IPM Gap Analysis for Vegetable Pathology

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VIC Department of Primary Industries

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PRIMARY INDUSTRIES

National Vegetable Industry IPM Pathology GAP Analysis

Horticulture Australia VG06092

May 2007

Ian Porter, Caroline Donald and Elizabeth Minchinton

Primary Industries Research Victoria, Knoxfield Centre

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Purpose of project:
This project details the outcomes of a 12-month study to determine priorities for funding projects on the development of successful ' best practice' projects to increase on farm adoption of IPM for pathology issues.

Report completed: May 2007

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1. Media Summary

A series of eight national workshops attended by over 150 growers, researchers and agricultural consultants have led to the development of a $2 million research program to address development of new IPM strategies for the key disease problems in vegetable crops throughout Australia. The top six pathogens which workshop participants prioritised as causing the greatest losses throughout the industry were Sclerotinia, viruses particularly tomato spotted wilt and cucurbit viruses, downy mildew, Fusarium, Pythium and powdery mildew. Crop loss from these pathogens ranged between 5 to 100% depending on the region and the climatic conditions. The estimated cost in lost production from these diseases to industry was $100 million.

Six key sub program areas have been proposed to the industry advisory committee for funding from 2007 onwards for up to 3 years. The key sub program projects cover areas of chemical resistance management, the use of IPM compatible pesticides, development of best practice IPM programs for foliar, soilborne and viral diseases, a technology transfer program to deliver 'holistic' IPM packages for outdoor and greenhouse vegetables, and an innovation program that looks at new technologies that could improve use of IPM on farm. The sign off on the program will be made by the Vegetable IAC during July 2007.

2. Introduction

The Australian vegetable industry has significant annual investment in pest and diseases research and development programs. These programs are directed towards the sustainable management of a large range of plant disease issues caused by fungi, nematodes, viruses and insects that cause over $100 - 150 million of loss annually to the production of vegetable crops.

Under the current funding structure, a research and development levy is collected from all growers. This money is matched 1:1 by the federal government and further funding is sourced from state governments or the private sector supporting various proposals. The process is managed by Horticulture Australia Limited who call for research submissions on behalf of the vegetable industry annually. Research submissions are reviewed by industry leaders (key growers supported by industry development officers, exporters and other industry representatives) who allocate funds to priority projects. Traditionally urgent disease problems that limit productivity or quality are given priority funding (eg. clubroot of brassicas during the late 1980s and early 1990s, celery mosaic virus during the late 1990s and, more recently white blister of brassicas and white rot of spring onions). However, no coordinated approach to pathology research and development exists under the current structure. Researchers receive limited guidance from the vegetable industry aside from those within their circle of contacts during the project development phase. Equally, industry leaders face the daunting task of prioritising a multitude of research submissions within a poorly defined framework.

Many of the industry's disease issues have been around for a long time, however, since project outcomes are not collated in a readily available format, most growers could not hope to be aware of all of the projects conducted in the last 20 years let alone be familiar with their outcomes.

In 2006 a series of workshops was conducted by Sandra MacDougall to evaluate priorities for IPM management of insect pests of the major vegetable crops. At a meeting of stakeholders in Sydney in March 2006, it was identified that this program needed a complimentary program to address the key pathology issues that needed to be addressed throughout Australia. In July 2006, this project was commissioned to review vegetable pathology (disease) research conducted in the last 20 years. It also was to establish the current situation with uptake of pathology IPM, identify gaps in knowledge and make recommendations to industry for strategic short and long term investment priorities in vegetable IPM. Its brief was to conduct a series of meetings and reviews of past research to establish the key priorities that needed to be addressed in pathology. The primary outcome of the project was to develop a set of R, D and E priorities that were clear, concise and adequately reflected the needs of the industry in addressing IPM pathology issues. Another outcome was to develop a process for setting priorities for R and D which avoided the frustration to stakeholders of the ad hoc approach that previously existed. The program was to provide a structure which ensured collaboration and integration of IPM programs into a systems approach for pest and disease control on farm.

3. Methodology

The project used a series of workshops in each State of Australia, a database and knowledge from industry, researchers and other agrochemical representatives and consultants to develop a program for investment into R,D and E in pathology in the vegetable industry.

3.1 Strategic Priority Setting using Expert Information

It was recognised from the beginning of the project that there were two parallel approaches that could be taken to the process of identifying gaps in pathology research and development and setting research priorities.

The first utilises the knowledge held by current experts in the field (Fig 1, Part B). It seeks to source information from pathologists working with the pathogens, growers seeking to implement research findings and other members of the industry, including crop consultants and resellers, working directly with growers to manage their pathogen problems. This method provided accurate and up to date information, however, the information provided is subjective and open to influence by one or two vocal participants (influential growers, agricultural consultants or research providers). This process is often biased towards addressing the short term priorities that exist because of the influence of short term problems on farm, ie drought, climate, epidemics, etc. The consistency of information across States meant that information from this process proved to invaluable for setting up the priorities of the whole program.

Both approaches were used in parallel (Fig 1.).

3.2 Strategic Priority Setting using Structured Databases

This approach (Fig 1, Part A) involved a rigorous review of past research in HAL projects, past reports from National Vegetable Pathologist Research Meetings in 2003 and 2005, the development of decision making databases with the growers and agricultural consultants and a science database. This approach provided an objective summary of the available information, the success of the research programs and a longer term view of the likelihood of R, D and E to achieve effective outcomes.

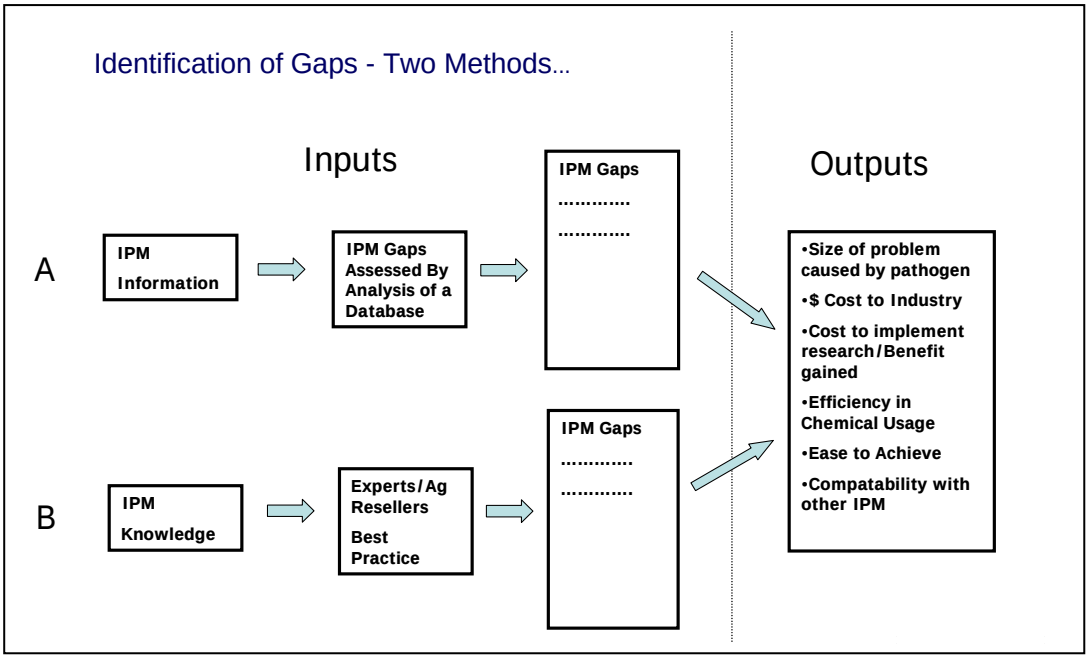


Fig 1. A diagrammatic representation of the two approaches taken to develop the priority research and technical transfer requirements of the National IPM pathology program

Review of background material – April 2006

The following background reference material was available at the onset of the project. This material was reviewed by the project team and the results (a series of priority issues) was presented to the Vegetable Industry Advisory Committee at a meeting held in the HAL offices, Sydney in April, 2006.

1. Coutts J, Purdon L and McDougall S. (2006). IPM Stocktake Survey. NSW Department of Primary Industries and Coutts J & R.
2. National Vegetable Pathology Working Group Meeting – Minutes. Brisbane Convention Centre, South Bank Brisbane. Monday 8th May, 2006.
3. McDougall S, Burfield T and Watson A (2006) IPM Stocktake data files (entomology/pest based). NSW Department of Primary Industries.

IPM Pathology Gap Analysis: July 2006 to May 2007

National workshop for pathologists and crop consultants to set key sub projects of the program

A two day workshop was conducted at the Department of Primary Industries, Knoxfield centre in November 2006. Key pathologists from each state and Northern Territory attended both days. They were joined by key crop consultants on the second day (see Appendix 1 – workshop agenda and attendees).

Prior to the workshop two surveys (one for the pathologists and one for the consultants) were developed (Appendix 2 and 3). The pathologists were sent both surveys. They were asked to complete the 'pathology' survey alone based on their own knowledge of the industry. They were also asked to take the 'industry' survey out to key chemical resellers, growers and other industry representatives to get their opinion before the workshop. The consultants were only sent the 'industry' survey and were asked to complete this before attending the workshop.

National Industry Workshops

Six pathology sub-program areas were developed from the preliminary workshop conducted at Knoxfield, Victoria and the review of background material. These sub-program areas including, key research activities, target pathogens and preliminary funding priority guidelines were summarised and a document prepared for use as prerequisite reading material for industry workshop attendees.
A series of eight industry workshops were then held to ensure that the priorities set were representative of the industry needs nationally:

- Victoria (DPI, Bairnsdale) - February 1st, 2007 (Preliminary workshop)
- New South Wales (Panthers Leagues Club, Bathurst) – February 6th, 2007
- Queensland (DPI, Gatton Research Station) – February 7th, 2007
- Tasmania (DPIWE, Devonport) – February 9th, 2007
- South Australia (Waite Campus) – February 13th, 2007
- Western Australia (Waneroo Tavern) – February14th, 2007
- South Australia (Virginia Horticultural Centre) – February 26th,2007
- Victoria (Amstel Golf Club) – February 28th, 2007

Workshop participants (over 150) included key growers, consultant, chemical resellers, and researchers from the relevant Departments of Primary Industries, National Universities, CSIRO and private sector providers. The aim of the industry workshops was to brainstorm pathology priorities of regional importance, align these with the sub-program areas determined during the preliminary workshop, identify points of significant difference and modify the sub-program areas accordingly.

