6 Participation rates over project period



Involvement was low in the first stage of the project as the intention was to have a few growers assist in the development of the manual. During this period, the program used draft materials. With the completion of the manual, participation was accelerated and very good participation was attained in the last 6 months (Figure 6).

The second benchmark was to have thirty percent (30%) of the participating growers implementing preventative pest and disease management practices. Of the 119 greenhouse growers who have participated in the program to date, the majority of growers implemented up to 4 new practices. At the final assessment conducted at the end of November 2009, 102 growers identified at least one practice that they were now doing which they were not when they attended one of the project workshops. This equates to almost 86% of the participating growers having implemented a new preventative pest and disease management practice.

Ninety growers (76%) have adopted gate signs as a check and control point as part of establishing a clean zone on the property. Sixty growers (50%) are currently using a footbath which they were not using 2 years ago. In NSW, 28 growers have revamped weed management programs around the farm. Fifteen of these growers have used gravel or weed matting to improve weed management around the greenhouses in the longer term.

The final benchmark was to achieve a ten percent (10%) reduction in crop loss due to disease for participating growers. This objective has been much more difficult to quantify for two reasons. Firstly, monitoring for pests and diseases and keeping records of both pest and disease levels as well as yield data is very poor in the target sector of the greenhouse industry. The majority of growers are not yet consistently monitoring, despite the range of IPM directed projects in recent years. Monitoring is identified as one of the 10 essential management practices. The second problem, closely linked to the lack of existing farm monitoring, has been that not only has the project timeframe been extremely short for an adoption outcome, the first two-thirds of the project required significant resources in the development of the resource guide and support materials. Consequently, the collection of benchmarks for pest and disease levels was not achievable and so it was not possible to adequately quantify the reduction in pests and diseases as a result of the preventative management program. To overcome this issue, specific sites were used to illustrate some gains due to preventative practices and three case studies were made.

Case study 1:

Growing cucumbers in the Sydney basin has been an increasingly difficult and costly occupation in recent years. A small enterprise in South West Sydney specialises in growing Lebanese cucumbers for the local market. A steady rise in the incidence of *Fusarium* had culminated in a consistent loss of 20% of the plants in every crop over the past 2 years. This loss did not include the reduced yields resulting from unthrifty plants in the greenhouse. A *Keep it Clean* farm review was undertaken. This farm was already practicing more than 60% of the preventative pest and disease management practices including 8 of the 10 essential management practices.

Routine monitoring consistently showed that most pests (particularly thrips) and the *Fusarium* problem commonly appeared first in two of the greenhouses. These structures were the nearest to a neighbouring greenhouse enterprise.

During discussions about the overall farm and problems encountered, it was commented that people regularly visiting the neighbouring property were not aware of the boundary and regularly wandered onto this farm. One of the two missing essential management practices was that *Employees and visitors do not visit another greenhouse before entering your greenhouse*. These wandering visitors from next door were a serious breach of the clean zone that had been established on the farm. It was decided that this practice needed to be implemented.

The almost non-existent boundary fence was repaired with new wires and a small hedgerow was planted to create a barrier between the farms. The fence immediately stopped the uninvited visitors. Monitoring indicates a small reduction in pest numbers though levels are still significant and consistently start in the same two greenhouses. Sticky trap monitoring suggested that the pests (particularly thrips) were coming across from the neighbouring greenhouses. The hedgerow is still growing and it is hoped that this will improve the situation.

The greenhouses are now routinely cleaned and disinfected between crops. The incidence of *Fusarium* dropped significantly in the new crops. From a consistent loss of 20 in every 100 cucumber plants across all 11 greenhouses experienced in the past 5 crops, this disease only occurred in one greenhouse following the exclusion of the visitors and with the good on-farm work procedures already in place, the disease did not get into the other crops. The loss of plants in the infected greenhouse remained high at approximately 13 plants per hundred but was a significant and valuable improvement.

Case study 2:

Capsicums, cucumbers and egg plants were being grown at a fairly typical farm in Virginia, SA. Capsicums are the main crop, but tend to suffer significant losses from tomato spotted wilt virus (TSWV) which is vectored by Western Flower Thrips (WFT). Since early 2000, a string of IPM programs have been tried and a number of improvements implemented that include: improved spray coverage and rotation as well as thorough and routine crop scouting with action thresholds for thrips depending on crop stage, time of year and (sometimes) the species identified.

In 2004 moderate success was achieved using predatory mites (*cucumeris*) for WFT control. Following investment in a high-tech hydroponic production system in 2006, confidence in IPM and biological controls was lacking due to the increased economic pressure of the new investment and a return to conventional strategies occurred. Losses due to TSWV (and WFT) were the worst on record.

With the development of the *Keep it Clean* project, assistance to improve preventative pest and disease management strategies was provided to enable a return to biologically based IPM.

A review of the farm was undertaken and 4 high priority gaps were identified:

1. Seedlings being used were not free from pests and diseases.

A new practice needed to be implemented: *All seedlings are checked and found free from pests and diseases before they are planted out into a clean greenhouse.* To implement this essential management practice, the decision was made to produce seedlings in-house. A seedling nursery was built.

2. People were regularly moving in and out of the farm and greenhouse without any checks or controls.

People were identified as being a high risk for introducing pests and diseases. *Check and control points are used to control movement of people, vehicles, plants and materials into the 'clean' zone.* A number of hygiene protocols were introduced to provide a check and control. A 'Do not enter' sign was erected at the front of the farm, a footbath installed at the entry to the greenhouse and all employees were given specific clean work routines which included gloves and clean work clothes.

3. Crop monitoring was insufficient.

While some monitoring was being undertaken, it was insufficient to provide adequate information for effective pest and disease management decisions. A refocus on an essential management practice – *Be able to correctly identify pests and diseases and routinely conduct a pest and disease check to ensure early detection and correct identification of problems* – was implemented as a cooperative approach between managers and workers.

4. Weeds were not being adequately managed around the greenhouse.

The essential management practice – *The greenhouse and farm surrounds are kept weed free* – was elevated to a priority farm management strategy rather than just an additional job when resources permitted.

The results of these low cost changes have been significant. Seedlings are now free from both thrips and virus allowing the crop to start clean. The clean seedlings also enabled the determination that the thrips outbreaks were emerging from the weed mat coverings enabling effective control strategies to be implemented. The changes in people traffic into and around the greenhouse and introduction of specific worker hygiene protocols resulted in an improvement in overall farm management and more consistent standards in work practices across the farm. Restricting visitors from the greenhouse has reduced the overall pressure and anxiety surrounding the potential for pest and disease outbreaks creating a better work environment.

The improved monitoring program is consistently resulting in early detection of hot spots within the greenhouse due to better employee awareness. This has enabled spot treatments with biologicals and soft chemicals, significantly delaying the need for whole crop sprays and subsequently has led to improved population levels of beneficials.

The implementation of these simple preventative pest and disease management practices has reduced the levels of TSWV infection by 90%, with over 13000 fewer plants becoming infected and having to be removed.

Case study 3:

In the Sydney basin greenhouse production area, several growers recognised that diseases, in particular Bacterial canker and *Fusarium*, were turning up in their greenhouses soon after the disease occurred in other farms in the area. As part of the *Keep it Clean* workshop, they discussed how the diseases could get to their farms and noted that it is common for growers to regularly visit nearby farms and meet for coffee to discuss the markets or production issues.

One grower mentioned that some employees will work at more than one farm and other visitors, such as sales representatives, would travel to several farms in one day.

Three of these growers stopped allowing people including themselves, if they had been to another farm, to go into their greenhouses until after they had changed their clothes, cleaned or changed their shoes and washed their hands. They implemented a number of preventative pest and disease management practices including;

- a) *The greenhouse is within a clean zone which is quarantined from the outside zone of the farm*
- b) *Check and control points are used to control movement of people, vehicles, plants and materials into the clean zone*
- c) *Employees and visitors do not visit another greenhouse before entering your greenhouse*
- d) *A parking area for employees and visitor vehicles is in the outside zone of the farm*

The three growers who started doing this have already noticed that there is less disease in their crops compared with the growers who have not changed. One grower estimated that the incidence of *Fusarium* was half of what normally occurred. Plant deaths from this disease were typically around 10% and occur from the start of the crop through to the end. The result of restricting the movement of people kept the disease out of the greenhouse until later in the crop cycle so fewer plants are getting infected by the end of the crop and the disease is not causing as many losses.

One of the growers producing tomatoes has had significant bacterial canker levels for 3 successive years resulting in practically a complete loss of one crop and severe losses in the other years. The greenhouse is cleaned and disinfected between crops. A clean zone was established around the greenhouse. A rope gate was installed and the "Do not enter" *Keep it Clean* gate sign was erected. A *Keep it Clean* footbath, using chlorine solution replenished daily, was placed at the door to the greenhouse. Typically the disease showed up about mid-way through the crop cycle in several rows at the front of the greenhouse. This has not occurred this time. The disease was detected as a hot spot in one part of the greenhouse but not in the usual locations near the entry which remained clean. This indicates that the check and control strategies that have been implemented have effectively prevented the transmission of the disease onto the farm, though the disease from the previous crop was not completely removed during the greenhouse clean up procedure. The outbreak was managed by rouging the infected plants and maintaining a clear work procedure that involved leaving this 'contaminated' area to the end of each crop management job.

With the effective use of quarantine practices, a more thorough clean and disinfect procedure is expected to be able to achieve a freedom from this disease in future crops.

These simple practices, costing only a few dollars and some time are estimated to have saved these three growers more than \$60,000 in the first year.

Implementation outcomes

Implementation of major changes was unexpected in the project timeframe; follow-up visits however, have revealed a relatively high level of adoption of minor changes in basic hygiene practices. The isolation of a clean zone and the use of gates, signs and other indicators to reduce unnecessary entry to production areas and greenhouses have been widespread. The use of footbaths has been just short of 100% for growers in NSW who received a free footbath. A large number of growers (24 in NSW) have made specific enquiries to confirm disinfectant choices and greenhouse cleaning procedures. This feedback is a good indicator of new practices to do with the greenhouse clean-out and greenhouse clean-up being implemented as crops are replaced. (Data was not collected in SA.) For growers not already following clear crop management procedures and work

orders, the high degree of interest demonstrated in this area is expected to lead to good uptake, though this can not be evaluated within this project timeframe.

