FINAL REPORT

VG05043

Benchmarking vegetable integrated pest management systems against other agricultural industries

Or

Field Vegetable IPM Stocktake

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Project No: **VG 05043**

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Statement of purpose: This report is a summary of the research and consultation conducted by the project team as part of the IPM stocktake for vegetables.

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Media Summary

Integrated pest management (IPM) is internationally accepted as the best approach to manage pests. However there are neither the people nor the resources to have specific IPM projects for all vegetable commodities. The IPM approach or basic strategy is not crop specific. A well developed IPM strategy in a particular crop will have specific tools that will assist in monitoring the crop and it's suite of pests and diseases, tools to assist making management decisions and tools to modify the crop environment. In the past HAL funded IPM projects have typically been crop specific and the extension materials or activities directed at a specific crop. Given that many of our important pests and diseases affect a range of crops the research outcomes and IPM tools developed within a particular cropping system can be useful to growers of other crops.

This project has begun the process of looking critically at what IPM research and extension has been conducted in field vegetables and some selected non-vegetable crops. The aim was to provide recommendations on how to better use the limited research and extension resources for crop protection in field grown vegetables.

IPM researchers, extension specialists, consultants and some growers were consulted by way of a number of questionnaires, surveys, workshops and direct conversations. They were asked about many aspects of IPM development. A workshop of 'experts' also considered the potential IPM strategies for 10 crops that were not covered by national IPM projects.

Recommendations were made to continue the vegetable IPM strategic planning process, to continue to review the existing IPM information and collate it into forms that are more accessible to growers, consultants and researchers alike. Recommendations were made on research and extension priorities for IPM in field grown vegetables in general and specifically for the 10 selected crops.

Technical Summary

Over the last 10 years HAL/AUSVEG has invested $43 million into 'plant health' projects. The underlying approach of most of these projects has been integrated pest management (IPM). Yet vegetable IPM is still in its infancy. Effective co-ordination of IPM priorities for ongoing investment is vital to address the issue of limited funding resources, an ever reducing base of state expertise and continuing pressure from new pests and diseases, and increasing competition in the national and international market place.

This project sought to consult with those working in vegetable IPM as well as 'experts' from other industries with developed IPM systems. They were asked to clarify what the basic IPM strategy is across their industries, the IPM development process that has been used, what has been successful, where the barriers have lain, what tools were deemed effective and important, and what are the limitations. Consultation was conducted via inviting IPM 'experts' to fill in a web-based survey, vegetable research and extension people were also asked to fill in a number of questionnaires relating to vegetable IPM, and to comment on or add to the collated lists of Australian IPM resources, and management options for major pests and diseases. Two 2-day vegetable IPM workshops were also part of the consultation process of this project.

This project intended to review current IPM methods and tools that have been developed in some field vegetable crops and selected non-vegetable commodities that have the potential to be used or used with modifications more broadly in vegetables. Collating the available information proved to be a more challenging and time consuming process than expected, so this project has become the beginning of a longer process of review. It has collated a list of IPM projects funded by HAL and other Research and Development Corporations, it has summarized a selection of the field grown vegetable IPM projects, listed Australian vegetable IPM tools, and begun collating management options for key pests and diseases. It has summarized pests and diseases found in 10 vegetable crops not covered by National IPM projects, evaluated existing management options, and proposes what is currently adoptable as IPM strategies and suggests how they may be further developed.

Recommendations were made on research and extension priorities for IPM in field grown vegetables in general and specifically for the 10 selected crops. Recommendations were made to continue the vegetable IPM strategic planning process, to continue to review the existing IPM information and collate it into forms that are more accessible to growers, consultants and researchers alike. Twelve areas for further work include:

1. IPM Working Group
2. IPM Sector workshops
3. IPM Clearing House/Web Hub
4. IPM Consultants
5. General IPM information Toolbox
6. Active surveillance for pests and diseases
7. Crop/Product Group Strategic Planning
8. Access to soft chemistry and biopesticides
9. Using beneficial organisms
10. Integrated soil management strategies
11. Integrated Disease Management
12. Cultural controls

Introduction

Integrated pest management (IPM) is internationally accepted as the best approach to manage pests. However there are neither the people nor the resources to have specific IPM projects for all vegetable commodities. And there are some issues/tools/methods in IPM that are not crop specific or can be modified slightly for use in different crops.

There has been a major ongoing demand from the vegetable industry for pest management Research, Development and Extension (R,D&E). This is due to a range of issues that have been challenging sustainable crop protection, most of which arise from relying on technologies centred on a single, pesticide based, control strategy. They include insecticide resistance problems with key pests, and other forces being applied by market trends and community expectations about pesticide residues in food and the environment. These concerns have driven a major investment in Integrated Pest Management (IPM) strategies through HAL/AUSVEG projects over the past 10 years with 'plant health' funding in excess of $43 mill. Effective co-ordination of priorities for ongoing investment is vital to address these issues with the limited funding resources, an ever reducing base of state expertise and continuing pressure from relentless pest issues and increasing competition in the national and international market place.

Delivering value to industry through useful outcomes is paramount. Pest management is costly and the price of expensive new chemicals can be a major economic factor unless the overall production system is cost effective. Alternative strategies must be developed and maintained that provide growers with a practical and affordable way to get off the insecticide treadmill and meet evolving community standards, but this is not achieved by treating R&D as a last minute option. A genuinely strategic approach to IPM R, D&E puts in place a means for developing, promoting and continuously improving the skills and tools required to meet industry needs rather than waiting to react to crises.

Australian Vegetable Production

Vegetable production in Australia was worth $2,268 M in 2004/5 (Table 1). The vegetable market is divided into the fresh and processing markets 60:40 (IBIS 2005). Queensland and NSW account for the largest areas in vegetable production however Victoria returns the greatest value for its' vegetable production output.

Table 1. Gross Value of Vegetable production (2002/3 ABS data)

Product	($m)
Potatoes (total)	485.4
Tomatoes (total)	229.7
Mushrooms	213
Carrots	198.5
Onions white and brown	163
Lettuce	113.4
Asparagus	65.9
Melons	124.9
Capsicum (chillies and peppers)	64.2
Cauliflowers	56.3
Broccoli	65.4
Pumpkins	47.5
French & runner beans (total)	53.2
Sweet corn	52.7
Cabbages	27.4
Celery	26.1
Zucchini	22.6
Cucumbers	18.5
Sweet potatoes	
Beetroot	8.3
Chinese cabbage (bok choy and wombok)	7.8
TOTAL Vegetables	**2,268.50**

The National Vegetable levy was introduced in 1996 to fund research and development projects to benefit all vegetable growers. Some vegetable sectors chose to remain independent of the National Vegetable levy and either have no R&D levy at all e.g melons, a voluntary R&D levy e.g. processing tomatoes, or an levy managed by HAL and the commodity group but independent of AUSVEG e.g. Onions. These funds were matched by Australian Government funds dollar for dollar. Prior to the National Vegetable levy some vegetable projects were conducted with matched voluntary contributions.

Since the National Vegetable levy was introduced $43,607,643 has been allocated to crop protection projects (Table 2), of which 15% was directly attributed to integrated pest management strategies (Figure 1) but in all likelihood many of the pathology and entomology projects also took an integrated pest management approach.

Figure 1. Vegetable R&D funding in crop protection by sector (data provided by HAL)

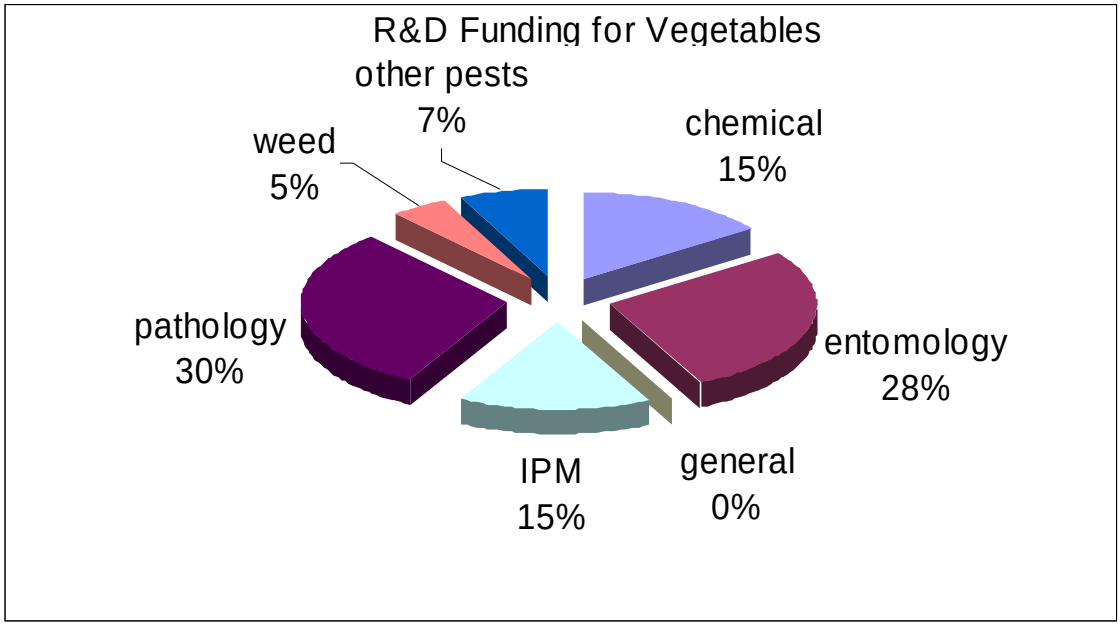


Table 2 Vegetable crop protection funding 1996-2006 (data provided by HAL)

Sector	Vegetable $
chemical	$7,012,388
entomology	$12,974,498
IPM	$7,076,120
pathology	$14,431,518
weed	$2,113,118
other pests	$3,206,572
TOTAL	$46,814,214

The vegetable production sector is diverse in business size, geographic location and ethnic background. A recent report to AUSVEG on the vegetable industry demographics has documented the high proportion of growers whose primary language is not English (Table 3). Many of these growers would be considered smaller growers or 'market gardeners' and are usually found in the peri-urban areas around the capital cities.

Table 3 Estimates of vegetable grower's primary language by state

	Total growers[1]	English as predominant language	Language Other than English	LOTE growers as % of total
New South Wales	1000	190	810	81%
Victoria	905	855	50	6%
South Australia	1105	475	630	57%
Queensland	1600	1195	405	25%
Western Australia	800	590	210	26%
Northern Territory	60	10	50	83%
TOTAL	**5470**	**3315**	**2155**	**39%**

Source: Vegetable Growers with Language Other than English - a snap shot, October 2005

[1] Estimate based on data supplied by state Vegetable IDOs and AUSVEG

[report available from www.AUSVEG.com.au]

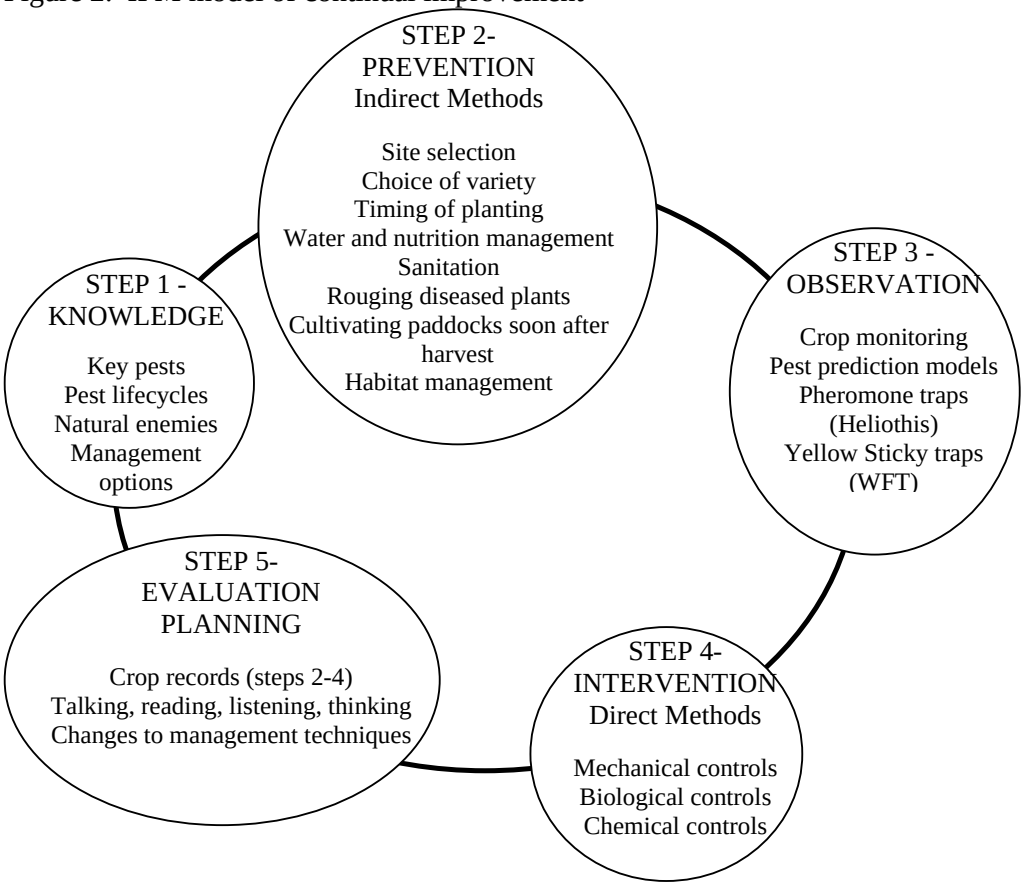
What is IPM?

Integrated Pest Management (IPM) is a term that has many definitions and was originally applied to management of insect pests. A well developed IPM strategy includes all agricultural pests: diseases, weeds, invertebrate (e.g. insects & mites) and vertebrate (e.g. birds, mice, bats) pests. IPM is a strategy to manage pests so that their population numbers are below the point where they are causing unacceptable loss in marketable yield. IPM management strategies use a range of complementary tools and control techniques. IPM considers the production system as a whole and looks at all aspects of the system as potentially impacting on pest populations and where possible manipulating those components to reduce pest populations.

In practice IPM growers fall in a continuum from "Integrated Pesticide Management" to a biointensive IPM. Integrated Pesticide Management involves routine crop monitoring, appropriate timing of pesticide applications, attention to good spray application technique and following pesticide resistance management strategies. A biointensive IPM strategy relies primarily on beneficial organisms to manage pests and when greater pest control is needed interventions chosen are complementary to the survival of beneficials.

IPM is a model of continual improvement (Figure 2) both for IPM research and for adoption. They typically focus initially on management strategies of a single key insect pest, usually after 'conventional' insecticides fail to control the pest adequately. As strategies are developed for the target pest, focus moves to other key or minor pests, diseases and weeds. IPM can become part of a fully integrated farm management system and potentially involve the whole market chain.

Figure 2. IPM model of continual improvement



IPM Research and Adoption in Australia

IPM research usually begins by focusing on a single key pest in a particular commodity. A basic IPM strategy is developed which typically will have a crop monitoring strategy, some narrow spectrum chemical options, some biological options and a few cultural practices to manage the key pest. Often management practices for other pests' conflict with the IPM strategy for the dominant pest so the research effort moves to find more IPM compatible management practices for these other pests. As the IPM strategy for the crop develops effort can then move towards whole farm management and generally encouraging more generalist predators through changes in cultural, chemical and habitat management.

Disease and weed IPM have usually been considered separately and are integrated by the growers rather than the researchers. Historically there have been fewer chemicals available for managing diseases so a lot of seed company research effort has and continues to be directed to breeding for plant disease resistance. Disease IPM heavily relies on resistant varieties and source control i.e. disease-free seed, sanitation and crop rotations. Overall there are fewer chemical control options and preventative or 'protectant' sprays are often needed. Soil and water management, and avoiding plant injury can be very important for fungal and bacterial diseases. Viral disease management involves management of the vector and the source of infection, often surrounding weeds or neighbouring affected crops. More sophisticated fungal disease IPM systems involve disease prediction models, although no models are routinely or widely used in Australia.

Weed IPM is very poorly developed. Herbicides and cultivation are heavily relied upon in vegetable production. Classical biological control for weeds is an IPM strategy that selectively introduces insects that feed on the target weed however it is more suited to perennial systems. IPM options in intensive vegetable production include mulching, various cultivation techniques, weed mapping, rotations and selective spraying. Pest resistance or no adequate chemical options are important drivers in IPM

research, development and adoption and these drivers are probably relatively weak when it comes to investing in weed management strategies.

IPM research is conducted through all the research institutions including: universities, CSIRO, State agricultural departments, and some private companies. State agricultural departments are the main providers. Basic infrastructural funding has come from the research institutions themselves and specific project funds come through grower levies and federal funds managed by the Research and Development Corporations (RDCs) such as the Grains RDC, Grape and Wine RDC, Rural Industries RDC, Cotton RDC, and Horticulture Australia (HAL).

Information from each of the Research Development Corporations was accessed on what specific IPM projects they had funded and lists are attached in Appendices I-V. Final reports from a selection of the vegetable IPM projects are summarised and are available on the supplementary CD.

Learning from IPM industries

IPM Case studies

Case studies were conducted on five commodities which have had a history of IPM research and development. The commodities selected were cotton, citrus, processing tomatoes, sweet corn and brassicas. The cotton industry has invested the most heavily in IPM and is the only industry to successfully integrate non-insect pests. Citrus was one of the earliest commodities to develop and adopt IPM strategies in Australia, and processing tomatoes were one of the first vegetable commodities to develop IPM. Brassicas and sweet corn have had significant investment from the AUSVEG levy in developing national IPM strategies.

In each case study a short summary is provided of the industry, the history of IPM, resources developed and lessons learnt. These case studies are found in Appendices VI-X.

A crisis, in the form of a key pest developing resistance to the insecticides used against it, was the major driver to development of an IPM strategy in all the case studies crops except citrus. The vision of a researcher, consultant and grower was the initial motivation to develop citrus IPM and its adoption throughout the industry was based on proven cost savings by using biological control agents instead of frequent insecticide sprays.

In all cases successful IPM involves routine crop monitoring of pests and beneficials, and either access to soft chemistry or biological control agents for control when endemic beneficials are not successfully managing the pest population. In all cases the successful development of IPM has involved a long-term partnership between the industry, consultants and researchers. Successful IPM recommendations have been based on rigorous science hence IPM development has required long-term funding of IPM research.

Typically IPM development has initially focused on a primary key pest and the removal of broad-spectrum insecticides from the management strategy has then required development of IPM strategies for secondary and minor or infrequent pests. In the case of processing tomatoes where research funding ceased after developing an IPM strategy for the key pest, growers follow an ‘integrated pesticide management’ strategy. This is necessary because all secondary or minor pests are managed using broad spectrum insecticides and hence substantially removing beneficial insects from the system. Regional differences in pest complexes have required regionally different management strategies although all using the same IPM approach. Regional differences are not significant in processing tomatoes where the industry is localised in one region.

Adoption of IPM strategies has been most successful where there have been commercial demonstrations. Regular, timely, well substantiated and printed information was considered necessary for successful IPM adoption. In many industries regular group meetings or industry conferences/workshops are also considered important for developing and maintaining expertise and interest in IPM (cotton, citrus, processing tomatoes).

Each industry has particular characteristics in its IPM strategy that reflects differences between industries, for example cotton has now integrated disease and weed management into its IPM strategy

and has expanded its focus to integrated crop management encompassing community and environmental considerations. Citrus IPM has been encouraged by OH&S requirements and consumer pressure for reduced pesticide use.

The most significant barriers to IPM adoption cited are the availability of crop consultants (citrus, processing tomatoes, sweet corn and brassicas), cost of new chemistry or biological control agents in conjunction with reduced returns on produce (citrus, sweet corn, and processing tomatoes), and increased cosmetic fruit standards (citrus).

IPM development

The IPM programs for each of the case study crops have followed a similar progression: initial work is usually on understanding the key pest or disease problem – biology, populations on growers' properties, seasonal variation, environmental or management factors that impact on the population, including beneficials are investigated. Crop monitoring techniques or protocols and in some cases thresholds are developed in the first phase. Efficacy trials involving new chemistry and biorational products are conducted and then as a number of options become clear 'Best Management Option' trials are conducted. Successful IPM projects involve collaboration between growers, agronomists/consultants and researchers, and ideally the broader industry players. On-farm trials are an important tool for testing strategies under commercial conditions and for communication between the broader project team. Some research station trials are often necessary to gain suitable control over inputs, particularly when management options are negatively effected by the grower's existing practices. Producing pest and/or disease information sheets, field guides and newsletters for growers are usually part of the first phase of IPM development in a crop. Other areas of investigation usually involve spray application techniques, pest/disease source, beneficials, and cultural practices.

Once a basic IPM strategy is in place, often in only a few locations, then a second or follow-on phase of IPM development commences. This phase involves testing/modifying the IPM program for variations in other regions. Usually specific areas of investigation are needed to solve particular regional problems with the key pest and work usually needs to start on secondary pests, pests that had previously been controlled by use of broad-spectrum insecticides intended for the key pest. Use of beneficials will often become more important in this phase as the IPM strategy reduces reliance on the broad-spectrum insecticides. Methods to enhance beneficial population or reduce source populations of pest or diseases are then investigated. This approach moves into landscape management and requires more integration between all aspects of the crop and farm management.

The follow-on phase can continue on indefinitely as new pests and diseases enter the system, market requirements change, new options emerge and understanding of the impact of particular practices have on either the pests/diseases or their beneficials. The cotton industry has invested more heavily into IPM than any other Australian commodity and they have broadened their perspective to include wider community and environmental needs whilst still investing significantly on developing pest thresholds, conducting efficacy studies, studies into the ecology and population dynamics of pests and beneficials, studies into the impact of pesticides on beneficials, developing tools to aid IPM decisions and IPM training.

IPM Surveys

As part of the IPM Stocktake key informants were invited to answer a web-based survey. The informants were researchers with many years work in IPM development, extension specialists involved in IPM implementation, consultants offering IPM services and IPM growers. Although the survey was trying to target key informants from industries with successful IPM, including non-vegetable industries, the majority of the 52 respondents referred to vegetable industries. The non-vegetable industries represented included cotton, fruit crops, field crops, summer grains, ornamentals and wine grapes. Eighteen of the respondents referred to brassicas as their successful IPM industry, 5 to tomatoes, 4 to cotton, 3 to ornamentals and the remaining industries were represented by 1 or 2 respondents. Of the 52 key informants, 26 were researchers, 10 IPM consultants or agronomists, 6 were growers 5 extension, and 3 Industry Development Officers. The full survey report and the survey questions are on the supplementary CD. A supplementary telephone survey specifically targeting 20 IPM consultants was conducted by Virginia Brunton as part of the Lettuce IPM (VG05043) project. The survey report and the survey questions are on the supplementary CD.

Conclusions from the On-line IPM Survey

Respondents were asked check boxes of attributes, IPM drivers or barriers and IPM tools of the successful IPM industry they were responding for. The most common have been listed and specific differences with particular industries noted.

The attributes of successful IPM industries most commonly noted were that *growers work together* and are *generally well educated*, and in most cases the *industries are competitive*. Cotton has one of most successful IPM strategies and is characterised by *growers working together*, *being well educated*, but having an *industry that is cohesive* and *culturally homogenous*.

Current 'Best Practice IPM' is *routine crop monitoring*, *using soft chemistry* and including some *monitoring of beneficial insects*. Cotton & greenhouse ornamentals have widespread adoption of best practice IPM but most other industries with successful IPM have pockets of growers using IPM. In the brassica industry *monitoring* and *spraying* is still the dominant practice. Tomato, brassica & sweet corn industries have some IPM practices widely adopted.

IPM Adoption is supported most by *availability of skilled consultants* and *crisis*; whereas *ideological reasons*, *QA* and *market push* were not considered important at all. *IPM support groups* and having *an IPM culture* were also important supports of adoption of IPM. In brassicas *regulation* and *QA* are also considered important drivers.

That *current control practices are adequate* is the major barrier to IPM adoption. *Lack of available IPM consultants*, *too few soft options* and *market requirements* are also important barriers. Another important barrier is that *IPM adoption is seen as too complicated or risky* and *there is no perceived advantage*. Brassica respondents considered *unsupportive consultants* a major barrier to IPM adoption.

The most important IPM tools are *new softer chemistry*, the *availability of biologicals* and *crop monitoring protocols*. *IPM guidelines, endemic beneficials, training courses, water & nutrition management, post-harvest cultivation* and *best-bet thresholds* were all also considered to be important IPM tools. *Experimentally derived thresholds, tolerant varieties, weed management within and around crops*, and *crop rotation* were considered somewhat important. Whereas *inundative releases, cover crops, CD roms*, and *web sites* were not considered important. *Rouging diseased crops* and *prediction models* had variable responses, and *newsletters* and *Ute/field guides* were largely considered "neutral".

All the important tools were used by more than 50% of industry. *New chemistry* was by far the most widely used followed by *weed management within crop, water management, biological insecticides, nutritional management, scouting* and *crop rotations*. *Training courses* is the only tool deemed important that was not rated as being used by many growers.

Conclusions from the IPM Consultant Survey

The survey of consultants that work with clients growing lettuce has demonstrated that these particular consultants generally have a well developed skill set. They report high levels of confidence in providing advice on general agronomic and pest management practices, but lack confidence in providing advice on biocontrol strategies. They have a sound understanding of the concept and principles of IPM but lack detailed knowledge. They profess to be experts on pest and disease recognition and have good access to support services to back up diagnoses. They have high levels of confidence in crop monitoring.

In general the consultants suggest that farmer understanding and acceptance of IPM and the complexity of IPM limit the adoption and adoption is improved by publicised commercial successes and by 'outside' influences (lack of available chemicals, resistance crises).

Several options for improving support of IPM were identified by consultants. The main suggestion was education or training. Improving the knowledge and awareness of IPM amongst growers was seen to make the job of the consultant easier. The consultants would prefer to focus on the details of the IPM strategy with the grower rather than having to educate the grower on the IPM concept. The consultants identified the supermarkets' demands for completely insect free produce as a major barrier to IPM adoption. They suggested IPM education for buyers and consumers as a possible solution and that if there is a general understanding and acceptance of IPM amongst growers and their customers, adoption of IPM could be improved.

Consultants also identified their own training needs and made suggestions including (consultant only) workshops and resources that would assist them to improve IPM consultancy services they offered. Calls for technical support included: more information about softer or biorational pesticides and their interaction with beneficials, and back up support in identification and problem solving. Consultants were suggesting that there were conflicting and competing messages are being delivered on and about IPM and that better networking could improve confidence in IPM as a sound means of pest management.

A general impression gained from the survey was that IPM messages were considered an important part of current and future of their consultancy services but that they require greater surety about IPM implementation.

Summary of lessons learnt, key tools or approaches for IPM implementation

Integrated Pest Management is not a single defined end-point, it is a strategy. Given the 'conventional' pest/disease management strategy has been dominated by routine applications of broad-spectrum chemicals developing an IPM strategy for particular commodities has also been a strategy to transition growers/agronomists to be more knowledge based and drawing on a larger range of tools. The ultimate IPM strategy requires few chemical interventions but lots of monitoring and manipulating the cropping/farm environment to reduce sources of pests or diseases and increase sources of beneficials.

Drawing from recommendations from previous IPM projects, the IPM case studies presented earlier, the key informant or crop consultant surveys and the summaries from the IPM meetings held in 2005/6 (available on the supplementary CD) some key generalisations hold:

Successful IPM projects include:

- ✓ Unsprayed plantings/plots
- ✓ Collaborative research – multidisciplinary
- ✓ Participative – involving range of stakeholders
- ✓ On-farm trials/demonstrations – proof of concept
- ✓ On-going info. – always evolving

Drivers for IPM include:

- ✓ Crisis – often chemical resistance and/or new major pest/disease, loss of chemical options
- ✓ Successful commercial IPM demonstrations
- ✓ Positive IPM environment

Barriers to IPM include:

- ✓ Few IPM consultants – for routine crop monitoring and giving specific week to week recommendations
- ✓ Few available soft options and biologicals
- ✓ Market requirements for blemish/insect free produce
- ✓ Poor understanding of IPM
- ✓ Active undermining of IPM, bad news travels faster than good news

Important Tools for IPM include:

- ✓ Soft chemistry & biologicals
- ✓ Crop monitoring protocols
- ✓ IPM guidelines
- ✓ Endemic beneficials
- ✓ Training courses
- ✓ Water & nutrition management
- ✓ Post-harvest cultivation
- ✓ Best-bet thresholds

Training in IPM for growers and consultants was considered important but lacking. Information tools such as field guides and CDs don't make for adoption but they are tools to assist those already wanting to adopt.

Applying the lessons to 10 selected vegetable crops

Given limited funding and professional resources to develop IPM, it is unrealistic to expect that all vegetable crops could be individually funded with long-term IPM projects. One method this project proposed was to gather a group of IPM professionals into a workshop, provide some supporting information and ask the group to define a 'best-bet' IPM strategy. The group was also asked to identify an improved IPM strategy that could be possible with a small investment.

Method

The method used was to prepare lists of pests, diseases and registered chemical options from the InfoPest Data base. Crop production areas were taken from the HAL web site. Lists were also prepared of:

1. Fungal diseases, their hosts, alternative crop hosts, and mode of transmission
2. Chemical registrations for fungal diseases
3. Transmission, alternative hosts and control of bacterial diseases
4. Transmission and alternative hosts of viral diseases
5. Nematodes and other disorders mode of transmission
6. Insecticides of low to moderate toxicity to beneficials
7. New chemistry insecticides, registrations, chemical group, target pests
8. Regional importance table of pest and diseases for each selected crop
9. Available resistant varieties for selected crops
10. IPM resources i.e. field guides, fact sheets, CD roms, books, posters etc.

IPM information guides, pest or disease fact sheets and field identification guides were also available for reference.

The workshop group was divided into smaller groups to cover all 10 crops in two three hour sessions. Each group consisted of at least one entomologist, one pathologist, one extension specialist and some groups had a grower or commercial consultant. Each group worked with the available information and constructed a table of key pests and diseases and considered the following areas:

Diagnosis/detection	Pesticide lists	Newsletters
Monitoring	Other Controls	Prediction models
Thresholds	Training	IRM
Beneficials	Fact sheets	R&D Gaps
Biologicals	Field guides	
Cultural controls	Information guides	

The workshop table was subsequently cross checked with written materials and some additions or subtractions were made based on the regional importance of pests and diseases. Pests or diseases were included only if they had a 'Major' impact and were 'Regular' in 2 or more growing areas. The growing regions for each crop were initially taken from the crop summaries from the HAL web site. These were then modified based on contact with 'experts' in each state or region. An expert is defined as a vegetable entomologist, pathologist, industry development officer, agronomist and/or grower. Subsequent to the workshop the gaps in the regional importance of the pests and diseases were partially filled in via direct contact with local experts. Some gaps have not been filled.

The workshop materials are available on the supplementary CD.

Results

Perhaps not surprisingly some pest groups or diseases are major problems in many of the crops. Aphids were classed as a major pest in 7 of the 10 nominated crops, aphid vectored viruses were nominated as a major problem in 6 of the 10 crops, two spotted mites, thrips (particularly Western Flower thrips) and powdery mildew are major pests or diseases in half the crops, and whitefly, sclerotinia and damping off are all major pests or diseases in 4 of the 10 selected crops.

Basic IPM practices

The following elements are basic to an IPM strategy that all field grown crops more or less follow depending on the relative importance of the major pest and disease groups:

Basic disease management:

1. Select resistant varieties
2. Source disease-free seed
3. Heat treat seed if bacterial and fungal diseases a major problem
4. Avoid double cropping or cropping after crops in same family
5. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
6. Chip diseased plants
7. Good sanitation particularly in presence of bacterial diseases
8. Manage virus vectors when virus is present in crop or neighbouring area
9. Manage weeds within and in surrounding crops particularly those that host diseases that affect your crop
10. Minimise mechanical damage of growing plants, and of harvested produce
11. Ensure good sanitation practices of any washing process
12. Harvesting crops in cooler conditions and rapid post harvest cooling will minimise post-harvest breakdown
13. Plough in crop residues soon after harvest

Basic insect management:

1. Where possible select insect resistant varieties
2. If planting seedlings use seedlings preferably from greenhouses that have good insect proof netting and excellent sanitation practices.
3. Pre monitor soil if soil pests are typically a problem or on new ground.
4. Bare fallows prior to planting can often reduce soil pest problems. Baits and border spraying can also help with some soil pests.
5. Avoid new plantings next to crops about to be harvested
6. Consecutive plantings can assist with movement of beneficials but where insect transmitted viruses are a significant problem then they may be undesirable.
7. Be aware of where the major pests may be coming from and where the pressure from these pests is greatest or the crop most vulnerable.
8. Plantings of cereals adjacent to crops where aphids are typically a major problem can assist in building beneficial numbers without providing a pest or disease reservoir
9. Use pheromone traps to monitor for flights of the major pests which have pheromones available (e.g *Helicoverpa armigera*, *H. punctigera*, Diamond back moth)
10. Use sticky traps to monitor thrips and whitefly in covered cropping systems and can be assistance in field systems particularly when trying to understand whether pests are migrating in from particular edges.
11. Monitor crops on weekly basis – Bug vac, visual inspection, pheromone and sticky traps
12. Monitor and record numbers of pests, beneficials and damage. Compare numbers from previous weeks and crops.

13. Decisions to apply pesticides need to consider whether they will be effective, their cost, timing of application, impact of beneficials and potential to induce further pest problems and potential for residues.
14. Weed management in and around crops can reduce pest harbours, similarly cultivating crops soon after harvest will reduce pest carry over.

Each crop has its' own suite of pests and diseases and that the relative importance of these will vary between regions. Hence the importance of individual growers and their consultants or advisors to choose the particular management strategies that assist them to reduce the carry over of pests and diseases between crops and seasons, and to increase the activity of beneficials. Unfortunately some of the activities that reduce pest or disease carryover will also reduce beneficials the relative importance of each has to be based on the relative seriousness of the damage caused by the pest and diseases, and what other control options are available.

Potential IPM

The areas of work that would most quickly and easily assist growers of these crops include getting permits for use for insecticides and fungicides that have registrations in other crops but are not currently permitted for these crops.

A second area of great promise for insect pest management is a number of biological insecticides and new chemistry that are being trialled for a range of sap suckers and caterpillars. If these trials demonstrate their effectiveness it is recommended that permits be sought to cover crops that have the target insect as major pests.

Prediction models, such as TOMCAST that use prevailing weather conditions to predict infection periods for Downy mildew in tomatoes could be of great assistance in disease management of some foliar diseases. An assessment of the costs and benefits of using these models more broadly is recommended.

Priority areas for general IPM research

Each working group indicated areas of research that would have benefit across many or most field (and greenhouse) vegetable crops, including:

1. Status of fungicide efficacy and resistance for the key diseases, a resistance strategy where loss of efficacy is suspected and permits to give access to new chemistry. A cross industry fungicide management strategy needs to be supported.
2. Insecticide and fungicide resistance management strategies should be integrated into regional or area-wide strategies where possible.
3. IPM requires good knowledge on the impacts of fungicide and insecticide on beneficials, including sublethal effects.
4. Soil disease management strategies that include prediction modelling, crop rotations, cultural controls and biological options need investigation including understanding of degradation of soil pathogens.
5. In-field disease identification test kits
6. New chemistry, bio-rational and biological control opportunities need to be explored for all pests but are urgent for sucking pests such as Silverleaf whitefly, thrips particularly Western flower thrips, Rutherglen bugs and leafhoppers.
7. Monitoring and prediction guidelines and soft management options for soil pests, including nematodes, weevils, cutworm and wireworm are needed.
8. Clarification of efficacy of petroleum spray oils
9. Potential of trap crops and insectary crops
10. Regional crop loss impacts are not well known or documented making assessment of relative priorities difficult to estimate.
11. Training materials for potential and current IPM service providers, including technical support, better interaction between consultants and researchers

Summaries of growing areas, pests and diseases, regional importance, insecticide and fungicide registrations, resistant varieties, current available IPM, potential IPM and suggested areas for further work for the 10 selected crops are in Appendices XI-XX. The following is a very short summary of the status of IPM in the crop and specific areas that need further work.

Beans

Green beans are primarily grown in Queensland and Tasmania. Bean IPM is being developed via two funded projects, one focusing on insects and the second on diseases. The workshop team identified nine areas that are not currently funded that would assist with development of bean IPM:

1. Registration/permit: Success® & Avatar® for bean pod borer, NPV for Heliothis, Chess® for SLWF
2. Action thresholds/recommendations for key pests
3. Potential to develop of pheromones for Bean pod borer
4. Evaluation of biopesticides for SLW, thrips and leafhoppers
5. Clarify whether observed damage to beans in Tasmania is caused by thrips or wind
6. Need cultural control options for common bacterial blight
7. Work needed on Ashy stem blight across host range and investigating possible cultural and chemical control options
8. Management options for bean stem & root diseases still in progress
9. Field identification guide (funded)

Beetroot

Beetroot for processing is predominantly grown in Queensland with a smaller processor sourcing from NSW. Bunching beetroot and beetroot as babyleaf is grown typically in the peri-urban market gardens or by the larger babyleaf producers. Diseases were the main problem with only the occasional insect related problems. It was recommended that pests or diseases affecting the leaf be considered along with an existing Asian vegetable project (L. Tesoriero NSW DPI). A voluntary contribution agronomy project has recently begun in Queensland however there is no currently or previous IPM related work. The workshop team identified four areas of work that would assist with development of beetroot IPM:

1. Benchmarking current practices and monitoring rejections from processor and from markets if possible
2. Understanding of beneficials in the crop / use of sequential planting- processing and baby leaf
3. Ute guides that cover baby leaf and processing beets incl. symptoms, size scale, weeds
4. Refer beetroot baby leaf to Asian vegetable project (similar pests, beneficials, pesticide requirements (incl. short WHP, training, etc.) for Baby leaf

Capsicum

The bulk of the $64 million (ABS 2001) industry is situated in Queensland. Soft options and beneficial options for caterpillar pests are effective however the management of the sucking and particularly vectoring insects such as Silverleaf whitefly (SLW) and Western Flower thrips (WFT) is not currently effective with soft options. The release of the parasitoid *Eretmocerus* spp. may become quite effective but there is also need for biopesticide or soft chemical options as a back up option. The workshop team identified most of the general areas of work and three specific areas of work that would assist with development of capsicum IPM:

1. Need solanaceous fruit IPM and field guides [insects and natural enemies of capsicums in dry tropics is available]
2. Fruit fly regulatory requirements an issue - Export markets require growers to use dimethoate and/or trichlorfon even when no Queensland fruitfly are present and this disrupts IPM programs.
3. Varietal susceptibility to powdery mildew unknown, and status of fungicide resistance

Carrots

Carrot production is worth $198.5 million [ABS 2002] and grown in all states but primarily in WA and Victoria. Insects are relatively unimportant so no insect related work has been conducted on carrots however a few disease related projects have been supported and a summary of disease recommendations from WA is available as a VegeNote and carrots are covered in the Tasmanian Vegetable IPM guide. The workshop group identified four specific areas of work that would assist with IPM development in carrots.