Each workshop was facilitated and followed a structured development process (see Appendix 2). The key tasks were to determine key priority problems, the % loss, the cost to the industry and then the areas where industry felt IPM research and delivery would benefit the industry.

Pathology Research and Development database

As part of the information review a database of past projects was developed using Microsoft Access 2003. The database contains summaries of pathology projects conducted within the last 20 years. It includes, without being restricted to, Horticulture Australia Ltd funded projects. The database contains project summaries, identifying information (such as project title, project number, chief investigator etc) and categorises each project according to the IPM tools researched or developed, the pathogen, crop and/or region/s studied (Appendix 4).

The database was used during the project as a source of reference material. In particular it was used during the formulation of the key research activities within each subprogram areas. Beyond the project it will exist as a stand-alone database for industry to use to review in detail past information and avoid unnecessary duplication of R and D. Present work is being targeted to see if it can be linked into the AusVeg website databases for use by all stakeholders nationally and internationally.

4. Results

4.1 Review of background material

The following priority research areas were identified as the key issues to be addressed at the past meetings of the National Vegetable Pathology Workshops held in 2003 and 2006:

Fungicide resistance management

- Development of resistance management strategies for major pathogens to maximise the longevity of existing chemistries. Strategies similar to that for the insect pest diamond back moth needed (eg. white blister). Nurseries should be included since they may be applying several fungicide applications for a single pathogen.
- Investigate the extent of resistance for several pathogens (eg. pathogens of cucurbits, copper resistance issue for bacterial spot of capsicum and black rot of brassicas)
- Investigate alternative chemistries for major pathogen groups (eg. Powdery mildews, downy mildews, white blister and Botrytis).

Seed borne diseases

- Undertake review/scoping study to develop a strategy to address the issue of healthy seed for the Australian vegetable industry. Identify key diseases of concern.
- Seedling project to address seedling health, nursery best practice – production of disease free seedlings.

- Develop methods of testing and managing seedborne diseases (issue for root crops, tomato, capsicum and brassicas to a lesser extent).
- Tomato project addressing potato spindle tuber viroid and bacterial canker.

Extension

- Develop and implement Brassica model for other key commodities (beginning with lettuce and carrot). Consider setting aside dollars to fund similar commodity based roadshows with associated printed materials on a regular basis, perhaps every 3 years.

Diagnostics

- Review predictive and diagnostic tests available world-wide, their availability, effectiveness and ease of use, determine the practicality of in-field diagnostic tests and validate for Australian conditions.
- Develop diagnostic tests (eg. for soilborne diseases of root crops)
- Develop sampling strategies for collection of soils for diagnostic testing. How to collect a sample that will give a good reflection of the disease present in the field. One sample or many? How many? etc.
- Collect field data to correlate test result with disease outcomes in a range of soils and conditions. Determine thresholds for disease (ie. ground truth these tests).

Best practice

- Network pathologists, entomologists, agronomists etc for each major commodity group to develop 'best practice' guidelines for the commodity. Identify key recommendations for each major pest/disease issue within the commodity and test these against what is known for other pests and pathogens that affect that commodity. Are we sending conflicting recommendations. Identify best practice – this will most likely be a compromise outcome for all pest/pathogens. Prepare guidelines as summary sheets.

New chemistry

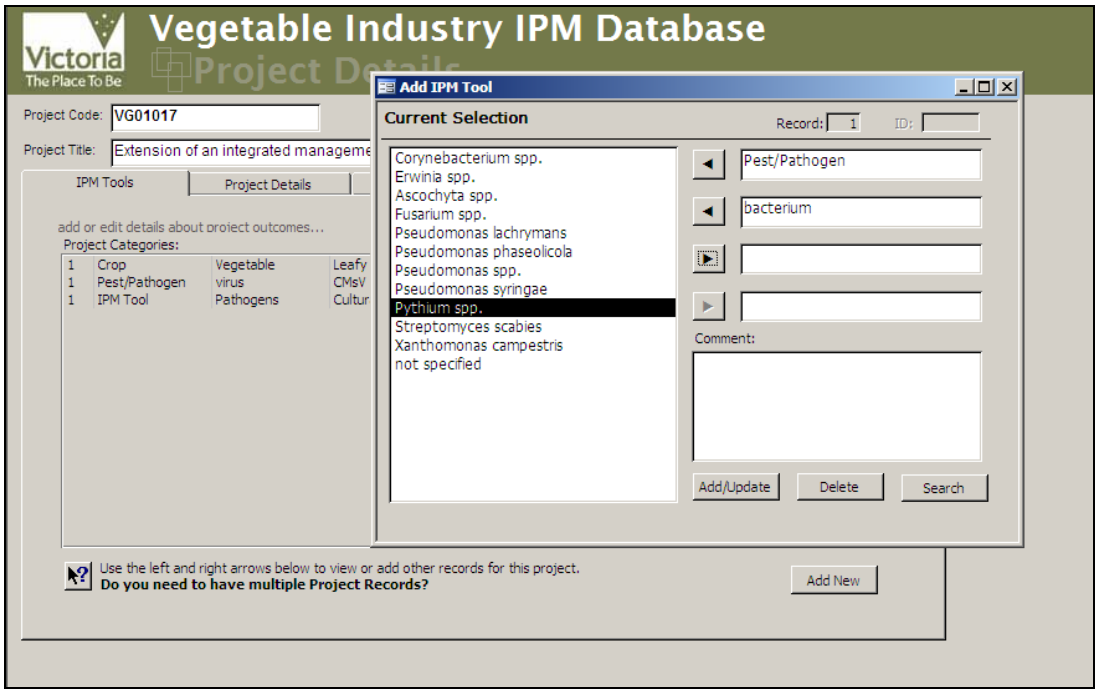
- Investigate new chemistry to increase the available arsenal available to combat pathogens. Ability to control some important pathogens restricted to only one or two groups. Resistance is inevitable. Liaise with the outputs from the Minor Use program conducted by Agaware and Peter Dal Santo (AH04009).

4.2 *Database of Past Pathology Research*

Project information was gathered for the database using various methods. Searching the HAL website for media summaries in the vegetable industry, using lists of current HAL research projects, emailing researcher from the various countries DPI's and universities, as well as collecting from previous IPM investigations. Over 180 research projects were reviewed, 61 of them were found to be relevant to the vegetable pathology IPM analysis.

The media statements and project summaries were then reviewed and then categorised using predetermined IPM research areas (see *IPM Tools for pathogens* in Appendix 4). Other relevant research areas were also categories against the project summary including location, pathogen and crop. This information was recorded in the form of Keyword descriptors and enabled cross-tabulations to be created for investigating, for example, disease by IPM tools, or crop by IPM tools. An example of the user interface that was created for entering data is shown in Figure 2.

Fig 2. User Interface for adding an IPM Tool into the database



A frequency table of the IPM tools by crop is shown in Table 1. Currently, discussions are underway with Tony Burfield and representatives from AusVeg to look at incorporating this information into a format accessible to Growers.

Table 1 - Table of the Number of Existing Research Projects (by Vegetable Group) that have Outcomes Related to the IPM Tools Categories.

Pathogens	Alliums	Asian Veg	Brassica	Cucurbits	Leafy Veg	Legumes	Root Crops	Solancea	other*
Diagnosis & Detection			3		2	1	1	1	
Key Disease information				1		1		1	1
Sampling & decision making strategies					2	3			2
Seedling health			2		3	1	1		2
Cultural management strategies		1	4	3	5	4	2	1	4
Biological control				1	3		1	1	
Chemical control			2	2	5	3	3	2	1
Other non-chemical tools	1		6		2	3	1	3	1
Complete management guidelines			3		5	2	1	2	2
Resources			3		1		1	2	
TOTAL Number of research projects	1	1	11	5	12	9	7	8	7

* 'other' consists of beetroot, rhubarb, sweet potato and sweet corn.

4.3 *IPM Pathology Gap Analysis*

4.3.1 National Workshop to Determine Program Structure

Six sub-program areas were proposed at the National workshop of key stakeholders in November 2006. A summary of key outcomes from this workshop is shown in Appendix 2. Key research areas are detailed below. The key pathogens identified as important from crop loss in the industry are shown in Table 2. The key drivers that growers need to consider in order to take up further IPM practices are shown in Table 3. The present grower use of IPM for pathology issues is extremely low as most growers still mostly calendar spray and do not base spray schedules on the first sign of diseases or use predictive tools to monitor the pathogen loads in soil (Table 4). A structure for the program (Fig. 3), detailed breakdown of the projects commissioned to satisfy the program (Fig. 4) and the relationship of the IPM Pathology Program with the other HAL programs and its place within the wider field of IPM pest management (Figs. 5) are provided. A description of each of the sub program areas and the relevant research projects that have been commissioned are shown below.

4.3.2 Vegetable Industry IPM Pathology Program

The outcome from the eight State workshops which addressed the key priorities for research and technical transfer are shown in the following 6 sub program areas. A summary of key outcomes from these workshops and the growers surveys is shown in Appendix 1 and 3. Within each sub program area are the key areas that the sub program addresses and the projects that have been commissioned to address these key problems. Note, it was a prerequisite for each stakeholder interested in submitting

projects that they showed the linkages to the rest of the IPM pathology program especially the sub program 5 which was to deliver the outcomes on farm.

Sub program 1: Chemical Use

Key Research Areas:

- **Review of IPM compatibility of pesticides**
- **Impact of pesticide withdrawals**
- **Reducing chemical footprint**
- **Resistance management of fungicides**

Key Research Projects To Be Considered for Funding from 2007:

Project A (12 months, up to $75000)
Prepare IPM, market access and environmental profiles for existing fungicides in conjunction with AgAware.
Develop best practice IPM pesticide programs for the following priority pathogens:

- Sclerotinia, Downy mildew, Fusarium, Pythium, Powdery Mildew, Rhizoctonia

Project B (2 yrs, up to $100 000/yr)
i) Screen key pathogens for resistance to the major chemical groups used for control, eg. Azoxystrobin, metalaxyl, dimethamorph (white blister), azoxystrobin, iprodione, procymidone, boscalid (Sclerotinia), copper (bacteria), metalaxyl (Downy in lettuce), iprodione, procymidone (botrytis).
ii) In consideration of site history determine the effect of repeated use of multicrop fungicides on the same pathogen population.
iii) Provide results to and liaise with AgAware to develop and report on improved resistance management programs for the pathogens above.
iv) Determine the most effective copper formulations to manage bacterial pathogens.

