



*Know-how for Horticulture™*

**National vegetable  
pathology working  
group meeting  
Bunbury, Western  
Australia  
30 April – 2 May 2002**

E Davison  
Department of Agriculture,  
Western Australia

Project Number: VG01018

## **VG01018**

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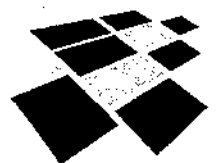
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# **HORTICULTURE AUSTRALIA PROJECT VG01018**

**NATIONAL VEGETABLE PATHOLOGY  
WORKING GROUP MEETING  
BUNBURY, WESTERN AUSTRALIA  
30 APRIL - 2 MAY 2002**

**PREPARED BY:**

**DEPARTMENT OF AGRICULTURE , WESTERN AUSTRALIA**



**JULY 2002**

## HORTICULTURE AUSTRALIA PROJECT VG01018

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This is the final report of project VG01018 biennial meeting of the National Vegetable Pathology Working Group, 2002, that was held in Bunbury WA from 30 April - 2 May 2002. This meeting was attended by a vegetable pathologist from each Australian State, the Northern Territory and New Zealand, State Vegetable Industry Development Officers and an officer from Horticulture Australia. The focus of this meeting was to review disease problems in different States, to discuss current and recently completed research, and to identify areas for research or better disease management.

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## **MEDIA SUMMARY**

The National Vegetable Pathology Working Group met in Bunbury, Western Australia, from 30 April–2 May 2002. This group comprises a vegetable pathologist from each State in Australia, the Northern Territory, and New Zealand. State Vegetable Industry Development Officers also attended. This meeting was funded by Horticulture Australia Ltd.

The group discussed vegetable diseases that have been seasonally important in the past year. They discussed quarantinable diseases such as asparagus rust, onion smut and potato spindle tuber viroid. Most of the meeting, however, reviewed research projects on vegetable diseases that have been, or are being undertaken in Australia and New Zealand.

The working group considered that the following important problems that threaten the vegetable industry in Australia and New Zealand need to be addressed:

- Minimising the spread of pathogens in propagating material, such as seed, nursery transplants and other nursery stock. Some of these pathogens are brought into Australia on contaminated seed, some pathogens cycle within a nursery in soil or on contaminated tools. Growers who believe that infected seedlings have contaminated their land may resort to litigation.
- Sampling protocols for soil borne pathogens to ensure that the increased sensitivity of molecular diagnostic tests are maximised for the benefit of growers.
- Succession planning to ensure that there are sufficient specialists who can identify potential pathogens and diagnose diseases.

The next meeting of the working group is planned for 2004.



## TECHNICAL SUMMARY

### The National Vegetable Pathology Working Group

The National Vegetable Pathology Working Group comprises a vegetable pathologist from each State or Territory in Australia. The meeting in 2002 was held in Bunbury, Western Australia, and hosted by the Department of Agriculture. It was held in conjunction with a meeting of State Vegetable Industry Development Officers (IDOs). A vegetable pathologist from New Zealand, and a representative from Horticulture Australia Ltd, also attended. The meeting was funded by HAL.

The aims of the NVPWG are to review disease problems in the different States and to report on current research and development projects and discuss priorities for future vegetable research.

### Season update of vegetable diseases

The cool, moist summer in south eastern Australia has favoured diseases such as late blight (*Phytophthora infestans*) of potatoes in Tasmania, white rust of broccoli in Victoria and diseases spread by aphids (potato leaf roll virus, potato virus S, tomato spotted wilt virus). Bacterial diseases of tomatoes have been important in Queensland and Western Australia.

Soil borne diseases, such as clubroot of brassicas, powdery scab and common scab of potatoes, and fusarium diseases of a number of crops continue to cause problems.

Recently introduced pathogens, and others that are subject to quarantine, include potato spindle tuber viroid, onion smut, asparagus rust and asparagus stem blight.

### Current research and development projects

Most of the meeting reviewed research on vegetable diseases that is being undertaken throughout Australia and NZ. The breadth of projects is huge. It ranges from using molecular techniques to improve the sensitivity of soil assays for pathogens, to writing reference guides for pests and diseases of specific crops.

The bulk of this report covers these projects, presented as summaries or recent milestone reports.

### Future issues

The quality of imported seed is an important issue, because there are a number of pathogens that do not occur in Australia and NZ that can be introduced in this way. One example is wilt and crown rot of basil, caused by *Fusarium oxysporum* f.sp. *basilici*. This pathogen is spread on seed harvested from diseased plants, and was spread around the world in the 1980s and 1990s in this way. Seed testing and certification will minimise the likelihood of such introductions.

Soil borne diseases are difficult to diagnose and difficult to control. Although molecular techniques have improved the detection of pathogens, sampling protocols are needed to adequately sample a site when the distribution of the pathogen is patchy. Enhanced biodegradation means that many of the chemicals used for their control are no longer effective. New initiatives include biofumigation and biological control, however their effectiveness and reliability remain to be proven on a commercial scale.

In a few years time there will be a critical shortage of specialist pathologists who are able to service the vegetable industry. There is a need to train a cohort of specialists who can accurately identify potential pathogens and diagnose plant diseases.

## **Field visits and grower meetings**

Field visits were made to a vegetable seedling nursery, an intensive carrot, potato and cauliflower vegetable farm near Perth, and two cauliflower producers near Manjimup.

Two meetings were organised for growers. A meeting on onion diseases was held in Bunbury, which was addressed by pathologists from South Australia and Tasmania. Another meeting on diseases of tomatoes, capsicums, lettuce and basil was held in Wanneroo (Perth). This meeting was addressed by vegetable pathologists from Queensland, New South Wales, the Northern Territory, Tasmania and Western Australia. This meeting was attended by about 40 growers.

## **INTRODUCTION**

### **The National Vegetable Pathology Working Group**

The National Vegetable Pathology Working Group comprises a vegetable pathologist from each State or Territory in Australia. It has met three times previously, in 1997 and 1998 (both in Victoria) and 2000 in Queensland. The meeting in 2002 was held in Bunbury, Western Australia, and hosted by the Department of Agriculture. Funding for the meeting was from Horticulture Australia Ltd (Project VG01018).

In order to ensure the practical focus of the Bunbury meeting, it was held in conjunction with a meeting of State Vegetable Industry Development Officers (IDOs). Representatives from HAL and AQIS were also invited.

A vegetable pathologist from New Zealand attended.

This meeting allows vegetable pathologists to:

- review disease problems in the different States;
- report on current research and development projects and discuss priorities for future vegetable research; and
- improve the collaboration between researchers from different States and Territories, and between Australia and New Zealand.

HAL, through the AusVeg levy, funds many of the current research and development projects. All of these projects report regularly to HAL through milestones. Summaries, recent milestone reports and proposals of the majority of HAL funded projects that have a vegetable pathology component, are collated in the appendices of this document. Reports of additional research not funded by HAL are also included.

Reports from this meeting will be posted on the HAL website so that they will be readily available to vegetable growers, industry representatives, plant pathologists and other interested persons.

## AGENDA

### Tuesday 30 April

- Morning**
- Depart Perth for Department of Agriculture, Bunbury
  - Visits to a vegetable seedling nursery and market garden south of Perth

- Afternoon**
- Welcome and introductions

Item 1 Seasonal update of vegetable disease in States, Territories and NZ

Item 2 Quarantine and related issues

Item 3 Methyl bromide phaseout, and other chemical issues

Item 4 Onion and other allium diseases:

Item 5 Leafy vegetables

Item 6 Legumes

Item 7 Sweet corn

### Wednesday 1 May

#### Morning

Item 8 Potatoes

Item 9 Capsicums, tomatoes, eggplants and melons

Item 10 Carrots, celery and beetroot

Item 11 Brassicas

- Afternoon**
- Visit to cauliflower and potato farms near Manjimup

### Thursday 2 May

#### Morning

Item 12 Enhanced breakdown of chemicals and biocontrols

Item 13 Extension material

Item 14 Diseases of nursery stock

Item 15 Where are we going?

Any other business

**Afternoon** Return to Perth

**Evening** Grower meetings:

- Onion diseases, Bunbury
- Diseases of tomato, capsicum, lettuce and basil, Wanneroo

## PARTICIPANTS

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**PRIORITY VEGETABLE CROPS BY STATE/TERRITORY/COUNTRY**

Commodity	New Zealand <sup>1</sup>	Australian State/Territory						
		QLD	NSW	WA <sup>5</sup>	VIC	NT	TAS	SA
Asian vegies						1 <sup>4</sup>		
Asparagus			10		7			
Beans	9						6	
Beetroot		7						
Broccoli	7 <sup>2</sup>	6		9	4		5	
Brussel sprout								8
Cabbage	2							7
Capsicum	10	2		10		8		5
Carrot	8	3	7	2	2		2	3
Cauliflower	2			3	4		8	9
Celery				7	8			
Chinese cab.								
Cucumber						3		6
Garlic								
Leeks								10
Lettuce		4	3	5	6	4		4
Melons		9	5		9	2		
Mushroom			4		3		7	
Onion	2		2	4			3	2
Parsley								
Parsnip								
Peas	3						4	
Peas, snow								
Potato	1	8	1	1	1		1	1
fresh								
processing								
seed								
Pumpkin		10	6	6		5		
Spring onion								
Sweet corn	4		8		10			
Squash	6							
Sweet potato <sup>3</sup>		5	9					
Swede							10	
Tomato	5	1		8	5	7		
fresh	G			G & F				
processing	F							
Vegies for seed							9	
Zucchini					9	6		

G = Greenhouse, F = Field.

<sup>1</sup> New Zealand priorities based on \$NZ value (domestic expenditure plus export value), as provided by New Zealand Department of Statistics for year ended 30 June 2001.

<sup>2</sup> All brassicas for New Zealand (Brussels sprouts, broccoli, cabbage, cauliflower) included under broccoli.

<sup>3</sup> New Zealand local varieties (kumara).

<sup>4</sup> Includes snake beans.

<sup>5</sup> WA figures are value produced in 1997.

## ITEM 1: SEASONAL UPDATE OF VEGETABLE DISEASE IN STATES, TERRITORIES AND NZ

There are always a number of important diseases, such as root diseases, that are perennial problems. These are difficult to control and much research effort goes into trying to minimise their effects. In addition there are diseases that may be seasonally severe, possibly because of favourable weather conditions, newly introduced pathogens, or new races of pathogens.

### Queensland

#### Bob Davis, Queensland Department of Primary Industries

Clubroot of brassicas became a problem in the Gatton area in 2001. This is surprising because it is an area with alkaline soils. It is thought that the disease may have been spread to the area on machinery. This problem will be monitored in 2002.

Bacterial canker of tomatoes has been devastating in a range of gourmet and cherry tomato varieties over the last two seasons in the Bundaberg region. Outbreaks occur every few years. The disease is thought to have originated from infected seed.

A vascular *Fusarium* disease has increased in distribution in melon crops throughout the State in the past two to three years. The symptoms are not typical of fusarium wilt as they develop in the secondary runners.

*Botrytis* has been a problem in Cos lettuce, as has *Pythium*. Symptoms are unusual because they resemble *Sclerotinia*.

### New South Wales

#### Andrew Watson, New South Wales Agriculture

*Fusarium* on melons is a new disease to the Murrumbidgee Irrigation Area that is of concern.

*Fusarium* has become a problem on sweet corn cobs. Another disease of sweet corn is boil smut that has become more important in the past year.

Varnish spot has been troublesome on lettuce in the Sydney region, including lettuce produced hydroponically.

### Victoria

#### Nigel Crump, Agriculture Victoria

The cool moist summer and unseasonably warm autumn has contributed to disease development.

Major problems in brassicas include clubroot and an outbreak of white rust in broccoli seedlings.

Problems in potatoes include powdery scab, a range of viruses including leaf roll, potato virus S and tomato spotted wilt.

## Tasmania

**Lisa Gibson, Department of Primary Industry Water and Environment, Tasmania**

The vegetable disease problems in Tasmania are not new, but have flared up, probably as a result of the recent cool, wet summer.

Brassica problems include clubroot and head rot in broccoli.

The weather conditions have resulted in considerable late blight (*Phytophthora infestans*) of potatoes. The *Fusarium* complex of seed potatoes has also been a problem, as has powdery scab. Potato viruses including leafroll and virus S have been a problem.

*Botrytis allii* has been severe on onions.

The cool summer has resulted in downy mildew diseases being severe on a large number of crops.

## South Australia

**Trevor Wicks, South Australian Research and Development Institute**

The past summer has been the coolest on record.

The most important problems on potatoes have been leaf roll virus, tomato spotted wilt virus and common scab.

Carrot virus Y has been seen widely.

There has been a *Pythium* problem in hydroponic lettuce.

## Western Australia

**Elaine Davison, Department of Agriculture, Western Australia**

Potato spindle tuber viroid was found in a hydroponic tomato crop in 2001. It has been successfully eradicated.

Brassica problems include black leg and the bacterial diseases black rot/leaf scald and peppery leaf spot.

Potato problems include target spot (*Alternaria*), powdery scab, *Sclerotinia* rot and *Fusarium* dry rot. Seed potato growers have had on-going problems with *Fusarium*, *Rhizoctonia* potato leaf roll virus and viruses S and X. Seed certification scheme has assisted with keeping PLRV at a reasonably static level.

Tomato spotted wilt virus has been a problem in the Perth metro area on a range of crops in the summer 01/02, because cool weather in late spring/early summer allowed a build up of thrip numbers.

Nematodes have caused problems in carrot production on the Swan Coastal Plain. Root knot nematode (*Meloidogyne* spp.) is widespread on properties south of Perth. There have been problems in controlling it using fenamphos. Bacterial soft rot has been a major problem in some packing sheds.



Bacterial canker of tomatoes has been a problem in the Carnarvon district in 2001. Other tomato diseases include bacterial speck and TSWV.

There was an outbreak of zucchini yellows mosaic virus in cucurbits in the Kununurra region in 2001.

Melon problems include sudden wilt and fusarium wilt.

Sweet corn diseases include blue eye (*Penicillium*) and bipolaris root rot.

This year has been bad for pink root (*Pyrenochaeta terrestris*) in onions in the Manjimup region.

## **Northern Territory**

**Barry Condé, Isagani Arao-Arao, and Rex Pitkethley, Dbird-Primary Industry, Darwin, Northern Territory**

### ***Cultural problems***

The vegetable problems in the NT tend to mainly involve Asian vegetables. Some of these are cultural types of problems relating to insufficient preparation of the ground. In these cases, the vegetables often encounter water logging problems with subsequent association of *Pythium* or of *Fusarium* rots. Together with this, we find plants struggling at establishment due to insufficient or no basal fertiliser. If this is the first crop on the ground after clearing from the bush, growers can still experience phosphorus deficiency even though basal fertiliser has been applied. This is because the inability of phosphorus to move.

### ***Snake bean Fusarium wilt***

Snake bean wilt, caused by *Fusarium oxysporum* f.sp. *tracheiphilum*, has affected the industry badly. The industry was worth \$1.1 million in 1999 when the disease was first discovered. By 2001, 75 per cent of farms which grew snake beans were affected by the wilt disease. Production is down below 50 per cent. Because of the significance of this disease, several lines of cowpeas and 49 lines of snake beans were screened for resistance to this disease in two major groups. The remainder of the snake bean lines will be processed in a third screening. Because a resistant bean with culinary and horticultural characters similar to the current industry standard was not identified, a back-crossing breeding program was initiated in 2001.

### ***Fusarium wilt and crown rot of basil***

Fusarium wilt and crown rot of basil, caused by the fungus, *Fusarium oxysporum* f.sp. *basilici* (Fob) is the most severe disease of basil in the NT. It is still reported as a problem on some properties. Good control was demonstrated through the use of the Israeli-developed resistant sweet basil selection called Nufar F1 (see separate paper). Thai or Vietnamese basil is also affected by the fungus to a lesser extent than sweet basil (see separate paper). At present, there are no resistant selections of this basil available in Australia.

### ***The Cucurbit mosaic viruses***

Papaya ringspot virus-cucurbit strain (PRSV-W) and Zucchini yellow mosaic virus (ZYMV) have caused several \$100,000 loss to diverse crops such as zucchini, squash, cucumber and long melon (*Lagenaria siceraria*). The problem is almost exclusively in the Asian vegetable growing sector. In recent years ZYMV seems to be the dominant virus. Some of the problems are that the farms are very close together and cropping is done sequentially to

meet the requirements of the markets. No matter how much a farm does to protect itself from cucurbit viruses, aphid vectors can continually bring them in from neighbouring infected crops.

### **Root knot nematode**

Root knot nematode, *Meloidogyne* spp. is another problem encountered by Asian vegetable growers in a diverse range of crops such as long melons, okra, snake beans and luffas. Incorporating large quantities of green manure or plant mulch in the wet season some time before planting is very effective in controlling the root knot problem. However, this is not carried out by some Asian vegetable growers because it interrupts their growing schedule or because they are growing crops on leased land and don't have a continuity of cropping land from season to season.

### **Bacterial wilt**

Bacterial wilt affects tomato, chilli and eggplant and other crops. Grafting tomatoes onto resistant tomato rootstock (Chancellor) or resistant eggplant rootstock (wild Malay eggplant) is regularly carried out by either a nursery in Darwin or by growers themselves to avoid high losses due to bacterial wilt.

### **Powdery and downy mildews**

Powdery and downy mildews are an ongoing problem for melon growers and for Asian vegetable growers. Constant vigilance needs to be exercised in detection and spraying to prevent large crop losses.

### **Asparagus anthracnose**

Asparagus anthracnose (*Colletotrichum gloeosporioides*) is a severe disease of asparagus limiting asparagus production in the NT. A third major grower was so severely affected in the last few years that he ceased production in 2001. At present no asparagus is produced in Katherine, NT as a direct result of this disease.

### **Hydroponic lettuce**

A major producer of hydroponic lettuce in Alice Springs offering Iceberg and specialty lettuce for local trade including restaurants suffered major losses in 2001. After much investigation, the problem was traced to chlorine toxicity from bleach treatment to sterilise plant containers and other equipment.

## **New Zealand: Disease surveys and plant pest databases in New Zealand**

Richard E. Falloon<sup>1</sup>, Mark Braithwaite<sup>2</sup>, Anna Tier<sup>2</sup> and Peter R. Johnston<sup>3</sup>

<sup>1</sup>New Zealand Institute for Crop & Food Research Ltd, Private Bag 4704, Christchurch, <sup>2</sup>National Plant Pest Reference Laboratory, MAF, PO Box 24, Lincoln, <sup>3</sup>Landcare New Zealand Ltd, Mount Albert Research Centre, Auckland, New Zealand.

### **Disease surveys**

Country-wide crop surveys, which have included disease and pest assessments, have been carried out over a number of years by the New Zealand Ministry of Agriculture, concentrating on specific crops or crop types (e.g. wine grapes, citrus, apples, subtropical crops, cereals). These surveys have helped to build the PPIN database (see below). The Ministry of Agriculture and Forestry (MAF) also provide free diagnoses for suspected new and unusual

exotic organisms likely to be pathogens, and new host/pathogen associations. This organisation is currently scoping resources required in preparation for possible new surveillance programs for high impact exotic diseases (e.g. Pierce's disease, European brown rot, citrus canker). These new surveillance activities are likely to be funded by government and/or relevant industries. Relevant Crown Research Institutes, Universities, Agriquality NZ Ltd, and private crop protection consultants also informally provide disease surveillance information.

### ***The Plant Pest Information Network (PPIN)***

PPIN is a national database and scientific network for the collection, collation, management and dissemination of plant pest surveillance information. The database is maintained by the National Plant Pest Reference Laboratory, and surveillance information is reported to the Director Plants Biosecurity and the Director Forest Biosecurity of MAF Biosecurity Authority. These reports are facilitated by the Biosecurity Act 1993 (as amended in the Biosecurity Act 1997). The PPIN database holds records of pest occurrence, and their hosts and distribution. Records include arthropod, nematode, fungal, protozoan, bacterial, and virus pests. The types of plant pest records added to the database include organisms that are new to New Zealand, new pest/host associations and new plant pest distributions. New pest listings include records of organisms as primary, secondary, in soil, contaminant, casual, saprophyte, predator/parasitoid, unknown, health concern or symbiotic. Records are authenticated before entry, with voucher specimens entered in publicly accessible collections in New Zealand, and validation of information by appropriate authorities as necessary. The PPIN Information is accessible to allied organisations (e.g. research institutes, museums, universities), who are also actively encouraged to enter information.

### ***The NZFUNGI databases***

Landcare Research is developing the New Zealand fungal databases. These databases (NZFUNGI) include modules relating to Names, Literature and Collections.

The **Names module** includes: all names which have been applied to fungi in a New Zealand context (total approx. 25,000, of which approx. 12,000 are from New Zealand and approx. 6,000 are 'currently accepted'); full literature citation; indication of validity (in terms of the International Botanical Code of Nomenclature); synonymy (with currently accepted name indicated); estimation of the 'biostatus' of the fungus (e.g. exotic or indigenous); descriptions and images of fungi (original published description with a New Zealand type specimen); and pathology notes.

The **Literature module** includes: articles containing original descriptions of all names in the Names module; articles and books which include reference to a New Zealand fungus; hosts recorded for each named fungus; and notes on articles or host/fungus combinations, where relevant.

The **Collections module** includes: data on all collections in the New Zealand Fungal Herbarium (PDD); and data on all cultures in the International Collection of Micro-organisms from plants (ICMP).

The NZFUNGI databases are fully searchable on <http://nzfungi.landcareresearch.co.nz>.

## ITEM 2: QUARANTINE AND RELATED ISSUES

Outbreaks of important new diseases that have occurred recently include potato spindle tuber viroid, onion smut, asparagus rust, stem blight and anthracnose. Documents circulated before the meeting relating to these diseases are included in Appendix 1, page 27.

### Potato spindle tuber viroid

There have been several outbreaks of the quarantinable disease, potato spindle tuber viroid in Australia and New Zealand. The most recent was in WA in 2001. The host range of PSYVd includes tomatoes and potatoes as symptomatic hosts, and eggplants and capsicums as symptomless hosts. It is extremely infectious and can be readily spread on secateurs.

Barry Condé described an outbreak in tomatoes in the NT in 1992-5, Lindrea Latham described the 2001 outbreak in hydroponic tomatoes WA and Richard Falloon described an outbreak in tomatoes and capsicums in NZ in 2001.

PSTVd is difficult to diagnose by visual symptoms because they are non-specific. The symptoms on tomatoes include stunting, leaf distortion, yellowing and mottling. Better illustrations of the range of symptoms on tomatoes would aid diagnosis of this disease. Confirmation of PSTVd is by tomato bioassay together with molecular methods.

There was considerable discussion about the origin of these sporadic outbreaks of PSTVd on tomatoes. The most likely route is from infected seed, but this has not been confirmed.

HAL has approved a project to evaluate the effect of PSYVd on commercial potato varieties (Appendix 1).

### Onion smut

Trevor Wicks described the situation with onion smut, another quarantinable disease that is only known from in parts of South Australia. This disease occurs sporadically in the Adelaide Hills and Mannum areas. The most recent outbreak was in 2001.

Onion crops are surveyed annually for smut because it is easy to diagnose in the seedling stage. If an outbreak is detected the infected crop is destroyed and surrounding properties are inspected for the disease in the same and following season. Machinery and bins are thoroughly cleaned and disinfested before being moved from an infested property. Infested properties are prohibited from growing onions and other related crops.

### Asparagus stem blight, rust and anthracnose

Bob Davis outlined a number of newly recorded asparagus diseases that have been found in Queensland.

Asparagus rust was found in Queensland in 2000. Initial attempts to eradicate the disease were unsuccessful and it has now spread more than 700 km in 18 months. The rust weakens infected plants and reduces yield. It appears to be less serious than originally thought and growers believe that it can be managed with relatively little effort.

Asparagus stem blight (*Phomopsis asparagi*) appeared southern Queensland in 2000. It is more damaging than asparagus rust and is difficult to manage. It is most severe after prolonged wet weather.

Anthracoze (*Colletotrichum gleosporioides*) was first observed on small scale plantings in Katherine (NT) in 1991, and on a larger scale on commercially cultivated asparagus at Katherine in 1996. It was found on native asparagus and on an ornamental asparagus in the Northern Territory in 1997. In 2001 it was first found in northern Queensland. It is a serious disease that causes stem death. This disease is not known in other countries and may be an example of a pathogen jumping hosts from native species to commercial crops.