1. Pirimicarb and pymetrozine for aphid control
2. Spinosad and indoxacarb for cutworm control
3. Nematicides, biological and nematode control strategies
4. Cavity spot management options

Celery

Close to 60% of the $26.1 million [ABS 2002] celery production is grown in Victoria. A celery IPM project covering insects was funded and completed with a VegNote produced. Some celery disease work is still being pursued and as yet no recommendations available. The workshop group identified many of the general recommendations and four specific areas of work that would assist with IPM development in celery.

1. Pesticide permits - spinosad for Thrips, Light Brown Apple moth (LBAM) and Cutworm control; indoxacarb for Heliothis, LBAM and cutworm; pirimicarb and pymetrozine for aphids
2. Investigate whether there is a closely related species to LBAM in some celery crops
3. Need cutworm pheromone lure
4. Ground truth the use of the TOMCAST model for septoria spot in celery.

Chinese Cabbage

Close to 50% of the $7.8 million [ABS 2002] Chinese cabbage industry is based in SA, 25% in Victoria and Tasmania also has significant production. Considerable research into Brassica IPM has been funded and has direct benefit for Chinese cabbage production. In most states the Vegetable Industry Development Officers have included Chinese cabbage growers in their contact lists for Brassica related information, however no specific IPM recommendations have been made for Chinese Cabbage and it is not clear how well known it is to Chinese cabbage growers that Chinese cabbage is perhaps the most susceptible Brassica crop for clubroot. Chinese cabbage is not routinely included in registrations or permits sought for brassicas and so currently has fewer options than other Brassica crops. The workshop group made the following seven recommendations for further work to assist with IPM development in Chinese cabbage:

1. Pesticide permits – NVP for Heliothis, pymetrozine for aphids, fluazinam for clubroot
2. Potential of biopesticides for DBM and aphids
3. Soft options for Rutherglen bug
4. Prediction model for clubroot
5. Better integration between recommendations from insect and disease management (eg Brassica weeds to enhance beneficials vs white blister host)
6. Modification of cultural controls and treatment application recommendations from other brassica work for use in chinese cabbage
7. Role of predators versus parasitoids

Cucumber

Of the $18.5 million [ABS 2002] cucumber industry approximately 40% is situated in NSW and 40% in Queensland, with WA having a small but significant industry. In NSW a significant proportion of the industry is grown in ‘low-tech’ covered cropping situations. Currently significant work on cucumber IPM in covered systems is being funded. Cucumbers have also been included in some previous cucurbit disease work in WA and Queensland. From the IPM workshop the four specific recommendations relate primarily to greenhouse production but are likely to have benefit for field grown cucumbers as well.

1. Pymetrozine for aphid control, pyriproxifen for whitefly
2. Need more biological control agents to cope with range of greenhouse conditions for greenhouse whitefly and thrips
3. Organosilicone wetter has thrips activity and needs a permit for use
4. Agri50E looks promising as thrips control but needs testing for beneficial impact

Pumpkins

Close to 50% of Australia's $47.5 million [ABS 2002] pumpkin production is in Queensland, 25% in NSW, and both WA and Vic have significant pumpkin production. Pumpkins, perhaps more than any other vegetable crop are grown 'opportunistically' by non-vegetable growers. They are considered to be relatively cheap and easy to grow with little specialized equipment being needed. Few IPM recommendations exist for pumpkins. Mostly disease related work has been funded but few practical resources are available for growers or consultants to assist with managing either diseases or pests. The workshop made eight specific pumpkin recommendations:

1. Test efficacy of Bt - coloradensis on leaf feeding beetles, seek permit if effective
2. Access to pymetrozine for aphid control
3. Prediction models for powdery mildew, testing variety susceptibility and fungicide efficacy
4. Effect on sulphur on beneficials
5. Increased options of fungicides for resistance management
6. Ute guide for cucurbits [NB. cucurbits are included in insect pest guide for dry tropics]
7. Management guidelines targeting growers who opportunistically grow pumpkins
8. Recommendations for insectary crops versus virus hosts

Sweet potato

There is no readily available information on the size of the sweet potato industry. The majority of the industry is based in Queensland with some significant plantings in NT and WA. Sweet potatoes are grown commercially in Rockhampton, Bundaberg, Cudgen, Broome and Katherine. Soil diseases are reportedly the most significant problems yet there are no registrations for fungicides in sweet potatoes. There are some registrations or permits for insecticides. A project has begun in Queensland working on soil pest and disease management options. The workshop made five specific recommendations as well as supporting many of the general recommendations reported earlier:

1. Efficacy of commercially available nematodes for wireworm control
2. Efficacy of Bt- coloradensis on sweet potato weevil
3. Pymetrozine for aphid control
4. Test kits for viruses
5. Registrations or permits for insecticides and fungicides to cover pests and diseases including enough options for a resistance management strategy for the major pests.

Zucchinis

Close to 70% of the $22.6 million [ABS 2002] zucchini industry is based in Queensland, 15% is in NSW and 10% in Victoria. As with the other cucurbits, relatively little IPM related information is available for growers or consultants interested in using IPM in managing their pests or diseases. Zucchinis are one of the crops included in the currently funded Sydney Basin virus management extension project. The workshop made three specific recommendations to further IPM in zucchinis:

1. Access to pymetrozine for aphid control
2. Efficacy of biopesticides for aphids and other sap suckers
3. Cucurbit field guide and information guide

The full summary sheets for each crop are in Appendix XI-XX. Workbooks for the regional pest distribution, workshop recommendations, and transmission and alternative crop hosts for viral, bacterial and fungal diseases are on the supplementary CD.

Discussion

As a process, getting 'experts' together and spending two hours to identify the current available IPM strategy and priority areas for further research was flawed. Although everyone involved was working in IPM in some or a number of vegetable crops they did not necessarily have any experience in the focus crop, the information available is scarce and those involved did not feel comfortable making 'best guesses'. Scientists, as most of the experts were, are schooled in making recommendations only where there is supportive evidence and by definition the crops selected had little previous research. The group's best guess of key pests or diseases did not necessarily reflect what was considered key pests and diseases through the regional pest and disease surveys.

The use of chemical registrations as the basis for the pest and disease lists was flawed particularly through the crop pest and disease registrations of older chemistry. Many pests that are not found on

crops had registrations for that crop and many diseases subsequently listed by informants as important do not have any registered control option.

Some of the crops selected did have current or previous IPM related work, although not on a national scale, which went to highlight the need for greater communication within the research community, including within the funding organisations about what work has and is being done. The preparation of the available resources and the response to those that were physically available at the workshop highlighted again the need for better communication between all of us working in vegetable IPM. A great many of the resources that have been produced are hard to find and had only a limited distribution when initially produced. Web based resources are the easiest to find although printed versions are easiest to use.

The general areas recommended for further IPM work were quite consistent in the separate workshops and via the on-line survey. Specific crop recommendations from the workshop would benefit from critical analysis by growers, consultants and other researchers involved with the respective industries. The funding of a separate disease IPM stocktake will address some of these issues.

Greenhouse IPM was not specifically addressed in this project although many of the recommendations and basic IPM practices would apply. The difference between greenhouse and field IPM lie with the greenhouse structure itself. The potential for using insect proof netting and controlling the environment allows for the introduction and maintenance of beneficial organisms to a greater extent than field grown vegetables. Therefore the potential for a biointensive IPM is high in greenhouses. On the otherhand chemicals are slower to breakdown in greenhouse environments so when there is no biological option to manage specific pests and chemical insecticides are used, they can more seriously disrupt the biological contols used for other pests.

Conclusions

Be it from the on-line survey of researchers, consultants and some growers, the IPM case studies, the IPM workshops and general recommendations from IPM projects there is widespread agreement of what are the key tools for IPM, the process of development and the drivers and barriers to adoption. This project has begun the process of reviewing the previous IPM research and looking more strategically at where to invest future IPM research or extension funds.

The extra-ordinary round of funding called in April 2006 and the 2007/8 funding call demonstrated the commitment of the AUSVEG grower committees and Vegetable IAC to a more strategic approach to IPM investment. Interim recommendations arising from the February IPM stocktake workshop were the basis for the seven crop protection priorities areas of the extra-ordinary round and for the insect or general IPM priorities for the 07-08 funding call.

The enthusiasm with which people participated in the workshops and surveys showed a willingness to co-operate to develop better IPM strategies and an eagerness to learn from each other. All vegetable IPM researchers consulted voiced a frustration with the current short-term project focus and concern about the diminishing numbers of researchers funded through the respective state departments of agriculture.

Resources

Part of this project was to collate a list of Australian IPM resources. These include books of pests and diseases of vegetables, information guides, field identification guides, CD roms, posters and fact sheets. The resource list is no doubt incomplete as many resources have small distribution and once projects have finished they are usually not actively marketed. Many are available via the various department of agricultures bookstores however the fact that a publication was published by a particular state department does not mean that it is available through its bookstore. A partial list of IPM resources for other crops in Australia has been produced but there was not time to complete this list let alone collate useful information from the web or other international resources. It was hoped to look critically at the resources and make individual assessments about which might be worthwhile updating or distributing further. The list is in Appendix XXI.

Recommendations to Continue the Review Process

This project was never intended to be the definitive review of Australian vegetable IPM nor a definitive critical review of the lessons to be learnt from other industries. In part the collation of the list of IPM related projects, the resource list, the workshop outcomes and the surveys will greatly assist researchers, consultants and growers interested in IPM to be aware of the scope of work that is being done and to seek more information about projects or resources they may previously been unaware of. There is still a huge job to more actively seek information that could feed into IPM development in Australia. It was hoped to achieve more this past year but a start has been made and the following are recommendations to continue the process.

1 IPM Working Group

Situated under the AUSVEG – HAL vegetable R&D process.

- Annual planning for IPM
- Identifying potential/current pest management crises
- Select crops for pest & disease surveys and strategic planning session
- Select groupings for IPM sector meetings
- Review outcomes and feed into planning processes
- Overview current or proposed projects to improve collaboration between projects or add additional activities to improve overall IPM outcomes.
- Develop IPM project guidelines on HAL site
- A rotating IPM co-ordinator appointed/elected to carry co-ordination for 12 months (some funding to offset time for State funded employees or pay for time of private or 'soft' funded individuals)
- Group consisting of HAL, AUSVEG, DAWA, NSW DPI, QDPIF, SARDI, Tas DPWIE, VIC DPI, ?NT Gov, IPM consultants (2), IPM growers (2). Need to include pathologists, extensionists and entomologists

2 IPM Sector workshops

Broader gathering of people than the IPM working group to discuss vegetable IPM issues.

- Entomology, pathology and IPM stakeholder meetings were useful last year and may be funded as part of existing projects or as individual workshops
- Have defined focus and goal
- Space for discussion
- Have pre-workshop preparation so that the gathering has some practical and tangible outcomes e.g. critical evaluation of some IPM resources, web site development, project development, etc.
- Need to broaden to include market chain
- Need to rotate participants, workshops shouldn't be too big but overtime we need to draw on a range of perspectives within and between sectors
- Biennial may be frequent enough perhaps with the outgoing and current IPM co-ordinators doing workshop organisation

3 IPM Clearing House/Web Hub

IPM information sources are vast and dispersed. This will assist in collating Australian IPM information and links to other international sources

- Needs IPM technical moderator
- Logistical support
- The HAL IPM project list and summaries of the IPM projects should be included.
- The resource list would be enhanced with an image of the cover and perhaps pdf of contents and link if available on web.
- A section for workshop/working group minutes/notes
- Develop an area that includes information on pests, beneficials, diseases & disorders and crop information.
- Develop an IPM tool area that includes information on IPM strategy, crop monitoring; biological control, biopesticides, cultural controls, pesticide application, impact of pesticides on beneficials, and other useful information.

4 IPM Consultants

The stocktake process has highlighted the importance of people with practical IPM experience to work on a day to day basis with growers. In many cases these will need to be independent consultants or agronomists. Very few experienced IPM consultants exist around Australia and the need for giving technical support and training to existing consultants or those interested in offering an IPM service to growers.

The Western Flower thrips projects in QLD, NSW and WA aim to have commercial IPM services available to vegetable growers in the project areas. Two other projects that were funded in the extraordinary funding round are also aimed at supporting IPM consultants, one to establish IPM consultants in Tasmania and the second to develop a network for existing IPM consultants.

- Encourage collaboration with consultants in IPM projects

5 General IPM information Toolbox

- Develop with multiple users in mind - incl. trainers, consultants, growers, extension staff, resellers, farm hands, LOTE speakers
- Develop with multiple levels of information requirements – generic to specific
- Develop with multiple formats in mind – potential for print, electronic, web, CD or DVD, or PDA format
- Some generic IPM information
- Specific pest, beneficial, disease & crop disorder information
- Specific crop IPM recommendations where possible
- Resource list & guide
- Series of training workshops in major cropping areas for growers and for consultants

6 Active surveillance

The difficulty in getting regional pest and disease information for the 10 selected crops highlighted the lack of data collection on pests and diseases. This information is useful for developing IPM strategies, making strategic decisions about chemical access and it has a strong biosecurity benefit. State Departments historically collected data independently but now tend to only collect data as part of funded projects

6.1 Recommend some funding be allocated for active surveillance of pests and diseases of vegetable crops nationally including crop loss evaluation
6.2 Consult with state departments to develop a joint strategy that can satisfy biosecurity and crop protection needs
6.3 At minimum crop focused research projects need to include pest and disease surveys in all major growing areas of the target crop
6.4 Potential to work collaboratively with crop consultants to gather information

7 Crop/Product Group Strategic Planning

7.1 Gap analysis and strategic planning –at least every 4 years during the Nov- May period (prior to annual AUSVEG/HAL priorities being set)
7.2 Include collation of survey work and summary of completed and current projects

8 Access to soft chemistry and biopesticides

As old chemistry is removed all growers are looking to new options and IPM growers need options that do not also diminish their key beneficials so on-going work needs to continue to test efficacy and then get registrations or permits for all vegetable crops that need control of the target pests.

8.1 Minor use permits & strategic planning (existing project)
8.2 Efficacy work in major crops priority to sucking insects - Silverleaf whitefly, thrips particularly Western flower thrips, Rutherglen bugs and leafhoppers. (partially covered by extraordinary round project)
8.3 Beneficial testing to define relative softness (project funded in the extraordinary round)
8.4 Clarification of efficacy of petroleum spray oils in vegetables

9 Beneficials

Beneficial organisms are those that predate or parasitize insect pests or are antagonistic to plant fungal pathogens. They can naturally colonise fields if toxic pesticides are reduced or removed or they can be introduced from other sources. They are integral to an IPM strategy but typically cannot control all pests to non-damaging levels hence the need for compatible chemical or biopesticide options.

9.1 Evaluate the role of insectary crops to increase beneficial numbers
9.2 Surveys for predators or parasitoids for key pests with priority to Western Flower thrips

10 Integrated soil management strategies

10.1 for soil pests including monitoring, prediction strategies and soft management options for nematodes, weevils, cutworm, wireworm and other soil pests.
10.2 For soil diseases including prediction modelling, crop rotations, cultural controls, biological options with work on understanding of degradation of soil pathogens.

11 Integrated Disease Management

11.1 Integrated Disease Management stocktake (project funded in the extraordinary round)
11.2 Test kits for disease identification in-field
11.3 Evaluation of disease prediction models and cost-benefit of modifying for Australian conditions and disease variants
11.4 Status of fungicide efficacy and resistance for the key diseases, a resistance strategy where loss of efficacy is suspected and permits to give access to new chemistry. A cross industry fungicide management strategy needs to be supported.

12 Cultural controls

12.1 Revegetation by design – further work on developing suitable plants for planting around greenhouses, channel banks and tree breaks that decrease pest and disease refuge and enhance beneficials –2006-2009 (SA and QLD)

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We would like to thank all the people who contributed their time and experience in attending the workshops, commenting on the surveys and tables, in responding to the surveys and those who took on collating information:

Citrus case study: Andrew Creek (NSW DPI)
Sweet corn case study: Peter Deuter and Bronwyn Walsh
Brassica case study: Djana Jevremov (SARDI)

Web-based IPM Stocktake Survey: hosted and analysed by J&R Coutts
IPM Consultant Survey: Virginia Brunton (NSW DPI)

Collation of pest & disease regional distribution – assistance by Scott Munro (NSW DPI)
Collation of crop pest & disease lists, pesticide registrations and crop management information – assistance by Kathryn Bechaz and Lauren Poulsen

Appendices

I. Horticulture Australia Vegetable IPM Projects 1996 - 2006

II. COTTON RDC IPM Projects 1992 - 2006

III. Grape and Wine RDC IPM Projects 1989 - 2006

IV. Rural Industries RDC IPM Projects 1999 – 2006

V. Rural Industries RDC IPM Projects 1995 – 2006

VI. IPM in the Australian Cotton Industry

VII. IPM in the Australian Citrus Industry

VIII. IPM in the Australian Processing Tomato Industry

IX. IPM in the Australian Sweet corn Industry

X. IPM in the Australian Brassica Industry

XI. Beans: General Information

XII. Beetroot: General Information

XIII. Carrots: General Information

XIV. Capsicum: General Information

XV. Celery: General Information

XVI. Chinese Cabbage: General Information

XVII. Cucumbers: General Information

XVIII. Pumpkin: General Information

XIX. Sweet Potato: General Information

XX. Zuchinni: General Information

XXI. Australian Vegetable IPM Information Resources

Horticulture Australia Vegetable IPM Projects 1996 - 2006

CODE	DATE	TITLE	FOCUS	RESEARCH TEAM
1. BRASSICA STUDIES				
VG213	-1996	Sustainable Cropping Systems in Brassicas	Various insect pests	QDPI Sue Heisswolf
VG97014	1997 -00	Advancing the integrated management of diamondback moth in Brassica vegetables	DBM	SARDI Greg Baker
VG99006	1999 - 02	Integrated pest management 'Research to Practice' for brassicas	?	DPIVic Anita Chennell
VG00055	-2003	Implementing pest management of diamondback moth	DBM	SARDI Greg Baker
VG03034	2003 -	Control of diamondback moth in brassica vegetables with fungi	DBM	CSIRO Richard Vickers
2. LETTUCE STUDIES				
VG01038	2001 - 04	Improving lettuce insect pest management- Victoria	?	DPI Vic Robert Dimsey
VG98082	1998 - 01	Lettuce - Best management production practice to meet market requirements of consistent product quality and shelf life	?	DPI Vic Robert Dimsey
VG04067	2004 - 05	Integrating lettuce aphid into IPM for lettuce- a commercial trial	CLA	DPIWE Tas Lionel Hill
VG033	Sep 1992	Reduced pesticide use on lettuce	Various insect pests	SARDI Trevor Wicks
VG339	Aug 1994	Investigations of vectors and alternate hosts of tomato spotted wilt virus in lettuce crops	Thrips and TSWV	DPIWE Tas Calum Wilson
VG96007	1996 - 03	Genetic transformation of lettuce for resistance to viruses	?	DPIF Qld Ralf Dietzgen
VG106	Jun 1994	An evaluation of egg parasites for the management of heliothis	Heliothis	DPIF Qld Brad Scholz
VG01028	Oct 2005	Improving lettuce insect pest management- NSW and SE Queensland	Various pests	DPI NSW Sandra McDougall
VG04068	2004 - 05	Generation of efficacy and residue data for Confidor (imidacloprid) in leafy and head lettuce for control of lettuce aphid	CLA	Serve-Ag Research Phillip Frost
VG226	Jun 1993	Control of lettuce downy mildew	Downy mildew	SARDI Trevor Wicks
VG327	Jun 1996	Cause and control of new lettuce diseases	Various diseases	DPIF Qld Rob O'Brien
VG511	Jun 1997	Molecular identification of strains of Sclerotinia species	Sclerotinia	UQ Elizabeth Aitken
VG99015	1999 - 03	Improvement in lettuce quality by reduction in losses due to soil borne diseases	Various diseases	Dep Ag WA Dominie Wright
VG00048	2000 - 04	Development of biological controls for Sclerotinia diseases of horticultural crops in Australia and New Zealand	Sclerotinia	DPI Vic Ian Porter
VG03003	2003 - 05	Scoping study of the management of varnish spot in field and hydroponic lettuce	Varnish spot	DPI NSW Andrew Watson
VG04012	2004 - 07	Effective management of root diseases in hydroponic lettuce	Various diseases	DPI NSW Len Tesoriero
VG02062	2002 - 04	Weed Management in Lettuce	Weeds	Serve-Ag Research Phillip Frost

CODE	DATE	TITLE	FOCUS	RESEARCH TEAM

3. CAPSICUM STUDIES

VG98004	1998 -	Investigation of capsicum genetic resistance to tomato spotted wilt virus, tospovirus serotype IV and bacterial spot disease	TSWV CCV Bacterial Spot	QDPI Bowen DJ McGrath

4. POTATO and SWEET POTATO STUDIES

PT538		Comparative benefit cost of IPM and conventional pest management in potatoes	Various insect pests	Scholefield Robinson, Pamela Strange
PT656		National IPM program for potato pests	Various insect pests	IPM Technologies: Paul Horne
VG98002	1998 -	Development of strategies to control sweet potato weevil	Sweet potato weevil	QDPI:Bruno Pinese

5. SWEET CORN STUDIES

VG97036	1997 - 02	Insect Pest Management in Sweet Corn	Heliothis	QDPI: Peter Deuter
VG97040	1997 - 00	Developing Trichogramma wasps for use in integrated pest management programs of brassica and sweet corn	Heliothis	BioResources: Richard Llewellyn

6. TOMATO STUDIES (FRESH AND PROCESSING)

VG98135	1998 -	Evaluating the impact of R&D on integrated pest management in the processing and fresh tomato industries	insect pests + disease	Harley Juffs and Associates Pty Ltd
VG98150	1998 -	Identifying the Integrated Pest Management (IPM) needs of the fresh market tomato industry in northern Vic	insect pests + disease	?
TM208	-1999	Evaluation of the role of Thimet in integrated pest management for processing tomatoes	Establishment pests	University of Sydney: S.A. Lane
TM95001	1995 ?	Advanced integrated pest management in processing tomatoes (cont'd TM501)	insect pests + disease	DPI Vic: Jane Moran & Mark Smith
TM501	-2001	Advanced integrated pest management in processing tomatoes	insect pests + disease	DPI Vic: Jane Moran & Mark Smith
TM97004	1997 -	IPM in tomatoes - from research to practice	insect pests + disease	DPI Vic: Jean Bently
TM98009	1998 - 01	Integrated Pest Management (IPM) for processing tomatoes	insect pests + disease	DPI Vic: Jane Moran

CODE	DATE	TITLE	FOCUS	RESEARCH TEAM
7. COMBINED VEGETABLE CROP STUDIES (CAPSICUM, TOMATO, CUCURBITS)				
VG020	c1991	Pest management in northern Queensland vegetables	Various insect pests	QDPI: Iain Kay
VG034		Implementation of an IPM pilot program for the fruit & vegetable industries in the Bundaberg district	Leaf miner (Potato tuber moth)	Crop Tech: John Hall
VG424		Integrated pest management in vegetable crops grown in the dry tropics of North Queensland	Various insect pests	QDPI: John Brown
VG412		Strategic use of pesticides as part of Integrated Pest Management programs for vegetables	Various insect pests	Crop Tech: John Harden & John Hall
HG99034	1999 -	Development and implementation of pest management strategies for fruit and vegetable industries in Queensland	Various insect pests ?	Growcom: Richard Ross
VX99035	1999 - 03	Heliothis and fruit fly integrated pest management strategies for tomato, vegetable and melon crops	Heliothis Fruit fly	QDPI: Iain Kay
VG00026	2000 -	Development and implementation of integrated pest management systems in eggplant and capsicum	Various insect pests	QDPI: John Brown
VG00048	2000 -	Development of biological controls for Sclerotinia diseases of horticultural crops in Australasia	Sclerotinia	DPI Vic: Ian Porter
VG01069	2001 -	Molecular ecology of pest thrips	Thrips	CSIRO: Paul De Barro
VX02016	2002 - 05	Improved Management Strategies for Silverleaf Whitefly in Vegetables	SLWF	CSIRO: Paul De Barro
VX03011	2003 - 04	Feasibility of mating disruption for heliothis species in tomatoes and capsicums	Heliothis	University of New England: David Britton & Peter Gregg
8. VARIOUS SPECIFIC VEGETABLE CROP STUDIES				
VG214	?	Integrated pest management on beans	Various insect pests	QDPI: John Brown
VG96014	1996 ?	Management of pest constraints to quality and production of melons (cont'd VG614)	Various insect pests	QDPI: John Brown
VG99070	1999 ?	Development of an integrated pest management program in celery	Various insect pests	IPM Technologies: Paul Horne
VG00084	2000 -	Improving the reliability and consistency of processing beetroot production	Various diseases	QDPI: Heidi L. Martin
VG00031	2000 - 04	Management of downy mildew disease of pea crops and its possible resistance to metalaxyl	Downy mildew	Serve-Ag Research: Hoong Pung
VG00034	2000 -	Weed management in capsicums and chillis	Weeds	Serve-Ag Research: Phillip Frost
VG01066	2001 - 04	Weed management in carrots	Weeds	Serve-Ag Research: Phillip Frost
VG03057	2003 -	Scoping study on the importance of virus diseases in Australian vegetable cucurbit crops	Various viruses	Dep Ag WA: Brenda Coutts

CODE	DATE	TITLE	FOCUS	RESEARCH TEAM
9. GENERIC VEGETABLE/IPM STUDIES				
HG96011	1996 - 00	Extending petroleum spray oil based integrated pest management for horticulture	Various pests	UWS: GAC Beattie
VG97050	1997 - 00	Biofumigation - bioactive Brassica rotations for IPM of soil borne pests and diseases	Soil borne pests and disease	CSIRO: John Matthiessen
VG98006	1998 -	Developing an IPM strategy to reduce tomato spotted wilt	TSWV	
NY99044	1999 -	Biological control of phytophthora, pythium and sciarid fly	Phytophthora, pythium and sciarid	
HG00020	2000 - 04	Insecticide screen development for sucking pests of Australian horticulture	Various pests	CSIRO: Peter East
VG00066	2000 -	Improvements to biological control systems and development of biorational chemicals for integrated pest management of greenhouse vegetables	Various pests	DPI NSW: Stephen Goodwin
VG01097	2001 -	Suppressive soils for biological control of root-knot nematodes on vegetable crops	Nematodes	Biological Crop Protection: Graham Stirling
VX01006	2001 -	Developing cost effective UV protection of biological pesticides	Various pests	University of Sydney: Brian Hawkett
10. EXTENSION PROJECTS				
HG97017	1997 -	Development of a national IPM program in greenhouse/protected crops	Various insect pests	DPI NSW: Stephen Goodwin
VG98048 Levy +VC	1998 - 02	Adapting to change: enhancing change skills through collaboratively developing an integrated pest & disease management strategy for lettuce	Various insect pest and disease	DPI NSW: Sandra McDougall
VG99002	1999 - 04	Organic production systems - technology transfer	Various pests, diseases and weeds	DPIWE Tasmania: Felicity Wardlaw
VG00081	2000 -	Development and extension of improved horticultural practices to increase profitability in the greenhouse cucumber industry	Various pests and diseases	DPI NSW: Leigh James
VG00078	2000 - 03	Western flower thrips : industry communication and development of training package	WFT and TSWV	DPI Vic: Alison Medhurst
VG00085	2000 - 02	Western flower thrips management strategy - Information delivery pilot project	WFT and TSWV	SARDI: Tony Burfield
VG02040	2002 - 05	Regional strategies in IPM adoption	Various pests and TSWV	SARDI: Tony Burfield

COTTON RDC IPM Projects 1992 - 2006

Web link used to extract project lists: http://www.crdc.com.au/ > RESEARCH > pdf list of research for this time period

INSECT PEST RELATED

Multiple Pest/IPM

CODE	TITLE	RESEARCH TEAM	DATES
3 DAQ58C	Integrated pest management in raingrown cotton	Mr Craig Murray	1/07/1992 30/06/1996
3 CSP46C	Improved pest management for mites and thrips on cotton	Dr Lewis Wilson	1/07/1993 30/06/1996
A AWA1C	Field evaluation of Ingard cotton varieties and integrated pest management (IPM) systems in the Kimberley	Dr Brian Thistleton	1/08/1996 30/06/1999
A CSP82C	Physiology of crop responses to insect pests	Dr Tom Lei	1/07/1997 30/06/2000
A CSE81C	Research support of trap Cropping Experiments for the Boggabilla Landcare Group	Mr Martin Dillon	19/11/1998 30/06/1999
A CSP103C	Management of early season damage and secondary pests in cotton	Dr Lewis Wilson	1/07/1999 30/06/2002
A DAQ96C	IPM in dryland cotton on the Darling Downs	Dr Brad Scholz	1/07/1999 30/06/2002
A DAN141C	Role of Conventional and Novel Insecticides in Integrated Pest Management in Cotton	Mr Viliami Heimoana	1/07/1999 30/06/2002
3 DAQ111	New biopesticides against emerging sucking pests	Mr Damien Cupitt	1/07/2001 30/06/2005
A CRDC112C	Integrated Pest Management (IPM) survey and Roundup Ready survey	CRDC	1/07/2000 30/09/2001
3 AWA3C	Development of sustainable pest management practices for Bollgard IITM production in the Kimberley	Dr Amanda Annells	1/07/2002 31/12/2003
3 DAN160C	Impact and Role of Novel insecticides in Integrated Pest Management	Mr Viliami Heimoana	1/07/2002 30/09/2005
3 CRDC252	Impact on predation on emerging cotton pests	Dr Mary Whitehouse	1/07/2004 30/06/2005

Resource creation/update

A CRDC88C	IPM Guidelines & Support	CRDC	1/07/1999 30/06/2000

Insecticide Tactics

CODE	TITLE	RESEARCH TEAM	DATES
A UQ23C	Monitoring and evaluation of spray drift mitigation best management practices in the Australian cotton industry	Dr Nicholas Woods	1/07/1997 30/06/1999
A DAQ86C	Improve pesticide application performance	Mr Peter Hughes	1/07/1998 30/06/1999
A DAQ106C	Design and construction of a high clearance multi-treatment spray rig	Dr David Murray	1/07/2000 30/06/2001
A UWS2C	Oil and biological pesticide-based integrated pest management in cotton	Dr Andrew Beattie	1/07/2000 30/06/2001
A UQ31C	The Impact of LDP Spray Application upon the Biological Efficacy of Cotton Insecticides	Dr Jamie Nicholls	1/07/2000 30/09/2002
A CRDC171C	Review of spray application research, development, and extension	Dr Steve Parkin	1/07/2001 30/06/2002

Resource creation/update

A DAN155C	Postgraduate: Brendon Griffiths - Simple field based test kit for pyrethroids	Dr Kate Griffiths	1/07/2001 30/06/2002

Resistance

CODE	TITLE	RESEARCH TEAM	DATES
3 UWS1C	Postgrad: Chris Benson - Biochemistry of host plant resistance	Mr C Benson	1/04/1993 31/12/1996
3 CSE34C	Evaluation of insect pest resistance in Australian cotton	Dr Gary Fitt	1/07/1993 30/06/1996
3 DAN080C	Management of resistance to synthetic insecticides (i)	Dr N Forrester	1/07/1993 30/06/1996
A CSE59C	Evaluation of insect pest resistance in Australian cotton	Dr Gary Fitt	1/07/1996 30/06/1999
A DAN118C	Resistance Management in Australian cotton: Conventional insecticides & transgenic cottons	Dr Johnathon Holloway	1/07/1998 30/06/2001
A CRDC148C	Review of resistance program projects	CRDC	1/07/2001 20/06/2002
A CSE84C	Insect pest resistance and the role of induced responses to damage in Australian cottons	Dr Geoffrey Baker	1/07/1998 30/06/2003
B CSP115C	Targeted expression of genes for manipulation of the systemic acquired resistance responses of cotton for improved tolerance to fungal pathogens	Dr Helen McFadden	1/07/2000 30/06/2003

Beneficial Insects

CODE	TITLE	RESEARCH TEAM	DATES
A CSE51C	The dynamics of beneficial insect communities in cotton agroecosystems and the role of alternative crops in producing natural enemies for cotton	Mr P Walker	1/07/1995 30/06/1998
A DAN98C	Conservation and utilisation of beneficial insects in the cotton agroecosystem for integrated pest management in conventional, transgenic and organic cotton	Dr Robert Mensah	1/07/1995 30/06/1998
A DAN119C	Conservation and utilization of beneficial insects in the cotton agroecosystem for Integrated Pest Management in conventional and transgenic cotton II	Dr Rober Mensah	1/07/1998 30/06/2001
3 UQ29C	Postgraduate: Mark Wade - Biology, ecology and utilisation of the Damsel Bug as a predator in cotton - towards real IPM	Mr Mark Wade	28/02/2000 31/08/2003
A UNE34C	Review of Research into Role of Beneficial Insects in Cotton Farming Systems	Dr Peter Gregg	3/04/2000 30/06/2000
A CRDC153C	The impact of insecticides on beneficials.	CRDC	1/07/2001 30/06/2002
3 CRC40C	The comparison of spider communities in cotton around Australia	Dr Mary Whitehouse	1/03/2002 30/09/2003
3 CRC30C	Postgraduate: Ingrid Rencken - Role of native vegetation in harbouring beneficial insects and reducing insect pest damage in cotton	Ms Ingrid Rencken	1/01/2002 30/06/2006
3 CRC74	Mirid Predation	Dr Mary Whitehouse	1/07/2005 30/06/2007

Resource creation/update

A CRDC150C	Upgrade of "Pest and Beneficials Guide"	CRDC	1/07/2001 30/06/2002

Heliothis: biology

CODE	TITLE	RESEARCH TEAM	DATES
3 CSE28C	Regional validation and implementation of Heliothis population dynamics model	Mr Martin Dillon	1/07/1992 30/06/1996
A CSE45C	Identification and predictive classification of the Australian Heliothine moths	Dr E Nielsen	1/07/1994 30/06/1999
3 CSE58C	Develop a chromosome-level genetic map of Helicoverpa armigera to aid management of Bt resistance	Mr David Heckel	1/07/1996 30/06/1997
A CSE57C	Ecology on minor Lepidopteran pests of cotton and applications of the HEAPS Helicoverpa Population Dynamics Model	Mr Martin Dillon	1/07/1996 30/06/1999
A CSE64C	Ecological aspects of Helicoverpa populations related to the successful deployment of Bt transgenic cottons	Dr Gary Fitt	1/07/1997 30/06/2000
A UQ25C	Population genetics of heliothis migration and recruitment to support a regional management strategy	Mr Glenn Graham	1/07/1998 30/06/1999
A UQ24C	Heliothis movement and pest management: Effects of movements within and between cropping regions	Prof Myron Zalucki	1/07/1998 30/06/2000
A CRC23C	Forecast of spring helicoverpa migration from central Australia	Dr Peter Gregg	1/06/2000 30/06/2000
A CSE90C	Ecological studies of Helicoverpa populations related to the successful implementation of IPM systems based on Bt transgenic cottons	Mr Colin Tann	1/07/2000 30/06/2003
A UQ32C	Population Genetics of Heliothis Migration, Recruitment and Origins	Mr Glenn Graham	1/07/2000 30/06/2003
A UQ30C	Understanding the behaviour of egg laying Helicoverpa moths: New designs for integrated control in cotton	Dr Paul Cunningham	1/08/2000 30/06/2003
3 UQ35C	Population genetics of heliothis migration, recruitment and origins	Dr Kirsten Scott	1/07/2003 30/06/2005
3 CRC72	Ecology of Helicoverpa in relation to transgenic cotton and the efficiency of refuge crops	Dr Geoffrey Baker	1/07/2003 30/06/2006
3 CRC76	Tracking H. armigera migration and the accumulation of insecticide resistance	Dr Kirsten Scott	1/07/2005 30/06/2006

Heliothis: chemical insecticide strategies

CODE	TITLE	RESEARCH TEAM	DATES
3 DAN081C	Management of resistance to chemical insecticides in Helicoverpa armigera (ii) Resistance mechanisms	Dr Robin Gunning	1/07/1993 30/06/1996
A DAN104C	Organophosphate and carbamate resistance management in Helicoverpa armigera	Dr Robin Gunning	1/07/1996 30/06/1999
A DAN105C	Role of conventional insecticides in integrated pest management in cotton	?	1/07/1996 30/06/1999
3 DAN140C	Management of Resistance to Conventional Chemicals in Helicoverpa spp	Dr Robin Gunning	1/07/1999 30/06/2004
A CRDC228C	Insecticide Resistance in Helicoverpa spp and the role of IPM/Area Wide Management in Resistance Management	Dr Louise Rossiter	1/09/2002 30/06/2003
3 DAN173C	Insecticide resistance in Helicoverpa spp and the role of IPM/Area Wide Management in Resistance Management	Dr Louise Rossiter	1/07/2003 30/06/2005
3 DAN178	Insecticide resistance management in Helicoverpa Spp	Dr Robin Gunning	1/07/2004 30/06/2005
3 DAN185	Helicoverpa spp Insecticide Resistance: Monitoring, mechanisms and management	Dr Louise Rossiter	1/07/2005 30/06/2008

Heliothis: non-chemical strategies

CODE	TITLE	RESEARCH TEAM	DATES
3 UNE13C	Assessing the effectiveness of predators of Heliothis spp	Dr Peter Gregg	1/07/1992 30/06/1995
3 CTPM2C	Field assessment of Heliothis Viruses on cotton	Dr R Teakle	1/01/1996 30/06/1996
A CSE73C	Genetics of Bt Resistance in H. armigera: Genetics and mode of action of resistance to Bt toxins in heliothine pests of cotton	Dr Joanne Daly	1/07/1998 30/06/2000
A CSE72C	Resistance to Bt toxins in heliothine pests of cotton	Dr Ray Akhurst	1/07/1998 30/06/2001
A CSE74C	Efficacy of Bt cotton plants and causes of variation in performance	Dr James Ridsdill-Smith	1/07/1998 30/06/2001
A DAQ85C GRDC1C	Regional Management of Heliothis on the Darling Downs	Dr Melina Miles	1/07/1998 30/06/2001
A CSE76C	Augmentation and conservation of Helicoverpa parasitoid populations in cotton	Dr Mary Whitehouse	1/07/1998 30/06/2002
A UQ26C	Ecology of Trichogramma egg parasites in the Ord River Irrigation Area and thier role in cotton IPM	Prof Myron Zalucki	1/07/1999 28/02/2003
A CSE86C	Quantifying behavioural responses of Helicoverpa moths to trap crops for area wide management	Mr Martin Dillon	1/07/1999 30/06/2002
A DAQ97C	Development of trap cropping protocols for heliothis management on cotton in central Queensland	Dr Richard Sequeira	1/07/1999 30/06/2002
A DAQ95C	In-field development of novel options for Helicoverpa control in central Queensland	Dr Paul Grundy	1/09/1999 30/06/2002
A DAN142C	IPM in cotton: Semiochemicals of cotton plant surfaces and pest management - change in focus	Dr Robert Mensah	1/07/1999 30/06/2000