Sub-program 2: Integrated Soilborne Disease Management (Focus Sclerotinia, Pythium & Fusarium)

Key Research Areas: (Priorities on Sclerotina, Fusarium, Pythium and Rhizoctonia)

- **Non-chemical controls**
- **Seedling health**
- **Sampling, forecasting and detection**
- **Benchmark parameters for pathogen management**
- **Host Resistance**

Key Research Projects To Be Considered for Funding from 2007:

Project A – Integrated management of soilborne pathogens (Sclerotinia on beans, lettuce, carrots, celery & other)
(3 yrs, up to $375, 000/yr)

- Develop strategies that eradicate soilborne inoculum and/or prevent infection in the field with particular emphasis on crop rotations, organic amendments, crop residues, germination stimulants.
- Develop amendments (organic and biocontols) that can be added to the speedling trays that are as effective as chemical controls.
- Investigate potential to forecast ascospore phase for *Sclerotinia sclerotiorum* (beans, carrots)

- Evaluate cultural practices, i.e. – Planting density, plant architecture, leaf wetness and soil humidity parameters conducive to *Sclerotinia sclerotiorum* infection and develop irrigation and cultural practices accordingly (beans, carrots).
- Screen international varieties for resistance (particularly beans).
- Deliver an extension package to improve best practice management of sclerotinia. This will include improved fungicide placement and timing.

Project B - Fungicide alternatives for soilborne diseases (Rhizoctonia, Pythium, Fusarium, Sclerotinia in conjunction with project A)
(3yrs, up to $350 000/yr)
i. Identify natural soil factors (chemical and biological) that are associated with inoculum reduction and disease suppression.
ii. Develop fungicide alternatives (physical, chemical, organic and biological) with potential for inoculum reduction and disease prevention for the key soilborne pathogens.
Project to include a review of fungicide alternatives (physical, chemical, organic and biological) for the control of soilborne pathogens and development of an understanding of the mechanisms of pathogen control.

Project C (1yr, 20,000)
(Rhizoctonia in beans, lettuce (and carrots)
- A review be conducted (in conjunction with PPR and D program) to identify effective early fungicide spray programs for rhizoctonia diseases and the use of crop rotations and organic amendments to reduce pathogen loads in soils and subsequent disease in vegetable crops

Sub-program 3: Integrated Foliar Disease Management

Key Research Areas:

- **Non-chemical controls**
- **Seed Health**
- **Aerial sampling, detection and modelling**
- **Benchmark parameters for pathogen management (Downy, Powdery and Leaf spots)**
- **Host Resistance**

Key Research Projects To Be Considered for Funding from 2007:

Project A – Fungicide alternatives for foliar diseases
(3 yrs, up to 250 000/yr)
Develop IPM strategies, (ie. fungicide alternatives) to manage the following key foliar pathogens:

- Powdery mildew
- Downy mildew
- Anthracnose
- White blister

This will include a review of fungicide alternatives (physical, chemical, organic and biological) for the control of foliar pathogens, studies on host pathogen interactions and the development of an understanding of the mechanisms of pathogen control.

Project B – Benchmarking parameters for pathogen management (downy mildew, powdery mildew, septoria, white blister)
(3 yrs, up to 300 000/yr)
i Develop methods for aerial sampling, detection and modelling of foliar pathogens with focus on pesticide reduction (link with VG 05054, VG 06047, VG 04013)

ii Determine the influence of nutritional status, irrigation and moisture on disease development.
iii Develop benchmark parameters for pathogen management.

Sub-program 4: Integrated Viral Disease Management

Key Research Areas:

- **Technology transfer**
- **Alternate hosts**
- **Sources of epidemics**
- **Vector Management**
- **Host Resistance**

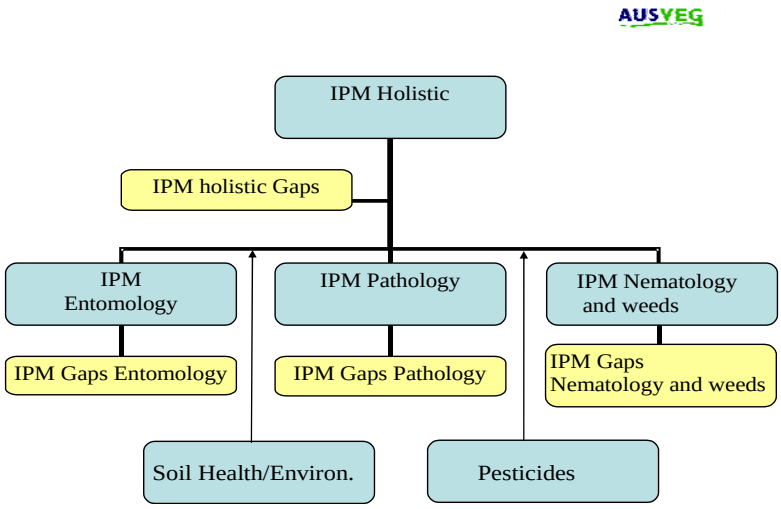
Key Research Projects To Be Considered for Funding from 2007:

Project A: Improved IPM management of viral pathogens (3 yrs, up to 200 000/yr)
i) Develop extension package to promote the effective management of virus diseases of vegetable crops (in conjunction with VG 6022). Consider whole farm approach to virus control which includes an,

- understanding of methods of virus transmission (eg. persistent vs non-persistent) and
- management of alternate hosts
- means to control vectors
- use of resistant or tolerant varieties

ii) Study epidemics to determine alternate source and identify risks.
iii) Review previous survey information to determine gaps in knowledge of the spread and importance of key viruses of vegetable crops, particularly the extent of crop loss.

Sub-program 5: Communication and Extension program



Schematic representation of the disciplines needed for a holistic IPM program

Key Issues:

- Commodity based (except viruses) NOT project based
- Should draw together and package information from across the entire IPM program. In particular must link chemical use sub-program and with the other HAL IPM programs.

Each package to include:

- National Workshops, field days and training events
- Published material (eg. factsheets)
- Scout and consultant training
- Where possible, 'best practice programs' linking pest and disease outcomes to be developed and presented for commodities.
- Role for industry development officers to coordinate (each taking on the commodity that they are responsible for within HAL industry groups)

Key Research Projects To Be Considered for Funding from 2007:

Project A: Best practice production models (lettuce, brassicas, cucurbits) (2 yr, up to 100 000/yr)
- To utilise national IPM experts (pathology, entomology, nematology, weed sciences) to develop whole farm holistic packages which identify and deliver to industry the best practice strategies for successful implementation of IPM on farm.

Project B: Greenhouse hygiene
(2 yr, up to 100 000/yr)
- Deliver extension program to improve management of soilborne and foliar pathogens by managing crop debris, production practices, hygiene and minimising pathogen contamination in greenhouse water sources.

Project C: To update and improve distribution of IPM information packages to industry (1 yr (10,000))
- Update Diseases of Vegetable Crops (DPI Q)

Sub Program 6: Novel Strategies and New Technologies

Key Research Areas:

- **New production systems**
- **Emerging Technologies**

Project A (Up to 3 years, 100,000/yr)
To use new DNA technologies to provide a greater understanding of host pathogen relationships and improve disease control on farm without the use of pesticides.

Project B (1 yr, 25,000)
To review use of predictive and diagnostic tests available world-wide, identify and validate those with potential for use on farm in Australia.

(Identify novel production systems to minimise the impact of diseases)

Driver for this work to be reducing costs, increasing productivity or minimising environmental impact of production. It is anticipated that a maximum of 3 years funding could be sought from the trust and that at the end of this time, if appropriate, the technology or idea developed would be further researched through sub-programs 1-4. Applications for funding to the trust must include an annual 'stop/go' clause to enable Horticulture Australia and the research provider to opt out of further work if the novel strategy/new technology is deemed inappropriate for Australian conditions, too difficult to implement etc. Appropriate stop/go points could include completion of a review, preliminary trials etc.

Table 2 Priority Pathogens across Australia as determined by industry at National workshops in 2007. (10 = Top priority to 5 = Lowest priority of the key pathogens)

Pathogen/ Disease	Key crops	VIC[A]	TAS	QLD	SA[A]	NSW	WA	Total
Sclerotinia	Lettuce (Sm) Brassica (S.s.) Beans (S.s) Carrots (Ss)	10	10	8	-	5	10	**43**
Viruses[B]	Lettuce, Cucurbits, Celery, Carrots, Capsicum, Brassicas	5 CeMV CarVY TSWV TuMV	-	10 TSWV CaCV WMV	6 TSWV CMV CarVY LBVV	10 TSWV LMV TuMV	7 TSWV ZYMV LBVV	**38**
Downy mildew	Lettuce Brassicae seedlings	9	7	-	9	7	-	**32**
Fusarium	Melons Capsicums Snow peas	-	-	9	7	8	8	**32**
Pythium	Beans, Peas, Carrots, Brassicas	-	-	-	10	9	9	**28**
Powdery mildew	Greenhouse Cucumbers, Cucurbits	-	6	7	-	6	5	**24**
Rhizoctonia	Brassicas	-	8	5	5	-	6	**24**
White blister	Brassicas Proc. Broccoli (Tas)	7	9	-	-	-	-	**16**
Botrytis		-	5	-	8	-	-	**13**
Clubroot	Brassicas	8	-	-	-	-	-	**8**
Anthracnose		6	-	-	-	-	-	**6**
Sclerotium	Caps, Beans, Eggp, carrot	-	-	6	-	-	-	**6**

A - Data from two workshops combined; B – Viruses were considered as a single group therefore the priority rating was not for one particular virus, however the key viruses for the respective crops are shown below the table

Table 3 Priorities that would drive growers to adopt of IPM for pathology issues on farm

(10 = Top of the key priorities, 5 =Lowest of the key priorities)

IPM driver	VIC 1	VIC 2	TAS	QLD	SA 1	SA 2 (Greenhouse)	NSW (Greenhouse and open)	WA	Total
Reduce cost of treatment (eg. Reducing spray number)	7		8	8	7		10	6	46
Improved disease control		10	9		10	10			39
Chemical failure (mainly due to resistance)	10	8			8	9			35
Chemical loss (withdrawal or deregistration)		7			9	8		10	34
Public image	6	4					9	7	26
Chemical residues restricting market access	5	5			6	7			23
Reduce dependence on chemicals		9		7					16
Reliability of production			5	9					14
Environmental issues		6						8	14
Reducing crop loss	8							5	13
Increasing profit			10						10
Efficiency of production				10					10
Lack of available chemicals	9								9
Meet QA requirements								9	9
Stop the need to calendar spray			7						7
Ability to pre-empt disease			6						6
Improved crop quality								4	4
Increasing suite of available methods of control		3							3

Notes: Growers were asked to nominate what would ‘drive them’ to use IPM on their farm. The responses were listed in priority order by group consensus at each workshop. Their responses have been allocated a score where 10 was the highest priority, 9 the next highest priority etc. The number of priorities nominated at each workshop varied.