### **ITEM 3: METHYL BROMIDE PHASEOUT AND OTHER CHEMICAL ISSUES**

The phaseout of methyl bromide has resulted in a reassessment of other control measures for pests, pathogens and weeds. Research projects addressing alternatives to methyl bromide, a problem with copper tolerance in bacterial pathogens, and boosting plant defences are included in Appendix 2, page 38.

#### **Methyl bromide phaseout**

Methyl bromide has been used in specialised situations in the horticultural industry to control pests, pathogens and weeds in high value crops such as capsicums, melons, strawberries and flowers. Australia is a signatory to the Montreal Protocol and is developing alternatives to methyl bromide that will provide growers with alternatives that will have minimal impact on horticultural production.

Two national projects have been funded by HAL to allow growers, fumigation contractors and researchers to trial alternatives to methyl bromide. These projects are coordinated from Victoria and Nigel Crump described their progress. Trials of Telone® C-35, metham sodium/chloropicrin mixtures and reduced rates of dazomet have given results comparable to methyl bromide.

Some problems have become apparent. There have been problems with the application machinery and with tarping the treated soil. The experiments have emphasised the importance of soil condition in achieving effective application.

Growers are kept informed with the progress of these projects through the National Methyl Bromide Update newsletter.

Richard Falloon mentioned that in NZ application of pesticides in aerosols, using CO<sub>2</sub> as the carrier, was more effective than when applied by themselves. NZ researchers are considering the possibility of using CO<sub>2</sub> as a carrier in soil injection.

#### **Copper tolerance in bacteria**

Copper-based chemicals are the only chemicals registered in Australia for the control of bacterial plant diseases. As they are protectants they need to be used regularly. This can result in copper accumulating in the soil, giving rise to copper toxicity in the crop. Another problem is the development of copper tolerance in the pathogen population. A HAL funded project, being conducted in Queensland, is determining the best copper formulation and application method for controlling bacterial diseases. It will also determine whether copper-tolerant strains occur in Australia.

## Boosting the plant's defences

Bion is a novel chemical that activates the plant's natural defences and improves disease control. Hoong Pung outlined a HAL funded project that is examining the potential of Bion for disease control on a number of horticultural crops.

## ITEM 4: ONION AND OTHER ALLIUM DISEASES

Onions are a major crop in Australia and New Zealand. Projects on onion and leek pathology that are being undertaken in Australia are included in Appendix 3, page 45.

### Onion white rot

One of the most important and difficult to control diseases of onions is white rot, caused by *Sclerotium cepivorum*. Sclerotia of this fungus persist in soil for up to 20 years. Bob Davis outlined a new approach to managing this disease which has proven to be very effective in lowering the inoculum of this pathogen in Queensland and Tasmania. The chemical diallyl disulphide (DADS) induces the germination of sclerotia in the absence of host roots. The fungus then dies. DADS is a derivative of naturally-occurring sulphides present in roots of all *Allium* spp. It does not have a fungicidal effect; it mimics root exudates. DADS lowers the soil inoculum so that other means of control (such as fungicides and bio-control agents) are effective. DADS is the only product that is effective in sites with a high inoculum.

DADS is manufactured and distributed by a US company. It is registered for use in NZ, but not in Australia.

There are problems relating to the use of DADS in Australia. The US company advises that the NRA requires DADS to be registered as a fungicide and that the cost compared to their likely sales here is more than they are willing to come up with. Without DADS onion white rot is not a manageable disease in Queensland. There has already been a decline in onion production in Queensland due to this disease.

There was considerable discussion about the options for onion growers with a white rot problem. Could DADS be registered as a soil additive? It was suggested that Bob should contact the onion growers in Australia to support such a registration. It was also suggested that Bob should find out how DADS has been registered in New Zealand.

### Diseases of leeks

Trevor Wicks described some of the leek diseases that had been found in Australia as part of a HAL funded project. Fortunately many of the diseases of leeks known overseas were not found in Australia. Experiments are underway to determine the most effective way of controlling *Fusarium* basal rot and *Stemphyllium* leaf blight.

A Leek Newsletter has been produced, and is available on the SARDI website.

## ITEM 5: LEAFY VEGETABLES

The crops included in this section were lettuce and basil. Milestone reports or summaries are included in Appendix 4, page 51.

### Lettuce diseases

Projects on controlling lettuce diseases are being conducted in NSW, Victoria, WA and Queensland. Surveys have shown that the main diseases are downy mildew, *Sclerotinia*, bacterial diseases, *Rhizoctonia* and virus diseases. These diseases vary in severity between different growing regions. In some areas crops have not been harvested because of varnish spot (*Pseudomonas*) or big vein virus.

There appears to be a great deal of variation in growers' ability to recognise different diseases. Future publication of IPM Manuals for lettuce by NSW Agriculture and NZ will assist growers with disease diagnosis. Some symptoms can be extremely confusing, for example, *Botrytis* in Cos lettuce grown with overhead irrigation can be confused with *Sclerotinia*.

One of the most pressing problems is the lack of chemical options for controlling *Sclerotinia*. Bob Davis suggested that drip irrigation, rather than overhead irrigation, is one way of reducing this disease.

WA work with big vein virus has shown that infected nursery seedlings is an important way of introducing the disease into uninfested areas. Some lettuce cultivars show good tolerance to this disease.

### Basil

Basil wilt, caused by *Fusarium oxysporum* f. sp. *basilici* has recently become a major disease of sweet basil. It is a seed borne disease. In the 1980s and 1990s basil seed was mass produced in areas of the world with cheap labour. Seed was harvested from infected plants and sold world wide. Once a site is infected with basil wilt, chlamydospores can persist in the soil for many years.

Basil is an important crop in the NT, especially amongst Vietnamese growers. Pathologists in the NT have identified several lines of sweet basil that are resistant to basil wilt, and have commercial potential.

## ITEM 6: LEGUMES

There are several HAL funded projects and other projects on bean and pea crops. Milestone reports and summaries are presented in Appendix 5, page 67.

### Beans

Barry Condé outlined his recent research into *Fusarium* wilt of snake bean and its control. The Darwin snake bean industry is worth \$1.1 million. *Fusarium* wilt of snake beans was first recorded in 1999. Surveys in 2002 and 2001 have found this disease in most major snake bean growing areas of Darwin. Several control measures have been investigated. These include screening seed lines for resistance, breeding for resistance and grafting onto resistant rootstocks.

## Peas

Hoong Pung spoke about her research into downy mildew of peas in Tasmania. This disease is being controlled by seed treatment with metalaxyl. Metalaxyl tolerant races of pea mildew have been recorded in NZ and she has found that metalaxyl tolerant races also occur in Tasmania. Additional control measures for this disease include other seed dressings and/or foliar sprays. Results from this project are extended through grower meetings.

Collar rot is another important pea disease. The causal pathogen (*Ascochyta*) is a wound pathogen. Hoong Pung explained how herbicides are being used to minimise stem damage, and therefore reduce potential entry points for this fungus.

## ITEM 7: SWEET CORN

Two sweet corn projects were discussed, project summaries are presented in Appendix 6, page 73.

Bob Davis outlined the breeding program that is underway in Queensland that is improving resistance to common rust and northern corn leaf blight caused by *Exserohilum turcicum*. One hybrid, H772, has good leaf blight and rust resistance.

Andrew Watson described a new project that will review current management of northern corn leaf blight, and determine whether there are better cultural and chemical control methods. This project will also look at varietal susceptibility.

Richard Falloon mentioned that a new project on head smut in sweet corn is starting in NZ.

## ITEM 8: POTATOES

Potatoes are the most important vegetable crop in most Australian States, and in NZ, and consequently command considerable research funding. Project summaries are presented in Appendix 7, page 76.

New publications include a Potato Disease Manual that will be available from AgVic, and a field guide to pests, beneficials and diseases that is being prepared in NZ.

## Soil borne diseases

Molecular techniques have the potential to improve the speed and sensitivity of detecting soil borne pathogens of potatoes, such as streptomyces (common) scab, powdery scab, potato cyst nematode and verticillium wilt. Several HAL funded projects are developing better diagnostic protocols that will ultimately replace conventional isolation and bioassay techniques. These new techniques will have many advantages for growers including the development of disease prediction tests. Growers will be able to anticipate problems. Results are extended to growers through meetings and newsletters.

Reliable soil testing will involve improved soil sampling, in addition to increased sensitivity. At the moment the cost of each test is \$10-20, but this should drop with increasing numbers of samples.

One of the problems with soil borne diseases is that once the pathogens are introduced they are almost impossible to eradicate. Contaminated seed is the main way that these pathogens are introduced into new areas. Nigel Crump outlined some of the Victorian work



that has identified these pathogens in packing shed dust. This study has found that wooden surfaces have a higher pathogen load than plastic, concrete and metal, while dirty surfaces carry more pathogens than clean ones.

Many of the studies of soil borne pathogens are evaluating the efficacy of chemical control of pathogens on potato seed, in order to minimise transmission to new crops.

Another approach for disease control is the selection of resistant cultivars. Richard Falloon outlined NZ work that has identified resistance to powdery scab. One variety Swift, has extremely resistant tubers, although the roots are susceptible. One promising variety, Red Rascal has been tested in NSW.

Black dot, caused by *Colletotrichm coccodes*, is another widespread soil borne disease. It causes skin blemishes that result in tubers being down-graded. In SA it has been introduced into new areas on contaminated seed. Trevor Wicks has found that it can persist in infested sites on infected fat hen and silverleaf nightshade. He is undertaking field trials to determine varietal resistance to black dot.

## Late blight

Late blight (caused by *Phytophthora infestans*) has become increasingly important worldwide because of the build up of metalaxyl tolerance. It is a minor disease Australia only becoming important in Tasmania and Victoria in wet years. In New Zealand it is important in the Auckland region but not around Canterbury. A survey of this fungus in Australia has shown that all isolates are A1 mating type, and none were metalaxyl tolerant.

## Potato viruses

Regular monitoring of seed potato crops has resulted in very low incidence of virus diseases. However, the situation can change rapidly. In WA there are two extension projects that target management of the aphid vectors of these viruses. One project will produce a video advising growers how to monitor and manage aphids, the other project will introduce seed growers to an interactive pest and disease monitoring service.

Genetic engineering is being used by Agriculture Australia to develop transgenic potato lines that are resistant to potato leaf roll virus and potato virus Y.

## Post harvest problems

Trevor Wicks described his work on post harvest breakdown caused by *Erwinia*. This is a difficult problem to control because the bacteria are both internal and external. He has found there is a variation in the likelihood of tubers from different sites to rot. Once infected potatoes were introduced into a washing line all of the tanks and belts become contaminated, with most infection occurring in the initial dump tank. Sanitisers added to rinse water and recycled water were not always effective. The most effective way of controlling bacterial soft rot so far, was to use hot air drying.

The depth of the dump tank is important. In deep tanks the hydrostatic pressure forces bacteria into the lenticels where it is protected from sanitisers and other chemicals. There are also problems with temperature differences between the crop and the dump water, if hot potatoes are washed in cool water there is a greater incidence of rot.

Potatoes harvested under dry conditions are more likely to be wounded, and are more susceptible to soft rot.

Calcium status is important for minimising soft rot, but it has proven extremely difficult to improve the Ca status of potatoes with a range of fertilisers and other additives. There are problems with planting seed into hot soil. One approach being investigated is to look at seed quality in relation to susceptibility to soft rot.

Trials on pink rot control are being undertaken in SA.

## **ITEM 9: CAPSICUMS, TOMATOES, EGGPLANTS AND MELONS**

Capsicums, tomatoes and melons are important crops in most Australian States and in New Zealand. Project summaries are in Appendix 8, page 101.

### **Disease survey of greenhouse capsicums and cucumbers**

A survey of greenhouse grown cucumbers and capsicums is being undertaken in south eastern Australia. It aims to identify which diseases affect these crops and will ultimately develop and evaluate integrated management strategies for them. Root rots and wilts, associated with *Pythium* and *Fusarium oxysporum*, have been found in NSW.

### **Virus diseases**

Tomato spotted wilt virus is becoming increasingly important in all States, mainly because of the spread of its vector, the western flower thrip. A HAL funded project in Queensland is looking at resistance to TSWV, with evaluation of new genetic material in both QLD and WA. Tospovirus serotype IV (capsicum chlorosis virus) is now more important than TSWV in the Bundaberg region, symptoms are similar to TSWV. Bacterial spot is also included in this project.

Measures to control western flower thrip are being developed in WA. There was some discussion about how the results from this project can be extended to other States.

Barry Condé spoke about a recent survey of geminiviruses in northern Australia. The only virus detected was tomato leaf curl virus (TLCV-Au), which is spread by the Australian indigenous biotype of the silverleaf whitefly, *Bemisia tabaci*. There are several strains of this virus in the wild. It is not seed transmitted. There is an emerging problem with this virus. The newly introduced silverleaf whitefly, *Bemisia tabaci* biotype B is a much more efficient vector of TLCV, and insecticide resistant strains of this whitefly have arisen in the USA and Spain. This silverleaf whitefly is now only 150 km from the nearest known TLCV infection and it is anticipated that there is the potential for a problem similar to TSWV developing with TLCV in northern Australia. The virus has also been spread by the nursery industry because infection with the gemini virus is the cause of the natural-yellow veined variant of Japanese honeysuckle (*Lonicera japonica* 'Aureo Reticulata') which has been sold throughout Australia as an ornamental creeper.

### **Melons**

Zucchini yellows mosaic virus (ZYMV) is the most common virus throughout the melon growing region of QLD, but there is an increase in the incidence of papaya ringspot virus. ZYMV has become a major problem in cucurbits in the Darwin region of the NT. Control

measures are aimed at managing aphid numbers. Another strain of *Acidovorax*, the cause of bacterial spot of melons, has been identified during pathogenicity testing.

## Capsicums

Sudden wilt of capsicums is an important disease in the dry tropics of QLD. It is associated with two pathogens, *Pythium* and *Fusarium*, but there also appears to be an interaction with temperature.

## ITEM 10: CARROTS, CELERY AND BEETROOT

Carrots are one of the most important crops across southern Australia. Project summaries and outlines are included in Appendix 9, page 112.

### Fungal soil borne and seed borne diseases

Elaine Davison presented recent results from a HAL funded project on cavity spot disease of carrots. There are two causal organisms in Australia, *Pythium sulcatum* is the most widespread. The genetic diversity of *P. sulcatum* in Australia indicates that it may be an indigenous, rather than an introduced pathogen. The host range of *P. sulcatum* is restricted to Apiaceae. Control measures are based on tolerant varieties rather than chemicals, because enhanced breakdown of metalaxyl (the most effective chemical) has developed on sites where it has been frequently used. The results from this research are extended to growers through field days, industry magazines and a web page.

Trevor Wicks described work in SA on *Alternaria radicina* on carrots. These HAL projects were funded because SA growers were having problems with seedling establishment during summer. *A. radicina* was isolated from affected seedlings. It causes seedling mortality, foliar disease and black rot in mature roots. Seed of some varieties of carrots is badly infested, and once this pathogen has been introduced into a site it will persist for at least 8 years. Current seed treatment with chemicals is only partly effective. Control measures that are being investigated include chemical control on plants being used for seed production, improved seed treatment, foliar fungicides to reduce seedling damping off, and cultural practices to minimise infection. Wind damage may also be a contributing factor in the poor seedling establishment, however, the high levels of *A. radicina* in seed are a cause of concern. The results from this project are being extended to growers through field days and industry magazines.

Bacterial blight (caused by *Xanthomonas campestris*) is another seed borne disease of carrots that can also be a problem in coriander.

Beetroot is an important crop in the Lockyer Valley of Queensland. This is an all the year round crop that is produced by 12 or 13 growers. They have difficulty producing sufficient beetroot to meet the demand. The main problem is damping off, caused by *Aphanomyces*, *Pythium* and *Rhizoctonia*. Seedlings that survive are disfigured and unmarketable. QDPI have funded a project that will give growers more options for controlling these diseases. Variety trials have identified several promising cultivars. Fungicide trials have identified hymexazol as an effective fungicide for controlling *Pythium*, and an application for a minor use permit has been lodged with the National Registration Authority. Beetroot growing occurs all the year round, and regular sampling of *Pythium* from infected plants has shown that different species are important at different times of year. Cultural methods of disease control are also being investigated.

## Nematode diseases

Nematodes are a major problem on some carrot farms affecting both yield and carrot quality. Elaine Davison spoke about a national project that is being coordinated from Tasmania. This is a wide ranging project that includes a survey of which nematodes are associated with damaged carrot crops in the different Australian States. So far the most commonly isolated nematodes are several species of lesion nematodes (*Pratylenchus* spp.) and root knot nematodes (*Meloidogyne* spp.). There are several experiments underway to establish the relationship between nematode numbers in soil and root damage in the final crop, and also the host range of the different nematodes. Other experiments are determining the optimum sampling strategies for pre-planting predictive tests for nematodes. Enhanced breakdown of the nematicide fenamiphos is of concern in WA. The recent registration of 1,3-dichloropropene in Australia provides growers with an additional chemical for nematode control. Experiments on chemical control are being undertaken in WA.

Barry Condé mentioned that in the NT sorghum used as a green manure, is a very effective way of controlling root knot nematode. Lisa Gibson said that a new project will be looking at using pyrethrum to control *Pratylenchus*. Trevor Wicks mentioned that Jackie Nobbs, a nematode taxonomist in SA is producing a CD on the identification of nematodes.

## Virus diseases

Carrot virus Y is a new disease of carrots that causes unmarketable, knobby roots in early infected plants. The virus is non-persistently transmitted by aphids. Lindrea Latham described the progress of a national project, funded by HAL, that is investigating the occurrence and control of this disease. Survey work has concentrated on identifying the virus in leaf samples, rather than identifying the disease from distorted roots. CVY has been found at a high incidence in areas where carrots are grown all the year round (WA, Vic, SA, NSW), but in areas where they are only a summer crop (Tas) there is a much lower incidence. Carrots are only host known of CVY. Carrots are presently the only known host of CVY. Vectors are being investigated by Violetta Triacevski in Vic and also in WA. The possibility that this virus has the potential to be seed transmitted at a very low level is being investigated. Screening trials of 20 readily available varieties have shown that there is minimal tolerance to the disease.

Celery mosaic is another virus disease that is non-persistently transmitted by aphids. It causes stunting and leaf curling and infected plants have a reduced shelf life. It can be rapidly spread through a crop and to adjacent crops. It can become a major problem in crops that are grown year round and has recently become a serious problem in WA where growers requested assistance in managing this disease. Lindrea Latham described the resulting HAL funded extension project. Celery growers are working together to establish a celery free period to minimise the carryover of infection from one crop to the next. This strategy effectively controlled CeMV in SA about 10 years ago. Other management measures that are being used in WA include ensuring that transplants are free from CeMV, roguing and removing weeds that may act as a virus source.

A biotechnology project that is being funded by HAL will look at the options for modifying carrot and celery germplasm with the aim of ultimately developing novel varieties that are resistant to CeMV, CVY and cavity spot disease.

## Post harvest issues

One of the problems experienced by vegetable farms and packhouses is the amount and quality of washing water. Issues of water quality are being investigated by a HAL funded project that aims to develop best practice protocols for the treatment of wastewater. Fiona Benyon indicated that this is a high priority area for the vegetable industry. Nigel Crump outlined what has been achieved. An initial survey has characterised the microbial and chemical quality of the source and waste water from packhouses in several growing regions. There is no indication of chemical contamination of the source water, however there is some contamination by fungal plant pathogens and faecal coliforms. Bacterial plant pathogens were not assessed. Settling ponds can be used to improve water quality, however it is essential that they work efficiently. Guidelines have been developed for the vegetable industry that address the re-use of washing water for washing and irrigation, and are being circulated for comment. The results of this work have been extended through field days, industry magazines and a newsletter 'In the Wash'.

## ITEM 11: BRASSICAS

Brassicas for domestic consumption and the export market are important crops in all States in Australia and in New Zealand. Project summaries and milestone reports are presented in Appendix 10, page 130. An important extension tool produced by a HAL funded project is the recently published 'A Field Guide to Pests, Diseases and Disorders of Vegetable Brassicas' that has been distributed free to all growers of vegetable brassicas in Australia.

### Black rot

Andrew Watson described a new project on black rot that is funded by HAL. Black rot is caused by the bacterial pathogen *Xanthomonas campestris*, and is the most destructive disease of brassicas worldwide. The disease is seed borne and can be rapidly spread during seedling production in the nursery. The recent increase in this disease in south eastern Australia is associated with an increase in the requirement for seed of new cultivars which are being produced outside Australia. Low levels of seed infection can result in high levels of infection in the field. There is also the potential for the introduction of new races and strains of the bacterium. Seed treatment is used to control this disease. The project will develop more sensitive detection methods for *X. campestris* and will review seed treatment methods.

### Clubroot

HAL has funded several projects relating to the control of clubroot. A molecular method for detecting *Plasmodiophora brassicae*, the cause of clubroot, will give growers a rapid diagnostic test for this disease. Nigel Crump explained that the aim is to have a quantitative test that will be used in association with site information to determine the economic threshold for control measures. A project is being developed with Horticulture Research International in the UK to develop an on-farm, do-it-yourself test kit for clubroot. Rachael Lancaster described a total crop management project that had been developed in association with the brassica commodity group. A combined banding/planting machine has been developed to deliver chemicals in the root zone of seedlings. The chemicals used include fluzinam, flusulfamide and lime. Soil type can affect their efficacy. Large scale demonstration trials of the most effective control measures have been established in different States. Other control measures being explored are the use of leafy daikon as a bait crop to reduce the number of clubroot spores, and heavy irrigation to leach spores below the root zone. It is essential that brassica seedlings are free of clubroot to prevent the disease being introduced into

uninfested areas. Information is being extended to growers in field days, industry magazines and through a newsletter 'Galls and All'. Richard Falloon said that in New Zealand growers were also using leafy daikon radish as a bait crop for clubroot.

## Other diseases

Lindrea Latham has been conducting a survey of virus diseases of brassicas in WA. Although symptoms of turnip mosaic virus have been seen in supermarkets, and several viruses occur in canola crops in WA, low levels of virus incidence were found in brassica crops and surprisingly high levels of virus incidence in nearby brassica weeds.

Head rot of broccoli is an important problem in crops grown for processing in Tasmania. Hoong Pung described progress in this HAL funded project. So far, isolations have shown that there are a number of microorganisms, such as *Alternaria*, *Botrytis*, *Sclerotinia* and *Pseudomonas marginalis* are associated with this problem. Some pathogens require the removal of the waxy surface layer by surfactants before they can invade, however, *Sclerotinia*, *Botrytis* and *Fusarium* can invade undamaged tissue. Results of this work are extended to industry through regular updates to managers.

Nigel Crump mentioned that there have been recent problems with white blister rust (*Albugo candida*) on broccoli. Bob Davis said that it was seen on other brassicas, but not broccoli in Queensland.

## Genetic improvement

Previous work funded by HAL has developed protocols to genetically modify brassicas to enhance resistance to diamond back moth and clubroot, so that pesticide use is reduced. Another aim is to extend shelf life. Some transgenic lines with potential against diamond back moth and clubroot have been identified, however the transformation system used needs to be improved. The present project is continuing this work. A newsletter has been produced that advises the vegetable industry of the progress of this project.

## ITEM 12: ENHANCED BREAKDOWN OF CHEMICALS AND BIOCONTROLS

Soil borne diseases are often difficult to diagnose, the pathogens are often difficult to identify accurately, chemicals used to control them are difficult to apply, are expensive, extremely toxic, and do not always work. Other options for controlling root pests and pathogens include the use of biological control. HAL funded projects that address some of these issues are presented in Appendix 11, page 140.

### Enhanced breakdown of metalaxyl and metham sodium

Metalaxyl is a fungicide that is effective against oomycete plant pathogens of vegetable crops. Although it has been very effective against the soil borne pathogens *Pythium* and *Phytophthora* it becomes less effective with repeated use because of biodegradation by soil microorganisms. Hoong Pung described a HAL funded literature review that she had undertaken that shows that enhanced breakdown of metalaxyl has been reported from many sites where it has been used repeatedly. The rate at which enhanced breakdown develops depends on frequency of use, soil type, rate of leaching and cultural practice. On sites where enhanced breakdown occurs, metalaxyl will not give adequate disease control. A leaflet covering this information has been prepared for industry.

