Department of Primary Industries

Biosciences Research Division
Knoxfield Centre

Workshop Meeting

Tuesday 9th February 2010

3.00 pm – 5.00 pm

Vegetable IPM Project Updates on Foliage Diseases

Lettuce:- Nutrients, Downy Mildew, Anthracnose
Brassicas:- White Blister
Cucurbits: - Powdery Mildew

Where:

Amstel Golf Cub
1000 Cranbourne Frankston Rd
Cranbourne
Melway 133 D5

Afternoon tea provided

Speakers:

Belinda Rawnsley, SARDI, Victor Galea UQ, Desmond Auer DPIVic, Joanna Petkowski DPIVic & Liz Minchinton DPIVic, Lindsay Trapnell

For more details contact:

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Research supported by your Vegetable Industry Levy, Horticulture Australia, and the Victorian Department of Primary Industries

Table of Contents

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Chemical Use
The chemical use reported in the publication is off label information; consequently the DPI does not recommend it for use. All off label use is at the growers own risk.

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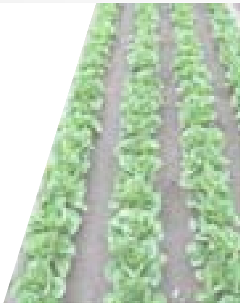
Milestone VG07070 – Effect of Nutrients on Disease



SARDI Staff:
Ms Barbara Hall, Senior Research Scientist
Dr Belinda Rawnsley, Senior Research Officer
Ms Lee Bartlett, Technical Officer

The objective of our study is to determine if the rate and form of Nitrogen increases lettuce susceptibility to disease.

To assess lettuce susceptibility to Downy Mildew (*Bremia lactucae*), a number of experiments were conducted to assess (i) infection conditions required, (ii) lettuce variety and (iii) the role of Nitrogen in plant growth.

Downy mildew was collected from field infected lettuce and inoculated onto fresh young seedlings grown in controlled environment growth rooms (CER). Suitable environmental and inoculation conditions were assessed for survival of Downy Mildew on lettuce. It was deemed 12 hr light/12 hr dark at 14°C when applied to 7-day old lettuce seedlings (2 cotyledon stage) grown in soil under humid conditions were suitable for infection to occur. Symptoms appeared 7-10 days after inoculation.

Initial experiments were conducted to determine the susceptibility of 21 lettuce varieties to Downy Mildew. Varieties were deemed resistant, moderately resistant and susceptible. Four varieties were used to assess the growth of lettuce in response to various rates of Nitrogen prior to inoculation studies with Downy Mildew. Lettuce seedlings were watered with Potassium nitrate (KNO_3), a commonly used nursery fertilizer. The findings constituted what Nitrogen rates were considered low, medium and high when applied to lettuce grown in CER conditions (Figure 1).

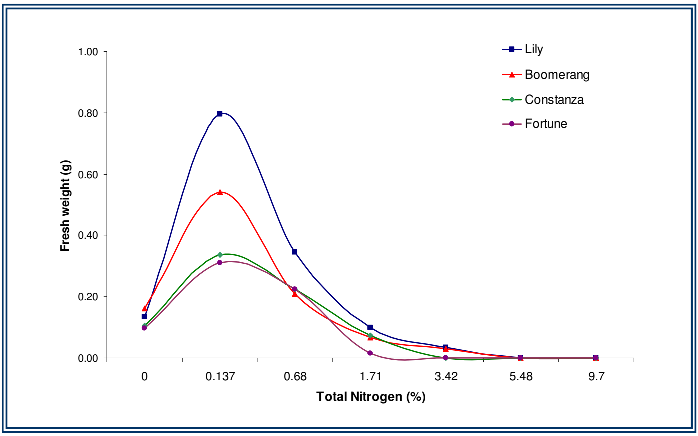


Figure 1. Fresh weight of 4 lettuce varieties in response to various rates of Nitrogen.

Using four lettuce varieties, 15 replicate plants were grown in soil containing no Nitrogen and watered with 4 rates of Nitrogen; no N, low, medium and high (0, 2, 10 and 50 mM, respectively) with two sources of Nitrogen; Potassium Nitrate (KNO_3) and Calcium Nitrate $Ca(NO_3)_2$. Lettuce seedlings were inoculated with Downy Mildew and the incidence (no. of plants infected) and disease severity (% leaf area infected) was assessed 20 days post-inoculation. Fresh weight was also recorded.

Results showed that there was a significant varietal difference in susceptibility to Downy Mildew. Although varieties Lily and Boomerang showed no infection by Downy Mildew, cv. Constanza was significantly more susceptible to the disease at the highest KNO_3 rate applied (Figure 2). Infection also occurred when watered with $Ca(NO_3)_2$.

Assessment of fresh weight indicated that there was a combined detrimental effect of high Nitrogen and infection by Downy Mildew on growth of lettuce (Figure 3).
Growth of cv. Constanza was reduced following infection with Downy Mildew and application of high rates of KNO_3. Using higher rates of N did not improve plant growth.

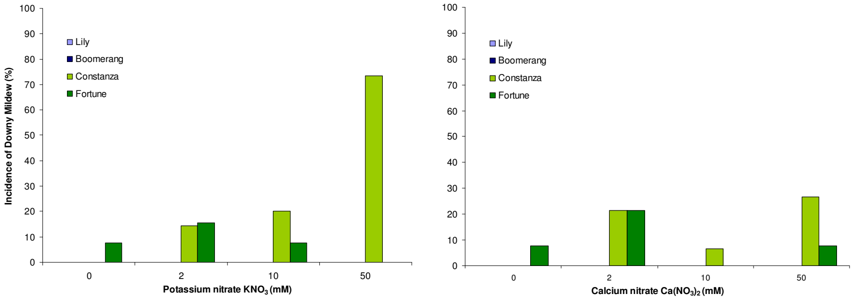


Figure 2. Incidence of Downy Mildew on four varieties of lettuce watered with either (a) Potassium nitrate or (b) Calcium nitrate.

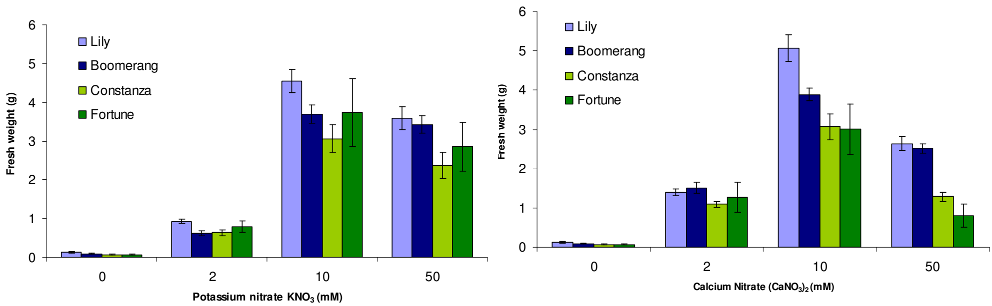


Figure 3. Fresh weight of four lettuce varieties inoculated with Downy Mildew and watered with either (a) Potassium nitrate or (b) Calcium nitrate.