Table 4 Current use of IPM and effectiveness of current method to control key pathogens (ie. Those pathogens that were considered top priority at State meetings)

No IPM: *Calender = sprays at regular or routine intervals (ie. weekly or at the start of the crop),*
Some IPM: *First sign = Controls applied at first sign of disease, Predictive = grower monitors pathogen/weather conditions to decide on treatment.*
Effectiveness of Current Treatment: *Y=Effective, N=Not effective, Y/N = predominantly effective, N/Y = predominantly not effective, Y & N refers to equal numbers of yes and no responses.*

	Current method of control		Method of application		Efficacy			
	Greenhouse/hydro	Field	Greenhouse/hydro	Field	Greenhouse/hydro		Field	
Sclerotinia		Fungicides		Calendar			Y/N	N
Viruses	Insecticides Resistant varieties	New land (escape) Insecticides Resistant varieties	Calendar	Calendar or first sign	N	N	N/Y	N
Downy Mildew	Fungicides Resistant varieties	Fungicides	Calendar or first sign	Calendar or first sign	Y	N	N/Y	N
Fusarium	No control (WA) Fumigation Fungicides	No control (QLD) Cultural	Calendar	na	N/Y	N	N	N
Pythium	No control (NSW/WA) Cooling towers Fungicides	Fungicides Fumigants	Calendar or first sign	Calendar (Preventative)	N (occasionally Y)	N	Y & N	N
Powdery Mildew	Fungicides	Fungicide (1 product)	First sign	Calendar	N (due to resistance)	N	Y	N
Rhizoctonia	Fungicides	Seed treatment (fungicide) Fungicides Biologicals	Calendar	Seed treatment, first sign or predictive (based on weather)	Y	N	N	N
Botrytis	Fungicides	Fungicides	Calendar or first sign	Calendar (at flowering beans)	Y/N	N (resistance)	Y & N	N
White blister		Fungicides		Calendar			Y & N	N (resistance)
Clubroot		Lime Fertiliser Fungicide		Calendar (Preventative)			N (resistance)	N
Anthracnose		Fungicides		Calendar (if weather conducive to disease)			N	N
Sclerotium		No controls (capsicum and eggplant)		na			N	N
Leaf spots		Fungicides		Calendar or predictive (eg after hail)			Y	Y