Metham sodium is another widely used agricultural chemical that is subject to enhanced breakdown. John Matthiessen explained that the active ingredient was methyl

isothiocyanate (MITC), which is released in moist soil. In a HAL funded project, he has found that on sites where metham sodium has been used repeatedly, MITC had degraded completely within 7 hr, whereas in a similar soil where metham sodium had not been previously used, it degraded completely in 18 days. The higher the pH, the more rapid was the development of enhanced degradation. Sandy soils, such as those in WA appear to be more at risk of an enhanced biodegradation problem than heavier soils, such as those in Queensland. Growers are kept informed of this work through industry magazines and a newsletter 'How Degrading'.

Other chemicals that are, or may be subject to enhanced breakdown include procymidone for onion white rot control, fenamiphos and 1,3-dichloropropene.

## Biofumigation

Isothiocyanates are natural breakdown products of glucosinolates (GSL), chemicals that are produced by brassicas. Most edible brassicas have been selected for low GSL levels, but many fodder mustards and rapes have high concentrations of these chemicals. John Matthiessen has been screening GSL levels in many of these plants, in a HAL funded project. These naturally occurring GSLs have the potential to control soil borne pests and pathogens. *In vitro* tests with isothiocyanates derived from a range of GSLs have shown that many of these chemicals are toxic to fungal pathogens. The most promising varieties are being evaluated in the field, and experiments are underway to determine how the plant biomass should be incorporated into soil, to maximum effect. The information from this project is being extended to growers through field days, articles in industry magazines and through the 'Biofumigation Newsletter'.

A recently funded ACIAR funded project in northern Queensland and the Philippines is also examining the potential of biofumigation to control bacterial wilt in tomato and eggplant. Tropical brassicas have high GSL levels.

## Biological control

A biocontrol project that is funded by HAL is examining the potential to control *Sclerotinia minor* diseases with *Trichoderma*, and *Coniothyrium minitans*. Research findings are being presented to growers through growers' meetings.

There was some general discussion about the potential of biological control agents. There is increasing in the vegetable industry, because of the reduced number that are now registered, and because many soil applied chemicals are subject to enhance biodegradation. Biocontrol agents are seen as an environmentally friendly, long-term alternative. They are less reliable than chemicals, however, and need to be treated differently. There are issues of quality control, reliability of the information that growers receive, and the suitability of strains of microorganisms used. Local isolates were deemed to be best.

## ITEM 13: EXTENSION MATERIAL

Technology transfer is an important issue. Vegetable growers will only feel that their levy money is well spent if they see what is in it for them. These outcomes need to be presented as briefly and clearly as possible, for example in minimal words but with good pictures. The most important thing is that it is relevant, easy to understand and easy to use.

Researchers are not always good communicators. HAL recognises this, and has funded Industry Development Officers in all States as a team of professional communicators.

The IDOs, who had been listening so quietly for the earlier part of this working group meeting, suddenly exploded into voice. They see themselves as the interface between researchers, vegetable growers and other stakeholders. They talked about what they do, how they deal with problem of language, how they communicate with vegetable growers and other stakeholders in their State, over large geographical areas and over a wide range of crops. A formal outline of their communication channels is given in Appendix 12, page 149. Initiatives that they have made include regular mail outs to growers, using e-mail (although not all growers have access to e-mail), organising meetings and workshops. Another important initiative is translating technical information into other languages such as Vietnamese.

The Northern Territory does not have an IDO. Barry Condé said that information on new diseases is usually extended to farmers by direct contact. This is followed up with informal Information Sheets that can be prepared quickly. The formal advisory notes are 'Agnotes'. Some of these Information Sheets and Agnotes are translated into Vietnamese for the large community of Vietnamese growers. Joint articles are written with the Asian Vegetable Communications Officer, who is Vietnamese, for the NT Horticulturalist. Examples of the NT extension material is presented in Appendix 12, pages 153-162.

Richard Falloon said that in New Zealand extension officers are grower funded, not government funded.

HA funded projects that have been well extended include 'Insect pest management in sweet corn' (VG97036), 'Western flower thrips: industry communication and development of training package' (VG00078) and 'Implementing integrated pest management of diamondback moth in brassica vegetables' (VG00055). All of these projects have communication plans and communication officers. Regular newsletters are important in keeping growers aware of progress in these projects. Hands-on workshops that are portable, and can be run in different States are also an excellent way of extending research findings, and this has been done for the diamondback moth project.

Websites are a useful tool for extending research results, and will become increasingly important as more growers get access to the internet. Radio and television programs, together with videos and tapes, are additional ways of providing information to growers.

A new initiative from HAL is the production of VegeNotes which will be similar to farmnotes and factsheets. These provide solutions from projects directly to growers. It is anticipated that 10 notes in this series will be produced annually.

Another way in which the IDO network can assist researchers is by advising on priority topics. They can also provide feedback on concept development proposals, particularly in relation to how these will be viewed by the members of the grower commodity panels. The way that a proposal is presented can make all the difference between acceptance and rejection by growers.

## **ITEM 14: DISEASES OF NURSERY STOCK**

Many vegetables are initially raised as seedlings for transplanting. Common examples include brassicas, lettuce, tomatoes, capsicums and melons. If seedlings are infected when they are dispatched from the nursery, pathogens can be spread very rapidly. Results include the introduction of diseases into previously disease-free areas, or the spread of fungicide-resistant races, making disease control more difficult. Examples of diseases spread on nursery seedlings are given in Appendix 13, page 163.



Some nurseries maintain extremely high standards and are ISO accredited, but this is not universal. Litigation may result from poor quality seedlings supplied by nurseries.

## Seed quality

The increased production of seed in countries with cheap labour and poor quality control, has resulted in a perceived reduction in seed quality. Black rot of brassicas, caused by the bacterium *Xanthomonas campestris*, and fusarium wilt of basil, caused by *Fusarium oxysporum* f. sp. *basilici*, are examples. Seed is bought by number, rather than quality or percentage germination. Seed can be treated with hot water or fungicides to kill contaminating pathogens, however these treatments may result in reduced germination.

Other seed-borne diseases that are of concern are bacterial canker, bacterial fruit blotch and potato spindle tuber viroid.

Tasmania has a vegetable seed industry, and Lisa Gibson pointed out that the growers demand clean seedlings from the nursery industry. This in turn puts pressure on seed companies to provide clean seed.

Seed testing is one way to identify seed-borne pathogens. Dominic Wright suggested that as a priority, all imported seed should be quarantined and tested, before being released. David Ellement said that not all seed was coming into Australia legally. Seed that is coming in by mail may not have the appropriate phytosanitary certificates, and may not be intercepted. This is an area where State grower groups should raise their concerns with AusVeg, who in turn should raise the matter with AQIS.

## Seedling diseases

In addition to pathogens that are introduced on seed, there are also diseases that cycle within nurseries, such as downy mildew of brassicas and lettuce, or that are spread vectors from adjacent crops, such as tomato spotted wilt virus on tomatoes and capsicums. Examples of nursery diseases that have been causing concern to growers include downy mildews, clubroot, lettuce bigvein virus and TSWV. One of the problems with this type of disease is that nurseries are often located in growing areas, so that seedlings can become infected even though nursery managers maintain high standards of hygiene.

The nursery industry in Australia has a voluntary accreditation scheme that sets standards for nursery hygiene in relation to *Phytophthora* diseases of ornamental plants. Vegetable diseases are not specifically targeted by this scheme, although it has raised awareness of general standards of hygiene.

Infected seedlings can result in financial losses to growers. Richard Falloon said that there has been a recent case of litigation against a nursery in NZ. This case could be used as a cautionary tale for other vegetable seedling growers.

## ITEM 15: FUTURE DIRECTIONS

### The role of private industry in agricultural research

Hoong Pung works for Serve-Ag Research, a private company that employs one of the largest teams of technical staff in Australian agriculture. The other vegetable pathologists are public servants employed by local departments of agriculture. The opportunities and expectations of people in private industry differ from those of public servants. Hoong

described the activities of Serve-Ag, and how this private research provider services the needs of its clients (Appendix 14, page 166).

## Collaboration between Australia and New Zealand

Australia and New Zealand are large countries geographically, with small populations. As many of the problems of the vegetable industry are common to both countries, it makes good sense to pool resources where this is possible. Fiona Benyon spoke of moves by HAL to facilitate collaborative research and development to achieve industry-focused outcomes (Appendix 14, pages 167-168). HAL can match both NZ industry contributions and NZ Government Funds as voluntary contributions, because there is an identifiable benefit to Australia. There is also the potential to match overseas voluntary contributions by HAL, and this is determined on a case by case basis.

Collaborative research projects between Australia and NZ include: VG00048, Development of biological controls for *Sclerotinia* diseases of horticultural crops in Australasia, VG01096, Stop the rot - managing onion white rot in spring onions, and PT01031, Enhanced detection of PCN and bacterial wilt to improve market access for the Australia and New Zealand Potato Industries.

Overall, this collaboration is seen as a very positive move. There is however, some grower sensitivity, especially amongst export carrot and cauliflower growers who are competing in the same markets.

## Future priorities

The projects discussed at this working group meeting illustrated the range of disease problems on many different crops. Priority issues that emerged during the discussions are listed below.

### Seed quality and seedling health

As noted above (Item 14), these are not new problems. The ways of minimising these diseases may be known, but not necessarily applied. Pressure from growers may result in improved seedling quality.

### Soil borne diseases

The many projects dealing with soil borne diseases high-lights their importance. They are difficult to diagnose and difficult to control. Some of the chemicals that have been used in the past to control them are no longer registered, or are no longer effective because of enhanced biodegradation.

New initiatives include biofumigation and biological control, however their effectiveness and reliability remain to be proven on a commercial scale.

Soil sampling is often undertaken in order to determine whether it is necessary to treat the site before seeding. Although molecular techniques have improved the detection of pathogens in the sampled soil, there are still difficulties in how to adequately sample a site when the distribution of the pathogen is patchy. A robust protocol is needed.

## **Succession planning**

It takes many years to build up the skill and experience to identify plant pathogens and the diseases that they cause. There has been a gradual greying of the profession, with staff not being replaced when they retire. In NZ there is only one virologist and one nematologist who deal with vegetable diseases. Similarly in Australia the number of nematologists, virologists and bacteriologists is declining. There are still sufficient fungal plant pathologists to service the vegetable industry. Departments of agriculture need to train sufficient specialists who can accurately identify potential pathogens and diagnose plant diseases.

Many of the skills needed to service the vegetable industry are no longer taught at universities. One possibility is that HAL should fund cadetships to build up the pool of expertise.

There is a nationwide shortage of specialists in the taxonomy of microorganisms.

## **The National Vegetable Pathology Working Group**

There was general agreement that the meeting had been a success. It had provided a full overview of the projects on vegetable pathology that were underway in Australia. Richard Falloon's presentation of NZ research was particularly valuable. There was two way communication between the IDOs and the researchers.

Trevor Wicks and Craig Feutrill agreed to organise the next meeting of the NVPWG in 2004, the suggested location was the NT. HAL would be approached for funding.

## **ITEM 16: ANY OTHER BUSINESS**

None.

# APPENDICES

## APPENDIX 1: QUARANTINE AND RELATED ISSUES

### POTATO SPINDLE TUBER VIROID

#### POTATO SPINDLE TUBER VIROID IN TOMATO IN THE NT

Barry Condé and Rex Pitkethley, DBIRD-Primary Industry, Darwin, NT

There is only one known outbreak of Potato Spindle Tuber Viroid (PSTVd) in the NT. This was in 1992-5 in the NT Government Plant Pathology glasshouse at Berrimah Farm, Darwin.

We first realised that we had another virus-like disease in the glasshouse in May 1993 during intensive investigations into the graft-transmissible tomato disease, Australian tomato leaf curl virus (TLCV-Au). The symptoms were first observed on cherry tomatoes (*Lycopersicon esculentum*) variety Sweetie. First symptoms developed 6 weeks after infection in contrast to 2-4 weeks for symptoms to develop when infected with Australian tomato leaf curl geminivirus (TLCV-Au).

Cherry tomato plants affected by PSTVd showed three distinct zones. First there was a zone of normal growth followed by a zone of bunched or condensed growth followed by a final zone of elongated growth with small leaves.

First symptom is severe down-curling and puckering of new leaves (epinasty). This is followed by cessation of growth with shortened internodes, new leaves being distorted and usually displaying characteristic necrotic streaking of petioles and veinal necrosis of leaflets. The final zone appears as spindly growth with smaller leaves, longer internodes and thinner stems which are eventually hairless. PSTVd-infected tomatoes in contrast to TLCV-Au infected tomatoes continue to produce flowers and fruit, although fruit is smaller than normal.

In 1992 (prior to the discovery in 1993 of the viroid new to Darwin), there were some Grosse Lisse tomatoes with necrotic streaks suggestive of PSTVd infection. It is possible that the PSTVd had been in the Darwin glasshouse system in 1992-1993, being spread as contamination on grafting knives and secateurs. The detection was made on cherry tomatoes in 1993 because many cherry tomatoes were held for an extended period of time and were under close observation together with control plants.

On 2 February 1995, we realised that the disease was similar to Tomato Bunchy Top disease reported from South Africa by McLean in 1931, 1935 and 1938 (cited by Smith in 1957). Tests by TASAG confirmed that this disease in the NT was PSTVd.

Roistacher *et al.* (1969) found that a related viroid, citrus exocortis viroid could be inactivated on pruning tools by using a solution of 20 per cent household bleach (containing about 1 per cent sodium hypochloride). The corrosive action of the bleach was avoided by dipping in a mixture of vinegar, water and emulsifiable oil. This system was adopted regularly for the sterilisation of secateurs. Since pool bleach (calcium hypochloride) was already in use to sterilise pots, any danger of PSTVd being spread on pots was eliminated. Infected material was either incinerated or autoclaved and benches were swabbed with bleach solution. As a result, no more PSTVd was detected in the glasshouse system.

This was only the third known outbreak of PSTVd in Australia up till this time. The question was where did this PSTVd come from in this outbreak? A diligent search was made to test material being grafted for the presence of PSTVd; this was negative. The tomato seed used was Yates Sweetie and Yates or New World Grosse Lisse. This seed was used before 1992 and since 1995 and no further infections were detected, so it seems unlikely that this was the source of the PSTVd outbreak. Also, tomato fields in Darwin were inspected and samples were indexed onto tomatoes in the glasshouse for PSTVd since the discovery of the glasshouse outbreak in 1993. All samples were negative for PSTVd.

We have formulated the hypothesis that this NT PSTVd outbreak originated from a host other than tomato or potato, perhaps a non-solanaceous host. Diener in 1979 lists 11 families other than Solanaceae which are experimental hosts of PSTVd; most of these are symptomless hosts which could act as a symptomless reservoir of PSTVd. Our hypothesis is that if our outbreak did not originate from contaminated tomato seed, then it could have originated from an unknown symptomless carrier which contaminated secateurs or knives, so infecting the symptomatic and sensitive tomatoes.

To back this hypothesis up, Holliday (1989) states that PSTVd has not been found in wild potato spp. or local cvs. in the Peruvian Andes. Its distribution in potatoes can be explained by clonal multiplication worldwide once the viroid entered a potato crop somewhere in the world. As far as I am aware, PSTVd does not infect tomato in its

geographical origin. It follows that the natural host/s of PSTVd is most likely not potato or tomato and could even be a non-solanaceous plant. Many of the recent PSTVd infections in tomato crops in NT, NZ and WA and NSW were in glasshouses where they are grown intensively, with much chance for contact with secateurs as well as intensive people contact.

Three references from this outbreak. Condé *et al.* (1995), Behjatnia *et al.* (1996), & Condé *et al.* (1996)

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**POTATO SPINDLE TUBER VIROID ERADICATED IN WESTERN AUSTRALIA  
(DISEASE NOTE FOR APP, IN PRESS)**

A.E. Mackie<sup>1</sup>, S.J. Mckirdy<sup>1</sup>, B. Rodoni<sup>2</sup>, and S. Kumar<sup>1</sup>.

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**Abstract**

Potato spindle tuber viroid (PSTVd) was detected for the first time in an isolated hydroponic greenhouse tomato (*Lycopersicon esculentum* Mill.) crop in the great southern region of Western Australia (WA). An urgent eradication plan was activated because of the highly contagious nature of the pathogen. The tomato crop on the infected property was destroyed and the greenhouses and surrounding area were decontaminated. Surveys of 15 other hydroponic tomato crops did not detect any other PSTVd infected tomato plants in WA.

PSTVd originated in North America but subsequently spread to other continents through infected potato seed. The disease is reported to occur in Asia, Africa, North America, South America, Europe (Smith *et al.* 1997) and recently New Zealand (Elliott *et al.* 2001). There have been previous detections of PSTVd in breeding programs of tomatoes in the Northern Territory (Condé *et al.* 1996), and potatoes in New South Wales, Victoria and Tasmania (Constable and Moran, 1996; Australian National Collection of Fungi Accession Numbers DAR40450a and DAR73029a). In each case the disease was eradicated.

PSTVd causes a serious disease in three solanaceous crops, tomato (*Lycopersicon esculentum* Mill.), potato (*Solanum tuberosum* L.) and eggplant (*Solanum melongena* L.) as well as other *Solanum* spp. (Salazar L.F. 1989). Mild and severe strains of the disease occur. Symptoms can be confused with those of nutrient imbalance, spray damage, insect damage or plant viruses. Symptoms become more pronounced in warm conditions and under high light intensity. Severe strains can result in yield losses of up to 65 per cent in potatoes and 50 per cent in tomatoes (Salazar, 1989).

PSTVd symptoms initially appeared in patches throughout a crop of hydroponic tomatoes in a greenhouse located in the great southern region of Western Australia. Symptoms eventually spread along rows of the greenhouse as the season progressed. Infected plants were stunted and spindly with severe yellowing of the leaves and in some cases a purple tinge appeared in leaves and laterals. Lower leaves were typically darker green in colour, with a leathery texture and compressed appearance. Upper leaves and tip leaves were yellow and mottled, leaflets were slightly puckered and smaller basal leaflets were yellow with downward curling. Infected plants produced less fruit and experienced increased fruit abortion. Fruit did not ripen fully and remained hard with distinct green patches evident on the surface.

Samples were taken of both symptomatic and symptomless plants and tested for PSTVd using RT-PCR. RNA extraction and RT-PCR conditions were as described previously using primers TG21 and CT20 (Davis *et al.*, 2001; Constable and Moran 1996). A PCR product of the expected size was amplified from the symptomatic tomato leaves and the positive control (PSTVd infected potato) but not from healthy tomato tissue. To confirm this result, the RNA extraction and RT-PCR was repeated and the same result was produced. A second shipment of samples (both symptomatic and symptomless tissue) confirmed the presence of PSTVd in the tomato plants.

The PCR product produced from the symptomatic tomato leaf material was excised from the gel, purified, and submitted for sequencing. Sequence analysis showed high homology with the type strain of PSTVd. Based on 219 bp of the 258 bp PCR product, the most similar PSTVd strain to the tomato isolate from the greater southern region of WA was the 'Naaldwijk' strain (Accession number X17268) (Puchta *et al.*, 1990) with 98 per cent homology. The strain of PSTV detected in New Zealand was also most similar with this strain of PSTV (Elliott *et al.* 2001).

PSTVd is regarded as an extremely contagious pathogen that is easily spread by contact between infected and non-infected sap (Salazar, 1989). The movement of plant material and fruit from the infected property was restricted. An eradication program was developed in order to prevent the spread of PSTVd to other potato and tomato production areas within WA and Australia. For the eradication program to be effective it was necessary to remove and bury all plant material and associated hydroponic equipment. The entire greenhouse structure and all equipment that was used in the production of tomato plants had to be decontaminated with an appropriate

disinfectant (VirKon S and/or Sodium hypochlorite). VirKon S forms a mixture of biocidal agents in solution, with one of the most important being hypochlorous acid (Squire, 2001).

A period of six weeks was required after the decontamination process before any plants could be introduced back into the greenhouse structure. The subsequent crop has been thoroughly inspected 6, 12 and 18 weeks after planting and no symptoms consistent with PSTVd have been observed. RT-PCR tests completed on leaf samples collected displaying symptoms different to healthy plants have tested negative. The crop will continue to be monitored every six weeks for symptoms of PSTVd.

A survey of 15 commercial greenhouse tomato properties in WA was conducted after the positive result for PSTVd was confirmed from the Namikup property. 100 random samples were collected from all greenhouses surveyed and tested.

The surveys of the hydroponic tomato crops did not detect any other PSTVd infected crop in WA. Surveys for PSTVd of other hydroponic tomato producers will be undertaken this growing season.

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## **POTATO SPINDLE TUBER VIROID DISEASE (PSTVD) IN TOMATO AND CAPSICUM- A SUMMARY OF THE NEW ZEALAND EXPERIENCE**

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Potato spindle tuber viroid disease (PSTVd) was confirmed present in glasshouse tomato crops grown in South Auckland early in 2001, as a result of testing conducted by the Dutch Plant Protection Service. This record was independently confirmed by New Zealand Ministry of Agriculture and Forestry (MAF) through the Central Science Laboratory in York, UK.

Typical symptoms on tomato included: leaf distortion, yellowing and mottling, with reduced plant growth, leading to plant collapse. Fruit on affected plants were smaller than on healthy plants, and were sometimes slightly misshapen, with yellowing on the top of each affected fruit. These symptoms were first observed in 2000, but as the range of causes was very large (> 100 potential viruses as well as nutrient imbalances, fungal root diseases and possible herbicide damage), diagnosis proved difficult, and confirmation of PSTVd took some time.

A survey conducted by MAF covered 45 tomato glasshouses from throughout New Zealand, and as a result two further affected properties in the Auckland region and one in Nelson were confirmed. Since that time MAF and Crop & Food have received and tested 'suspicious' tomato plants from more than 10 properties and only one further outbreak in tomatoes has been recorded. This was found in September 2001, again in the Auckland region.

This outbreak of PSTVd has been attributed to a seed-borne infection, although no direct evidence of infected tomato seed has been found. Seed transmission would also account for the narrow distribution of the outbreak.

MAF discussed the outbreak with industry and initially took the view that this was a problem for industry to resolve. The NZ Vegetable & Potato Growers' Federation and growers, with advice from MAF, Crop & Food Research and overseas experts, were quick to apply control measures to this outbreak of PSTVd. Grower and worker education, sanitisation programs, and UV treatment of nutrient solutions have contributed to the successful limitation, and hopefully to elimination, of the problem on most of the affected properties.

No initial survey of potato crops was undertaken, apart from ware crops close to PSTVd outbreaks. Because of the tomato outbreak, a phytosanitary requirement has been imposed for freedom from PSTVd from some of the countries importing ware and seed potatoes from New Zealand. This has meant that export potato crops in the past 9 months have been field sampled and tested for PSTVd using an RT-PCR assay developed by MAF and refined by Crop & Food Research. Approximately 60 potato crops have been assayed and none have been found to have PSTVd. There is no detectable problem with PSTVd in the New Zealand potato industry at present.

In December 2001, MAF identified PSTVd in samples of capsicums from two glasshouses in the Auckland region. The isolate has been sequenced by the University of Auckland, and it has an RNA sequence identical to the tomato isolates. Further surveys of tomato and capsicum crops are now being conducted by MAF. Furthermore, the process of placing PSTVd under official control is currently being put in place. This will involve MAF working in collaboration with industry to sustain the momentum for eradicating the disease when it is detected.

## **PT02004, PATHOGENICITY OF POTATO SPINDLE TUBER VIROID STRAIN ON AUSTRALIA'S POTATO VARIETIES**

**Principal investigator:** Simon Mckirdy  
**Project start:** 01-Jul-02, Finish: 30-Jun-05  
**Organisation:** Department of Agriculture, Western Australia  
**Contact phone:** (08) 9368 3261

### **Outline**

In May 2001, the national potato industry became concerned when potato spindle tuber viroid (PSTV) was detected in a hydroponic tomato crop in south-west Western Australia. After national surveys were undertaken, the disease was also detected in NSW. Eradication and decontamination plans were put in place for both properties to prevent spread to other properties.

PSTV is a quarantinable disease for Australia and it poses a serious threat to Australia's potato and tomato industries. It was estimated that the disease was causing significant losses in the affected tomato crops (~ 50 per cent). The impact of this strain of the disease on potatoes is uncertain as overseas data suggests that different strains can vary somewhat in their impact on potato production.