In conclusion, our results show that the source and rate of Nitrogen has an effect on the susceptibility of lettuce to infection by Downy Mildew. More disease occurred on lettuce plants when high rates of N were applied as KNO_3. Applying more N can increase susceptibility of certain lettuce varieties to disease.

Developing a disease forecasting system for powdery mildew in cucurbit crops

PhD Student, Zaiton Sapak at The University of Queensland (UQ) is conducting research on powdery mildew of cucurbits in a project funded by Horticulture Australia Limited (VG07070). Her work involves a precise study of the infection process in the laboratory with the aim of developing a model which can be used as the basis of a disease forecasting system in the field. Zaiton's supervisors are Dr Victor Galea & Professor Daryl Joyce (UQ) and Dr Elizabeth Minchinton (DPI Victoria).

Inoculation techniques

Although powdery mildew is a widespread problem in field and glasshouse crops, it can be difficult to work with in the laboratory. Zaiton has had to develop a spore settling tower for precisely applying dry powdery mildew spores onto test plants (Figures 1 and 2). This development has allowed Zaiton to more reliably and accurately infect plants using spores produced on powdery mildew infected leaves in the glasshouse.

The plants are then removed from the tower and placed in climate controlled chambers in a growth cabinet in the laboratory. These chambers are electronically monitored for temperature and humidity levels (Figure 3). The infection process is carefully observed on plants kept in these chambers. The results from Zaiton's work will allow her to accurately determine the temperature and relative humidity requirements for powdery mildew infection in field and greenhouse grown cucurbit crops (Figure 4).


Fig 1 (left) Zaiton standing with the spore settling tower she developed.
Fig 2 (right) Cucumber plants at the base of the tower during inoculation with powdery mildew spores.

Fig 3 Zaiton with the climate controlled chambers containing test plants

Fig 4 Powdery mildew on cucurbits in the glasshouse.

Powdery mildews are sensitive to the presence of atmospheric humidity. In some systems, the measurement of Vapour Pressure Deficit (VPD) is used to predict powdery mildew activity in greenhouse crops. In California, field occurrence of cucurbit powdery mildew has been associated with low VPD values, but this has not been examined to produce a useful predictor of disease activity.

The next step will be to develop a model that can be used by growers to accurately predict powdery mildew infection events and the need for fungicide applications. The aim is to improve management of fungicide spray regimes, reduce the number of sprays required for disease control and reduce the cost of disease management. Data collected from field trials being conducted by Dr Gerry MacManus and Dr Chrys Akem at DEEDI (formerly QDPI) in Ayr, north Queensland will be used by Zaiton to fine-tune her model when it is developed.

For more information contact Dr Victor Galea, University of Queensland v.galea@uq.edu.au

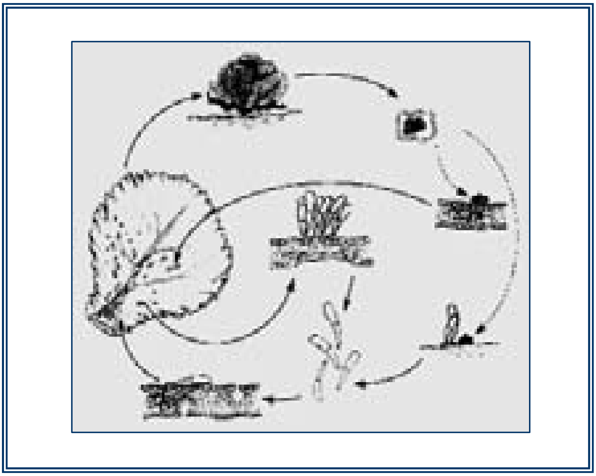
Lettuce anthracnose is a serious disease caused by the fungal pathogen *Microdochium panattonianum*. Another name for this disease is shot-hole.

Survival:

The lettuce anthracnose fungus survives on farm between crops in two ways. Firstly it can survive on rogue lettuce plants or the weed prickly lettuce (*Lactuca serriola*) growing in headlands or other parts of the farm. Secondly, the fungus can survive in decomposing lettuce trash in the soil in the form of **microsclerota,** which have been shown to survive for up to 4 years in some circumstances. There is no evidence that lettuce anthracnose is carried in seed.

Infection of plants:

Lettuce anthracnose infects plants through fungal spores called **conidia**. Conidia are produced on the surface of infected plants and can enter the soil from a previously infected crop. Infected crop trash cultivated into the soil can result in high concentrations of **conidia** and **microsclerotia** in a field. In following crops, the microsclerotia and conidia in the soil can be splashed onto plant surfaces where they can start new infections.



Life cycle of the lettuce anthracnose fungus

Spread in the field:

Once the disease is established in a new crop, it spreads by splashing during overhead irrigation or rain. Anthracnose spores can be spread easily by this method travelling almost 3 metres from a source plant.

Lettuce leaves showing the shot-hole symptom of lettuce anthracnose

Management of the disease:

Lettuce anthracnose requires an integrated management approach. As the disease can be found in seedling nurseries, good hygiene practices, monitoring and preventative treatment with fungicides should produce clean seedlings. Lettuce cultivars with some degree of resistance to anthracnose have been developed from cross breeding with another species, *Lactuca saligna* (wild lettuce).

Lettuce growers should rotate their crops to prevent the build up of microsclerotia and conidia in the soil. This will reduce the risk of carryover from one season to the next. Good weed management and removal of rogue lettuce plants are also essential to break the life cycle of the fungus.

After planting, close monitoring of the crop for the first signs of anthracnose is essential. Disease development is assisted by cool showery weather and overhead irrigation. Drip irrigated lettuce is less likely to be affected.

Machinery which has been used in an infected crop should be pressure washed before moving into a healthy one as conidia can be easily transferred on mulch and crop debris. Anthracnose affected blocks should be rotary hoed immediately after harvest has been completed to ensure that good breakdown of crop residues occurs. It is good practice to rotate a diseased block with a different crop. Following on with lettuce will result in carryover infection.

Previous research on fungicides in Victoria has shown that a range of protectants (mancozeb and copper hydroxide) and some systemic compounds used to mange other lettuce diseases, are also effective in managing anthracnose.