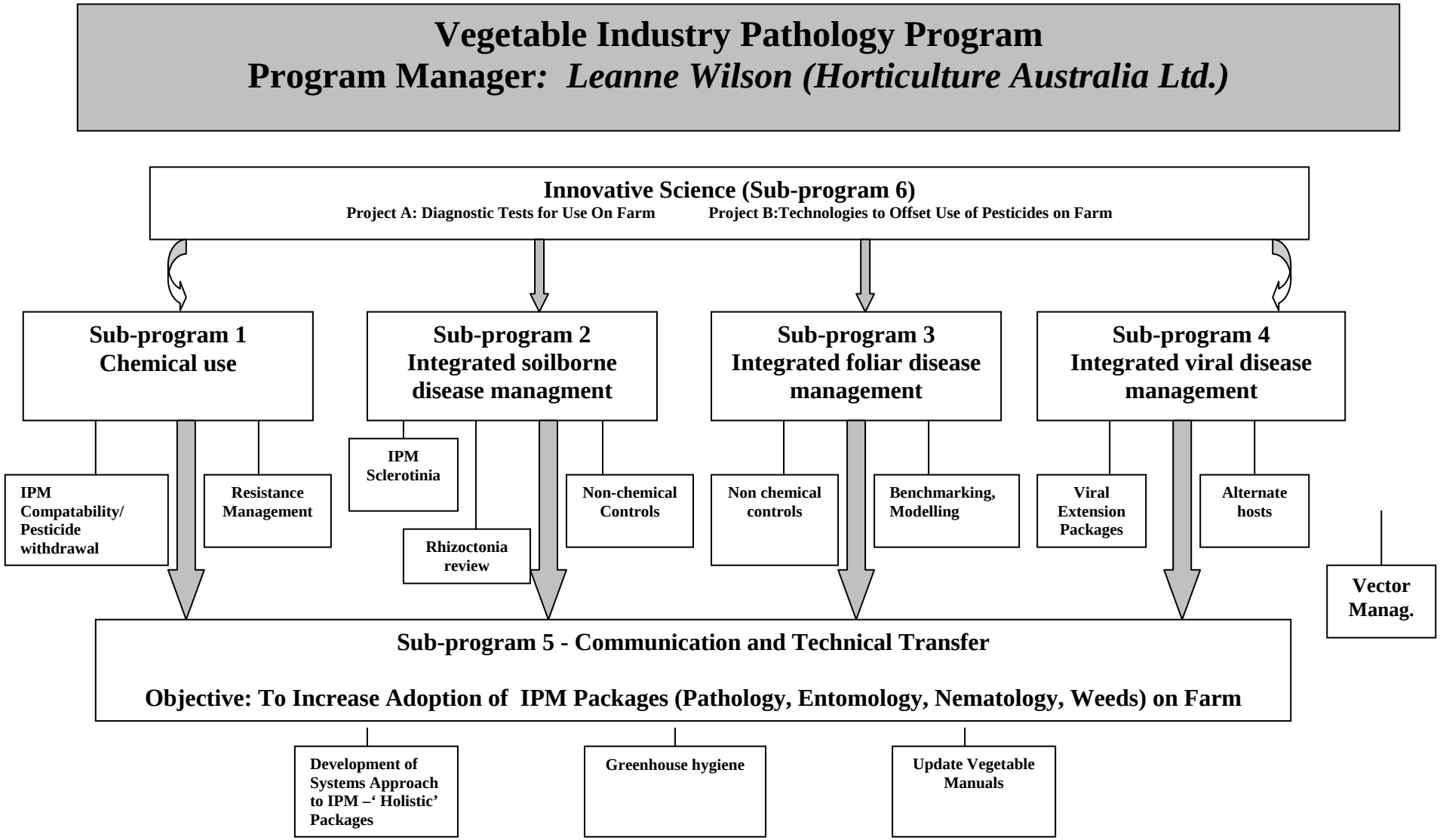


Fig. 3: Vegetable Industry IPM Pathology Program

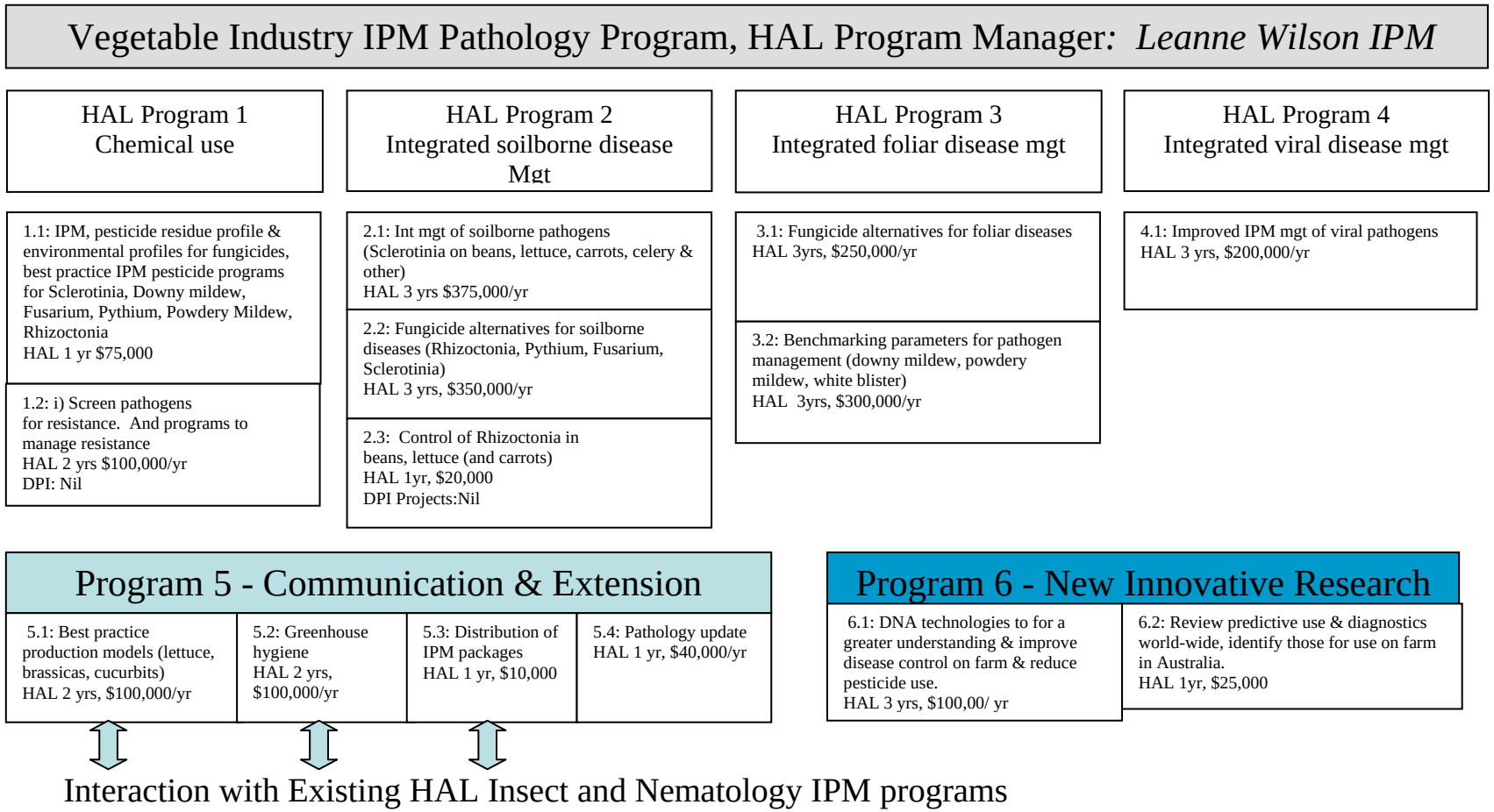


Fig 4. Detailed Breakdown of the Vegetable Industry IPM Pathology Program

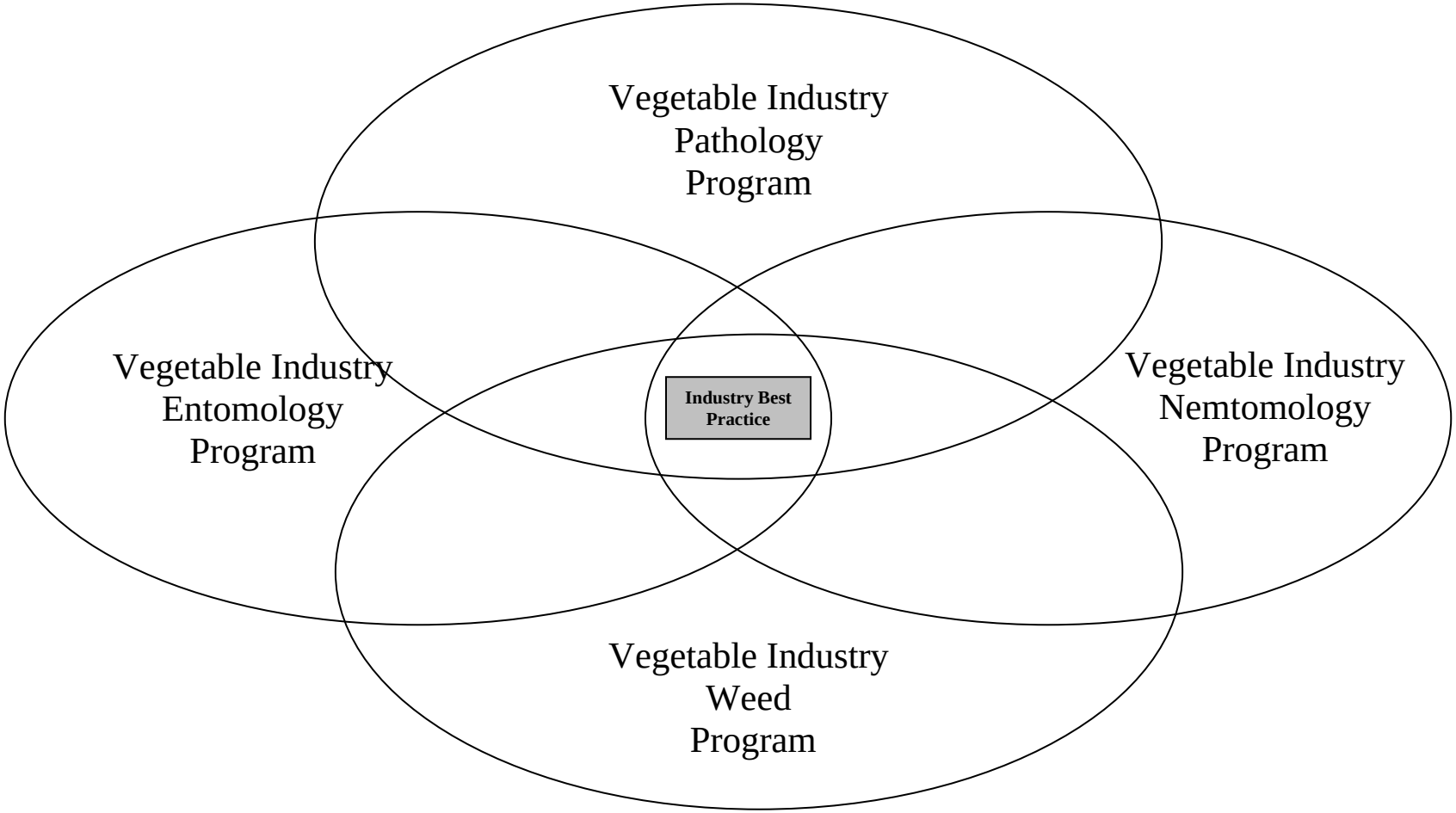


Fig. 5: Relationship between IPM Path and other Vegetable IPM industry programs

5. Recommendations

Feedback during the National workshops conducted as part of the project indicated that growers and other stakeholders were impressed with project and the strategic priorities established. Feedback received by HAL from a key stakeholder was that ' this is the best mechanism for calling for projects, I have seen so far. The description of what is required, in the main is comprehensive, and the budget guidance is exactly what is required for us to be able to design a project to meet the requirements within the timeframe stated. The process used to develop the proposed vegetable industry R, D and E program was considered to be an excellent model for development of future strategic direction of research programs.

As a result of the process, the industry supported the proposed program structure and endorsed the commissioning of the $2 million research program. The period for submission of research proposals was 4 weeks and at the time of conducting this report the final approval of the program had not been ratified by the incoming IAC, This meeting will be held on the 4th July. Irrespective of the outcome from this meeting, it is recommended that the National Vegetable Industry consider the proposed Vegetable Industry Pathology program, as a framework for development and funding of future research programs. .

Appendix 1. Summary of key outcomes from State IPM gap analysis meetings

NSW IPM Gap Meeting – 6th February 2007

A. General Comments:

- Overall would like to deal with issues on a crop basis (eg. take lettuce and consider sclerotinia together with all of the other diseases affecting lettuce) and consider all of the pathology issues together. Which fungicides are compatible? What is the overall package of IPM?
- Chemical resistance issue is a huge need. Molecular solutions exist to fungicide resistance screening to make this a much faster process.
- Need to develop and utilise on farm detection tests for a range of diseases.
- Soil management (cultivations and rotations).
- Holistic view – linking everything together.
- We are losing things at the end. Needs to be a far better way to do the extension, particularly to the smaller growers.

Technology transfer

- Issue in NSW with there being a huge number of smaller growers – the info gets out to the big growers but doesn't filter through to the smaller growers.
- Market agents and wholesalers could be a useful point of contact.
- Research to practice aspect of all programs needs to have strong emphasis.
- Ensure that outcomes are practical. Many farms have an element missing that will cause new disease management practices to fall over. Have to make sure that these basics are covered.
- Need to prove project findings in a practical sense in each sense (ie. A demo farm).

B. Key Pathogen Issues:

Fusarium (on corn cobs – endophytic, probably from soil or seed)

- Issue for northern tropicalk climates from NSW up.
- Varieties
- Seed dressing/biological control/antagonists
- Is an issue for maize as well
- Fusarium on cucurbits already covered in existing project.
- New chemicals – no currently effective treatments.

Sclerotinia on lettuce

- Ground truthing of project outcomes in other states (eg. biocontrol work from Oscar's projects needs ground truthing on at least one demo property in key states with an issue).
- Hydroponics not a major problem – but some knowledge needed to clarify where it is coming from and prevent this (eg. hygiene issues).
- Sclerotinia products may also be used for botrytis some technology transfer needed to transfer this info across. Issue with misdiagnosis.
- Filan and Amistar – issue with how long will these products last.
- Some growers using steam heating treatment and are still getting sclerotinia.

- Effects of crop rotation on sclerote numbers and development of rotations that do not muck up rotations for other crops (eg. rotations using brassica biofumigants).
- Big need for extension package that deals with how best to use existing chemicals.
- Sclero on brassicas not an issue.
- Chemical registrations.
- Reduction of sclerotial numbers by any means (eg. mechanical, rotation, chemical etc.).

Downy Mildew on lettuce

- Varietal resistance
- Temperature relationship (for Downy on spinach). Disease prediction (needs far less in Australia – comment that it is not needed as you get rains and a fog you know that the disease will come in, don't need a model in this region).
- Softer chemicals (ie. Phosphorus acid). Or replacements for Agriphos.
- Spinach down mildew (when people changed over from multicut to one cut spinach). Never seen before, needs investigation into why/where it has come from and what races are in Australia.

Pythium **(Hydro lettuce and cucumbers**)

- System design for hydroponics.
- Extension
- Existing project covering much of this work.
- No real registrations available for vegetables – not even covered under the permit system.

Powdery mildew **(Cucurbits and greenhouse lettuce)**

- Chemical resistance
- Extension in management of greenhouse environment/climate
- Races present why resistant varieties are breaking down.

Viruses

- If nothing is done about it soon within two years hydroponic lettuce will not exist.
- Stacey has submitted a project for TSWV in hydro lettuce.
- Vector management for thrips (possibility of biocontrols).

Seedling Health

- Seedborne pathology, preventing entry and transmission of diseases on seed. This information is needed by nurserymen as well as growers.
- Survey/audit of where these diseases are coming in from.
- Seedling hygiene.
- Contact person Andy Ryland (NSW) has many useful ideas on this topic.

Gatton IPM Meeting - 7th February 2007.

A. General comments

- Tomato and melons – big problems with diseases
- New science – molecular diagnostics for seeds.
- Need a disease book – national publication; ute guide, more diagnostics aids needed.
- Diagnostics national – funding is under threat, needed for education, biosecurity, training, diagnostics
- New science – DNA seed test – helps manage your seed. Farmer thinks should be used as a standard, should be adhoc.
- Genaral Priorirty should be given to improved technical transfer and programs on seed health

B. Key Priority Pathogens

Sclerotinia

Current crop loss in beans and lettuce can be up to 100%. Current controls are expensive and effective depending on rotations and chemical access.

- Rotations (to reduce inoculum)
- New fungicides
- Cultural practices (Planting densities in beans)
- Resistant varieties
- Irrigation practices (changed due to water availability and weather and could be spreading the disease)

Sclerotium

Current capsicum crop loss 0-100% (sporadic) with no practical control (can also be confused with sclerotinia).

- resistant varieties
- extension on identification, hygiene and farming practice
- targeted fungicide

Fusarium

Current crop loss can be 0 – 100% with no treatment available. Current disease problems are due to the history of soil and seed cleanliness

- seedling health (seedborne in snow peas and suspected with capsicum)
- characterise the problem (possible complex with pythium; is Fusarium opportunistic?)
- cultural practices (help to maintain healthy root system)
- resistant varieties

Priority pathogens (HAL projects exist, but further consideration may be needed)

***Viruses: (*TSWV, CCaV, watermelon mosaic virus – cucurbits, lettuce, capsicum)**

Viruses are mainly a vector control problem, the cost of which is high. Current preventative treatments okay (along with hygiene) but there is concern of resistance (as with NSW). There is the possibility of new resistant varieties coming out soon. There are current projects that perhaps need to extend their coverage to more states.

- Extension of current research
- Incorporation of other states into current QLD project or alignment of new projects with QLDs

Powdery Mildew

- High crop loss and cost to control in cucurbits but there is a current project.

- Need for Extension

TASMANIA IPM Gap Meeting: Devonport – 9th February, 2007

A. General Comments

Priorities Across pathogens

- monitoring levels of inoculum (currently done for clubroot)
- extension (where is all the information from previous projects. Perhaps a group is organised that can update on current controls across the state)
- cultivar resistance
- more choices for disease control: ie. new/ alternative fungicides, biological control and rotations
- Align R&D with other programs currently being conducted on non-levy paying crops in the region. These crops often impact greatly on disease loads and share control treatments (leading to increased biodegradation)

B. Key Priority Pathogens

Sclerotinia on all crops.