Commonly grown potato varieties will be inoculated with the pathogen to determine pathogenicity. The identity of the strain of the viroid will be determined by complete sequencing of the genome. Work will be done to determine if PSTV is seed-borne in tomato seed and a PCR test will be validated to enable large-scale testing of seedlots for the pathogen. Further surveys will be undertaken in WA, Victoria and NSW to determine the extent of distribution of PSTV. An awareness package will be developed and presented to the Australian potato industry.

## ONION SMUT

### ONION SMUT IN SOUTH AUSTRALIA

Trevor Wicks And David Cartwright, Sardi And Pirsia

Onion Smut is caused by the fungus *Urocystis cepulae*. It is a seedling disease that attacks only members of the onion group (*Allium* spp.) and has been found on onion, leek, shallot, chives and garlic.

**Distribution:** Onion Smut has been found in Europe, North and Central America, Chile, Peru, North Africa, several Asian countries and parts of New Zealand.

Apart from one outbreak in NSW in 1966 all other reports of Onion Smut are from South Australia. These were reported in 1950, 1966, 1975, 1979, the 1980's and recently in 2001. Prompt action by growers and the State Department of Agriculture has prevented the spread of the disease in the main onion growing areas.

**Importance:** The outbreaks of Onion Smut have serious implications to the onion industry of South Australia. If the disease become established, onions for both the Australian and export markets could be prohibited from that area. More than a third of this state's total onion production is sold interstate with about 7-10 per cent going overseas.

**Symptoms:** The disease is first apparent in the emerging seedling when black streaks are found beneath the skin of the first and succeeding leaves. This may be seen when the sun shines through the leaves or when they appear thickened and bumpy, and twist and bend downwards. When broken open, the leaves are found to contain masses of black spores (fungus seeds) which will erupt through the leaf within a few days.

Black spore-producing streaks may be obvious within the bulb scales of weak and diseased seedlings which are normally killed within 3 or 4 weeks of emergence.

Occasionally plants survive in a weakened condition and produce bulbs with black streaks contain spores in the outer fleshy scales.

Onion Smut does not rot the bulb during storage.

**Spread:** Spores that erupt through the leaves and scales are released into the soil. Spores are dispersed by wind, water and in soil. The disease can be spread by soil adhering to cultivating implements, bins, sprinklers, boots and on plants harvest from infested soil.

The spores of the Onion Smut fungus may germinate and either infect a new onion crop or live on organic matter in the soil or they may remain dormant for an indefinite number of years. Severe outbreaks of the disease have been known to occur in soil that had not grown onions for more than 15 years.

The smut fungus grows slowly in the soil, and a contaminated area does not enlarge rapidly if the soil is left undisturbed.

Spread can also be diseased onion plant parts such as onion sets, transplants and bulbs. The disease is not considered to be seedborne, although seed could become contaminated if left exposed in an infected area.

**Infection:** Infection takes place before the seedlings emerge through the soil. They are susceptible from the second day after germination until the first true leaf. The susceptible period may last for up to 3 weeks but depends upon weather conditions that affect seedling growth and on the depth as which the seeds are planted.

If the fungus has reached the growing point of the plant each newly developing leaf will successively become infected.

The Onion Smut fungus grows up the plant within the developing leaves and about 5 days after infection black streaks are visible within the leaves as well as the leaf sheaths and bulbs.

**Temperature and moisture:** Onion Smut spores germinate at temperatures between 13 to 22°C, infect onion seedlings at soil temperatures above 10 to 12°C. Rate of infection reduces after 25°C and there is none at soil temperature of 29°C and above.

Soil moisture does not directly affect the fungus but excessive water keeps the soil temperature low and slows the growth of the seedlings thus prolonging their period of susceptibility.

**Quarantine procedures:** Because of the serious nature of Onion Smut, other States are notified of an outbreak and they may then implement strict quarantine procedures.

When outbreaks are detected, surrounding crops in the area are inspected to determine the extent of the disease. Infected crops are destroyed in the field with a weed killer and the soil treated with dilute formalin to destroy spores on the soil surface and to sterilise the soil.

To prevent further build up of the disease, growing onion crops and other related crops such as leeks are prohibited on the infected areas.

Onion crops grown on adjacent properties in the same or following seasons are inspected for Onion Smut.

Machinery, bins and other equipment should be thoroughly cleaned and treated with formalin before moving from an infected property.

## ASPARAGUS DISEASES IN QUEENSLAND

### ASPARAGUS STEM BLIGHT

Bob Davis, QDPI

Asparagus stem blight, [*Phomopsis asparagi*], is a serious disease of asparagus in China and Japan but has remained confined to asparagus properties in the Warwick area of southern Queensland since 2000. This was the first detection of the disease in Australia. Asparagus stem blight causes stem death, fern defoliation and loss of production and is particularly damaging during moist humid conditions. The disease can affect edible asparagus as well as some other species.

The first symptom of stem blight is discolouration of the stem tissue, followed by the appearance of oval-shaped areas with light brown centres and slightly darker margins. As the infection progresses, affected areas become shrivelled and turn into well defined spots surrounded by dark margins. The centre of these spots will eventually become ashy-white. Berries appear not to be affected, however the disease can be found on leaves and any parts of the stems. Infected stems turn brown and die. It is most commonly observed after prolonged periods of wet weather, often in late Spring-early Summer. Symptoms have also been found on asparagus spears.

Currently this disease is of major concern to growers on affected properties. It is very difficult to manage, and yield and spear quality appears to be dropping significantly.

### Asparagus rust

Bob Davis, QDPI

Asparagus rust, [*Puccinia asparagi*], is probably a less serious disease than *Phomopsis* stem blight. It affects all above ground plant parts except the berries and is most damaging during prolonged dry periods. It affects edible and some ornamental asparagus. The disease weakens plants and reduces marketable yield of asparagus spears. It has been found in a number of asparagus growing districts in Queensland in 2000, and appeared in a tropical production area near Ayr in 2001. It has not been recorded from outside Queensland at this stage. Overseas it occurs in eastern and central Asia, southern and eastern Africa, Europe, and North America with the nearest location outside Australia being the Philippines. Rust can survive in a broad range of conditions and could be expected to survive and colonise in most asparagus growing areas in Australia and New Zealand.

All stages of rust have now been observed in Queensland (known commonly as the orange, red and black spore stages). Although regarded as a potentially major concern initially, growers now believe asparagus rust could be managed with relatively little effort, provided some basic crop management principles are followed. Infected crops may still produce spears but production will be unsustainable if management is not properly directed. Rust has already decimated a feral roadside population of plants at one location in southern Queensland.

### Anthracnose

Bob Davis, QDPI

Anthracnose, [*Colletotrichum gloeosporioides*], was recorded on native asparagus in northern Australia in 1991 before being observed in a crop of edible asparagus in 1996 near Katherine in the NT. Severe anthracnose destroyed this commercial planting. In 2001, the disease was found in several crops of asparagus growing in northern Queensland. Anthracnose is so far restricted to tropical production areas here. Typically, large, spreading lesions with water-soaked, ill-defined margins appear on fern stems. The centres of these lesions become pale and depressed and develop a concentric pattern of dark acervuli as they age. Large numbers of conidia are produced which rapidly lead to secondary infections. Stem death is common during the usual wet and humid summer period as a result of continual infection. Anthracnose symptoms closely resemble those produced by *Phomopsis asparagi*. Anthracnose has not been found on harvested spears. Young asparagus fern inoculated with isolates of *C. gloeosporioides* derived from field symptoms developed anthracnose symptoms within 7 days. It is not yet known whether the causal fungus is a specialised form of *C. gloeosporioides* but as an unspecialised form it is a common pathogen of many hosts in Australia. Anthracnose is a potentially debilitating disease of asparagus and is not believed to exist in other asparagus producing countries. There is great interest from overseas countries regarding development of this disease here.

Anthracnose appears to be a very serious disease at this early stage.

## ASPARAGUS ANTHRACNOSE IN THE NORTHERN TERRITORY

Barry Condé, Rex Pitkethley and Isagani Arao-Arao,  
DBIRD-Primary Industry, Darwin, NT

**First record in 1991 and major disease in 1996:** Anthracnose (*Colletotrichum gloeosporioides*) is the most significant disease of asparagus in Katherine. The disease was first identified and recorded by Plant Pathology Branch in 1991 as one of a number of fungal infections on trial plantings. Its importance did not become apparent until more recent years with the increased plantings of asparagus in the area. The *C. gloeosporioides* isolated from infected plants was confirmed as the cause of the disease by pathogenicity tests in the glasshouse in 1996. Crops on two properties were destroyed by this disease in 1996. This particular anthracnose is a disease of above-ground parts of the plants and causes elliptical whitish coloured lesions on the stems. The springing structures (acervuli) of the fungus are visible on the lesions as concentric black rings. Lesions are often, but not always, centred around leaf axils or nodes. Affected stems can die and dry out. Because of this, food reserves in the rhizome are not replenished and so are depleted, leading to reduction in yield. Bob Davis (Qld DPI) recorded this disease from north Queensland in March 2001 from specimens sent from Mareeba.

**Screening for Resistance:** Because of the importance of asparagus anthracnose, several inbred lines were screened for resistance to the disease in the Plant Pathology glasshouse at Darwin. The asparagus seedlings in tubes were spray inoculated twice with a spore suspension of *C. gloeosporioides* grown on agar plates. The screening was inconclusive. No resistant lines could be identified from this glasshouse screening experiment. It was felt that screening in a disease nursery situation would be more productive.

**Anthracnose found on native asparagus 1997:** The disease spreads within a crop by rain (or irrigation) splash and over longer distances by wind-driven rain. There is no evidence that the disease is seed-borne but that cannot be ruled out. Lesions on living stems, dead stems and trash provide inoculum for infections. The original source of the disease is most likely from native asparagus in the Top End. The disease was found on a native asparagus in the Top End (*Protasparagus racemosus* (Willd.) Oberm.) and on an ornamental asparagus, both in 1997. Asparagus anthracnose is most likely caused by a distinct strain of *C. gloeosporioides*, and there is no evidence to suggest a threat to mangoes or other crops. Anthracnose diseases of herbaceous plants tend to be host specific, compared with those affecting fruit trees. *C. gloeosporioides* is recorded as a disease of asparagus in USA. It is also known to exist in asparagus growing areas of Mindanao, the Philippines. It is possible that races may have developed independently in different countries.

**Third crop infected 1997, no asparagus 2001:** In the instances of the first two asparagus crops destroyed in 1996, it took two to three years for the inoculum to build up to cause significant damage in the crops. Our hypothesis is that the primary inoculum is from the native asparagus. Once the *Colletotrichum* from the bush finds its way into the asparagus crop, it has ideal conditions to multiply rapidly within the crop. A new crop planted by a new grower in 1996 was already severely damaged by anthracnose during the 1996-1997 wet season. This new crop was planted next to one of the old crops which was severely damaged by 1996. The neighbour had not destroyed his anthracnose damage crop, allowing it become a large source of inoculum to be spread by wind-driven rains to the newly planted *Colletotrichum*-free crop.

**Inoculation Experiments:** Initial inoculation experiments in Darwin indicated that symptoms and sporulation occurred in 10 days when strong mature plants (variety UC157) in pots were spray inoculated with a spore suspension of *Colletotrichum gloeosporioides* from agar culture. The first symptoms seen were oval-elliptical lesions with a colour slightly paler than the normal green plant colour with copious orange sporulation.

In another inoculation experiment commenced in April 2000, six isolates were used to inoculate two six inch pots each of cultivar UC157. This was done to compare incubation times for the isolates, pathogenic reactions, and to learn more of the pathogenic process. Again, the first symptoms were observed in 10 days. An interesting result was that in three instances where the inoculum was in low concentration, symptoms were first observed 33 days after inoculation.

Another inoculation experiment was done in March 2001, involving spray inoculation of very young asparagus seedlings in polystyrene cups with a concentrated spore suspension from young actively growing cultures on PDA. Extensive lesions and sporulation on the very thin stems were observed within only 4 days.

**Other observations:** In another experiment, dormant crowns of asparagus were taken from Katherine to Darwin. Anthracnose symptoms were observed on new fern growth arising from several of these asparagus crowns cv. Atlas 48 days after the crowns were brought to Darwin. The causal *C. gloeosporioides* was isolated from these symptomatic plants. This suggests that the *C. gloeosporioides* inoculum can remain viable for at least 48 days as saprophytic growth on debris on asparagus crowns.

**Disease outbreak Observations in Katherine, NT and Kununurra, WA:** Whilst investigating asparagus anthracnose at Katherine, we received several specimens of diseased asparagus from growers in Kununurra, Western Australia. All Kununurra specimens proved to be infected with purple or fern spot caused by *Stemphylium* sp. No anthracnose was found. The *Stemphylium* disease appeared to be more severe in Kununurra than in southern Queensland, perhaps because of the higher temperatures in Kununurra. It would appear that the *Stemphylium* was introduced into Kununurra with asparagus or some other crop.

Fortunately no *Stemphylium* has been found in Katherine, NT. The geographical range for the native asparagus (*Protasparagus racemosus*) extends from the top of Western Australia through the Top End of NT into Cape York and coastal north Queensland. Since this native asparagus appears to be the native host for asparagus anthracnose, this explains the occurrence of this disease in the crops in Katherine and north Queensland. The absence of this disease in the Kununurra growing area can be explained if the bush including native asparagus had been thoroughly cleared in the Kununurra growing areas.

The origin of the anthracnose in native asparagus also explains why it took two to three years / seasons for the anthracnose to enter the crop and build up to significant extent to cause damage in the first two crops. The third crop was grown by a new neighbour in a paddock next to one of the 1996 outbreaks where the heavily diseased crop was left standing. Wet season wind driven rains took the inoculum from existing heavily diseased crop to the new as yet unaffected crop. Unfortunately, the new grower was given inaccurate advice that there were no serious asparagus problems. The new grower also used a centre pivot irrigation, which gave ideal humid conditions for the spread of this disease.

In glasshouse trials, benomyl and copper oxychloride gave satisfactory control of asparagus anthracnose. However, this was not the case on the farms. The disease causes lesions on ferns and also lesions on newly emerging and older spears at ground level. The lesions at ground level are of far greater consequence to the crop because the whole spear and fern dies, and no carbohydrates are fed back into the crowns, thus depleting the reserves in the crowns. Large fern growth prevents the spray penetration to the base of the spears where it is most needed. Also saprophytic anthracnose growth on dead asparagus material provides ideal inoculum for infecting newly emerging spears.

**Towards a management strategy for asparagus anthracnose:** Firstly, it needs to be kept in mind that anthracnose is a serious disease where it occurs in the tropics and it is important to put in place management strategies to get on top of it. So monitoring is important. It is important not to use overhead watering as this creates an atmosphere that encourages the disease buildup. Rather, T-tape irrigation should be used. Katherine experiences wet season rains, which can not be avoided. A suitable management strategy involves slashing the crop under the soil surface just before the wet season by 'root pruning' and removal of infected plant material by either burning or carting away. This both removes inoculum and opens the plants up for efficient spraying for more effective spray control of the disease at the base of newly emerging spears. Plants should be slashed and sprayed in a similar fashion at the end of the wet season.

## New Zealand asparagus projects

**Pathogens:** *Puccinia asparagi*, *Phomopsis asparagi*  
**Research aim:** New diseases, integrated control, cultivar reaction, disease prediction  
**Principal investigator:** Lian Heng Cheah  
**Institution:** Crop & Food Research

**Pathogen:** *Phytophthora megasperma*  
**Research aim:** Resistance breeding  
**Principal investigator:** Peter Falloon  
**Institution:** Aspara Pacific

**Pathogen:** *Phytophthora megasperma*  
**Research aim:** Biological control with natural products and fungi  
**Principal investigator:** Lian Heng Cheah  
**Institution:** Crop & Food Research

**Pathogen:** *Asparagus virus 2*  
**Research aim:** Pathogen-free seed production  
**Principal investigator:** Jeanne Jacobs, Peter Falloon  
**Institution:** Crop & Food Research, Aspara Pacific

## APPENDIX 2: METHYL BROMIDE PHASEOUT, AND OTHER CHEMICAL ISSUES

### HG98051, LOCAL GROWER TRIALS TO IMPROVE ADOPTION OF ALTERNATIVES TO METHYL BROMIDE SOIL FUMIGATION

**Principal investigator:** Alan Shanks  
**Project start:** 01-Nov-98, finish: 31-Dec-02  
**Organisation:** Agriculture Victoria  
**Contact phone:** 03 9210 9222

#### Executive summary

A regional grower trial program (HG 98051) was established in 1998 to allow growers, fumigation contractors and local researchers to trial best-bet alternatives to methyl bromide (MB) in their industries, assess the effectiveness against pests, diseases and weeds, and identify any barriers to their adoption. Two rounds of trials have been conducted since 1998.

This season trials were established at:

- Sunraysia, Vic
- Jandabup, WA
- Brisbane, Qld
- Camarvon, WA
- Camden, NSW
- Virginia, SA

#### Major findings

- Six trials were established evaluating 8 fumigant alternatives (Telone® II, Telone® C-35, Telone® C-60, metham sodium / chloropicrin mixtures (3 rates), chloropicrin 98 per cent, dazomet) and 3 non-fumigant alternatives (solarisation, recycled green waste and mustard meal) to MB.
- Fumigant alternatives have performed well in regional trials with Telone® C-35, metham sodium / chloropicrin mixtures (Sunraysia melons) and reduced rates of dazomet (WA capsicums) providing results comparable with MB.
- Regional trials have increased grower confidence in low-concentration MB mixtures (i.e. MB 30:70), however, adoption rates are low in most States except Victoria. Efforts need to be increased in other States to encourage the use of MB 50:50 and MB 30:70 so that national consumption falls within the quotas required to meet the 70 per cent phase-out being imposed on 1 January 2001.
- Development of experimental machinery for the application of dazomet for the Camarvon capsicum trials.
- Measurement of fumigant profiles has resulted in an improved understanding of application issues relating to dazomet, Telone® C-35 and metham sodium / chloropicrin mixtures.
- Trial data was used to assist with the registration of Telone® II and Telone® C-35 by Dow AgroSciences Ltd.
- Trials in WA capsicum and Sunraysia melon industries identified that further investigation of application equipment/techniques are required for metham sodium and dazomet.
- Reduced rates of dazomet (250 kg/ha) provided the best early vigour, weed control and highest fruit yields in Camarvon capsicum trials.
- Biofumigants (i.e. mustard meal) have potential for inclusion in IPM systems to replace MB in WA capsicum trials (in combination with solarisation and low-rate application of fumigant alternatives) and NSW flower trials (incorporated under plastic mulch).
- Soil solarisation has great potential for inclusion in IPM systems to replace MB. High ambient and soil temperatures in summer have demonstrated some potential in WA strawberry and WA capsicum trials this year.



## **HG01005, FACILITATING NATIONAL ADOPTION OF METHYL BROMIDE ALTERNATIVES**

**Principal investigator:** Alan Shanks  
**Project start:** 12-Nov-01, finish: 30-Nov-04  
**Organisation:** Agriculture Victoria Knoxfield  
**Contact phone:** (03) 9210 9222

### **Milestone report**

The national methyl bromide (MB) communication project (HG96049) and national grower trial program (HG98051) have played an essential role in assisting growers to adopt key outcomes from the national R&D projects. In Australia, growers are gradually changing soil disinfestation practices so that horticultural industries, worth over \$300 million, will be able to maintain productivity without economic loss. The project has also insured that Australia has been able to fulfil its commitments to phase-out MB by 25 per cent under the Montreal Protocol.

HG96049 was completed in June 2001, however, with only three growing seasons left before phase out of MB for soil disinfestation and the likelihood that restrictions will be imposed for quarantine and pre-shipment (QPS) uses, the adoption of alternatives by growers in the next few years is paramount. The communication and national grower trial program involved in this project are essential to achieving this outcome.

### **The project will:**

- (1) facilitate the adoption of MB alternatives through the continuation of the successful national grower trial program;
- (2) disseminate R&D results to industry via the National Methyl Bromide Update newsletter;
- (3) communicate information on international requirements and/or restrictions on MB for QPS uses;
- (4) provide a vehicle to enable growers and other parties to give feedback to EA on QPS uses;
- (5) continue to provide growers with the most relevant information from Protocol meetings, research conferences, computer databases and the internet.

### **Outputs**

Newsletter communicating outcomes of R&D programs from around Australia and overseas.

Newsletter articles targeting newsletters of chemical re-sellers and Industry Development Officer networks.

Website highlighting Australia's approach to the MB phase-out.

Tailored information packages for MB users in specific industries.

Training programs in the use of alternatives where identified as appropriate.

### **Outcomes**

- (i) Adoption of MB alternatives by industry facilitated through communication of findings from Australian and overseas R&D programs.
- (ii) Australia meets MB phase-out targets set by the Montreal Protocol with minimal impact on key horticultural production components, e.g. disease and weed control, yields.
- (iii) Australia's approach to the MB phase-out coordinated through maintenance of national and international communication networks including Federal and State governments, industry, chemical companies and contractors.
- (iv) Industry needs assessed in relation to soil disinfestation and feedback provided to the MB R&D Committee to maintain relevance of funding R&D.

## NATIONAL GROWER TRIAL UPDATE FEB 2001

### **QLD - Flowers**

**Researcher:** John Hargreaves, QDPI Redlands no significant difference between MB, Telone, Telone C35, Basamid® and untreated; negative treatment effect possibly due to low disease pressure.

Repeat in 2001 after disease build-up.

### **WA - Strawberries**

**Grower:** Gerry Verheyen  
Support from Dennis Phillips, Ag WA

Visual assessment of 99/00 trial suggested that MB 50:50, Telone C35 and Metham sodium (trickle application) increased plant establishment and yield compared with the untreated plots.

The 99/00 trial will be repeated in 2001 but with objective yield, disease and weed measurements.

### **SA - Glasshouse capsicums**

**Researcher:** Trevor Wicks, SARDI

**Consultant:** Domenic Cavallaro Grower: George Panuccio no significant difference in plant height and yield between treatments: MB 98:2 (Hot gas), Telone C35, Chloropicrin, Metham sodium and untreated; trial results deemed invalid due to severe outbreak of tomato spotted wilt virus (TSWV); Future trials will use capsicum varieties resistant to TSWV.

### **Vic - Melons**

**Researcher:** Gerard Kelly, NSW Ag, Dareton

**Grower:** Fred Dawson

In July 2000 a trial was established looking at reduced rates of methyl bromide (50:50) and Telone C35 with virtually impermeable films (VIFs).

Grower meetings were held after establishment and during the harvest to discuss fumigant action and yield data

Growers were pleased with the plant vigour in VIF plots

VIF plots with a reduced rate of MB or Telone C35 had similar yields to normal MB rates with low-density polyethylene tarps.

### **WA - Field capsicums**

**Researcher:** Kesi Kesavan, WA Ag, Canarvon

Treatments - Dazomet (250 & 500 kg/ha), Fumafert (mustard meal and neem cake) and metham sodium under clear and black plastic;

Dazomet and Fumafert treatments provided the best early yield data;

Final yield data supported the preliminary results;

Future work aims to confirm the results with these products and look at solarisation effects in conjunction with these treatments.

### **NSW - Glasshouse flowers (crop: stocks)**

**Researcher:** Bettina Golnow, NSW Ag, Camden

Treatments - comparison of traditionally-used fumigants (MB 70:30 & 30:70, Dazomet) against 'organic/biological' approaches (mustard meal and surface applied compost);

Trial to be conducted over two years as the organic/biological treatments may have a gradual effect;

Site has a known population of Sclerotinia, Pythium, Rhizoctonia and Fusarium; Weed growth, yield (marketable # stems and fresh weight) and disease incidence data is currently being analysed.

## VX99021, DETECTION AND MANAGEMENT OF COPPER-TOLERANCE IN BACTERIAL DISEASES OF VEGETABLES

**Principal investigator:** Heidi Martin  
**Project start:** 01-Jul-99, finish: 30-Jun-02  
**Organisation:** QLD Department of Primary Industries  
**Contact phone:** 07 4783 2355

### Project aims

Regular applications of copper-based bactericides are currently recommended for pre-harvest control of watermelon fruit blotch, bacterial spot of capsicum and black rot of brassicas. Under conditions favourable for disease development, copper treatments are applied soon after seedling emergence and are re-applied weekly. Such regular applications are often associated with foliar toxicity symptoms, plant stunting and reduced fruit set and fruit size at maturity, particularly in melon crops. Copper contamination of soil is another undesirable side effect, which is often linked to regular copper usage. In addition, the development of copper-tolerant bacterial strains is an increasing problem worldwide and has been associated with poor levels of control in some areas treated with recommended copper concentrations. In Australia, there are currently no compounds registered which may be used to control these pathogens if copper is ineffective.

