BEST PRACTICE FOR VEGETABLES

Introductory document

The documents prepared under the "Best Practice' series provide information essential for economic and sustainable control of a specific diseases in Australian vegetables. It has been conducted under the Horticulture Australia Ltd project: VG07109.

This document covers the principles of Good Agricultural Practice (GAP) that have been incorporated in the following documents:

- Downy mildew in vegetables
- Fusarium, Pythium and Rhizoctonia in vegetables
- Powdery mildew in vegetables
- Sclerotinia in beans
- Sclerotinia in lettuce

These diseases and crops were selected as those of greatest concern to growers in regards to:

- current control options
- effective control mechanisms
- impact on production

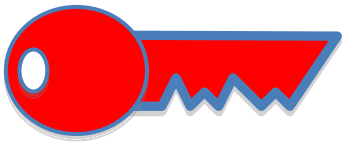
A theme that will be discussed throughout the documents is:

- Integrated Crop Management (ICM)
- Integrated Pest Management (IPM)

ICM is becoming increasingly important for vegetable production to control diseases and insect pests. ICM includes the principles of IPM including the use of beneficial organisms for the control of various diseases, insect pests and weeds. This has been driven by the desire to manage pesticide use to:-

- minimise the impact of pesticide resistance developing
- satisfy the consumers' desire for minimum residue food
- reduce environmental impact
- limit possible restrictions in trade (domestic and export)

For each of the diseases/crops reviewed in the documents, there are one or more key components which are integral for the management of the specific diseases - these will be called the "KEYS" and highlighted by:-



Advice given in this strategy is current as at 30 Oct 2009.
Prepared and funded by:-

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DOCUMENT STRUCTURE

1. INTRODUCTION
Introduces the scope of each Best Practice documents.

2. INTEGRATED PEST MANAGEMENT
A short general introduction /description of ICM and IPM and its relevance to vegetable production. As there is a huge quantity of information already available to growers on IPM: the principles, mechanisms and practice (eg. Ausveg website), they are not elaborated any further in this section.

3. DISEASE BACKGROUND
This section provides a brief background to each disease within each document. It includes crops, correct names, symptoms and variety susceptibility. It is not intended to be a comprehensive précis of each disease as this information is available from other sources (eg. state agriculture department websites).

4. CURRENT REGISTERED AND PERMIT PRODUCTS
A list of all registered and permitted fungicides is listed for each disease. This includes all registered formulations for each active (eg. all registered copper products). It provides any precautions that are listed on labels or reported from field use.

Before any fungicide is used, the label or permit should be thoroughly read to determine if the use and situation is appropriate to the growers needs. The latest information on labels and permits is also available on the APVMA website.

Information and labels on registered fungicides can be obtained from the APVMA Pubcris website at: http://services.apvma.gov.au/PubcrisWebClient/welcome.do;jsessionid=vskyFtjLZKvxGrpbpnfpZXLRLqj9Z390Z9Gk5JWF2nQBccpBXFFw!546591743

Information and copies of permitted fungicides can be obtained from the APVMA Permit website at: http://www.apvma.gov.au/permits/permits.shtml

5. ENVIRONMENTAL PROFILE OF FUNGICIDES
One of the main aims of the project was to provide growers with information to rate each fungicide on their applicator, worker, IPM, environmental and consumer fit. After considering different methods and databases used worldwide, we adopted the Cornell University, New York, USA, Environmental Impact Quotient (EIQ) system: http://www.nysipm.cornell.edu/publications/EIQ/

EIQ assess each fungicide for:

- Applicator effects } Farm worker effects
- Picker effects } Farm worker effects
- Consumer effects
- Leaching
- Fish effects } Ecology effects
- Bird, bee & beneficials } Ecology effects

EIQ rates each of these factors and gives a rating that can be used to compare one fungicide with another for its environmental profile.

The EIQ data for each of the disease/fungicide combinations is presented in table format to give a quick concise summary for comparison. Unfortunately, not all fungicide data was available.

6. IMPACT OF FUNGICIDES ON BENEFICIALS INSECTS AND MITES- AUSTRALIAN DATA

In order to provide the best available local data; information from other projects was included, eg. VG06087 'Pesticide effects on beneficial insects and mites in vegetables.'

Only data relevant to each particular fungicide was included. Unfortunately, not all fungicide data was available.

7. PRODUCT APPLICATION RATES AND OTHER INFORMATION

To support the EIQ data it was necessary to summarise all other relevant information for each fungicide. This information is available on product label, but is presented in summary form – chemical group, maximum number of applications, rate per hectare, spray intervals and product concentration.