A UNE33C	Postgraduate: David Britton - Studies of slow-release formulations for semiochemicals in cotton pest management	Mr David Britton	1/08/1999 30/09/2002
3 DAQ105C	Improved application and formulation of viral biopesticides against Helicoverpa	Dr Andrew Reeson	1/07/2000 28/02/2005
3 CRC17C	Post Doc: Sarah Mansfield - Enhancing the impact of early season predation on Helicoverpa spp	Dr Sarah Mansfield	16/01/2001 16/01/2004
A CSE95C	Honeybee dissemination of Heliothis NPV onto cotton flowers	Mr Martin Dillon	1/07/2001 30/06/2002
A CSE97C	Selection and field efficacy of improved Helicoverpa NPV insecticides for Australian cotton	Dr Andrew Richards	1/07/2001 30/06/2002
3 CRC36C	Managing Helicoverpa spp on cotton with semio(signalling)- chemicals	Dr Chris Moore	1/07/2001 30/06/2004
3 DAQ116C	Assessment of the potential for resistance to Gemstar	Dr Caroline Hauxwell	1/07/2001 30/06/2004
3 CRDC152C	Dog training for detection of heliothis pupae in cotton fields	Mr Craig Murray	1/07/2001 30/09/2004
3 UNE36C	Postgraduate: Sam Lowor - Pheromones for occasional pests of cotton	Mr Samuel Lowor	1/01/2002 30/06/2004
A DAQ125C	Utilising parasitoids in south Queensland cotton	Dr Brad Scholz	1/07/2002 30/06/2003
A DAN161C	Biochemical mechanisms of resistance to Bacillus thuringiensis endotoxins in Helicoverpa armigera	Dr Robin Gunning	1/07/2002 30/06/2003
3 CSE101C	High level Cry1Aac resistance in H. armigera	Dr Ray Akhurst	1/07/2002 30/06/2004
3 CSE104C	Potential for the evolution of resistance to Bt by Helicoverpa armigera	Dr Rod Mahon	1/07/2002 30/06/2004
3 CSE102C	Monitoring Bt resistance	Dr Sharon Downes	1/07/2002 30/06/2005
3 DAN172C	Biochemical mechanisms of resistance to Bacillus thuringiensis endotoxins in Helicoverpa armigera	Dr Robin Gunning	1/07/2003 30/06/2005
3 CSE108C	Genetics of Bt resistance in H. armigera : Resistance to Cry2Ab	Dr Rod Mahon	1/07/2003 30/06/2006
3 CRC60	Managing Helicoverpa spp on cotton with semiochemicals	Dr Chris Moore	1/07/2004 30/06/2005
3 CSE109	Fitness and mechanism of resistance to Cry2Ab in Helicoverpa armigera	Dr Rod Mahon	1/07/2004 30/06/2007
3 DAQ133	Calibration and application of pupae detection dog	Mr Greg Horrocks	1/11/2004 30/06/2007
3 CRC75	Trichogramma incidence in cotton and grains growing regions of Australia - Consequences for Helicoverpa	Dr Kirsten Scott	1/07/2005 30/06/2006
3 DAN187	Biochemical resistance mechanisms in Helicoverpa to Bacillus thuringiensis delta endotoxins II	Dr Robin Gunning	1/07/2005 30/06/2008

Aphid: biology

CODE	TITLE	RESEARCH TEAM	DATES
3 CSP145C	Improving understanding of the ecology and management of cotton aphid	Dr Lewis Wilson	1/09/2001 30/06/2004

Aphid: chemical insecticide strategies

CODE	TITLE	RESEARCH TEAM	DATES
3 DAN093C	Insecticide resistance in cotton aphid	Dr Grant Herron r	1/03/1995 30/06/1996
A DAN117C	Insecticide resistance in field-collected cotton aphid	Mr Grant Herron	1/07/1997 30/06/1999
A DAN158C	Post Doc: Emma Cottage - Mechanisms of insecticide resistance in the cotton aphid, Aphis Gossypii	Dr Emma Cottage	1/10/2001 15/08/2002
3 CSP147C	Incorporating aphids, insecticides and early season plant compensation in Integrated Pest Management (IPM)	Dr Lewis Wilson	1/07/2002 30/06/2005
3 DAN163C	Insecticide Resistance Management in cotton aphid (Aphis gossypii) and cotton mite (Tetranychus urtice)	Dr Grant Herron	1/07/2002 30/06/2005
3 DAN164C	Mechanisms of insecticide resistance in the cotton aphid, Aphis gossypii	Dr Emma Cottage	1/07/2002 30/06/2005
3 DAN184	Resistance management of aphids and mites in cotton	Dr Grant Herron et	1/07/2005 30/06/2008

Aphid: non-chemical strategies

CODE	TITLE	RESEARCH TEAM	DATES
B ULA5C	Post Doc: Roland Chung - The structure and sites of biochemical action of cotton defensive proteins and secondary metabolites	Mr R Chung	1/04/1995 30/06/1998
A CRDC168C	Survey of aphid management practices 2000/2001	CRDC	1/07/2000 30/09/2001
A DAQ119C	Aphid biocontrol in cotton	Mr Bernard Franzmann	1/07/2001 30/06/2002
3 DAQ121C	Aphid bio-control in cotton	Mr Bernard Franzmann	1/07/2002 30/06/2004
3 CSP165	Aphids - control, ecology and CBT resistance	Dr Lewis Wilson	1/07/2004 30/06/2007
3 DAQ134	Postgraduate: Jamie Hopkinson - Managing cotton aphids with parasitoids	Mr Jamie Hopkinson	1/07/2005 30/06/2008

Bemisia tabaci/SLWF: biology

CODE	TITLE	RESEARCH TEAM	DATES
A DAQ79C	Seasonal phenology, hosts and natural enemies of the silverleaf whitefly in cotton areas of Queensland	Dr. Richard Sequeira	1/07/1996 30/06/1998
A DAQ92C	Postgraduate: David Lea - Risk factors for silverleaf whitefly outbreaks in Cotton	Mr David Lea	1/02/1999 30/06/2002
A DAQ102C	Risk factors for silverleaf whitefly outbreaks in cotton	Mr David Lea	1/07/1999 30/06/2002

Bemisia tabaci/SLWF: chemical insecticide strategies

CODE	TITLE	RESEARCH TEAM	DATES
3 DAN92C	Distribution of, and insecticide resistance in Australian B-type Bemisia Tabaci	Dr Robin Gunning	1/01/1995 30/12/1995
A CSP74C	Management of mites and early season sucking pests on transgenic cotton	Dr Lewis Wilson	1/07/1996 30/06/1999
A DAN106C	Insecticide resistance management in Bemisia tabaci	Dr Robin Gunning	1/07/1996 30/06/2008
A CRDC182C	Silverleaf Whitefly knockdown pesticide screen in cotton - Emerald	Mr Derek Litzow	8/02/2002 30/06/2002

Bemisia tabaci/SLWF:non-chemical strategies

CODE	TITLE	RESEARCH TEAM	DATES
A UNE31C	Postgraduate: Emma Cottage - Management of resistance in Bemisia tabaci to insect growth regulators and juvenile hormone mimics	Dr Emma Cottage	1/02/1998 30/09/2001
A CSE60C	Pre-emptive research into the biology and biological control of Bemisia Tabaci biotype B	Dr Paul De Barro	1/07/1996 30/06/1999
A DAQ118C	Monitoring silverleaf whitefly (SLW) (Bemisia tabaci Type B) in cotton	Mr Bernard Franzmann	1/07/2001 30/06/2002
A CRDC183C	Introduction of the exotic parasitoid, Eretmocerus hayati to improve control of silverleaf whitefly	Dr Paul De Barro	11/02/2002 30/06/2003
3 CSE113	Release and post-release monitoring and follow up release of Eretmocerus hayati in cotton production areas	Dr Paul De Barro	1/07/2005 30/06/2007

Mirids and Bugs

CODE	TITLE	RESEARCH TEAM	DATES
A DAQ72C	Toward sustainable mirid management in cotton	Dr David Murray	1/07/1995 30/06/1998
A DAN114C	Post Doctoral: Mr Moazzem Khan - Ecology and management of Apple Dimpling Bugs on cotton	Dr Moazzem Khan	1/07/1997 30/06/2000
3 DAQ131	Improved understanding of the damage, ecology and management of mirids and stinkbugs in Bollgard II	Dr Moazzem Khan	1/07/2004 30/06/2007
3 CRC111	Postgraduate: James Hereward - Is the source of mirids in cotton derived from local dispersal or long distance migration?	Mr James Hereward	1/03/2006 28/02/2009

DISEASE RELATED

Integrated disease management

CODE	TITLE	RESEARCH TEAM	DATES
3 US17C	Induced resistance to cotton disease as part of integrated pest and disease management	Prof BJ Deverall	1/07/1993 31/12/1996 1/07/1997 30/06/1999
3 US18C	Postgrad: Emma Colson - Induced resistance to cotton diseases as part of integrated pest and disease management	Dr E Colson	1/01/1994 31/12/1996

Fungal

CODE	TITLE	RESEARCH TEAM	DATES
3 US21C	Management of Va Mycorrhizal Fungi for sustainable production of cotton	Mr Peter McGee	1/07/1993 30/06/1996
B DAN96C	Biological control of verticillium wilt and seedling diseases of cotton (II)	Dr Subbu Putcha	1/07/1995 30/06/1998
B DAQ76C	Ecology and management of fusarium wilt in cotton	Dr Joe Kochman	1/07/1996 30/06/1999
B DAQ87C	Adoption of Fusarium wilt management strategies in the cotton industry	Mr Greg Salmond	1/07/1997 30/06/1998
B DAQ99C	Ecology and development of management strategies for fusarium wilt in cotton	Dr Joe Kochman	1/07/1998 30/06/2000
B CRDC127C	Large scale trials for biological control of Fusarium Wilt	Dr Subbu Putcha	1/07/2000 30/06/2001
B CRDC155C	Large scale field trials of biocontrol agents for control of Fusarium Wilt	Mr Dallas Gibb	1/07/2001 30/06/2002
3 DAQ107C	Ecology and development of management strategies for fusarium wilt in ?	Dr Joe Kochman	1/07/2000 30/06/2004
3 DAN176C	Severity factors in Fusarium wilt of cotton	Mr Chris Anderson	1/07/2003 30/06/2006
3 CSP156C	The potential for native Fusarium to give rise to new cotton field pathogens	Dr Bo Wang	1/01/2004 31/12/2006
3 DAQ130	Management of Fusarium wilt of cotton	Dr Joe Kochman	1/07/2004 30/06/2007
3 UQ37	Postgraduate: Jennifer Whan - Investigation of the effects of Silicon application on the resistance of cotton to Fusarium oxysporum fsp vasinfectum	Ms Jennifer Whan	1/07/2005 30/06/2008

Bacterial

CODE	TITLE	RESEARCH TEAM	DATES
3 UNE26C	Postgrad: Therese Honess - Epidemiology of black root rot of cotton	Ms T Honess	1/02/1995 1/02/1996
3 DAN153C	Managing Black Root Rot of Cotton	Dr Om Jhorar	1/07/2001 30/09/2004

Viral

CODE	TITLE	RESEARCH TEAM	DATES
3 CRC78	Postgraduate: Jason Moulynox - Survival of the soil-born fungal pathogen Thielaviopsis basicola in association with cotton and other plants	Mr Jason Moulynox	1/08/2005 31/07/2008

Resource creation/update

CODE	TITLE	RESEARCH TEAM	DATES
B DAN121C	Diseases of Cotton - VI	Dr David Nehl	1/07/1998 30/06/2001
B QUT1C	Review of molecular diagnostic R & D for detecting fusarium wilt in cotton	Prof James Dale	1/07/2000 31/12/2000
B CRDC125C	Fusarium workshop for researchers, growers and consultants	CRDC	1/07/2000 30/06/2001
3 DAN177	Diseases of Cotton VIII	Dr David Nehl	1/07/2004 30/06/2007

WEEDS

Resource creation/update

CODE	TITLE	RESEARCH TEAM	DATES
B DAN97C	Sustainable weed management for cotton on permanent beds	Mr Graham Charles	1/07/1995 30/06/1998
B CRDC167C	Weeds extension material - WeedPAK	Dr Stephen Johnson	1/07/2001 30/06/2002
3 DAN174C	Expanding WEEDpak: developing integrated weed management packages for the cotton farming systems	Mr Graham Charles	1/07/2003 30/06/2006
3 CRC77	Improving management of summer weeds in dryland cropping systems with cotton	Mr Jeff Werth	1/07/2005 30/06/2008

Grains RDC IPM Projects 2001 – 2006

From Annual Reports

INSECT PEST RELATED

Heliothis

CODE	TITLE	DATE
CSE136	Heliothis management for grains - strategic initiative	2001-02
CSE155	Baculovirus biopesticides for heliothis control - CSIRO Entomology Component	2001-02
CSE163	The regional management of Helicoverpa spp. in farming systems in southern NSW and northern Victoria	2001-04
DAQ481	Integrating IPM for heliothis and other major pests of pulses, peanuts and soybeans	2001-02
DAQ521	Development of fungal biopesticides for Helicoverpa management	2001-02
DAQ539	Heliothis management in the south Queensland farming systems	2001-03
UQ118	Baculovirus biopesticides for heliothis control - University of Queensland Component	2001-02
UQ140	Population genetics of heliothis migration, recruitment and origins	2001-03
DAW513	Management of native budworm in chickpeas, other new pulse crops and canola June	2001-02
UQ00016	The biological characterisation of ascovirus as a potential biological control for Helicoverpa	2002-04
UQ00029	Population genetics of Heliothis migration, recruitment and origins	2003-05
DAN00095	Helicoverpa spp. insecticide resistance—monitoring, mechanisms and management	2005-06
UQ00029	Population Genetics of Heliothis Migration, Recruitment and Origins	2005-06
UQ00036	Trichogramma incidence in grains and cotton growing regions of Australia—consequences for Helicoverpa management	2005-06

DBM

UMO00002	Source and resistance status of outbreaks of populations of Diamondback moth in Western Australia	2002-05
UWA00041	Biology of diamondback moth (DBM) in Western Australia Feasibility study to evaluate potential biocontrol agents (parasitic wasps) for sustainable management of diamondback moth (DBM) in canola	2002-06
DAW00041	Improving the management of diamondback moth (Plutella xylostella) in canola in the western region	2003-06
DAW00132	Improving the management of diamondback moth (Plutella xylostella) in canola in the western region (Phase 2? – see previous year)	2005-06

Aphids

CSE179	Insecticide resistance and sustainable management of aphids	2001-04
DAW609	Management of cereal aphids and BYDV in different climatic zones	2001-03
UWA290	Forecasting and decision support for aphid and virus control in crops and medic pastures	2002-03
CSE00027	Insecticide resistance and sustainable management of aphids	2004-06
NPB00001	Evolution of Russian wheat aphid virulence and resistance sustainability	2005-06

Mites

ULA45	Understanding and managing extreme variability in earth mite populations in rotational cropping systems	2001-02
DAN00018	The biological control of two-spotted mite in irrigated maize	2002-05
GRS33	Grains Industry Research Scholarship – (ULA) Biology and control of blue oat mites in NSW	2002-03
UM00022	Emerging mite pests in southern Australia	2004-06

Whitefly

DAQ00056	Development of an area-wide decision support system for whitefly management in central Queensland cropping systems	2002-04
CSE00024	Biological control of silverleaf whitefly	2003-04
CSE00028	Natural enemy evaluation of the silverleaf whitefly and ecological processes affecting SLW dispersal	2004-06
DAQ00056	Development of an area-wide decision support system for whitefly management in central Queensland cropping systems	2004-06

Etiella

DAS00054	Management of Etiella in lentils in southern Australia	2003-06

False wireworms

DAW612	Management of false wireworms and other new seedling pests of canola	2001-02

Nematodes

DAW623	Impact and management of root lesion nematodes in Western Australia	2001-02
DAQ435	Cropping options to limit root-lesion nematodes	2002-03
DAS281	Preparation of a CD-Rom library of plant parasitic nematodes	2002-03
DAS335	Root lesion and stem nematode: management strategies and resistant varieties to reduce yield loss	2003-04
DAW00030	A farming systems approach to sustainable management of root lesion nematodes in Western Australia	2003-05
ANU00006	Exploring a model system to develop controls for plant parasitic nematodes	2005-06

Snails and slugs

ACC1	Optimising on farm snail management	2001-02
ACC1	Optimising on-farm snail management	2003-04
DAS300	Integrated snail management in the southern region	2001-05
GRD144	Scoping Study: Identifying and prioritising snail management R&D opportunities	2001-02
JLC30	Snail Communication Strategy	2001-02
ACC1	Optimising on-farm snail management	2002-03
IPM00001	Development of integrated control strategies for slugs	2002-05
CSE00038	The application of novel genetic approaches to pest land snails—a feasibility study	2005-06

Biosecurity

CSE00010	Risk analysis for biosecurity of the grains industry	2002-04
DAW00018	Predicting and Managing Spread of Diseases and Insects	2002-04
PHA1	Farm biosecurity and incursion management framework for the Australian grains industry	2002-03 2004-05

IPM General

DAQ540	Biopesticides against emerging pests	2001-03
DAN00023	Viruses and vectors in the northern region: support for resistance breeding and integrated control	2002-05
DAQ00003	Integrating IPM for major insect pests of pulses, soybeans, and peanuts	2002-05
GRS32	Grains Industry Research Scholarship – (UQ) Increasing the effectiveness of natural enemies for the biological control of crop pests	2002-03
DAW753	Grain pest management for changing farming systems in high rainfall areas	2003-05
DAQ540	Biopesticides against emerging pests	2003-04
UWA00041	Feasibility study to evaluate potential biocontrol agents (parasitic wasps)	2003-04
DAW00018	Biological Hazard - Predicting and Managing Spread of Diseases and Insects	2004-05
DAQ00074	Facilitating adoption of IPM in northern region broadacre farming systems	2004-06
DAQ00083	Integration of biopesticides into IPM against sucking pests (DAQ540 phase II)	2004-06
DAN00086	Assessment of IPM strategies to control insects in rotational farming systems of the southern region	2005-06
DAQ00086	IPM for pulses in northern Australia—Sustainable production in a changing cropping environment	2005-06

DAW00127	Crop pest management for farming systems in high-rainfall areas of southern Australia	2005-06
IPM00002	Developing and demonstrating IPM in broadacre cropping	2005-06

DISEASE RELATED

General disease

DAS311	Diagnostic and decision support tools to assist management of soilborne diseases	2001-04
UA350	Minimising disease risk and yield decline in field pea crops	2002-03
DAW663	Factors in leaf disease management for northern agricultural areas of Western Australia	2002-04
DAW00042	Disease management support and disease risk warning system for the western region	2003-04
ELD00002	Determination of best management practices for multiple wheat diseases in the northern agricultural zone of WA	2003-04
DAQ00059	Minimising the impact of pulse diseases in Queensland	2004-05
DAN00068	Integrated disease management in field crops with emphasis on Scolerotinia stem rot in canola	2004-06 2005-06
DAQ00059	Minimising the impact of pulse diseases in Queensland	2005-06
DAW00106	Managing disease constraints in western region farming systems	2005-06
SFS00015	Optimising cereal profitability in the HRZ through the integration of disease management and canopy management principles	2005-06
CSE00013	Biological control of Emex (?)establishment and new agent assessment (?)	2002-04

Viral

DAV411	Surveys of viruses in pulse crops grown in south-eastern Australia Management of pulse viruses in the major pulse production areas of south-eastern Australia	2001-03
UWA313	Determining the yield limiting potential of new virus diseases of lupins and canola, and *surveying for virus infection reservoirs outside the growing season*	2001-03

Fungal and bacterial

DAW619	Epidemiology of Ascochyta and Botrytis diseases of pulses in mediterranean type environments to enhance integrated control	2002-03
ACC00004	Aschochyta and botrytis management in lentils with pre and post emergent fungicides.	2004-05

Bacterial

DAW00023	Improving knowledge of epidemiology of botrytis diseases and integrated disease management of pulse diseases in Mediterranean environments	2002-03
DAW665	Advanced management strategies for control of anthracnose and brown spot in lupins	2003-04
DAW665	Advanced management strategies for control of anthracnose and brown spot in lupins	2002-03
DAW00023	Improving knowledge of epidemiology of Botrytis diseases and integrated disease management packages of pulses in Mediterranean climates	2003-04

Fungal

CSP335	On-Farm Management To Reduce Ergot Levels In Grain Sorghum	2001-02
DAW621	Predicting and managing spread of blackleg and other important leaf and stem diseases in crops in mediterranean environments	2002-03
DAW589	Fungicide strategies in integrated management of wheat and barley leaf diseases in southern WA	2002-03
UM00005	Novel approaches for the control of blackleg of canola	2002-03
DAN485	Management of fusarium diseases and common root rot of cereals in the northern cropping zone	2003-04
UM00016	Fungal pathology developments for management of diseases of oilseed brassicas in Australia	2003-04
UM151	Fungal pathology developments for implementations in plant breeding programs, with particular emphasis on blackleg and canola	2003-04
UMU88	National program for foliar diseases caused by necrotrophic fungal pathogens	2003-04
UWA343	Manipulation of canola trash for the management of blackleg disease	2003-04
UM00016	Fungal pathology developments for management of diseases of oilseed Brassicas in Australia	2004-05
DAV454	Management strategies for the use of foliar fungicides in cereals	2004-05
AGL00005	Project Review 2005—Australian Cereal Rust Control Program	2005-06
CSP00007	Molecular relationships in the rust fungi particularly the family Pucciniaceae	2005-06
CSP00079	Non-race specific (broad spectrum) adult plant rust resistance in wheat	2005-06
DAN485	Management of Fusarium diseases and common root rot of cereals in the northern cropping zone	2005-06
DAS00032	Crown rot management in durum and bread wheats for the southern region	2005-06
UM00016	Fungal pathology developments for management of diseases of oilseed brassicas in Australia	2005-06
UNE62	Field studies and management of crown rot in the northern region	2005-06

WEED RELATED

CFI6	Assessment of control products for control of problem weeds in the Northern Grain region	2001-02
DAN465	Reducing the impact of weeds in wide row no-till cropping systems	2001-02
DAN465	Reducing the impact of weeds in wide row no-till cropping systems	2003-04
DAQ430	Integrated management of difficult to control weeds in central and south east Queensland	2001-02
DAQ527	Risk assessment and preventative IWM strategies for herbicide resistance in the diverse farming systems in the Northern Region	2001-04
DAS293	Development of cost-effective management strategies for the control of summer growing weeds	2001-02
		2002-03
DAV438	Managing weed growth in organic farming systems	2001-04
UA465	Managing weeds and crop vigour under no-till farming systems development	2001-02
UA466	On-farm monitoring of Weed Seed-banks for Optimising Weed Management Strategies	2001-02
UA469	Origins and spread of herbicide resistant weeds at the paddock and farm level	2001-02
UM127	Implications of ecological variation of wild radish for integrated management programs	2001-02
CSP297	Weed seed dormancy: implications for intensive seed bank management	2001-02
CSE167	Biological control of wild radish: importation of agents from regions of origin	2001-05
UQ166	Development of decision support models for weed containment and eradication	2001-02
		2004-05
ACR4	IWM as a tool to prevent herbicide resistance becoming an impediment to sustainable farming	2001-05
DAW617	Weed control in crops using alternative technology to broadacre spraying systems	2001-02
DAW613	Understanding and driving annual weed seedbanks to very low levels	2003-04
BGP00001	Releasing agricultural weed seed dormancy through application of a novel smoke derived chemical	2004-05
DAQ00079	Modelling for sustainable glyphosate use in the northern region	2005-06
BWD00005	Improved techniques for managing herbicide-resistant ryegrass	2005-06
DAQ00064	Delivering applied solutions to weed issues in central Queensland	2005-06
DAW00114	Applied weed management in Western Australia	2005-06
DAW00123	A systems approach to enhance the adoption of IWM techniques in the Northern Agricultural Region of Western Australia	2005-06
DAW00131	Management of annual ryegrass using deleterious rhizobacteria	2005-06
NPB00003	Contingency plans for emergency plant pests of the grain industry	2005-06
UA00088	Understanding and management of weed resistance to glyphosate	2005-06
UQ00032	Advanced application technology to manage spray drift and improve the efficacy of weed management practices	2005-06
DAN00079	Risk assessment and preventative strategies for herbicide resistance in the northern region (Phase II)	2005-06
UWA399	Western Australian Herbicide Resistance Initiative	2005-06

Grape and Wine RDC IPM Projects 1989 - 2006

Web link used to extract project lists:

http://www.gwrdc.com.au/researchTopics.asp

> Research topics A-Z for project listings

Abbreviations:
DPI Vic: Department of Primary Industries Victoria
GVWIC: Greater Victorian Wine Industry Committee
HVVA: Hunter Valley Vineyard Association
NSW DPI: NSW Department of Primary Industries
SARDI: South Australian Research & Development Institute
UWS: University of Western Sydney

1. Agricultural chemicals

CODE	TITLE	RESEARCH TEAM	DATES
DAS 9GW	Reduced chemical usage and improved downy mildew control using a computerised simulator of disease	SARDI: Peter Magarey	1/01/1990
DAV 92/2	Minimisation of pesticide residues in grapevines by improving the efficacy and application of the biological insecticide, bacillus thuringiensis	DPI Vic: Greg Buchanan	1/01/1992
DAV 60A	Minimisation of pesticide usage through the development of controlled release formulations of Bacillus thuringiensis	DPI Vic: Greg Buchanan	1/01/1995
SPY 95/1	Optimisation of vineyard spray application technology through integrated testing and evaluation	Kieran Murphy	1/01/1995
DAV 98/1	Strategic use of sulphur in integrated pest and disease management (IPM) programs for grapevines	DPI Vic: Bob Emmett	1/07/1998
CRV 99/19a	Spray application in viticulture	DPI: John Lopresti	1/01/1999
USA 00/2	The application of pesticides to grape bunches	Uni. Sth Aust: Kieran Murphy	1/01/2000

2. Biological control

CODE	TITLE	RESEARCH TEAM	DATES
DAN 4GW	Biological control of grapevine mites	NSW DPI: David James	1/01/1989
DAV 92/4	The persistence of biological activity and the degradation of residues of key pesticides used on grapes	DPI Vic: Alison MacGregor	1/01/1992
DAN 92/3	Biological control of mites in inland viticulture	NSW DPI: David James	1/01/1992
DAN 93/2	Biological control of mites in Australian viticulture: implementation and sustainability	NSW DPI: David James	1/01/1993
UWS 99/1	Petroleum spray oil and biological-pesticide based IPDM for horticulture	UWS: N G Nair	1/01/1997
RT 04/06	Understanding the biology and improved management of longtailed mealybug in WA	Sue Vidovich	1/10/2004

3a. Pests

CODE	TITLE	RESEARCH TEAM	DATES
DAN 5	Occurrence and control of borers in Hunter Valley vineyards	NSW DPI: S Goodwin	1/01/1989
DAS 7V	Control of establishment pests in vineyards	SARDI: P Bailey	1/07/1987
DAV 99/1	Minimising the impact of European wasps on the grape and wine industry	DPI Vic: Greg LeFoe	1/07/1999
RT 02/34-4 RT 03/08-2	Elephant Weevil impact and control in vineyards	Fiona Wood	3/02/2003
RT 02/41-4	Pest and disease monitoring for sustainable viticulture	Lynette Deland	4/02/2003

3b. Diseases

CODE	TITLE	RESEARCH TEAM	DATES
CRV 96/2	Phomopsis/grapevine disease interaction; a molecular investigation	CRC Viticulture: D Melanson	1/01/1996
DAN 8GW	Grapevine disease management - cane blight (Dead Arm) disease research module	NSW DPI: N G Nair	1/01/1990
DAN 9GW	Grapevine disease management in New South Wales - Infrastructure Module	NSW DPI: N G Nair	1/01/1990
DAN 94/1	Strategies to reduce the incidence of cane and leaf blight disease of grapevines	UWS: N G Nair	1/01/1994
DAS 92/2	A reliable, cheap weather station as a predictor for improved disease and pest control	SARDI: Peter Magarey	1/07/1992
DAV 5GW	A revised management program for grapevine black spot	DPI Vic: Bob Emmett	1/07/1989
DNR 01/01	Post-entry quarantine protocols for host plans of Xyllela fastidiosa (National awareness and response strategy for Pierce's Disease	DPI Vic: Peter Merriman	1/07/2001
DPI 2	Grapevine heat treatment - Flavescene doree	Bureau Resource Science: D G McLean	1/07/1988
DPI 3	Grapevine heat treatment - Xanthomonas ampelina	National Vine Health Steering Committee: Bill Roberts	1/01/1990
SAR 01/04	Managing Sclerotinia shoot rot - a new disease of grapevines in Australia (Pilot project)	SARDI: Barbara Hall	1/01/2002
UA 99/3	Detecting DMI resistant strains of the grapevine powdery mildew fungus using molecular probes	Uni Adelaide: Eileen Scott	1/07/1999

3c. Biosecurity

CODE		RESEARCH TEAM	DATES
RT 01/16-2	Development of regional protocols for the management of exotic pest or disease incursions in Greater Victoria	Yarra Ridge Vineyard: Damien De Costella	1/11/2001
RT 02/30-4	Development and implementation of regional bio-security protocols throughout Gippsland and Mornington Peninsula regions of greater Victoria	GVWIC: Spencer Field	1/09/2002
RT 02/35-4	Development and implementation of regional pest & disease protocols throughout Grampians, Pyrenees and Bendigo regions of Greater Victoria	Bendigo and District Winegrowers: Paul Jenkins	1/11/2002

4. Mildews and other fungal diseases

CODE	TITLE	RESEARCH TEAM	DATES
DAS 3V	Evaluation of phosphorus acid as an inexpensive downy mildew fungicide	SARDI: Trevor Wicks	1/07/1987
DAS 4V	Sensitivity and tolerance to fungicides	SARDI: Trevor Wicks	1/07/1987
DAS 9GW	Reduced chemical usage and improved downy mildew control using a computerised simulator of disease	SARDI: Peter Magarey	1/01/1990
CSH 94/4	The role of chitinase and B-1,3-glucanase gene expression in the response of grapevines to fungal infection	CSIRO: Nigel Scott	1/01/1991
DAS 93/2	Analysis of epidemics of powdery mildew	SARDI: Peter Magarey	1/07/1993
DAS 93/3	Non-conventional control of powdery mildew	SARDI: Trevor Wicks	1/07/1993
CRV 96/3	Biological and chemical control of eutypa dieback	SARDI: Trevor Wicks	1/01/1996
CRV 99/14a N	Isolation of a major gene to powdery mildew	CSIRO : I Dry	1/01/1999
SAR 99/3	Management of new fungicides for the control of powdery mildew and other grape diseases	SARDI: Trevor Wicks	1/07/1999
RT 01/06	Downy mildew infection events in Western Australian viticulture regions	Wine Industry Ass. of WA: Kim Pervan	1/09/2001
UWA 00/1	Behaviour of infective propagules of Plasmopara viticola (causal agent of downy mildew on grapevines) under Western Australian conditions	Prof. Sivasithamparam, Siva	1/07/2001
RT 01/19-2	Improved control of bunch rots in Granite Belt winegrapes	Granite Belt Wine Industry: Juliane Ferguson	1/09/2001
DNR 02/05	Control of downy mildew of grapevines by boosting their natural defence system	DPI Vic: Ian Porter	1/07/2002
RT 04/18-4	Downy Mildew Action Plan - A regional model	CCW: Peter Burne	1/02/2005

5. Viruses and virus like diseases

CODE	TITLE	RESEARCH TEAM	DATES
CRV 95/2	National program for the management of phytoplasmas in Australian grapevines	DPI Vic: DeAnn Glenn	1/01/1995
CS 1V	Detection probe for virus associated dsRNA present in leafroll infected grapevine	CSIRO: Ali Rezaian	1/01/1987
CSH 94/1	Detection of closteroviruses associated with grapevine leafroll disease in Australia	CSIRO: Mark Thomas	1/01/1990
CSH 95/4	The status of virus and virus like diseases of grapevines and their relevance to Australian Viticulture	CSIRO: Nigel Scott	1/01/1995

6. Bunch rots (including botrytis)

CODE	TITLE	RESEARCH TEAM	DATES
DAN 1GW	Disease management of bunch rot of grapes	NSW DPI: Chris Green	1/01/1987
DAN 92/1	Practical management strategy for bunch rot of grapes	NSW DPI: N G Nair	1/01/1992
SAR 01/02	Improving fungicidal control of botrytis bunch rot	SARDI: Trevor Wicks	1/08/2001
RT 02/39-4	Fruit rot control in Hunter vineyards. Providing growers with tools to stop the rot	HVVA: Ian Tinkler	1/01/2003
RT 01/14	Control of Bitter Rot of Ripe Rot of grapes caused by Colletotrichum soo	HVVA: Ken Bray	1/10/2001
RT 01/05	Botrytis management an integrated approach	Wine Industry Assoc of WA: Sue Vidovich	1/09/2001

7. Weeds

CODE	TITLE	RESEARCH TEAM	DATES
MU 00/1	Biological control of weeds in vineyards	Murdoch Uni.: Graham O'Hara	1/07/2000

8. Resources and Extension Strategies

CODE	TITLE	RESEARCH TEAM	DATES
SAR 99/2	The Australian and NZ FIELD GUIDE for diseases, pests and disorders of grapes	SARDI: Peter Magarey	1/07/1999
RT 03/09-2	The publication of a checklist and resource materials for implementation of best practice Botrytis Control on vineyards throughout the Greater Victorian region	GVWIC - Spencer Field -	1/07/2003
CRV 96/4	Control of pests and disease in grapevines: From Research to Practice	DPI Vic: DeAnn Glenn	1/01/1996
DAS 8GW	Improved efficiency of grape production by better dissemination of research and technical information. Grape Production Series Number 1 Diseases and Pests	SARDI: Phil Nicholas	1/01/1990
CRV 96/4	Control of pests and disease in grapevines: From Research to Practice	DPI Vic: DeAnn Glenn	1/01/1996
DAN 92/4	Adoption of strategies to reduce the use of pesticides in wine grape production	NSW DPI: C R Turkington	1/01/1992
PI 99/1	Benchmarking viticulture extension and training in California	SARDI: Gayle Greiger	1/01/1999

Rural Industries RDC IPM Projects 1995 – 2006

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Pests and Diseases

CODE	**TITLE**	**RESEARCH TEAM**	**REPORT DATE**
UQ-24A	The Role of Parasites and Predators in Cashew Pest Control: Development of an Integrated Pest Management Programme	UQ: M Zalucki	1995
DEB-1A	Evaluating and managing lucerne seed wasp in lucerne seed crops	James De Barro De Barro Ag. Consulting	2001
AGR-7A	Rice blast fungicide development in Australia - Summary only available	Mr Malcolm Taylor, Agropraisals Pty. Ltd.	2001
SAR-4A	Development of an integrated pest management program (IPM) for the control of quandong moth in quandong orchards	SARDI: Peter Bailey	2001
IPM-1A	Pest management strategies for organic agriculture	Dr. Paul Horne	2001
DAQ-244J	Investigations. into the. management of. the darkling. beetle.	TA Lambkin	2001
DAV-178A	Integrated Pest Management in Peppermint Growing in South East Australia	Fred Bienvenu	2002
DAN-213A	Study of the small hive beetle in the USA	Douglas C Somerville	2003
DAN-184A	Improving bloodworm, earthworm and snail control in rice	NSW DPI: Mark Stevens	2003
DAQ-269A	Control of chalkbrood disease with natural products	Craig Davis & Wendy Ward; Centre for Food Technology	2003
EAV-1A	Chemical Use in Fodder Crops - Interim Report	Anthony Flynn EUREKA! Agresearch	2005
DNT-24A	Integrated management of Phytophthora diseases of durian	Dept PI NT: Chris Wicks	2003
CEO-1A	Early Detection of Exotic Pests and Diseases in Asian Vegetables by Imaging Spectroscopy	B. Datt, A. Apan, and R. Kelly; CSIRO	2005
DAQ-274A	Rambutan: Development of Integrated Pest Management	DPI Qld: David Astridge	2005
SAR-10A	Development of a bacterial wilt test to facilitate the export of lucerne seed	SARDI :Kathy Ophel-Keller	2005
US-85A	Development of an integrated control strategy for "lucerne yellows" disease in lucerne	Prof Geoff Gurr – Syd Uni	2005
UCA-6A	Vertebrate Biodiversity on Australian Rice Farms	Uni Can. J. Sean Doody	2005
PFA-1A	Review of Diseases of Oats for Hay: Current and future management - Part I: Relative importance of diseases	Pierre Fievez and Associates	2006
DAN-233J	Integrated management strategies for diseases and pests of Asian vegetables	Mr Len Tesoriero NSW DPI	2008

More general integration of management practices/knowledge

US-21A	Assessment of the Use Systemic Induced Resistance in Plants as a Component of Integrated Pest and Disease Management	Prof Brian Deverall Sydney Uni	1997
MS967-43	Determining the Effectiveness of Vegetation Management Programs	Joint venture	1999
DAT-37A	Integrated development of intensive organic vegetable production systems	Dr Jason Dennis & Julia French	2001
CSE-83A	National electronic modelling network for pest, disease and weed	Dr R W Sutherst CSIRO Qld	2002
UWS-17A	Sustainable Pest and Disease Management in Australian Olive Production	UWS : Robert Spooner-Hart	2005
UCQ-19J	Crop Protection - An issue for the Asian vegetables and herbs & spices industries	CQU : David Midmore	2005
SAR-49A	Native Vegetation and Profitable Perennials to Ameliorate Salinity, and Enhance Biodiversity, Beneficial Insects and Pest Control	Peter Taverner and Glenys Wood SARDI	2006

Weeds

UNE-65A	A Sustainable weed management for organic herb and vegetable production	UNE: Brian Sindel	2001
UCS 20A	Integrated weed management strategies for the rice weeds Cyperus difformis and Alisma plantago-aquatica	CSU: James Pratley	2004
DAN-163A	Weed control options in annual pasture legumes	NSW DPI : Brian Dear	2005
DAV-196A	Effective Weed Control for the Australian White Clover Industry	DPI Vic : Penny Riffkin	2005
UCS-20A	Development of integrated weed management strategies for the rice weed Cyperus difformis and Alisma	CSU: James Pratley	2002
UCS-26A	Integrated management of Alismataceae weeds to reduce herbicide resistance	CSU: Farzad Hahromi	2002

Extension

CTP-1A	Industry and Community Participation in Agricultural Extension: an Integrated Pest Management Case Study	UQ/CRC: Geoff Norton	2001
DAV-117A	Partnerships to enhance adoption of integrated pest management by industry	Dr Jenny Gordon Leon Berkelmans Centre for International Economics	2001

IPM in the Australian Cotton Industry

Industry

The cotton industry in Australia involves about 1200 cotton growers with 70% grown in NSW and the remainder in Queensland. A typical cotton farm is 500 to 2000 hectares and highly technologically sophisticated. Growers average yield is 1800 kilograms per hectare. Cotton is primarily an export crop.