Overseas work has identified copper-tolerance in populations of numerous bacterial diseases, including bacterial spot of capsicum. The copper sensitivity status of Australian populations of watermelon fruit blotch, bacterial spot of capsicum and black rot of brassicas is unknown, however given the seed-borne nature of these diseases and considering the international traffic of seeds, the introduction of copper-tolerant strains into Australia on contaminated seed is a possibility.

This project will provide knowledge of the copper-sensitivity status of these pathogens in the two major vegetable production districts in Queensland, as well as identifying chemical formulations which may be used as alternatives to registered copper bactericides to control existing and prevent further development of copper-tolerant bacterial strains

### Progress

Two field assessments of selected bactericides were completed for control of black rot of brassica (*Xanthomonas campestris* pv. *campestris*) at Applethorpe Research Station in 2001. A total of nine treatments have been examined in these assessments. Both trials were inoculated with *Xanthomonas campestris* pv. *campestris* at the commencement of the trials.

A field assessment of copper formulations for control of bacterial spot of capsicum (*Xanthomonas campestris* pv. *vesicatoria*) was completed at Gatton Research Station, January-May 2001. Inoculated seedlings were planted in the guard rows to ensure that the disease pressure was high. Twelve treatments were compared in a randomised complete block design with 3 replications. Sprays were applied weekly using a knapsack hydraulic sprayer fitted with hollow cone nozzles. Plants were assessed for disease severity and incidence at three times throughout the crop.

Means followed by the same letters are not significantly different at the 5 per cent level.

Plots sprayed with Mankocide DF and tank mixes of Kocide DF and Mancozeb WG were the best treatments in the trial. Both of these treatments offered significant improvement over the standard industry practice (Kocide DF).

A selection of trials was also conducted at Gatton Research Station in 2001, comparing the efficacy of various spray application technologies. Copper-based bactericides are protectant chemicals. Consequently, optimising spray delivery and plant coverage is critical to ensure disease control potential is maximised. Trials have been completed to assess spray application methods (conventional hydraulic boom, air-assisted boom) and nozzle types (flat fans, hollow cones, twinjets, air induction) for rockmelons and watermelons. Application methods (conventional hydraulic boom, air assisted boom, conventional hydraulic boom with droppers, knapsack sprayer), nozzle types (flat fans, hollow cones, twinjets, air induction) and application volumes (100 L/ha, 200 L/ha, 300 L/ha and 400 L/ha) have also been assessed for capsicum. A selection of results from these trials is presented below.

The air assisted spray rig was superior to other application methods in providing an even distribution of spray droplets on the upper and lower leaf surfaces of both watermelon and rockmelon plants. Twinjet nozzles provided the most uniform coverage of watermelon leaves when they were fitted to a conventional hydraulic boom

Air assisted spray rigs produced the most uniform distribution of spray droplets throughout the canopy of mature capsicum plants.

Additional field and glasshouse assessments of bactericides and spray application technologies have been scheduled for the 2001-2002 growing season. These trials include investigations into spray application rates and schedules, spray adjuvant assessments and additional replicated spray application trials.

## **HG00048, DEVELOPMENT OF A PLANT DEFENCE BOOSTER TO ASSIST DISEASE MANAGEMENT IN A RANGE OF CROPS**

**Principal Investigator:** Ian Macleod  
**Project start:** 01-Jan-01, finish: 30-Jun-02  
**Organisation:** Serve-Ag Pty Ltd  
**Contact phone:** 03 6427 0800

### **Background**

Many horticultural industries have limited options for control of diseases. In particular, bacterial and viral diseases are very difficult to manage with conventional crop protection products. Increasingly, efforts are being made to find new products that take a bigger picture approach to managing plant diseases. Plant defence activators provide a new management tool to assist in achieving this.

Syngenta (previously Novartis Crop Protection) has discovered a new product, Bion, which has been shown to provide significant control of a range of plant pathogens in a number of crops overseas, through defence activation. Due to the complex nature of plant defence activation, and the many permutations of usage and target disease / crop combinations, it is not commercially viable to develop this product in Australia under normal company development systems.

Syngenta is developing partnerships with other commercial and research groups to facilitate the development of Bion. By working with those that have expertise in plant diseases in horticultural crops, it is possible to bring to market a new product with potential to assist with the control of a range of fungal, bacterial and viral diseases in key crops such as grapes, cucurbits, tomatoes and lettuce.

### **Objectives**

- Alternative management tool for certain fungal, bacterial and viral diseases.
- A potentially viable new crop protection tool.
- Reduction in the use of traditional crop protection products.

### **Work undertaken to date and outcomes**

- Trials are being conducted to evaluate Bion on cucurbits, lettuce, tomato, strawberry, grapes, pea, and rose for various diseases caused by bacteria, fungi, and viruses.
- Initial studies showed that it has good potential for the control of downy mildew on lettuce and pea, and bacterial spot on tomato. Other trials are still in progress.

### **Technology transfer**

Updates given in milestone reports to Horticulture Australia Ltd, and regular review of trials with Syngenta.

**VX01006, DEVELOPING COST EFFECTIVE UV PROTECTION OF BIOLOGICAL PESTICIDES**

**Principal investigator:** Brian Hawkett  
**Project start:** 01-Dec-01, finish: 30-Jun-03  
**Organisation:** University of Sydney  
**Contact phone:** (02) 9351 6973

No report available.

## APPENDIX 3: ONION AND OTHER ALLIUM DISEASES

### SCLEROTIAL GERMINATION STIMULANT SUPPRESSES ONION WHITE ROT

G.P.V. MacManus<sup>A</sup>, R.D. Davis<sup>a</sup>, K.L. Bell<sup>b</sup> and R.A. Kopittke<sup>c</sup>

<sup>A</sup>Queensland Horticulture Institute LMB 7, M/S 437 Gatton Q4343

<sup>B</sup>Biometry, Queensland Department of Primary Industries PO Box 102 Toowoomba Q4350

<sup>C</sup>Biometry, Queensland Department of Primary Industries LMB 4, Moorooka Q4105

#### Introduction

White rot (*Sclerotium cepivorum* Berk.) is one of the most widespread and destructive fungal diseases of *Allium* species. It is difficult to manage because of the longevity of sclerotia, which can survive in the soil for up to 20 years. The optimum soil temperature for sclerotial germination is 14–18°C (1). In SE Queensland this occurs normally during the winter months (June–August). Diallyl disulfide (DADS) which is produced by *Allium* roots or synthetically, stimulates sclerotial germination. DADS has significantly reduced disease and increased yield in Tasmania and Queensland (2), NZ, UK and US (1). DADS is injected into the soil months before onions are sown, when soil temperatures are favourable for sclerotial germination.

#### Materials and methods

In 1999 DADS was applied to a farm site in the Lockyer Valley with a history of high onion white rot incidence using a modified metham sodium application rig. The DADS was applied under pressure (200 kPa) to a maximum soil depth of 30 cm. Treatments were applied as single and split applications as follows:

1. DADS 9.5 L/ha (May) + 14 L/ha (July)
2. DADS 9.5 L/ha (May) + 9.5 L/ha (July)
3. DADS 14 L/ha (May) + 9.5 L/ha (July)
4. DADS 9.5 L/ha (May)
5. DADS 14 L/ha (May)
6. Control (Untreated)

Local onion seed (Neuendorf Golden Brown) was sown on 28 March 2000 using a Randomised Complete Block Design of six treatments and three replicates. Each plot comprised two beds, 10 m in length with eight rows/bed on 1.6 m centres. Weekly disease assessments commenced from 14 July to 18 August with infected bulbs being removed at each sampling time. Soil temperatures at 15 cm depth were recorded. The trial was harvested on 23 August, 148 days after planting (148 DAP), with the number of marketable bulbs and yield being recorded. Statistical analysis (ANOVA) was performed using GENSTAT5 (3).

#### Results and discussion

First infection was noticed in the Control plots on 31 May when the soil temperature ranged from 13.4 to 16°C. Levels of disease incidence and marketable yield are recorded in Table 1.

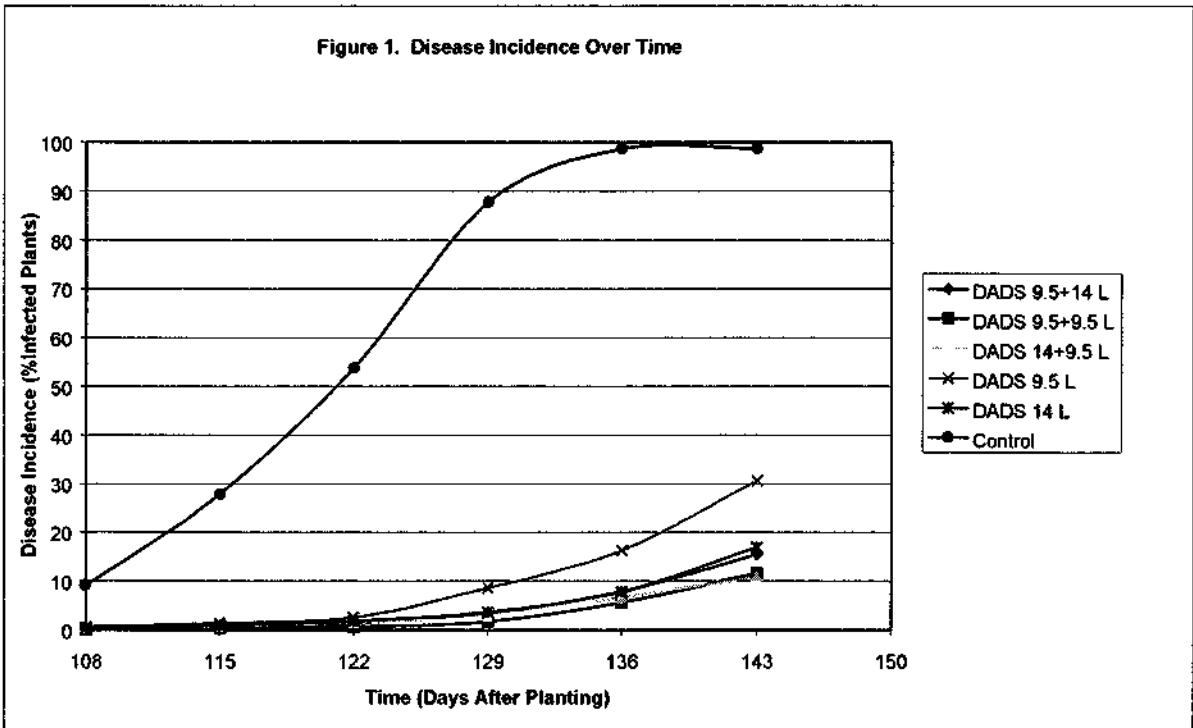
Table 1. Effect of DADS applications on disease incidence and marketable yield of onions

Treatment (Rate & timing of DADS)	Disease Incidence (% Infected)	Yield (t/ha)
1. 9.5 L (May) + 14 L (July)	15.4 a*	37.5 ab
2. 9.5 L (May) + 9.5 L (July)	12.2 a	37.7 ab
3. 14 L (May) + 9.5 L (July)	10.6 a	41.1 a
4. 9.5 L (May)	30.7 b	29.7 bc
5. 14 L (May)	21.2 ab	25.2 c
6. Control	95.1 c	0
LSD (P < 0.05)	14.2	10.9

Treatment means followed by the same letter are not significantly different (P < 0.05) using Fisher's LSD test.

The Control treatment showed very high levels of disease (95.1 per cent bulbs infected) and no marketable yield. In contrast, the DADS treatments showed significantly lower infection levels, varying from 10.6 per cent to 30.7 per cent, with marketable yield ranging from 25.2 to 41.1 t/ha. Split applications were no better than single applications and there was no benefit from using the higher rates of application. (The Control treatment was omitted from the analysis since its variability differed to the DADS treatments and to have included it would have violated the assumptions of ANOVA). In NZ Alli-Up<sup>®</sup>, a commercial formulation of DADS (900 g/L a.i.) is recommended for use at 5-10 L/ha as split applications (spring and autumn) when soil temperatures are in the 12°C-20°C range.

The disease progress curve Figure 1 shows clearly that 4 weeks prior to harvest (122 DAP, on 28 July) there was very little infection in the DADS treatments (0.6 per cent to 2.6 per cent) compared to 53.8 per cent for the Control. One week later (129 DAP) the level of disease in the DADS treatments was still very low, ranging from 1.7 per cent to 8.7 per cent, while 87.8 per cent of the plants in the Control plots were infected. It is proposed that the subsequent late infection in the DADS treatments was most likely due to infection emanating from below the 30 cm treated zone of the soil profile which concurs with other research findings (1).





## **VG98140, OPTIONS FOR MANAGING ONION WHITE ROT**

**Principal investigator:** Gerry MacManus  
**Project start:** 12-Apr-99, finish: 01-Mar-03  
**Organisation:** QLD Department of Primary Industries  
**Contact phone:** 07 5466 2222

### **Project aims**

Components of the project include: developing and implementing expedient registration of diallyl disulphide (DADS) for use in Australia; developing fungicide treatments for practical disease management; investigate the use of various biologically based products for controlling white rot; assess the potential for using onion transplants; develop an awareness among producers and itinerant harvesters to onion white rot and their responsibilities regarding its spread.

### **Progress**

All experiments on target for completion by end of project. Trials are running according to plan. During the 2002 season three off-station trials on growers' farms have been planned using DADS and dried garlic powder (DGP) as pre-plant treatments with some post-plant fungicide or biological treatments to be applied. Two of these trials have been planted (late March) with the remaining one to be planted in early April. At the Gatton Research Station five field trials are planned with two already planted (late March) and the remaining three to be planted in April. These include trickle as a total management package (nutrition, irrigation and fumigation), solarisation, seed treatments (fungicides +/- granulation treatment), Yates varietal assessments and Trichoderma trials. A glasshouse trial comparing different seed treatments is also planned for April/May. United Agri Products, NRA and TIAR consulted regarding registration of DADS.

## VG00013, MANAGING DISEASES OF LEEKS

**Principal investigator:** Trevor Wicks  
**Project start:** 01-Jul-00, finish: 30-Jun-03  
**Organisation:** SA Research & Development Institute  
**Contact phone:** (08) 8303 9563

### Aims

To determine the main diseases of Leeks in Australia and to develop strategies for control.

### Outcomes

Leek plantings in South Australia have been sampled on a regular basis to isolate organisms from diseased plants. Pathogenicity tests with a number of fungi and bacteria have been carried out and it appears that Fusarium Basal Rot, Stemphylium Leaf Blight and Purple Blotch (*Alternaria porri*) are the main pathogens. *Pseudomonas syringae* and *Botrytis cinerea* have also been found but are not significant pathogens. Fusarium Basal Rot is the major problem in Leek production in South Australia and possibly in Western Australia and Victoria. Several Fusarium species were recovered from roots and crowns of damped off seedlings and rotting mature plants. Pathogenicity tests showed that 21 per cent of the isolates produced crown rot in seedlings. The two most pathogenic isolates have been sent for formal identification. Up to 60 per cent of seedling have been infected with Fusarium before planting however the source of infection is unknown.

### Trials

Five field trials have been set up to determine the effectiveness of pre plant fungicide drenches of Bavistan, Octave and the biological agent Trichoderma as a means of managing Fusarium Basal Rot.

### Future Directions

Further fungicide trails to control Fusarium Basal Rot and Stemphylium Leaf Blight.

Determine the source of Fusarium infection in seedlings.

## **VG01096, STOP THE ROT - MANAGING ONION WHITE ROT IN SPRING ONIONS**

**Principal investigator:** Ian Porter  
**Project start:** 01-Apr-02, finish: 30-Jun-05  
**Organisation:** Department of Natural Resources and Environment  
**Contact phone:** (03) 9210 9222

No report available.

## **VX99046, ASSESSMENT OF THE POTENTIAL OF DEHYDRATED GARLIC PRODUCTS TO ASSIST WITH THE INTEGRATED CONTROL OF ONION WHITE ROT**

**Principal investigator:** Jason Dennis  
**Project start:** 01-Jan-00, finish: 31-May-02  
**Organisation:** Field Fresh Tasmania  
**Contact phone:** (03) 6428 3555

No report available.

## **VX00020, ASSESSING POSTHARVEST HANDLING SYSTEMS FOR FRESH GARLIC PRIOR TO VALUE ADDING AS PHARMACEUTICALS**

**Principal investigator:** Howard Hollow  
**Project start:** 15-Oct-00, finish: 16-Nov-00  
**Organisation:** PIRSA Rural Solutions  
**Contact phone:** (08) 8389 8800

No report available.

## **NEW ZEALAND ONION PROJECTS**

**Pathogen:** *Sclerotium cepivorum*  
**Research aim:** Integrated disease management, biological control and resistant cultivars  
**Principal investigator:** Alison Stewart  
**Institution:** Lincoln University

**Pathogen:** *Sclerotium cepivorum*  
**Research aim:** Fungicide control  
**Principal investigator:** Bob Fullarton  
**Institution:** HortResearch

**Pathogen:** *Sclerotium cepivorum*  
**Research aim:** Pathogen genetic diversity  
**Principal investigator:** Bob Fullarton, Alison Stewart  
**Institution:** HortResearch, Lincoln University

**Pathogen:** *Sclerotium cepivorum*  
**Research aim:** Disease prediction  
**Principal investigator:** Bob Fullarton  
**Institution:** HortResearch

**Pathogen:** *Sclerotium cepivorum*

Research aim: Disease resistance through genetic engineering  
Principal investigator: Colin Eady  
Institution: Crop & Food Research

**Pathogen:** *Aspergillus niger*

Research aim: Effects of soil inoculum and storage conditions  
Principal investigator: Bob Fullarton  
Institution: HortResearch

**Pathogen:** *Peronospora destructor*

Research aim: Disease forecasting for improved efficiency of fungicide control  
Principal investigator: Robert Beresford, Peter Wright  
Institution: HortResearch, Crop & Food Research

**Pathogen:** *Botrytis cinerea*

Research aim: Develop disease prediction tool for decision support system  
Principal investigator: Suvi Viljanen-Rollinson  
Institution: Crop & Food Research

**Pathogen:** *Bacterial softrot*

Research aim: Cultural control  
Principal investigator: Peter Wright  
Institution: Crop & Food Research

## APPENDIX 4. LEAFY VEGETABLES

### VG98048, ADAPTING TO CHANGE: ENHANCING CHANGE SKILLS THROUGH COLLABORATIVELY DEVELOPING AN INTEGRATED PEST AND DISEASE MANAGEMENT STRATEGY FOR LETTUCE

**Principal investigator:** Sandra McDougall  
**Project start:** 01-Jul-98, finish: 31-Mar-02  
**Organisation:** NSW Agriculture  
**Contact phone:** (02) 6951 2728

#### Summary

Lettuce is a crop in which all but a few outside wrapper leaves are harvested and sold for consumption. It therefore has very little tolerance for damage. Diseases and pest injury need to be prevented as early as possible. Prior to this project lettuce growers in Australia were principally calendar sprayers using overhead boom sprayers. Many growers were not confident in recognising lettuce insect pests, beneficial insects or insects that have no serious impact on lettuce. Growers were routinely using a synthetic pyrethroid and methomyl for general caterpillar control and dimethoate for thrips or aphid control.

This project defined a crop monitoring protocol, identified the key pests and diseases, developed management guidelines for all key pests, increased the number and improved the efficacy of control methods available to lettuce growers, and developed tools to aid growers in making pest management decisions.

Regular pest and disease surveys in Hay, NSW were conducted to monitor the range and incidence of pests in head lettuce throughout the growing season. *Heliothis* (*Helicoverpa armigera* and *H. punctigera*), particularly *H. armigera* is the key insect pest in Hay in late summer, early autumn. Loopers (*Chrysodeixis* spp.) and Cluster caterpillars (*Spodoptera litura*) were also found in autumn and spring. Aphids (various species) were usually only present in late autumn and Thrips (various species) were primarily a problem in spring. Rutherglen bug (*Nysius vinitor*) can be a spring pest, primarily as a contaminant of lettuce rather than from direct feeding damage. Very few insects were found in the crops in June or July. Sclerotinia (*Sclerotinia sclerotiorum* and *S. minor*) was the most frequent and widespread disease. Most winters Big Vein virus was present and prevented some lettuce from hearting. Vamish spot (*Pseudomonas* sp.) was observed in late winter and in some paddocks the crop was unharvestable. Necrotic Yellows virus was an occasional disease and reached levels above 1-2 per cent in only one paddock.

A similar suite of pests and diseases are a problem in QLD. *Helicoverpa armigera* is the key insect pest in QLD, with Loopers, Cluster caterpillar, Thrips, Aphids and Rutherglen bug occasional or minor pests. Lucerne leafroller (*Merophyas divulsana*) is also a occasional pest in lettuce in QLD. In order of importance, Downy Mildew (*Bremia lactucae*), Sclerotinia, bacterial diseases (leaf spots and soft rots), *Rhizoctonia* and virus diseases are the most commonly found disease disorders in lettuce growing regions of Queensland.

Replicated small plot field trials were conducted in NSW and QLD to assess efficacy of various insecticides: Heliothis nuclear polyhedrosis virus (NPV), *Bacillus thuringiensis* (Bt), petroleum spray oil (PSO), spinosad, indoxacarb, emamectin benzoate, and azidoxactin. Feeding stimulants, Pheast® and milk powder, and an extender-sticker, NuFilm-17® were trialed as additives to improve the efficacy of Bt. Spinosad, indoxacarb, Bt, emamectin benzoate and chlorfenapyr all performed well in controlling Heliothis. Bt efficacy was not improved by the additives. The NPV had some effect on Heliothis but was not as effective as a conventional program. Azidoxactin performed poorly. The data from these efficacy trials have helped with the registration of Success® (spinosad), Avatar® (indoxacarb) and Gemstar® (NPV), and the permit for Bt. Data for emamectin benzoate (Prodigy®) and chlorfenapyr (Secure®) will aid with future registration.

*Trichoderma* spp., a biological fungicide was trialed in Hay against Sclerotinia with some success. A single application of procymidone immediately after thinning (direct seeded crop) gave almost complete control of Sclerotinia.

Some 'best management option' trials were conducted to assess the potential of an IPM strategy using the best available options at the time of the trial as compared to the current grower practice. In the trials Bt and spinosad were the softer options available and performed as well as the conventional plots but were more expensive. For the new generation chemistries to be widely adopted the level of control must be better than the conventional insecticides under current prices.

The most widely used spray applicator for lettuce is the standard hydraulic nozzle boom sprayer. A comprehensive trial was conducted comparing all the application methods currently used in lettuce. This included conventional booms, air-assisted boom, controlled droplet applicators (CDA) and a boom with nozzles extensions/ short droppers (30 cm long). The trial showed that a boom fitted with short droppers plus over the top spraying gave an significant increase in droplet densities in the bottom part of the plant canopy zone, compared to spraying with and without air assistance. The conventional boom had the lowest deposit within all zones, the bottom and top part of the canopy received below the recommended droplet densities for insecticide and fungicide application.

Further testing is required with air-assisted sprayers using leaves as targets to determine if there are significant differences in the spray deposit for the different settings (air velocity and angle) that can be used on this equipment. Similarly work is needed on the use of shrouds on all applicator types trialed to investigate whether significant improvements in coverage and reduction in drift could be attained.

Pest identification workshops were held in Hay, Sydney, Werribee and central western NSW. Spray nights were held in Gatton and Hay. Discussion evenings were held in Hay, Sydney and Gatton. Some pest and disease information sheets and draft crop monitoring protocols were produced and combined into an IPM handbook for head lettuce.

## **VG01028, LETTUCE IPM PROJECT**

**Principal investigator:** Sandra McDougall  
**Project start:** 2002, finish: 2005  
**Organisation:** NSW Agriculture  
**Contact phone:** (02) 6951 2728

### **Summary**

This extension will follow on from the work of VG98048 but only focus on the insect side of pest management.