The results of the farm reviews have been collated. Of the 77 identified practices, the average compliance was 58.3%. Of the 10 essential practices, the average compliance was 72%. This is a reasonably good position though it indicates substantial benefits can be achieved within the industry by implementing more preventative management practices.

Within 3 months of participating in the workshops and farm reviews, the majority of growers implemented up to 4 new practices, increasing average compliance to 64%. Most growers were able to or are working towards implementing clean zones and buffer areas as well as installing footpaths.

Action plans prepared within the project activities identified a range of practices to be adopted over the next 6 months. Again, clean zones and buffer areas and weed control around the farm were the most common though a few other preventative practices include windbreaks and gravel roadways. Growers in South Australia are well placed to make better use of windbreaks due to other programs investigating effective native species for reducing pests and diseases.

One of the main failures across the industry and in SA particularly, has been work procedures. Training and having employees follow policies is a common difficulty. Better awareness as to the importance of good practices and also the risk level of people in terms of introducing and spreading pests and diseases is the first step in creating change in this area. The project has done this. Substantial interest was received from SA growers seeking advice on how to manage the employee hygiene issues. Similar interest was expressed in NSW, though many Sydney basin growers reduced staffing during the project period for economic reasons so overall interest in employee issues was diluted.

A common failure where little change is likely in the short term is with reuse of substrates. The perceived savings attainable by reusing substrate for multiple crops makes many growers unwilling to start each new crop with clean, pest and disease free substrate. This is known to be a problem. Qualitatively, there is an indication that most growers are aware of the risk and mostly manage this risk with crop rotation though it adversely impacts on the capacity for growers to properly clean and disinfect the greenhouse between crops.

Insect screening is a major structural change that approximately 12% of growers are investigating as an option over the next couple of years. Screening does reduce airflow and venting capacity of greenhouses so it needs to be carefully planned within the context of the complete management of the growing environment. Air circulation fans are another technology option that is being considered by a few growers.

The following three figures represent the typical use of preventative management practices, categorised into 5 main areas as well as a total use figure. These graphs have been designed to illustrate the proportion of growers who are using specific practices. Figure 7.1 shows the situation before the workshops and farm review program were conducted. Figure 7.2 has taken into account the implementation of new practices during the project period. Figure 7.3 is a forecast of new practices based on action plans with growers that have been developed during the project.

Figure 7.1

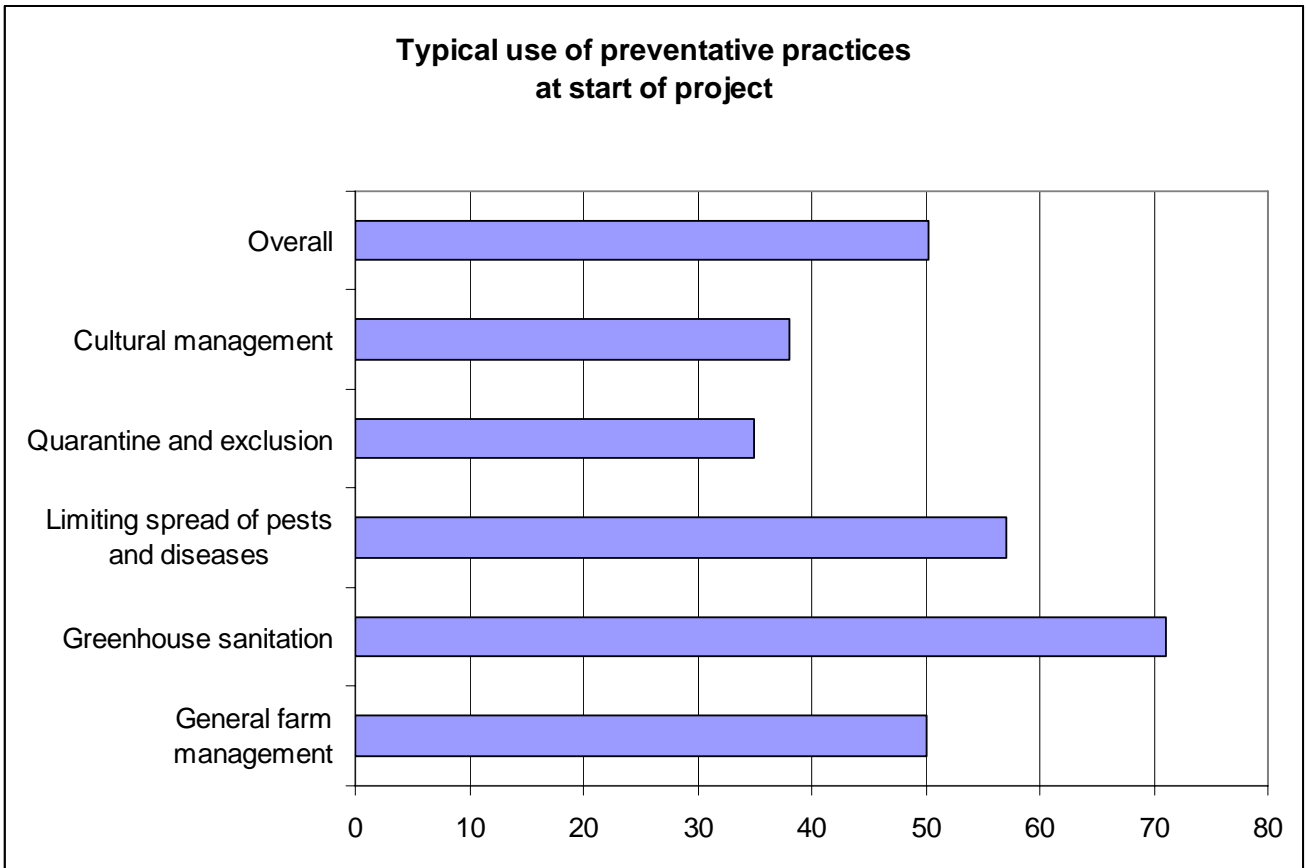


Figure 7.2

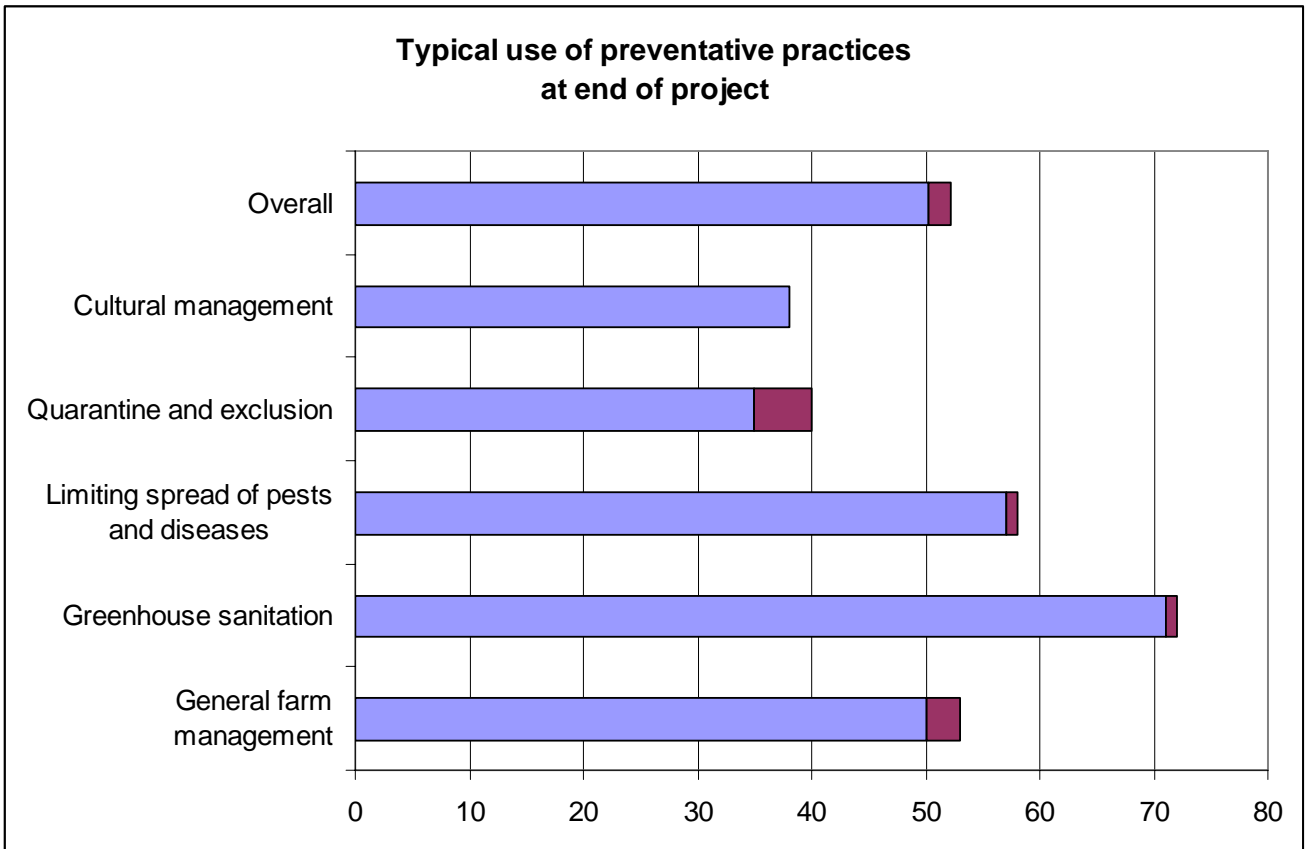
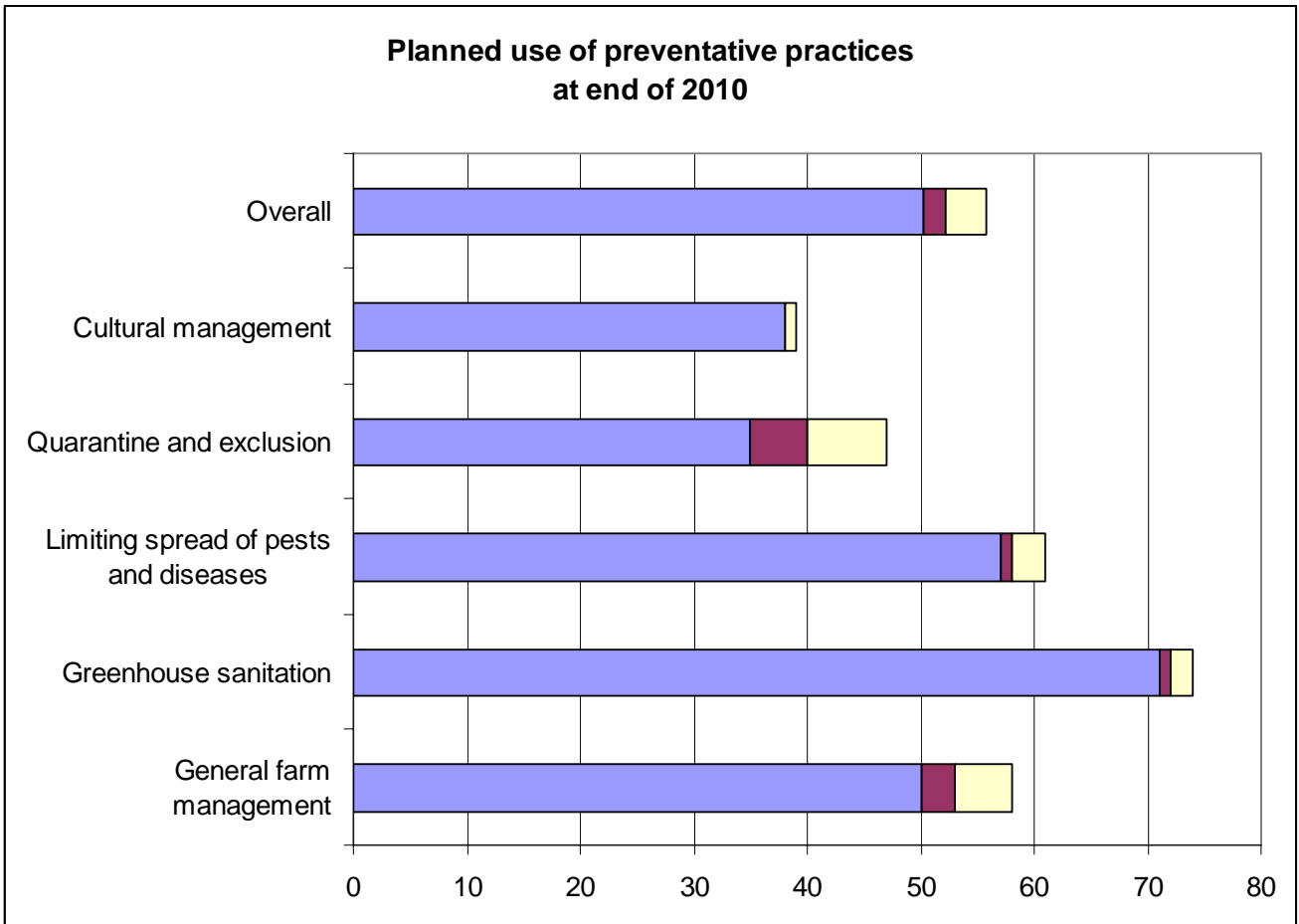