Cotton growers are highly innovative and supportive of research. According to the CRDC annual report 2004-5 "in the past decade the application of innovative biotechnology has provided a foundation for rapid adoption of integrated pest management (IPM) practices, which have helped the industry to reduce overall insecticide use by 70 per cent". It is estimated that 60% of the 2005 crop was produced under the Cotton Best Management Practices program that includes following an integrated pest management strategy for insects, diseases and weeds.

This success can be attributed in part to significant funding, and close proximity of research providers, industry and CRDC. Both CRDC and the Australian Cotton Research Institute (ACRI) are located in Narrabri, a significant cotton growing area. ACRI houses NSW DPI, CSIRO and the Cotton CRC secretariat. QDPI is the other main research provider and their main cotton research site is in Toowoomba.

IPM History

In the early 1970s resistance of *Helicoverpa armigera* to DDT heralded the need for a new pest management strategy (Fitt 1994). Some IPM principles were adopted with the development of the computer-based pest management program SIRATAC. Routine crop monitoring and use of thresholds were widely adopted after it was shown that yield and quality could be maintained with fewer insecticides. Thus began an era of insecticide resistance management (IRM) that was often called IPM. New chemistry was quickly registered and incorporated into the IRM strategies. Adoption was rapid as resistance levels of *Helicoverpa armigera* in particular were high. This "integrated pesticide management" strategy continued until the early to mid 1990ies.

The introduction of the transgenic cotton Ingard®, that expresses the BT endotoxin and is therefore lethal for most lepidoptera to eat, provided a platform for development of a biologically based IPM strategy. Work on food sprays, and beneficial refuges illustrated the potential for beneficial insects to play an important role in managing crop pests. In 1994 the first collation of IPM guidelines with reference to beneficials was made and the cotton IPM shortcourse was developed. Adoption of IPM has subsequently been rapid.

Development of truly integrated crop management strategies have come with significant assistance of three rounds of funds under the Commonwealth CRC program. The Cooperative Research Centre for Sustainable Cotton Production was funded from 1993-99, the Australian Cotton CRC was funded from 1999-2005 and the Cotton Catchment Communities CRC has recently received a further $138 million to fund it until 2012.

IPM Resources

Cotton has by far the most extensive set of IPM related resources of any commodity in Australia (Table 1). A study to assess the use and value of the information resources was undertaken in 2003 (Christiansen *et al*. 2003). The study concluded that all the information resources produced and provided by the Cotton CRC and CRDC are highly valued by the industry. 90% of the survey respondents indicated that they both had and utilised the resources. Agronomists/consultants are the most likely to use the resources. This industry is highly computer literate with 91% of respondents having access to the internet and 61% accessing daily.

Table 1: Key information resources provided to the cotton industry by the Cotton CRC, CRDC and NSW Agriculture

Resource Title	Editions/Updates
SOILpak Soil constraints and management	1990, 1991,1998
SPRAYpak Spray application technology	1994, 2003
ENTOpak *Incorporating the* IPM Guidelines	Updated regularly
MACHINEpak Machinery use / cultivation / pupae busting	1999
NUTRIpak Crop nutrition	2001

WEEDpak Weed identification and management	2002
Integrated Disease Management Guidelines Identification and management of cotton diseases	2002
CottonLOGIC *Incorporating E*ntomoLOGIC and NutriLOGIC Computerised decision support tool for insect and nutrient management. Includes Agronomic record keeping.	Updated annually
Cotton Pest Management Guide Pest management options, including chemical options, also incorporate IPM guidelines and IRMS.	Updated annually
Insect Management in Cotton Pocket Guide Pocket size identification guide – with IPM Guidelines	2000
Insecticide Resistance Management Strategy (IRMS) Cotton industry strategy - produced as cards and in Cotton Pest Management Guide.	Updated annually
Cotton Tales Regional, timely news and information– fax/email newsletter.	Weekly-monthly
Information Updates Any topic – many as updates to COTTONpaks.	As need arises
Cotton CRC Website All resources except MACHINEpak and CottonLOGIC are available on the Cotton CRC website: www.cotton.crc.org.au.	Since 1994

The newsletter, the Insecticide Resistance Management Strategy, Pest Management Guide, IPM Guidelines, Information updates and the Insect Pocket guide were used most frequently. COTTONpaks, which are reference resources, are used less often. The more frequently used resources such as CottonTales newsletters were considered to be the most useful (Figure 6). Growers prefer to receive their information from an agronomist, via CottonTales newsletters and the COTTONpaks. Printed versions are preferred over electronic versions of information although 45% of respondents indicated that it would be useful to have the information also available in an electronic format. 85% of respondents indicated that workshops or seminars would help them to gain more benefit from the information resources (Figure 7).

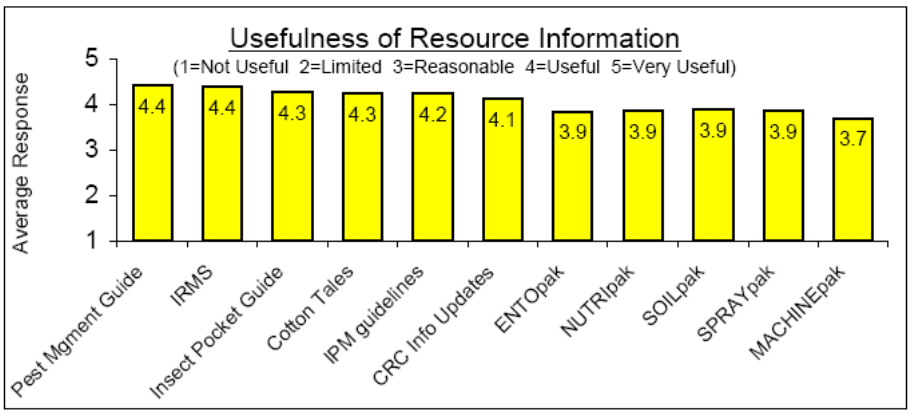

Figure 6: Perceived Usefulness of the Information Resources

(from Christiansen *et al*. 2003)

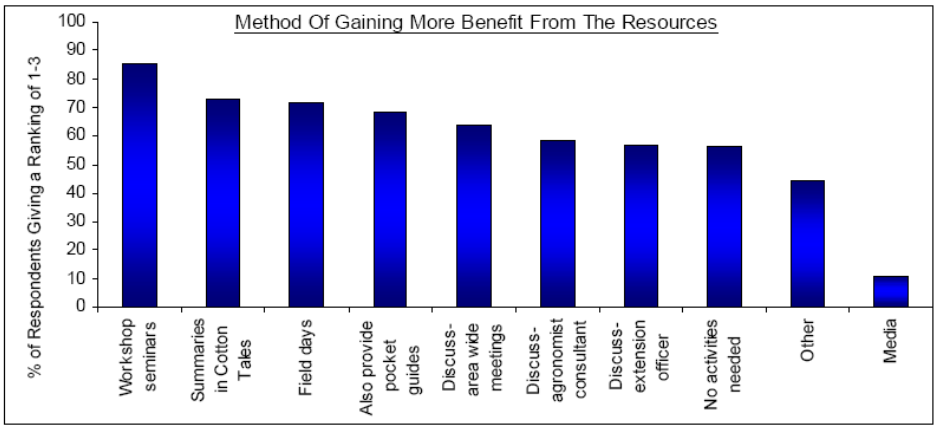

Figure 7: Preferred activities that respondents felt would help them gain more value from the Information resources.

(from Christiansen *et al*. 2003)

Lessons

- ✓ Crisis is a strong driver for change
- ✓ Cotton IPM began as insecticide resistance management for a single pest and evolved to incorporate more pests, diseases, weeds and now is also looking at whole communities.
- ✓ All recommendations are based on rigorous science
- ✓ Consultants are extremely important
- ✓ Regular, timely, well substantiated and printed information necessary
- ✓ Substantial continuous funding been important for development of Cotton IPM

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IPM in the Australian Citrus Industry

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Industry

The Australian citrus industry comprises 32,000ha of citrus plantings, managed by some 2800 growers. The varieties of citrus grown include Valencia and Navel oranges, mandarins, grapefruit, lemons and limes. Total Australian citrus production is 700,000 tonnes (ACG, 2005). Citrus is grown in all mainland states of Australia and the Northern Territory. The four main production areas, by volume, are Riverina (NSW), Riverland (SA), Sunraysia/Mid Murray (VIC/NSW) and Gayndah/ Mundubbera (QLD). Fruit is grown for both processing and fresh markets.

Australian Citrus Growers Inc. (ACG) is the national body representing nine regional grower associations throughout Australia. Growers in larger producing areas are additionally serviced by regional citrus boards, those being Murray Valley Citrus Board (MVCB), South Australian Citrus industry Development Board (SACIDB) and Riverina Citrus (RC).

IPM is well established in production areas, some of which are serviced by citrus consultants. There are several commercial insectaries that provide beneficial insects for release by citrus growers. Release of *Aphytis* wasps for scale control is widespread as well as the use of petroleum spray oils.

Newer generation insecticides with selective modes of action against Lepidoptera and some sap sucking pests have recently been registered and due to their selectivity these products will fit well into IPM systems. The current low returns within the citrus industry have increased grower focus on high priced export and domestic markets. The market demand for blemish free fruit, new pest incursions and the relatively high expense of the new insecticide chemistry will continue to provide challenges for IPM into the future.

IPM History

The Australian citrus industry has an extensive history of using beneficial organisms to assist with pest control. In 1904, an exotic wasp parasite of red scale, *Aphytis chrysomphali*, was first introduced to Western Australia, and into New South Wales in 1925 (Wilson, 1960). This wasp established better in coastal areas than the inland citrus districts. Before the 1950's citrus growers in the inland, Murray River region commonly used hydrogen cyanide to manage citrus pests (Smith et al 1997)

Between 1950 and 1970 growers generally used insecticide spray schedules to control scale. Inland districts used either petroleum spray oil (PSO's), a mix of oil and an insecticide, or insecticides alone. PSO's were generally mixed with broad spectrum insecticides during the 1960's and 1970's to improve efficacy (Beattie, 1997). In Queensland, where pest pressure was higher, growers were applying up to ten insecticide applications each year (Smith & Papacek 1985). Chemicals like DDT, organophosphates (parathion, maldison, azinphos methyl, dimethoate, methidathion) and carbamates (carbaryl and promecarb) featured in grower spray schedules.

During the 1970's attitudes towards pest control changed dramatically throughout the industry after a number of very successful biological control releases. *Aphytis melinus* established in the inland production areas, allowing growers to substantially reduce insecticide use. Similarly, by 1973 biological control had worked so successfully in Queensland for white wax scale that sprays were no longer needed for this pest (Smith & Papacek 1985).

The success of biological control and the high cost of insecticides were the main drivers for IPM in the citrus industry. The cooperative work of a private entomologist, the Queensland Department of Primary Industries and a number of large growers saw the development of a commercial insectary and an IPM strategy for Queensland citrus (Smith 1990). During the 1980's similar IPM strategies were developed by State Department of Agriculture entomologists and private consultants with growers in coastal and inland NSW, the Riverland and Sunraysia districts. The development of better quality PSO's, with less phytotoxicity in the early 1980's enhanced the development of IPM. The IPM strategies had crop monitoring as a basis, used beneficial insect releases, the 'softest' insecticides available and targeted the sprays at the pest's most vulnerable lifecycle stage. IPM strategies greatly

reduced insecticide use in the Queensland citrus industry (Smith 1990) and similarly in Sunraysia and Riverland districts (Smith et al 1997).

Today, market pressure for reduced insecticide use and changing occupational health and safety on farms are added drivers for the adoption of IPM by citrus growers. Many growers continue to use augmentative releases of *Aphytis spp.*, a parasitic wasp for red scale control combined with strategic petroleum oil sprays. Most production districts have pest scouts that provide monitoring services. There are several commercial insectaries that sell beneficial organisms used by citrus orchards.

The Australian Citrus Industry continually funds well directed and practical IPM focused research projects. The range of pests studied include scale pests, jassids, spined citrus bug, light brown apple moth, citrus leafminer, Kelly's citrus thrips and mealy bugs. These projects have identified natural enemies and established best practice management techniques for these pests. Relatively recent chemical registrations of insect growth regulators for light brown apple moth, some scale and leafhopper insect pests will further enhance IPM in citrus.

Fruit fly is a serious pest of citrus that can add to the cost of production and also limit the markets for fruit. Strategic bait spraying for fruit fly rather than broad spectrum dimethoate cover sprays are an accepted orchard practise in most production areas. Queensland fruit fly is not established in the southern citrus production regions so an exclusion zone exists to maximise access to export markets. The TriState Fruit Fly Committee exists between NSW, VIC and SA, with funding from state governments and affiliated citrus boards (MVCB, SACIDB and Riverina Citrus). The committee maintains the fruit fly exclusion zone through road blocks, monitoring (trapping grid), controls out breaks and coordinating community awareness of the exclusion zone. Release of sterile fruit flies to eradicate Queensland fruit fly incursions is part of the integrated approach industry takes towards managing this pest.

IPM adoption is generally not as high in the southern states as it is in Queensland, where IPM is accepted as the industry norm (Papacek and Smith 1998). A sod culture of selected grasses and/or legumes is commonly planted throughout Queensland and coastal NSW orchards. A weed free tree row is maintained and the grassed inter-row is slashed alternately to maintain a beneficial refuge in the orchard (Duddy et al 1997). To some extent, areas in the southern states (MIA, Riverland and Sunraysia) have always had a beneficial refuge in the Valencia plantings. Valencia is predominantly grown for juice, so there is a greater tolerance for insect damage and generally less insecticide use.

A national industry magazine "Australian Citrus News" has been published since the 1920's. The magazine extends project outcomes and provides relevant information to industry. It is distributed free of charge with assistance from the national research levy. A definitive guide to IPM in Australian citrus was published by Smith et al in 1997. CITTgroups Australia is a levy funded project that encourages the adoption of new technologies. CITTgroup meetings do this by facilitating communication between researchers and growers. Meetings are organised as needed regionally and at times they extend IPM research.

IPM Resources

IPM resources have primarily been developed for the citrus industry as parts of funded projects (Table 1). Information and resources about IPM have been disseminated through ACG, State Department of Agriculture Advisory Officers, Industry Development Officers, CITTgroup meetings, the annual ACG conference, newsletters and industry magazines.

Table 1: Key information resources provided to the Citrus industry

Resource Title	Editions/Updates
Protect your citrus (Broadley *et al* 1987)	1987
Best friends, natural enemies IPM in citrus video QDPI	1987
Pest and disease management guide for coastal citrus in New South Wales (Hardy 1995)	1995
Biological control of Honeydew-Producing Insects on Citrus in inland Australia (Pywell *et al* 1996)	1996
Citrus pests and their natural enemies (Smith *et al* 1997)	1997
Citrus Pests a field guide (Smith *et al* 1997)	1997
An illustrated guide to the parasitic wasps associated with citrus scale insects and mealybugs in Australia (Malipatil *et al* 2000)	2000
Industry Development Officers[1]	full - time
State Department of Agriculture Advisory Officers	full-time, numbers vary across states
Regional CITTgroup meetings[1]	as needs basis
ACG conference[1]	annual
Australian Citrus Growers Web site[2]	on going
Magazine and Newsletters[3]	various

[1] vehicle for dissemination of information to industry but only covers IPM issues when crisis or funded projects have generated the information

[2] A central Web site for industry covering all aspects of citrus production and marketing. The site is regularly updated with outcomes of current research and best practice management information.

[3] Australian Citrus News is a bi-monthly magazine published by ACG. Several newsletters are also available to the citrus industry on a monthly, bi-monthly and a quaterly basis, depending upon the publication. The newsletters are mostly regionally based and published by citrus boards or state departments of agriculture. The magazine and newsletters at times feature IPM issues.

Lessons

- ✓ Insecticide cost, market pressure for reduced insecticide use and changing OH&S environment on farms are strong drivers for change
- ✓ Demonstrated success of biological control in an orchard situation is a strong driver for change
- ✓ Continued strong investment in IPM based research projects
- ✓ All recommendations are based on rigorous science
- ✓ Cooperation between researcher, consultant and grower is essential
- ✓ Availability of beneficial organisms at a cost effective price
- ✓ Tri-state co-operation essential for Queensland fruit fly management
- ✓ Regular and timely printed information delivered to growers
- ✓ Regular, as needs be CITTgroup meetings facilitating information delivery between researchers and growers
- ✓ Local IPM crop scouts / consultants are important
- ✓ Low returns and rising costs mean growers avoid using new chemistry
- ✓ New insect pests and lower market tolerance for fruit blemish continually challenge IPM adoption

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IPM in the Australian Processing Tomato Industry

Industry

Processing tomatoes are grown in northern Victoria and southern NSW. There are now 30 growers growing 325,000 tonnes of tomatoes for a variety of processed products. The industry has contracted but significantly increased yields and management is highly mechanised (Moon 2004).

In processing tomatoes close to 60% of the cropped area is routinely monitored for insect pests (Moran *et. al*. 1999), all the scouts check the parasitism levels of the eggs and a single action threshold for Heliothis is used. The Heliothis threshold was developed in 1987, monitoring egg parasitism was incorporated in ~1993 and the use of thresholds for thrips and other sap suckers was similarly introduced in the early to mid nineties. There was immediate adoption of the crop monitoring protocols and thresholds by the commercial scouts in the industry (Walker 1995). Although new chemistries and some biologicals are available almost none is routinely used in the industry.

IPM History

In 1980 the Australian Processing Tomato Grower was first published under the auspices of the Irrigation Research and Extension Committee in 1980 (editorial APTG 1980). At this stage Heliothis control was not a major issue but controlling the leafhopper vector of Big Bud disease (Osmelak 1981) was one of the first projects funded from a levy collected from tomatoes delivered in Victoria (Shea 1984). In 1984 a levy on all processing tomatoes was collected and the Australian Processing Tomato Research Committee (APTRC) was formed to administer the funds and assumed control of the magazine (Shea 1984). In 1973 resistance of *H. armigera* to DDT and Endosulfan was noted (Hamilton 1983).

John Hamilton, NSW Agriculture, began testing for Heliothis thresholds. In 1987 a commercial demonstration illustrated the potential savings from insecticide reduction when using the threshold of 5 eggs per 30 petioles. When DDT was banned in 1988 the industry was ripe for the introduction of IPM for Heliothis (Hind 1995). With a 1 year grant from the APTRC in 1988/9 John Hamilton confirmed the threshold and presented at the 7th annual Tomato Industry Symposium held in 1989 (Hamilton and Macdonald 1989).

The first major IPM project in processing tomatoes was funded in 1992, involving the two commercial scouts at the time, and a team of researchers led by Mark Smith from Agriculture Victoria. The combination of the involvement of the commercial scouts, the annual symposium, the industry magazine and the appointment of the Industry Development Officer allowed for rapid and thorough communication to the industry. The major contributions of this project were the accounting for egg parasitism within the Heliothis egg threshold modifying the threshold to 5 “viable” eggs per 30 petioles; incorporating other insects into the monitoring and developing thresholds for other caterpillars, thrips, aphids and leafhoppers.

In 1996 the processing tomato industry set a target of 100% adoption of IPM techniques by 2001. Grower perception and lack of trained scouts were identified as the main barriers. In 1996 only three scouts serviced the industry and whilst there was very good adoption of IPM techniques in the immediate areas serviced by the scouts there was equally poor adoption in the areas not serviced. Since adoption of IPM was highly correlated to proximity to a commercial scout a project was initiated to train and accredit scouts (Bentley 1998). Nine trainees from areas without crop scouts did the training workshop but none progressed through the full accreditation (Moran 2001). Some of the trainees implemented the techniques on their own or family’s farm, and at least one scouted commercially. Their activities did increase the area under IPM by 18% to an industry total of 57%. The practicalities of IPM scouting, as a profession, seems to be a major barrier to getting more commercial scouts working in the industry.

A second research IPM project was funded in 1998 and incorporated both disease and insect management components. Through this project new generation chemistry was evaluated for efficacy and impact on Trichogramma egg parasitoids (Hewa-kapuge *et al.* 2003). As a result some new generation chemistry was registered but adoption by industry has been slow due to the considerably

higher cost of the insecticides compared to the existing older chemistry. Trials with nursery crops and inoculative releases to increase the egg parasitoid populations were not highly successful. The absence of establishment pests in the two years of trials on alternative chemistries to control them did not lead to the significant steps towards a more biologically based IPM system that was expected (McDougall et al. 1999, McDougall 2002). From about 1998 Heliothis pressure has been consistently high so the differences in numbers of spray applications between the non-IPM and IPM growers has not been as high as was reported by Smith (1996).

A review of the success of tomato IPM, commissioned by the APTRC and HRDC, was reported in Juffs and Taylor (1999). They concluded that there was a "high level of adoption of IPM practices among tomato growers", that "formidable barriers to universal and full adoption of IPM remain", and that the returns to IPM R&D in the processing sector have been poor. They recommended: 1. Conducting demonstrations and farm walks, 2. One-to-one introductions to IPM for growers 3. A network of crop monitoring professionals, 4. Use of case studies, and 5 Development of IPM protégés.

With the completion of IPM 2001, the review of tomato IPM, and a new strategic plan for the APTRC the research committee decided to focus its resources on other non-IPM projects.

IPM Resources

IPM resources have been developed for the processing tomato industry as parts of funded projects (Table 1). Information and resources about IPM have been disseminated through the APTRC. The APTRC facilitates the annual symposium and magazine, the quarterly newsletter, an industry development officer and a series of regional meetings, as well as making decisions about projects to fund.

Resource Title	Editions/Updates
Heliothis thresholds	1989
A guide to Common Pests & Beneficial Insects in Processing Tomatoes – colour photocopied guide	1996?
IPM Sampling Guidelines & Spray Thresholds	1996
IPM crop consultant course	1999
Tomato Topics newsletter*	quarterly
Australian Processing Tomato Grower magazine*	annual
Industry Development Officer*	Part-time
Web site*	
Symposium*	annual

* vehicle for dissemination of information to industry but only covers IPM issues when crisis or funded projects have generated the information

Lessons

- ✓ Heliothis insecticide resistance and removal of DDT i.e. a crisis, was the main driver for change
- ✓ IPM quickly developed as integrated pesticide management
- ✓ A biologically based IPM strategy is only followed when the egg parasitoid, Trichogramma is found in significant numbers early in the season and when heavy chemistry is not used for other pests
- ✓ Advances were made with researcher/consultant/grower team
- ✓ Consultants are extremely important and available consultants are a major limitation
- ✓ Steady price and rising costs mean growers avoid using new chemistry
- ✓ Advances made when projects funded

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IPM in the Australian Sweet corn Industry

Peter Deuter, DPI&F Qld, Project leader and Bronwyn Walsh, DPI&F, Qld

Industry

Sweet corn is grown in all states of Australia with the majority being produced in New South Wales (NSW), Queensland and Victoria.

In 1995, the Australian Sweet Corn industry produced 73 000 t for an on-farm value of $30.5M (ABS, 1995). NSW produced 53% of the Australian tonnage from 2 200 ha, mostly for the processed market. Queensland produced 19% of the Australian tonnage and 36% of the $ value (14 000 t and $11M annually); Victoria produced 10% of the Australian tonnage for fresh domestic and export markets. By 2001 the Australian industry was estimated to have increased production to be 120,000 t per annum.

IPM History

Heliothis (*Helicoverpa armigera*) has always been the major pest of sweet corn, and until the early 1990s it was easily controlled by scheduled sprays of carbamates, organo-phosphates or synthetic pyrethroids.

By 1994, growers in Queensland, NSW and Victoria were having difficulties supplying a fresh product to the export market in South East Asia. These growers had significant difficulties due to the inability to produce cobs free from heliothis larvae and larval damage. This was due to heliothis control failures, as a result of the high levels of resistance in *Helicoverpa armigera* (heliothis) populations to the traditional groups of insecticides.

Pyrethroid insecticide resistance was 57% and 41% respectively in two heliothis samples submitted from the Lockyer Valley (Queensland) in Dec/Jan 1995/96, and carbamate resistance was 15% in Jan 1996. Unmanageable levels of resistance were recorded in North Queensland in the winter of 1996. These levels represented the magnitude of the problem in all production districts in Australia, and were continuing to rise towards unmanageable levels.

Most pesticides were applied by air due to the size of fields and the need to cover these areas regularly during the silking growth stage. A few growers were using ground rigs, and in the majority of cases those growers were not experiencing the same level of damage and loss as those using aerial application.
The range of synthetic insecticides and carbamates registered on sweet corn was small, and increasing resistance levels were making them less effective.

The damage caused by heliothis in sweet corn cobs is not readily detectable in the field, nor in the pack-house. Therefore a large percentage of infected cobs can make their way onto the market, with consequential negative effects on demand and price.
In 1997 a project, "Insect Pest Management in Sweet Corn" – VG97036, was funded by HAL, and included team members and work programs in Queensland, NSW, Victoria and Tasmania, with linkages into WA.
This project aimed to reduce the risks of crop loss from insect damage, mainly *Helicoverpa armigera* (heliothis), and improve production and quality in sweet corn aimed at domestic (fresh and processing) and export markets. Project activities to address the issues were:

- Identify and promote integrated pest management systems for sweet corn
- Reduce the production risks, particularly for export oriented production systems
- Protect and increase the small range of insecticides used for insect pest management including alternatives to broad spectrum insecticides
- Test and promote improved application techniques
- Identify technology which can separate damaged and undamaged cobs during the grading and packing process

An evaluation of the project in 2001 showed that all its objectives were achieved, and particularly in the areas of application technology, risk reduction through adoption of IPM and more and softer

insecticide choices available to sweet corn producers throughout Australia. The major benefit of the project was that industry made significant changes to its pest management practices as a result of the project's activities and results.

Since 1997 the industry has moved a long way in pest management – from calendar spraying synthetic broad-spectrum insecticides (often onto resistant pests and with inefficient application technology) to managing IPM systems which integrate monitoring, selective insecticides and beneficial insects with improved application equipment targeting appropriate plant parts at the right time.

The future direction of IPM in sweet corn was recommended in the evaluation and by the sweet corn industry in the final report as – "Further progress for the industry will rely on developing systems to manage diseases and the secondary pests which have started occurring under IPM, the introduction of pest tolerant plant varieties with high market acceptability and improved in-line damage detection for whole cobs in packing houses. Additional pesticide options will be essential to develop an effective resistance management strategy. This technology also has the promise to increase access to export markets.

Subsequently a further IPM project, "Improved IPM Systems in the Australian Sweet Corn Industry" – VG05025 has commenced to build on the outcomes of VG97036 and to further understand the complexity of IPM in sweet corn, by focussing on the broader range of pests and diseases, and their management in an IPM context. The work program will include:

- An assessment of new "soft options" as additional components of Integrated Pest Management;
- Improved monitoring protocols for a wider range of pests and diseases in sweet corn;
- Identifying naturally occurring beneficial organisms (natural enemies) which have the potential to contribute to sweet corn IPM systems;
- Developing and testing improved IPM strategies, which may include new "soft options" and the enhancement of naturally occurring beneficials; and
- Developing disease management options.

IPM Resources

IPM resources have been developed for the sweet corn industry (Table 1), and disseminated to all growers during the project.

Table 1. IPM resources available to the sweet corn industry

Resource Title	Editions
Sweet Corn Ear Newsletter – 13 Editions	1998 - 2002
Proceedings of Workshops 1. Gatton Research Station, QLD. 2. Bathurst, NSW 3. Bowen Research Station, QLD 4. East Gippsland, VIC	May 1998 May 1999 June 2000 Apr 2001
Milestone reports	
MS2. Documented the present pest management systems associated with major sweet corn growing regions of Eastern Australia; and the identification of Best Management Options (BMO) that would contribute towards an integrated approach to pest management.	April 1998
MS3. Major stakeholders in the sweet corn industry (Confidential Report to HAL).	Aug 1998
MS4. Pesticide application techniques	
MS5. Insect scouting protocols for sweet corn production regions	April 1999
MS6. Compared Best Management Options (BMO) with standard grower practice in each of the major regions in Eastern Australia.	Sept 1999 April 2000
MS7. Conducted cultivar evaluation trials to assess quality, yield and tolerance to pests and diseases.	
MS8. Assessed the practicalities, commercial potential and reliability of techniques for mechanically sorting damaged and undamaged cobs in a sweet corn pack-house.	May 2001 April 2001
Insect pest Management in Sweet Corn – Evaluation: Industry Changes	2001
Spray Application in Sweet Corn Crops – Design Details of Spray Droppers by Tom Franklin, QDPI, Redlands Research Station, Cleveland, Qld.	1999

Sweet Corn Growers Handbook, DPI&F, Queensland	2005
Sweet Corn Insect pests and their natural enemies This is a publication developed by Richard Llewellyn in a related project (VG97040), with input from VG97036 project team members.	2000

Lessons

- ✓ Heliothis and insecticide resistance was the crisis that led to IPM adoption
- ✓ As more biologicals are used a range of secondary pests (aphids, mites and thrips) have emerged as important pests.
- ✓ Scouting protocols an integral part of IPM system
- ✓ Monitoring beneficial insects important
- ✓ Consultants and Field Officers extremely important in the development and adoption of IPM systems
- ✓ Engagement and information sharing between researchers, industry members and their partners essential
- ✓ Access to 'softer' options and knowledge about how to use them important.
- ✓ Regional differences in IPM strategies and adoption

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IPM in the Australian Brassica Vegetable Industry

Dijana Jevremov, SARDI

The Industry

Brassica vegetables are grown in all states of Australia with the majority being produced in New South Wales, Victoria and Western Australia. IPM research in Australia has focussed on addressing pest issues in brococoli, brussels sprouts, cauliflower and cabbages. The many other Asian brassicas grown in Australia have largely not been included in research or extension outside of these European crop varieties. A variable population of around 1400 brassica vegetable growers have been the target group for IPM information, together with their consultants.

The proportion of growers is roughly as follows:

NSW – 400 European, 350 Chinese, 80-100 Vietnamese (1/4 of produce grown is mostly long white radish, kailan, choisum and mizuna)

VIC – 400 European, 13 Vietnamese

WA – 240 European

QLD – 160 European, 50 Vietnamese

TAS – 100 European

SA – 62 European

Of all the states, WA has the largest export market of its produce and Tasmania has the largest market for processing of brassicas.

IPM History

Typical pests of brassica vegetables are Diamondback moth *(Plutella xylostella)*, Centre grub *(Hellula hydralis)*, Cabbage cluster caterpillar *(Crocidolomia pavonana)*, Cluster caterpillar *(Spodoptera litura)*, Heliothis *(Helicoverpa armigera and punctigera)* Cabbage white butterfly *(Pieris rapae)* various aphids and thrips, and in Queensland – Silverleaf whitefly. There are several natural enemies to the pests' such as predatory beetles, lacewings, spiders, and predatory bugs.

Diamondback moth (DBM) is the most destructive pest of brassica vegetables in Australia. Damage is caused by larvae tunnelling into the heads of cabbage and brussels sprouts and by pupal contamination inside cauliflower and broccoli florets. In extreme cases, produce is rendered unmarketable and damaged crops are ploughed in.

DBM is difficult to control with insecticides because it develops rapidly, has overlapping generations, continually available host-plants, low threshold numbers for control, feeds on the undersides of leaves thereby avoiding spray deposits and develops resistance to chemicals rapidly.

For the past 50 years the principal control tactic for DBM has been the use of synthetic insecticides. These treatments invariably disrupt natural enemies, and select for insecticide resistance in DBM. Due to the progressive development of synthetic pyrethroid (SP) and organophosphate (OP) resistance in Australia in the 1980's and 1990's, it became necessary to spray more frequently to achieve control of DBM. Growers found themselves on a "chemical treadmill". Despite the increased spraying, crop losses due to DBM attack continued, often on a larger scale than previously experienced. Significant resistance occurred in the Lockyer Valley Queensland in the mid 1990's leading to no brassica crops being grown and interest in alternative experimentation with crop pest control. It allowed the growth of IPM in the area supported by consultants and resellers.

In the late 1990's two important developments occurred in Australia. Firstly, a national industry-funded (HRDC levy) project (VG97014) to advance the integrated management of DBM in brassica vegetables was initiated. Secondly, five new DBM insecticides were sequentially registered for use in brassica vegetable crops. These insecticides each have different modes of action and metabolism, and several are relatively safe to natural enemies. These developments provided a unique opportunity to improve DBM management and to limit the further development of insecticide resistance by DBM and other brassica pests.

Project VG97014 devised and promoted a "two-window" insecticide resistance management (IRM) strategy in conjunction with AVCARE, and promoted integrated pest management (IPM) as a method for dealing with brassica pests. Several things were actively promoted: the strategic use of insecticides with timing of applications based on information gained through crop monitoring, techniques to achieve

good spray coverage, the avoidance of tank mixes of multiple insecticides, the use of clean seedlings, the maintenance of vigorous plants to resist pests and diseases and the use of crop breaks to reduce DBM numbers and levels of insecticide resistance. Research into DBM movement between vegetable crops was initiated to improve future IPM and IRM systems.

Most Recent Developments

The key outcomes are:

1. A substantial improvement in the awareness and adoption of good IPM and IRM principles and practices by Australian brassica vegetable growers.
2. A major investment in extension activities, focused through grower consultation.
3. The development and validation of a dynamic crop-monitoring guide, which assesses the need to spray based on the number of plants infested with DBM larvae, the crop type, market destination, the stage of crop development and parasitism levels. This guide helps growers and consultants make informed decisions about pest control, incorporates benefits from natural enemies, and saves pest control costs while still delivering a high quality crop. It is explicitly linked with a development calculator for different stages of the pest, the IRM strategies and an Insecticide Toxicity Chart and can be used as a complete IPM/IRM package.
4. Surveys revealed that the adoption of crop monitoring and the "two-window" IRM strategy in the Brassica industry is increasing. This is assisting growers to control DBM and other key pests more cost-effectively and with less selection pressure for resistance.
5. Insecticide resistance screening of DBM populations from around the nation identified widespread synthetic pyrethroid resistance. With the exception of some reduced susceptibility to fipronil in a QLD population, there was no evidence of any shift in susceptibility in any of the screened populations to the new DBM insecticides and the biopesticide, *Bacillus thuringiensis*.
6. Studies of the local movement of DBM and its parasitoids have revealed that in actively growing crops most DBM moths remain within several tens of metres of where they emerged, and their parasitoids move greater distances. Following crop cultivation disturbance, more of the parasitoids dispersed than before cultivation, suggesting that disturbance increased parasitoid movement, which was not the case for DBM.

IPM Resources

IPM resources have been developed for the brassica industry (Table 1), and are freely available to all growers and consultants nationally.

Table 1. IPM resources available to the Brassica industry

Resource Title	Editions
Brassica IPM National Newsletter – 9 Issues so far produced in English and translated to Traditional Chinese.	2002 - 2006
Three State based **IRM strategies** in chart form and updated when needed.	Ongoing since 1998
The Handbook – Integrated Management of Diamondback Moth in Crucifers, National Diamondback Moth Project Team	1998 updated 2000
Field Guide to Pests, Diseases and Disorders of Vegetable Brassicas. Produced by Ag Victoria with HRDC funding.	May 2000
CD & Video **Integrated Pest Mangement for Brassicas**. A comprehensive insight into IPM in Australia on grower properties for both disease and insect pests. Produced in Victoria with levy funding.	2002
Vegenotes – **Brassica Integrated Pest & Disease Management**	Spring 2003
Impact of Insecticides on Natural Enemies Found in Brassica Vegetables – Chart	Reviewed & reprinted 2005
The electronic **crop-monitoring guide and lifestage development calculator**. Accessible at http://www.dpi.vic.gov.au/ (Click on 'Agriculture & Food', then 'Plant Disease & Pests').	2005

In production – **Brassica Vegetable Toolkit**. An interactive decision support CD for diagnosis and treatment of brassica crop issues. Incorporating the electronic crop monitoring guide of the National DBM project. Being produced in Queensland DPI for release in 2007. To be circulated nationally.	pending

Recommendations

The Key recommendations to brassica vegetable growers are:

- To monitor crops to make an informed spray decision
- To make any spray decisions by referring to the DBM project crop-monitoring guide,
- adhere to the AIRAC 'two-window" IRM strategy for their State,
- spray to target larvae rather than moths,
- consult the Insecticide Toxicity Chart to choose products that are soft on beneficials.

Lessons

- ✓ Following an IPM program and the "two-window" IRM strategy will delay DBM developing resistance particularly given movement of DBM is localised.
- ✓ Spraying insecticides to kill moths is an ineffective strategy that may in fact increase the rate of resistance.
- ✓ IPM is improving the economics of brassica vegetable production, increasing the lifespan of the new DBM insecticides, enhancing the benefits from natural enemies, and improving worksafe outcomes and consumer attitudes through reduced reliance on sprays.
- ✓ Future R&D is required on integration of IPM for other brassica pests, better enhancement and management of the natural enemy complex, and to further educate growers and chemical resellers on brassica IPM/IRM.

Useful References *(additional to project resources listed in Table 1)*

Endersby, N.M., Ridland, P.M., (2001). *The management of diamondback moth and other crucifer pests*. In:- "Proceedings of the Fourth International Workshop 26-29 November 2001", Melbourne, Victoria, Australia.

Baker, G et al. (2004). Implementing Pest Management of Diamondback Moth. A final report prepared for Horticulture Australia Limited Research and Development Corporation (HAL Project VG00055 June 2000 – June 2003).

Ridland, P.M., Baker, G (2000). Advancing the integrated management of diamondback moth (DBM) in Brassica vegetables. A final report prepared for the Horticultural Research and Development Corporation (HRDC Project VG97014 June 1997 – June 2000).