The project will:

1. publish a UTE guide for Pest/Disease and Nutritional Disorders in Lettuce;
2. evaluate more biological and new chemistry insecticides for possible registration in lettuce;
3. publish a bimonthly newsletter reporting on all AUSVEG funded lettuce projects to lettuce growers;
4. host two National Lettuce Conferences (Gatton and ?Sydney Markets);
5. hold hands on workshops associated with the conferences and in WA, VIC and SA in non-conference years.

## VG99015, IMPROVEMENT IN LETTUCE QUALITY BY REDUCTION IN LOSSES DUE TO SOIL BORNE DISEASES

**Principal investigator:** Dominie Wright  
**Project start:** 01-Jul-99, finish: 31-Jul-02  
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### Milestone No. 4

Lindrea Latham, Christine Wood, Simon McKirdy, D. Wright, Dennis Phillips, Roger Jones, Calum Wilson, Lisa Gibson, Chris Archer, Paul Schupp

#### (a) Screening lettuce big vein virus (LBVV) tolerant lettuce germplasm for WA conditions

To search for genotypes of lettuce with greater LBVV resistance a field experiment screened a collection of breeding lines near release and available cultivars with reputed LBVV resistance.

In early winter 2000, 20 seedlings/plot of 12 cultivars or breeding lines of lettuce (including 2 susceptible controls) were transplanted in a replicated randomised block design into an irrigated bay on a lettuce growers property at Wanneroo in the Perth Metropolitan area. The plots were rectangular and replicated 4 times. The area used had a cropping history of continuous winter planted lettuce for the previous 15 years associated with severe LBVV infection. The plants were observed fortnightly for symptoms of LBVV. At harvest all plants from each plot were weighed individually to determine total plant weight.

Symptoms of LBVV were first noted in young leaves of all genotypes 4 weeks after transplanting. Spread then occurred rapidly reaching infection levels greater than 90 per cent in cvs Assassin and Oxley at harvest (Fig. 1). Genotypes Assassin, Del Oro, Oxley and Titanic were ranked as highly susceptible with greater than 75 per cent LBVV infection, Del Rey, Greenway, Jacqueline, Magnum, Pacific and LEC 8550 as susceptible with 25-75 per cent infection and LE169 and Veronica as moderately resistant with less than 25 per cent infection.

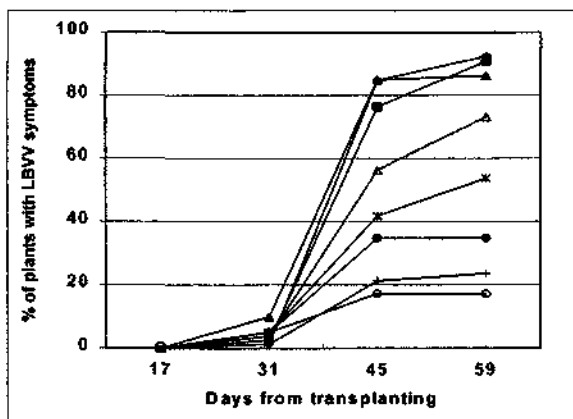


Figure 1. Spread of LBVV in selected genotypes Oxley (&), Assassin (.), Titanic (≡), Magnum (□), LEC 8550 (per cent), Greenway ()), Veronica (∇) and LE169 (O).

The genotype with the lowest LBVV infection, LE169, also had excellent agronomic characteristics and formed large hearts with an average gross yield of 1.11 kg (Table 1). However, cv. Veronica which, like LE169, was ranked as moderately resistant to LBVV produced only moderate yields, 0.71 kg/lettuce. Some other cvs (e.g. Del Oro and Titanic) yielded well despite high infection incidence with LBVV, while cv. Assassin was highly susceptible to LBVV and yielded poorly.



**Table 1. Gross yield at harvest and susceptibility to LBVV of lettuce genotypes grown in LBVV infected soil in winter on the Swan Coastal Plain**

Genotype	Above ground plant weight (kg)		Susceptibility ranking
LE169	1.11	(a)	MR
Greenway	1.00	(a)	S
Del Oro	0.84	(bc)	HS
Titanic	0.84	(bc)	HS
LEC8550	0.82	(bod)	S
Del Rey	0.76	(cde)	S
Oxley	0.72	(cde)	HS
Veronica	0.71	(cdef)	MR
Magnum	0.69	(defg)	S
Jacqueline	0.68	(efg)	S
Pacific	0.58	(fgh)	S
Assassin	0.52	(h)	HS
df, lsd	42, 0.13		
P	< 0.001		

MR = moderately resistant, S = susceptible, HS = highly susceptible.

### Conclusions

- Breeding line LE169 had useful resistance to LBVV and gave highest gross yields.
- Cv. Oxley was highly susceptible to LBVV and produced only moderate yields.
- Lower yield was not always associated with high LBVV infection.
- Using resistant lettuce cultivars like LE169 as a component of an integrated disease management strategy should help to minimise lettuce quality and yield losses due to LBVV.

### (b) Yield losses due to LBVV in WA

A field experiment was done to quantify yield and quality losses associated with LBVV infection and to determine what time of infection was the most critical.

In late July 2000, the roots of seven hundred 6 week old lettuce cv. Oxley seedlings were left to soak overnight in a slurry of macerated LBVV-infected lettuce roots. Another 700 seedlings were left unsoaked. The LBVV-infected seedlings were transplanted into one half of a large irrigated bay with no known previous plantings of lettuce and the healthy seedlings into the other half, the two halves constituting two plots. Plants were inspected weekly for characteristic LBVV symptoms. On each occasion when symptoms were first seen, plants were marked by placing a colour coded stake next to them. For each date the percentage of plants infected was calculated and virus disease progress determined. Fifty infected and 50 healthy lettuce plants were harvested at maturity for each assessment date. Total above ground plant and heart weight was determined for each plant. Data for pairs of healthy and infected plants were subjected to t-tests. In addition a sensitivity ranking of 1-5 was given for leaf symptoms: 1 = symptomless, 5 = very severe.

In the plot with inoculated seedlings, symptoms of LBVV were first seen three weeks after transplanting in a few plants. Spread increased exponentially until 6 weeks after transplanting when nearly 80 per cent of plants showed symptoms (Figure 2). In the control plot, the first plant developed symptoms three weeks after transplanting and spread continued at a slower rate plot until harvest, when 15 per cent of the plants showed symptoms.

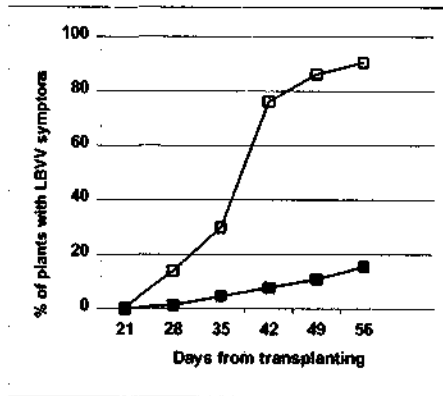


Figure 2. Spread of LBVV in plots of lettuce with (□) and without (■) inoculation of seedlings before transplanting.

Symptoms in plants that were infected early were mild, but those infected later had severe symptoms at harvest (Table 2). When symptoms of LBVV appeared four or five weeks after transplanting there was a 14 per cent loss of total weight, which translated into a 39 per cent loss of heart weight. However, if symptoms appeared six weeks after transplanting there was no significant loss of total weight and only a 14 per cent loss in heart weight. Neither were significantly affected if plants developed symptoms seven weeks or later after transplanting. Early symptom expression resulted in 24-36 per cent of plants not forming hearts while with later infection 14-16 per cent of plants failed to form hearts.

Table 2. Effect of LBVV on yield and quality of lettuce cv. Oxley infected at different times

Time of infection (weeks)		Total above ground weight (g)	Heart weight (g)	Symptom severity (1-5)
4	Infected	1605	582	2.3
	Healthy	1877	960	
	P, lsd	< 0.001, 62	< 0.001, 62	
5	Infected	1645	609	2.3
	Healthy	1907	1005	
	P, lsd	< 0.001, 74	< 0.001, 74	
6	Infected	1829	803	2.7
	Healthy	1856	931	
	P	ns	0.046, 62	
7	Infected	1877	862	3.2
	Healthy	1950	902	
	P	ns	ns	

**Conclusions**

- Substantial losses in gross yield resulted from infection of lettuce with LBVV. This appears to be the first report of gross yield losses caused by the virus, although quality losses were documented.
- Early infection resulted in failure of hearts to form, but later infection caused more severe leaf symptoms.
- Due to the magnitude of these losses a reappraisal of the importance of LBVV to lettuce production is warranted.
- Control measures involve cleaning up seedling nurseries from infection, avoiding contaminating new land for lettuce and using LBVV resistant lettuce cultivars.

**(c) Metham sodium and Sclerotinia Leaf Drop (SLD) incidence in WA**

The aim of year 1's research was to determine if metham sodium has an effect on SLD incidence. The incidence of SLD was greater in beds that hadn't been treated with metham sodium. However, in general metham sodium was not found to be as effective on many grower's properties.

**(d) Surveys for *Sporidesmium* isolates in WA**

A survey was conducted of farms growing lettuce within Western Australia to determine the presence of *Sporidesmium sclerotivorum*. Soil samples were collected and tested from the main lettuce and brassica growing regions around the metropolitan area. Soil was also collected from Manjimup as the soil type was more similar to the soil types in other lettuce growing regions of the Eastern States. No *Sporidesmium* was detected in soil samples collected in Western Australia. Protocols for determining the presence of *Sporidesmium* were fine tuned after Ms D Wright visited the US and collected more information. Manjimup soils will be tested for pH to determine if they are very different from soils in eastern Australia where *Sporidesmium* has been recovered.

**(e) Field and nursery surveys in Tasmania**

There are two major producers of lettuce seedlings in Tasmania. Production practices vary between the producers in respect to handling of seedlings and seedling boxes. Producer A always using new boxes and potting media, Producer B recycles planting boxes once returned from commercial lettuce properties. This may pose a risk for introduction of disease agents to nurseries from commercial properties.

Seedlings (100 per batch) were sourced from both Tasmanian suppliers twice during the growing season. Seedlings were planted out into sterilised potting mix and grown either in a strip-house or on open benches to maturity. Observations of plant health were made.

Results: Negligible disease (viral or fungal) was observed in any of the batches tested.

Newly planted bays of lettuce on a commercial property at Margate, Tasmania was observed for presence of disease.

Results: High incidence of LBVV (> 75 per cent) was evident in some, but not all, of the planting's of Del Rio planted from producer B. Negligible LBVV was found in other varieties, in some Del Rio planting's from this seedling supplier and in all seedlings from the producer A. Disease distribution strongly suggested disease introduction with planting material.

**(f) Evaluation of insect deterrent activity of surface applied limil in Tasmania**

To obtain a more realistic assessment of any potential effect of surface applied limil on insect repellence through light reflectance; four large squares of material (10 m<sup>2</sup>) were applied within commercial lettuce. Insect traps (clear sticky traps to avoid any attractant activity of trap itself) were placed within the centre of each square and replaced weekly. Total insects as well as individual thrips and aphids numbers were counted

Light reflectance reading were taken too give an indication of the amount and spectrum of light reflected.

Results: Reasonable numbers of thrips and other insects (but relatively few aphids) were trapped. There was no significant effect or observable trends) of surface applied limil on insect numbers (total, thrips or aphids) trapped within the squares suggesting limited ability to deter insect pests and virus vectors.

**(g) Effect of roguing on minimising disease losses due to *Sclerotinia minor* in Tasmania**

Immediately following infection, large numbers of new sclerotia are produced by the pathogen, which will be dispersed through the cropping soils in subsequent cultivation. In this trial we looked at the efficacy of removing infected plants immediately after symptom expression and surrounding infested soil in inoculum reduction.

A trial was established on a commercial property in Cambridge, Tasmania. The trial consisted of three major plots (5 rows wide by approximately 19 metres) each containing eight subplots of alternating rouged or non-rouged lettuce.

Lettuce were planted in March 2001, plot one contained cvs. Red Coral and Red Oak, plot two contained cv. Monet, plot three contained cv. Red Coral.

Each plot was inspected weekly. Infections were recorded and in rogued treatments the infected plants and approx 1/2-cup of soil surrounding the infected plant removed.

Results: Variable infection levels were found through the trial. Any effect of the treatments will not be evident until replanting of site in spring/summer 2001/2002

## 2. Field days held in WA and Tasmania to extend results to industry

A field day was held at the Wanneroo Recreation Centre at which field results for year 1 year presented to growers. All lettuce growers in WA were officially invited to the day and refreshments provided. The results for the lettuce big vein work and *Sclerotinia* work were presented. The turn out from the growers was extremely disappointing.

All studies to date have been conducted in association with major Tasmanian industry partners mostly within commercial crops. Current studies and results and future research plans have been regularly discussed (every 4-6 months) with major Tasmanian producers.

## 3. Year 2 Field trials planted in WA and Tasmania

### *LBBV resistance screening field trials*

The second of three lettuce planting dates has been planted onto three growers properties to screen three advanced breeding lines from Yates with promising resistance to LBBV. One of the lines is the resistant LE169, selected from last years screening trials which displayed outstanding agronomic features as well as disease resistance characteristics.

On one of the properties the effect of growing lettuces in black plastic mulch is being observed. The theory is that the plastic will reduce flow of soil moisture from plant to plant and create higher soil temperatures, i.e. conditions that are not conducive to the development of LBBV symptoms.

### (b) *Sclerotinia field trials*

#### (i) *Effect of fungicides, soil amendments and composting on controlling Sclerotinia lettuce drop (SLD) on lettuce.*

A field experiment has been established at Medina Research Station (01MD14) to determine the best practice for fungicide control of *Sclerotinia minor* on crisphead lettuce (cv. Oxley) by timing of fungicide applications. Treatments were applied to determine if the number of fungicide applications can be reduced but effective control of SLD still achieved. Reduced fungicide applications are important for issues such as food safety and resistance management.

Treatments are Rovral (Iprodione), Bavistin (carbendazim), Sumisclex (procymidone) rotation. Bavistin (carbendazim) replaced Benlate (benomyl), because Benlate was withdrawn from the market. Bavistin is not currently registered for use on lettuce in Western Australia. Its efficacy is thought to be similar to that of Benlate as carbendazim is the 1<sup>st</sup> breakdown product of benomyl.

The following treatments will be compared: (1) full fungicide (weekly spraying); (2) minimal fungicide (spraying every 2 weeks); (3) strategic applications (application of Sumisclex when symptoms first appear); (4) reduced full fungicide (weekly spraying to commence after 1<sup>st</sup> symptoms appear); (5) Sumisclex drenching of plots post-transplant (thought to be a necessary treatment for good control of SLD during the season; and (6) untreated control.

Transplants were planted onto beds treated with the soil fumigant, metham sodium. As this year's trial was planted over the site of last year's trial, this provides beds with differing histories of metham sodium application (1 year – this year only, 2 years – this year and last year). Data on the residual effects of metham sodium applications to SLD may be obtained from this trial design.

#### (ii) *Effect of metham sodium on SLD incidence*

A mini trial (01PE17) has been established on a grower's property to determine the effect of metham sodium on SLD incidence. Two areas within the same bay will be compared for SLD (both *S. sclerotiorum* and *S. minor*) incidence. One was treated with metham sodium prior to transplant and the other wasn't.

#### (iii) *Fungicide plate tests*

The efficacy of fungicides in controlling *Sclerotinia minor* and *S. sclerotiorum* was tested in vitro. Two isolates of *S. minor* and one isolate of *S. sclerotiorum* (collected during the survey work) were tested against the following fungicides Sumisclex, Benlate, Rovral and Amistar (azoxystrobin). Growth of the isolates was assessed at the

following concentrations for all fungicides; 100 ppm ai, 50 ppm ai, 10 ppm ai, 5 ppm ai, 1 ppm ai, 0.5 ppm ai, 0 ppm (control).

Results were similar for all isolates. These tests indicate that Sumisclex, Benlate and Rovral all inhibit growth of *Sclerotinia* spp, however, Sumisclex has the highest efficacy. Amistar showed poor control of growth of all isolates, however, mycelial growth was less dense than the control plates and sclerotial production was also less. Further work with amistar as a possible chemical will not continue due to its poor control in this work.

There is a need for further plate testing to determine which new fungicides should be put up for minor use permits for SLD. It is proposed that the following fungicides; Ronilan, Spin flo (carbendazim, cf. Bavistin), Dithane (mancozeb), Shirlan (fluazinam), and Switch (cyprodinil/fludioxonil) be examined for efficacy by plate tests before testing in the field.

Due to the lettuce growing season in Tasmania commencing in late spring the following trials are planned to be planted then

Replanting of roguing trial and continuation of treatments for one further season

Limil rate trial: examining the range of effective rates of limil/polymer treatments, focussing on salad mix cropping system.

Cover crop trial, looking at effect of short rotation crops (fallow, oats, salad herbs, and brassica) between lettuce plantings.

#### **4. Glasshouse trials to complement field trials started**

##### **(a) Survey of lettuce speedling health at a large speedling nursery**

A single tray of 100 lettuce speedlings ready for transplanting were collected from a large vegetable speedling nursery, north of Perth, every 6-12 weeks for the last 18 months. Speedlings were transplanted into pots and grown on in the glasshouse for 6-8 weeks under hygienic conditions. Each plant was then scored for LBVV symptoms. Of the 9 sampling times only two samples did not have any infected speedlings. On all the other 7 sampling dates infection ranged from 2 per cent in samples collected of cv. Raider in September, 2000 to 31 per cent in cv. Magnum collected in September 1999.

##### **(b) Experiments to determine origin of LBVV infection in seedling nurseries**

Due to the determination that LBVV is being distributed to lettuce growing properties on lettuce speedlings from seedling nurseries a series of glasshouse experiments are being done to determine the original source of infection. The aim is to be able to advise the seedling nurseries how they can control the source of LBVV infection in their nurseries and produce healthy seedlings.

Samples were collected from a large speedling growing nursery of lettuce seed, recycled lettuce speedling trays, potting compost, water used for watering speedling trays and the soil from under the benches where the speedlings are grown. They were brought back glasshouses at the WA Department of Agriculture (DAWA) and under hygienic conditions bait tested for LBVV with clean control comparisons.

On three separate occasions compost pine bark collected from the nursery when bait tested for LBVV produced lettuce plants with LBVV symptoms. On one sampling date the soil collected from under the benches when bait tested also produced LBVV infected plants. The other samples collected from the nursery, the seed, the trays, and the water did not produce LBVV infected lettuce plants.

##### **(c) Glasshouse experiments to investigate *Sporidesmium***

As local isolates of *Sporidesmium sclerotivorum* were not detected, this work will not be pursued. Instead work is being undertaken to look at alternative fungicides to Benlate (benomyl) and other non-registered fungicides. This may be necessary for resistance management purposes.

#### **5. Publications arising from VG99015**

##### **Refereed journal articles**

Wong, J.A.L., Archer, C.A., Wilson, C.R., Schupp, P.J., Gibson, L.J., DeLittle, J.A. (2000).

Novel control of lettuce drop disease. *Phytopathology* 90: S84.

**Conference proceedings**

- Archer C., Wilson C., Gibson L. (2000). Improving lettuce quality through reduction in losses due to soil borne diseases. *In: Proceedings of the Australian Lettuce Industry Conference*, Hay New South Wales, June 6-8, 2000 pp. 80-85.
- Kumar, S., Latham, L., Wood, C. (2000). Controlling *Sclerotinia* and big vein virus in iceberg lettuce. *In: Proceedings of the Australian Lettuce Industry Conference*, Hay New South Wales, June 6-8, 2000 pp. 86-90.
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- Latham L.J., McKirdy S.J., Jones R.A.C. (2001). Yield and quality losses due to lettuce big vein virus in winter grown lettuce. *In: Proceedings of the Second Australasian Soilborne Diseases Symposium* Cumberland Lorne Resort, Victoria 5-8 March 2001 p. 135.
- Latham L.J., Jones R.A.C. (2001). Integrated disease management of lettuce big vein virus. *In: Contributed Papers Horticulture Program Leading today, shaping tomorrow. Biennial Conference* Mandurah Quays Resort 18-19 September 2001 p. 25.
- Latham L.J., McKirdy S.J., Jones R.A.C. (2001). Yield and quality losses due to lettuce big vein virus in winter grown lettuce. *In: Contributed Papers Horticulture Program Leading today, shaping tomorrow. Biennial Conference* Mandurah Quays Resort 18-19 September 2001 p26.
- Latham L.J., McKirdy S.J., Jones R.A.C. (2001). Identifying lettuce genotypes with useful resistance to lettuce big vein virus. *In: Contributed Papers Horticulture Program Leading today, shaping tomorrow. Biennial Conference* Mandurah Quays Resort 18-19 September 2001 p. 27.

**Extension articles**

- Latham L. (2001). Lettuce disease research in WA. *Leafy Crops Newsletter* Vol. 1 No. 2. pp. 6
- Phillips D., Latham L. (2001). Black spot in lettuce. *Leafy Crops Newsletter* Vol. 1 No. 2. pp. 6
- Latham L. and Jones R. (2001). Managing lettuce big vein virus. *Good Fruit and Vegetables* Vol. 12 No. 1, 40.

## VG98083, A STUDY OF POSTHARVEST BACTERIAL ROTS AND BROWNING IN LETTUCE AND THE DEVELOPMENT OF CONTROL METHOD

**Principal investigator:** Robert Premier  
**Project start:** 01-Jul-98, finish: 31-May-02  
**Organisation:** Agriculture Victoria  
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### Milestone report 5

Description of the types and numbers of bacteria detected in soil and on lettuce plants over the autumn/winter period.

Information on the detection of the types and numbers of bacteria over the autumn/winter period has been collected and is presented here as Milestone 5. Sampling of total aerobic bacteria and *Pseudomonas* species has been ongoing since October 1999. Levels of *Pseudomonas* species have varied from each season and also each year of sampling. Various types of *Pseudomonas* species have been detected with the saprophytic species dominating the population.

### Detection of Pseudomonad species in soil over autumn and winter

The Victorian lettuce growing regions used in this study are shown in Figure 1. Two properties from each region were selected and soil sampling commenced in October 1999. Sampling is ongoing and is to be concluded in October 2001.



### Types of fluorescent pseudomonads in the soil

As mentioned in previous reports, fluorescent pseudomonads are widespread in soil. Large populations of pseudomonads are often associated with organic matter in the soil and can live readily in water and on the plant surface (1). Species and numbers of fluorescent pseudomonads also vary with the level of decomposition of organic matter. The dominant fluorescent pseudomonads found in the soil are saprophytic, which do not produce any pectolytic enzymes. These types of bacteria are still able to elicit a browning reaction when inoculated onto cut surfaces of lettuce. Pectolytic species are considered a small component within the soil and are often incorporated on plant material or from water sources (1,2).

Research conducted over the last two years has shown similar results to other smaller studies (2). As Table 1 shows, saprophytic pseudomonads dominated the isolates at each of the sampling times throughout autumn and winter. Of the fluorescent pseudomonads isolated 87 per cent (108 of 124 isolates) were identified as saprophytic pseudomonads. These species were *Pseudomonas fluorescens* (biovar V), of which 44 isolates were identified and *Pseudomonas tolaasii* (biovar V), of which 64 isolates were identified.

The pectolytic pseudomonads identified composed 11 per cent of the isolates. Of these three were identified as *Pseudomonas marginalis* (biovar IV) and 11 were identified as pectolytic *Pseudomonas fluorescens* (biovar IV). The pathogenic species, *Pseudomonas cichorii*, was identified on two occasions from sampling conducted during autumn 2000. Similar results were also found with the isolates identified from the spring and summer samplings conducted over the same years. Saprophytic bacteria dominated the identifications with 72 per cent of the fluorescent pseudomonads identified as saprophytic *Pseudomonas fluorescens* (biovar V) and *Pseudomonas tolaasii* (biovar V). Those results are in the previous milestone report (3).