Before any fungicide is used, the label or permit should be thoroughly read to determine if the use and situation is appropriate to the growers needs. The latest information on labels and permits is also available on the APVMA website.

8. DISEASE CONTROL PROGRAM (EXAMPLE)

This section provides a diagrammatic representation of the crops growth cycle and critical stages when fungicides and other disease control options can be employed.

This representation is a guide only.

9. APPLICATION

General details on fungicide application are described, including droplets, coverage and spray adjuvants. More detailed information on application is available on product labels, the fungicide manufacturer or sprayer manufacturer.

10. FUNGICIDE RESISTANCE

The appropriate use of chemical fungicides will prolong their useable life and reduce the potential for fungicide resistance to occur.

Throughout the Best Practice documents, chemical groups are listed (eg. Group M1 - copper). These should be used as a guide to fungicide rotations between the different groups to minimise any resistance developing.

The CropLife Australia Fungicide Resistance Management Strategies for various crops and diseases are listed, where appropriate. These strategies provide the appropriate use patterns for most fungicide / disease combinations. Further CropLife Australia information can be found at: www.croplifeaustralia.org.au

Some Best Practice documents make reference to HAL Project VG07119 (Barbara Hall, SARDI and Leanne Forsyth, NSWDPI) who are investigating fungicide resistance by testing diseased samples collected in the field. From initial testing, Hall and Forsyth have found resistance in some diseases to commonly used fungicides. Further testing is underway.

11. OTHER ICM CONSIDERATIONS

To reduce the emphasis on thinking disease control is dependent only on use of fungicides, a list of other management options (eg. resistant varieties, rotations, site selection, etc) is provided to assist growers in their decision making.

12. BIOLOGICAL CONTROL OF FUNGICIDES

The information on the availability and use of biological control agents (BCA) to control diseases in vegetables in Australia is limited as there are very few or no BCA registered.

Although there appears to be a lot of interest in BCA by growers and researchers, very little scientific validated information is available.

13. SUMMARY POINTS

The key points for each disease / fungicide / crop are summarised.

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Advice given in this strategy is current as at 30 Oct 2009.
Prepared and funded by:-

AgAware Consulting Pty Ltd

Best Practice - Sclerotinia in lettuce

Introduction

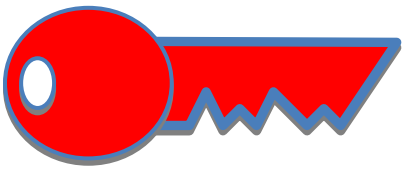
The following document incorporates information essential for economic and sustainable control of a specific disease in Australian vegetables. It has been conducted under the Horticulture Australia Ltd project: VG07109.

This document is one of a series of documents intended to provide information on "best practice" control of diseases of vegetables. As a result it conforms to the strategy of Integrated Crop Management (ICM) where the "whole" crop is managed to achieve our aim of disease control. However, there is a bias in this document towards fungicide control options with other strategies blended in to the mix of disease control.

The following are the main principles of ICM used in this document for best practice:-

- To select from the available range of economically effective methods to manage plant pathogens below the threshold for disease
- To manage these methods to prolong their effectiveness as long as possible
- To use these methods to minimise adverse effects on users, environment and other crop management systems eg IPM for insect control

For each disease there is one or more key components which are integral for the management of the specific diseases - these will be called the "KEYS" and highlighted by:-



Sclerotinia in beans
(Photo courtesy of D. Wite Vic DPI)

Advice given in this strategy is current as at 30 Oct 2009.
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Integrated Crop Management (ICM)

There is increasing attention on incorporating Integrated Crop Management (ICM) systems for vegetable production to control diseases and insect pests. ICM includes the principles of Integrated Pest Management (IPM) that relates specifically to the use of beneficial organisms for the control of various diseases, insect pests and weeds. This has been driven by the desire to manage pesticide use to:-

- minimize the impact of pesticide resistance developing
- satisfy the consumers' desire for minimum residue food
- reduce environmental impact
- limit possible restrictions in trade (domestic and export)

An ICM/IPM program needs to be developed for all the major crop-disease combinations included in this project. Traditional methods of disease management including crop hygiene, crop rotation and irrigation management remain important elements of ICM. Today a range of fungicides treatments are also available to assist in the management of crop diseases as are some disease resistant crops varieties.

Pesticide treatments vary in cost, efficacy, withholding period, re-entry period and environmental impact. It is accepted that knowledge in this area is incomplete and dynamic.

This document presents a summary of the IPM compatibility of the fungicides currently used in Australia to manage soilborne diseases caused by **Sclerotinia** as well as their pesticide residue and environmental profiles.