For more information contact Dr Victor Galea, University of Queensland v.galea@uq.edu.au

Downy Mildew Prediction Software for Lettuce

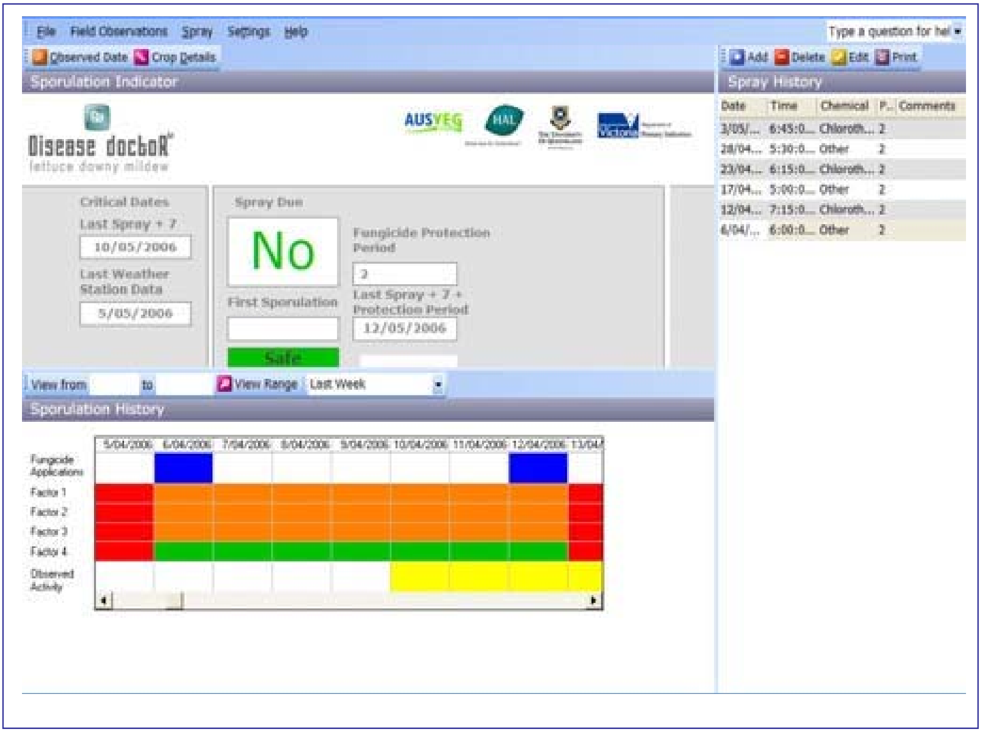
Following from the development of the Disease Doctor™ program to predict late blight activity in celery a new program to assist with the management of downy mildew is being developed for lettuce growers in a project funded by Horticulture Australia (VG07070).

Disease prediction (forecasting) systems for vegetable diseases have been used experimentally and commercially for many years. Regional systems for the management of diseases such as apple black spot and grape downy mildew have helped growers to maximise disease management by timing fungicide sprays more strategically.

Disease prediction systems use a weather station to measure in-crop conditions such as air temperature, humidity, rainfall, wind speed, solar radiation and leaf wetness. The data is downloaded from the weather station one or more times per day and a computer program interprets the influence of weather conditions on the plant disease being managed. Each plant disease has its own 'model' and disease forecasting systems for each crop may operate in different ways. For some diseases such as lettuce downy mildew, the 'model' has been well defined for experimental purposes.

To extend the use of a disease model to industry, the first critical step is to develop a user-friendly computer program which allows growers to operate the model on-farm, and to receive sensible information which can be used to improve their management decisions. This is currently being done by Dr Vic Galea and Elizabeth Ure at the University of Queensland. They are developing the lettuce downy mildew model used for research purposes into a computer program (Disease Doctor™ Lettuce Downy Mildew) with an easy-to-operate system for transferring the data from any electronic weather station and interpreting the results.

The program also allows growers to track performance of individual crops if more than one weather station is used. The output screen allows growers to make informed decisions about the need to spray fungicides based on the risk of disease developing in the crop and spray history. The program also allows the grower to record spray history which is seen on the screen to assist with the decision making process.



Screen view of the development of Disease Doctor™ Lettuce Downy Mildew

The lower half of the screen uses colour coded bars to show how the level of disease is calculated in relation to the various weather factors influencing disease development. A spray warning is given clearly in the top half of the screen. The software is still under development with some improvements needed to make it more useable. The program will be trialled in 2010 and released for use later this year.

For more information contact Dr Victor Galea, University of Queensland *v.galea@uq.edu.au*

Evaluation of management strategies for downy mildew on cos lettuce (Trial No. 2)

Aim:

To evaluate the DownCast model, BremCast model, weekly sprays (STD) and soft chemical options against unsprayed control plants for control downy mildew on cos lettuce cv Amadaus (Fig 1).

Methods:

Trial site was located at D. Schreurs, 1380 North Rd Devon Meadows, Vic. The trial design was a randomized block, planted in P block on 24 August 2009. Plot dimensions were 6m x 1.62m and plants were transplanted at 4 rows/bed. The spray schedule is listed in Table 1. The trial was assessed for downy mildew on the 12th and 26th of October (weeks 8 and 10, respectively.

Fig 1 Downy Mildew on upper (R) and lower (L) leaf surfaces of cos lettuce leaves

Table 1 Spray schedule for the Cos lettuce trial

Treatment	Date sprayed (2009)	No. sprays
Control	nil	0
Bion	29/9, 8/10	2
Bozul	2/9, 10/9, 18/9, 29/9, 8/10, 16/10, 19/10	7
BreamCast	2/9, 10/9, 18/9, 29/9, 14/10	5
DownCast	2/9, 21/9, 29/9, 9/10, 16/10	5
Grower	2/9, 10/9, 18/9, 29/9, 8/10, 16/10	6

Results:

There was a low level or incidence of Downy Mildew (9.45%) on unsprayed or control plants, and a high incidence of lettuce anthracnose (*Microdochium panattonianum*). Downy Mildew appeared late in the crop's life at week 8 (Fig 2). The unsprayed control plants had more (significantly) Downy Mildew than all other treatments. The incidence of downy mildew on all other treatments did not differ significantly (Fig 3).

Fig 2 Efficacy treatments to control Downy Mildew on cos lettuce at Devon Meadows Sept – Oct 2009

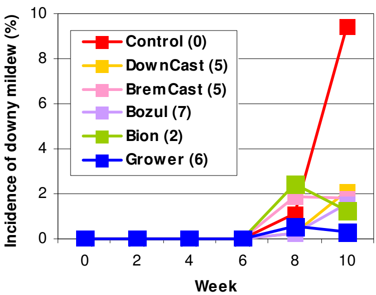
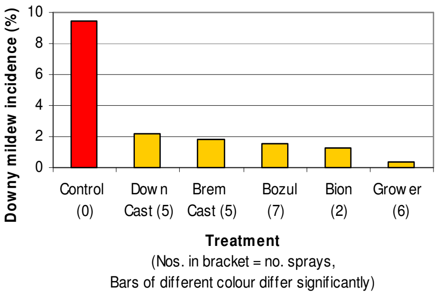


Fig 3 Efficacy of treatments to control Downy Mildew on cos lettuce at harvest, Oct 2009



Conclusion:

- Under low disease pressure all treatments provided the same level of Downy Mildew control.
- Both models reduced one spray compared with the grower practices.
- Bion™ (25g/ha & 2 applications) controlled the disease with 4 fewer sprays compared with the grower practice and no phytotoxicity was observed.
- Bozul™ had efficacy against downy mildew but weekly sprays were required.