Figure 7.3



During the project period, the main gains were achieved in quarantine and exclusion practices followed by general farm management. Both these areas also featured strongly in action plans for implementing new practices over the next 6 – 12 months. A number of low cost and highly effective preventative practices are represented in these two areas. Notably, the essential management practices of designating a clean area and implementing check and control points to manage the clean area have been high on the implementation plans of participating growers. Combined with weed management and buffer areas, substantial gains in pest and disease management will be attainable at very low cost.

Discussion

This project has been very successful – achieving its ambitious aims within a tight schedule and providing an on-going opportunity for growers to implement more preventative management practices as well as offering consultants and other industry stakeholders a ready-made information resource and program for improving farm practices.

The three key result areas set out in the initial project have all been achieved. A total of 125 people participated in the workshops with 119 growers involved in the workshop and review program which is close to the project target of 10% based on the current estimated industry size. Almost 86% of the participating growers have implemented a new preventative pest and disease management practice. The target was 30%. Finally, we sought to reduce losses from diseases by 10% using preventative management practices. Anecdotally, *Fusarium* was successfully reduced by 35% on one property, losses due to TSWV and thrips were cut by 90% on another participating farm and the incidence of *Fusarium* was halved while bacterial canker was almost eliminated respectively in two other greenhouses.

This project was initiated and designed to address two problems inherent in the greenhouse industry. The first of these is the limited access many growers have to practical information on pest and disease prevention and secondly, to attempt to overcome the barriers to adopting these recommendations. The project team set out to provide greenhouse growers with a manual explaining farm hygiene and preventative pest and disease management and then to use and present this information with the goal of getting growers to make some real changes on-farm in their management of pests and diseases. Both of these objectives have been achieved. The short 2 year timeframe of the project limited the capacity to measure and evaluate uptake and industry capability but early indicators have shown that adoption barriers have been overcome to a degree with the approach used.

Typically, extension outcomes in the Australian greenhouse industry have approximately an 8 year cycle, that is, the delivery of effective messages to industry start to gain adoption around 8 years later. In this project, we sought to gain some on-farm changes within the project timeframe – a tall order in just 2 years. A participatory approach was adopted in the development of the manual so that the growers would be engaged early in the information and education process.

The involvement of growers in the content and format of the manual produced some valuable improvements to the publication, though the additional time required for meetings and awaiting feedback was not adequately accommodated in the original project timelines. This resulted in the publication being delayed and effectively it was available 5 months after the planned publication date. This did not adversely affect the project but needs to be considered in development of future major publications. The manual was published in the second half of the project. This publication was a critical success factor for the project and it was delivered to a very high standard.

Keep it Clean – Reducing the costs and losses in the management of pests and diseases in the greenhouse is a comprehensive and major publication which has been well received by growers. It combines ready to use and easy to read information to assist growers at all levels to determine where improvements can be made in the management of pests and diseases.

The extension and research process culminated in a list of 77 preventative management practices that can be used by greenhouse growers to cost effectively improve their management of pests and diseases and reduce the cost and losses associated with pest and disease management. Ten essential management practices were identified from the practice list. These have been highlighted as practices that every greenhouse grower needs to be practicing as part of a cost effective management program.

Adoption of essential management practices

Of the 10 essential management practices, monitoring, identifying and recording pests and disease levels and setting and using action points are critical failure points. The workshop program and the development and extension of the pest and disease check model resulted in 30 growers starting or increasing their use of monitoring as a preventative management tool. Unfortunately, this project did not have the time and resources necessary to fully engage growers on this specific area. Participants demonstrate an awareness of the importance, but this is not currently leading to sustained adoption.

The essential practice of inspecting seedlings prior to accepting delivery is contentious. Many growers readily agree that pests and diseases can easily enter their greenhouse through new seedlings, but very few growers

have the willingness or economic security to reject poor quality seedlings. None of the growers participating in this project have quarantine facilities on site where they can keep seedlings for observation prior to transplanting.

Almost all growers who were not already removing crop debris and disposing of it away from the greenhouses have indicated that they either will or have already started doing so. Implementation of this practice is currently 66% of participating growers with another 20% indicating change is imminent.

Cleaning the greenhouse is another essential practice which is generally conducted but highly compromised. The most common failure point is the reuse of substrate which constrains the capacity for growers to adequately clean and disinfect the greenhouse before replanting. Many of the reviews indicated that the greenhouse is cleaned and disinfected but closer examination revealed critical hygiene gaps. For all except the substrate issue, changes to the clean out and clean up process are being widely adopted. A number of growers (9) have implemented new disinfecting procedures for equipment, containers and greenhouse covers.

The final essential management practice calls for the restrictions on employees and visitors who have visited another greenhouse. There has been a rapid adoption of gate signs and farm policies to stop visitors entering greenhouses if they have come from another farm. Anecdotally, many growers were aware of this as a significant problem but did not have the capacity to implement an effective policy due to peer pressure and even cultural 'habits'. The project has created some momentum and support for growers as well as a critical mass of growers implementing similar policies. This further increases the measure across the industry.

The project team also presented the program in a commercial context, though it was offered free to participants. The provision of a consultancy package is one of the additional outcomes of this project. The manual, factsheets and farm management review booklet have been created as an integrated package to provide opportunity for consultants and allied traders in the industry to continue the adoption of preventative management practices. This can be used on a commercial basis or as add-on value to other services. This material is particularly relevant for any purveyor of IPM practices as it encompasses the fundamental building blocks for successful integrated management programs.

Costs and benefits

Quantifying and costing the achievements in this project is complex as insufficient data is available from growers regarding pest and disease levels, impacts and relevant yield data. However, preliminary results have shown some excellent savings.

The majority of preventative pest and disease management practices described in this project are very low cost. It was estimated at the initial project development stage that the typical cost of controlling pests and diseases in the target audience was around \$20,000 per hectare. This figure did not take into account the losses in production as a result of pests and diseases. The average cost of implementation of preventative management practices by participating growers in the final 6 months of the project was \$1200. Materials including the gate signs and footbaths (provided free to growers) and weed mat averaged just over \$900. Additional time spent planning or implementing changes cost approximately \$250 (valued at \$30/hr). Savings, where they can be estimated from reductions in problems, amount to close to \$10,000 though with some farms the value is clearly higher. Conservatively, implementation of preventative pest and disease management practices as part of this project, has achieved a benefit to cost outcome of almost \$8 for every dollar spent.

On a whole of project basis, with 119 participating growers to date, the return on industry investment so far is estimated to be \$6 for every dollar spent. With State government funding included, the return on investment is still significant at over \$2 per dollar invested.

A greater focus on attaining broader implementation of preventative management practices throughout the industry offers significant and long term gains to individual growers and the industry as a whole.

This project was conducted over a very short timeframe yet the project team was able to gain improvements in industry practice. The materials generated for industry in this project will continue to assist growers to recognise the importance and to implement preventative pest and disease management practices in the coming years; though it should be noted that considerable additional progress could be made with further funded extension of this program.