0-100% crop losses costing $200-1000/ha because the effectiveness of controls is dependant on weather conditions. (Current controls also cover botrytis on beans so a project may cover both pathogens). There is limited treatment choice and the application is pre-emptive. Many of the Tasmanian rotation crops are sclerotinia hosts and this is causing increased disease pressure and reduced effectiveness of treatment.

- Alternatives to fungicides – crop/ irrigation management.
- Cultural practices to reduce sclerotes
- Cultivar resistance
- Strategic timing of fungicides
- Screening international varieties for resistance (**)
- Review of other industries approaches to sclerotinia
- Extension – nutrition management for bean plant architecture
- Fungicides – new chemistry

Rhizoctonia in beans (and carrots).

0 – 100% crop losses costing $300 – 6000/ha. Currently the seed is treated with Amistar (which is not effecive for long – if at all) and there is no treatment past seed treatment. This is often a carry over effect from previous rotations (eg. potato crops)

- early fungicide spray
- organic amendments to reduce pathogen load
- Determine AG groups
- Align work with Potato R&D

White Blister in brassica.

5 – 20% crop loss costing $350 - $2000/ha. Currently treated with Ridomil which is not effective due to ridomil resistance. Predictive model being effectively used in brassicaes produced for the fresh market.

- cultivar resistance (***)
- curative fungicide to minimise spread early
- validation of the predictive model
- disease suppression – reduce pressure/inoculum
- new systemics and protectants

SA IPM Gap Meeting: Adelaide – 13th February, 2007

A. General Comments

- Soft options foliar
- Soil/seedling/field management for stem canker complex. Nursery (drenches), field (fumigation, fungicides).
- Communication aspects – major publication ie. book such as citrus IPM, must come from this work. Must make a stand at some stage and put it all together into a publication (quality publication) for growers. Big book for consultants. Growers get field guide. Training through farm BIS.
- Soilborne diseases highest priority. Composts?
- Streamlining management from nursery right through. Understanding interaction between soil types and disease/management. Face to face aspect of extension and back up regularly on farm to follow up project outcomes.
- Information and availability of it.
- Integration of knowledge for better extension/communication.

B. Key Priority Pathogens

Downy mildew (mainly greenhouses but also field)

Where it is coming from. Understanding how it gets in there, why it occurs. Understanding interactions between environmental conditions and disease. Controls. Better fungicides. Rotation of fungicides to make them last.

Pythium (greenhouse cucumbers, hydro lettuce)

Investment in technology for hygiene (and reducing costs of these technologies)
Education around hygiene, disposal of infected material etc.

Botrytis

Late may to July significant problem. Extension. Hygiene education.
Climate control technology and extension (ventilation technology eg. blowers, pruning techniques, spacing etc to get rid of low humidity). Low cost technology.

Rhizoctonia (40 % district wide)

Currently using Rovral, biocontrols, biocontrols.
Existing project (Catherine)
Diagnosis (work out the complex)
Fungicide program

Fusarium

(Metham, Terraclor, Sprayphos, Fungarid). Crop rotation, effects on soilborne inoculum. Soil specific advice. Influence of soil factors on disease (eg. organic matter levels).

Viruses

Carrot virus Y (carrots) – project existing
TSWV – High priority will run out of chemicals soon. Big problem, urgent issue in field and greenhouse. It is the problem that throws IPM right out. Over use of chemicals for thrips (Vertimet) leads to resistance for other pests ie. two spotted mites. Could possibly be some issues with increasing disease because of chemical use (ie. cutical stripping).
Use of oils and their interaction with fungi.

Biosecurity: Threat of yellow leaf curl virus moving south from Queensland.

SA IPM Gap Meeting: Virginia – 26th February 2007

A. General Comments

- Chemical resistance
- Residues affecting market access
- Lack of integration of weed/pathology/entomology problems – worry that spraying for insects will negatively influence diseases etc.
- Changing % of crop loss (ie. change that is cost neutral but does not adversely affect yield)
- Identification of all the chemicals – all of their names (actives, common names). Makes it difficult for rotation of chemicals if you are using 2 things with different names but the same active.
- Follow up on farm extension.
- Integrating weed, pathogen and insect management with soil health and environment. Ie. how do you clean up and at the same time build up beneficials.
- Crop to crop interactions (eg. canola crop down the road breeding up insects that transfer to the vegetable brassica crops).

B. Key Priority Pathogens

Viruses

Greenhouses – TSWV

- Thrip transmitted
- 70 % of total costs spent on all diseases is spent to manage TSWV.
- Spraying protectively, rarely identifying thrips, occassionally using sticky traps.
- Resistant varieties needed.
- Need chemicals that can be used to rotate with Success. Since Nitofol withdrawn there is nothing to rotate with. Biologicals not working as they are dying out with the drought.
- Greenhouse design not integrated to manage insect pests and diseases. A lot of money being spent changing greenhouses to no avail.
- Extension work desperately needed. Annual roadshows needed.

Outdoor – Carrot Virus Y up to 50% crop loss (ie. $2500) Aphid transmitted.
Hygiene in the district is a huge issue. Extension to recognise sources of latent infection. Get rid of nylon string and replace with biodegradable string. Reintroduce burning to get rid of old crops being pushed out of glasshouses and left to rot or clean up and send bill like in Qld. (If glasshouse grower opens his house and the wind is blowing through. Crops next door will be down within 3 days). Weed hosts – extension needed.

Fusarium

- Greenhouses soil issue.
- Hygiene issue – debris remaining in greenhouse. Waste disposal issue. And cleaning of contract machinery. – Extension for hygiene.
- Need more effective replacement for MB

Downy mildew

Outdoor Lettuce 10-40 % crop loss (2500/ha)

- Resistance is breaking down.
- Predictive models
- Milk and casein products works on onions (one grower using nothing else)
- Straight oils also can be effective
- Investigate the influence of ethylene on disease (ie. when crop lush)

Greenhouses: Consider the impact of ventilation/temperature and timing of irrigation

Botrytis

Greenhouses 5-40 % losses.

- Treatments effective with good timing. But resistance is a major concern.
- Ventilation

Rhizoctonia

Greenhouse capsicum

- New chemicals
- Effect of cultivation and drier soils – seems to be controlled more with heavy tillage in dryer soils. Moist surface layers in greenhouse soils may exacerbate problem.

Pythium

Outdoors: Pythium on carrots causes 10-25 % crop losses of $5000/ha, currently calender spraying in a preventative program

Greenhouse: Pythium (60 houses per hectare), 40c cucumber, $1 grafted, 60c capsicum
5-10 % loss

- Fumigation as preventative
- New chemicals
- New disinfestation treatments
- Effect of composts on cavity spot?? Could be just a seasonality effect.
- Predicting wetness events??

Sclerotinia

- Outdoor lettuce, fortnightly sprayed.
- Visual monitoring.

Vic 1. IPM Gap Meeting: Cranbourne – 28th February

A General Comments

- Soil health with rising reemergance of soilborne diseases (pythiums, fusarium etc)
- Survival of pathogens in dams and the potential for recycling pathogens back onto dams.
- Pesticide application reviews (eg. fluid delivery of P)

B. Key Priority Pathogens

C.

Sclerotinia

Main host crops are lettuce minor, celery sclerotiorum, brassicas sclerotiorum, endive minor

- Eradicant treatments available to reduce inoculum levels in the soil.
- Need control mechanisms (celery, no control mechanisms that are legal)
- New chemicals.
- Need something to kill sclerotes in the soil. Erradicant disinfestant. Selective disinfestant to kill off sclerotes but not good bugs.
- Biological controls??

Clubroot (brassicas)

Main hosts cabbage, broccoli, cauliflower, Asian veg.

- Shirlan appears to be no longer working in this location.
- No other chemical treatments available/registered.
- Continues extension needed
- Loss of chemicals, needs new chemistries.

Downy mildew

Main hosts spring onions, lettuce, spinach and silver beet

- Appears that new pathotypes are always occurring.
- More chemicals to alternate with.
- Determine the effect of surfactant products on cuticals (important issue across the board for foliar).
- Ensure that the surfactant information above is well communicated to growers.

Pythium

Main hosts carrots, parsnips, celery, lettuce

- Sources of infection not known.
- Worse in cooler months (Autumn and early spring)
- Prediction and inoculum thresholds needed
- Extension
- Modelling, finer details (eg soil temperatures)
- Pathogenic biocontrols (other pythiums)

White blister

Main hosts broccoli, Asian vegetables including Chinese cabbage, radish, turnips

- Losses of 25-50% Werribee, 0-25% locally
- Screening of varieties for resistance, particularly Asian varieties.
- Resistance management (Werribee).
- Alternative controls.
- Review of potential loss, especially on Asian veg.

Viruses **(**celery mosiac/carrot virus Y celery, TSWV Lettuce, Turnip mosaic turnips)

- Company currently close to releasing resistant celery.
- Spraying to manage the insects considered a waste of time.
- Resistant varieties are what's needed.

Vic 2. IPM Gap Meeting: Bairnsdale – 2 February,2007

A General Comments

- Pesticide reduction
- Risk of losing key pesticide
- Environmental problem with current methods (ie. Pesticide or organic matter residue – softer options required)
- Pesticide residues in production affecting market access
- Image
- Greater selection of methods availability

B. Key priority pathogens

Downy Mildew

On lettuce can cause losses of up to 20-30%($2,500 - $15,000)

- Source of pathogen? Area wide management
- Marketable resistant varieties
- New effective pesticides
- Irrigation scheduling (shorter cycling, dawn sprays)
- Extension

Anthracnose

On lettuce and spinach can cause losses of 10 -15% ($2000-3000/ha).

- Treatments are not effective and costly.
- varietal resistance
- new effective pesticides
- Nursery hygiene
- forecasting model

Sclerotinia

Causes severe losses on lettuce (15-20%) and beans (0-50%) costing up to $3000/ha.