Comparison of DownCast and BremCast disease predictive models for downy mildew control in Cos lettuce

DownCast

- Sporulation and infection component
- Both night and day temperatures (before midday) <22°C
- At least 3 hours leaf wetness at night, with >95% RH
- At least 2 hours leaf wetness after dawn

BremCast (Kushalappa 2001)

- Sporulation and infection component
- Maximum risk of sporulation (SPOR) if $\geq$ 4 hrs night leaf wetness, 91% RH and temperature between 7 and 20°C
- Maximum risk of infection (INF) if $\geq$ 6 hours leaf wetness after dawn and morning temperature $\leq$ 15°C
- Has an additional on /off switch ie +/– Downy Mildew in the area
- Disease Severity Value (DSV) calculated on both
- INF value 3-5, SPOR value 2-3 gives DSV of 4-5, indicating maximum risk of Downy Mildew infection

- Both models had more predictions later in the crop's life (Fig 4).
- There was a 60% agreement between both models (Fig 5).
- Both models produced equivalent control of the disease (Fig 3).

Fig 5 Comparison of DownCast and Bremcast models for predictions: Cos lettuce trial Devon Meadows Sept-Oct 2009

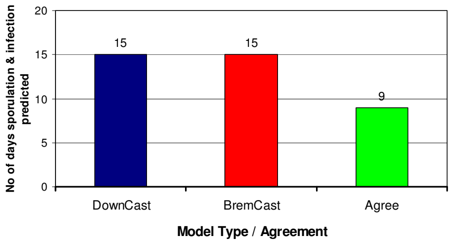
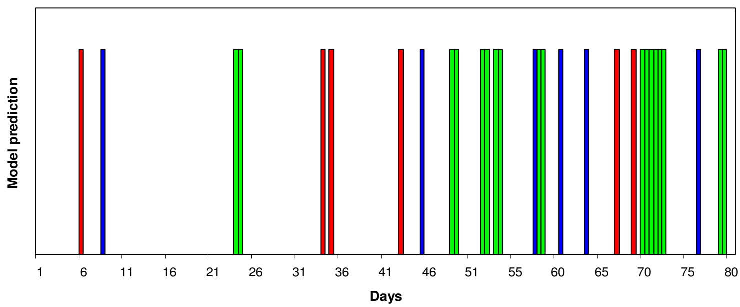


Fig 4 A comparison of predictions for sporulation & infection with either the DownCast or BremCast models during the Cos lettuce trial Sept – Oct 2009 Devon Meadows



Evaluation of management strategies for downy mildew on Red Oakleaf lettuce (Trial No. 3)

Aim:

To evaluate the DownCast model, BremCast model and grower spray program against unsprayed control plants for control Downy Mildew on red oakleaf lettuce variety Prunai, during December to January 2009.

The trial:

Trial site was located at Butlers Market Gardens 125 Taylors Rd Skye, Vic. The trial design was a randomized block, planted 4th December 2009. Plot dimensions were 6m x 1.62m and plants were transplanted at 3 rows/bed. The spray schedule is listed in Table 1. The trial was assessed for Downy Mildew on the 13th January 2010.

Table 1 Spray schedule for the Downy Mildew control trial on Red Oakleaf kettuce at Skye December 2009 to January 2010 Red Oakleaf lettuce trial

Treatment	Week of application/Date in 2009/10							Total	Incidence		No. of 2 Kg
	0	1	2	3	4	5	6	No.	of	Yield	boxes
	4-Dec Planted	11-Dec	18-Dec	25-Dec	1-Jan	8-Jan	13-Jan Harvest	sprays	Downy mildew (%)	(t/ha)	(boxes/ha)
Control	-	-	-	-	-	-	-	0	0	14.83	7,413
BremCast	-	9-Dec A	-	-	-	-	-	1	0	14.83	7,413
DownCast	-	10-Dec A	-	-	-	-	-	1	0	14.83	7,413
Grower	-	-	-	-	2-Jan A	-	-	1	0	14.83	7,413

Results:

- ***No symptoms of Downy Mildew appeared in the trial (Fig 1).***
- The plants were well spaced with good ventilation evident, the site was very open and distant from other lettuce crops (Fig 2). Consequently there was no Downy Mildew disease in the vicinity.
- Both models predicted a spray early in the crops' life, whilst the grower applied a spray late in the crops' life (Table 1). None of the sprays were necessary.
- ***It is possible that these models need an "ON" (disease present) and "OFF" (disease absent) switch before use.***

Fig 2 Well spaced mature plants of Red Oakleaf

Fig 1 View of the field trial for control for Downy Mildew control on Red Oakleaf leaf lettuce at Skye January 2009 to December 2010

Economic Analysis of Lettuce Trials for Control of Downy Mildew

Lindsay Trapnell, Principal Consultant, Farmanomics Research and Consulting, P. O. Box 286 Benalla, 3671

Assumptions:

1. Changes in profitability were due to changes in variable costs for the treatments comprising changes in the cost of chemicals used for the various treatments, the number of applications required for the chemicals, cost of seed for resistant and susceptible varieties, and changes in yields that affect harvesting and packaging costs.
2. Treatments that utilise a weather station plus a fee for acquiring software to interpret data on optimum times to spray will involve extra costs.
3. All other growing costs such as the costs of tillage and bedding, herbicide costs for controlling weeds, costs of fertiliser, and general costs for growing lettuce will be the same for the control and all treatments.
4. Cost for applying chemicals was assumed to be $50/ha (Table A).
5. Iceberg lettuce was marketed in 10 kg boxes that have an average price of $12.78 per box.
6. Cos lettuce was marketed in 4 kg boxes that have an average price of $13.45 per box.
7. Red Oakleaf lettuce was marketed in 2 kg boxes that have an average price of $12.00 per box.
8. Harvesting costs were assumed to be $2.50 per box.
9. Packing costs were assumed to be $1.50 cents per box.
10. Additional packaging costs were incurred for removing wrap leaves and head leaves that were affected by Downy Mildew. Extra costs per hectare were $674 for the Control, $701 for *B.subtilis*, $660 for DownCast Model and $866 for the Weekly treatment.
11. The weather station for the DownCast Model had an assumed cost of $2,500, would have a life of 10 years and would provide data for 5 hectares of crop (Table B).
12. Repairs and maintenance for the weather station was estimated to be $8 per hectare. That is, $40 per 5 ha.