Recommendations

- Considerable additional progress in gaining on-farm adoption of preventative pest and disease management practices could be made with further funded extension of this program. While the materials are available for use by consultants and other service providers, the use of consultants remains limited in this industry particularly at the low technology end where greatest gains in preventative management could be made. With the on-going and important focus on IPM in this industry, it is recommended that the preventative management practices described in the *Keep it Clean* manual be incorporated into all IPM focussed extension programs.
- The active participation of growers in drafting and producing industry publications is to be recommended, however projects need to be sufficiently designed to accommodate the additional time and resources required to make best use of this involvement. This has repercussions in funding, project timelines and in the allocation of project personnel.
- This project identified that there needs to be a robust initiative on assisting growers to undertake routine pest and disease monitoring and keeping of records. Growers also need better skills in setting useful action points and where possible, research needs to develop guidelines as to effective action points and decision support tools for managing key pests and diseases.
- Extension is a complex process involving delivery of key information in specific ways and recognising and addressing a diverse range of adoption barriers. Any extension program involves significant building of relationships and gaining detailed understanding of issues pertinent to the target audience and the outcomes being sought. Failure to allocate sufficient time to an extension program or communication drive limits the potential achievements. Funding was only available for a two year project. The achievements gained in such a short period are due to a good knowledge of the industry and an existing relationship with the project team, but significantly greater returns in extension project could be achieved with longer timeframes.

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Appendix 1: Factsheets on the 10 Essential management practices

10 essential practices for all growers

The profitability and productivity of your greenhouse can be significantly improved by minimising the losses caused by pests and diseases.

Preventative pest and disease management is about planning, cleaning and quarantining.

No single practice on its own can completely prevent pests and diseases causing losses to your crop and to your business.

The key to cost effective pest and disease management is integrating the most suitable strategies from all the available options and establishing a solid prevention program.



Use as many tactics and practices as possible



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For more information: **Jeremy Badgery-Parker**

There are 10 essential practices for every farm

1. Be able to correctly identify pests and diseases (or have them identified for you) and routinely conduct a pest and disease check to ensure early detection and correct identification of problems
2. Action points are determined and pest and disease check information is used for all decision making including chemical, biological, whole-crop and hot-spot treatments
3. The greenhouse is within a 'clean' zone which is quarantined from the 'outside' zone of the farm
4. Check and control points are used to control movement of people, vehicles, plants and materials into the 'clean' zone
5. Employees and visitors do not visit another greenhouse before entering your greenhouse
6. All seedlings are checked and found free from pests and diseases before they are planted out into a clean greenhouse
7. A 5 - 10 metre wide clean buffer area is maintained around every greenhouse
8. The greenhouse is always cleaned and disinfected before planting new crop
9. The greenhouse and farm surrounds are kept weed free
10. Crop debris is removed and stored/disposed of outside



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1

Preventing pests and diseases in the greenhouse

Always check for pests and diseases

Monitoring the crop regularly and routinely enables you to find pests and diseases early. This means you will have more management options available to you.

Do a pest and disease check in every greenhouse at least 2 times per week in summer and once per week in winter. Inspect at least 12 plants per greenhouse and sticky traps.

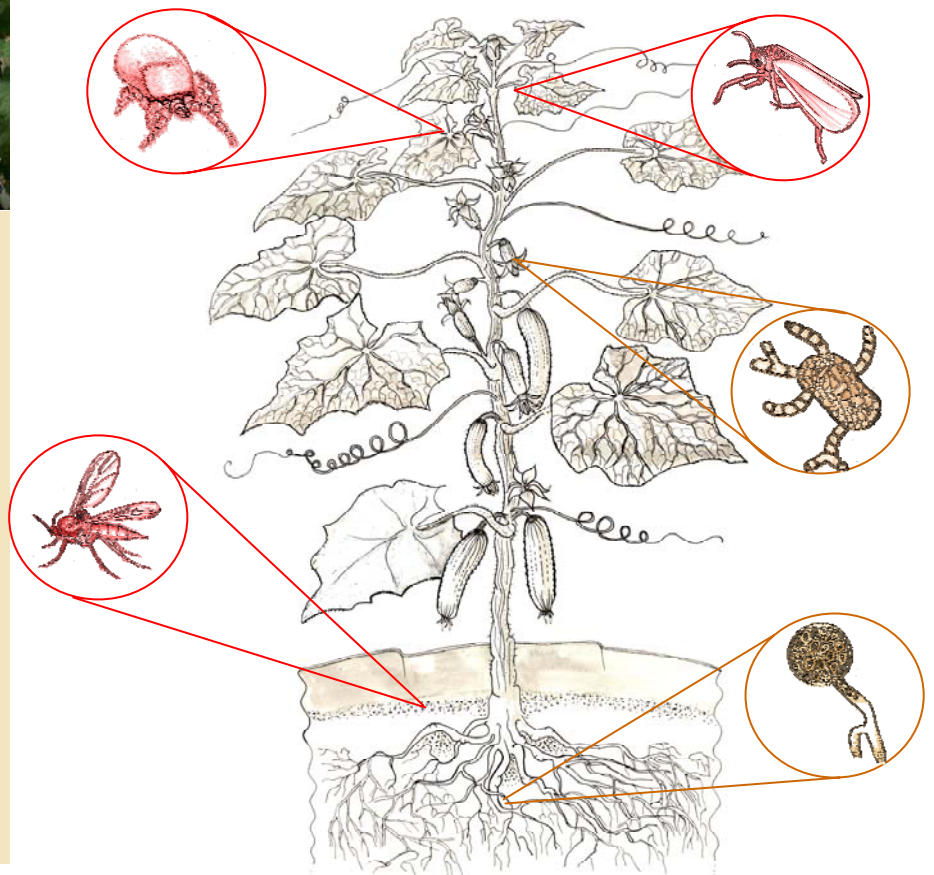
Set up each greenhouse beforehand and mark check points in your greenhouse to make the job easier. Use pre-prepared charts to make record keeping fast and easy.

Checking pest numbers routinely has enabled a grower to reduce his number of spray applications. He now averages 2 less sprays per crop, saving hundreds of dollars.



Make sure you can correctly identify pests and diseases

Check routinely and keep records. Use a hand lens and check every part of the plant:



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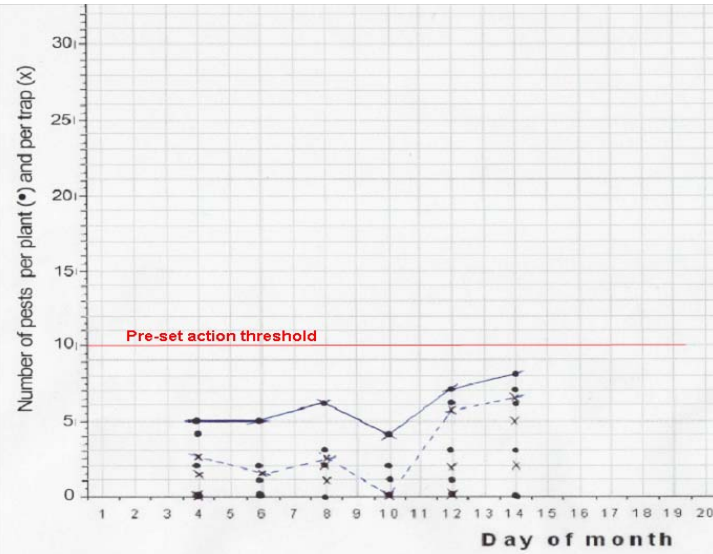
Use action points for making decisions

An action point (or threshold) is the level of pests or disease at which point you implement an active treatment strategy. These are set points that you use to make decisions about what, if any, management action you need to take.

There are different ways that you can use to describe an action point. You also need to plan what the action will be before you plant your crop.

You need to be able to adjust action points as you gather information from your crop.

The more accurate your action point, the more cost effective your management of pests and diseases will be.



Action points (thresholds) are a guide as to when to act

Example action point plan

Pest	Action point (threshold)	Action
X	10 on a plant	release preventative numbers of <i>predatory insect A</i> check an extra 12 plants in the greenhouse
	15 on 5 plants	apply a whole crop application of <i>insecticide B</i>
Y	8 on a plant	apply a spot application of <i>insecticide D</i> on target plant and surrounding plants
	15 on 5 plants	apply a whole crop application of <i>insecticide B</i>
Disease		
Z	10 plants infected	apply a whole crop application of <i>fungicide E</i>

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By preplanning action points and treatments, a NSW cucumber grower has reported that he has been able to reduce his action point for whiteflies (now tolerating a higher number before spraying) and this has saved 3 sprays in a crop without affecting yield.

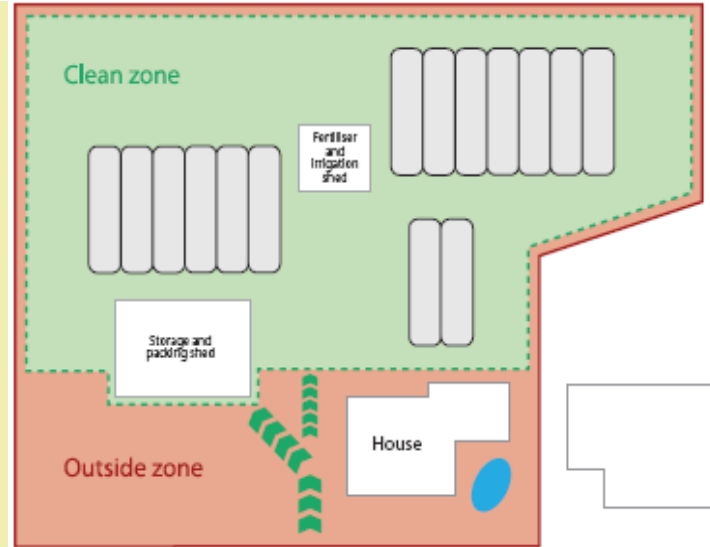
Make a clean zone around the greenhouse

Separate your farm into two (2) zones - a 'clean' zone and an 'outside' zone.

A clean zone is space around your greenhouse and production area which you use to create a barrier to pests and diseases.

Include all the greenhouses, shadehouses and hydroponic tables and the area immediately surrounding these production areas in the clean zone, as well as the packing and storage sheds and the roadways between these structures.

The 'outside' zone is the remainder of your property, including your house and driveway and everywhere off-site.