For further information on ICM and IPM research initiatives in the Australian vegetable industry can be found on the Ausveg website: www.ausveg.com.au.

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1. Disease background

Long term control of Sclerotinia is difficult in lettuce due to a number of factors including:

- A wide host range including bean, brassica, carrot, celery, lettuce, onion, pea, potato and tomato.
- The formation of long-lived sclerotia (up to 10 years) in the soil.
- The formation of mycelium in living or dead plants.
- With the correct conditions sclerotia produce a fruiting body or ascocarp which releases ascospores into the air.
- The aggressive nature of the infection process.
- The lack of resistant varieties.
- Reliance on fungicides for control.
- Lack of a wide range of alternate modes-of-action fungicides.
- Multiple cropping and poor rotation practices.
- Rotation with non-host crops (cereals) is difficult and at least 3 years is required.
- Control is required in lettuce from just after transplanting up to harvest. This is particularly important for follow-up crops as they can also be highly susceptible, eg. beans following lettuce in SE Qld.

Two species of *Sclerotinia* are important pathogens in Australia on lettuce crops:

1. ***Sclerotinia minor***
   Affects mainly lettuce and is more problematic in southern cooler districts.
   Sclerotinia minor attacks the outer leaves of lettuce that are in contact with the soil in addition to root hairs and plant crowns.
   Wilting of these leaves is the initial symptom.
   The infection moves inwardly until the entire plant wilts (Lettuce drop).
   Look for soft watery decay, white mycelium and black sclerotia the size of mustard seeds.
   Early prevention of infection by *Sclerotinia minor* at the base of the young lettuce plant is critical and depends on correct application techniques.

2. ***Sclerotinia sclerotiorum***
   Affects mainly beans, but also potatoes, brassicas and lettuce and is more common in northern warmer districts. In South Australia *Sclerotinia sclerotiorum* is more common than *Sclerotinia minor*).
   Sclerotinia sclerotiorum can also produce Lettuce drop symptoms and aerial phase can infect upper leaves and cause a head rot.
   Large black sclerotia, the size and shape of rat faece pellets, are probably *Sclerotinia sclerotiorum*.
   The aerial infection phase of *Sclerotinia sclerotiorum* is difficult to control because of additional factors such as:
   - Inability to accurately predict ascospore release.
   - Lack of knowledge about site factors that influence infection.
   - Difficulty in selecting the optimum timing for the first spray.
   - Spray efficacy (eg. droplet size).
   - Canopy leaf wetness and humidity (managed via row spacing/direction etc)

Sclerotinia produces long lived sclerotes which can infest soil for many years. Reduction of the inoculum potential is a key to the long term control of this disease. The use of long rotations (lettuce free), fumigants or biofungicides is essential prior to planting lettuce in soils with high levels of inoculum/sclerotes.
Dependence on Sclerotinia fungicides alone for disease control in high risk situations is not sustainable.

Photos showing characteristic ascocarps (left) and black sclerotes / white fluffy mycelium of *Sclerotinia sclerotiorum* (right). (Photo courtesy of D. Wite Vic DPI)

Lettuce drop of mature iceberg lettuce
(Photo courtesy of D. Wite Vic DPI)

2. Current registered product(s) for Sclerotinia control in lettuce

Fungicides (chemical)

Iprodione (various formulations and trade names)

- Group 2 dicarboximide fungicide with preventative and curative activity, but only works on contact. For Sclerotinia, need to use a seedling drench and foliar spray.
- Controls Sclerotinia Lettuce drop (*Sclerotinia minor)* and Sclerotinia rots *(S. sclerotiorum*).
- 7 day WHP.
- Can be used on all types of lettuce.
- According to growers/consultant reports, efficacy varies from state to state. Poor efficacy in some states eg Qld (7).
- Only registered fungicide for *Sclerotinia minor* and *Sclerotinia sclerotiorum*.
- Toxic to fish and bees.

Tebuconazole (430 g/L)

- Group 3 triazole (demethylation inhibitor) with systemic curative and protectant activity.
- Only registered for control of *Sclerotinia sclerotiorum* in lettuce.
- Campbell's 'Isis®', Farmoz 'Orius®' and Genfarm 'Blast®' registered in lettuce.
- Can be used on all types of lettuce (field grown only).
- Apply only during early stages of plant development - 35 day WHP.

Fumigants

The use of fumigants is not considered ICM/IPM "friendly" as they are total biocides. However, in salvage situations or where high levels of sclerotia have been monitored or anticipated, soil fumigation may be necessary as an initial control method. All fumigants provide varying degrees of pre plant soil fumigation for bacteria, diseases (soil borne), insects, nematodes and weed seeds.