Table A Chemical application rates and costs per hectare for all Downy Mildew trials on lettuce

Trade name	Active ingredient	Application rate/ha		Cost per unit (L or kg)	Cost /ha
		$		$	$
Acrobat®	Dimethomorph	360.0	g	346.50	124.74
Agriphos®	Phosphorous acid	0.85	L	6.49	5.52
Amistar®	Azoxystrobin	300	g	200.00	60.00
Antracol®	Propineb	2.0	kg	43.67	87.34
BION®	Acinbenzolar -s-methyl	50.0	g	1,000.00	50.00
Bozyl®	Compound X	400	g	?	?
Du-wett®	Trisiloxane ethoxylate	300	ml	61.6	18.48
Fulzyme®	*Bacillus subtilis*	2.5	L	108.90	272.25
Penncozeb®	Mancozeb	1.6	kg	11.41	18.25
Polyram®	Metiram	2.2	kg	13.20	29.04
Seasol®	Seaweed extract	0.833	L	10.45	8.70
Synertrol®	Vegetable oil	300	ml	8.58	2.57
Tri-Base Blue	Copper	1.4	L	14.65	20.50

Table B Overhead costs of the weather station for 5 hectares of crop

Year	Investment at start of year	Annual depreciation	Investment at end of year	Average investment	Interest at 10% per annum
	$	$	$	$	$
1	2,500	250	2,250	2,375	238
2	2,250	250	2,000	2,125	213
3	2,000	250	1,750	1,875	188
4	1,750	250	1,500	1,625	163
5	1,500	250	1,250	1,375	138
6	1,250	250	1,000	1,125	113
7	1,000	250	750	875	88
8	750	250	500	625	63
9	500	250	250	375	38
10	250	250	0	125	13
Average		250			125

$75 for depreciation and interest = $250 + $125 = $375 /5 = $75

Trial No. 1 Iceberg Lettuce Rosebud March – May 2009

Table 1.1 Spray program over 10 weeks to reduce the incidence of Downey Mildew on lettuce Rosebud March to May 2009

Treatment	Week of application											Total
	0	1	2	3	4	5	6	7	8	9	10	Applications
Control	-	-	-	-	-	-	-	-	-	-		0
B. subtilis	+	+	+	+	+	+	+	+	+	+	-	10
DownCast model		AP	AP	AP	AP	CT	CT	CT	CT	CT	-	9
Weekly	AP	AP	AP	AP	AP	CT	CT	CT	CT	CT	-	9
Bion	-	-	+	+	-	-	+	-	-	-	-	3

A = Acrobat® P = Pencozeb® C = Antracol® T = Tri-Base Blue

Table 1.2 Cost of chemicals applied per hectare to reduce the incidence of Downey Mildew on lettuce

Treatment	Chemical	No. of applications	Cost of chemical per application	Total cost of chemicals	Total cost of chemicals per treatment	Total cost of application[a]	Total cost of chemicals applied per treatment
			$/ha	$/ha	$/ha	$/ha	$/ha
B. subtilis	Fulzyme®	10	272.25		2,723	500	3,223
DownCast model	Acrobat®	4	124.74	499	572	200	1,561
	Penncozeb®	4	18.25	73			
	Antracol®	5	87.34	437	539	250	
	Tri Base Blue	5	20.51	103			
Weekly	Acrobat®	5	124.74	624	715	250	1,754
	Penncozeb®	5	18.25	91			
	Antracol®	5	87.34	437	539	250	
	Tri Base Blue®	5	20.51	103			
Bion	BION®	3	50.00		150	150	300

a The cost per application was $50 per ha.

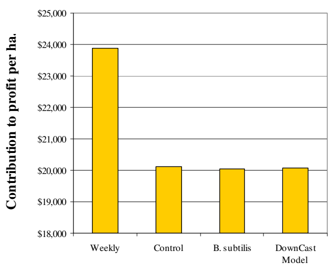
Table 1.2 Contribution to profitability Trial No. 1 Downy mildew on lettuce Rosebud March - May 2009

Treatment	Total cost of applying chemicals	Yield fresh	Harvesting @ $2.50 per 10 kg box	Packaging @ $1.50 per box	Extra labour cost for packaging	Annual depreciation & interest on weather station	Repairs and maintenance of weather station[a]	Farm gate income @ $12.78/box	Contibution to farm	Ranking increase in farm profit
	$/ha	t/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	
Control	0	10.89	2,723	1,634	674			13,917	8,887	1
B. subtilis	3,223	10.89	2,723	1,634	701			13,917	5,638	3
DownCast model	3,094	10.89	2,723	1,634	660	75	8	13,917	5,725	2
Weekly	3,670	10.89	2,723	1,634	866			13,917	5,025	4
Bion[b]	300	na								

a A cost for repairs and maintenance of the weather station was estimated to be $40 per annum for 5 ha. of lettuce or $8 per ha.

b The high application rate of Bion had a phytotoxic effect on lettuces making them unmarketable.

Fig 1 Contribution of treatments to profitability for Downy Mildew on iceberg lettuce rosebud March – May 2009



Comments:

- The spray program and costs for this processing lettuce crop are listed in Tables 1.1 and 1.2.
- Bion was phytotoxic in this trial and was omitted from the economic analysis.
- There was no significant difference in the incidence of downy on any of the treatments, consequently yields were averaged (Table 1.3).
- **The ranking of profitability was Weekly, Control (unsprayed) and then little difference between the DownCast model and *B. subtilis* (Table 1.3 & Fig 1).**
- **Although there was no difference in yields between treatments, the cost of the weather station reduced the benefit of a single spray reduction with the DownCast model.**

Trial No. 2 Cos lettuce Devon Meadows August – October 2009

Table 2.1 Spray program over 10 weeks for Downey Mildew on Cos lettuce Devon Meadows August - October 1009

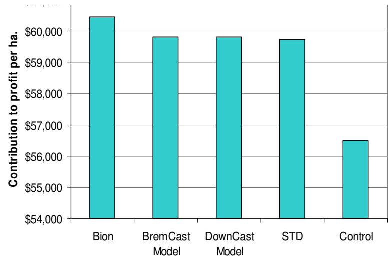
Treatment	Week of application										Total
	0	1	2	3	4	5	6	7	8	9	Applications
Control											0
Bion						+	+				2
Bozyl		+	+	+		+	+	+	+		7
BremCast		S1	S2	S3		S1	S2				5
DownCast		S1		S2		S3	S1	S2			5
STD		S1	S2	S3		S1	S1	S3			6

STD = Standard grower practice; S1 = Acrobat + Polygram + Seasol; S2 = Amistar + Synertrol + Seasol; S3 = TBB + Synertrol + Agriphos

Table 2.2 Cost of chemicals applied per hectare for Downey Mildew on Cos lettuce Devon Meadows

Treatment	Chemical	No. of applications	Cost of chemical application	Total cost of chemicals	Total cost of chemicals per treatment	Total cost of applicationa	Total cost of chemicals applied per treatment
			$/ha	$/ha	$/ha	$/ha	$/ha
Bion	BION®	2	50	100	100	100	200
Bozyl	Unknown	7					
	Du-wett®	6					
BremCast	Acrobat®	2	124.74	249	544	100	1,426
	Polyram®	2	60.00	120			
	Seasol®	2	87.34	175			
	Amistar®	2	50.00	100	312	100	
	Synertrol®	2	18.48	37			
	Seasol®	2	87.34	175			
	Tri-Base Blue	1	29.04	29	320	50	
	Synertrol®	1	18.48	18			
	Agriphos®	1	272.25	272			
DownCast model	Acrobat®	2	124.74	249	544	100	1,426
	Polyram®	2	60.00	120			
	Seasol®	2	87.34	175			
	Amistar®	2	50.00	100	312	100	
	Synertrol®	2	18.48	37			
	Seasol®	2	87.34	175			
	Tri-Base Blue	1	29.04	29	320	50	
	Synertrol®	1	18.48	18			
	Agriphos®	1	272.25	272			
STD	Acrobat®	3	124.74	374	816	150	1,912
	Polyram®	3	60.00	180			
	Seasol®	3	87.34	262			
	Amistar®	1	50.00	50	156	50	
	Synertrol®	1	18.48	18			
	Seasol®	1	87.34	87			

Fig 2 Contribution of treatments to profitability for Downy Mildew on Cos lettuce Devon Meadows August – October 2009



Comments:

- The spray program and associated costs are listed in Tables 2.1 and 2.2.
- There was no significant difference in the incidence of downy mildew between any of the treatments; so yields were averaged (Table 2.3).
- **There was little actual difference in the rank of profitability which was Bion, BremCast & DownCast, STD and then unsprayed control (Table 2.3 and Fig 2).**
- Bion is expected to be mixed with other fungicides for sale.
- Bozyl is an unregistered post harvest chemical.