Beans: General Information

Common Name: Green & French Beans, Snake beans
Scientific Name: *Phaseolus vulgaris*
Value: $53.2 million (green & French beans) [ABS 2002]
Grown: 33,687 tonnes (green & French beans ABS 2002)

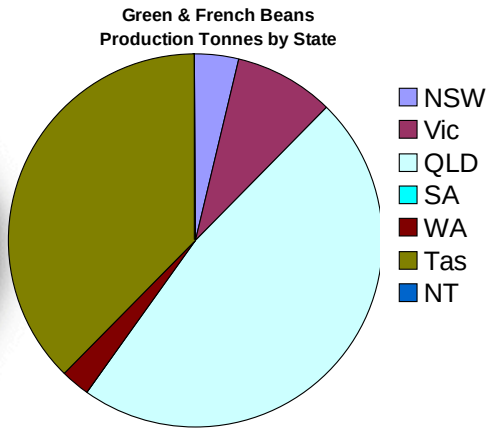


Table 1: Insect Pests of Beans

Insect Pests (workshop)	Scientific Name
Bean root aphid	*Smynthurodes betae*
Green Peach Aphid	*Myzus persicae*
Bean Blossom Thrips	*Megalurothrips usitatis*
Plague Thrips	*Thrips imaginis*
Western Flower Thrips	*Frankliniella occidentalis*
Melon Thrips	*Thrips palmi*
Onion Thrips	*Thrips tabaci*
Leafhoppers	Cicadellidae/Delphacidae
Silverleaf(Poinsettia) whitefly	*Bemisia tabaci (biotype B)*
Green Vegetable Bug	*Nezara viridula*
Rutherglen Bug	*Nysius vinitor*
Beanflower caterpillar	*Jamides phaseli*
Budworms	*Helicoverpa spp.*
Cutworms	*Agrotis spp.*
Loopers	*Chrysodeixis spp.*
Grass blue butterfly	*Zizina labradus labradus*
Whitefringed weevil	*Graphognathus leucoloma*
Bean fly	*Ophiomyia phaseoli*
2-spotted (spider) mites	*Tetranychus urticae*
Australian Plague Locust	*Chortoicetes terminifera*
Brown Slugs	*Deroceras parnormitanum*
Snail	Gastropoda

Table 2 Bean insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
carbaryl	1A
methomyl	1A
pirimicarb	1A
chlorpyrifos	1B
diazinon	1B
dimethoate	1B
disulfoton	1B
maldison	1B
methidathion	1B
parathion-methyl	1B
trichlorfon*	1B
endosulfan	2A
dicofol+tetradifon	2B
bifenthrin	3A
esfenvalerate	3A
permethrin	3A
imidacloprid	4A
spinosad	5A
Btk	11C
propargite	14A
paraffinic oil	
petroleum oil	

* NT & QLD only

Table 3. Bean diseases

Diseases with registered chemical control options	Scientific Name	Diseases reported with no registered chemical control options	Scientific Name
Angular Leaf Spot	*Phaeoisariopsis griseola*	Ascochyta Spot	*Ascochyta fabae*
Anthracnose	*Colletotrichum lindemuthianum*	Ashy Stem Blight	*Macrophomina phaseolina*
Chocolate Spot	*Botrytis fabae*	Cottony leak	*Pythium aphanidermatum*
Damping Off	*Pythium spp.*	Scald	*Rhynchosporium*
Leaf Blight	*Ascochyta fabae*	Root Rot Complex	*Fusarium:Aphanomyces; pythium*
Root Rot	*Rhizoctonia solani*		
Stem Rot	*Rhizoctonia solani*		
Sclerotinia Rot	*Sclerotinia sclerotiorum*		
Rust	*Uromyces viciae-fabae*		
Cercospora Leaf Spot	*Alternaria/Cercospora spp.*	Summer death	
Common Bacterial Blight	*Xanthomonas campestris*	Brown Leaf Spot	*Plieochaeta setosa*
Halo Blight	*Psuedomonas syringe*	Pod Twist	*Pseudomonas flectens*
		Vascular Wilt	*Verticillium*
		Spotted Wilt	
		Bean Yellow Mosaic Virus	
		Peanut Mottle Virus	
		Other: Baldhead	
fungi	bacteria	virus	

Table 4 Bean fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
iprodione*	B
bitertanol	C
tebuconazole	C
oxycarboxin	G
boscalid	G
azoxystrobin	K
chlorothalonil	Y
Copper - various sources	Y
mancozeb	Y
metiram	Y
quintozene	Y
sulfur	Y
thiram	Y
zineb	Y

*QLD only

Bean Variety Resistance available for:
Angular Leaf Spot
Rust
Summer death

Table 5a Regional distribution of pests

Bean Pest / Disease	Perth Metro WA	Carnarvon WA	Kununurra WA	Adel. Plains SA	NW TAS	Northern Midlands TAS	Sunraysia VIC	E & Sth. Gippsland VIC	Sydney Basin NSW	Mid Nth. Coast NSW	Stanthorpe QLD	Gympie QLD	Bundaberg QLD	Bowen QLD	Burdekin QLD	Lockyer Valley QLD
Cowpea Aphid								m	m							
Green Peach Aphid		MR					l	m	R		m	m	m	m	m	m
Bean Root Aphid								m	ml		l	l	l	l	l	l
Bean Blossom Thrip								m	m		l	l	l	l	l	l
Plague Thrip	R			ml	MR	MR	m	m R	R		R	R	R	R	R	R
Western Flower Thrip	R			MR			m		R		?	MR	MR	MR	MR	MR
Melon Thrip											l	l	l	l	l	l
Onion Thrip							R	m R	mR		m	m	m	m	m	m
Leafhopper	l						m	m			MR	MR	MR	MR	MR	MR
Silverleaf Whitefly		MR							mR?					M		M
Greenhouse Whitefly							M	m R	R							
Green Vegetable Bug								m	mR		l	l	l	l	l	l
Rutherglen Bug	l				mR	mR	R	m	mR		l	l	l	l	l	l
Green Mirid	l							m								
Bean pod borer								m				M	M	M	M	M
Budworm/ Heliothis		MR			MR	MR		m	M		M	M	M	M	M	M
Cutworm					MR	MR		m	ml							
Armyworm		MR							ml							
Looper	R	MR						m	m		m	m	m	m	m	m
Grass Blue Butterfly								m								m
White Fringed Weevil								m l	m							l
Bean Fly											M	M	M	M	M	M
2-Spotted Mite	R	MR		mR			R	m	R		m	m	m	m	m	m
Red-Legged Earth Mite				ml				m								
Wingless Grasshopper	l							m	ml							
Black Field								m	l							
Field Cricket								m	l							
Mole Cricket								m	l							
Plague Locust								m	ml		l	l	l	l	l	l
Snail				ml				m	m							
Lucerne Flea				ml				m								
Nematode		mR							m							
M - Major Pest	m - Minor Pest		R - Regular		I - Infrequent		Duff	Workshop	Cavallaro	Dimsey	Chilman	Walsh	Scott*	Ian P.	watson	James

Table 5b Regional distribution of diseases

Bean Pest / Disease	Perth Metro WA	Carnarvon WA	Kununurra WA	Adel. Plains SA	NW Tasmania TAS	Northern Midlands TAS	Sunraysia VIC	E & Sth. Gippsland VIC	Sydney Basin NSW	Mid Nth. Coast NSW	Stanthorpe QLD	Gympie QLD	Bundaberg QLD	Bowen QLD	Burdekin QLD	Lockyer Valley QLD
Angular Leaf Spot								m	ml	ml						
Anthracnose								m		ml	m	m	m	m	m	m
Chocolate Spot					MR	MR			ml		l	l	l			l
Damping Off	l			ml					ml	ml	Ml	Ml	Ml	Ml	Ml	Ml
Powdery Mildew		MR							MR							
Rust							l	m	mR	mR		R		R	R	l
Sclerotinia Rot	l				MR	MR	m	l	ml	ml	MR	MR	R			R
Cercospora Leaf Spot									m	ml	ml	ml	ml	ml	ml	ml
Rhizoctonia				ml					ml	ml		R		R	R	
Ascochyta Spot					ml	ml			m	ml	m	m	m	m	m	m
Ashy Stem Blight									ml	ml		M			Ml	Ml
Cottony Leak										ml	m	m	m	m	m	m
Scald																
Vascular Wilt																
White Mould					MR	MR										
Root Rot Complex	l		mR	ml	MR	MR		l		MR	m	MR	MR	Ml	Ml	l
Anthracnose				ml												
Bacterial Brown Spot									ml	ml	ml	ml	ml	ml	ml	ml
Common Bacterial Blight				ml				m	ml	ml	Ml	Ml	Ml	Ml	Ml	Ml
Halo Blight								m	ml	ml	Ml	Ml	Ml	Ml	Ml	Ml
Brown Leaf Spot									ml	ml	ml	ml	ml	ml	ml	ml
Pod Twist									ml	ml						
Bean Yellow Mosaic Virus											ml	ml	ml	ml	ml	ml
Bean Common Mosaic Virus			mR								ml	ml	ml	ml	ml	ml
Peanut Mottle Virus											ml	ml	ml	ml	ml	ml
Summer Death																Ml
Wind Scar					MR	MR										
M - Major Pest	m - Minor Pest		R - Regular		I - Infrequent		Duff	Workshop	Cavallaro	Dimsey	Chilman	Walsh	Scott*	Ian P.	watson	James

Table 6a Current and possible management options for key pests

BEANS	Heliothis	Bean pod borer	Silverleaf whitefly	Thrips (WFT, onion, plague)	Beanfly	Leafhoppers	Two Spotted mite
Diagnosis/detection	visual/damage	visual/damage	visual	visual/damage	visual	visual	visual
Monitoring	pheromones, visual	visual	bugvac, visual, sticky traps	bugvac, visual, sticky traps	bugvac, visual, sticky traps	bugvac, visual, damage	visual/damage
Thresholds	none						
Beneficials	*Trichogramma*, general predators and parasites	predators	*Eretmocerus*	few	few	few	predators
Cultural controls	post harvest cultivation		crop break	weed management			
Pesticide lists	Bt, spinosad, OPs, permethrin, carbamates	Bt, OPs, carbamates	imidacloprid, bifenthrin	methomyl, esfenvalerate, endosulfan, OPs, spinosad	diazinon, dimethoate, methomyl	endosulfan, OPs	dicofol + tetradifon, dicofol, dimethoate, sulfur, propargite
Controls							
Training	Pest ID workshops/ field days/demo plots/spray application as part of two funded projects						
Fact sheets	DPI Notes bean series: Sucking pests, Chewing pests, Beneficials, Crop monitoring, IPM						
Field guides	Field guide being proposed as extension to current project through QLD and HAL, Included in *Vegetable insect pests and their natural enemies in the dry topics* QDPI &F						
Information guides	Included in: *IPM in Vegetables in Tasmania* (TAS DPWIE)						
Newsletters	*IPM in green beans* newsletter (QDPI&F)						
Prediction models	No						
IRM			too few options	too few options (WFT)			
Best Management options	start made in VG02030						
R&D Gaps	NPV registration, Threshold work could be looked at.	spinosad, indoxacarb Pheromones could be developed	pymetrozine as foliar	Work needed to address Tasmania issue (wind scorch?), Soft options		soft options, biologicals	

Table 6b Current and possible management options for key diseases

BEANS	Damping off	Sclerotinia	Root rot complex	Ashy stem blight	Common bacterial blight	Powdery Mildew	Halo Blight	Chocolate Spot
Diagnosis/detection	visual/lab	visual	lab- difficult	visual/lab	lab-difficult	visual/lab	visual/lab	visual/lab
Monitoring		visual						
Thresholds		Apply fungicide at flowering onwards						
Beneficials	unknown							
Cultural controls	clean seed, crop rotation, avoid overwatering	rotation		Crop rotations	clean seed, crop rotation, implement santitation	am watering	clean seed, crop rotation, implement santitation	clean seed, crop rotation
Pesticide lists	thiram	azoxystrobin, boscalid, iprodione			Cu		Cu	Cu, mancozeb, chlorothalonil
Controls							Resistant Var.	
Training	Pest ID workshops/ field days/demo plots/spray application as part of two funded projects							
Fact sheets	NSW DPI producing as part of existing project				DPI Vic			
Field guides	Field guide being proposed as extension to current project through QLD and HAL							
Information guides	No							
Newsletters								
Prediction models			No	No	No	No	No	No
IRM								
Best Management options	working on in VG03002							
R&D Gaps		Development of sclero prediction model Biocontrol of soil fungi options	management options needed	need management options	Work needed for control options, PCR testing of seed, cultural.	management options	Work needed on possible cultural and chemical control options	Fungicide resistance screening

Current IPM options

Basic disease management:

1. Select resistant varieties
2. Source disease-free seed
3. Heat treat seed if bacterial and fungal diseases a major problem
4. Avoid double cropping or cropping after other legume
5. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
6. Chip diseased plants
7. Good sanitation particularly in presence of bacterial diseases
8. Manage virus vectors when virus is present in crop or neighbouring area

Basic insect management

1. Monitor crops on weekly basis – Bug vac, visual inspection
2. Heliothis: monitoring eggs, larvae, & moths, Bt, and/or Success® and endemic beneficials & Trichogramma parasitoid
3. Beanborer: Bt, Success® and beneficials
4. SLW: *Eretmocerus* spp. biological control, crop break (need break from all SLW hosts), reduce weeds that host SLW

Potential Options

1. Biopesticides for SLW and thrips
2. Registration/permit: spinosad (Success®) & indoxacarb (Avatar®) for bean pod borer, NPV for Heliothis, pymetrozine (Chess®) for SLWF

Recommended work

Specific

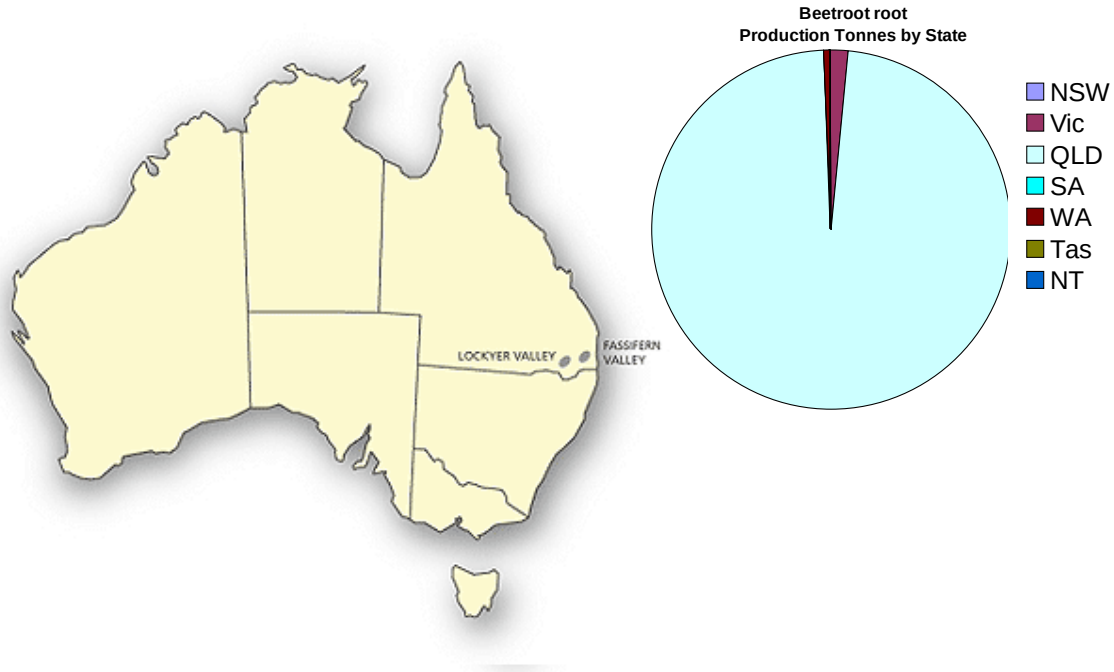
1. Registration/permit: Success® & Avatar® for bean pod borer, NPV for Heliothis, Chess® for SLWF
2. Action thresholds/recommendations for key pests
3. Potential to develop of pheromones for Bean pod borer
4. Evaluation of biopesticides for SLW, thrips and leafhoppers
5. Clarify whether observed damage to beans in Tasmania is caused by thrips or wind
6. Need cultural control options for common bacterial blight
7. Work needed on Ashy stem blight across host range and investigating possible cultural and chemical control options
8. Management options for bean stem & root diseases still in progress
9. Field identification guide (funded)

General

1. Soil diseases - prediction modelling, crop rotations
2. Biological options for soil diseases, including understanding of degredation of soil pathogens
3. IRM to integrate with other cropping systems - regional / Area Wide
4. Soft options and biocontrol for SLW, thrips RGB and leafhoppers needed
5. Screening fungi resistance to fungicides
6. Test kits for disease identification

Beetroot: General Information

Common Name: Beetroot
Scientific Name: *Beta vulgaris* spp vulgaris
Edible Plant Part: Root/ Baby leaf
Value: $8.3 million (gross value beetroot root) [ABS 2002]
Grown: 39,013 tonnes



Grown successfully in most parts of NSW & Qld.

Table 1 Beet root and leaf pests

Insect pests (workshop)	Scientific Name
Aphids	Aphididae
Thrips	Thysanoptera
Leafhoppers	Cicadellidae
Rutherglen Bug	*Nysius vinitor*
Beet Webworms	*Hymenia recurvalis*
Cutworms	*Agrotis spp.*
Black Field Cricket	*Teleogryllus commodus*
Earwigs	Dermaptera
Leafmining flies	*Liriomyza betae*
Root-knot Nematodes	*Meloidogyne spp.*

green= leaf

Table 2 Beet insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
endosulfan	1A
pirimicarb	1A
methomyl	1A
dimethoate	1B
fenamiphos	1B
diazinon	1B
chlorpyrifos	1B
Lambda-cyhalothrin	3A
spinosad	5A
pymetrozine	9A
paraffin & paraffinic oil	
petroleum oil	

Table 3. Beet diseases

Diseases with registered chemical control options	Scientific Name	Diseases reported with no registered chemical control options	Scientific Name
Leaf Spot	*Cercospora beticola*	Black Root Rot	*Aphanomyces cochlioides*
Rhizoctonia/ Stem Rot	*Rhizoctonia solani*	Damping Off	*Pythium*
		Botrytis	
		Sclerotium Base Rot	*Sclerotium rolfsii*
fungi	bacteria	virus	

Table 4 Beet fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
procymidone chlorthalonil	B B
iprodione	B
propiconazole	C
tolclofos-methyl	X
Copper various sources	Y
mancozeb	Y
zineb	Y

Table 5 Regional Distribution of Pests and Diseases

Beetroot Pest / Disease	Cowra NSW	Lockyer Valley QLD	Fassifern Valley QLD
Aphids			
Green Peach Aphid			
Potato Aphid			
Fennel Aphid			
Carrot Aphid			
Thrips			
Leafhoppers			
Bugs			
Green Vegetable Bug			
Rutherglen Bug			
Beet Webworm		mR	
Cutworms	I		
Black Field			
Earwig			
Leafmining Fly			
Root Knot Nematode		ml	
Fungi			
Cercospora Leaf Sopt		M m	M m
Rhizoctonia	I	MR	MR
Black Root Rot		MR	MR
Botrytis		ml	ml
Pythium (Aphanidermatum, Ultimum, Dissotocum)		MR	MR

M - Major Pest
m - Minor Pest
R - Regular
I - Infrequent

Walsh
Workshop
McDougall

Table 6 Current and possible management options for key pests & diseases

BEETROOT	Cercospora (foliar)	Rhizoctonia	Damping Off	Black root rot
Fresh/process/babyleaf Diagnosis/detection	*Cercospora* babyleaf visual/lab	*Rhizoctonia* processing visual/lab	*Pythium* processing visual/lab	*Aphanomycetes* processing visual/lab
Monitoring	seasonality	visual/lab	visual/lab	visual/lab
Thresholds	none			
Beneficials	Unknown	Unknown	Unknown	unknown
Cultural controls		Crop rotation needed	Crop rotation, avoid over watering	Crop rotation needed
Pesticide lists	chlorothalonil, Cu, mancozeb, zineb	Rizolex®	Phos acid	
Other Controls		rotations, sanitation	rotations, sanitation	rotations, sanitation
Training	none			
Fact sheets				
Field guides	Field guide needed, foliar pests and diseases should be included in a leafy veg field guide			
Information guides	none			
Newsletters	none			
Prediction models		Needed	Needed	Needed
IRM	none			
Best Management options	none			
R&D Gaps		Prediction model for soil diseases		

Current IPM options

Basic disease management:

1. Source disease-free seed
2. Heat treat seed if bacterial and fungal diseases a major problem
3. Avoid double cropping
4. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
5. Chip diseased plants
6. Good sanitation particularly in presence of bacterial diseases

Basic insect management:

1. Monitor fresh market crops on weekly basis – Bug vac, visual inspection for leaf diseases
2. Process crops: visually monitor during early establishment for insect pests, treat if infestation causing serious damage (not currently defined)

Potential Options

Recommended work

Specific

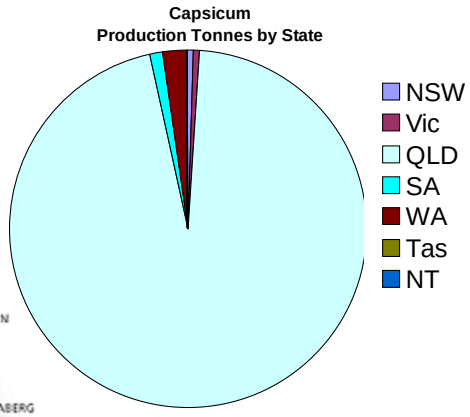
1. Benchmarking current practices and monitoring of rejections from processors and fresh markets
2. Refer to Asian vegetable project (similar pests, beneficials, pesticide requirements (incl. short WHP, training, etc.) for Baby leaf
3. Field guides for both baby leaf and processing beets incl. symptoms, size scale, weeds
4. Understanding of beneficials in the crop / use of sequential planting-processing and baby leaf

General

1. Soil diseases - prediction modelling, crop rotations
2. IRM to integrate with other cropping systems - regional / Area Wide
3. Soil pests need monitoring/predicting guidelines and soft options for managing
4. Soft options and biocontrol for thrips, Rutherglen bug and leafhoppers needed

Capsicums: General Information

Common Name: Capsicum
Scientific Name: *Capsicum annuum*
Edible Plant Part: Fruit
Value: $64.2 million gross value (ABS 2002)
Grown: 41,859 tonnes (ABS 2002)



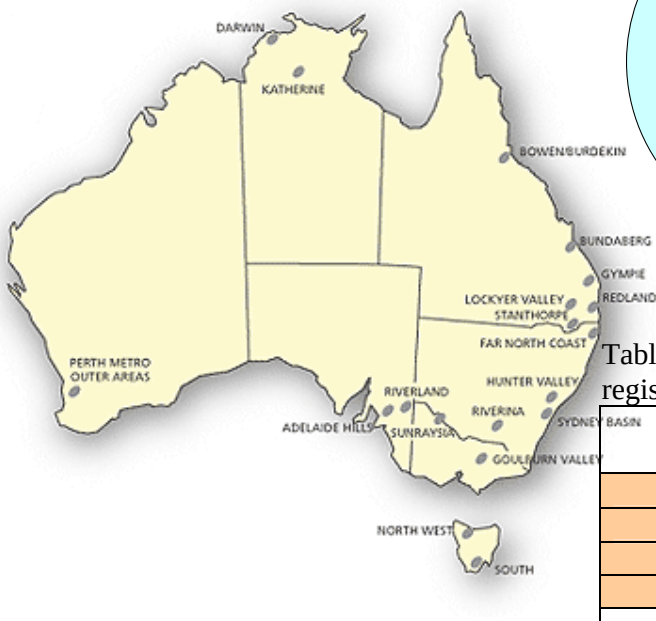


Table 1 Capsicum insect pests

Insect pests (workshop)	Scientific Name
Aphids	Aphididae
Green Peach Aphid	*Myzus persicae*
Cowpea Aphid	*Aphis craccivora*
Cotton Aphid	*Aphis gosspii*
Potato Aphid	*Macrosiphum euphorbiae*
Thrips	Thysanoptera
Melon Thrips	*Thrips palmi*
Western Flower Thrips	*Frankliniella occidentalis*
Tomato Thrips	*Frankliniella schultzei*
Onion Thrips	*Thrips tabaci*
Leafhoppers	Cicadellidae/Delphacidae
Whitefly	Aleyrodidae
Silverleaf(Poinsettia)whitefly	*Bemisia tabaci*
Bugs:	Hemiptera
Green Vegetable Bug	*Nezara viridula*
Rutherglen Bug	*Nysius vinitor*
Budworms	*Helicoverpa spp.*
Cutworms	*Agrotis spp.*
Vegetable beetle	*Gonocephalum elderi*
Fruit flies	Tephritidae
2-Spotted Mite	*Tetranychus urticae*

Table 2 Capsicum insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
pirimicarb	1A
carbaryl*	1A
methomyl	1A
thiodicarb	1A
acephate	1B
dimethoate	1B
fenthion	1B
parathion-methyl^	1B
chlorpyrifos	1B
methamidophos	1B
fenthion	1B
methidathion	1B
diazinon	1B
trichlorfon	1B
endosulfan	2A
dicofol+tetradifon	2B
beta-cyfluthrin	3A
imidacloprid	4A
spinosad	5A
emamectin as benzoate	6A
abamectin	6A
Btk	11C
indoxacarb	22A
botanical oil - emulsifiable	
paraffin or paraffinic oil	
petroleum oil	
* NSW only ^ QLD only	

Spider Mite	Tetranychidae
Redlegged Earth Mite	*Halotydeus destructor*

Table 3. Capsicum diseases

Diseases with registered chemical control options	Scientific Name	Diseases reported with no registered chemical control options	Scientific Name
Anthracnose	*Colletotrichum acutatum*	Stem Rot	*Fusarium Solani*
Damping Off	*Pythium spp.*	Sudden Wilt Complex	*Pythium spp.*
Grey Mould	*Botrytis cinerea*		
Phytophthora soil fungus	*Phytophthora spp.*		
Powdery mildew	*Sphaerotheca spp.*		
Sclerotium base rot	*Sclerotium rolfsii*		
Target spot/early blight	*Alternaria solani*		
Alternaria Fruit Rot	*Alternaria sp.*		
Downy Mildew	*Pseudoperonospora cubensis*		
Septoria Spot	*Septoria spp.*		
white mould/rot	*Sclerotinia sclerotiorum*		
Base Rot	*Rhizoctonia solani*		
Bacterial Canker	*Clavibacter michiganensis ssp. michiganensis*	Bacterial Soft Rots	*Erwinia carotovora*
Bacterial Spot	*Xanthomonas campestris pv. vesicatoria*	Bacterial wilt	*Ralstonia solanacearum*
		Mosaic (Potato virus Y)	
		Tomato spotted wilt virus	
		Cucumber mosaic virus	
		Capsicum mosaic virus	
		Other: Yolo spot	
fungi	bacteria	virus	

Table 4 Capsicum fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
procymidone	B
triadimenol*	C
metalaxyl	D
metalaxyl-M	D
bupirimate	H
chlorothalonil	Y
copper - Various Sources	Y
mancozeb	Y
quintozene^	Y

* QLD and WA only ^QLD only

Cultural Management Options

Resistant/tolerant varieties are available for Bacterial spot, Mosaic (Potato virus Y), TSWV and Yolo spot.

Table 5 Resistant or Tolerant Capsicum Varieties

CAPSICUM:	Company	Bacterial Spot	PVY	TSWV	Pepper Mild Mottle	TMV	Yolo Spot (Stip)	Blossom End Rot	Crazing	Russeting
Heated Varieties										
Derby	De Ruiter Seeds				H					
Boogie	RZ				H					
Inspiration	RZ				H					
Mandy	RZ				H			S	S	
Orangery	RZ				H					
Zamboni	RZ			HP	H				S	
Kapto	SPS			L						
Unheated Varieties										
Hugo	De Ruiter Seeds				H					
Requena	De Ruiter Seeds			HP	H					
Emily	RZ				H	H				
Mazurka	RZ				H		S			S
Taranto	RZ				H					
Trovo	RZ		H	HP	H					
Yatasto	RZ		H	HP	H					
Blocky										
DRP 3948	De Ruiter Seeds			P						
PurpleFlame	De Ruiter Seeds							S		
Flamenco	RZ					H		H	H	
Sympathy	RZ					H				
Sweet										
Bendigo	Terranova Seeds	H								
Broadbeach	Terranova Seeds	H								
Denison	Terranova Seeds	P	P	P		P				
Dorito	Terranova Seeds	H								
Blitz	Yates	H					P			
Captivate	Yates	H					P			
Carnival	Yates	H								
Logie	Yates	H								
Mamba	Yates	H	H							
Red Emperor	Yates	H								
Yolo Wonder	Yates						P			
Bullhorn										
Ace	Yates					Int				

Int=Intermediate
H=High
S=Strong
L=Low
P=Partial

Table 6a Regional distribution of pests

Capsicum Pests	Perth Metro WA	Carnarvon WA	Darwin NT	Nth. Adel. Plains SA	Adel. Hills SA	Riverland SA	NW TAS	Sunraysia VIC	Goulburn Valley VIC	Sydney Basin NSW	Far Nth. Coast NSW	Stanthorpe QLD	Lockyer Valley QLD	Bundaberg QLD	Bowen / Burdekin QLD
Aphid		MR													
Cotton Aphid									m	ml					
Green Peach Aphid	m ml R	MR		ml	ml		MR	R	m R	MR		M	mR	mR	
Cowpea Aphid							Ml	R	m R	ml					
Potato Aphid										Ml					
Thrips		MR								R					
Melon Thrips			MR						M					m	
Western Flower Thrips	MR	MR		MR	MR		mR	M	M	MR			R	MR	
Tomato Thrips	mR			mR	MR			R	m R	MR				m	
Onion Thrips	mR			mR	mR		MR	R	m R	MR				mR	
Leafhopper	l				ml			R	R	R					
Whitefly		MR		mR						MR					
Silverleaf Whitefly		MR							m	R				ml	
Green Vegetable Bug	ml				ml				m	ml				ml	
Rutherglen Bug	ml				ml			m	m	m				ml	
Lace Bug									m						
Mealybug	ml	MR							m	ml				ml	
Green Stink Bug									m					ml	
Harlequin Bug									m						
Leptocoris Bug									m						
Coon Bug									M						
Caterpillar		MR		ml			Ml								
Budworm (*Heliothis*)	m	MR			ml		mR	m	M m	Rm		M	MR	MR	
Armyworm		MR					Ml								
Cluster Caterpillar		MR							m					M-m R-l	
Eggfruit Caterpillar									m	R			ml	ml	
Potato Moth (Leafminer)										ml					
Cutworm					ml		MR		m				mR	ml	

Capsicum Pests	Perth Metro WA	Carnarvon WA	Darwin NT	Nth. Adel. Plains SA	Adel. Hills SA	Riverland SA	NW TAS	Sunraysia VIC	Goulburn Valley VIC	Sydney Basin NSW	Far Nth. Coast NSW	Stanthorpe QLD	Lockyer Valley QLD	Bundaberg QLD	Bowen / Burdekin QLD
Looper Caterpillar	ml	MR		ml	ml		mR			ml					
Northern False Wireworm													ml	ml	
Vegetable Beetle	ml														
Fruit Fly		MR								m			R	MR	
Cucumber Fly									m					NP	
Metallic-Green Tomato Fly									m						
Ferment Fly								m	m	m					
Tomato Russet Mite	ml							m	M	m				m	
2-Spotted Mite	MI R	MR		MR	MI		MI	m	m	MR		I	MR	M-m R	
Spider Mite	MI R								m	MR		I		M-m R	
Broad Mite	I			mMI	ml				m	mR				m R-I	
Red-Legged Earth Mite		MR			ml				m	I					
Wingless Grasshopper	ml								m	I		I			
Australian Plague Locust	ml								m	I					
Yellow-Winged Locust	ml								m						
Brown Slug					ml				m						
Reticulated Slug									m						
Common Garden Snail	ml														
Root Knot Nematode		m		mMR	MR			m	m	m		m			

M - Major Pest m - Minor Pest R - Regular I - Infrequent Broughton Chilman Cavallaro Dimsey Porter WG Steiner Walsh

Table 6b Regional distribution of diseases

Capsicum Diseases	Perth Metro WA	Carnarvon WA	Darwin NT	Nth. Adel. Plains SA	Adel. Hills SA	Riverland SA	NW TAS	Sunraysia VIC	Goulburn Valley VIC	Sydney Basin NSW	Nth. Coast NSW	Stanthorpe QLD	Lockyer Valley QLD	Bundaberg QLD	Bowen / Burdekin QLD
Anthracnose					ml					m		mR	m	MR (Chilli)	m
Pythium/Damping Off		M		mMR	MR					ml		m	m	m	m
Botrytis/Grey Mould	I			MR	MR		MI	R	R	mR		ml	ml		
Phytophthora Soil Fungus				ml	ml					ml					
Powdery Mildew	I	MR		MR	MR			m	m	R		MR	MR	MI	MR
Sclerotium Base Rot	I			m	ml			m	m	m		MR	MR		MR
Target Spot (Early Blight)		MR		MI	ml			m	m	m				m	m
Alternaria Fruit Rot				m	ml					m		m	m	m	m
Downy Mildew								m	m	I					
Septoria Spot				m	M	M									
Black Spot		m													
Sclerotinia/White Mould				M											
Base rot *Rhizoctonia solani*				M	MR	M				R		m	m		
Stem Rot	I			m											
Sudden Wilt Complex										m		m		MR	MR
Bacterial Canker					ml					m					
Bacterial Spot				m	ml	m		m	m	m		M	MI	MI	MI
Bacterial Soft Rot				m						m		MI	MI	MI	MI
Bacerial Wilt										ml					
Mosaic (Potato Virus Y)				MR	MR	MR				MR		m	m	m	m
Tomato Spotted Wilt Virus	MR			MR	mR MR	mR		M	M	m		mR	mR	mR	MR
Cucumber Mosaic Virus		mR						R	R	m					
Capsicum Chlorosis Virus												mR	mR	MR	MR
Capsicum Mosaic Virus (Pepper Mild Mottle Virus)								R	R	m					
Yolo Spot												mR	mR	m	m

M - Major Pest m - Minor Pest R - Regular I - Infrequent Cavallaro Chilman Porter Steiner Walsh Dimsey WG Broughton Burfield

Table 7a Current and possible management options for key pests

CAPSICUM	Caterpillars (Heliothis, Armyworm)	Thrips	Whiteflies	Aphids	Two spotted mite	Fruitfly	Root Knot Nematode
Diagnosis/detection	visual	visual	visual	visual	visual	visual	lab
Monitoring	Pheromones, visual, bugvac	sticky traps, bugvac, visual	sticky traps, bugvac, visual	sticky traps, bugvac, visual	bugvac, visual	baits	soil sample, root inspection
Thresholds							
Beneficials	*Trichogramma*, general preds & parasitoids	few -poorly understood	*Eretmocerus* (SLW)	general predators & parasitoids	predatory mites		
Cultural controls			Crop break	cereal plantings to build beneficial populations on cereal aphids			clean machinary, water and uninfested seedlings, remove plants from soil after harvest, weed free fallow and cereal rotations
Pesticide lists	Bt, Bt aizawai for cluster caterpillar, NPV (Heliothis), indoxacarb	spinosad (WFT), OPs, pyrethrins, Endosulfan	oils, Agri50, Beauveria	pirimicarb, pymetrozine, pyriproxyfen, OPs	dicofol + tetradifon, abamectin, dicofol, dimethoate, sulfur, propargite	dimethoate, fenthion, trichlorfon	
Controls		Insecticide only (current)	Insecticide and beneficial	Insecticide and beneficial	Insecticide and beneficial		
Training	during funded projects						
Fact sheets	WFT/resistance management (NSW), Growing capsicum and chilli - Common questions (QDPI)						QLD, Vic, NSW
Field guides	no						
Information guides	*Capsicum and chilli Agrilink* (QDPI), *Multi-tactic crop protection manual for outdoor capsicums* (NZ), *Pests, diseases, disorders and beneficials in greenhouse vegetables* (NSW DPI), *IPM for greenhouse capsicums* (NZ)						
Newsletters		WFT - Qld newsletter					
Prediction models	No						
IRM							
Best Management options							
R&D Gaps		soft options: predators & biopesticides	soft options	impact of insectary crops, biopesticides	liquid S (broadmite), bifenazate , amorphous silica	control options and trade reqirements (whether present as pest or not) disrupt caterpillar management	need management options

Table 7b Current and possible management options for key diseases

CAPSICUM	Damping Off	Botrytis/ Grey Mould	Powdery mildew	Sclerotium Base Rot	Target Spot (Early Blight)	Base rot/ Rhizoctonia	Sudden wilt (complex of fungi)	Capsicum Chlorosis Virus	Potato Virus Y	TSWV
Diagnosis/detection	visual/lab	visual/lab	visual/lab	visual/lab	visual/lab	visual/lab	visual/lab	visual/lab	visual/lab	visual/lab
Monitoring	germination visual inspection	visual	visual	visual	visual	visual	visual	visual	visual	visual, test kits
Thresholds										
Beneficials	poorly known									
Cultural controls	clean seed, crop residues		none	rotation	clean seed, rotations			crop rotation for some diseases and resistant cv for some other viruses		resistant varieties
Pesticide lists		chlorothalonil	triadimenol, bupirimate	procimidone, quintozene	mancozeb					
Controls								management of solanaecous weeds	Aphid & solanaecous weed management	Thrips & weed management
Training										
Fact sheets	*WFT/resistance management* (NSW), *Growing capsicum & chilli - Common questions* (QDPI)									WA
Field guides	*Pests, diseases, disorders and beneficials in greenhouse vegetables* (NSW DPI), Included in *Vegetable insect pests and their natural enemies in the dry topics* (QDPI &F)									
Information guides	*Capsicum and chilli Agrilink* (QDPI), *Multi-tactic crop protection manual for outdoor capsicums* (NZ), *IPM for greenhouse capsicums* (NZ)									
Newsletters	No									WFT newsletters
Prediction models	No	potential			No					
IRM	few options									
Best Man. options	No									
R&D Gaps	varietal susceptibility & status of fungicide efficacy/ resistance & more permitted options to allow for resistance management								varieties currently grown have no resistance to PVY	

Current Capsicum IPM options

Basic disease management:

1. Select resistant varieties
2. Source disease-free seed
3. Heat treat seed if bacterial and fungal diseases a major problem
4. Avoid double cropping or cropping after other solanaceous crops
5. Monitor crops on weekly basis – Bug vac and visually inspect flowers, sticky traps for SLW, pheromone traps with Heliothis, fruitfly
6. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
7. Chip diseased plants
8. Good sanitation particularly in presence of bacterial diseases
9. TSWV – remove thrips & wilt weed hosts, monitor thrips numbers manage WFT with spinosad. No soft options for other thrips. WFT, Tomato, Onion and Melon thrips are vectors.