Table 1. Isolates identified from soil samples taken from each lettuce growing region during autumn and winter 2000-2001

Season	Region	<i>P. marginalis</i>	<i>P. fluorescens</i> (pectolytic)	<i>P. fluorescens</i> (saprophytic)	<i>P. tolaasii</i>	<i>P. cichorii</i>
Autumn 2000	Morn. Penn.	1	2	13	1	2
	Werr. Sth		1	2		
	Gippsland			5		
Winter 2000	Morn. Penn.			4	7	
	Werr. Sth		3	5	14	
	Gippsland			1	4	
Autumn 2001	Morn. Penn.			5	5	
	Werr. Sth			5	6	
	Gippsland			1	6	
Winter 2001	Morn. Penn.	1	1	2	6	
	Werr. Sth		1	1	9	
	Gippsland	1	3		6	
	Total	3	11	44	64	2

### Types of fluorescent pseudomonads found on lettuce

Sampling of lettuce plants from the field was not done due to the lettuce season slowing down in production over the sampling months. However, isolates of fluorescent pseudomonads were identified from lettuce plants with rots and browning harvested in early autumn 2000. The cos lettuce varieties showed pinking in the midrib regions of leaves and stems as well as blackening within the upper leaf tissue. Upon identification, the species obtained were a mixture of saprophytic and pectolytic fluorescent pseudomonads, including *Pseudomonas marginalis*, pectolytic *Pseudomonas fluorescens* and saprophytic *Pseudomonas fluorescens*. The pectolytic pseudomonads, which are major contributors to soft rot, were isolated from the blackened, soft tissue found within the upper/inner leaves, whilst the saprophytic pseudomonads were mainly isolated from the pinking regions within the leaf veins and core xylem vessels.

### Numbers of fluorescent pseudomonads detected

The previous milestone report showed the levels of fluorescent pseudomonads in the soil over the spring/summer months. Levels decreased over summer and steadily rose over the spring months. The results obtained for autumn and winter seem to follow the trends observed during the other seasons. As Table 2 and Figure 2 show, average levels of pseudomonads detected in the soils varied over the seasons as well as between each region. Statistical analysis of the results have not been conducted as yet, due to the incompleteness of the soil sampling.

Table 2. Average levels of total aerobic bacteria (TAC) and *Pseudomonas* species in the soils of lettuce growing regions of Victoria

	Werr-TAC	Werr-Pseudos	Morn.- TAC	Morn.-Pseudos	Gipps- TAC	Gipps- Pseudos
Autumn 2000	$8.8 \times 10^6$	$1.1 \times 10^4$	$2.5 \times 10^7$	$2.7 \times 10^4$	$1.5 \times 10^7$	$3.3 \times 10^4$
Winter 2000	$1.7 \times 10^7$	$5.4 \times 10^4$	$7.8 \times 10^6$	$3.8 \times 10^4$	$5.2 \times 10^6$	$2.7 \times 10^4$
Autumn 2001	$1.2 \times 10^7$	$3.6 \times 10^4$	$1.3 \times 10^7$	$3.4 \times 10^4$	$6.9 \times 10^6$	$3.6 \times 10^4$
Winter 2001	$2.6 \times 10^7$	$5.5 \times 10^4$	$1.4 \times 10^7$	$5.7 \times 10^4$	$4.6 \times 10^6$	$3.3 \times 10^4$

General observations show that levels of pseudomonads within soils of lettuce growing regions of Victoria have varied over each season, as well as between years. Pseudomonad species were high in the soil of all regions throughout most of the seasons. During the autumn/winter period, levels of pseudomonads tended to fall during autumn and started to rise during winter. This was evident in the soils taken from Werribee south and the Mornington Peninsula, however in Gippsland, no evident patterns have emerged. This may be due to temperature fluctuations in the soil, as pseudomonad species prefer temperatures below 20°C for favourable growth.



### Future work

Soil sampling is to be completed in spring 2001 after which time trends in pseudomonad levels can be further analysed and interpretation of the data can be undertaken. The information from the soil sampling experiments will be used to develop control experiments to help reduce the level of pseudomonads, particularly around the times of higher levels.

### Extension and publications

10<sup>th</sup> Australian Food Microbiology conference (Melbourne 28-30 March 2001). Poster presented titled: Rapid browning of cut lettuce by *Pseudomonas* species.

2001 Australasian Postharvest conference (Adelaide, 23-27 September, 2001). Poster presented titled: Lettuce cultivars show differences in the effects of pseudomonads on cut surfaces.

Contribution to the annual IHD report.

Contribution to the Lettuce Leaflet, February, 2001.

Contribution to Veg Cheque's newsletter, 'Vegetable Matters'

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## PROJECT: GENETIC TRANSFORMATION OF LETTUCE FOR RESISTANCE TO VIRUSES

### Ralf Dietzgen, QDPI

This project aims to introduce into four commercial lettuce cultivars modified gene sequences derived from lettuce mosaic potyvirus (LMV) and lettuce necrotic yellows rhabdovirus (LNYV). The stable expression of these sequences in lettuce is expected to protect lettuce from infection by these two economically important viruses. Virus-derived 'resistance genes' used will be the nucleocapsid gene for LNYV and putative cell-to-cell movement genes for LMV. These genes will be subcloned into suitable plant expression vectors and introduced into the lettuce genome via *Agrobacterium tumefaciens*-mediated transformation. Transformed lines will be selected and analysed prior to glasshouse and field assessment.

### Progress

In excess of 100 transgenic lines of the four lettuce cultivars Centenary, Seagreen, LE126 and Mr Mac have been generated. The genomic analysis of these lines has been completed and several contain single copies of the introduced gene, the nucleoprotein gene N of Lettuce necrotic yellows virus (LNYV) in a translatable or untranslatable form. These introduced genes are expected to provide resistance to infection by LNYV. However, so far none of our experimental approaches to determine if these lines are virus-resistant have given us the reliable, high level infection required to confidently identify such resistant lines. This includes infection of lettuce seedlings with viruliferous aphids and mechanical co-inoculation with synergistic viruses. Permission was given by the Office of the Gene Technology Regulator to proceed with a second, previously GMAC-approved field trial to identify LNYV-resistant lettuce lines (following natural infection by aphids in the field) and to evaluate their agronomic performance. This trial which includes a total of > 800 plants from all four cultivars and has commenced in the Lockyer Valley in the spring 2001 lettuce growing season.

## CONTROLLING FUSARIUM WILT AND BASE ROT IN SWEET BASIL

Barry Condé, Isagani Arao-Arao, and Rex Pitkethley, Dbird-Primary Industry, Darwin, NT

Fusarium wilt and crown rot of basil is the most severe and limiting disease of sweet basil world wide. It came to our notice in the NT DPIF in Darwin in 1997 and again in May 2000 with Vietnamese growers. It was probably introduced to Darwin three years or so before 1997 in infected seed. It is caused by the fungus, *Fusarium oxysporum* f.sp. *basilici* (Fob). This disease has affected basil in Atherton Tableland, Bowen, southern Queensland, and in glasshouses in Victoria

**The disease:** Seed of sweet basil was mass produced in the 1980's and early 1990's in countries where labour was inexpensive. Seed was harvested from Fusarium infected plants and sent throughout the world, thus spreading the disease in the 1980's and 90's. Fusarium infected sweet basil stops growing, leaves become chlorotic (paler), the plant wilts and leaves drop off. Necrotic streaks appear on the stem and the growing tip becomes necrotic. Then the plant dies. The fungus, in common with others in the same species, produces three types of spores, small one and two celled microspores, larger macrospores, and thick-walled resting spores known as chlamydospores. However, the basil fungus is unusual among the *Fusarium oxysporum* species in that it causes both a wilt and a crown or base rot. Seed transmission is responsible for long distance spread from country to country and to new regions and localities. Local spread in plantings is by spores produced on the decaying roots and crown, and by air-borne macroconidia produced on infected stems. Spores are spread in the soil by watering, cultivation and as soil clumps on implements, footwear, vehicles, farm machinery and even on root vegetables such as shallots, spring onions and yam beans. A few infected plants infected by seed transmission most likely go unnoticed. However, the thick-walled clamydospores produced by these plants last for many years (perhaps up to 40 years) and infect more plants in the next season. Sweet basil seed certified as Fusarium-free has been available from seed companies for five years or so.

**Other basil**s can also be affected by this Fusarium wilt and crown rot, e.g. Greek basil and Thai/Vietnamese basil. Thai basil has purple flowers and stems in contrast to the white flowers of sweet basil. Limited field and glasshouse observations suggest that the Thai basil is both more resistant to infection and more tolerant of infection by Fob.

**Resistance in Sweet Basil:** Several lines of sweet basil with resistance to Fob were released in the last few years. Three of these, '5170', 'UH sweet basil' and 'Nufar F1' were given to Vietnamese growers to trial in their fields. UH sweet basil was obtained from Hawaii, 5170 was obtained from Rijk Zwaan seeds, and 'Nufar F1', was developed in Israel, marketed by Richters Seeds, Canada and obtained through their Australian distributor, Eschol Springs Nursery, Gingin, Western Australia. Growers found both 5170 and UH sweet basil unsuitable for the present Australian market. The leaves of the UH sweet basil were too small for commercial acceptance. Nufar F1, whilst not totally resistant, is more resistant than conventional sweet basil. The market prefers the normal susceptible sweet basil, but will accept the Nufar F1

### In summary

In summary, Fusarium wilt free sweet basil seed can be used where the soil is not known to be contaminated with the disease. Vietnamese basil can be affected by the disease, but observations suggest that this basil is both more resistant to and more tolerant of Fob infections. Nufar F1 sweet basil is more resistant to Fob than conventional sweet basil and is also acceptable to the commercial market, but at a lower price than conventional basil if this is available. The practice of removing and destroying obviously infected Nufar F1 plants should reduce the buildup of Fob inoculum and so allow the remaining Nufar F1 plants to last longer before they succumb to the disease.

Nufar F1 sweet basil can be obtained from Eschol Springs Nursery, Lot 3488 Quin Road Gingin WA 6503; PO Box 61 Gingin, WA 6503, Telephone (08) 9575 7522, Fax (08) 9575 7622.

## **VG98116, EXTENDING SHELF LIFE OF MINIMALLY PROCESSED LEAFY ASIAN VEGETABLES**

**Principal investigator:** Tim O'Hare  
**Project start:** 01-Jul-98, finish: 31-Jan-02  
**Organisation:** QLD Department of Primary Industries  
**Contact phone:** (07) 5466 2257

No report available.

## **VG01045, DISEASE MANAGEMENT STRATEGIES FOR THE PRODUCTION OF BUNCHING VEGETABLES**

**Principal Investigator:** Elizabeth Minchinton  
**Project start:** 01-Dec-01, finish: 30-Jun-04  
**Organisation:** DNRE Agriculture Victoria IHD Knoxfield  
**Contact phone:** (03) 9210 9222

No report available.

## **NEW ZEALAND LETTUCE PROJECTS**

**Pathogens:** *Sclerotinia* spp.  
**Research aim:** Biological control with *Trichoderma*  
**Principal investigator:** Alison Stewart  
**Institution:** Lincoln University

**Pathogen:** *Botrytis cinerea*  
**Research aim:** Biological control using fungi  
**Principal investigator:** Alison Stewart  
**Institution:** Lincoln University

**Pathogen:** *Pythium* spp.  
**Research aim:** Biological control using *Trichoderma*  
**Principal investigator:** Alison Stewart  
**Institution:** Lincoln University

## APPENDIX 5. LEGUMES

### FUSARIUM WILT OF SNAKE BEANS - A PROGRESS REPORT

Barry Condé, Isagani Arao-Arao and Rex Pitkethley, Dbird-Primary Industry, Darwin, NT

**First report in 1999:** Fusarium wilt of snake bean (*Vigna unguiculata* ssp. *sesquipedalis*) was first recorded in Darwin in 1999. The causal fungus is *Fusarium oxysporum* f.sp. *tracheiphilum* (Fot). The isolates of Fot in 1999 were plum red coloured on PDA medium aging to purple. Koch's postulates were satisfied demonstrating that this fungus was the cause of the wilt. A previous crop of snake beans grown on the same field in 1998 by another grower was abandoned because of poor plants. It is possible that this crop in 1998 was infected with Fusarium wilt. Vietnamese call the disease 'early die' because the plants die much earlier than they should. However, this name 'early die' is also given to plants that die early for other reasons such as root knot nematode infection. The Darwin snake bean industry was worth \$1.1 million in 1999. By the end of 1999, the Fusarium wilt was found in a major snake bean growing area in Darwin many kilometres away from the first farm. This is understandable since there is much interaction between many of the Vietnamese farmers. Isolations from infected plants from all farms were all the plum red Fot colony on PDA.

**2000 and 2001 surveys:** Surveys conducted in 2000 and 2001 found Fusarium wilt affected snake beans in most major snake bean growing areas in Darwin. However, in contrast to 1999, a pale yellow/white fungus was isolated from wilt affected plants sampled in the 2000 and 2001 surveys. Koch's postulates were again satisfied with this pale off-white fungus, demonstrating that this fungus was the cause of the wilted snake beans observed in 2000 and 2001.

**Screening for resistance:** Snake bean lines were obtained locally in Darwin, from Biloela, Queensland, from Sunland Seeds, NSW, from Taiwan, from West Indies, and from USA. Forty nine snake bean lines and several cowpea lines were screened for resistance to a 1999 isolate of Fot in two major screenings in 2000 and 2001. It is planned to screen the remainder of the snake bean lines in a third major screening. Five snake bean lines were identified with resistance to the 1999 isolate. However, none of these five snake bean lines had the desirable culinary and horticultural characteristics that would enable them to immediately replace the standard commercial variety, Green Pod Kaohsiung.

**Breeding for resistance:** We commenced a back crossing breeding program with assistance from Jeff Ehlers, UC-Riverside in 2001 with the aim of incorporating resistance from a cowpea into the standard commercial snake bean, line, Green Pod Kaohsiung. The final variety from this program needs to have the desirable horticultural and culinary characteristics of the Green Pod Kaohsiung snake bean, with strong stable resistance to all Fot found in commercial farms in Darwin.

**Grafting to control fusarium wilt:** Prior to a resistant variety being found or developed that can replace the current susceptible variety, many growers are no longer producing snake beans. A successful workshop was held with the Horticulture extension officer, the Asian Vegetables Communication Officer and several interested growers to demonstrate how the GPK variety can be successfully grafted onto resistant cowpea and grown in Fusarium wilt infested soil. We hope that this can be used as an interim measure until a satisfactory resistant variety is released.

**Races of Fot:** World wide, four races of Fot are known that attack cowpeas or snake beans. All four of these races are present in USA, different States having different combinations of races. At present, the race or races of Fot attacking snake beans in Darwin is not known. The standard differential cowpea lines previously used to distinguish the races in USA are no longer identifiable. We are aiming to build up a new set of cowpea differential varieties from UC-Riverside, USA which should enable us to identify the race or races of Fot in Darwin.

**Honours project:** Isagani Arao-Arao is intending doing an Honours project on examining the relationship between the types of Fot isolated in 1999 and in 2000-2001, involving inoculation of sets of cowpea differentials, VCG and other characteristics, and surveys of the distribution of the different types of Fot in Darwin.

## **VG00020, MODELLING OF SPORE RELEASE AND ALTERNATIVE METHODS OF CONTROL FOR STEM ROT (*SCLEROTINIA SCLEROTIORUM*) IN BEANS**

Principal investigator: Chris Archer  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: Tasmanian Institute of Agricultural Research  
Contact phone: 03 6233 6830

### **Technical transfer plan**

For 'Modelling of spore release and alternative methods of control for *Sclerotinia sclerotiorum* in beans'

The technical transfer program to be utilised within the project strategy for adoption is intended to maximise information exchange on project progress and research findings to stakeholders via a range of activities.

Tasmanian vegetable growers, processors and other industry representatives will be informed of project progress by way of:

- Involvement with trials - Currently Simplot Pty. Ltd. is assisting with trials and the field officer for green beans (Mr Garry McNab) is facilitating the chemical trials by providing information on crop establishment and production methods. Production managers and field officers are being provided with copies of milestone reports as they are produced.
- Annual field days for industry held at Forthside Research Farm (next to be held on December 13, 2001)
- Annual TIAR research presentations - to be held in July / August 2002 in Launceston Tasmania).

Regular milestone reports will be provided to both HRDC and to all vegetable Industry Development Officers (the latter is being coordinated by Mr Roger Tyshing, vegetable IDO for Tasmania)

A major component of extension will comprise printed media allowing dissemination of the projects findings to the widest possible audience. Target publications will include Good Fruit and Vegetable in addition to the regular state based newsletters generated by Industry Development Officers. This will commence after the second year of the project when further results are obtained from Queensland spore trapping and the Tasmanian chemical trials. That is, as there has only been one year of spore trapping from one site, it is impossible to offer a general recommendation of the spore release profile. A larger data set needs to be generated from several years to allow for crop, climate and site differences.

Project collaborators (in year 2 and 3) will conduct field days /seminars within Queensland and Victoria in addition to the diffusion of information achieved through conduct of trials on participating grower's properties.

Communication of results to the scientific community will be achieved via University seminars, writing of scientific papers for relevant journals and by attendance at National plant pathology conferences.

### **Additional information**

Discussions held with Drs Pung and Porter regarding trial collaboration has centred on potential use of new biological control material being developed for control of *Sclerotinia* within their current HAL funded project. Additionally, Dr Pung has suggested use of several new chemical products that may have efficacy against the *Sclerotinia* pathogen. No mention was made of the planned Queensland trials within the last milestone as all Queensland trials are composed solely of spore trapping trials within naturally infected bean crops.

All chemical and biological control trials are to be conducted in Tasmania at the University of Tasmania research farm. The experimental site is to be artificially inoculated with *Sclerotinia* so as to guarantee disease expression.

## VG00031, MANAGEMENT OF DOWNY MILDEW DISEASE OF PEA CROPS AND ITS POSSIBLE RESISTANCE TO METALAXYL

Principal investigator: Hoong Pung  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: Serve-Ag Research  
Contact phone: 03-6427 0800

### Background

Downy mildew (*Peronospora viciae*) can cause severe losses in peas grown for processing. Yield losses of up to 20 per cent, or even unharvested crops, may result from severe downy mildew infections. In Australia, seed treatment with metalaxyl (Apron) is currently being used to control downy mildew on pea seeds and provide early protection from the soilborne and airborne inoculum of the pathogen. In recent years, however, downy mildew resistance to metalaxyl has been confirmed in America and New Zealand. This has raised concerns in the Australian processing pea industry, as almost all seed is imported from New Zealand. The incidence and severity of downy mildew on pea crops also appears to be increasing in recent years. It is not known if the current use of metalaxyl seed treatment still provides adequate downy mildew control and whether resistant strains of *P. viciae* are also present in Australia. As the metalaxyl seed treatment constitutes a high proportion of the pea seed cost, adding about 10 per cent to the total seed cost to the industry, these questions need to be addressed.

### Objectives

This project aims to determine whether:

- *Peronospora viciae* strains in Australia are resistant to metalaxyl.
- Metalaxyl treated seed is providing adequate disease control on seeds and young seedlings.
- There are alternative products for the control of metalaxyl resistant downy mildew.
- There are other methods of managing downy mildew.

### Work undertaken to date and outcomes

- A total of 16 isolates of *P. viciae* were collected from pea crops at different sites in northern Tasmania for bioassay test in 2001. The test, conducted in New Zealand, showed that 38 per cent of isolates were sensitive to metalaxyl, 31 per cent were resistant and another 31 per cent were partially resistant.
- Fungicide seed dressings that have been developed commercially for control of downy mildew, as well as other seedborne pathogens, Apron & P-Pickel T, Aliette Super, and Wakil XL, were examined in a series of field trials in the 2000 and 2001 seasons. A range of other alternative fungicide mixtures including Amistar, Bion, Fongarid, Maxim, and Tecto, were also examined.
- The fungicide seed dressings, Apron & P-Pickel T, Aliette Super, and Wakil XL, generally gave the best performance, consistently increasing plant density, and seedling growth. Apron & P-Pickel T, and Aliette Super tend to perform better in downy mildew control compared to Wakil.
- Seeds treated with Apron & P-Pickel T, Aliette Super, or Wakil XL and stored for almost one-year showed no adverse effects on germination and seedling growth.
- In three field trials conducted in 2001, the foliar spray treatments with Penncozeb + Agri-Fos and Bravo + Agri-Fos, consistently gave effective downy mildew control on infected crops, and increased yield of peas. In a crop with severe downy mildew, the average pea yield in untreated control was equivalent to 1.7 tonne/ha compared to 5.1 tonne/ha with Penncozeb + Agri-fos treated plants and 3.5 tonne/ha with Bravo + Agri-Fos treated plants.

### Technology transfer

- Preliminary findings from field trials were presented at an extension forum held on 12 October 2000 at Serve-Ag, Bellfield. Dr Richard Falloon, NZ research collaborator, gave a presentation on pea production and studies of pea diseases conducted in NZ.
- Meetings were held with the project focus group on 22 February 2001, and on 3 July 2001 to discuss plans for the 2<sup>nd</sup> year's studies.
- A field day was held on 16 November 2001 on a trial site at Sassafra, with staff from McCains Food and Simplot Australia, to demonstrate the best foliar treatments for downy mildew control.

## **VG00058, INCREASING THE COMPETITIVENESS OF THE AUSTRALIAN PROCESSING PEA INDUSTRY THROUGH MINIMISING THE ECONOMIC IMPACT OF COLLAR ROT DISEASE (ASCOCHYTA)**

Principal investigator: Lloyd Williams  
Project start: 01-Jul-00, finish: 01-Jul-03  
Organisation: Horticultural Technical Services  
Contact phone: 08 9777 2888

### **Milestone 2**

Report on progress of variety and herbicide trials and the control of *Ascochyta* fungal disease, Lloyd Williams

All herbicide trials were implemented in commercial crops and the trials successfully completed.

Four pre-emergent herbicides were applied to commercial pea crops on two properties in the Mt Barker region of Western Australia. Treatments of Authority, Brodal and a combination of Command and Frontier were applied at full and half rates. Rates were selected from past research both in WA and Tasmania with the assistance of Serve-Ag Research.

#### **Full rates used were:**

1. Authority 500 g/ha at a rate of 200 L/ha water
2. Brodal 200 mL/ha at a rate of 200 L/ha water
3. Command 500 mL/ha at a rate of 200 L/ha water
4. Frontier 1.5 mL/ha at a rate of 200 L/ha water.

#### **Half rates used were:**

1. Authority 250 g/ha at a rate of 200 L/ha water
2. Brodal 100 mL/ha at a rate of 200 L/ha water
3. Command 250 mL/ha at a rate of 200 L/ha water
4. Frontier 750 mL/ha at a rate of 200 L/ha water.

All herbicides were applied the day after seed sowing. All herbicides were applied to a randomised plot area of a minimum of 100 m<sup>2</sup> with three replicates. The control was sprayed with water only.

The effectiveness of each treatment in controlling weeds was assessed using the EWRS Scale with ratings from 1-9. The raw data was statistically determined using ANOVA, means of each treatment and finally by the 'Greenhouse-Geiser Correction Factor' to determine the effect of time on each significant treatment.

Results showed that the treatment of Command and Frontier as a combination pre-emergent herbicide was the most effective treatment in the trials and had the longest activity spectrum of all the herbicides trialed. With better weed control achieved and with treatments able to be applied prior to crop emergence, the risk of introducing disease such as *Ascochyta* was greatly reduced as no mechanical damage to the crop was experienced through post emergent herbicide applications.

Two new pea varieties were screened this season against the industry standard. Both varieties were planted later than expected due to the late rains and subsequently could not be harvested mechanically and processed. The commercial crop they were planted within was also unable to be harvested. These varieties will be further evaluated next season where they will be planted in more than one locality.

### ***A record of the adoption rate of industry to new strategies***

Compaction from farm machinery is a potential problem in processing pea crops due to the damage to the vines. Once a vine has been damaged by machinery the potential for disease entry is great under the climatic conditions experienced around the MT Barker district.



A method for reducing the potential damage to vines is to provide roadways for all farm machinery to travel for the duration of the crop. With machinery travelling on the crop up to five times post sowing, the destruction is great not only to established plants but also to emerging seedlings.

Roadways were introduced into the commercial crop and penetrometer and yield measurements were taken to compare the effect of compaction and the resulting incidence of disease and the subsequent loss of yield.

With two out of three roadways showing a greater degree of compaction compared to the commercial area where farm machinery was absent, the advantages to the crop were beneficial. An average sample of peas collected from two areas of the commercial crop where machinery had repeatedly been driven, showed a calculated yield of 2.35 t/ha compared to the paddock yield of 3.1 t/ha. With this small sample comparison, the impact of losing cropping area to permanent roadways would be 75 per cent less for the area taken up by roadways. However, the loss of yield far outweighed the potential for disease risk due to the continued use of driving farm machinery over vast areas of the crop.