Table 2.3 Contribution to profitability Trial No. 2 Downey Mildew on Cos lettuce Devon Meadows August-October 2009

Treatment	Total cost of applying chemicals	Yield	Yield	Harvesting @ $2.50 per 4 kg box	Packaging @ $1.50 per box	Annual depreciation & interest on weather station	Repairs and maintenance of weather station[a]	Farm gate income @ $13.45/box	Contibution to farm profit	Ranking increase in farm profit
	$/ha	t/ha	Boxes/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	
Control		23.91	5,978	14,944	8,966			80,397	56,487	4
Bion	200	25.67	6,418	16,044	9,626			86,315	60,445	1
Bozyl	0	25.67	6,418	16,044	9,626					
BremCast	1,426	25.67	6,418	16,044	9,626	75	8	86,315	59,137	2
DownCast	1,426	25.67	6,418	16,044	9,626	75	8	86,315	59,137	2
STD	1,912	25.67	6,418	16,044	9,626			86,315	58,734	3

a A cost for repairs and maintenance of the weather station was estimated to be $40 per annum for 5 ha. of lettuce or $8 per ha.

Trial No. 3 Red Oakleaf Lettuce Sky December 2009 – January 2010

The spray program and associated costs are listed in Tables 3.1 and 3.2.

Table 3.1 Spray program over 6 weeks for Downy Mildew on Red Oakleaf lettuce Skye December 2009-January 2010

Treatment	Week of application							Total
	0	1	2	3	4	5	6	Applications
Control	-	-	-	-	-	-	-	0
BremCast model		A						1
DownCast model		A						1
STD					A			1

STD = Grower practice; A = Antracol®

Table 3.2 Cost of chemicals applied per hectare for control of Downy Mildew on Red Oakleaf lettuce Skye December 2009 - January 2010

Treatment	Chemical	No. of applications	Cost of chemical per application	Total cost of chemicals	Total cost of chemicals per treatment	Total cost of application[a]	Total cost of chemicals applied per treatment
			$/ha	$/ha	$/ha	$/ha	$/ha
BremCast model	Antracol®	1	87.34	87	87	50	137
DownCast model	Antracol®	1	87.34	87	87	50	137
STD	Antracol®	1	87.34	87	87	50	137

a The cost per application was $50 per ha.

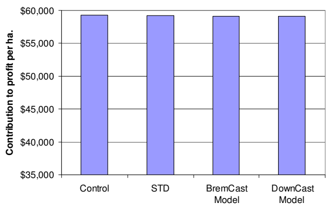
Table 3.3 Contribution to profitability for Red Oakleaf lettuce Skye December 2009-January 2010

Treatment	Total cost of applying chemicals	Yield	Harvesting @ $2.50 per 10 kg box	Packaging @ $1.50 per box	Annual depreciation & interest on weather station	Repairs and maintenance of weather station[a]	Farm gate income @ $12.00/box	Contibution to farm profit[b]	Ranking increase in farm profit[b]
	$/ha	t/ha	$/ha	$/ha	$/ha	$/ha	$/ha	$/ha	
Control	0	14.83	18,538	11,123			88,980	59,320	1
BremCast model	137	14.83	18,538	11,123	75	8	88,980	59,100	3
DownCast model	137	14.83	18,538	11,123	75	8	88,980	59,100	3
STD	137	14.83	18,538	11,123			88,980	59,183	2

a A cost for repairs and maintenance of the weather station was estimated to be $40 per annum for 5 ha. of lettuce or $8 per ha.

b Differences in contribution to farm profit for the Control and Treatments were insignificant

Fig 3 Contribution to farm profitability for treatments designed to control Downey Mildew on Red Oakleaf lettuce Skye December 2009 -January 2010 (Trial No. 3)



Comments:

- No downy mildew appeared in any of the trial treatments, so yields were averaged for the economic analysis (Table 3.3).
- **Although the rank of profitability was unsprayed control, STD (grower practice), then DownCast and BremCast (Table 3.3 and Fig 3); there is little actual difference in the data.**

Development of airborne spore test kit for white blister on brassicas

Background

The Brassica$_{spot}$™ Disease Predictive Model uses weather data collected by a weather station in the crop, to predict when conditions are conducive for infection. However, if there are no *Albugo candida* spores in the crop, any sprays applied will be wasted. An air-borne spore test kit is being developed to detect *A. candida* spores in the air above the crop, thus adding a sporulation component to the model. This additional tool will ensure that sprays will only be applied when spores are present and the weather is conducive to infection.

Stages in development of the kits:

1. The UK collaborators have developed antibodies that selectively recognise air-borne spores of the Australian white blister (*Albugo candida*) (Fig 1).
2. The specificity of antibodies will be validate on known races of Albugo grown on host plants located in the glasshouse and then on field collected samples from both types of spore traps (Fig 2), next Easter.
3. The 'in field' detection kits for air-borne spores of *Albugo candida* will be field tested next Easter (Fig 3).
4. Test model predictions, trap spores and test the lateral flow kits for within crop and between crop spread of white blister spores (Fig 4).

Fig 1 Airborne spores

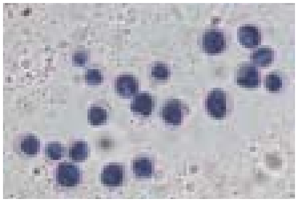
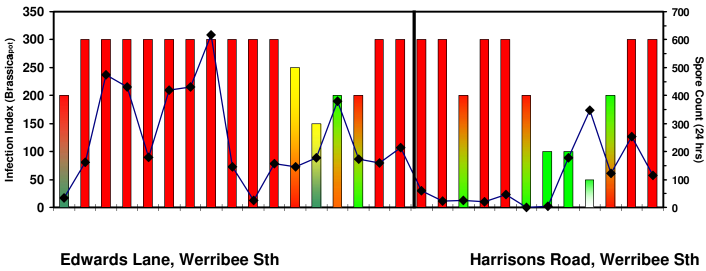


Fig 2 Spore trap tape mechanism

Fig 3 Lateral flow device to test airborne spore samples

Fig 4 Tape spore counts compared to Brassica$_{spot}$ model



♦ Spore numbers over a 24-hr period, Bars indicate Brassica$_{spot}$ model: red=high risk; yellow=medium risk; green=low risk.