Compound	Chemical group	Crop	Disease
chloropicrin eg. Chloropicrin	Group8A Fumigant - insecticide/fungicide	All crops	Sclerotinia + others
dazomet eg. Basamid	Fumigant - insecticide/fungicide	All crops	Sclerotinia + others
metham sodium eg. Metham	Group1A Fumigant - insecticide/fungicide	All crops	Sclerotinia + others

WARNING: Lettuce is extremely sensitive to fumigant residues and adequate plant back periods are required to prevent phytotoxicity.

IMPORTANT NOTICE
Before any fungicides are used via the above list, the label should be thoroughly read to determine if the use and situation is appropriate to your needs. The latest information of current permits is available on the APVMA website: www.apvma.gov.au.

3. Current fungicides used under permit for Sclerotinia control in lettuce

*** These permits are current as at 30th October 2009.**

Azoxystrobin (AMISTAR® - Group 11)

Permit Number	Description	Date Issued	Expiry Date
PER10261	Azoxystrobin: Brassica / White blister; Beans / Sclerotinia rot: Lettuce / Sclerotinia rot	3-Jan-08	1-Jan-10

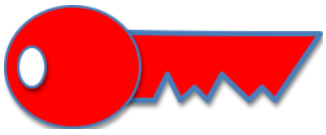
- Azoxystrobin (Amistar 250SC) is a member of the Quinone outside inhibitors (QoIs) activity group (Group 11)
- Has protectant and systemic fungicidal properties. But Amistar works best when used as a protectant for disease control.
- Reduced-risk fungicide.
- Efficacy has been questioned in high pressure lettuce/Sclerotinia situations in Australia.
- APVMA permit PER10261 - 1 day WHP.
- Maximum of 3 applications at 7 - 14 day intervals.
- Registered in tomatoes for Sclerotinia control.
- Registration under consideration.

Boscalid (FILAN® - Group 7)

Permit Number	Description	Date Issued	Expiry Date
PER8819	Boscalid / Brassica, Brassica Leafy Vegetables, Lettuce, Beans (green pods and immature seeds) / Sclerotinia rot	10-Oct-05	31-Jan-10

- Boscalid (Filan Fungicide) is a Group 7 oxanthiin fungicide
- Inhibits spore germination, mycelial growth and sporulation - preventative and curative.
- Reduced-risk fungicide.
- Backbone of green lettuce/Sclerotinia programs in Australia at present.
- Well favoured but some variability in performance under high disease pressure in some regions.
- APVMA permit PER8819 - 14 day WHP
- Permit to control Sclerotinia rot (*Sclerotinia minor & S. sclerotiorum*) on all types of lettuce.
- Maximum of 2 applications at 7 day intervals.
- Registration under consideration.

IMPORTANT NOTICE
Before any fungicides are used via the above list, the permit should be thoroughly read to determine if the use and situation is appropriate to your needs. The latest information of current permits is available on the APVMA website: www.apvma.gov.au.



Iprodione, tebuconazole, Amistar® and **Filan®** are the only fungicides available for **Sclerotinia** control in lettuce. Careful use of these products is required to ensure their useable life.

4. Environmental profile of fungicides

The choice of fungicide should not be based on efficacy or price alone as other considerations need to be taken into account when employing an ICM/IPM based best management practice.

The Cornell University, New York, USA (2) have developed a system that assesses the environmental profile of many pesticides. The Environmental Impact Quotient (EIQ) system is incorporated in their New York State Integrated Pest Management Program.

EIQ assess each fungicide for:

- Applicator effects } Farm worker effects
- Picker effects } Farm worker effects
- Consumer effects
- Leaching
- Fish effects } Ecology effects
- Bird, bee & beneficials } Ecology effects

EIQ rates each of these factors and gives a rating that can be used to compare one pesticide with another for its environmental profile.

Further information on EIQ can be found on their web site - see reference (2).

The EIQ system can be used as a guide by growers wishing to minimise effects on beneficial insects, workers, consumers, the environment and other crop management systems.
The lower the EIQ rating the better the environmental profile.

The following table includes information for those products that could be considered for *Powdery mildew* control in vegetables. Some of the information can already be found on product labels (eg. chemical group, withholding period, re-entry period, etc).

Below are the explanations for terms used in the table.