Basic insect management

1. Monitor crops on weekly basis – Bug vac, visual inspection
2. Manage virus vectors when virus is present in crop or neighbouring area
3. Heliothis: visual monitoring of eggs, larvae & damage, and pheromone traps for moth flight & species monitoring: Bt, NPV, spinosad, indoxacarb and endemic beneficials & Trichogramma parasitoid. Target sprays at egg hatch.
4. Cluster caterpillar: monitoring eggs & larvae: Bt, spinosad and beneficials
5. SLW: *Eretmocerus* spp. biological control, crop break (need break from all SLW hosts), reduce weeds that host SLW
6. Aphids: endemic beneficials, pirimicarb or pymetrozine
7. Fruitfly: monitoring traps, baits, destruction of crop residues

Potential Capsicum IPM Options

1. Biopesticides for thrips, SLW and aphids
2. Biocontrol for thrips, SLW and aphids
3. Insectary crops
4. Prediction models for Powdery Mildew
5. Broader fungicide options
6. Disease resistant varieties

Recommended work

Specific

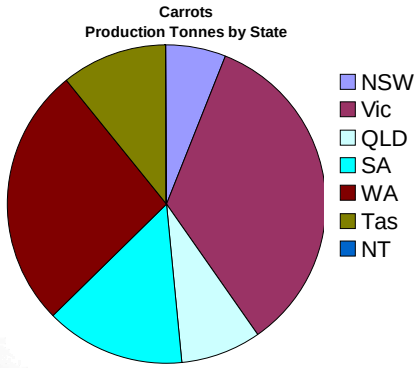
1. Permit or registration for mite control of liquid sulphur (broad mite), bifenazate (TSM) and amorphous silica (TSM)
2. Need solanaceous fruit IPM and field guides
3. Fruit fly regulatory requirements an issue - Export markets require growers to use dimethoate and/or trichlorfon even though no Qfly present.
4. Varietal susceptibility to powdery mildew and other fungal diseases

General

1. Efficacy and registration data required for thrips, whiteflies, aphids and mites
2. Data on side effects of existing and potential pesticides on beneficials needs to be quantified incl. reproduction
3. Status of fungicide efficacy/resistance
4. Fungicide impacts on beneficials

Carrots: General Information

Common Name: Carrots
Scientific Name: *Daucus carota*
Edible Plant Part: Root
Value: 331,130 tonnes $198.5 million [ABS 2002]



Grown:

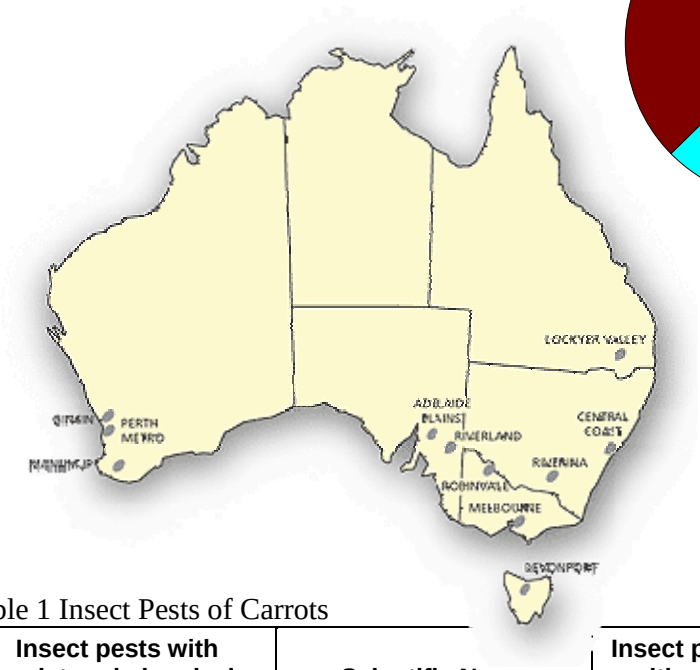


Table 1 Insect Pests of Carrots

Insect pests with registered chemical controls	Scientific Name	Insect pests reported with no registered chemical controls	Scientific Name
Aphids:	Aphididae		
Carrot Aphid	*Cavariella aegopodii*		
Fennel Aphid	*Dysaphis foeniculus*		
Cowpea aphid	*Aphis craccivora*		
Thrips	Thysanoptera		
Leafhoppers	Cicadellidae		
Bugs:	Hemiptera	Green Mirid	*Creontiades dilutus*
Green Vegetable Bug	*Nezara viridula*	Coon Bug	*Oxycarenus arctatus*
Rutherglen Bug	*Nysius vinitor*	Roolt Mealybug	*Rhizoecus falcifer*
Caterpillars	Lepidoptera		
Lucerne Leafroller	*Merophyas divulsana*		
lightbrown apple moth	*Epiphyas postvittana*		
Cutworms	Agrotis spp.		
Corn earworm	*Helicoverpa armigera*	Whitefringed weevil	*Naupactus leucoloma*
28-spotted potato ladybird	*Epilachna vigintisexpunctata*	vegetable beetle	*Gonocephalum elderi*
Spotted vegetable weevil	*Desiantha diversipes*	wireworms	*Elateridae*
vegetable weevil	*Listroderes difficilis*	False wireworms	*Gonocephalum walkeri*
Leafminer flies	*Agromyzidae*		
Mites:	Acarina		

Redlegged Earth Mite	*Halotydeus destructor*		
Spider mites	*Tetranychus spp.*		
Field crickets	Gryllidae		
Mole Crickets	Gryllotalpidae		
Wingless Grasshopper	*Phaulacridium vittatum*		
Black Field Cricket	*Teleogryllus commodus*		
Australian Plague Locust	*Chortoicetes terminifera*		
Yellow winged Locust	*Gastrimargus musicus*		
Black-keeled slug	*Milax gagates*		
brown slug	*Vaginulus plebeius*		
reticulated slug	*Deroceras reticulatum*		
Snails	*Gastropoda*		
Root-knot nematode	*Meloidogyne spp.*		

Table 2 Carrot insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
carbaryl*	1A
chlorpyrifos	1B
diazinon	1B
dimethoate	1B
fenamiphos	1B
maldison	1B
parathion-methyl*	1B
phorate	1B
endosulfan^	2A
spinosad	5A

* QLD only ^ WA and SA only

Table 3 Carrots Fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
procymidone	B
difenoconazole	C
metalaxyl	D
metalaxyl-M	D
azoxystrobin*	K
chlorothalonil	Y
mancozeb	Y
metiram	Y
zineb	Y
thiram^	Y
Copper - Various Sources	Y

* SA and WA only ^QLD only

Table 4 Carrots Diseases

Diseases with registered chemical control options	Scientific Name	Diseases reported with no registered chemical control options	Scientific Name
Alternaria Leaf Spot	*Alternaria dauci*	Rhizopus rot	*Rhizous arrhizus*
Damping off	*Pythium spp., Rhizoctonia* and *Alternaria radicina*	Cavity Spot	*Pythium sulcatum*
Sclerotinia rot	*Sclerotinia spp.*	Black Root Rot	*Thielaviopsis basicola*
Phytophthora Soil Fungus	*Phytophthora spp.*	Sclerotium Base Rot	*Sclerotium rolfsii*
Septoria Spot	*Septoria spp.*		
Leaf Blight	*Alternaria dauci*		
Early Blight	*Alternaria/Cercospora spp.*		
Cercospora Leaf Spot	*Cercospora carotae*		
		Black Ring	*Fusarium spp.*
		Bacterial Soft Rot	*Erwinia chrysanthemi*
		Soft Rot	*Erwinia carotovora*
		Scab	*Streptomyces scabiei*
		Motley Dwarf Diseases	
		Celery Mosaic Virus	
Fungi:	Bacteria:	Virus:	

Cultural Management Options

Resistant/tolerant varieties are available for Alternaria, Cercospora, Cavity spot and Black rot.

Table 5 Resistant or Tolerant Carrot Varieties

CARROT	Company	Alternaria	Powdery Mildew	Cavity Spot	Cercospora	BlackRot	Bolting
Baby/Bunching							
Adelaide F1	Bejo	H	H				
Napoli F1	Bejo			H			
Maincrop							
Nigel F1	Bejo			H		H	
Processing/Industry							
Cascade	Bejo	H		H	H		
Kamaran F1	Bejo	H				H	
Kathmandu F1	Bejo	H			H		P
Kendo	SPS	Eint					
Leonardo	SPS			R			R
Stefano	SPS	Int		Int			

E=Excellent
H=High
P=Partial
Int=Intermediate
R=Reasonable

Table 6 Regional distribution of pests and diseases

Carrot Pest / Disease	Gin Gin WA	Perth WA	Myalup WA	Adel. Plains SA	Riverland SA	NW TAS	NE TAS	Devonport TAS	Robinvale VIC	Melbourne VIC	Riverina NSW	Lockyer & Fassifern Valleys QLD
Aphids	ml	ml	ml							m		
Green Peach Aphid										m		
Carrot Aphid				ml						mR I	m	
Fennel Aphid										mR		ml
Cowpea Aphid										mR		
Thrips				ml						m R		
Leafhopper									I	m R		
Green Vegetable Bug										m R		
Rutherglen Bug									m	m R		
Green Mirid Bug										m		
Coon Bug									m	m		
Root Mealybug										m		
Caterpillar				ml							ml	
Light-Brown Apple Moth										m	m	
Lucerne LeafRoller										m	m	
Cutworm	ml	ml	ml			MR	MR			m	ml	
Vegetable Weevil	ml	ml	ml							m		
Wireworm				ml						m	MR	
False Wireworm				ml						m	ml	
Red-Legged Earth Mite				ml		mR	mR			m		

Carrot Pest / Disease	Gin Gin WA	Perth WA	Myalup WA	Adel Plains SA	Riverland SA	NW TAS	NE TAS	Devonport TAS	Robinvale VIC	Melbourne VIC	Riverina NSW	Lockyer & Fassifern Valleys QLD
Spider Mite										m		
Field Cricket									I	m	ml	
Mole Cricket										m	ml	
Wingless Grasshopper										m		
Black Field Cricket										m		
Australian Plague Locust										m		
Yellow Winged Locust										m		
Black-Keeled Slug										m		
Brown Slug				ml						m		
Reticulated Slug										m		
Snail				MR						m		
Root Knot Nematode	MR	MR	MR						R	I		
Nematode	MI	MI	MI	MR		MR	MR					
Lucerne Flea						mR	mR					
Diseases												
Alternaria Leaf Spot				ml		MI	MI	R	m	I	MR	MI
Damping Off				MI				M	R	R	MR	ml
Leaf Disease / Spot				ml						I	mR	MI
Sclerotinia Rot				ml		ml	ml		I	I	ml	MI
Phytophthora						MI	MI			I	ml	
Septoria Spot									I			
Leaf Blight	MR	MR	MR	MR					m	I	MR	MI
Early Blight				ml						I		ml
Cercospora Leaf Spot				ml					I			ml
Rhizopus Rot										I		ml
Cavity Spot	MR	MR	MR	MR		MR	MR		M	R		
Rhizoctonia solani						MI	MI					
Black Root Rot	MI	MI	MI	ml					I	R / I		
Common Scab						MI	MI		I	R I		
Sclerotium Base Rot				ml						I		
Tip Rot						ml	ml					
Black Ring						ml	ml					
Bacterial Soft Rot	MI	MI	MI	ml					I	R I	ml	
Motley Dwarf Disease												ml
Carrot Y Virus				MI								
Celery Mosaic Virus				MI					R	R		m

M - Major Pest m - Minor Pest R - Regular I - Infrequent McKay Porter Dimsey Cavalaro Walsh Hickey Scott

Table 7 Current and possible management options for key pests and diseases

Carrots	Aphids (fennel, GPA)	Cutworm	Nematodes	Damping off	Cavity Spot	Alternaria/Cercospora
Diagnosis/detection	visual & handlens or microscope	visual	soil sampling & lab	visual, lab	visual	visual & lab confirmation
Monitoring	bugvac, visual, sticky traps	visual, damage	inspect roots	germination visual inspection	visual	Protocols and services ?
Thresholds	No	No	Y root knot in Tas	No	No	No
Beneficials	endemic predators/parasitoids	generalist predators	Need development – fungal parasite	unknown		
Cultural controls	Cereal trap crops, post-harvest cultivation	soil cultivation weed and irrigation mangement	crop rotation, good drainage, bare fallow	Crop rotn, Cultivars – partial resistance, avoid over watering	crop rotation, resistant varieties, avoid late harvesting	Clean seed, Crop rotn, Cultivars – partial resistance
Pesticide lists	endosulfan, OPs	OPs, Bt, carbaryl	fenamiphos	metalaxyl, thiram		chlorothalonil, difenoconazole, Cu, mancozeb, zineb, metiram
Other Controls			Overseas alginate product working well		post harvest hypochlorite wash	Disrupting germination – oils
Training	No					
Fact sheets	No	No	NSW, QLD, VIC, Vegenote	No	DAWA	Vegenote, DAWA
Field guides	No					
Information guides	*component in IPM in Vegetables in Tasmania* [Tas DPWIE]					
Newsletters	No					
Prediction models			Damage prediction, difficult to validate numbers, soil sampling protocol needed			Need
IRM	No	possible	No	possible	No	possible
Best Management options	Some recommendations in *IPM in Vegetables in Tasmania* and *Diseases of Carrots* Vegenote					
R&D Gaps	pirimicarb, pymetrozine, biopesticide efficacy work	spinosad, indoxacarb	fungal, control options		management options	infield diagnosis

Current Carrot IPM options

Basic disease management:

1. Select resistant varieties
2. Source disease-free seed
3. Treat seed by heat if bacterial or fungicide if fungal diseases a major problem
4. Avoid double cropping
5. Remove carrot related weeds
6. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
7. Monitor crops on weekly basis –visually inspect
8. Chip diseased plants
9. Good sanitation particularly in presence of bacterial diseases
10. Manage virus vectors when virus is present in crop or neighbouring area
11. Minimise mechanical damage of carrots at harvest and in packing shed
12. Post harvest wash with hypochlorite (care needs to be taken that wash water does not become source of bacterial contamination)
13. Cool chain management
14. Deep ripping if sclerotinia a recurrent problem

Basic insect management

1. Preplant monitoring of soil for nematodes
2. Use bare fallow before planting where nematodes and cutworm expected
3. Cereal plantings nearby with cereal aphids can increase aphid predator numbers
4. Monitor crops at germination for cutworm damage
5. Subsequently monitor crops weekly, if virus present then aphid numbers need to be managed

Potential Carrot IPM Options

1. Biopesticides, soft chemicals and cultural controls for aphid management
2. Soft options for cutworm management
3. Biological and cultural options for nematode management
4. Greater varietal resistance to diseases
5. Soil management strategies to reduce soil pests & disease problems

Recommended Carrot work

Specific

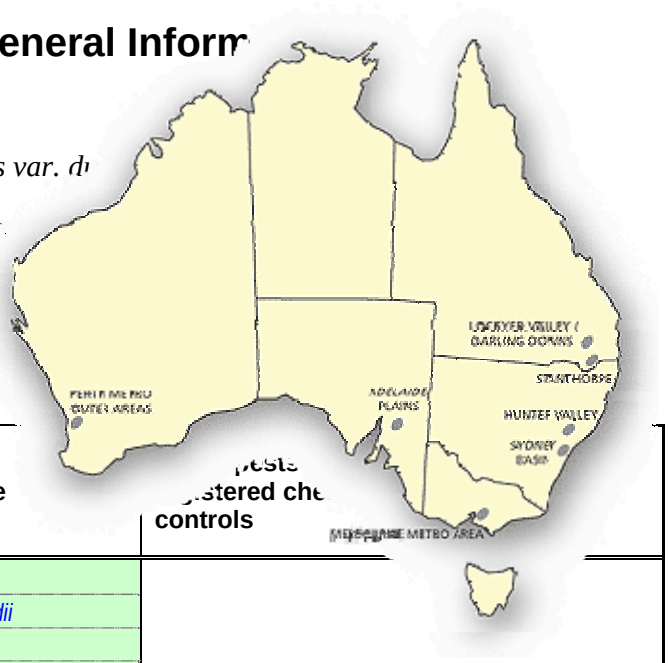
1. Pirimicarb and pymetrozine for aphid control
2. Spinosad and indoxacarb for cutworm control
3. Nematicides, biological and nematode control strategies
4. Cavity spot management options

General

1. Regional crop loss impacts – cost benefit analysis > no clear thresholds
2. New chemistry and bio-rational opportunities need to be explored
3. Cultural control - rotations
4. No tools to deliver an IPM service/training – uncertain level and quality of technical support
5. Infield diagnosis (how do it)
6. Fungicide/insecticides impacts on beneficials
7. Needs analysis for training

Celery: General Inform

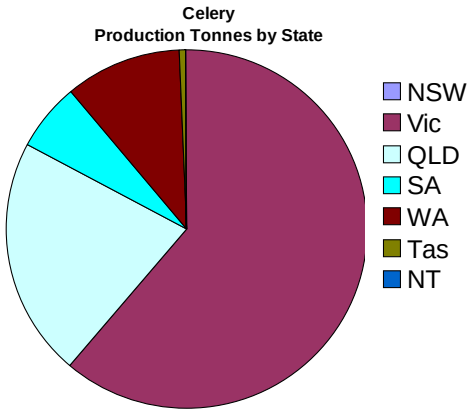
Common Name: Celery
Scientific Name: *Apium graveolens var. d*
Edible Plant Part: stem
48,312 tonnes $26.1 million [ABS 200



Grown:

Table 1 Celery insect pests

Insect pests with registered chemical controls	Scientifc Name	pests registered che controls	
Aphids	Aphidae		
Carrot Aphid	*Cavariella aegopodii*		
Cowpea Aphid	*Aphis craccivora*		
Green Peach Aphid	*Myzus persicae*		
Thrips	Thysanoptera		
Plague Thrips	*Thrips imaginis*		
Western Flower Thrips	*Frankliniella occidentalis*		
Tomato Thrips	*Frankliniella schultzei*		
Onion Thrips	*Thrips tabaci*		
Leafhoppers (Jassids)	Cicadellidae/Delphacidae		
Bugs:	Hemiptera		
Rutherglen Bugs	*Nysius vinitor*		
Green Vegetable Bug	*Nezara viridula*		
Green Mirid	*Creontiades dilutus*		
Coon Bug	*Oxycarenus arctatus*		
Vegetable Beetle	*Gonocephalum elderi*		
Caterpillars/Moths:			
Cutworms	Agrotis spp.		
Budworms (Heliothis)	*Helicoverpa spp.*		
lucerne leafroller	*Merophyas divulsana*		
Looper caterpillars	*Chrysodeixis subsidens*		
Lightbrown Apple Moth	*Epiphyas postvittana*		
28-spotted potato ladybird	*Henosepilachna vigintisexpunctata*	Wireworms	Elateridae
Spotted vegetable weevil	*Desiantha diversipes*	False Wireworms	*Gonocephalum spp.*
Vegetable weevil	*Listroderes difficilis*		
Leafminer flies	Agromyzidae	Celery fly	*Melanagromyza apii*
Mites:	Acarina		
Two-Spotted Mite	*Tetranychus urticae*		
Redlegged Eartrh Mite	*Halotydeus destructor*		
Rust Mites	Eriophyidae		
Spider mites	*Tetranychus spp.*		
Wingless Grasshopper	*Phaulacridium vittatum*		
Mole Crickets	*Gryllotalpidae*		



Black Field Crickets	*Teleogryllus commodus*
Field Crickets	*Gryllidae*
Australian Plague Locust	*Chortoicetes terminifera*
Yellow-winged Locust	*Gastrimargus musicus*
European Earwig	*Forficula auricularia*
Black-keeled slug	*Milax gagates*
Brown Slug	*Vaginulus plebeius*
Reticulated Slug	*Deroceras reticulatum*
Striped Field Slug	*Lehmannia nyctelia*
Common garden snail	*Helix aspersa*
Root knot nematode	*Meloidogyne spp.*

Table 2 Celery insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
methomyl	1A
maldison	1B
dimethoate	1B
chlorpyrifos	1B
diazinon	1B
trichlorfon*	1B
fenamiphos	1B
endosulfan*	2A
dicofol +tetradifon	2B
permethrin	3A
esfenvalerate*	3A
alpha-cypermethrin*	3A
bifenthrin*	3A
cypermethrin*	3A
imidacloprid	4A
spinosad	5A
Btk	11C
Helicoverpa NPV	

***** only a few states

Table 3 Celery fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
iprodione	B
propiconazole	C
thiram	Y
chlorothalonil	Y
metiram	Y
zineb	Y
mancozeb	Y
propineb	Y
ziram	Y
Copper - Various Sources	Y

Table 4 Celery diseases

Diseases with registered chemical controls	Scientific Name	Diseases with no registered chemical controls	Scientific Name
Blight	*Cercospora*	Leaf Curl	*Colletotrichum acutatum*
Botrytis Rot	*Botrytis cinerea*	Black Leg Disease	*Phoma lingam*
Early Blight	*Cercospora apii*		
Sclerotinia rot	*Sclerotinia sclerotiorum*		
Septoria Spot/ Late blight	*Septoria apiicola*	Tomato Spotted Wilt	
Bacterial Soft Rot	*Erwinia carotovora*	Celery mosaic virus	
Fungi:	Bacteria:	Virus	

Table 5a Regional distribution of pests

Celery Pests	Adel. Plains SA	NW TAS	Melbourne (Metro Area) VIC	Stanthorpe QLD	Lockyer Valley / Darling Downs QLD
Green Peach Aphid			mMr		
Carrot Aphid	ml		mMr	m	
Cowpea Aphid			Mr	m	
Thrip			m R Ml	m	
Leafhopper			m	l	
Rutherglen Bug	ml		ml-R	m	
Green Vegetable Bug			ml	l	
Green Mirid			ml		
Coon Bug			ml		
Light-Brown Apple Moth			m Mi		
Cutworm			mR Mr		
Budworm (*Heliothis*)	ml		mR l Mr/Mi	M	Ml
Lucerne Leafroller			m		
Looper Caterpillar			m Mi		
Spotted Vegetable Weevil			m		
Vegetable Weevil			m Mi	l	
Wireworm			m		
False Wireworm			m		
Leafminer Fly			m l		
2-Spotted (Red Spider) Mite			m		
Red-Legged Earth Mite	ml		m		
Spider Mite			m		
Wingless Grasshopper			m i		
Mole Cricket			m		
Black Field Cricket			m		
Field Cricket			m		
Australian Plague Locust			ml		
Black-Keeled Slug			m mr		
Reticulated Slug			m mr		
Brown Slug	ml		m mr		
Striped Field Slug			m		
Coomon Garden Snail			m		
Root Knot Nematode	ml		mr		
Porter	Cavallaro	Dimsey	Walsh	Scott	Horne

M - Major Pest m - Minor Pest R - Regular I - Infrequent

Table 5b Regional distribution of diseases

Celery Diseases	Adel. Plains SA	NW TAS	Melbourne VIC	Stanthorpe QLD	Lockyer Valley / Darling Downs QLD
Blight				mI	mI
Botrytis Rot	mI		I		
Early Blight			R I	MI	MI
Sclerotinia Rot	mI		I	m	m
Septoria Spot	mI	MR	R I	MR	MR
Late Blight			MI R		
Leaf Curl				I	I
Bacteria Soft Rot			I		
Soft Rot			I		
Celery Mosaic Virus	mI		R	mR	mR
Cucumber Mosaic Virus	R		R		
Tomato Spotted Wilt Virus			MR		
Pythium Root Rot			R		
Fusarium Root Rot			I		
Blackheart Ca Deficiency			I		
Rust		MR			
	WG	Porter	Cavallaro	Dimsey	Walsh

M - Major Pest m - Minor Pest R - Regular I - Infrequent

Table 6 Current and possible management options for key pests and diseases

CELERY	Heliothis	Thrips	Veg Weevil	LBAM	Aphids	Cutworm	Sclerotinia	Septoria	CMV
Diagnosis/detection	visual	visual	visual	visual	visual	visual	visual	visual/lab	visual/lab
Monitoring	visual, pheromone, bugvac	sticky traps, visual, bugvac	pit fall trap	pheromones	sticky traps, visual, bugvac	damage, bait			
Thresholds								Vic	
Beneficials	endemic predators & parasitoids	few	few		generalist predators, parasitoids				
Cultural controls			borders sprays, weed management				rotations, water quality, sanitation		area wide crop break, weed & aphid management
Pesticide lists	Bt, spinosad, NPV, OPs, SPs	imidacloprid, OPs, methomyl	chlorpyrifos, carbaryl, SPs	Bt	imidacloprid, OPs	Bt, carbaryl	propinazole, chlorthainol, zineb	mancozeb, Cu	
Other Controls									
Training	some conducted as part of VG99070 in Victoria						no		
Fact sheets	VegeNote						no		
Field guides	no						no		
Information guides	no						no		
Newsletters	no						no		
Prediction models	no							TOMCast model	
IRM	no formal								
Best Management options	Part of VG99070								
R&D Gaps	indoxacarb	spinosad, biocontrol and soft options	indoxacarb	spinosad, indoxacarb	pirimicarb, pymetrozine	spinosad, indoxacarb, develop pheromone lure		Truth model	

Current Celery IPM options

Basic disease management:

1. Select resistant vareties
2. Source disease-free seed
3. Heat treat seed if bacterial and fungal diseases a major problem
4. Avoid double cropping
5. Monitor crops on weekly basis – Bug vac, Heliothis pheromone traps
6. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
7. Chip diseased plants
8. Good sanitation particularly in presence of bacterial diseases
9. Manage virus vectors when virus is present in crop or neighbouring area

Basic insect management:

1. Place pheromone traps for Heliothis and LBAM in or close to crop at crop height, check weekly
2. Visually monitor crop on a weekly basis – 50 upper and 50 lower leaves and check inside base of stalks. Look for Heliothis, Looper, Cutworm and LBAM eggs and small larvae, damage, thrips, aphids, Rutherglen bug and vegetable weevil.
3. Heliothis can be managed with endemic beneficials & Trichogramma parasitoids and applications of Bt, NPV and/or spinosad if numbers are increasing to damaging levels
4. Aphids are usually managed by predators or parasitoids but if numbers are increasing to damaging levels or Celery mosaic virus is in the crop or neighbouring weeds use available pesticides – note that pirimicarb and pymetrozine are not legally available for use in states other than Victoria.
5. Rutherglen bug, vegetable weevil and a number of minor pests often come from weedy edges so check all edges of crops for damage or patchy infestations. Border sprays may be necessary.
6. Keep surrounding weeds and within crop weeds managed.

Potential Options

1. Biopesticides for aphids, thrips
2. Aphids: monitor, pirimicarb and pymetrozine for management of aphids

Recommended work

Specific

1. Pesticide permits - spinosad for Thrips, Light Brown Apple moth (LBAM) and Cutworm control; indoxacarb for Heliothis, LBAM and cutworm; pirimicarb and pymetrozine for aphids
2. Need to find softer options for thrips
3. Investigate whether there is a closely related species to LBAM in some celery crops
4. Need cutworm pheromone lure
5. Soft options for Rutherglen bug
6. Ground truth the use of the TOMCAST model for septoria spot in celery.

General

1. Soil diseases - prediction modelling, crop rotations
2. Biological options for soil diseases, including understanding of degredation of soil pathogens
3. IRM to integrate with other cropping systems - regional / Area Wide
4. Soft options and biocontrol for thrips, Rutherglen bug, aphids, vegetable weevil and cutworm needed
5. Screening fungi resistance to fungicides
6. Test kits for disease identification

Chinese Cabbage: General Information:

Common Name: Chinese Cabbage
Scientific Name: *Brassica rapa var. pekinensis*
Edible Plant Part: Leaf
11,513 tonnes $7.8 million [ABS 2002]

Grown:

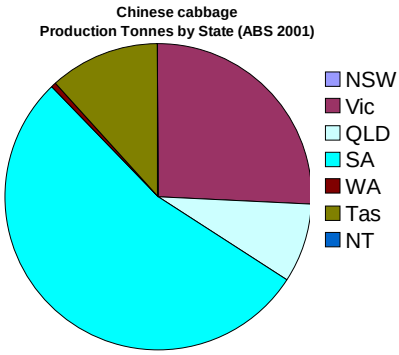


Table 1: Chinese Cabbage Insect Pests

Insect pests with registered chemical control options	Scientific Name	Insect pests reported with no registered chemical control options	Scientific Name
Aphids	Aphidae		
Cabbage Aphid	*Brevicoryne brassicae*		
Green Peach Aphid	*Myzus persicae*		
Turnip aphid	*Lipaphis pseudobrassicae*		
Thrips	Thysanoptera		
Onion thrips	*Thrips tabaci*		
Whiteflies	Aleyrodidae		
Coon Bug	*Oxycarenus arctatus*		
Harlequin Bug	*Dindymus versicolor*		
Green Vegetable bug	*Nezara viridula*	Vegetable weevil	
Rutherglen Bug	*Nysius vinitor*	African black beetle	*Heteronychus arator*
Cabbage cluster caterpillar	*Crocidolomia pavonana*	Ground Beetle	Carabidae
Cluster caterpillar	*Spodoptera litura*	Striped Flea Beetle	*Phyllotreta undulata*
Cabbage-centre grub	*Hellula hydralis*	Vegetable Beetle	*Gonocephalum elderi*
Diamondback moth	*Plutella xylostella*	False Wireworm	*Gonocephalum walkeri*
Cabbage white butterfly	*Pieris rapae*	True Wireworm	Elateridae
Corn Earworm	*Helicoverpa armigera*	Spotted Vegetable Weevil	*Steriphus diversipes*
Native Budworm	*Helicoverpa punctigera*	Whitefringed Weevil	*Naupactus leucoloma*
Cutworms	*Agrotis spp.*	Lucerne Weevil	
Looper caterpillars	*Chrysodeixis spp.*	Apple Weevil	*Otiorhynchus cribricollis*
Cabbage Leafminer	*Liriomyza brassicae*	Onion maggot	*Delia platura*
European earwig	*Forficula auricularia*	Leafmining fly	Scaptomyza flava
Redlegged Earth Mite	*Halotydeus destructor*	Vinegar flies	
Blue Oat Mite	*Penthaleus major*		

Wingless Grasshopper	*Phaulacridium vittatum*		
Yellow-Winged Locust	*Gastrimargus musicus*		
Australian Plague Locust	*Chortoicetes terminifera*		
Black Field Cricket	*Teleogryllus commodus*		
Brown Slug	*Vaginulus plebeius*		
Black-Keeled Slug	*Milax gagates*		
Reticulated Slug	*Deroceras reticulatum*		
Snails	Gastropoda		
Root-knot Nematode	*Meloidogyne spp.*		

Table 2 Chinese cabbage insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
pirimicarb	1A
methomyl	1A
prothiofos	1B
cypermethrin	3A
alpha-cypermethrin+permethrin	3A
alpha-cypermethrin	3A
beta-cypermethrin	3A
imidacloprid	4A
spinosad	5A
Btk	11C
chlorfenapyr	13A

Table 3 Chinese cabbage fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
metalaxyl-M mancozeb	D/Y
boscalid	G
mancozeb	Y
quintozene	Y
phosphonic acid	Y
dimethomorph	X

Table 4: Diseases of Chinese Cabbage

Diseases with registered chemical control options	Scientific Name	Diseases reported with no registered chemical controls	Scientific Name
White Blister	*Albugo candida*	Powdery Mildew	*Sphaerotheca spp.*
Club Root	*Plasmodiophora brassicae*	White Leaf Spot	*Pseudocercosporella capsellae*
Downy Mildew	*Peronospora parasitica*	Cercosporella Leaf Spot	*Cercospora beticola*
Ring Spot	*Mycosphaerella brassicicola*	Zonate Leaf Spot	*Gloeocerospora spp.*
Alternaria Spot	*Alternaria brassicicola*	Turnip Anthracnose	*Colletotrichum higginsianum*
Papery Leaf Spot	*Antracnose spp.*		
White Mould, Sclerotinia Rot	*Sclerotinia sclerotiorum*		
Damping Off	*Fusarium or Pythium*		
Grey Mould	*Botrytis cinerea*		
Black Leg Disease	*Phoma lingam*		
Root Rot	*Rhizoctonia solani*		
Bacterial Soft Rot	*Erwinia carotovora*		
Dry Leaf Spot,Head Rot, Black Rot	*Xanthomonas campestris*		
		Beet Western Yellow Virus	
Other:		Cauliflower Mosaic Virus	
Tipburn		Turnip Mosaic Virus	
Gomasho		Yellows (Zucchini)	
fungi	bacteria	virus	

Cultural Management options

Resistant varieties available for Downey & Powdery Mildews, Club root, Tipburn, and Gomasho. Irrigating in the early morning helps for Anthracnose, and Bacteria soft and Black rots.

Table 5 Resistant or Tolerant Chinese Cabbage Varieties

CHINESE CABBAGE:	Company	Gomasho	Club Root	Downy Mildew	Soft Rot	Fusarium Yellows	Powdery Mildew	Tipburn	Bolting
Manoko F1	Bejo					H			E
Nikko F1	Bejo		P			H			
Optiko F1	Bejo					H	T	G	E
Alibi	SPS	Int							
Kilo (2344)	SPS	Int	Int						
Matilda	SPS	Int							
Mt Fuji	Takada			T	T				

E=Excellent
H=High
Int=Intermediate
G=Good
T=Tolerant

Table 6a Regional distribution of diseases

Chinese Cabbage Pest / Disease	Gin Gin WA	Perth WA	Darwin NT	Nth. Adel. Plains SA	Sunraysia VIC	Melbourne Gippsland VIC	Sydney Basin NSW	Stanthorpe QLD	Lockyer Valley QLD
White Blister				ml		M m	ml	M	M
Club Root				ml		M m	MR	M	m
Downy Mildew				ml	R	R	MR	Ml	Ml
Ring Spot				ml		R I	R	m	m
Alternaria Spot				ml	R	R I	R	m	m
Papery Leaf Spot						m	m		
White Mould				ml		R	MR	M	M
Rhizoctonia solani				ml		/	ml	m	m
Damping Off				ml	I	I	m	m	m
Grey Mould						m	mR	m	m
Black Leg Disease						I	Ml	Ml	Ml
Powdery Mildew					R	I	I		
White Leaf Spot						I			
Cercosporella Leaf Spot				ml		I	ml		
Zonate Leaf Spot							ml	ml	ml
Bacterial Soft Rot						I	mR	M	M
Black Rot						I	mR	Ml	Ml
Dry Leaf Spot (Head Rot)						I	I		
Cauliflower Mosaic Virus							mR		
Turnip Mosaic Virus						m	M	m	m
Yellows							m	m	m
Tipburn					R	m	R	M	M
Gomasho				ml	R	m	mR		M
			Cavallaro		Porter	Dimsey		James	Walsh

M - Major Pest m - Minor Pest R - Regular I - Infrequent

Table 6b Regional distribution of pests

Chinese Cabbage Pest / Disease	Gin Gin WA	Perth WA	Darwin NT	Nth. Adel. Plains SA	Sunray sia VIC	Melbourne Gippsland VIC	Sydney Basin NSW	Stanthorpe QLD	Lockyer Valley QLD
Cabbage Aphid	ml	ml			l	m R	mR	M	M
Green Peach Aphid	ml	ml		ml	R	m l	m		
Turnip Aphid	ml	ml				m	m		
Onion Thrip	ml	ml			l	m l	m	m	m
Whitefly	ml	ml		ml	l	m l	m		m
Coon Bug					l	m			
Harlequin Bug					l	m l			
Green Vegetable Bug	ml	ml			l	m R	ml		
Rutherglen Bug	ml	ml		Ml	l	m R	M		M
Cabbage Cluster Caterpillar						R	mR	m	R
Cluster Caterpillar	mR	mR				m R	mR	m	R
Cabbage-Centre Grub	mR	mR			R	m R	mR	m	R
Diamond Back Moth	MR	MR		MR		M R	MR	M	R
Cabbage White Butterfly	mR	mR		ml	R	m	MR	M	m
Budworm/ Heliothis	MR	MR				m	mR	M	R
Cutworm	ml	ml			l	m l	ml	m	RM
Tiger Moth								m	
Looper Caterpillar				ml		m	m	m	m
African Black Beetle	ml	ml				m	m	m	m
Striped Flea Beetle						m			
False Wireworm						m		m	m
True Wireworm						m			
Spotted Vegetable Weevil						m			
White Fringed Weevil						m	m		
Lucerne Weevil						m			
Apple Weevil						m			
Cabbage Leafminer						m R			
Onion Maggot						m			
Leafmining fly							m		
Red-Legged Earth Mite				ml		m			
Blue Oat Mite						m			
Wingless Grasshopper						m R			
Yellow-Winged Locust						m			
Australian Plague Locust						m			
Black Field Cricket						m l			
Brown Slug						m R			
Black-Keeled Slug						m			
Reticulated Slug						m			m
Vegetable Weevil						R			
Vinegar Fly									M

Broughton Cavallaro Porter Dimsey McDougall James Walsh

M - Major Pest m - Minor Pest R - Regular I - Infrequent

Table 7a Current and possible management options for key pests

CHINESE CABBAGE	Diamond back moth	Cab. white buterfly	Heliothis	Aphids	Rutherglen bug
	Plutella xylostella	*Pieris rapae*	*Helicoverpa spp.*	GPA, Cabbage	*Nysius vinitor*
Diagnosis/detection	visual	visual	visual	visual	visual
Monitoring	visual, pheromones bugvac	visual, bugvac	visual, pheromones bugvac	visual, bugvac, sticky traps	visual, bugvac
Thresholds	for trad. Brassicas	No			
Beneficials	Parasitoids, *Zoopthora fungi*	*Cotesia glomerata Pteromalus puparum*	generalist predators & parasitoids	predators & parasitoids	few
Cultural controls	production break			avoid excess nitrogen	
Pesticide lists	Bts, SPs, OPs, chlorfenapyr carbaryl, spinosad	spinosad, Bts, SPs, OPs, chlorfenapyr, carbaryl	Bt, SPs, carbamates, OPs, spinosad	OPs, pirimicarb, imidacloprid	
Other Controls	insectary crops to promote beneficials				
Training	has been conducted but may be need for targeting chinese cabbage				
Fact sheets	DBM but others under development, WA pest bulletin covering many pests				
Field guides	covering traditional brassica pests & diseases (Vic, QLD, WA)- relevant to chinese cabbage				
Information guides	IPM of DBM, Agrilink				
Newsletters	Brassica IPM National Newsletter				
Prediction models	development model				
IRM	regional strategies				
Best Management options	need to adjust from brassicas				
R&D Gaps	potential of biopesticides, trap cropping		NPV	pymetrozine, biopesticides	Biocontrol, soft options, cultural management

Table 7b Current and possible management options for key diseases

CHINESE CABBAGE	Club root	White blister	Downy mildew	White mould	Blackleg	Bacteria soft rot	Dry leaf spot	Tipburn
	Plasmodiophora brassicae	*Albugo candida*	*Peronospora parasitica*	*Sclerotinia sclerotiorum*	*Phoma lingam*	*Erwinia carotovora*	*Xanthomonas campestris*	
Diagnosis/detection	lab	visual	visual/lab	visual	visual/lab	visual/lab	visual/lab	visual
Monitoring	field detection kit soon							
Thresholds								
Beneficials	not well known			*Trichoderma*	not well known			
Cultural controls	use exisiting Brassica recommendations, modify for chinese cabbage as is most sensitive of brassicas to club root		crop rotation, some tolerant varieties	crop rotation, sanitation	clean seed, rotation, sanitation, brassica weed management	rotation, sanitation & avoid water contamination	rotation	water in evening, maintain optimal nutrition & water particularly in summer
Pesticide lists	quintozene	mancozeb + metalaxyl	cu oxychloride; dimethomorph, mancozeb + metalaxyl, phos-acid	boscalid				calcium
Other Controls						post harvest hypochlorite wash		
Training	has been conducted but may be need for targeting chinese cabbage							
Fact sheets	DPI VIC, WA, NZ	DPI VIC, QLD,	DPI VIC					
Field guides	covering traditional brassica pests & diseases (Vic, QLD, WA)- relevant to chinese cabbage							
Information guides								
Newsletters	Brassica IPM National Newsletter							
Prediction models		required/developing for each region						
IRM								
Best Management options								
R&D Gaps	Shirlan®, early warning system required	monitoring protocol & prediction model needed		Poor knowledge on rotation crops and diseases (reducing inoculum)				

Current Chinese Cabbage IPM options

Basic disease management:

10. Select resistant vareties
11. Source disease-free seed
12. Heat treat seed if bacterial and fungal diseases a major problem
13. Avoid double cropping with other brassicas
14. Monitor crops on weekly basis – visual, Heliothis and Diamond back moth (DBM) pheromone traps
15. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
16. Chip diseased plants
17. Good sanitation particularly in presence of bacterial diseases
18. Manage virus vectors when virus is present in crop or neighbouring area
19. Control neighbouring brassica weeds
20. Good nutrition and water management
21. Have strategy for reducing between field contamination with *Erwinia* through water recycling
22. Evening watering in summer to reduce tipburn

Basic insect management:

23. Place pheromone traps for Heliothis and DBM in or close to crop at crop height, check weekly
24. Visually monitor crop on a weekly basis – Look for DBM, Heliothis, Cabbage white butterfly (CWB), Cluster caterpillar and other caterpillar eggs and small larvae, damage, thrips, aphids, whitefly and Rutherglen bug.
25. DBM, CWB and Heliothis can be managed with endemic beneficials & parasitoids, and applications of Bt, NPV (Heliothis) and/or spinosad if numbers are increasing to damaging levels without beneficials also increasing
26. Green peach aphids are usually managed by predators or parasitoids but if numbers are increasing to damaging levels use pirimicarb – note that pymetrozine is not legally available for use in states other than Victoria. Cabbage aphid is not readily attacked by beneficials.
27. Rutherglen bug and a number of minor pests often come from weedy edges so check all edges of crops for damage or patchy infestations. Border sprays may be necessary.
28. Keep surrounding weeds and within crop weeds managed.