Alison Wakeham and Roy Kennedy will be in Victoria during March to April 2010 to conduct this work.

Relative susceptibility of commercial broccoli cultivars to field populations of *Albugo candida*, the pathogen causing white blister rust

Experiment:

Seven broccoli and three European cabbage cultivars were tested to determine their susceptibility/resistance to the *B. oleracea* - specific field populations of *A. candida*.
The glasshouse experiment was conducted on host (cultivar) seedlings as a randomised complete block of treatments (cultivars) with eight replicated blocks.
Cultivars Greenbelt and Tyson (both had previously identified susceptibility and resistance to the local populations of *A. candida*) were used as positive and negative controls, respectively.

Disease assessments:

Seven-week-old seedlings were assessed for the incidence and severity of white blister disease. The incidence is a percentage of seedlings with white blister symptoms. A scale of 0 to 4 was used to assess white blister severity. A healthy seedling received a score 0 and a seedling with blisters on cotyledons, leaves and leaf petioles received a score 4.

Results:

Each of the seven broccoli cultivars was moderately susceptible to the *A. candida* tested when compared to controls: cv Greenbelt (+) and Tyson (-). Mean incidences of all susceptible cultivars with the exception of Br 01 and Br 04 were significantly different (p < 0.001) from both controls. Cultivars Br 01 and Br 04 did not differ significantly from susceptible cv Greenbelt. The other susceptible cultivars were not different from each other.

Cultivar	Seedlings with blisters (%)*
Greenbelt	35.1^{a}
Broccoli 01	28.3^{ab}
Broccoli 02	17.9^{b}
Broccoli 03	19.8^{b}
Broccoli 04	24.3^{ab}
Broccoli 05	22.0^{b}
Broccoli 06	18.7^{b}
Broccoli 07	16.2^{bc}
Tyson	0^{d}
Cabbage 01	0^{d}
Cabbage 02	0^{d}
Cabbage 03	0^{d}
F<0.001	
lsd	12.09

*) Means followed by a different letter vary significantly at the 5% level.

Table 1 Mean incidence (%) of white blister rust on nine broccoli and three cabbage cultivars assessed on seven-week-old seedlings.

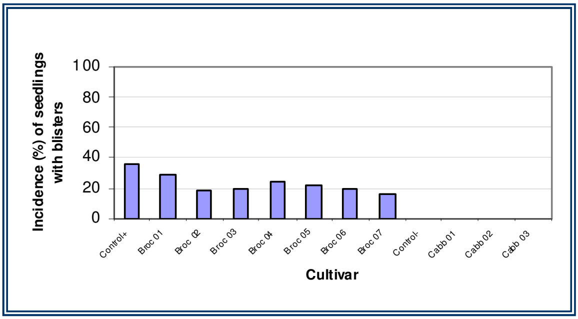


Figure 1 Mean incidence of white blister rust on seedling of twelve cultivars of broccoli and cabbage.

Severity

Although white blister symptoms were more severe on seedlings of Broc 01, 03, 06 and 07 than on the positive control cv Greenbelt (Table 2) after statistical analysis the evidence was not strong enough (p=0.092) to conclude that all susceptible cultivars differ in their levels of severity. Seedlings of the negative control broccoli (cv Tyson) and three cabbage cultivars (the latter are moderately susceptible to European white blister rust) were resistant.

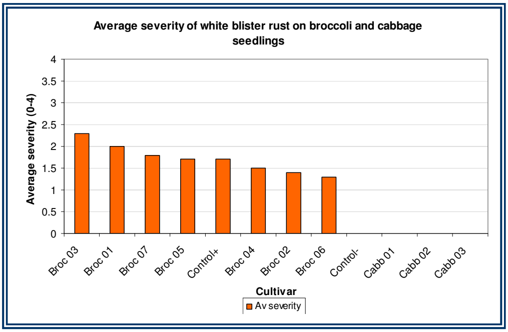


Figure 2 Average severity of white blister on seedlings of twelve cultivars of broccoli and cabbage.

Cultivar	Av severity
Broc 03	2.3
Broc 01	2.0
Broc 07	1.8
Broc 05	1.7
Control+	1.7
Broc 04	1.5
Broc 02	1.4
Broc 06	1.3
Control-	0
Cabb 01	0
Cabb 02	0
Cabb 03	0

Table 2 Average severity of white blister on seedlings of broccoli and cabbage.

Figure 3 *Brassica oleracea* cultivar testing in a glasshouse

The aim of this project is to identify resistance to white blister rust in commercial cultivars of Brassica vegetables and alternative options for chemical control of the disease.

The experiment:

Evaluation of non-conventional chemicals for control of White blister rust on two cultivars of *Brassica rapa*, Chinese cabbage 'Waltz' and Pak Choi 'Seven Gates' under glasshouse conditions.

Glasshouse experiment was set up to determine if any of the four alternative treatments (Du-Wet, Nu-Film, Bion, and *Bacillus subtilis*) were more effective against white blister rust than no spraying at all and if any of these treatments were as effective as Amistar®. The trial consisted of 6 replicates of 6 treatments (thus 36 trays) in a glasshouse.

Results

There was no disease on seedlings of both cultivars treated with Amistar and Bion. Disease levels on seedlings of both cultivars sprayed with Du-Wet, Nu-Film, and *B. subtilis* did not vary significantly from unsprayed control, therefore these alternative treatments were not effective against white blister rust (Figure 1). Bion was effective against the disease but extremely phytotoxic to plants (Figure 2). Due to the small size of the blisters on seedlings of both cultivars only the incidence of the disease was assessed.

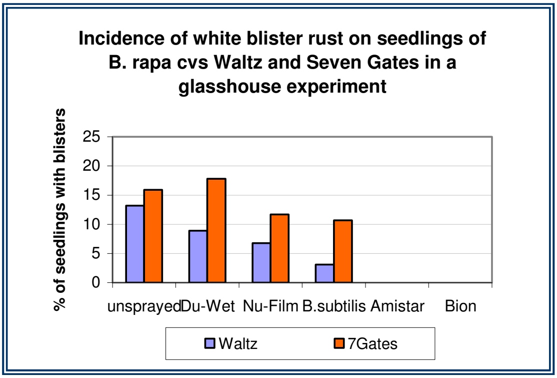


Figure 1 Incidence (%) of white blister rust on seedlings of two cultivars of *B. rapa*, Chinese cabbage 'Waltz' and Pak Choi 'Seven Gates' treated with Amistar, Du-Wet, Nu-Film, Bion, and *Bacillus subtilis* and unsprayed control.

Figure 2 Bion toxicity symptoms on seedling of *B. rapa* 'Waltz' and 'Seven Gates'

New project application:
VG10003 Disease predictive models for the vegetable industry

Phase II of Benchmarking Disease Predictive Models Project

These projects are part of the Vegetable IPM Pathology Program which resulted from the IPM Plant Pathology Gap Analysis Project VG06092.