1. WHP = withholding period for harvest
2. REP = re-entry period after spraying
3. EIQ = Environmental Impact Quotient. Rating system which provides a relative rating for pesticides active ingredients based on worker consumer and environmental effects. The lower the rating indicates a better environmental profile.
4. EIQ field rating = EIQ x product formulation concentration x application rate (kg or L/ha). A lower rating indicates a better environmental profile.
5. Effect on beneficials - Individual component of EIQ.
6. NIFWR = no information further work required

EIQ for registered and permitted products in lettuce

Product	Chemical Group	WHP[1] (days)	REP [2] (hours)	EIQ [3]	EIQ Field rating [4] (per app)	Effect on Beneficials [5] (IPM fit)	Comments
azoxystrobin eg. Amistar	11	1 (beans)	> Spray dried	15.2	5	3	Permit - brassica, lettuce, beans.
boscalid eg. Filan	7	14	after spray dried	44	22	31	Permit - brassicas, brassica leafy vegetables, lettuce, beans.
iprodione eg. Rovral	2	7	after spray dried	11	5	3	Only product registered for Lettuce drop (*Sclerotinia minor)* and Sclerotinia rots *(S. sclerotiorum*).
tebuconazole eg. Folicur	3	35	after spray dried	40	6	4	Some products registered. Permit only for other products.
chloropicrin eg. Chloropicrin	8A	N/A	Consult label	>100	>20000	300	No IPM fit
dazomet eg. Basamid	1A	N/A	48	>100	>20000	300	No IPM fit
metham sodium eg. Metham	1A	N/A	48	>100	>20000	300	No IPM fit

(See page 8 for explanations of terms used in this table)

5. Impact of fungicides on beneficial insects and mites - Australian data

Research work funded by HAL and the Vegetable R&D levy into the effects of pesticides on beneficial insects and mites in vegetables in Australia has been ongoing for 3 years. The following table summarises results of relevant *fungicides*.

These results show the short term (or acute) effects using adults. Potential long term effects such as impact on reproduction are not shown as they were not conducted. However, it is hoped that with further funding this aspect may be evaluated.

Product	**Beneficial insect or mite and their target pest**				
Fungicide **Active ingredient**	**Brown lacewing** (Aphids)	**Transverse ladybird** (Aphid)	**Common spotted ladybird** (Aphid)	**Damsel Bug** (Caterpillars)	**Trichogramma wasp parasitoid** (Caterpillars)
azoxystrobin (Amistar)					
boscalid (Filan)					

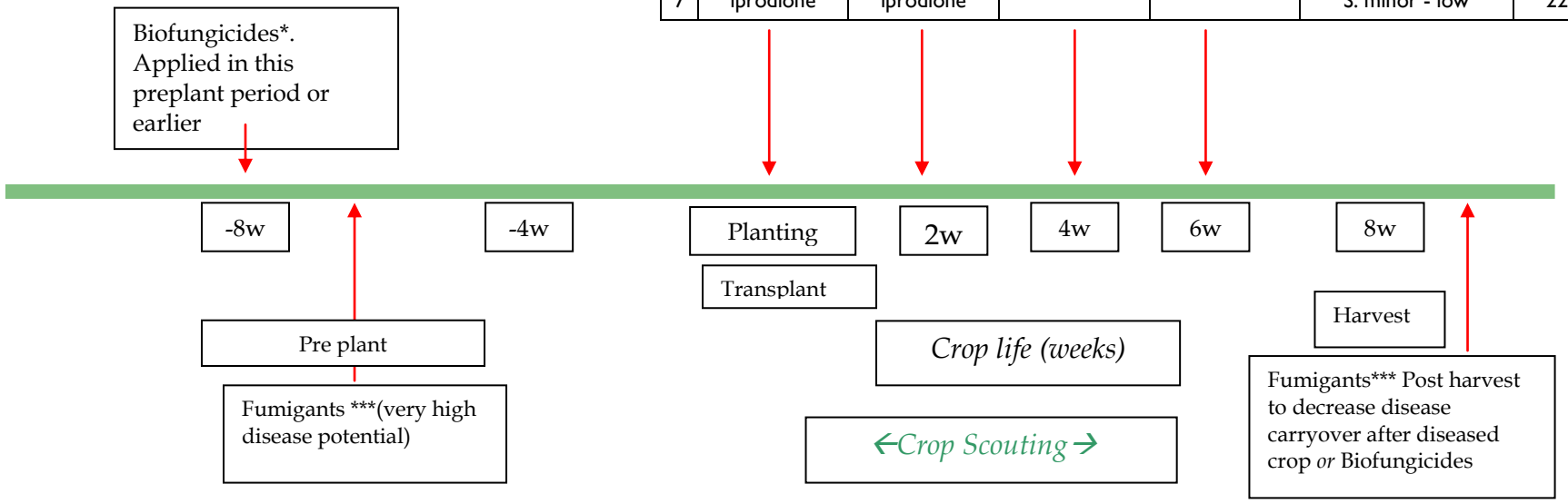
	= Harmless- less than 30% acute mortality
	= Mod harmful. 30->70% acute mortality
	= Harmful: greater than 70 %mortality

This work was performed by IPM Technologies Pty Ltd and the Department of Primary Industries (Vic). Funding by Horticulture Australia Ltd (HAL) and the Australian Vegetable Research and Development Levy, Project VG06087 'Pesticide effects on beneficial insects and mites in vegetables.'