Potential Chinese Cabbage Options

3. Biopesticides for aphids, DBM & Heliothis
4. Pymetrozine for management of aphids
5. Cultural and chemical options for club root
6. Cultural management to significantly reduce soil disease incidence and prediction models for diseases

Recommended Chinese Cabbage work

Specific

5. Pesticide permits – NVP for Heliothis, pymetrozine for aphids, Shirlan for clubroot
6. Potential of biopesticides for DBM and aphids
7. Soft options for Rutherglen bug
8. Prediction model for clubroot

9. Better integration between recommendations from insect and disease management (eg Brassica weeds to enhance beneficials vs white blister host)
10. Modification of cultural controls and treatment application recommendations from other brassica work for use in chinese cabbage
11. Role of predators versus parasitoids

General

7. Soil diseases - prediction modelling, crop rotations to reduce inoculum
8. Biological options for soil diseases, including understanding of degredation of soil pathogens
9. Screening fungi resistance to fungicides
10. Test kits for disease identification
11. Utilise prediction models for pathogens
12. Clarification of efficacy of PSOs for SLW and other pests
13. Soft options for sucking bugs
14. Potential of trap crops and insectary crops

Cucumbers: General Information:

Common Name: Cucumbers
Scientific Name: *Cucumis sativus*
Edible Plant Part: Fruit
13,872 tonnes $18.5 million [ABS 2002]

Grown:

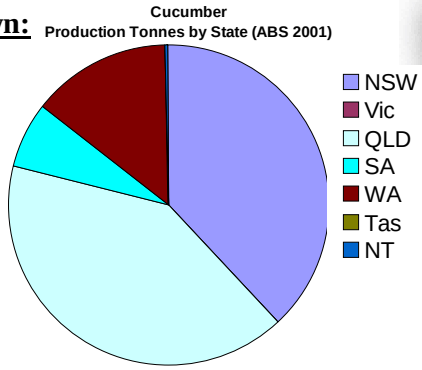


Table 1 Cucumber insect pests

Insect pests with registered chemical controls	Scientific Name	Insect pests reported with no registered chemical controls	Scientific Name
Aphids:	Aphididae		
Cotton Aphid	*Aphis gossypii*		
Green Peach Aphid	*Myzus persicae*		
Cowpea Aphid	*Aphis craccivora*		
Tomato Aphid	*Macrosiphum euphorbiae*		
Thrips:	Thysanoptera		
Melon Thrips	*Thrips palmi*		
Onion Thrips	*Thrips tabaci*		
Western Flower Thrips	*Frankliniella occidentalis*		
Leafhoppers (Jassids)	Cicadellidae		
Whiteflies:	Aleyrodidae		
Silverleaf Whitefly	*Bemisia tabaci*		
Greenhouse Whitefly	*Trialeurodes vaporariorum*		
Bugs:	Hemiptera		
Cucurbit Shield Bug	*Megymenum affine*		
Fruitspotting Bug	*Dasynus fuscescens*		
Green Vegetable Bug	*Nezara viridula*		
Mealybugs	*Pseudococcus spp.*		
Rutherglen Bug	*Nysius vinitor*		
Green Mirid	*Creontiades dilutus*		
Budworms	Helicoverpa spp.		
Native Budworms	*Helicoverpa punctigera*		
Cotton Bollworms	*Helicoverpa armigera*		
Cutworms	Agrotis spp.		
Cucurbit Stemborer	*Apomecyna histrio*		
Cucumber Moth	*Diaphania indica*	26-Spotted Ladybirds	*Henosepilachna vigintioctopunctata*
Loopers	Lepidoptera	Monolepta Beetles	*Monolepta australis*

Cucurbit Ladybirds	*Epilachna cucurbitae*	Vegetable Beetle	*Gonocephalum elderi*
28-Spotted Ladybirds	*Epilachna vigintisexpunctata*	Wireworms	Elateridae
Plain Pumpkin Beetle	*Aulacophora abdominalis*	Fuller's Rose Weevil	*Asynonychus cervinus*
Pumpkin Beetle	*Aulacophora hilaris*	Whitefringed Weevil	*Graphognathus leucoloma*
Cucumber Fly	*Bactrocera cucumis*	Seedling Bean Midge	*Smittia aterrima*
Mites:	Acarina	Onion Maggot	*Delia platura*
Rust Mite	Eriophyidae	Fungus Gnats	Mycetophilidae
2-Spotted (red Spider) Mite	*Tetranychus urticae*	Shore Flies	Ephydridae
Blue Oat Mite	*Penthaleus major*	Bean Spider Mite	*Tetranychus ludeni*
Broad Mite	*Polyphagotarsonemus latus*		
Clover Mite	*Bryobia graminum*		
Redlegged Earth Mite	*Halotydeus destructor*		
Spider Mites	Tetranychus spp.		
Ants	Formicidae		
Wingless Grasshopper	*Phaulacridium vittatum*		
Australian Plague Locust	*Chortoicetes terminifera*		
Yellow-winged Locust	*Gastrimargus musicus*		
Black-keeled slug	*Milax gagates*		
Brown Slug	*Vaginulus plebeius*		
Reticulated Slug	*Deroceras reticulatum*		
Snails	Gastropoda		
Root-knot Nematodes	*Meloidogyne spp.*		

Table 2 Cucumber insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
Methomyl	1A
Chlorpyrifos	1B
Diazinon	1B
Dimethoate	1B
Endosulfan	2A
Dicofol + tetradifon	2B
Bifenthrin	3A
Lambda-cyhalothrin	3A
Imidacloprid	4A
Spinosad	5A
Abamectin	6A
pyriproxyfen	7C
Buprofezin	17A
Botanical oil - emulsifiable	Spray Adjuvant
Petroleum Oil	
Pyrazophos	fungicide F

Table 3 Cucumber Diseases

Diseases with registered chemical controls	Scientific Name	Diseases reported with no registered chemical controls	Scientific Name
Alternaria Leaf Spot	*Alternaria cucumerina*	Alternaria Fruit Rot	*Alternaria*
Anthracnose	*Colletotrichum orbiculare*	Black Root Rot	*Thielaviopsis basicola*
Downy Mildew	*Pseudoperonospora cubensis*	Blue Mould Rot	*Penicillium digitatum*
Gummy Stem Blight	*Didymella bryoniae*	Cottony Leak (Stalk Rot)	*Pythium aphanidermatum*
Blight	*Cercospora*	Damping Off	*Rhizoctonia solani*
Powdery Mildew	*Sphaerotheca fuliginea*	Foot Rot	*Fusarium solani*
Rhizoctonia Ground Rot	*Rhizoctonia solani*	Fusarium Fruit Rot	*Fusarium*
Target Leafspot	*Corynespora cassicola*	Fusarium Wilt	*Fusarium oxysporum*
Septoria Spot	*Septoria cucurbitacearum*	Ghost Spot	*Botrytis*
		Grey Mould	*Botrytis cinerea*
		Papery Leaf Spot	*Anthracnose*
		Pink Mould Rot	*Trichothecium roseum*
Bacterial Spot	*Xanthomonas campestris*	Phytophthora Soil Fungus	*Phytophthora*
Angular Leaf Spot	*Pseudomonas syringae*	Rhizopus Soft Rot	*Rhizopus stolonifer*
Bacterial Fruit Blotch	*Pseudomonas*	Bacterial Soft Rot	*Erwinia carotovora*
Cultural Management Options Resistant/tolerant varieties are available for management of Cucumber, Squash, Watermelon and Zucchini Mosaic viruses and Papaya Ring Spot virus.		Cucumber Mosaic Virus Papaya Ring Spot Virus Squash Mosaic Virus Watermelon Mosaic Virus Zucchini Mosaic Virus	
Fungi:	Bacteria:	Virus:	

Table 4 Cucumber fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
Triadimefon	C
Bupirimate	H
Azoxystrobin*	K
Oxythioquinox	X
Chlorathalonil	Y
Copper - various sources	Y
Mancozeb	Y
Metiram	Y
Propineb	Y

* greenhouse only

Table 5 Resistant or Tolerant Cucumber Varieties

CUCUMBER:	Company	CMV	CVYV	PRSV	WMV	ZYMV	Powdery Mildew	Downy Mildew	Tip-Burn	Gummy Stem Blight	Botrytis	Scab	Angular Leaf Spot	Anthracnose
Continental (Long)														
Camaro	De Ruiter						Int							
24-70	RZ						H							
Aviance	RZ						Int		S					
Bologna	RZ						H		S	RS	RS			
Cumlaude	RZ						H							
Gardon	RZ	Int					Int		S					
Scotinos	RZ						Int							
Bandit	SPS						Int					Int	Int	
Reko	SPS											Int	Int	
Zone	SPS						Int							
Mini (Lebanese)														
Darbi	De Ruiter	Int	Int				H							
Mascot	De Ruiter	Int	Int				H							
Montana	De Ruiter	Int	Int				H							
Sigra	De Ruiter						H							
Deena	RZ						H							
Deltastar	RZ						H							
Khassib	RZ	Int	Int	Int	Int	Int	H							
Yaqout	RZ						H							
Austin	SPS						Int							
Colorado	SPS						Int							
Panama	SPS						Int							
Sultan	SPS						Int							
Green Slicer														
Adrian	RZ						H							
Alanis	RZ	Int					H							
Caman	RZ		Int				H							
Gremlin	SPS			Int	Int	Int	Int					Int	Int	Int
American Slicer														
Black Prince	SPS													
Camelot	Terranova	E		E	E	E	E	L				E	E	E
Catalina	Terranova						G	G				G	G	G
Lancelot	Terranova	E		E	E	E	L	L				E	E	
Thunder							P	P						
Glasshouse Lebanese														
Lotus	Terranova						E	E						
Adelle	Yates						P							
Glassouse Continental														
Amazon	Terranova						E	E						
Corolla	Terranova						E	E						
Greenhouse Slicer														
Concorde	SPS	Int										Int	Int	
Jazzer	SPS	Int											Int	
Specialist														
Crystal Salad	Terranova	M	M	M	M	M	M	M	M	M	M	M	M	M
Redlands Long Wt	Terranova						GP							

Int=Intermidiate
H=high
S=strong
RS= relatively strong
E=Excellent
G=Good
L=Low
P=Partial
M=Minimal

Table 6a Regional distribution of pests

Cucumber Pests	Geraldton WA	Carnarvon WA	Perth WA	Adel. Plains SA	Riverland SA	Sth. TAS	Sunraysia VIC	Melbourne VIC	Sydney NSW	Riverina NSW	Lockyer Valley QLD	Bundaberg QLD	Bowen QLD
Aphid		MR				mR							
Cotton Aphid								m	MR			MR	MR
Green Peach Aphid		MR	I	ml		mR		m R	M			MR	MR
Plague Thrips						MR			m				
Melon Thrips											mR	?	
Onion Thrips			R	ml			R	m R	M	m		mR	
Western Flower Thrips		MR	MR	MR			M	m	MR		M	MR	
Leafhopper			I				m	m R		m			
Whitefly		MR	I			MR	R	R	MR			ml	
Silverleaf Whitefly		MR							mR?		M	MR	MR
Greenhouse Whitefly			MR	MR				m	MR			ml	
Cucurbit Shield Bug								m				?	
Fruitspotting Bug												?	
Green Vegetable Bug			ml	ml				m				?	MR
Mealybug			ml				I	m	I				
Rutherglen Bug		MR	ml	ml			I	m	ml	m			
Green Mirid								m					
Coon Bugs							I						
Budworm/ Heliothis		MR		ml				m	ml	m		mR	
Armyworm		MR											
Cutworm								m		m			
Cucumber Moth								m	ml			m R - I	
Looper Caterpillar		MR	ml					m	ml				
Cluster Caterpillar		MR											
Cucurbit Ladybird								m	ml	m		m	
26-Spotted Ladybird								m	ml			m	
28-Spotted Ladybird							m	m	ml	m		m	
Monolepta Beetle								m					
Plain Pumpkin Beetle								m		m		m	

Cucumber Pests	Geraldton WA	Carnarvon WA	Perth WA	Adel. Plains SA	Riverland SA	Sth. TAS	Sunraysia VIC	Melbourne VIC	Sydney NSW	Riverina NSW	Lockyer Valley QLD	Bundaberg QLD	Bowen QLD
Pumpkin Beetle							R			m		m	
Vegetable Beetle										m			
Wireworm								m		m			
Fuller's Rose Weevil								m					
White Fringed Weevil							I	m					
Cucumber Fly									ml			MR	
Seedling Bean Midge								m					
2-Spotted (Red Spider) Mite		MR	MR	MR			R	m	MR		MR	M R - I	MR
Blue Oat Mite								m					
Broad Mite				ml				m	M				
Clover Mite								m					
Red-Legged Earth Mite				ml				m					
Spider Mite			MR					m	M				
Bean Spider Mite									M				
Fungus Gnat						MR			MR				
Shore Fly						mR			m				
Australian Plague Locust								m		m			
Wingless Grasshopper								m					
Black-Keeled Slug								m					
Brown Slug				ml				m					
Reticulated Slug								m					
Snail								m					
Root Knot Nematode				MR			I		m				
		Chilman	Broughton		Cavallaro	Scott	Dimsey	Porter	James	Steiner	McDougall		Walsh

M - Major Pest m - Minor Pest R - Regular I - Infrequent

Table 6b Regional distribution of diseases

Cucumber Diseases	Geraldton WA	Carnarvon WA	Perth WA	Adel Plains SA	Riverland SA	Sth. TAS	Sunraysia VIC	Melbourne VIC	Sydney NSW	Riverina NSW	Lock. Val. QLD	Bundaberg QLD	Bowen QLD
Alternaria Leaf Spot							I	m	R		ml		
Angular Leaf Spot							I		R		ml		
Anthracnose							I	R	m		ml		
Downy Mildew				MR			R	R	R		MR		
Gummy Stem Blight			I				R	R	R		MI		
Powdery Mildew	MR	MR	R	MR			M	M	R		MR		
Rhizoctonia Ground Rot				MR			I	I	I				
Target Leaf Spot		MR					I						
Septoria Spot							I	m					
Alternaria Fruit Rot							I		m		ml		
Black Root Rot									R				
Cottony Leak											ml		
Damping Off			R	MR					R				
Foot Rot									MR		MI		
Fusarium Fruit Rot	MR		R					m	MR				
Fusarium Wilt			R	MR			R	m	MR		MI		
Sclerotinia/Grey Mould			I	MR			R	m	R		ml		
Phytophthora Soil Fungus							I		R				
Rhizopus Soft Rot									ml				
Crown Rot						ml			R				
Bacterial Soft Rot									R		ml		
Mosaic Virus		MR							R				
Cucumber Mosaic Virus				ml			R	m	mR				
Papaya Ring Spot Virus				?							MR	MR	MR
Squash Mosaic Virus				?			I	I					
Watermelon Mosaic Virus				?			I	I			MR	MR	MR
Zucchini Mosaic Virus				?			I	I					MR
Tomato Spotted Wilt Virus						MR							

M - Major Pest m - Minor Pest R - Regular I - Infrequent Chilman Cavallaro Scott Dimsey Porter James Walsh

Table 7 Current and possible management options for key pests and diseases

Cucumber	Thrips	Two Spotted Mite	GH Whitefly, SLWF	Aphids	Downy Mildew	Powdery Mildew	Fusarium	Viruses
Diagnosis/detection	visual	visual	visual	visual	visual/lab	visual/lab	visual/lab	visual & lab confirmation
Monitoring	sticky traps, bugvac, visual	bugvac, visual	sticky traps, bugvac, visual	sticky traps, bugvac, visual	visual	visual	visual	visual
Thresholds	Depending on use of biocontrol, virus threat (aphid/whitefly)							
Beneficials	few	predators	*Eretmocerus* spp.	predators & parasitoids				
Cultural controls	Hygiene – clean-up		crop break				rotations	clean seed, removal of cucurbit weeds, remove old crops, varietal resistance
Pesticide lists	dimethoate, endosulfan, lamda cyhalothrin, abamectin, spinosad	abamectin, dicofol + tetradifon, dicofol, dimethoate, oxythioquinox, sulfur, propargite	bifenthrin, imidacloprid, buprofezin, chlorpyrifos	OPs, primicarb, endosulfan	azoxystrobin, chlorothalonil, Cu, dimethomorph, mancozeb, mancozeb + metalaxyl, metiram, phosphorous acid, propineb, propineb + oxadixyl, zineb	bupirimate, chlorothalonil, triadimefon, sulfur, oxythioquinox		pirimicarb for aphid management
Other Controls	weed management particularly important for WFT					milk sprays		
Training	GH field guide							
Fact sheets								
Field guides	Greenhouse field guide (NSW, NZ), Included in *Vegetable insect pests and their natural enemies in the dry topics* (QDPI &F)							
Information guides	Greenhouse field guide (NSW, NZ)							
Newsletters	greenhouse cucumbers covered in NSW IPM newsletter							
Prediction models	No				?modification of Tom Cast models			
IRM	WFT leaflets and fact sheet							

Best Management options								
R&D Gaps	biopesticide evaluation, potential bicontrol, continue evaluation of efficacy of wetters for thrips control		Biopesticides, pyriproxyfen	impact of insectary crops, biopesticides		varietal susceptibility & status of fungicide resistance		

Current Cucumber IPM options

Basic disease management:

1. Select resistant varieties
2. Source disease-free seed
3. Treat seed by heat if bacterial or fungicide if fungal diseases a major problem
4. Avoid double cropping
5. Remove cucurbit weeds
6. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
7. Monitor crops on weekly basis –visually inspect
8. Chip diseased plants
9. Good sanitation particularly in presence of bacterial diseases
10. Manage virus vectors when virus is present in crop or neighbouring area

Basic insect management

1. Cereal plantings nearby with cereal aphids can increase aphid predator numbers
2. Subsequently monitor crops weekly, if virus present then aphid numbers need to be managed

Potential Cucumber IPM Options

1. Biopesticides, soft chemicals and cultural controls for aphid management
2. Soft options for cutworm management
3. Biological and cultural options for nematode management
4. Greater varietal resistance to diseases
5. Soil management strategies to reduce soil pests & disease problems

Recommended Cucumber work

Specific

1. Pymetrozine for aphid control, pyriproxyfen for whitefly
2. Need more biological control agents to cope with range of greenhouse conditions for greenhouse whitefly and thrips
3. Organosilicone wetter has thrips activity and needs a permit for use
4. Agri50E looks promising as thrips control but needs testing for beneficial impact

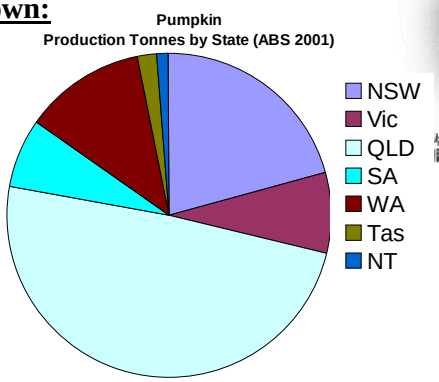
General

1. New chemistry and bio-rational opportunities need to be explored
2. Cultural control – rotations for soil disease management
3. Infield diagnosis for diseases
4. Fungicide/insecticides impacts on beneficials
5. Needs analysis for training
6. More soft options for thrips, whitefly and aphids

Pumpkin: General Inform[illegible]

Common Name: Pumpkin
Scientific Name: *Cucurbita maxima*
Edible Plant Part: Fruit
96,331 tonnes $47.5 million [ABS 2002]

Grown:



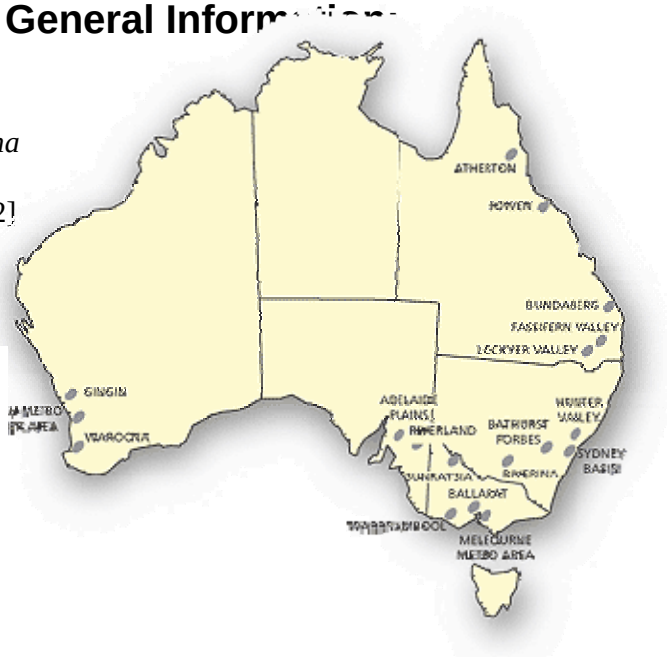


Table 1: Pumpkin Insect Pests

Insect pests with registered chemical controls	Scientific Name	Insect pests reported with no registered chemical controls	Scientific Name
Aphids:	Aphididae		
Cotton Aphid	*Aphis gossypii*		
Green Peach Aphid	*Myzus persicae*		
Cowpea Aphids	*Aphis craccivora*		
Thrips	Thysanoptera		
Melon Thrips	*Thrips palmi*		
Onion Thrips	*Thrips tabaci*		
Western Flower Thrips	*Frankliniella occidentalis*		
Leafhoppers	Cicadellidae		
Whiteflies	Aleyrodidae		
Silverleaf Whitefly	*Bemisia tabaci*		
Greenhouse Whitefly	*Trialeurodes vaporariorum*		
Bugs:	Hemiptera		
Cucurbit Shield Bug	*Megymenum affine*		
Fruitspotting Bug	*Dasynus fuscescens*		
Green Vegetable Bug	*Nezara viridula*		
Mealybugs	Pseudococcus spp.		
Rutherglen Bug	*Nysius vinitor*		
Green Mirid	*Creontiades dilutus*		
Passionvine Bug	*Fabrictilis gonagra*		
Caterpillars	Lepidoptera	26 Spotted Ladybird	*Henosepilachna vigintioctopunctata*
Budworms (Heliothis)	Helicoverpa spp.	28 Spotted Ladybird	*Epilachna vigintisexpunctata*
Corn Earworm	*Helicoverpa armigera*	African Black Beetle	*Heteronychus arator*
Cutworms	Agrotis spp.	Monolepta beetle	*Monolepta australis*
Cucumber Moth	*Diaphania indica*	Vegetable Beetle	*Gonocephalum elderi*

Cucurbit Ladybird	*Epilachna cucurbitae*	Wireworms	*Elateridae*
Plain Pumpkin Beetle	*Aulacophora abdominalis*	Fuller's Rose	*Asynonychus cervinus*
Pumpkin Beetle	*Aulacophora hilaris*	Whitefringed Weevil	*Graphognathus leucoloma*
Cucumber Fly	*Bactrocera cucumis*	Onion Maggot	*Delia platura*
Mites:	Acarina		
2-Spotted Mite	*Tetranychus urticae*		
Redlegged Earth Mite	*Halotydeus destructor*		
Spider Mites	*Tetranychus spp.*		
Clover Mite	*Bryobia graminum*		
Blue Oat Mite	*Penthaleus major*		
Ants	*Formicidae*		
Wingless Grasshopper	*Phaulacridium vittatum*		
Australian Plague Locust	*Chortoicetes terminifera*		
Yellow-winged Locust	*Gastrimargus musicus*		
Black-keeled Slugs	*Milax gagates*		
Brown Slugs	*Vaginulus plebeius*		
Reticulated Slugs	*Deroceras reticulatum*		
Snails	*Gastropoda*		
Root-knot Nematodes	*Meloidogyne spp.*		

Table 2: Pumpkin Insecticide Registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
Methomyl^	1A
Pirimicarb	1A
Chlorpyrifos	1B
Diazinon	1B
Dimethoate	1B
Endosulfan	2A
Bifenthrin*	3A
Permethrin*	3A
Spinosad	5A
Pyriproxyfen*	7A
Buprofezin#	17A
Petroleum Oil@	

^ NT & WA only * QLD, NT & WA only
# QLD only @ WA only

Table 3: Pumpkin Fungicide Registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
Triadimefon^	C
Mancozeb + Metalaxyl*	DY
Bupirimate	H
Dimethomorph	X
Oxythioquinox	X
Chlorothalonil	Y
Mancozeb	Y
Sulfur - various sources	Y

^ NSW only *QLD only

Table 4 Pumpkin Diseases

Diseases with registered chemical controls	Scientific Name	Diseases reported with no registered chemical controls	Scientific Name
Alternaria Leaf Spot	*Alternaria cucumerina*	Alternaria Fruit Rot	*Alternaria alternata*
Anthracnose	*Colletotrichum orbiculare*	Brown Etch	*Fusarium oxysporum, Fusarium roseum Ascochyta cucumis*
Downy Mildew	*Pseudoperonospora cubensis*	Crown Rot	*Fusarium*
Gummy Stem Blight	*Didymella bryoniae*	Fusarium Foot Rot	*Fusarium solani*
Powdery Mildew	*Sphaerotheca fuliginea*	Fusarium Fruit Rot	*Fusarium*
Rhizoctonia Ground Rot	*Rhizoctonia solani*	Fusarium Wilt	*Fusarium oxysporum*
Septoria Spot	*Septoria cucurbitacearum*	Pink Rot	*Trichotehecium roseum*
Target Leaf Spot	*Corynespora cassicola*	Rhizopus Soft Rot	*Rhizopus stolonifer*
		Scab	*Cladosporium cucumerinum*
		Stalk Rot	*Stemphylium spp.*
		White Leaf Spot	
Bacterial Soft Rot	*Erwinia carotovora*	Bacterial Fruit Blotch	*Pseudomonas*
		Bacterial Spot	*Xanthomonas campestris*
Cultural Management Options Resistant/tolerant varieties are available for management of Powdery Mildew, Cucumber, Squash, Watermelon and Zucchini Yellow Mosaic viruses, and Papya Ring Spot virus.		Cauliflower Mosaic Virus Cucumber Mosaic Virus Papaya Ring Spot Squash Mosaic Virus Turnip Mosaic Virus Watermelon Mosaic Virus Zucchini Yellow Mosaic Virus	
Fungi:	Bacteria:	Virus:	

Table 5 Resistant or Tolerant Pumpkin Varieties

PUMPKIN:	Company	Powdery Mildew	WMV	ZYMV	PRSV	Surface Etch (Rust)
Kens Special Hybrid 864	SPS	Int	Int			
Dulong QHI	SPS		Int	Int	Int	
Sunset QHI	SPS			Int	Int	Int

Int = Intermediate

Table 6a Regional distribution of pests

Pumpkin Pest	Carnarvon WA	Kununurra WA	NW TAS	NE TAS	Northern Midlands TAS	Sunraysia VIC	Melbourne VIC	Riverina NSW	Sydney NSW	Bathurst / Forbes NSW	Lockyer/ Fassifern Valleys QLD	Bundaberg QLD	Bowen QLD	Atherton QLD
Aphid	MR								R			MR	MR	MR
Cotton Aphid		MR					m		mR		MR			
Green Peach Aphid	MR						m R		R		mR			
Cowpea Aphid							m R		m		mR			
Potato Aphid									m		ml			
Thrips	MR								R					
Melon Thrip		m					R				mR			
Onion Thrip							m	m	m	m	mR			
Western Flower Thrip	MR					I	m		R					
Leafhopper								m	m	m				
Silverleaf Whitefly	MR								mR?			MR	MR	MR
Greenhouse Whitefly						m	m		MR					
Cucurbit Shield Bug							m R				ml			
Green Vegetable Bug							m I		ml		ml			
Mealybug	MR						m							
Rutherglen Bug	MR					I	m I	m	R	m				
Coon Bug						I	m							
Green Mirid Bug							m							
Passionvine Bug							m				ml			
Caterpillar	MR								R					
Armyworm	MR								m					
Budworm/Heliothis	MR	mR					m	m	R	m	ml			
Cutworm			ml	ml	ml		m I	m		m	ml			
Cucumber Moth							I		ml		ml			
Tiger Moth							m							
Looper	MR								mR					

Pumpkin Pest	Carnarvon WA	Kununurra WA	NW TAS	NE TAS	Northern Midlands TAS	Sunraysia VIC	Melbourne VIC	Riverina NSW	Sydney NSW	Bathurst / Forbes NSW	Lockyer/ Fassifern Valleys QLD	Bundaberg QLD	Bowen QLD	Atherton QLD
Cucurbit Ladybird							m	m	R	m	MR	MR		
26-Spotted Ladybird									MR					
28-Spotted Ladybird						m		m	MR	m				
African Black Beetle							m l		m					
Monolepta Beetle							m							
Plain Pumpkin Beetle							m	m	m	m	MR	MR		
Pumpkin Beetle		MR				m		m	R	m	MR	MR		
Vegetable Beetle								m		m				
Wireworm							m	m		m				
Fuller's Rose Weevil							m							
White Fringed Weevil							m		m					
Cucumber Fly							l		m		MI			
2-Spotted Mite	MR					l	m		MR		MR	MR	MR	MR
Blue Oat Mite							m							
Broad Mite							m		R					
Clover Mite							m							
Red-Legged Earth Mite							m							
Spider Mite							m		MR					
Ant							m							
Aust. Plague Locust							m	m	ml	m				
Wingless Grasshopper							m l		ml					
Black-Keeled Slug							m							
Brown Slug							m							
Reticulated Slug							m							
Snail							m							

M - Major Pest m - Minor Pest R - Regular l - Infrequent Dimsey Porter Scott James Walsh

Table 6b Regional distribution of diseases

Pumpkin Diseases	Carnarvon WA	Kununurra WA	NW TAS	NE TAS	Northern Midlands TAS	Sunraysia VIC	Melbourne VIC	Riverina NSW	Sydney NSW	Bathurst / Forbes NSW	Lockyer/ Fassifern Valleys QLD	Bundaberg QLD	Bowen QLD	Atherton QLD
Alternaria Leaf Spot						I	m	m	m	m	ml			
Anthracnose						I	m		m		ml	ml	ml	ml
Downy Mildew	MR	MI				m	m	m	m	m	MI	MI	MI	MI
Gummy Stem Blight						m			m		MI	MI	MI	MI
Powdery Mildew	MR	MI	ml	ml	ml	M	M	M	MR	M	MR	MR	MR	MR
Rhizoctonia Ground Rot						m								
Target Leaf Spot	MR													
Alternaria Fruit Rot						I	I							
Brown Etch		MI *						m		m	MI	MI	MI	
Crown Root							I		m					
Fusarium Fruit Rot						I								
Fusarium Wilt						I	I	m	mR	m				
Pythium		mR							m					
Bacterial Soft Rot											ml	ml	ml	
Bacterial Fruit Blotch								m		m			ml	
Bacterial Spot							m				ml	ml	ml	
Macrophomina		mR												
Phytophthora		mR							m					
Cucumber Mosaic Virus						R	I							
Papaya Ring Spot Virus		mR									MR	MR	MR	
Squash Mosaic Virus		MR				I								
Turnip Mosaic Virus									R					
Watermelon Mosaic Virus		mR				R			R		MR	MR	MR	
Zucchini Yellow Mosaic Virus	MR	MR				R			R				MR	
Sclerotinia			ml	ml	ml									

M - Major Pest m - Minor Pest R - Regular I - Infrequent

Dimsey Porter Scott James Walsh

Table 7 Current and possible management options for key pests and diseases

PUMPKINS	Aphids	Various leaf feeding lady beetles	Two spotted mite	Powdery mildew	Downy mildew	Viruses (ZYMV, Papaya Ringspot V, WaMV)
Diagnosis/detection	visual	visual	visual	visual	visual	visual & lab confirmation
Monitoring	sticky traps, bugvac, visual	bugvac, visual	bugvac, visual	visual	visual	visual
Thresholds	No					
Beneficials	predators & parasitoids	minor	predators			
Cultural controls	hygiene	No		resistant varieties, irrigation management	Irrigation management	clean seed, removal of cucurbit weeds, remove old crops, varietal resistance
Pesticide lists	pirimicarb, endosulfan, OPs	carbaryl,maldison	dicofol, dimethoate, oxythioquinox, sulfur, propargite	bupirimate, chlorothalonil, triadimefon, sulfur, oxythioquinox	azoxystrobin, chlorothalonil, Cu, dimethomorph, mancozeb, mancozeb + metalaxyl, metiram, phosphorous acid, propineb, propineb + oxadixyl, zineb	pirimicarb for aphid control
Other controls	cereal plantings as insectary crops		usually induced pest	milk sprays		
Training				No		
Fact sheets				NZ - for squash		
Field guides	ncluded in *Vegetable insect pests and their natural enemies in the dry topics* (QDPI &F)			No		
Information guides	No					
Newsletters	No					
Prediction models	No			New project	No	
IRM	No			Yes	Yes	
Best Management options						
R&D Gaps	impact of insectary crops, biopesticides	Potential for Bt - coloradensis		varietal susceptibility & status of fungicide resistance		

Current Pumpkin IPM options

Basic disease management:

1. Select resistant varieties
2. Source disease-free seed
3. Treat seed by heat if bacterial or fungicide if fungal diseases a major problem
4. Avoid double cropping with other cucurbits
5. Remove cucurbit weeds
6. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
7. Monitor crops on weekly basis –visually inspect
8. Chip diseased plants
9. Good sanitation particularly in presence of bacterial diseases
10. Manage aphids when virus is present in crop or neighbouring area

Basic insect management

1. Preplant monitoring of soil for soil pests if recurrent problem
2. Use bare fallow before planting where nematodes, wireworm or cutworm expected
3. Cereal plantings nearby with cereal aphids can increase aphid predator numbers
4. Monitor crops at germination for soilpest damage
5. Subsequently monitor crops weekly, if virus present then aphid numbers need to be managed
6. Leaf feeding beetles need only to be controlled if causing significant defoliation – no threshold has been set.

Potential Pumpkin IPM Options

1. Soft option for leaffeeding beetles, likely to reduce chemical induction of two spotted mite problem.
2. Biopesticides, soft chemicals and cultural controls for aphid management
3. Soft options for cutworm management
4. Biological and cultural options for nematode management
5. Greater varietal resistance to diseases
6. Soil management strategies to reduce soil pests & disease problems

Recommended Pumpkin work

Specific

1. Test efficacy of Bt - coloradensis on leaf feeding beetles, seek permit if effective
2. Pymetrozine for aphid control
3. Prediction models for powdery mildew, testing variety susceptibility and fungicide efficacy
4. Effect on sulphur on beneficials
5. Increased options for fungicides for resistance management
6. Ute guide for cucurbits
7. Management guidelines targeting growers who opportunistically grow pumpkins
8. Recommendations for insectary crops versus virus hosts

General

1. Disease prediction models
2. Fungicide efficacy and IRM strategies across industries
3. Fungicide/insecticides impacts on beneficials
4. Needs analysis for training

Sweet Potato: General Information

Common Name: Sweet potato

Scientific Name: *Ipomoea batatas*

Edible Plant Part: Root

Grown: Sweet potatoes are grown commercially in Rockhampton, Bundaberg, Cudgen, Broome and Katherine.