A clean zone is quarantined from the rest of the farm

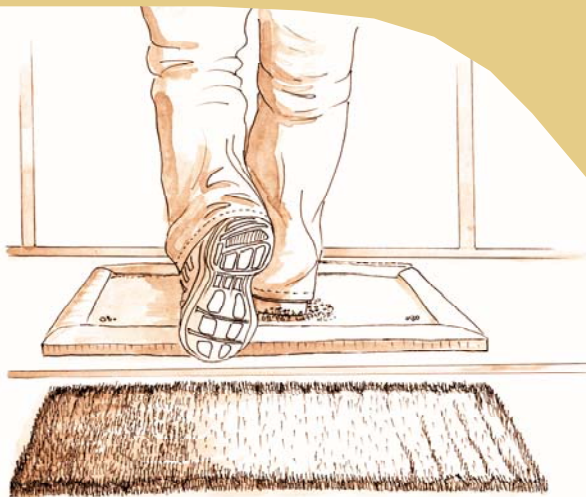
In the clean zone:

- No weeds
- No crop debris or rubbish
- Minimise exposed soil – cover paths and roadways
- All vehicles, tools and all equipment are kept free from soil, crop debris and rubbish.
- Anything being taken into the clean zone must be cleaned first

Keeping the farm clean has always been difficult for one busy greenhouse grower. He marked off two-thirds of the property which included all the greenhouses and sheds and made this the clean zone. A rope gate was put across the access road and a hedgerow planted around the perimeter.

This area is now kept free of weeds and crop debris and visitors are only allowed in if they have not come from another greenhouse.

Thrips are usually a very big problem every spring/summer but since creating the clean zone, only a few thrips have made it into the greenhouse, saving a lot of money and time. He did not have to spray for thrips last summer.



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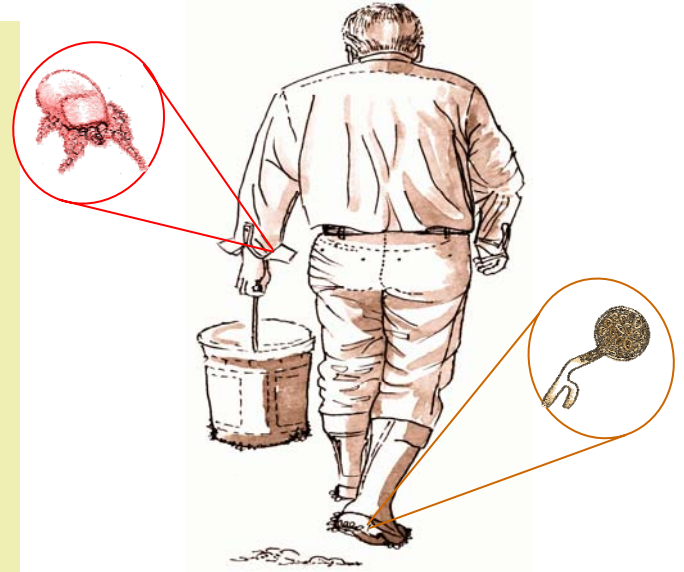
Control what goes into your clean zone

The aim of having a clean zone is so that you can more easily keep the area in and around your crop clean and free from pests and diseases.

Once the clean zone has been set up, you need to control everything that moves into it.

Check and control points are places, items and practices around the farm that ensure pests and diseases are not accidentally carried into the clean zone.

Movement of staff/workers and visitors around the farm is one of the most common ways for pests and diseases to spread.



Always check people, vehicles, plants and materials

There are many different check and controls that can be used:

- A gate or rope across the road
- A sign telling visitors not to enter
- A footbath
- A vehicle washing bay
- A cleaning station
- Work procedures explaining how jobs are to be done
- Work procedures describing what order greenhouses are to be worked
- A loading dock on the boundary between the two zones

A greenhouse farm in South West Sydney consistently had pests and diseases getting into crops planted in tunnel houses closest to an adjacent farm. Two problems were found. Firstly, there was no barrier between the farms and so problems could 'blow' across. Secondly, people visiting the adjacent farm did not notice the boundary and simply walked over bringing pests and diseases with them.

The boundary fence was repaired with new wires and immediately uninvited visitors stopped bringing over problems. A hedgerow was planted to create a barrier between the farms.

While pest levels have not changed yet, a key disease (Fusarium) has been kept out. Prior to controlling entry, Fusarium generally could be found on more than 20 in every 100 cucumber plants for the previous 3 crops. Fusarium did not get into the latest crop.

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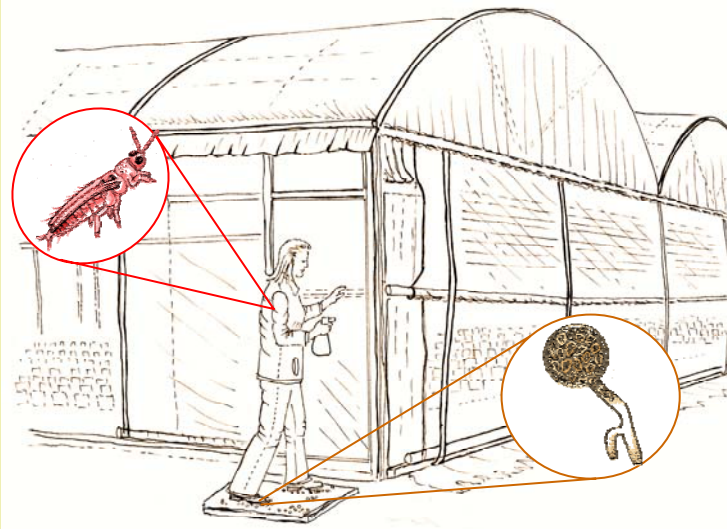
Do not go to another greenhouse

Movement of staff/workers and visitors onto and around the farm is one of the most common ways for pests and diseases to spread - pests and diseases will stick onto your clothes and shoes.

Employees should not go to another greenhouse unless they change clothes before coming to work.

If you visit another person's greenhouse, make sure you change clothes and shoes before going back into your own clean zone.

It is very easy to accidentally carry pests and especially diseases from one farm to another and from one greenhouse into another.



No one should visit another greenhouse before yours

"Be clean and quarantine"

In the Sydney basin greenhouse production area, several growers recognised that diseases, in particular Bacterial canker and Fusarium, were turning up in their greenhouses soon after the disease occurred in other farms in the area.


They discussed how the disease could get to their farms and noted that it is common for growers to regularly visit nearby farms and meet for coffee to discuss the markets or production issues.

They also noted that some employees will work at more than one farm and other visitors, such as sales representatives, would travel to several farms in one day.

A couple of these growers stopped allowing people including themselves, if they had been to another farm, to go into their greenhouses until after they had changed their clothes, cleaned or changed their shoes and washed their hands.

The three growers who started doing this have already noticed that there is less disease in their crops compared with the growers who have not changed. Even when the disease does get in, it comes much later in the crop and so does not cause as many losses.

With this very simple rule, which costs almost nothing to do, these growers have saved whole crops from dying.



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6

Preventing pests and diseases in the greenhouse

Have buffer areas around the greenhouse

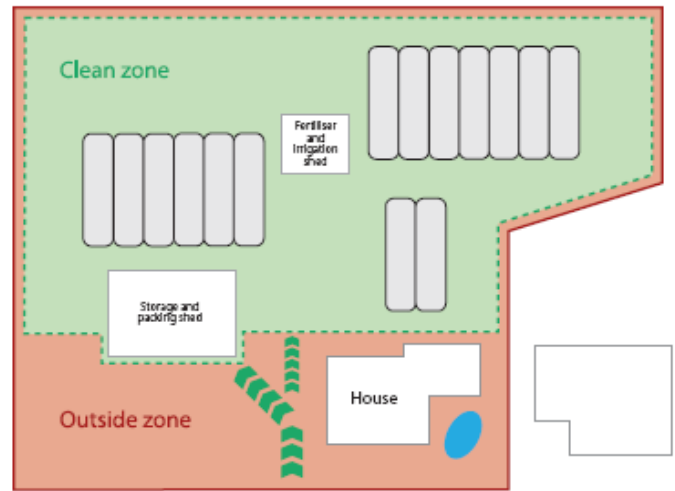
Buffer areas are an effective and relatively low cost pest and disease management strategy.

A buffer area is a space around the greenhouse that is kept clean and clear of things which could shelter pests and diseases.

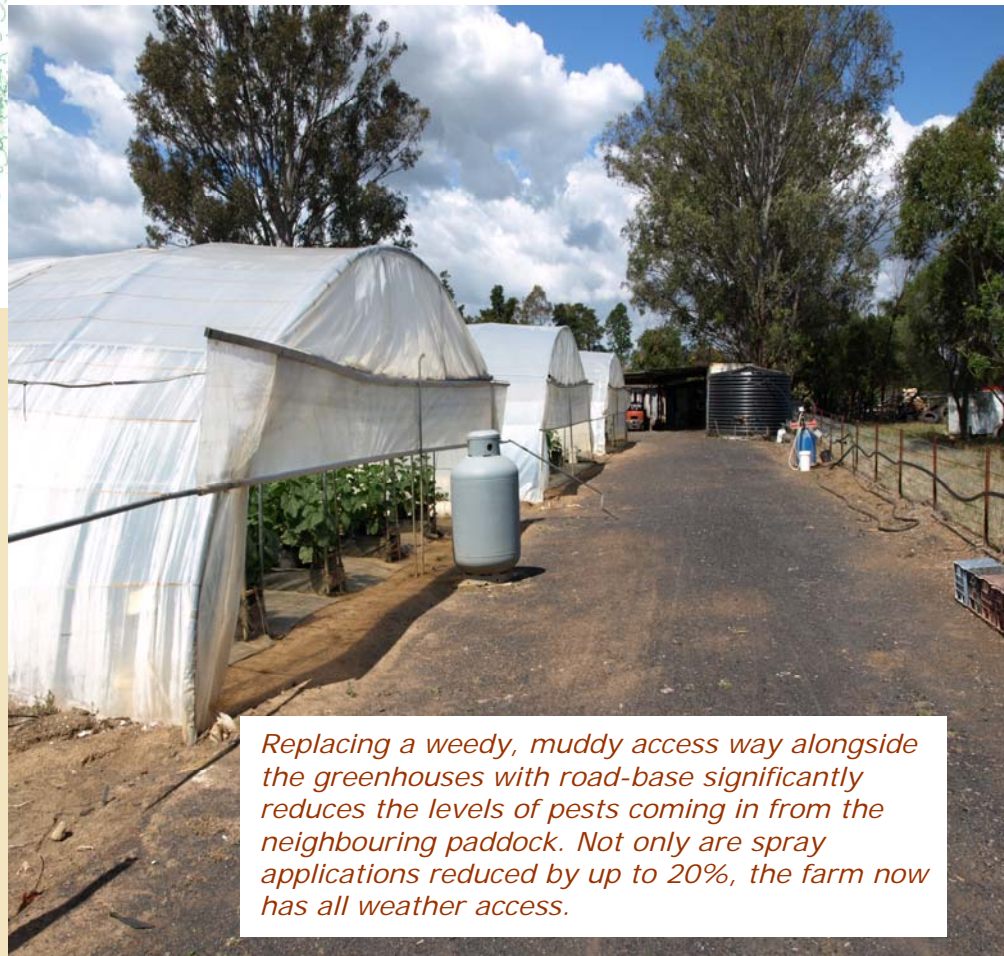
Make the buffer area at least 5 metres wide, or 10 metres if you can.