6. Disease control programs example incorporating ICM options

Examples of possible fungicide programs

	1st application	2nd application	3rd application	4th application	Disease potential	EIQ**
1	Filan	Filan	iprodione	iprodione	S. sclerotiorum - high	66
2	tebuconazole	tebuconazole	iprodione	iprodione	S. sclerotiorum - high	34
3	iprodione	iprodione	iprodione	iprodione	S. sclerotiorum - high/medium	44
4			iprodione	iprodione	S. sclerotiorum - medium/low	22
5	Filan	Filan			S. minor - high/medium	44
6	tebuconazole	tebuconazole			S. minor - high/medium	12
7	iprodione	iprodione			S. minor - low	22



* compatible with foliar program
** EIQ rating for program
*** not compatible with Biofungicide

7. Product application rates and other information

Fungicides presently registered or used under permit

Product Name (active)	Concentration	Group	Application Rate (per ha)	Max no. of apps per crop	Spray interval (days)	Withholding Period (days)
AMISTAR (azoxystrobin)	250 g/L	11	500-600 mL/ha or 50-60 mL/100L	3	7-14	14
FILAN (boscalid)	500 g/kg	7	800-1000 g/ha	2	14	14
ROVRAL (& others) (iprodione)	500 g/L	2	1.0 L/ha	4	10	7
ISIS (& others) (tebuconazole)	430 g/L	3	350 mL/ha	2	10	35

IMPORTANT NOTICE

Before any fungicides are used via the above list, the label or permit should be thoroughly read to determine if the use and situation is appropriate to your needs. The latest information of current permits is available on the APVMA website: www.apvma.gov.au.

8. Application of fungicides

Sclerotinia minor

Ensure early fungicide applications

1. Apply as a seedling drench soon after transplanting or seed emergence.
2. If conditions favour Sclerotinia development or disease pressure is expected to be moderate/high, apply another application 2 weeks after transplant/emergence.
3. Use a high volume system (minimum of 1000 L/ha) or alternatively as a directed drench to base of transplants.

It is essential that the early fungicide applications for *Sclerotinia minor* are used at high water volume which enables the fungicide to be effectively "washed/distributed" into the root zone and base of plant

Sclerotinia sclerotiorum

Choose appropriate application indices (spray intervals, droplet size, volume etc) and technique to ensure adequate coverage to prevent ascospore infection. These are sometimes outlined in fungicide label directions. Use of adjuvants with fungicides may also be required.

Follow label directions for application intervals, droplet size, volume, etc.

In areas that are prone to Sclerotinia, the timing of the first application is likely to be the most important factor in determining the level of disease control.

See 10 regarding strategies to minimise fungicide resistance.

Spraying of crops.
(Photo courtesy of R. Holding)

Fumigant application

Fumigants should only be considered in very high disease risk situations when all other control measures have been considered first. Fumigants are not compatible with IPM systems.

Careful attention is required prior to and after fumigant application eg. Metham sodium. Significant seedbed preparation and time is needed prior to application and appropriate safe withholding periods need to be observed after application.

As an example the following are directions taken from a Metham sodium label:-

Soil should be carefully prepared in advance according to the directions for use.
Cultivate the area thoroughly and break up clods.
Loosen soil deeply one week in advance of application.
Soil should be kept moist until application, and if soil has not crusted in the meantime, re-cultivate lightly.
Soil temperature should be in the range 10-32°C to depth of 8cm.
Where fumes become unpleasant spray with water to seal fumes in.
Planting may take place 14-21 days after application if soil is light-medium texture and not excessively wet or cold.
A minimum interval of 30 days is necessary where soil texture is heavy, high in organic matter, wet or soil temperature is less than 15°C.
A 60 day interval is required if application rate is greater than 1100L/ha.
Sow an indicator crop to test that no toxic METHAM remains in the soil, approximately 7 days before main crop.
Lettuce or radish is suitable for this purpose because of their rapid germination process. Check for root damage which will indicate whether or not soil is still toxic.