- Current treatments are not effective and costly.
- new chemicals (Filan losing effectiveness (+ tri base?))
- crop rotations
- modelling (beans)
- sclerotia reduction

WA IPM Gap Meeting – 28th February, 2007

A. General Comments

To provide a list of safe pesticide products (human, environment) and (others)

B. Key Priority Pathogens

Sclerotinia (often confused for sclerotium therefore control not effective)

- Lettuce (S. minor)
- Brassicae (S. sclerotiorum)

Key Issue: To provide methods or crop rotations which reduce inoculum in soil

Pythium

Spinach, Greenhouse cucumbers

- Determine source
- Cultural practices to reduce disease
- Manipulation of moisture
- Monitoring and forecasting

Fusarium

Greenhouse cucumbers

- Project already exists
- New fungicide controls

Viruses TSWV Lettuce, Zucchini Yellow Mosaic Virus, Lettuce Big Vein

- Good extension program exists for TSWV
- Sources of virus important
- Hygiene and weed control
- Must have 1 to 1 extension

Rhizoctonia brassicas

- Particularly an issue in Manjimup

Powdery Mildew

Greenhouse cucumbers, cucurbits

Appendix 2 - Agenda and Workshop Participants (Preliminary Workshop, Knoxfield 29th & 30th Nov)

Aim:

1. To develop a series of research and delivery IPM gaps which will be used in future workshops to set priorities for consideration by HAL for investment in the 2007/08 rounds of funding from the AusVeg levy.
2. To set up a mechanism for future development of strategic priorities for the National vegetable Industry.

Participants (see below for list):

Day 1: National pathologists, HAL
Day 2: National pathologists, Vegetable Industry Reps, HAL

Agenda:

Wednesday 29th November (National pathology research network)

9:00 –9.15 am	Arrive
9.15 – 9.30	Objectives of Meeting - Leanne Wilson/Ian Porter
9.30 – 10.15	Review of information available for workshop Review Nematode Workshop Outcomes - Frank Hay Review of Ag Chemical Resellers Gap Review – Caroline Donald Review of Pathogen Gap worksheets Gap reviews (distributed previously) – Ian Porter
10.15 – 10.45	Morning tea
10.45 – 12.30	Overview of pesticide Risk Analysis – (Dal Santo) Identification of research gaps from Reviews
12.30 – 1.30	Lunch
1.30 – 3.30	Gap Identification (continuation)
3.30 – 3.45	Break
3.45 – 6.00	Prioritisation of Gaps (reason for R and D and benefit to Industry)
7.00 pm	Dinner

Thursday 30th November (group to be joined by crop consultants)

9.00 – 9.15	Arrive
9.15 – 9.30	Overview of Day 1
9.30 – 10.00	Review of Chemical gap analysis – Peter Dal Santo Overview of IPM database – Leanne Trinder
10.00 – 10.15	Introduction of process
10.15 – 10.45	Morning tea
10.45 – 12.30	Review and development of Research Gaps (Reassess against a set of key criteria: ie. size of problem, cost to industry, cost to implement research, chemical reduction/efficiency, ease to achieve, compatability with pest IPM programs) ie. Develop HAL priorities
12.30 – 1.30	Lunch
1.30 - 2.30	Presentation and development of HAL priorities cont.
2.30 – 3.30	Where to from here.
3.30- 4.00pm?	Workshop closure

Workshop Participants

State	Name	Occupation	Organisation
New South Wales	Andrew Watson	Entomologist/Pathologist, Researcher	NSW DPI
New South Wales	Leanne Wilson	Program Manager	HAL
Northern Territory	Barry Conde	Pathologist, Researcher	
Queensland	John Duff	Pathologist/Entomologist, Researcher	DPI Queensland
Queensland	Victor Galea	Pathologist Researcher	University of Queensland
Queensland	David Carey	Consultant	
South Australia	Barbara Hall	Pathologist, Researcher	SARDI
South Australia	Dominic Cavallaro	Consultant	
Tasmania	Frank Hay	Pathologist, Researcher	DPIWE
Victoria	Ian Porter	Pathologist, Researcher	DPI VIC
Victoria	Liz Minchinton	Pathologist, Researcher	DPI VIC
Victoria	Caroline Donald	Pathologist, Researcher	DPI VIC
Victoria	Karl Reidel	Consultant, Reseller	EE Muir & sons
Victoria	Simon Drum		HAL
Victoria	Peter Dal Santo	Consultant researcher (Chemical Minor Use)	
Western Australia	Shane Condron	Vegetable Researcher	DPI WA
Western Australia	Lachlan Chilman	Consultant	

Appendix 3 - Industry survey of Present Control of Pathogens

The results below are representative of the current management and possible best practice IPM management that could be used on farm using information from the National growers and crop consultants.

Column 1 represents the conventional program used presently
Column 2 represents the present IPM changes that could be made
Column 3 represents the ideal IPM program that could be researched

Carrot management

Carrots	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases –– Field				
Sclerotinia	Rovral, Filan	Rovral, Filan, *QLD3 - crop rotations* *TAS – Adjust row spacing in bed to improve airflow*	*QLD3 - Alternative control options*	Further controls for Sclerotinia *QLD – YES* *TAS – Not considered a problem in TAS export carrot by 1 agronomist with reduced plant density. More of a problem in carrot stored in soil? Leaf trimmer designed by Agriculture and Agrifood Canada recently could be investigated.*
Rhyzoctonia	Rovral, Terrachlor	Rovral, Terrachlor, *QLD3 - Rizolex*	Longer rotations, Cereal crops	
Cavity spot - Pythium	Phos acid, Ridomil, Fumigation with Metham.	Trichoderma, Biofumigants. *QLD3 - Soil amendments* *TAS – Rotations of >4yrs*	Longer rotations, Cereal crops Tolerant varieties	*TAS – Potential for resistance to metalaxyl*
Alternaria leaf spot	Chlorthalonil, Mancozeb, Coppers, *TAS – Score (difenoconazole)*	Coppers	Tolerant varieties *QLD2 - Use of predictive models - forecasting*	*QLD2 - Data collection – in field met station Vs. BOM data sets* *TAS – Not a major issue. Mancozeb not used much in TAS. Cabrio was being considered for registration.*
Cercospora leaf spot	Chlorthalonil, Mancozeb, Coppers *TAS – Score (difenoconazole)*	Coppers	Tolerant varieties	*TAS – Not a major issue.*
Virus				
Carrot Mosaic		Aphid control, Hygiene	Planting breaks	
Holistic Issues	Interactions of fungicides and insecticides not known (Cabrio worse than Amistar for impact on beneficials?)			
	Impact of biologicals for root diseases			
	No joint IPM program exists *QLD - long supply chain promotes continous cropping and specialist operations(monoculture) QLD3 - could be part of overall farm management program to control soilborne diseases.*			
	Networks for IPM delivery			
	Output from pesticide risk assessment (Peter Dal Santo)			

BRASSICA MANAGEMENT

Brassicas	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases - Nursery				
Downy mildews (nursery)	Ridomil, Phos. Acid, Acrobat	Ridomil, Phos. Acid, Acrobat	Micronutrients, ventilation, varieties	Nursery monitoring,micronutrient program
Black rot	Hot water seed *WA - (not always 100% effective)* CU and wetter	Drop Cu and wetter	Seed treatment and hygiene *QLD - Seed Co compulsory DNA seed test for Black rot.*	Wetters increase disease *TAS – Not major issue by 1 agronomist. Fungicide treated seedlings and varieties less susceptible.*
Diseases - Field				
Clubroot	Metham *(WA metham not used*), Shirlan, $CaCO_3$ *TAS – Seedlings treated with Shirlan* *WA - crop rotation*	Nitrabor? CaO *(WA CaO not used),*	Diagnosis, Monitoring, Resistant varieties	Immunoassay kits – Forum with AQIS
White blister	Barrack, Bravo, Dithane, Cu, Amistar TAS – Bravo (chlorothalonil) and copper to prevent leaf infection. Put on with insecticides. Ridomil (2 applications) to protect head. Some use of Acrobat (dimethomoph), Mancozeb, Amistar (azoxystrobin), Phosphorus acid, Cabrio (Pyraclostrobin) *WA - Ridomil Gold MZ (Barrack, Bravo and Dithane not used)*	Model for spray reduction – curatives after 4 weeks	Modelling, resistant varieties	
SA - Root rot complex				
Ringspot	Controls for WB TAS – Mancozeb, Bravo (clorthalonil, Bayfidan (triadimenol)	Controls for WB	Rotations to minimise controls	New controls for ringspot
QLD3 - Black rot *WA*	*WA, QLD3 - Cu*	*WA- Crop rotation, crop entry management*	*QLD3 - Rotations*	
QLD3 - Soft rot	*QLD3 - Cu*			
TAS – Head rot	*TAS - Bravo (chlorothalonil)*			TAS - More control options required. Head rot of cauliflower a problem this year, cause not known.
WA, TAS - Rhizoctonia	*Tas - Limited use of Terraclor* *WA - Rovral, crop rotation, early paddock preparation*	*WA - Drop Rovral (not always effective)*	*WA - Resistant varieties*	TAS - More control options required.
Holistic Issues	Interactions of fungicides and insecticides not known (Cabrio worse than Amistar for impact on beneficials?)			
	Impact of biologicals for root diseases			
	No joint IPM program exists *QLD - Seed industry needs to adopt clean seed policy*			
	Networks for IPM delivery *QLD - Control of magic addative s which may have negetive impact on plant health*			
	Output from pesticide risk assessment (Peter Del Santo)			

Celery management

Celery	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases - Nursery				
Septoria	Mancozeb, Copper, Chlorthalonil	Irrigation management, Coppers.*QLD - Insufficient. Seed treatment*	Ventilation *QLD - seed treatment. Disease free seed . production break . structure hygiene*	Monitoring
Bacterial Pseudomonas & Erwinia	Coppers	Resistant varieties, Seed treatment, Coppers	Seed treatment	Flies may spread disease *QLD - so does irrigation*
Diseases - Field				
Septoria	Mancozeb, Coppers, Chlorthalonil as Preventatives. Tilt, Score, Bavistin as Curatives.	Model sporulation to help timing of spray. Coppers.	Model infection with monitoring around canopy closure in particular	Irrigation duration and timing. Trickle irrigation instead of overhead.
Sclerotinia	Rovral, Filan, Bavistin. Filan does not have a registration on Celery as yet. *QLD - amistar*	*QLD - Rotate ground , hygiene QLD3 - Soil amendments, biofumigants, crop rotations*	Organic toxins (NH3, phenols) to weaken sclerotia and then control somehow!	Further controls for Sclerotinia
Pythium	Phos acid, Ridomil	Trichoderma drench Biofumigation prior to planting *QLD - which trichoderma – is it effective.*	Diagnostic for dam water/drainage, Biocontrols (P oligandrum)	Loss underestimated
Colletotrichum (Minor?)	Usual preventatives such as Chlorthalonil and Mancozeb but curatives such as Switch and Octave maybe useful.	Unknown		
Viruses				
CeMV *WA - (Fact sheet with IDM strategy – WA)*	Clean plants, hygiene, rotations, variety selection Aphid spraying no use *QLD - ?*	Clean plants, hygiene, rotations, variety selection, Avoid general insecticides that knock out beneficials.	Celery free periods	Already adopting IPM
Other Management		Chicken manure composted;		
	QLD - Cos Lettuce – treated differently for chemical minor use – eg talstar and avatar			
Holistic Issues	Calcium black heart issues, Sodium imbalance due to high EC			
	Some varieties have Boron issues			
	Interactions of fungicides and insecticides not known – minor issue			
	Use of biologicals for root diseases: Pythium; Sclerotinia research been done and not productive!			
	No joint IPM program exists *QLD3 - this could be investigated as part of overall farm management IPDM*			
	Networks for IPM delivery eg. Muirs,			
	Output from pesticide risk assessment (Peter Del Santo)			