The buffer area should be sealed, covered in gravel or mulched, though even a well kept grassed area (kept short and free of broadleaf plants) can make a big difference.

Use buffer areas to create your clean zone



Make a 5 – 10 metre wide clean area around the greenhouse



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Replacing a weedy, muddy access way alongside the greenhouses with road-base significantly reduces the levels of pests coming in from the neighbouring paddock. Not only are spray applications reduced by up to 20%, the farm now has all weather access.



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Clean and disinfect the greenhouse

The greenhouse always has to be cleaned and disinfected before planting a new crop.

The clean up activity provides a fresh starting point and reduces the risk that there are pests and diseases carrying over from the previous crop.

Make sure you have a clear work procedure for the clean up. Describe every step.

Clean out the greenhouse as soon as the crop is finished. **Clean up** and disinfect the greenhouse just before you plant a new crop.

Clean and disinfect the hydroponic system as well.



Always clean and disinfect before a new crop is planted

The greenhouse *clean out* (as soon as crop is finished)

1. Remove old crop and dispose of material away from greenhouse
2. Remove and dispose of items that will not be reused including substrate, bags, twine.
3. Remove from greenhouse all equipment, tools, plant containers, bins, clips and truss supports, plant hangers, dripper stakes and emitters and other items that will be reused.
4. Sweep down walls, floors and all internal structures. Remove all plant material.

The greenhouse *clean up* (before a new crop is planted)

1. Wash the walls, floors and all internal structures, including drains with a high pressure hose and detergent.
2. Rinse walls, floor and all internal structures with clean water.
3. Clean and disinfect the hydroponic (irrigation) system.
4. Open up greenhouse and allow surfaces to dry.
5. Wash walls, floors and all internal structures with a 0.5 – 1.0% chlorine solution or other appropriate disinfectant (wear personal protective equipment including a respirator).
6. Rinse walls, floor and all internal structures with clean water.
7. Close up greenhouse with just a small amount of vent opening and leave to dry.
8. Wash and refill footbaths.
9. Clean all equipment, tools, plant containers, bins and other items to be returned to greenhouse.
10. Disinfect all equipment, tools, plant containers, bins and other items to be returned to greenhouse.
11. Set up greenhouse for next crop making sure that no items, tools or equipment get contaminated.

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Check seedlings before planting

Seedlings can be a significant source of pests and diseases and are a very common way in which problems get introduced into a clean greenhouse.

Seedlings have come from outside of your clean production area – from outside of the 'clean' zone. So you need to have check and control strategies in place to reduce the risk that the seedlings are carrying pests and diseases.

Consider putting new seedlings in a quarantine area for a week or two before planting them out. This can give you an opportunity to detect potential problems.



Make sure seedlings are pest and disease free

Check seedlings carefully when they arrive. Consider putting them aside in a quarantine area:

Look for signs of diseases and pests.

If a seedling is diseased, the others in the tray might also be - even if they look healthy now!

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Can you tell?



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Get rid of all weeds

Weeds are one of the most significant sources of pests and diseases.

On most farms, there is a very high chance that the pests and diseases that affect your crop, have come from the weeds in and around your greenhouse.

Keep a weed free area around the greenhouse. Do not even leave weed seedlings.

Flowering plants and especially any plant that is in the same family as the crop you are growing are serious weeds. Grasses are generally a lesser problem though they must be kept short and free from broad leaf and flowering plants.



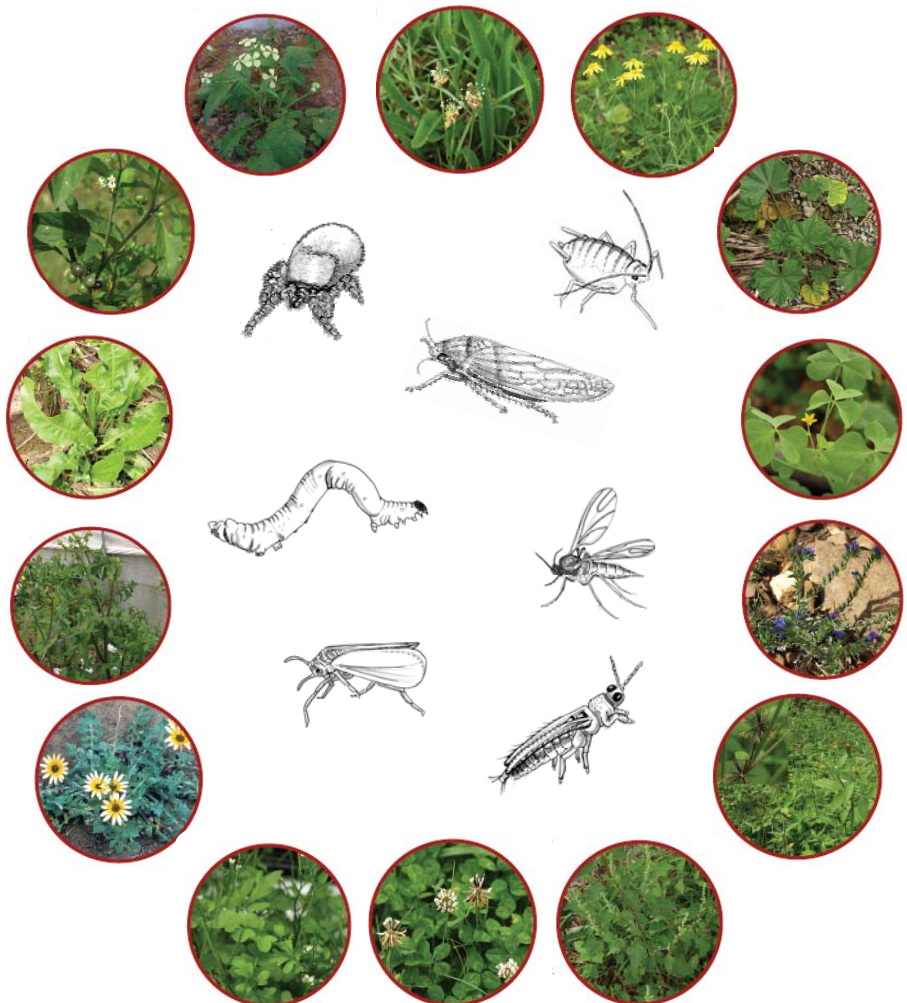
Keep the greenhouse and farm surrounds weed free

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Do not leave crop debris lying about

Piles of crop debris and discarded fruit left after pruning or harvesting your crop are a big source of pests and diseases.

Trolleys, garden carts and bins are very useful tools in the greenhouse. Put crop debris directly into the trolley or bin for easy removal – it saves time and money.

As soon as a crop is finished, clean out the greenhouse. Remove all plant material – leaves, stems, dropped fruit and weeds.

Place pruned material directly into a bin or bag and dispose of it appropriately.



Move crop debris away from the greenhouse

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Appendix 2: Farm review workbook

Preventing Pests and Diseases

Farm Management Review and Action plan

(Greenhouse Horticulture)

Property Owner or Operator: _____

Property Address: _____

Postal Address: _____
_____ Postcode: _____

Contact Phone: _____

Date of review: _____



This farm management review has been developed to guide greenhouse vegetable growers in implementing effective preventative pest and disease management practices.

This review can be used in conjunction with the greenhouse growers' guide to preventative pest and disease management – *Keep it CLEAN, Reducing the costs and losses in the management of pests and diseases in the greenhouse*, published by NSW Department of Primary Industries.

The farm management review has been produced in a form to enable comprehensive and efficient assessment of a grower's particular operations. Preventative pest and disease management strategies need to be used as an integrated, whole of farm approach.

For more information or a copy of the guide:

Mr Jeremy Badgery-Parker

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W www.dpi.nsw.gov.au

Conducting a Farm Management Review

1. Read through the resource manual, “Keep it Clean”

Completing the review:

2. For each greenhouse, complete a *Greenhouse structure* description
Page 3
3. Fill in the *Key pests and diseases* sheet. Using the risk assessment table in the manual, allocate a risk rating to each of your key pests and diseases
Page 4
4. Draw a map of your farm (label each greenhouse) and insert map
Page 5
5. Walk around your farm and make a list of the potential sources of pests and diseases on your farm (Refer to Section 1 of the manual for more information).
You may want to mark or label these places on your farm map.
Page 6
6. Work through the checklist and tick either “yes” or “no” depending on whether you are currently doing the practice mentioned. If you are only partly doing it, tick “no”.
Pages 8 – 13
7. Look at the practices for which you ticked “no”. These are things that you can do which will improve pest and disease management on your farm. Are there any of the 10 essential practices that you are not doing? These are highlighted with a 
8. Write out action plans for how you can implement and start doing the missing practices. Start with any of the 10 essential practices that you are missing. Then look up the practices listed in the manual for any pests or diseases that you graded as high risk and try to implement any of these that are missing.
Page 15

When writing an action plan, sometimes a couple of practices can be linked together and implemented with one action. Some practices might be done on their own. An example action plan is provided on page 14.