Consult respective product labels for full application details.

9. Fungicide Resistance

The appropriate use of fungicides will prolong their useable life and reduce the potential for fungicide resistance to occur.

Never use more than the recommended maximum number of applications per crop and where possible rotate to a fungicide with a different mode of action /activity group. Also, never use rates less than recommended by the label.

Always use fungicides according to the label directions:

- If the fungicide is to be used preventatively, then apply prior to the onset of main disease infection period.
- If the fungicide is to be used curatively, then apply as soon as possible after the onset of main disease infection period.
- Never use fungicides after infection has fully established and is visible.

Crop Life Australia (5) (formerly AVCARE) implement Fungicide Resistance Management Strategies for various crops and diseases in Australia. To date, no FRMS has been formulated for *Sclerotinia* diseases in Australia.

There have been reported losses of effectiveness of some fungicides in vegetable crops. In many situations it was found that poor commercial results may have been due to poor application by growers or poor application timing rather than fungicide resistance/tolerance.

Fungicide testing from other crops has shown that some strains of *Sclerotinia* are resistant to some fungicides from different activity groups. If using fungicides monitor the results to check for effectiveness and if results are not as expected contact your local DPI, agchem manufacturer or retailer to investigate further.

HAL Project VG07119 – Identification and monitoring of resistance in vegetable crops in Australia', (Barbara Hall, SARDI and Leanne Forsyth, NSWDPI) is investigating fungicide resistance by testing diseased samples collected in the field.

From initial testing in VG07119 it was found that:

- **of the 45 samples of *Sclerotinia sclerotiorum* received from Vic, SA, WA, NSW, Qld and Tas, 2 from NSW and 2 from Victoria were resistant to benzimidazoles (carbendazim, thiabendazole), 6 others showed reduced sensitivity and 5 were resistance to dicarboximides (iprodione, procymidone).**
- **of the 21 samples of *Sclerotinia minor* from lettuce tested, that 13 were resistant to benzimidazoles (carbendazim, thiabendazole) and 3 of these were also resistant to dicarboximides (iprodione, procymidone).**

Further testing is underway.

Sending diseased plant samples in for testing for chemical resistance

If you suspect that the applications of pesticides that you are applying to your crop are failing to suppress disease, the pathogen present on your farm may have chemical resistance. Currently a resistance testing project funded by HAL and Vegetable R&D levy being undertaken across Australia, assessing **Sclerotinia**, Botrytis, White blister, Downy mildew and bacterial pathogens for resistance to pesticides. If you are encountering spray failure you should have the pathogens tested to ensure you aren't wasting money applying chemicals which may not work as well as they normally do.

To have the pathogens present on your farm tested for resistance:

- Collect plants or parts of the plant showing the disease. It is important that the diseased plant isn't dead.
- Wrap the diseased plant tissue in slightly moist paper, and then wrap further in dry paper, then in a plastic bag. It is important not to wrap the diseased plant directly in plastic as it can cause the plant to "cook".
- It is important to collect the plant/plant parts on the day that you are going to send the sample in, and samples should not be sent on a Thurs/Friday.
- Samples should be sent preferably early in week eg. Monday or Tuesday to allow transit to their destinations prior to the weekend.
- Send the plant sample either by courier or by overnight post.
- Include with the sample information stating what plant cultivar is being used, what pesticides have been applied and any additional information e.g. more severe than in a regular season.

For Botrytis and **Sclerotinia** resistance testing samples should be sent to:

Barbara Hall
SARDI (South Australia Research & Development Institute)
Plant Research Centre
GPO Box 397, Adelaide, SA 5001
Ph: (08) 8303 9562
Email: hall.barbara@saugov.sa.gov.au`

Prior to sending please advise the above researchers by email or phone that samples are in transit

10. Other ICM consideration

Management Option	Recommendation
Scouting/thresholds	Record the occurrence and severity of Sclerotinia. No thresholds have been developed. Use history to make your decisions on paddock selection and spray timing.
Resistant varieties	No resistant varieties are available.
Crop rotation	Minimum of three year rotation with non-hosts such as grains is needed, if practical. Avoid double cropping with lettuce. Brassica crops could be considered as they are less likely compared with other crops to be Sclerotinia susceptible. Green manure crops as also a viable alternative. See Crop Disease Risk in table below.
Site selection Seed selection/treatment Post-harvest sanitation	Aim to select planting sites to minimise disease inoculum carryover especially for susceptible crops like green beans. No viable seed treatment available. Some post harvest options available.
Fungicide resistance	Overuse of fungicides from only one chemical group could lead to the development of resistance. Where possible rotate chemical groups. Monitor all fungicide application for effectiveness and make future fungicide selections based on previous performance.