Lettuce management

Lettuce	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases – Nursery				
Downy mildew	Ridomil, Phos. Acid, Acrobat, Rebound.	Ridomil, Phos. Acid, Acrobat, Rebound.	Micronutrients, ventilation, varieties	Nursery monitoring, micronutrient program
Diseases - Field				
Downy Mildew	Ridomil, Phos Acid, Acrobat, Rebound.	Ridomil, Phos Acid, Acrobat, Rebound.	Monitoring, Resistant varieties *QLD2 - Model infection – predictive forecasting*	*QLD2 - Could attempt to utilise BOM data set for "global" forecasting*
Sclerotinia	Rovral *QLD - relatively ineffective,* Filan *QLD - Amistar. Folicur .*	*QLD3 - Trichoderma in seedling mix Rovral, Filan*	*QLD - Rotate ground or preplant treatment*	Further controls for Sclerotinia.
Botrytis	Rovral, Filan	Rovral, Filan		
Pythium	Phos acid, Ridomil	Trichoderma, Phos acid, Ridomil		Losses underestimated
Corky root	Tolerant varieties	Tolerant varieties	*QLD - Is it still an issue? Rotate !*	
Anthracnose	Octave	Octave		Fungal gnat control?
Viruses				
Big Vein	Tolerant varieties, Fumigation?	Biofumigants, Resistant varieties.		Fungi relationship with the virus. *WA - Nurseries need to be cleaned up*
Necrotic yellows	Aphid control	Pirimor, Chess		*WA - Control of sowthistle weeds – main source of LNYV*
Tomato S. Wilt Virus	Thrip control with Dominex, Success, Hygiene *QLD - chess pirimor*	Hygiene eg weed control around the crop *WA - resistant varieties, remove old crops*	*WA - Must be integrated management phytosanitary and insecticide*	Nurseries need to be clean.
Holistic Issues	Interactions of fungicides and insecticides not known			
	Impact of biologicals for root diseases			
	No joint IPM program exists *QLD - Chains & direct supply, push over cropping and continuous supply*			
	Networks for IPM delivery *QLD - plastic bagging means reduced tolerance to all previous issues.*			

Leeks and Spring Onion management, SA - Include bulb onions

Leek and spring onions	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases –- Field				
Downy mildews (Onions)	Ridomil, Acrobat, Rebound, Phos acid as Curatives. Chlorthalonil, Mancozeb, Antracol, Coppers as protectants.	Ridomil, Acrobat, Rebound, Phos acid as Curatives. Chlorthalonil, Mancozeb, Antracol, Coppers as protectants.	Modelling program, Monitoring to determine when to use curatives.	Irrigation timings, Wetting agents stripping protective coatings – Designer and DuWet do not. *QLD - What about x77, agral,etc QLD2 - Possibility of accessing BOM data.*
Purple Blotch	Chlorthalonil, Mancozeb	Chlorthalonil, Mancozeb		Good Downy Mildew control appears to help lessen the impact of this disease.
White rot	Filan	Filan, Tricoderma sp*QLD - (which one is it effective*	Long crop rotations	Future use of DADS?*QLD - (what)* Germinate sclerotes prior to planting?
Rust	Chlorthalonil, Mancozeb		Avoid excessive Nitrogen Avoid excessive leaf wetness	Do not follow Leeks will Onions. Separate the crops
Fusarium oxysporum	Bavistin	Bavistin *QLD - (is it still available)*	Avoid over irrigation Avoid mechanical damage to roots	
Pseudomonas bacteria	Coppers	Coppers	Avoid overhead watering	Careful selection of wetting agents *QLD - water source*
Holistic Issues	Interactions of fungicides and insecticides not known			
	Impact of biologicals for root diseases *QLD - long term crop 150 days*			
	No joint IPM program exists			
	Networks for IPM delivery			
	Output from pesticide risk assessment (Peter Del Santo)			

Salad Mix management

Salad Mixes	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases -– NurseryQLD - nursey situation often multicrop per product application in practice				
Downy mildews	Ridomil, Phos. Acid, Acrobat	Ridomil, Phos. Acid, Acrobat	Micronutrients, ventilation, varieties	Nursery monitoring,micro nutrient program
Diseases - Field				
Downy Mildew	Ridomil, Phos. Acid, Acrobat, Rebound	Ridomil, Phos. Acid, Acrobat, Rebound	Ventilation, Tolerant varieties, Length of irrigation	*QLD - Switched on growers aware of irrig length weather uncontrolable*
Sclerotinia	Rovral, Filan.	Rovral, Filan	*QLD - Quintozene ? dependence on filan- a worry*	Further controls for Sclerotinia.
Anthracnose	Octave, Coppers	Octave, Coppers	Long rotations, good drainage, Don't over water	
Botrytis	Rovral, Filan	Rovral, Filan	Avoid over head irrigation Avoid excess Nitrogen, try to increase Calcium levels	
White Blister on the Mustards only	Ridomil, Amistar, Mancozeb	Ridomil, Amistar, Mancozeb	*QLD - Clean seed*	
Bacterial leaf spot mainly on the Mustards	Coppers	Coppers	Avoid crop injury with proper application of fertilizers, Avoid overhead irrigation, Good ventilation between plants.	
Holistic Issues	Interactions of fungicides and insecticides not known (Cabrio worse than Amistar for impact on beneficials?)			
	Impact of biologicals for root diseases			
QLD -	No joint IPM program exists. *Salad mixes are a multi species crop system- registration issues. Crop cut while young, and often bagged on farm fo markets*			
	Networks for IPM delivery			
	Output from pesticide risk assessment (Peter Del Santo)			

Comments from Queensland related to industry survey on salad mixes

- Increased returns to growers would allow increased investment in the often more expensive softer options, and increased resources to effectively manage an ipm transition.
- Food safety, and human health implication of minimally packaged product being bagged on farm, and going direct to store for consumption, means longer time in bag, cool chain management more critical from food safety point of view.
- Increasingly big end user (chainstore/ processor) are handing down recipe for crop production – this is often detrimental to growers attempting to pursue an IPM vision, as recipe for the outcome is often overkill (pardon the punn).
- Bagged product has nil tolerance for insect life- even if in the field these insects may be beneficial – consumer does not want a ladybird, spider, or lacewing in a bagged, lettuce or herb pack.
- Why can't Aust have a true federal (National) Chemical / product registration system – not the current state based disjointed approach.
- Does the current minor use permit system discourage the true registraion of new compounds in horticultural crops, <as this costs money>, while growers beg for
- product and levees pay the fees for the minor use work.
- A percentage of the increased revenue (to the product owner) garnered from product used under a minor use permit system should be redirected back to support the work required to obtain the permit. Eg Confidor permitted use revenue.stream (or should I say tsunami)

Green bean management, Queensland

Green beans	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases - Field				
Sclerotinia	Rovral, Filan, Amistar	Rovral, Filan, Amistar, Sumisclex	Crop rotation, biocontrol, soil amendments	Further controls for Sclerotinia.
Bacterial blight, spot, halo blight	Copper	Disease free seed, copper	Long rotations, good drainage, Don't over water	
Red root complex	Thiram seed dressing	Planting depth, irrigation, organic matter	Crop rotations	
Rust	Folicur, Plantvax, Mancozeb, Sulphur	Resistant varieties		
Ashy stem blight		Clean field, rotations, crop hygiene		
Pythium		Farm hygiene, irrigation		
Viruses				
Bean common mosaic and peanut mottle	resistant varieties, disease free seed	Certified seed		
Holistic Issues	Impact of fungicides not clearly known as to effect on beneficial insects			
	Impact of biologicals on root diseases			
	Need integrated approach to Sclerotinia control			
	Red Root complex still issue for some growers in Gympie region			

Capsicum and chillies management, Queensland

Green beans	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases - Nursery				
Diseases - Field				
Bacterial spot	Copper sprays		Resistant varieties	
Bacterial wilt			Resistant varieties	
Sudden wilt				
Powdery mildew*	Nimrod, Bayfidan			
Viruses				
TSWV		Some resistance about		needs to IPDM package
Capsicum chlorosis virus			Resistant varieties, hygiene	
Holistic Issues				

Cucurbits (melons, cucumbers, squash, zucchini and pumpkins) management, Queensland

Green beans	Conventional	IPM	Ideal IPM	Specific IPM Issues
Diseases - Nursery				
Diseases - Field				
Powdery mildew*	Amistar, carbendazim, Bravo, sulphur, Bayfidan	Milk, hygiene		
Downy mildew	Bravo, Amistar, copper, Mancozeb, Phos acids, metylaxyl			
Bacterial fruit blotch				
Fusarium wilt				
Sudden wilt				
Soft rots				
Viruses*				
Papaya ringspot virus		crop hygiene, tolerant varieties	IDM, education	Transmitted by aphids
WMV-2		crop hygiene, tolerant varieties		Transmitted by aphids
Zucchini yellow mosaic virus		crop hygiene, tolerant varieties		Transmitted by aphids
Squash mosaic virus		crop hygiene, tolerant varieties		Seed borne and transmitted by 28-spotted ladybird beetle
Holistic Issues	There is real need to integrate pest and disease management especially for virus control. Need to educate growers on this area especially since insecticides don't seem to control virus vectors sufficiently for disease control.			

Beans and Peas management, Tasmania

BEANS	Conventional	IPM	Ideal IPM	Specific IPM Issues
Sclerotinia	Filan (boscalid), Amistar (azoxystrobin)		Monitoring for spore release or forecasting spore release from weather conditions.	
Rhizoctonia	No control…need for seed treatment			
PEAS				
Collar rot	Bravo (chlorothalonil), Phosphorus acid, seed treatment, Cabrio (pyraclostrobin)			
Downy mildews	Mancozeb, phosphorus acid, seed treatments		Resistant vars., seed treatments	
Powdery mildew	Folicur (tebuconazole)		Resistant vars. reaching commercialisation.	