Table 1: Sweet Potato Insect Pests

Insects with registered chemical control options	Scientific Name	Insect pests reported with no registered chemical control options	Scientific Name
Insects - Sucking			
Aphids:	Aphididae		
Green Peach	*Myzus persicae*		
Thrips	*Thysanoptera*		
Leafhoppers	*Cicadellidae*		
Silverleaf Whitefly	*Bemisia tabaci*		
Rutherglen Bug	*Nysius vinitor*	Coon Bug	*Oxycarenus arctatus*
Cutworms	*Agrotis spp.*	Convolvulus Hawk Moth	*Agrius convolvuli*
Sweetpotato Leafminer	*Bedellia somnulentella*	Scrofa Hawk Moth	*Hippotion scrofa*
Corn Earworm	*Helicoverpa armigera*	Beet webworm	*Hymenia recurvalis*
Common Armyworm	*Leucania convecta*		
Grapevine Hawk Moth	*Hippotion celerio*		
Vine Hawk Moth	*Theretra oldenlandiae*		
African Black Beetle	*Heteronychus arator*	Vegetable Beetle	*Gonocephalum elderi*
Flea Beetle	*Galerucinae*	Chrysomelid beetles	
Wireworms	*Elateridae*	Flea Beetle	*Galerucinae*
Spotted Vegetable Weevil	*Desiantha diversipes*		
Sweetpotato Weevil	*Cylas formicarius*		
Vegetable Weevil	*Listroderes difficilis*		
Whitefringed Weevil	*Graphognathus leucoloma*		
Bean Spider Mite	*Tetranychus ludeni*		
2-Spotted Mite	*Tetranychus urticae*		
Redlegged Earth Mite	*Halotydeus destructor*		
Spider Mite	*Tetranychus spp.*		
Wingless Grasshopper	*Phaulacridium vittatum*		
Black Field Cricket	*Teleogryllus commodus*		
Field Cricket	*Gryllidae*		
Mole Crickets	*Gryllotalpidae*		
Australian Plague Locust	*Chortoicetes terminifera*		
Yellow-Winged Locust	*Gastrimargus musicus*		
Black-keeled Slug	*Milax gagates*		

Reticulated Slug	*Deroceras reticulatum*
Brown Slug	*Vaginulus plebeius*
Snail	*Gastropoda*
Root-knot Nematode	*Meloidogyne spp.*
Nematodes	

Table 2: Sweet Potato Insecticide Registrations
(Info Pest June 2006)

Insecticide registrations	Insecticide group
Carbaryl^	1A
Pirimicarb*	1A
Chlorpyrifos	1B
Fenamiphos	1B
Phorate	1B
Endosulfan#	2A
Fipronil*	2C
Bifenthrin*	3A
Imidacloprid	4A

* NSW, NT, QLD & WA only
^ QLD only # QLD & WA only

Table 3: Sweet Potato Diseases

Diseases with registered chemical control options	Scientific Name	Diseases reported with no registered chemical control options	Scientific name
		Early blight	*Alternaria/Cercospora spp.*
		Black Root Rot	*Ceratocystis fimbriata*
		Cercospora Leaf Spot	*Cercospora bataticola*
		Fusarium Rot	*Fusarium* spp.
		Pink Rot	*Pyrenophora terrestris*
		Rhizopus Rot	*Rhizopus stolonifer*
		Scab	*Elsinoe batatas*
		Scurf	*Monilochaetes infuscans*
		Bacterial Soft Rot	*Erwinia carotovora*
		Black Leg Disease	*Erwinia atroseptica*
		Sweet Potato Feathery Mottle Virus	
		Little Leaf Disease	
Fungi:	Bacteria:	Virus:	

Table 4: Sweet Potato Fungicide Registrations

Fungicide registrations	Fungicide group
No chemical control options given	

Cultural Management Options Planting virus free material.

Table 6 Regional distribution of pests and diseases

Sweet Potato Pest / Disease	Broome WA	Katherine NT	Rockhampton QLD	Bundaberg QLD	Cudgen QLD	Mareeba QLD
Green Peach Aphid			MR	mR	mR	mR
Silverleaf Whitefly			MI	MR	MR	MI
Convolvulus Hawk Moth (*Lepidoptera*)			mI	mI	mI	mI
Beet Webworm			mR	mR	mR	mR
Cutworm (*Agrotis spp.*)			mI	mI	mI	mI
Sweet Potato Weevil (*Cylas formicarius*)			MR	mR	mR	MR
White Fringed Weevil			mI	mI	mI	mI
Wireworm (*Haemonchus spp.*)			mI	MI	MI	mI
Chrysomelid Beetle			mR	R	R	mR
Flea Beetle			mR	m	m	mR
Black Field Cricket			mI	mI	mI	mI
Cricket (*Orthoptera*)			mI	mI	mI	mI
Mole Cricket (*Gryllotalpidae*)			MI	MI	MI	MI
Bean Spider Mite			mR	mR	mR	mR
Wingless Grasshopper			mI	mI	mI	mI
Nematode			M			
Field Mouse & Rat			mR	mR	mR	mR
Diseases						
Scurf				mI	MI	
Viruses			mR	mR	mR	mR

M - Major Pest m - Minor Pest R - Regular I - Infrequent Walsh

Table 7 Current and possible management options for key pests and diseases

SWEET POTATOES	Whitefly	Aphids	Wireworm	Mole crickets	Sweet Potato Weevil	Scurf	Viruses (feathery mottle, chlorotic stunt, etc)
Diagnosis/detection	visual/lab	visual/lab	visual/damage	visual/damage	visual/damage		Elisa kit, grafting onto susceptible material, EM
Monitoring	visual, sticky traps	sticky traps, bugvac, visual	preplant baiting, soil sampling	preplanting soil sampling	preplanting soil sampling		
Thresholds							
Beneficials	*Eretmocerus* spp.	predators /parasitoids	Nematodes, common brown earwigs	predators			
Cultural controls							clean plant material, rouging infected plants
Pesticide lists	imidacloprid	OPs, pirimicarb,	bithenthrin chlorpyrifos, fipronil, phorate	chlorpyrifos	bithenthrin chlorpyrifos		
Controls			insecticides, rotations			only problem in wet years and high pH soils	pirimicarb for aphid management
Training							
Fact sheets	Part of new projects						
Field guides	Part of new projects						
Information guides	Part of new projects						
Newsletters	Part of new projects						
Prediction models				Wireworm flights			
IRM	no	no	possible	no	no		
Best Management options	Current project looking at soil pests, diseases and nutritional management						
R&D Gaps	soft options: predators & biopesticides	pymetrozine, potential of insectary crops, biopesticides	potential of predatory nematodes	soil pest monitoring techniques & thresholds	soil pest monitoring techniques & thresholds		More viruses need to be characterised using elisa kits

Current Sweet potato IPM options

Basic disease management:

1. Select resistant varieties
2. Source disease-free planting material
3. Avoid double cropping
4. Avoid planting in high pH soils
5. Monitor crops on weekly basis –visually inspect
6. Chip diseased plants
7. Good sanitation particularly in presence of bacterial diseases
8. Manage aphids when virus is present in crop or neighbouring area
9. Minimise mechanical damage of sweetpotato at harvest and in packing shed

Basic insect management

1. Preplant monitoring of soil for soil pests
2. Use bare fallow before planting where soil pests are expected
3. Cereal plantings nearby with cereal aphids can increase aphid predator numbers
4. Monitor crops at germination for soil pest damage – spot spraying or baiting in patches of damage.
5. Subsequently monitor crops weekly, if virus present then aphid numbers need to be managed with pirimicarb
6. Control neighbouring weeds to reduce pest source
7. Have annual break in silverleaf whitefly hosts

Potential Sweet potato IPM Options

1. Soil pest monitoring protocol, cultural and biological or chemical management options
2. Biopesticides, soft chemicals and cultural controls for aphid and whitefly management
3. Greater varietal resistance to diseases
4. Soil management strategies to reduce soil disease problems

Recommended Sweet potato work

Specific

1. Efficacy of nematodes for wireworm control
2. Efficacy of Bt- coloradensis on sweet potato weevil
3. Pymetrozine for aphid control
4. Test kits for viruses
5. Registrations or permits for insecticides and fungicides to cover pests and diseases including enough options for a resistance management strategy for the major pests.

Zucchini: General Information

Common Name: Zuchinni
Scientific Name: *Cucurbita pepo*
Edible Plant Part: Fruit
15,231 tonnes $22.6 million (ABS 2002)
Grown:

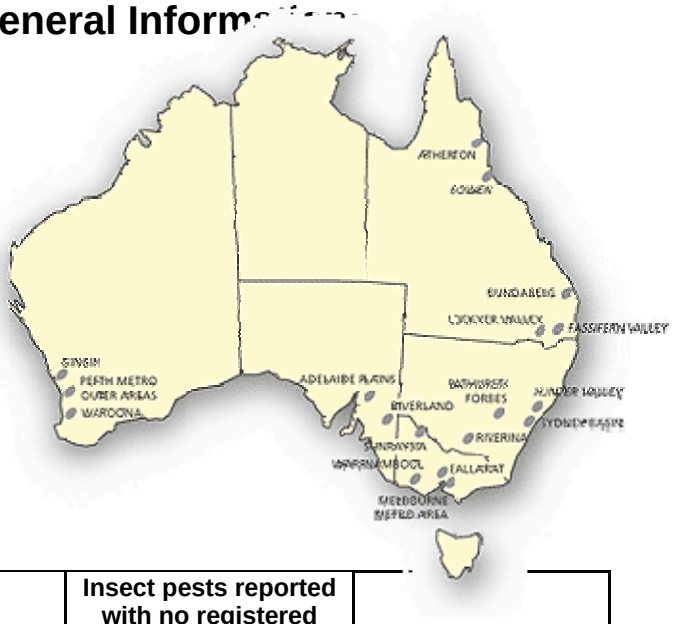
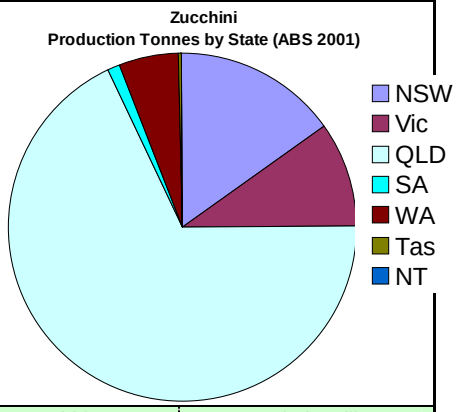


Table 1 Zucchini insect pests

Insect pests with registered chemical control options	Scientific Name	Insect pests reported with no registered chemical control options	Scientific Name
Aphids	Aphididae		
Cotton Aphid	*Aphis gossypii*		
Green Peach Aphid	*Myzus persicae*		
Cowpea Aphid	*Aphis craccivora*		
Tomato Aphids	*Macrosiphum euphorbiae*		
Thrips:	Thysanoptera		
Melon Thrips	*Thrips palmi*		
Western Flower Thrips	*Frankliniella occidentalis*		
Onion Thrips	*Thrips tabaci*		
Leafhoppers (Jassids)	Cicadellidae		
Silverleaf Whitefly	*Bemisia tabaci*		
Greenhouse Whitefly	*Trialeurodes vaporariorum*		
Green Vegetable Bug	*Nezara viridula*	Green Mirid	*Creontiades dilutus*
		Passionvine Bug	*Fabrictilis gonagra*
		Coon Bug	*Oxycarenus arctatus*
Corn Earworm	*Helicoverpa armigera*	Tiger Moth	Arctiidae
Cucurbit Stemborer	*Apomecyna histrio*		
Cucurbit Ladybird	*Epilachna cucurbitae*	Vegetable Beetle	*Gonocephalum elderi*
26-Spotted Ladybird	*Henosepilachna vigintioctopunctata*	Wireworms	*Elateridae*
28-Spotted Ladybird	*Epilachna vigintisexpunctata*	Fuller's Rose Weevil	*Asynonychus cervinus*
Monolepta Beetle	*Monolepta australis*	White Fringed Weevil	*Graphognathus leucoloma*
Plain Pumpkin Beetle	*Aulacophora abdominalis*		
Pumpkin Beetle	*Aulacophora hilaris*		
Cucumber Fly	*Bactrocera cucumis*	Onion Maggot	*Delia platura*
Mites:	Acarina	Seedling Bean Midge	*Smittia aterrima*
2-Spotted Mite	*Tetranychus urticae*		
Blue Oat Mite	*Penthaleus major*		
Redlegged Mite	*Halotydeus destructor*		

Broad Mite	*Polyphagotarsonemus latus*
Clover Mite	*Bryobia graminum*
Wingless Grasshopper	*Phaulacridium vittatum*
Australian Plague Locust	*Chortoicetes terminifera*
Yellow-Winged Locust	*Gastrimargus musicus*
Black-keeled Slug	*Milax gagates*
Brown Slug	*Vaginulus plebeius*
Reticulated Slug	*Deroceras reticulatum*
Snails	*Gastropoda*
Root-knot Nematodes	*Meloidogyne spp.*

Table 2 Zucchini insecticide registrations (InfoPest June 2006)

Insecticide registrations	Insecticide group
Dimethoate	1B
Fenamiphos	1B
Bifenthrin	3A
Abamectin	6A
Buprofezin	17A
Petroleum Oil	

Table 3. Zucchini diseases

Diseases with registered chemical control options	Scientific Name	Diseases reported with no registered chemical control options	Scientific Name
Alternaria Leaf Spot	*Alternaria cucumerina*	Alternaria Fruit Rot	*Alternaria*
Anthracnose	*Colletotrichum orbiculare*	Fusarium Fruit Rot	*Fusarium*
Downy Mildew	*Pseudoperonospora cubensis*	Pink Mould Rot	*Trichothecium roseum*
Gummy Stem Blight	*Didymella bryoniae*	Rhizopus Soft Rot	*Rhizopus stolonifer*
Powdery Mildew	*Sphaerotheca fuliginea*		
Rhizoctonia Ground Rot	*Rhizoctonia solani*		
Target Leafspot	*Corynespora cassicola*		
Septoria Spot	*Septoria cucurbitacearum*		
Bacterial Fruit Blotch	*Pseudomonas*	Angular Leaf Spot	*Pseudomonas syringae*
Bacterial Spot	*Xanthomonas campestris*		
		Watermelon Mosaic Virus	
		Papaya Ring Spot	
		Squash Mosaic Virus	
		Zucchini Yellow Mosaic Virus	
Fungi:	**Bacteria:**	**Virus:**	

Table 4 Zucchini fungicide registrations (InfoPest June 2006)

Fungicide registrations	Fungicide group
Chlorothalonil	Y
Copper - various sources	Y
Mancozeb	Y

Table 5 Resistant or Tolerant Zucchini Varieties

ZUCCHINI:	Company	ZYMV	WMV	PRSV	Pink Root Rot
Stinger	SPS	Int	Int	Int	
Hummer	SPS	Int	Int	Int	
Columbia	SPS	Int	Int		
Sungold	Terranova Seeds	Int	Int	Int	Int

Int= Intermediate

Cultural Management Option

Some resistant/tolerant varieties are available for management of Watermelon and Squash Mosaic viruses and Papaya Ring Spot virus.

Table 6a Regional distribution of zucchini pests

Zucchini Pest	Gin Gin WA	Perth WA	Carnarvon WA	Adel. Plains SA	Riverland SA	NW TAS	Sunraysia VIC	Melbourne VIC	Sydney Basin NSW	Lockyer Valley QLD	Fassifern Valley QLD	Bundaberg QLD	Bowen QLD	Atherton QLD
Cotton Aphid								m		R	R	MR	MR	MR
Green Peach Aphid			MR	ml				m	MR	R	R	MR	MR	MR
Cowpea Aphid										R	R			
Tomato Aphid										R	R			
Thrips			MR						MR					
Melon Thrip										m	m	?		
Western Flower Thrip				ml			M	m	MR	M	M	mR		
Onion Thrip				MR				m	m	R	R	?		
Leafhopper							l	m l		R	R			
Silverleaf Whitefly			MR						R?	R	R	MR	MR	MR
Greenhouse Whitefly				MR			m	m	MR	l (field)	l (field)	ml		
Green Vegetable Bug							l	m l	ml	M	M	ml		
Green Mirid Bug								m		R	R			
Passionvine Bug								m		l	R			
Coon Bug							l	m						
Rutherglen Bug			MR						R					
Mealybug			MR											
Budworm/Heliothis			MR					m	m	M	M	mR		
Cucurbit Stemborer										R	R			
Looper			MR											
Armyworm			MR						m					
Cluster Caterpillar			MR											
26-Spotted Ladybird								m	R	R	R	ml		
28-Spotted Ladybird							R	m R	R	R	R	ml		
Redshouldered Leaf Beetle								m		R	R			
Plain Pumpkin Beetle										R	R	ml		
Pumpkin Beetle							R	m R	R	R	R	ml		
Vegetable Beetle										R	R			

Zucchini Pest	Gin Gin WA	Perth WA	Carnarvon WA	Adel. Plains SA	Riverland SA	NW TAS	Sunraysia VIC	Melbourne VIC	Sydney Basin NSW	Lockyer Valley QLD	Fassifern Valley QLD	Bundaberg QLD	Bowen QLD	Atherton QLD
Wireworm								m		R	R			
Fuller's Rose Weevil								m		R	R			
White Fringed Weevil								m		M	M			
Cucumber Fly										R	R	MR		
Fruit Fly			MR											
Seedling Bean Midge										R	R			
2-Spotted Mite			MR					m	MR	M	M	mR	mR	mR
Blue Oat Mite								m		I	I			
Red-Legged Earth Mite				ml				m						
Broad Mite				ml				m	mR	I	I			
Clover Mite								m						
Australian Plague Locust								m	ml	R	R			
Yellow-Winged Locust								m		R	R			
Wingless Grasshopper								m	ml	R	R			
Black-Keeled Slug								m						
Brown Slug				ml				m		I	I			
Reticulated Slug								m						
Snail								m		I	I			
Root-Knot Nematode			mR	MR			I	I	mR					
Rabbit						MR								

M - Major Pest m - Minor Pest R - Regular I - Infrequent

Cavallaro Porter Scott Dimsey James Walsh

Table 6b Regional distribution of zucchini diseases

Zucchini Disease	Gin Gin WA	Perth WA	Carnarvon WA	Adel. Plains SA	Riverland SA	NW TAS	Sunraysia VIC	Melbourne VIC	Sydney Basin NSW	Lockyer Valley QLD	Fassifern Valley QLD	Bundaberg QLD	Bowen QLD	Atherton QLD
Diseases														
Alternaria Leaf Spot							l	l		ml		ml	ml	ml
Anthracnose							l	l						
Downy Mildew			MR	MR			l	l	R	Ml		Ml	Ml	Ml
Gummy Stem Blight							l	l	m					
Powdery Mildew			MR	MR		MR	M	M	MR	MR		MR	MR	MR
Rhizoctonia Ground Rot							l	l						
Target Leaf Spot			MR				l	l						
Septoria Spot							l	l						
Alternaria Fruit Rot							m	m						
Fusarium Fruit Rot							m	m						
Angular Leaf Spot							l	l						
Watermelon Mosaic Virus			MR	?			m	m l	MR	MR		MR	MR	MR
Papaya Ring Spot Virus				?				l	MR	MR		MR	MR	MR
Squash Mosaic Virus				?			m	m	MR					
Zucchini Yellow Mosaic Virus			MR	?			m	m l	MR				MR	MR

M - Major Pest m - Minor Pest R - Regular l - Infrequent Cavallaro Porter Dimsey James Scott Walsh

Table 7 Current and possible management options for key zucchini pests and diseases

ZUCCHINI	Aphids	Two-spotted mites	Thrips	Whitefly	Powdery Mildew	Downy Mildew	Viruses
Diagnosis/detection	visual	visual	visual	visual/lab (molecular)	visual/lab	visual/lab	visual, lab confirmation
Monitoring	sticky traps, bugvac, visual	bugvac, visual	visual, sticky traps	visual, sticky traps	visual	visual	visual
Thresholds	No						
Beneficials	predators/ parasitoids	predators	predators	*Eretmocerus* spp.			
Cultural controls	Refuge crops (non pest or disease hosts), clean seedlings				resistant varieties		clean seed, removal of cucurbit weeds, remove old crops, varietal resistance
Pesticide lists	pirimicarb, OPs endosulfan	dicofol, dimethoate, sulfur, propargite	OPs endosulfan	OPs, pyriproxyfen, pyrethrins	bupirimate, chlorothalonil, triadimefon, sulfur, oxythioquinox	azoxystrobin, chlorothalonil, Cu, dimethomorph, mancozeb, mancozeb + metalaxyl, metiram, phosphorous acid, propineb, propineb + oxadixyl, zineb	pirimicarb for aphids
Other Controls					milk sprays		aphid management
Training	Needed						
Fact sheets					NZ - for squash		
Field guides	Included in *Vegetable insect pests and their natural enemies in the dry topics* (QDPI &F)					No	
Information guides	Need a guide for field grown cucurbits						
Newsletters	some information covered in NSW IPM newletter						
Prediction models			need		could be developed		
IRM	potential	potential		potential	potential	potential	
Best Management options							
R&D Gaps	impact of insectary crops, biopesticides		soft options: predators & biopesticides		varietal susceptibility & status of fungicide efficacy/resistance		field test kits

Current Zucchini IPM options

Basic disease management:

1. Select resistant varieties
2. Source disease-free seed
3. Treat seed by heat if bacterial or fungicide if fungal diseases a major problem
4. Avoid double cropping with cucurbits
5. Remove cucurbit weeds
6. Use preventative fungicidal treatments when diseases are consistently a problem otherwise only apply fungicides when conditions are conducive and symptoms evident
7. Monitor crops on weekly basis –visually inspect
8. Chip diseased plants
9. Good sanitation particularly in presence of bacterial diseases
10. Manage aphids when virus is present in crop or neighbouring area
11. Minimise mechanical damage of zucchini at harvest and in packing shed
12. Cool chain management

Basic insect management

1. Preplant monitoring of soil for nematodes and other soil pests
2. Use bare fallow before planting where nematodes and soil pests are expected
3. Cereal plantings nearby with cereal aphids can increase aphid predator numbers
4. Monitor crops at germination for soil pest damage
5. Subsequently monitor crops weekly, if virus present then aphid numbers need to be managed
6.

Potential Zucchini IPM Options

1. Biopesticides, soft chemicals and cultural controls for aphid management
2. Soft options for cutworm management
3. Biological and cultural options for nematode management
4. Greater varietal resistance to diseases
5. Soil management strategies to reduce soil pests & disease problems

Recommended Zucchini work

Specific

1. Pymetrozine for aphid control
2. Efficacy of biopesticides for aphids and other sap suckers
3. Cucurbit field guide and information guide

General

1. Efficacy of biopesticides for aphids and other sap suckers in field crops
2. Impact of insectary crops on aphid and other pest management
3. Varietal susceptibility & status of fungicide efficacy/resistance
4. Field test kits for diseases

Australian Vegetable IPM Information Resources

Crops/topics	Type	Title	Date	Publisher	Author
Asian vegetables	Poster	Insects of asian vegetables in Northern Australia		NT Gov, QDPI	
Beans	Agriculture Notes	Red root rot of beans	1999	Vic DPI	Minchinton, E.
Beans	Agriculture Notes	Anthractnose of beans	1999	Vic DPI	Minchinton, E.
Beans	Agriculture Notes	Brown spot of beans	1999	Vic DPI	Minchinton, E.
Beans	Agriculture Notes	Common blight of beans	1999	Vic DPI	Michinton & Pullman
Beans	DPI&F Notes	An integrated approach to pest management	2006	QLD DPI&F	Duff J
Beans	DPI&F Notes	Chewing pests	2006	QLD DPI&F	Duff J
Beans	DPI&F Notes	Sucking pests	2006	QLD DPI&F	Duff J
Beans	DPI&F Notes	Beneficial insects in an IPM system	2006	QLD DPI&F	Duff J
Beans	DPI&F Notes	Crop monitoring	2006	QLD DPI&F	Duff J
Beans	DPI&F Notes	Cultural practices in an IPM system	2006	QLD DPI&F	Duff J
Beans	DPI&F Notes	Biological management options in an IPM system	2006	QLD DPI&F	Duff J
Beans	DPI&F Notes	Pesticide application	2006	QLD DPI&F	Duff J
Beans	Newsletter	IPM in green beans newsletter		DPI&F qld	
Beneficials	CD	Spiders of Australia	2002	ABRS	Raven et al.
Beneficials	Information guides	Good Bug Book 2nd Edition	2002	IPM pty ltd	Llewellyn et al.
Beneficials		The Good Bugs that Eat the Bad Bugs		DPIWE, Tas	McPhee, J
Beneficials	Poster	Beneficial Insects	1998	NSW Agriculture	McDougall, S.
Brassicas	Agriculture Notes	Downy mildew of brassicas	1999	Vic DPI	Michinton & Pullman
Brassicas	Agriculture Notes	Clubroot of cruciferous crops	2001	Vic DPI	Donald, C.
Brassicas	Brassica Bulletin 4582	Pests of Vegetable Brassica Crops in Western Australia	2003	DAWA	Learmonth et al.
Brassicas	CD	IPM for Brassica	2002	DPI VIC	anon
Brassicas	decision support toolkit		not yet released	DPI&F, Qld	Walsh et al
Brassicas	Farmnote 28/2003	Virus diseases of vegetable brassica crops	2003	DAWA	Latham & Jones

Brassicas	Farmnote 85/2000	Clubroot disease of crucifers in Western Australia	2000	DAWA	Lancaster, R.
Brassicas	Field guide	A guide to Common Pests & Beneficial Insects in Brassica crops	?1996	DPI VIC	Bentley
Brassicas	Field guide	Pests and Beneficials in Brassica crops	1997	QDPI	Heisswolf & Brown
Brassicas	Information guide	IPM of DBM in Crucifers: the handbook	1998, 2000	National DBM project team	Endersby et al.
Brassicas	Information guide	Brassica grower's handbook	2005	QDPI&F	Heisswolf et al.
Brassicas	Newsletter	Brassica IPM national newsletter		SARDI	
Brassicas	Picture guide	Field guide to Pests, Diseases and Disorders of vegetable Brassicas	2000	DPI VIC	
Brassicas	Picture guide	Brassica grower's problem solver	2005	QDPI&F	Heisswolf et al.
Brassicas	PrimeNote	Diamondback moth in selected brassica vegetable crops	2006	QDPI & F	Walsh & Heisswolf
Brassicas	PrimeNote	Growing brassicas - Common questions	2005	QDPI & F	Heisswolf et al.
Brassicas	PrimeNote	Managing weeds in broccoli, cauliflower and cabbage		QDPI & F	Henderson, C.
Brassicas	Video	integrated pest management for brassicas	2002	DNR&E (DPI Vic)	IHD Knoxfield
Bunching vegetables	Information guide	Guide to Common Diseases and Disorders of Bunching Vegetables in Australia	2003	DPI Vic	Kita et al.
Capsicum	PrimeNote	Bacterial spot of capsicum: What to expect from resistant varieties	2005	QDPI & F	Hibberd & Martin
Capsicum and chillies	Information guide	Capsicum and chilli Agrilink	1999	DPI, Qld	
Capsicum/Chillies	PrimeNote	Growing capsicum and chilli - Common questions	2005	QDPI & F	Lovatt et al.
Carrots	Farmnote 29/2003	Carrot Virus Y	2003	DAWA	Latham et al.
Carrots	Farmnote 73/95	Leaf blight diseases of carrots	1995	DAWA	Galati & McKay
Carrots		Carrot variety screening for cavity spot tolerance	2001	DAWA	McKay & Davison
Caterpillars	Pest key	Identifying major noctuid caterpillar pests	?	Rhone Poulenc/NSW DPI	Goodyear, G.
Celery	Agriculture Notes	Celery mosaic virus	2000	Vic DPI	Traicevski, V.
Celery	Factsheet 15/2001	Celery Mosaic Virus	2001	DAWA	Latham & Jones
Cucurbits	Information guide	Protect your cucurbits	1994	QDPI	Broadley RH
DBM	Agriculture Notes	Diamondback moth	1996	Vic DPI	Endersby & Ridland
Eggplant	Information guide	Growing eggplants in Qld	1999	DPI qld	Meurant et al
French Beans	Agriculture Notes	Sclerotinia white rot of french bean	1996	Vic DPI	Minchinton & Pullman

Fungicides	PrimeNote	Fungicide resistance: threats and strategies	2005	QDPI & F	Broadley, R.
Galls	Agfact H1.AB.3	Crown gall of plants	2001 2nd Ed	NSW DPI	Fahy, P.
Greenhouse	Book	Biocontrol in protected culture	2004	Ball Publishing	Heinz et al
Greenhouse vegetables	Field guide	Pests, diseases, disorders and beneficials in greenhouse vegetables.	2002	NSW DPI	Goodwin
Greenhouse vegetables	Information guide	Integrated pest management in greenhouse vegetables	2002	NSW DPI	Goodwin et al.
Heliothis	Agriculture Notes	Native budworm	1995	Vic DPI	McDonald, G
Heliothis	PrimeNote	Parasitoids: Natural enemies of helicoverpa		QDPI & F	
Heliothis	PrimeNote	IPM - *Microplitis demolitor* and ascovirus: Important natural enemies of *Helicoverpa*		QDPI & F	
Horticultural crops	Information guide	Managing insects and mites in horticultural crops	1994	DPI, Qld	Brough et al
Hygiene	PrimeNote	Farm hygiene for vegetable crops	?	QDPI & F	Grundy, T.
IPM	Fact sheet (No: 29/01)	Horticultural crop monitoring - the key to informed decisions	2005	PIRSA	Jevremov, D.
IPM	Fact sheet (No: 30/01)	Integrated pest management (IPM)	2005	PIRSA	Jevremov, D.
IPM	Manual	Vegetable Integrated Pest Management (IPM) in Tasmania: Manual	2004	DPIWE, Tas	Wardlaw, F.
IPM	PrimeNote	IPM - Understanding helicoverpa ecology and biology in southern Queensland: Know the enemy to manage it better		QDPI & F	
IPM	Report	CHURCHILL FELLOWSHIP advanced Integrated Pest Management (IPM) techniques, systems, and adoption in Scandinavia, Holland, and the United Kingdom	2002	DPIWE, Tas	Bishop, A.
Lettuce	Agriculture Notes	Growing Lettuce	2005	Vic DPI	Dimsey & Vujovic
Lettuce	Field guide	Lettuce Pests, beneficials, diseases and disorders	2003	NSW Agriculture	McDougall & Creek
Lettuce	Information guide	Scouting protocol for lettuce incorporating IPM	2005	DPI VIC	Dimsey et al
Lettuce	Information guide	Corn earworm control in lettuce	2005	DPI VIC	Dimsey et al
Lettuce	Information guide	IPM in Lettuce information guide	2000	NSW Agriculture	McDougall et al.
Lettuce	Information guide	Lettuce Agrilink	1997	QDPI	Heisswolf et al.
lettuce	Information Notes	Tiburn in lettuce	2005	DPI VIC	Murdoch et al.
Lettuce	Information Sheet	Information on Currant-Lettuce Aphid	2005	DPIWE, Tas	
Lettuce	Newsletter	Lettuce Leaf newsletter	bimonthly	NSW DPI	
Lettuce	Primefacts (154)	Lettuce IPM	2006	NSW DPI	McDougall, S.

Lettuce	Primefacts (155)	Currant lettuce aphid Nasonovia ribisnigri (Mosley)	2006	NSW DPI	McDougall & Creek
Lettuce	Quick notes	Lettuce aphid resistant lettuce varieties (October 2006)	2006	NSW DPI	
Mites	CD	Mites in Soil	2001	ABRS	Walter & Proctor
Mites	Farmnote 25/2002	Management of spider mites (Tetranychidae) in vegetable crops in Carnarvon	2002	DAWA	Azam, G.
Nematodes	Agriculture Notes	Root knot nematode on vegetables	1996	Vic DPI	Hinch, J.
Nematodes	PrimeNote	Alternatives to nematicides in fruit and vegetable crops	1993/94	QDPI & F	Vawdrey & Stirling
Onions	Field guide	Field guide to cream gold onion disorders and their control in Tasmania	1997	DPWIE	Dennis et al.
Onions	Information guide	Onion agrilink	1999	DPI qld	
Parsley	Field guide	Guide to Common Diseases and Disorders of Parsley	2006	DPI Vic	Minchinton et al.
Potatoes	Agfact H8.AE.5	Potato moth	1985	NSW DPI	Hamilton, J.
Potatoes	Agriculture Notes	Potato Y virus	2003	Vic DPI	Moran & Rodoni
Potatoes	Agriculture Notes	Potatoes - bacterial wilt	1995	Vic DPI	Osborn, R.
Potatoes	Agriculture Notes	Fusarium wilt of potatoes	1995	Vic DPI	Osborn, R.
Potatoes	Agriculture Notes	Insects of potato crops - southern Victoria	1999	Vic DPI	Henderson, A.
Potatoes	Agriculture Notes	Potato cyst nematode	1999	Vic DPI	Berg, G.
Potatoes	Agriculture Notes	Potatoes - black leg and soft rot	1995	Vic DPI	Osborn, R.
Potatoes	Agriculture Notes	Potatoes - management strategies for pests and diseases	2001	Vic DPI	Henderson & de Boer
Potatoes	Agriculture Notes	Potatoes - phoma or gangrene	1995	Vic DPI	Osborn, R.
Potatoes	Agriculture Notes	Rhizoctonia or black scurf disease of potatoes	1996	Vic DPI	Osborn, R.
Potatoes	Agriculture Notes	Root knot nematode on potatoes	1999	Vic DPI	Berg, G.
Potatoes	Agriculture Notes	Target spot (early blight) of potatoes	1995	Vic DPI	Osborn, R.
Potatoes	Agriculture Notes	The potato moth	1999	Vic DPI	Henderson, A.
Potatoes	Agriculture Notes	Tomato spotted wilt virus in potatoes	2004	Vic DPI	Rodoni & Henderson
Potatoes	Factsheet 02/2003	Potato Virus Y	2003	DAWA	Jones et al.
Potatoes	Field guide	A field guide to insects and diseases of Australian potato crops	2002	Melb. Uni Press	Horne et al.
Potatoes	Information guide	Potato agrilink	1997	QDPI	
Potatoes	Information guide	Insects and diseases of Australian potato crops	2002	Melb. Uni Press	Horne et al.
Root knot	Agfact AB.1	Root knot disease and its control	2003, 3rd Ed	NSW DPI	Rahman, L.

Sweet Corn	Agfact H8.1.39	Growing sweet corn	2005, 4th Ed	NSW DPI	Beckingham, C
Sweet corn	CD	IPM in Sweetcorn (final report & workshop reports)	2004	QDPI	Deuter et al.
Sweet corn	Field guide	Sweet corn insect pests and their natural enemies	2000	HRDC	Llewellyn
Sweet corn	Information guide	Corn Earworm in Sweet Corn - Managing Insecticide Resistance.	2001	DPI VIC	Ridland & Dimsey
Sweet corn	Information guide	Sweet corn grower's handbook	2005	QDPI&F	Wright et al
Sweet corn	Newsletter	Sweet corn ear	1998-2002, 2006	QDPI	
Sweet corn	Picture guide	Sweet corn problem solver and beneficial identifier	2005	QDPI&F	Wright et al
Sweet potato	Information guide	Sweet potato Agrilink		QDPI	
Thrips	CD	Thrips ID: Pest thrips of the world	2001	ACIAR	Mortiz et al
Thrips	Information guide	Western Flower Thrips	1994	DPI VIC	Hill
Thrips	Information sheet	Which thrips is that? A guide to the key species transmitting TSWV in NSW	2005	NSW DPI	Steiner et al.
Thrips	Pest key	Identification Guide to thrips associated with crops in Australia	1997	CSIRO/NSW DPI	Mound & Gillespie
Thrips	Quick notes	Western flower thrips (WFT) insecticide resistance management plan	2005	NSW DPI	Herron et al.
Tomatoes	Agriculture Notes	Grey mould (Botrytis) in greenhouse tomato crops	1996	Vic DPI	Gray Harrison
Tomatoes	Book	Growing tomatoes in Queensland	1998	QDPI	Fullelove & Meurant
Tomatoes	Picture guide	A guide to Common Pests & Beneficial Insects in Processing Tomatoes	?1996	DPI VIC	Bentley
Vegetables	CD	Managing WFT & TSWV in Vegetables	2003	DPI VIC	anon
Vegetables	Information guide	Development of Biological Controls for Sclerotinia Diseases	2004	DPI Vic	Villalta et al.
Vegetables	Information guide	Australian vegetable growing handbook	1998	Scope Publishing	Salvestrin
Vegetables	Newsletter	Vegenotes	quarterly	Arris/AUSVEG	
Vegetables	Newsletter	Vegetable Matters of Fact		DPI VIC	
Vegetables	Newsletter	Western flower thrips	quarterly	DPI&F qld	
Vegetables	Newsletter	Vegie bites	quarterly	NSW DPI	Napier, T
Vegetables	Newsletter	NSW IPM newsletter	quarterly	NSW DPI	Azzopardi, S
Vegetables	PrimeNote	Integrated weed management components in vegetable crops	2004	QDPI & F	Grundy & Henderson
Vegetables	Workshop manual	Identification of insects, spiders and mites in vegetable crops	1997	DPI, Qld	Heisswolf et al.

Vegetables & fruit	Field guide	Insect pests of fruit and vegetables	1991	QDPI	Swaine et al.
Vegetables & fruit	Information guide	Insects pests of fruit & vegetables in NSW	1982	NSW DPI	Hely et al
vegetables (beans, capsicum, cucurbits, eggplant, sweetcorn, tomato)	Field guide	Insect Pest Guide: a guide to identifying vegetable insect pests and their natural enemies in the dry topics	2004	QDPI&F	Brown
Vegetables (brassicas, carrots, green beans, green peas, onions, potatoes)	Information guide	IPM in Vegetables in Tasmania	2005	DPWIE	Wardlaw
Vegetables & other crops	CD	Primenotes	2005	DPI&F	
Vegetables & other crops	CD	Info pest AGVET (chemical registrations, permits & labels)	quaterly	QDPI	anon
Vegetables & other crops	CD	Info pest MSDS	quaterly	QDPI	anon
Whiteblister	PrimeNote	White blister of ornamentals and other plants	2005	QDPI & F	Forsberg, L
Whitefly	PrimeNote	Silverleaf whitefly in Queensland Project VG05050	2005	QDPI & F	
Whitefly	PrimeNote	Emerging plant pests - spiraling*whitefly	?	QDPI & F	Lambkin, T

Supplementary CD

VG05043 final report document (minus appendices)

Appendices:

I. Horticulture Australia Vegetable IPM Projects 1996 - 2006
II. COTTON RDC IPM Projects 1992 - 2006
III. Grape and Wine RDC IPM Projects 1989 - 2006
IV. Rural Industries RDC IPM Projects 1999 – 2006
V. Rural Industries RDC IPM Projects 1995 – 2006
VI. IPM in the Australian Cotton Industry
VII. IPM in the Australian Citrus Industry
VIII. IPM in the Australian Processing Tomato Industry
IX. IPM in the Australian Sweet corn Industry
X. IPM in the Australian Brassica Industry
XI. Beans: General Information
XII. Beetroot: General Information
XIII. Carrots: General Information
XIV. Capsicum: General Information
XV. Celery: General Information
XVI. Chinese Cabbage: General Information
XVII. Cucumbers: General Information
XVIII. Pumpkin: General Information
XIX. Sweet Potato: General Information
XX. Zuchinni: General Information
XXI. Australian Vegetable IPM Information Resources (including table of some NZ & Californian vegetable IPM, and table of some Australian non-vegetable IPM information resources)

Vegetable IPM project Summaries (32 projects)

May 06 Ent-Path-IPM workshop notes

2006 Entomology project summaries
2006 Pathology project summaries
Entomologist IPM workshop notes
IPM workshop notes

Surveys

Web IPM Survey report (86 pages)
Web IPM survey questions
IPM Consultant Survey (8 pages)

Selected 10 crops

XL Pest & disease tables for each crop
Regional Pest and Disease list
Disease trans-alt host tables
Transmission of Viral Diseases
Transmission and Control of Bacterial Diseases
Transmission and alternate hosts of Fungal Diseases
Best Bet IPM 10 crops – workshop lists
Best Bet IPM 10 crops – major pest & disease lists

Draft – new chemistry tables
Draft – Pest and Disease options tables