Crop rotation disease risk - Sclerotinia	
Crop	**Risk**
Beans	High
Potatoes	High
Onion	High
Carrots	High
Celery	High
Peas	High/medium
Tomatoes	High/medium
Turf	Medium
Clovers	Medium
Brassicas eg. Broccoli	Medium/Low
Cereal crops	Low
Sweet corn	Low

Information on rotation risk has been provided to guide growers in their choice of rotation crops. Avoid situations where highly susceptible crops eg. lettuce or green beans follow long periods of semi susceptible crops eg. potatoes.

11. Biological control agents and chemical biofungicides

Biofungicides and Biofumigant crops

Biological control includes any organism or extract from an organism of biological origins which exhibit biofumigant, biostimulant or biofungicidal activity on fungi. At present there are no biological control products that are registered in Australia for *Sclerotinia* spp. control, although there are some products sold under various guises that claim disease control.

Some biological control products are registered for *Sclerotinia* spp. control overseas.

Many different biological control agents and biofumigant crops have been trialled over many years in Australian conditions. A common observation from these trials is that the results are inconsistent from trial to trial and year to year.

It is the authors understanding that no manufacturer has presented appropriate efficacy data to APVMA to seek full registration for any biological control agents in vegetables.

12. Future directions

Additional fungicides may be registered for use or allowed by permit for Sclerotinia control in lettuce in the future.

Biological fungicides may also be evaluated for efficacy under Australian conditions and gain registration or permit if viable

13. Summary Points

- *Sclerotinia* produces long lived sclerotes which can infest soil for many years. Reduction of the inoculum potential is a key to the long term control.
- Iprodione and tebuconazole are the only currently registered fungicide for Sclerotinia control in lettuce. Amistar and Filan can be used under permit.
- The appropriate use of chemical fungicides will prolong their useable life and reduce the potential for fungicide resistance to occur.
- Other chemical fungicides and biofungicides are under review and may achieve registration or permit use in future.
- The EIQ system can be used as a guide by growers wishing to minimise effects on beneficial insects, workers, consumers, the environment and other crop management systems.
- Correct application techniques are essential for the most efficient use of chemical fungicides.
- Integrated Crop Management (ICM) - the effective control of disease requires the use of all management options. This includes site selection, crop varieties, crop timing, biological options, monitoring and rouging. Only when all these options have been employed should fungicide be considered to: control / prevent / decrease / delay disease infection.
- Careful consideration of crop rotation is also a powerful management tool.
- At present no biofungicides are registered in Australia for *Sclerotinia spp*. control, although there are some products sold under various guises that claim disease control.

14. References

1. Australian Pesticides and Veterinary Medicines Authority: www.apvma.gov.au
2. New York State Integrated Pest Management Program, Cornell University, New York, USA: www.nysipm.cornell.edu
3. Porter, Ian. DPI Vic Knoxfield. Verbal communication. Sept 2008.
4. Villalta, Oscar. DPI Vic Knoxfield. As reported in *Lettuce Leaf* (June 2004) Issue No 10.
5. 2nd Australasian Lettuce Industry Conference, 5-8 May 2002, University of Queensland, Gatton Campus. Development of biological controls for Sclerotinia diseases of horticultural crops in Australasia. Ian Porter & Oscar Villalta, Agriculture Victoria, Hoong Pung Serve-Ag Research Tasmania. Rosa Crnov and Alison Stewart, Lincoln University New Zealand
6. CropLife Australia Ltd: www.croplifeaustralia.org.au
7. Vegetable Industry Pathology Gap Analysis Final Report. May 2007. Horticulture Australia VG06092

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Peter has been involved with Australian agricultural since 1983. Peter's experience has included sales, marketing, research and development roles with major agchem multinational companies and Executive Officer for Crop Protection Approvals, which managed data collation and minor-use permits for the vegetable industry. Since 2003, Peter has been the Director and Principle Scientist of AgAware Consulting P/L which is a project management consultancy. AgAware manages the HAL funded project, 'MT07029 - Managing pesticide access for horticulture' to accessing minor-use permit for horticulture as well as other HAL projects. In 2009, Peter received the 'Ausveg Industry Recognition Award' for servicies to the vegetable industry.

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Ross has worked in the Agchem industry since 1985. First as Technical Officer/Manager Research and Development with a major multinational company (1985-1996) and then as Product Manager with an Australian agchem manufacturer(1997). Since 1998 has worked independently as a contract agricultural consultant specialising in field efficacy and residue trials in both horticulture and broadacre.