To write your action plans;

i) Go the *Practices to be implemented* section:

Write the 1 or 2 practices that you will be implementing into the space/s in the blank plan.

ii) Go the *Problem* section:

Describe the problem that you currently have which these practices will address. Consider the sources of pests and disease that you identified.

iii) Go the *Aim* section:

Write out what you aim to achieve with this action plan.

iv) Go the *Strategy/action* section:

Make a list of what you will do, where you will do it and how you will do it

v) Go the *Resources* section:

Make a list of what you will need, what it will cost and who will do it and how long you expect it to take to implement.

vi) Go the *Schedule* section:

When do you plan to have these practices in place?

vii) After you have completely implemented the practices and they are now part of your normal farm or greenhouse management, you can sign off on your action plan as being *completed*.

Work through all the missing practices. You should not expect to do everything straight away, but you do need to plan what and when you will do it. A couple of practices might not be feasible for you, in which case, leave them and concentrate on practices that you can do.

Greenhouse structure (name or ID number) _____

Area (m2) = _____

Height to gutter (m) = _____

Height to peak (m) = _____

Span width (m) = _____

Single span Multispan

Shape / features:

- | | | | |
|---|---|--|--------------------------------------|
| <input type="checkbox"/> Tunnel / igloo | <input type="checkbox"/> Gable – venlo type | <input type="checkbox"/> Gable – wide span | <input type="checkbox"/> Raised arch |
| <input type="checkbox"/> Flat arch | <input type="checkbox"/> Off-set arch | <input type="checkbox"/> Off-set gable | <input type="checkbox"/> Sawtooth |
| <input type="checkbox"/> Skillion | <input type="checkbox"/> Other _____ | | |

Technologies:

- | | | | |
|---|---|---|---|
| <input type="checkbox"/> Twin roof vents | <input type="checkbox"/> Single roof vent | <input type="checkbox"/> Wall vents | <input type="checkbox"/> Hydronic heating |
| <input type="checkbox"/> Hot air heating | <input type="checkbox"/> Insect screens | <input type="checkbox"/> Thermal screen | <input type="checkbox"/> Climate control |
| <input type="checkbox"/> Substrate culture (type _____) | <input type="checkbox"/> Water culture | <input type="checkbox"/> Soil | |
| <input type="checkbox"/> Other _____ | | | |

Cladding:

- | | | |
|--|--|--|
| <input type="checkbox"/> Single plastic film | <input type="checkbox"/> Twin plastic film | <input type="checkbox"/> Glass (_____ mm thickness) |
| <input type="checkbox"/> UV absorbing film | <input type="checkbox"/> Polycarbonate | <input type="checkbox"/> Other _____ |

Average yield (per m2):

Primary crop	(_____) =	_____
Secondary crop	(_____) =	_____
Tertiary crop	(_____) =	_____

crop

Pest and disease risk assessment – complete for each greenhouse

Key pests

- Thrips
- Whiteflies
- Broad mites
- Russet mites
- Rutherglen bug

Assessed
Risk level
(1, 2 or 3)

Key pests

- Aphids
- Caterpillars
- Spider Mites
- Flies (fungus gnats)
- Other

Assessed
Risk level
(1, 2 or 3)

Key diseases

- Fungal moulds and mildews
 - Botrytis (grey mould)
 - Downy mildew
 - Sclerotinia (white mould)
 - Leaf mould
 - Powdery mildew
 - Other

Assessed
Risk level
(1, 2 or 3)

Key diseases

- Bacterial leaf spots and soft rots
 - Angular leaf spot
 - Bacterial speck
 - Bacterial spot
 - Bacterial soft rot
 - Other

Assessed
Risk level
(1, 2 or 3)

Fungal leaf spots, blights and cankers

- Alternaria leaf spot
- Anthracnose leaf spot
- Grey leaf spot
- Gummy stem blight
- Other

Bacterial wilts

- Bacterial canker
- Bacterial pith necrosis
- Bacterial wilt
- Other

Fungal wilts and root rots

- Black root rot
- Damping off
- Fusarium
- Verticillium
- Other

Viruses

- Mosaic viruses
- Cucumber yellows
- Tomato spotted wilt virus
- Other

Nematodes

INSERT or DRAW YOUR FARM MAP

Sources of pests and diseases

Make a list of the potential sources of pests and diseases on your farm. Think about where pests and diseases can travel from and hide.

Plant sources of pests and diseases

eg *weeds growing to west of greenhouse # 3*
garden herbs growing in greenhouse

Weeds:

- _____
- _____
- _____

Other crops:

- _____
- _____
- _____

Pet plants:

- _____
- _____
- _____

Crop debris:

- _____
- _____
- _____

Seedlings:

- _____
- _____
- _____

Other:

- _____
- _____
- _____

Non Plant sources of pests and diseases

eg *vehicles driving in to production area from off-site
substrate in contact with soil and weather*

People and vehicles:

- _____
- _____
- _____

Greenhouse covers and structures:

- _____
- _____
- _____

Rubbish:

- _____
- _____
- _____

Tools, equipment, containers:

- _____
- _____
- _____

Substrate (or soil):

- _____
- _____
- _____

Irrigation system and water:

- _____
- _____
- _____

Other:

- _____
- _____
- _____

GENERAL FARM MANAGEMENT**Establish a 'clean zone'.....****Yes /No**

The greenhouse is within a 'clean' zone which is quarantined from the 'outside' zone of the farm

Check and control points are used to control movement of people, vehicles, plants and materials into the 'clean' zone

A 5 - 10 metre wide clean buffer area is maintained around every greenhouse

The greenhouse and farm surrounds are kept weed free

Work procedures for all jobs that need to be done in and around the greenhouse are written and explained to all workers

Crop work is done in cleanest, youngest crops first and dirty tasks are completed last in the day

A parking area for employee and visitor vehicles is in the 'outside' zone of the farm

All vehicles in the 'clean' zone are kept free from soil, plant debris and rubbish

All vehicles that travel off-farm ('outside' zone) are always cleaned before entering the 'clean' zone

Windbreaks are established around the farm or greenhouse

There is a neighbourhood agreement for managing weeds

Maintain clean surfaces..... **Yes /No**

Roadways and pathways in the 'clean' zone are sealed or covered

Roadways and pathways in the 'clean' zone are free from soil and mud, weeds, plant debris and rubbish

Floors and other surfaces of sheds in the 'clean' zone are sealed or covered for easy cleaning and are regularly cleaned


The greenhouse floor and other surfaces kept covered for easy cleaning

Water and drainage..... **Yes /No**

All water used in the 'clean' zone is disinfected and disinfected water is stored so that it can not be contaminated

Drainage ensures that there are no puddles or wet areas in the 'clean' zone and surface run-off does not wash into the greenhouse

Manage rubbish..... **Yes /No**

 Crop debris is removed and stored/disposed of outside 'clean' zone and away from greenhouse

A waste bin is located away from the greenhouse for management of bulk waste and is emptied regularly

Rubbish removed and stored/disposed of outside of 'clean' zone and away from greenhouse

Small 'day' and 'pruning' bins are located conveniently in or near the greenhouse and are emptied frequently

GREENHOUSE SANITATION

Greenhouse clean out..... Yes /No

Old crops completely removed from greenhouse at the end of the crop

Used substrate completely removed from greenhouse at the end of the crop

Greenhouse clean up..... Yes /No


 The greenhouse always cleaned and disinfected before planting a new crop


Appropriate disinfectant used for sanitising the greenhouse, tools, shoes and other equipment

All equipment, tools, containers, bins and other items are completely removed from greenhouse before the clean up

LIMITING THE SPREAD OF PESTS AND DISEASES

Assessing the problem..... Yes /No

 Be able to correctly identify pests and diseases (or have them identified for you) and routinely conduct a pest and disease check to ensure early detection and

 Action points are determined and pest and disease check information is used for all decision making including chemical, biological, whole-crop and hot-spot

Plant management..... Yes /No

Plants are pruned and trained appropriately and sharp, clean blades are used

Pruned plant material put directly into a 'pruning' bin or bag and disposed of appropriately

Infected plants (bagged before removal) are removed from the greenhouse (roguing)


De-leafing, truss or flower pruning and thinning used to reduce pest and disease risk

Spot treatments..... Yes /No

Spot treatments are used when appropriate

Chemical controls are assessed for any resistance issues or control failures and a resistance management plan is used

QUARANTINE AND EXCLUSION**Plants**..... **Yes /No**All seedlings are checked and found free from pests and diseases before they are planted out Only a single crop is grown at a time in the greenhouse and the greenhouse is kept free of non-crop plants including "pet" plants Hydroponic set up prevents plant to plant contact of run-off water **Substrate, plant containers and soil**..... **Yes /No**Only clean, pest and disease free substrate (new or sterilised) is used for each new crop Soil has appropriate biological, chemical and physical properties for the crop being grown Soil is solarised or fumigated with an appropriate and registered product between crops **Clean tools and equipment**..... **Yes /No**A cleaning station is set up at the greenhouse entry or other convenient location for sanitising tools before taking them into the greenhouse All containers (bins, boxes, tubs, buckets and trays) and other materials (eg twine and crop supports) to be used in the greenhouse are cleaned and disinfected before being taken into the greenhouse All tools and equipment (eg knives, secateurs, brooms and trolleys) to be used in the greenhouse are cleaned and disinfected before being taken into the greenhouse Pruning tools are regularly disinfected during the pruning task and when used in a diseased area of a crop are cleaned and disinfected before being taken into a healthy area of a crop The crop support twine is new or cleaned and disinfected before use in the greenhouse