Aim:

Phase II will develop a secure web-based IPM decision support tool, called “Disease Doctor” to:

- automatically download in-field crop weather data,
- execute 4 disease predictive models (Fig 1) and send daily reports to vegetable growers consultants on the probability of diseases occurring in their crops,
- validate this web-based collection and delivery system in commercial crops with scientists, crop consultants and growers,
- investigate incorporating forecast data from the Bureau of Meteorology into models for early disease warnings,
- determine the effectiveness of the Fuzzy Logic model to estimate leaf wetness,
- improve the white blister model by validating aerial spore trapping,
- promote adoption of “Disease Doctor” by providing training at field days and workshops, in one-on-one demonstrations and by using results from practice change research.

This is a collaborative project lead by DPI Vic, and involves The University of Queensland, VPAC, DEEDI (QLD), SARDI(SA), IINSW(NSW), Peracto (Tas) and HRI(UK).

Value (outcome) of the project will be:

- to fill in the gaps for the disease predictive models,
- adoption of validated IPM strategies i.e. decision support tools,
- reduction in spray applications,
- less pesticide in the environment and a lower exposure of workers and consumers to pesticides whilst maintaining disease control,
- better disease management and
- more profitable industries.

This proposed project is for 3 years, has a budget of $2.2M and the Benefit Cost Analysis (BCA) ranges from 1.12 – 22:1.

Fig 1 Diseases covered in the proposed project VG10003

Powdery mildew of cucurbits | Downy mildew of spring onions | Septoria late blight of celery | Downy mildew of lettuce | White blister of brassicas

PERMITS

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Below is a list of all registered products in lettuce for anthracnose *Michrodochium panattonianum*, downy mildew *Bremia lactucae* and in brassicas for White blister *Albugo candida.* Permits as of January 2010 and renewals currently with APVMA.

LIST OF ALL REGISTERED PRODUCTS FOR ANTHRACNOSE IN LETTUCE - PERMITS JANUARY 2010

None specifically for available

ANTHRACNOSE IN LETTUCE - REGISTRATION - JANUARY 2010

copper (various)	lettuce	Preventative control of Downy mildew, Bacterial leaf spot and Anthracnose
Acrobat (dimethomorph) + mancozeb or Polyram (metiram)	lettuce	Preventative and curative control of Downy mildew, Anthracnose and Septora leaf spot
Ridomil Gold MZ (metalaxyl-M + mancozeb)	lettuce	Preventative and curative control of Downy mildew, Anthracnose and Septora leaf spot
mancozeb (various)	lettuce	Preventative control of Downy mildew, Anthracnose and Septora leaf spot
thiram (various)	lettuce	Preventative control of Downy mildew, Anthracnose and Botrytis

SIMILAR CROPS APPLIED FOR PERMIT WITH APVMA

mancozeb	Parsley, coriander, brassica leafy vegetables, chicory, endive, radicchio	Anthracnose, Alternaria, Septoria
Ridomil Gold MZ (metalaxyl-M + mancozeb)	Chicory, endive, radicchio	Anthracnose, Downy mildew, Septoria
Copper	endive	Downy mildew, Anthracnose

SIMILAR CROPS WITH PERMITS

PER8768 - zineb	Silverbeet & spinach	Anthracnose	10/05/2011
PER8538 - copper	Endive & chicory	Anthracnose & Downy Mildew	31/10/2010

DOWNY MILDEW - LETTUCE PERMITS - JANUARY 2010

Permit Number	Pesticide	Crop	Disease	Expiry Date
PER7935	Acrobat Fungicide (dimethomorph)	Leafy lettuce (field grown)	Downy mildew	30-Sep-11
PER7905	phosphorous acid (various)	Leafy lettuce (hydroponic only)	Downy mildew	30-Sep-12

DOWNY MILDEW - LETTUCE REGISTRATION - JANUARY 2010

copper (various)	Lettuce	Preventative control of Downy mildew, Bacterial leaf spot, Anthracnose
Acrobat Fungicide (dimethomorph) + mancozeb or Polyram (metiram)	Head lettuce	Preventative and curative control of Downy mildew, Septoria leaf spot, Anthracnose
mancozeb (various)	Lettuce	Preventative control of Downy mildew, Septoria leaf spot, Anthracnose
Ridomil Gold MZ (metalaxyl-M + mancozeb)	Lettuce (field)	Preventative and curative control of Downy mildew, Septoria leaf spot,
Polyram (metiram)	Lettuce	Preventative control of Downy mildew, Septoria leaf spot
Rebound (propineb + oxydixyl)	Lettuce	Preventative and curative control of Downy mildew
Antracol (propineb)	Lettuce	Preventative control of Downy mildew

WHITE BLISTER (ALBUGO CANDIDA) PERMITS - JANUARY 2010

Permit Number	Pesticide	Crop	Disease	Expiry Date
PER7734	Ridomil Gold Plus (metalaxyl-M + cupric hydroxide)	Rose, Gerbera	Downy Mildew, White Blister	21-Mar-10
PER8538	copper	Horseradish	White blister	31-Oct-10
PER9186	chlorothalonil	Radish	White blister	1-May-11
PER9631	Nufarm Cabrio Fungicide (pyraclostrobin)	Brassica leafy vegetables	White blister	30-Jun-12
PER9916	Ridomil Gold Plus (metalaxyl-M + cupric hydroxide)	Leeks, Cucumber, Radish, Swede & Turnips	Downy Mildew, Purple Blotch & White Blister	30-Sep-10
PER10674	Ridomil Gold MZ (Mancozeb + Metalaxyl-M)	Brassica vegetables, Brassica leafy vegetables & Rocket	Downy Mildew & White blister	31-Mar-13
PER10816	Amistar 250SC (azoxystrobin)	Horseradish	Downy Mildew & White Blister	30-Jun-12
PER10907	Acrobat Fungicide (dimethomorph)	Brassica Leafy Vegetables	White blister	30-Sep-11
PER10914	Amistar 250SC (azoxystrobin)	Radish, leeks, carrots	White blister, Downy mildew, Powdery mildew	31-May-14
PER11350	mancozeb	Radish, swede & turnip	Alternaria, cercospora leaf spot, white blister	31-Mar-15

WHITE BLISTER (ALBUGO CANDIDA) REGISTRATION - JANUARY 2010

Residue data available	Amistar 250SC (azoxystrobin)	rocket	White Blister
Residue data available	mancozeb	broccoli, Brussels sprout, cauliflower, rocket	White Blister
Residue data available	chlorothalonil	broccoli, Brussels sprout, cauliflower, rocket	White Blister
Residue data available	Acrobat Fungicide (dimethomorph)	broccoli, Brussels sprout, cauliflower, rocket, radish	White Blister & Downy mildew

APPLIED FOR PERMIT WITH APVMA

mancozeb	horseradish	White Blister
Ridomil Gold MZ (metalaxyl-M + mancozeb)	horseradish	White Blister
Copper	Broccoli, Brussels sprout, cauliflower, radish, swede, turnip	White Blister
Amistar 250SC (azoxystrobin)	Broccoli, Brussels Sprouts, Cauliflower, radish	White Blister