Greenhouse structures and surrounds.....	Yes /No	
The number of greenhouse entry points has been minimised	<input type="checkbox"/>	<input type="checkbox"/>
Foot baths (or wheel baths) and doormats installed and used correctly at every entry point	<input type="checkbox"/>	<input type="checkbox"/>
Double entry doors (and fan) or a double curtain installed at all entry points	<input type="checkbox"/>	<input type="checkbox"/>
The greenhouse covering materials are kept clean and well maintained	<input type="checkbox"/>	<input type="checkbox"/>
Splash skirts are installed on all opening walls of greenhouse	<input type="checkbox"/>	<input type="checkbox"/>
Furrows or trenches (such as a gutter or drain) used to stop crawling pests	<input type="checkbox"/>	<input type="checkbox"/>
Insect screens are installed on opening sides	<input type="checkbox"/>	<input type="checkbox"/>
Insect screens are installed on roof vents	<input type="checkbox"/>	<input type="checkbox"/>
Windward vent opening restricted during warm windy conditions if feasible	<input type="checkbox"/>	<input type="checkbox"/>
Potential insect vectors are excluded or appropriately managed	<input type="checkbox"/>	<input type="checkbox"/>
Worker and visitor hygiene.....	Yes /No	
 Employees and visitors do not visit another greenhouse before entering your greenhouse	<input type="checkbox"/>	<input type="checkbox"/>
Disposable gloves are worn when in the greenhouse and are changed frequently	<input type="checkbox"/>	<input type="checkbox"/>
Employees have a clean change of clothes/overalls everyday for greenhouse work and clothes/overalls are changed after working in a 'dirty' greenhouse	<input type="checkbox"/>	<input type="checkbox"/>
Dedicated footwear or disposable shoe covers are used when working in or entering the greenhouse	<input type="checkbox"/>	<input type="checkbox"/>
Employees wash hands and disinfect personal items (eg mobile telephone) after working in a 'dirty' greenhouse	<input type="checkbox"/>	<input type="checkbox"/>
Employees and visitors who smoke wash their hands after smoking before entering the greenhouse	<input type="checkbox"/>	<input type="checkbox"/>
Bright yellow, mid-blue and white coloured clothing is avoided when working in or entering the greenhouse	<input type="checkbox"/>	<input type="checkbox"/>

CULTURAL MANAGEMENT

Monitor and manage greenhouse environment.....	Yes /No
Temperature and humidity in the greenhouse is properly managed (including monitoring) and temperature and humidity extremes in the greenhouse are	<input type="checkbox"/> <input type="checkbox"/>
The greenhouse has adequate and adjustable venting capacity	<input type="checkbox"/> <input type="checkbox"/>
The greenhouse has adequate heating capacity	<input type="checkbox"/> <input type="checkbox"/>
Overhead sprinkler/misting/fogging used (if appropriate and feasible) to maintain humidity levels	<input type="checkbox"/> <input type="checkbox"/>
Air circulation fans are installed and air movement is managed in the greenhouse	<input type="checkbox"/> <input type="checkbox"/>
Vibrating pollinators used in preference to blowers if pollinating crops	<input type="checkbox"/> <input type="checkbox"/>
The number of whole crop foliar sprays is minimised	<input type="checkbox"/> <input type="checkbox"/>
UV blocking covering material used (if appropriate and feasible) to disrupt pest behaviour	<input type="checkbox"/> <input type="checkbox"/>
Nutrition.....	Yes /No
A balanced and appropriate nutrient regime is provided to the crop	<input type="checkbox"/> <input type="checkbox"/>
Feed and drain EC and pH is managed (including monitored and recorded) at least daily	<input type="checkbox"/> <input type="checkbox"/>
Irrigation.....	Yes /No
Irrigation uniformity test is completed before planting new crop	<input type="checkbox"/> <input type="checkbox"/>
Feed and drain irrigation volume is managed (including monitored and recorded) at least daily	<input type="checkbox"/> <input type="checkbox"/>
Good root zone drainage is maintained	<input type="checkbox"/> <input type="checkbox"/>
Reduce planting and other risks.....	Yes /No
A crop break or rotation plan is used for the greenhouse	<input type="checkbox"/> <input type="checkbox"/>
Resistant or tolerant varieties are used when feasible	<input type="checkbox"/> <input type="checkbox"/>

Example Action plan

<p>Problem: (what is the problem that is causing a pest and/or disease risk?) <i>No records of pests and diseases available for effective decision making</i></p>	
<p>Aim: (what will you aim to do to fix the problem?) <i>Implement a routine pest and disease check procedure for all greenhouses</i></p>	
<p>Practices to be implemented: (select practices from checklist)</p> <ul style="list-style-type: none"> ● <i>Be able to correctly identify pests and diseases (or have them identified for you) and routinely conduct a pest and disease check to ensure early detection and correct identification of problems</i> ● <i>Action points are determined and pest and disease check information is used for all decision making including chemical, biological, whole-crop and hot-spot treatments</i> ● 	
<p>Strategy/action: (what action will you take? where? and how will you do it?)</p> <ol style="list-style-type: none"> 1. <i>A preferred recording system is decided upon including where records will be kept and in what form. Record sheets obtained.</i> 2. <i>Days of week that P&D check be done are decided.</i> 3. <i>Middle two rows will be purple zone for each greenhouse (2 purple zones per tunnel)</i> 4. <i>Each greenhouse is marked for P&D check with 3 orange crosses in each of 2 rows (6 orange zones per tunnel)</i> 5. <i>Sticky traps installed (2 per tunnel)</i> 6. <i>Initial action points defined for each key pest and disease</i> 	
<p>Resources: (what do you need? how much does it cost? and who will do the work?)</p> <ul style="list-style-type: none"> • <i>P&D check records</i> • <i>Sticky traps (22 needed per week in summer)</i> • <i>Hand lens</i> • <i>ID guide and posters</i> 	
<p>Schedule: (by when?) <i>End of March 09</i></p>	<p>Completed: (is it done?) <i>yes</i></p>

Action plan template

Problem: (what is the problem that is causing a pest and/or disease risk?)

Aim: (what will you aim to do to fix the problem?)

Practices to be implemented: (select practices from checklist)

●

●

●

Strategy/action: (what action will you take? where? and how will you do it?)

Resources: (what do you need? how much does it cost? and who will do the work?)

Schedule: (by when?)

Completed: (is it done?)

Action plan template

Problem: (what is the problem that is causing a pest and/or disease risk?)

Aim: (what will you aim to do to fix the problem?)

Practices to be implemented: (select practices from checklist)

●

●

●

Strategy/action: (what action will you take? where? and how will you do it?)

Resources: (what do you need? how much does it cost? and who will do the work?)

Schedule: (by when?)

Completed: (is it done?)

Action plan template

Problem: (what is the problem that is causing a pest and/or disease risk?)

Aim: (what will you aim to do to fix the problem?)

Practices to be implemented: (select practices from checklist)

●

●

●

Strategy/action: (what action will you take? where? and how will you do it?)

Resources: (what do you need? how much does it cost? and who will do the work?)

Schedule: (by when?)

Completed: (is it done?)



**NSW DEPARTMENT OF
PRIMARY INDUSTRIES**

Appendix 3: *Keep it Clean* cover image and publication details

Keep it CLEAN

Reducing costs and losses in the management of pests and diseases in the greenhouse

INTENSIVE INDUSTRIES DEVELOPMENT BRANCH



Know-how for Horticulture™



NSW DEPARTMENT OF
PRIMARY INDUSTRIES

About the author

Mr Jeremy Badgery-Parker BScAgr MBA is the extension and development horticulturist for greenhouse horticulture with the NSW Department of Primary Industries. He provides an extension service, seminars and presentations on all aspects of greenhouse and hydroponic production and is involved in a variety of research and development projects for the industry. Mr Badgery-Parker is based at the National Centre for Greenhouse Horticulture, Locked bag 26, Gosford, NSW, 2250.

About the project

This project VG 07118 - Build capacity of greenhouse growers to reduce crop loss through adoption of preventative disease management practices was designed and managed by NSW DPI with industry support through HAL/Ausveg.

The project was set up to provide greenhouse growers with the basic information and skills needed for integrated and preventative pest and disease management and to assist growers in overcoming barriers to adoption when implementing the foundations of integrated pest management (IPM).

Mr Tony Burfield BSc, BAdult.Ed. is the technology extension officer with the South Australian Research and Development Institute, primarily with the greenhouse industry at Virginia and has conducted the South Australian component of this project. His work focuses on reducing reliance on pesticides through crop scouting, managing farm hygiene, using beneficial insects and improving pesticide knowledge and use.

More recently, Mr Burfield has been involved with compost and soil health projects, basic hydroponics, revegetation by design and business management.

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Contents

Section 1 – Reducing the risk of pests and diseases	9	Monitoring and checking for pests and diseases	107
Where do pests and diseases come from?	9	The pest and disease check	107
Plant sources of pests and diseases	10	Conducting a simplified pest and disease check	111
Non-Plant sources of pests and diseases	11	Completing your record	114
What preventative actions and practices can you take?	14	Action points (threshold levels)	115
General farm management to reduce pests and diseases	14	Measuring the impact of pests and diseases	118
Establish a ‘clean’ zone	14		
Check and control points and work procedures	15	Appendix 1 – Farm self review and action plan records	122
Vehicles and deliveries	17	1. Overview of structures: Complete for each greenhouse	123
Buffer areas	18	2. Pest and disease risk assessment: Complete for each greenhouse	124
Weeds	19	3. Preventative practices checklist: Complete for each review	125
Windbreaks and vegetative screens	20	4. Action plan BLANK: Complete for each problem identified	129
Maintain clean surfaces	21	4. Action plan EXAMPLE:	130
The greenhouse	21		
Sheds and other structures	21	Appendix 2 – Common weeds	131
Water and drainage	22		
Manage rubbish	23	Appendix 3 – Disinfectants	135
Greenhouse sanitation	25	Halogens	136
Substrate, plant containers and soil	30	Alcohols	137
Clean tools and equipment	32	Oxidising agents	137
Greenhouse structures and surrounds	33	Acids and Alkalis	137
Vector management	36	Combination disinfectants	137
Worker and visitor hygiene	38	Phenolics	138
Limiting the spread of pests and diseases	40	Quaternary Ammonium Compounds (Quats)	138
What localised strategies can be used?	40	Other disinfectants	138
What whole crop strategies can be used?	43	Non-chemical disinfection	138
Reducing plant risks	47	Concentration of disinfectants	139
		Appendix 4 – Example charts	142
Section 2 – Implementing effective pest and disease management	48		
Assessing the risk of pests and diseases	50		
Risk assessments	51		
Recognising key pests and diseases	52		
Knowing and preventing your key pests	54		
Life cycles	55		
Knowing and preventing your key diseases (and the pathogens that cause them)	75		
Types of pathogens	75		
Fungal Moulds and Mildews	77		
Fungal Leaf Spots, Blights and Cankers	83		
Fungal Wilts and Root Rots	89		
Bacterial Leaf Spots and Soft RotS	94		
BACTERIAL WILTS	98		
VIRUSES	102		
NEMATODES	106		