From these results, farmers have agreed to set up a larger scale of this trial in an effort to replicate the conclusions and lessen the impact of *Ascochyta* on their crops. A commercial crop will be constructed in this manner and further data and conclusions made to enable the full-scale adoption of this technique.

The adoption to the new herbicides Command and Frontier would be conclusive at this stage throughout the WA processing pea industry if the chemicals were registered. Liaison between Western Australia, Tasmania and the NRA continues as does further trials to refine the chemicals' abilities.

#### ***Report on liaison with Tasmanian industry***

Communications remain active between both States with a large input by Tasmanian researchers particularly with their previous work on herbicides and fungicides. With herbicide work now having reached a stage where pea growers can see the economic effects of products such as Command and Frontier as an indirect method of potentially reducing the impact of *Ascochyta*, the push is on to register these products.

Fungicide work has been limited in this project due to its high economic cost compared to its potential return. Work in Tasmania has been thorough and conclusive with the WA committee deciding to look at other approaches to reducing the incidence of *Ascochyta*.

A final report will be sent to the respective Tasmanian researchers on last year's research once completed and further co-operation in registering the herbicides is expected.

#### ***Proposed 12 months work plan agreed to by industry***

A meeting is arranged for April with the pea committee to finalise the details of the forthcoming work plan. At this stage the work plan is as follows:

- A large-scale herbicide trial involving the industry standards and the Command/Frontier treatment.
- The undertaking of a full-scale paddock set-up involving the use of permanent roadways where all machinery will travel to avoid damaging the crop and subsequently reducing the impact of *Ascochyta*.
- Screen new pea varieties for higher performance and greater resistance to *Ascochyta*.
- Investigate the use of Phosphonic acid to reduce the incidence of *Ascochyta*
- Use aerial photography as a tool in reducing the incidence of *Ascochyta* by avoiding areas in the paddock that will lead to stressing of the crop and allowing the potential entry of disease.

## NEW ZEALAND LEGUME PROJECTS

**Pathogens:** *Erysiphe pisi*, *Peronospora viciae*, *Ascochyta* complex, *Pythium* spp., *Rhizoctonia*, *Fusarium oxysporum* (Race 1), *Aphanomyces eutiches*, PeaSbMV, Bean YMV, Alfalfa MV, Pea top YV

Research aim: Resistance breeding in peas  
Principal investigator: Dave Goulden  
Institution: Crop & Food Research

**Pathogen:** *Aphanomyces eutiches*

Research aim: Marker assisted selection, resistance breeding in peas  
Principal investigator: Gail Timmerman-Vaughan, Adrian Russell, Richard Falloon  
Institution: Crop & Food Research, NZ Plant Breeders Ltd.

**Pathogen:** *Aphanomyces eutiches*

Research aim: Biological control with bacteria in peas  
Principal investigator: Alison Stewart  
Institution: Lincoln University

**Pathogen:** *Peronospora viciae*

Research aim: Fungicide resistance  
Principal investigator: Richard Falloon  
Institution: Crop & Food Research

**Pathogen:** *Sclerotinia sclerotiorum*

Research aim: Biological control with *Coniothyrium* in beans  
Principal investigator: Alison Stewart  
Institution: Lincoln University

## APPENDIX 6. SWEET CORN

### VG99025, BREEDING DISEASE AND INSECT RESISTANT SUPERSWEET CORN

Principal investigator: Ian Martin  
Project start: 01-Jul-99, finish: 30-Jun-04  
Organisation: QLD Department of Primary Industry  
Contact phone: 07 40958419

#### Project aims

The sweetcorn industry in Australia is valued at \$30 million annually. There is good potential to increase this substantially as Australians come to appreciate the attractiveness of supersweet corn as a component of their diet and as presentation of the product in the supermarkets is improved.

Export also is an area where Australia can exploit its ability to produce a good, clean product. Already Golden Circle has had success in exporting canned supersweet corn to Japan where it has been rated superior to product from northern America. We can also expect to sell frozen cobs, cobettes and kernels on the export market.

However growers have experienced problems with disease and with insects in existing hybrids. Disease is being overcome with more resistant hybrids.

The insect problem is principally associated with the corn ear worm, *Helicoverpa armigera* (Heliiothis). It is far and away the most serious insect problem of sweetcorn in Australia. It inflicts economic damage by eating kernels, by leaving frass in the cob and by the presence of larvae in the cob. All of these make the cob unmarketable particularly for export where presence of larvae can prevent export. In the face of mounting resistance to chemical insecticides the industry is turning to non-chemical means of control. Such control of heliothis will require an integrated approach using resistant varieties, parasitic species (e.g. *Trichogramma* wasp), ear worm infecting viruses such as NPV, and bacteria such as *Bacillus thuringiensis*.

Using these techniques growers in the Lockyer Valley of Queensland have been able to control Heliiothis without resorting to insecticide application. The advantages are manifold - lower costs, lower chemical residues, less environmental damage, less health risk, better marketing appeal. In the context of insecticide-resistant biotypes of Heliiothis this integrated approach becomes a necessity rather than an option.

#### Progress

Figure 1 compares one of our new hybrids, H772 with two temperate hybrids, HY1012 and Dominion and the tropical hybrid, H5. For the two diseases, Turicum leaf blight and Common rust, higher ratings imply greater resistance. It is apparent that H772 is superior for blight resistance to the other three hybrids with the exception of HY1012. For rust only H5 has greater resistance than H772. Heliiothis resistance is also significantly better in H772 than the two temperate hybrids. In the area of tenderness and sweetness it is evident that H772 is well short of the standards set by Dominion, a hybrid regarded as setting the highest standards. However, it is substantially more tender than H5, the tropical hybrid.

We are now undertaking selection to improve both disease resistance and eating traits with cycles of recurrent selection. Improvement of eating traits involves taste testing on individual plants after self-pollination to facilitate preservation of elite individuals, then recombination of these individuals to commence the next cycle. Heliiothis resistance will be approached through a rating technique and with the aid of an introduced gene which produces a toxic chemical in the silks.

Other diseases receiving attention are Polysora rust and Sorghum downy mildew.

SUPERSWEET CORN HYBRIDS AT KAIRI, 2001

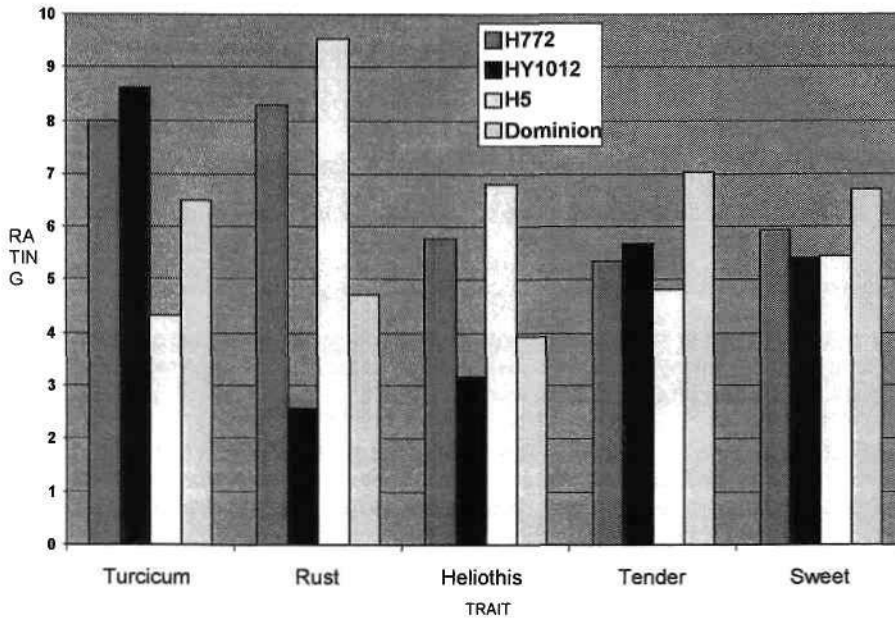


Figure 1. Comparison of temperate and tropical supersweet corn hybrids for disease and insect resistance

## VG01074, MANAGING NORTHERN CORN LEAF BLIGHT IN PROCESSING SWEET CORN

Principal investigator: Andrew Watson  
Project start: 01-Jul-01, finish: 30-Jun-03  
Organisation: NSW Agriculture  
Contact phone: 02 6951 2647

### Summary

Sweetcorn is a significant vegetable industry with a gross farm gate value of \$35m (ABS 1998). Processing is the major industry sector and the NSW processing sweet corn industry dominates Australian production for domestic and export markets. Significant expansion in NSW is predicted.

Turcica and rust diseases threaten the survival and development of the processing sweet corn industry. Northern corn leaf blight or turcica disease recently caused a total crop loss of 280 ha in 1999/2000 in the Central West of NSW and usually occurs each year.

Diseases of sweetcorn include various leaf diseases including rusts and leaf blights. Northern corn leaf blight is caused by the fungus *Exserohilum turcicum*.

This project will aim at developing best practice in controlling leaf blight, examining such factors as variety selection, stubble management, irrigation practices, and weather effects including leaf wetness.

Current spray recommendations will be reviewed. Chlorothalonil a protective fungicide is the only recommended fungicide available for this disease. Alternative fungicides could include curatives. Field trials will test such chemicals.

This project will be partly funded by a voluntary contribution from the Western Rivers Horticultural Council who through grower contributions will fund \$10 000 towards the research.

## NEW ZEALAND SWEET CORN PROJECTS

Pathogens: *Sphaerotheca reillana*  
Research aim: Fungicide control  
Principal investigator: Peter Wright, Bob Fullerton  
Institution: Crop & Food Research, HortResearch

## APPENDIX 7. POTATOES

### PT01019, PREDICTION AND MOLECULAR DETECTION OF SOIL-BORNE PATHOGENS OF POTATO

Principal investigator: Nigel Crump  
Project start: 01-Jul-01, finish: 30-Jun-04  
Organisation: IHD Knoxfield  
Contact phone: 03 9210 9222

#### Project progress/impact

Through an the NRE Scientific Exchange Program, the project leader spent four months working in a key Agriculture and Agri-Food Canada soil-borne disease laboratory in Ontario, Canada learning and developing techniques for the rapid detection and quantification of potato pathogens in field soil. This experience is now being put into practice in this project.

A State-wide field trial to evaluate the detection and quantification of pathogenic populations of *Streptomyces scabies*, the cause of common scab, (common scab) in field soil is in progress. Tests include a combination of the traditional selective media and new DNA technologies. The trials will test the relationship between soil populations of the pathogen and disease on tubers.

The development of molecular-based test to distinguish different strains (anastomosis groups) of the *Rhizoctonia solani* fungus has begun. Several hundred isolates of *Rhizoctonia solani* collected from potato and other crops in Victoria and a number of international tester isolates will be used to develop the tests.

Bioassay techniques and DNA probes are currently being developed for the quantification of populations of the powdery scab pathogen, *Spongospora subterranea* in field soil. The bioassay system will be used to verify data from the DNA tests. The DNA test has successfully verified positive bioassay results from naturally infected field soil.

The tools developed in this project will become indispensable in progressing research into the biology and management of soil-borne pathogens of potatoes. This project will ultimately lead to the development of soil tests for farmers which will be linked with disease prediction and management systems.

## **PT01031, ENHANCED DETECTION OF PCN AND BACTERIAL WILT TO IMPROVE MARKET ACCESS FOR THE AUSTRALIA AND NEW ZEALAND POTATO INDUSTRIES**

Principal investigator: Robert Faggian  
Project start: 01-Jul-01, finish: 30-Jun-04  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### **Summary of outcomes**

- Existing laboratory and field diagnostic protocols for bacterial wilt and PCN are inadequate.
- DNA-based diagnostic methods are vital for sensitive and accurate detection of bacterial wilt and PCN.
- The techniques required to monitor disease (pathogen numbers and yield) have been established.
- Field sites with a documented history of disease have been selected to validate newly developed tests.
- The development of new DNA probes is under way for both pathogens.

### **Progress against milestone**

#### **(1) Benefits of quantitative DNA probes**

The situation analysis indicates that the diagnostic tests currently available for bacterial wilt and PCN are inadequate and that rapid, sensitive DNA-based tests need to be developed.

*EPPO Protocols, used by the European Union to test suspect tubers for the presence of bacterial wilt and PCN, were reviewed and compared to DNA probe-based approaches. The review process included laboratory and field trial-runs of individual methods were possible.*

The EPPO protocols, while extensive, rely on detection techniques that have poor detection sensitivities. For instance, the EPPO detection protocol for bacterial wilt in seed requires the testing of 200 tubers from a 25 tonne batch, giving an 87 per cent chance of detecting a 1 per cent incidence of disease. The testing procedures are based on the ability to culture the bacterium on agar followed by tomato bioassays and biochemical tests. However, it is difficult to isolate bacteria from latently infected tubers because 1) the media used are not selective, resulting in the isolation of many species from a single tuber and 2) *Ralstonia solanacearum* is a slow-growing bacterium and its presence (if numbers are low) can be masked by faster growing species. The EPPO testing protocol is time-consuming and laborious, and therefore costly to carry out. At best, the protocol gives only some indication of the presence of bacterial wilt in non-symptomatic tubers. It is therefore essential to 1) develop a more sensitive testing procedure, such as a DNA-based diagnostic test and 2) to develop a test for soil to increase the likelihood of identifying the possible presence of the bacterium in suspect growing areas.

An assessment of PCN testing procedures in NZ led to the same conclusion. Fork testing, the current standard, is inadequate for a number of reasons. Firstly, the statistical basis for the fixed point sampling regime has not been tested and may therefore fail to account for the patchy spatial distribution of the disease. Secondly, visual inspection of plant roots for the presence of protruding female nematodes represents a very narrow window of opportunity - the nematodes quickly turn brown and become very difficult to see. A greater focus on soil and potato debris generated during the preparation of tubers for sale may be a more effective and efficient means of detecting disease. Again, a DNA-based diagnostic test would provide the speed and sensitivity to enable such a strategy to work. This will reduce the cost of PCN testing while also increasing test accuracy significantly.

#### **(2) Available field sites and monitoring routines determined, trial sites established**

Field sites with well-documented histories of PCN and bacterial wilt infection were selected in New Zealand (2 sites) and Australia (5 sites) respectively. The methods required to monitor pathogen and disease levels have been established (fork testing, elutriation and DNA probes in New Zealand / bacterial isolation and culturing, bioassays (tobacco), biochemical tests and DNA probes in Australia) and both research centres are equipped to use the techniques routinely now that the growing season has commenced.

**(3) Newsletter created and first issue released.**

The release of the first issue of the project newsletter has been delayed until the majority of growers can be informed of the project face-to-face. This has now largely been accomplished - In Australia, two grower meetings (facilitated by the NRE VegCheque team) were attended by more than 40 seed and ware growers from the Mirboo Nth and Koo Wee Rup areas. The response was extremely positive and led to the aforementioned field sites being made available. In New Zealand, growers have been visited individually by project staff.

**Additional achievements relevant to milestone**

**Bacterial wilt:** All available DNA probes (a total of twelve) for the detection of bacterial wilt were assessed for their ability to specifically detect the bacterium in infected tubers. All twelve probes resulted in either non-specific detection or poor detection sensitivity. DNA sequencing of Australian isolates of *Raistonia solanacearum* is underway to allow the design of more efficient and specific probes.

**PCN:** An existing DNA probe able to distinguish between the two PCN species, *Globodera rostochiensis* and *Globodera pallida*, has been tested and further refined to allow detection in soil.



## **PT01017, UNDERSTANDING THE IMPLICATIONS OF PASTURES ON THE MANAGEMENT OF SOIL-BORNE DISEASES OF POTATOES**

Principal investigator: Rudolf de Boer  
Project start: 01-Jul-01, finish: 30-Jun-04  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### **Project progress/impact**

This project aims to develop a better understanding of the ecology of major soil-borne potato pathogens in pastures and to develop strategies to better manage them in the pasture phase. Generally in Australia potatoes are grown after a pasture phase of two or more years and there is evidence from recent projects (06317, 06361) that the pasture phase supports populations of these pathogens. Target pathogens include those causing *Rhizoctonia* stem canker, powdery and common scab and pink rot. The project will also gather information in the literature on disease caused by other fungal and nematode pathogens.

### **Progress to date**

- A literature review is in progress.
- A long-term (3-year) field trial has been established on a grower's property to allow the tracking of pathogen populations, disease and potato yield under different regimes such as ryegrass-potato and clover-potato.
- A bioassay technique for detecting and quantifying populations of the powdery scab fungus is currently being developed and tested.
- Strains of *Rhizoctonia solani* from potato cropping systems are being characterised and new strains are being tested for pathogenicity against potato and pasture species.
- The project will use diagnostic tools developed in 07795 and 07785.
- An experiment to test the effects of changing pasture composition and timing of cultivation on pathogen populations and on disease and yield of potatoes is being planned.

## PT98018, CLEANING AND DISINFECTION PRACTICES FOR POTATO FARMS

Principal investigator: Dolf de Boer  
Project start: 01-Jul-98, finish: 30-Sep-02  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### Progress report

#### Summary of progress

- The potato pathogens *Helmithosporium solani* (silver scurf), (*Colletotrichum coccodes*) (black dot), *Rhizoctonia solani* (black scurf), *Streptomyces scabies* (common scab) and *Spongospora subterranea* (powdery scab) were detected in dust samples from growers sheds using a potato plant 'bioassay' technique. Silver scurf and black dot were the most common diseases detected in the dust samples, reflecting disease levels found on certified seed potatoes. This highlights the potential for contamination of seed potato stocks with potato pathogens from shed dust.
- The dust bioassay indicated that there was no greater risk of disease in dust from dirt-floored sheds than from concrete-floored sheds. However, unlike dirt floors, concrete floors can be cleaned to minimise dust levels and thereby reducing the risk of contaminating seed stocks.
- Spores of the silver scurf fungus were commonly found in air sampled from sheds and cool store environments. The high frequency of detection of the silver scurf fungus in dust as well as in the air in potato sheds highlights a very high risk of contamination of seed stocks and the spread of the silver scurf in the shed and cool store environment. This helps explain why this is the most common disease on seed potatoes.
- The powdery scab fungus was detected in dust samples from regions not considered to be risk of powdery scab. A DNA based test was used to detect the fungus in dust samples in a matter of hours compared with several weeks required for a result from a 'bioassay.'
- n experiments evaluating the effects of disinfectants against potato pathogens on different surface materials (metal, plastic, wood and concrete), bacterial and fungal potato pathogens were found to survive better on dirty surfaces than on clean surfaces. Of the surfaces tested, both clean and dirty wood harboured the greatest numbers of viable spores of both bacteria and fungi.
- Because of poor survival of pathogens on the different surfaces, the results of tests to evaluate the effect of disinfectants against the pathogens on surfaces were inconclusive. A more robust testing procedure is currently being developed.
- Potato tubers affected with sclerotia of *Rhizoctonia solani* were used as a model for the disinfection of an organic surface. Immersing tubers for 2 minutes in a solution of Biogram™ at a rate recommended for 'dirty' surfaces was as effective as a standard Formalin™ treatment which resulted in negligible growth of the fungus from sclerotia. In contrast, five times the recommended rate of a Peratec 5 Sanitiser™ solution was required to achieve the same effect as the Biogram™ and Formalin™ dips. Biogram is not recommended for use on potato tubers because subsequent tests have shown it to be very phytotoxic to potato sprouts. Formalin is not recommended for any purpose in the potato shed because it is a suspected carcinogen. None of the treatments tested are registered for use on potato tubers.
- Results of this project were presented at two grower workshops in Victoria and at the Potatoes 2000 Conference.

#### General progress

A number of laboratory, glasshouse and field based studies have been completed. However, progress towards the recommendation of disinfectant treatments for pathogens on different surfaces has been delayed because of unexpected problems in experimental procedures. This relates to the recovery of pathogens from untreated and treated surfaces (details of results below). New testing techniques are currently being developed and evaluated. Although cleaning of surfaces in the shed environment is a vital first step in a disinfection process, it is important that representative disinfectants from the major chemical groups are evaluated for their efficacy so that appropriate treatments are used with confidence as a final step in this process when required. Growers are faced with a bewildering choice of 'off-the-shelf' disinfectants sold as general purpose sanitisers. These do not carry recommendations for disinfection of plant pathogens in general. The majority of disinfectants sold are quaternary ammonium products and there is very little information on their effectiveness on potato pathogens.

Because of the delays, the R&D committee has been asked to consider granting a one-year extension to this project to ensure that it can be satisfactorily completed.

### **Change of staff**

Jacqueline Edwards resigned as scientist on this project to take up another position within Agriculture Victoria Knoxfield. The subsequent vacancy was advertised nationally early this year. Mr Nigel Crump was the successful applicant and commenced work in May 2000. He is a former employee of Charles Sturt University, Wagga Wagga NSW. Mr Crump has relevant experience in plant pathology, microbiology and molecular biology and will submit a PhD thesis for examination in December this year. He has taken on his new role in potato pathology R&D with enthusiasm, vigour and confidence.

### **Testing dust from sheds for potato pathogens**

Samples of dust were swept from the floors of potato sheds in the Colac/Otway and the Central Highlands (Ballarat) regions of Victoria during October 99 in order to evaluate disease risk from dust in sheds. Preliminary results were reported in Milestone 4. A total of 12 sheds were sampled (6/region), including dirt-floored and concrete-floored sheds. Dust was sampled from three locations in each shed (general thoroughfare, around potato bins and from under the grader). In order to determine which potato pathogens were present, 100 g samples of dust were 'sandwiched' between layers of potting media and planted with tissue-cultured Sebago or Kennebec plantlets in a technique known as a 'baiting' or a 'bioassay' test. The bioassays were harvested in March 2000.

The five diseases found on the skin of the progeny tubers, listed in order of frequency of detection, were silver scurf (*Helminthosporium solani*), black dot (*Colletotrichum coccodes*), black scurf (*Rhizoctonia solani*), common scab (*Streptomyces scabies*) and powdery scab (*Spongospora subterranea*).

Further analysis of the bioassay data revealed that black dot was the most common disease from dust samples taken in the central highlands district. Less common were silver scurf, common scab, black scurf and powdery scab. In contrast, silver scurf was the most common disease from dust in the Otway-Colac region with black scurf, black dot and powdery scab being less common. Common scab was not detected in any sample from the Otway-Colac region, although the disease has been common in crops in this area over the past few seasons. The relative incidence of the diseases from dust samples reflects the relative incidence of the diseases on seed potatoes from the two regions. Generally, black dot is the most common disease in the Central Highlands and silver scurf the most common in the Otway-Colac region.

Overall, there was no apparent difference in disease incidence and severity on bioassay tubers grown in dust from dirt floors compared with dust from concrete floors. It was expected that dirt floors would present a higher risk of disease. The advantage of concrete floors is that they can be cleaned through the combination of dust removal (sweeping or vacuuming) and washing. This is difficult with dirt floors which are constructed of rammed earth or crushed rock.

Disease incidence and severity from dust varied considerably from shed to shed. Overall, there were no major differences in incidence and severity when comparing dust samples from the different areas of individual sheds.

Finding powdery scab fungus in dust samples from the Colac region is surprising since the disease is not considered to be of any concern in this region, although powdery scab is a serious problem in the nearby Otway Ranges (adjacent to the Colac region). This means that seed potatoes grown in this apparently powdery scab 'free' area are at risk of contamination with the powdery scab fungus.

### **Sampling the air in potato sheds and stores for air-borne potato pathogens**

The air in sheds and cool stores was also sampled with a 'Rotorod™' sampler. A number of potato pathogens were found on the Rotorod tapes including *Helminthosporium solani*, *Fusarium* spp, *Rhizoctonia solani*, *Colletotrichum coccodes*, *Alternaria solani* (target spot) and *Spongospora subterranea*. Spores of *H. solani* were by far the most common. Fragments of *R. solani* hyphae were also found consistently in air currents in most sheds and cool stores. The relative abundance of *H. solani* spores varied considerably from shed to shed and within different parts of the shed. There was no apparent pattern in the relative abundance of spores from shed to shed. Surprisingly, large numbers of *H. solani* spores were detected in one shed where potato sorting was finished for the season and were also common in some cool stores.

In one shed, *H. solani* spores were considerably more abundant in the air over a dirt floor area than over an adjacent concreted area. This may be related to the proximity of consignments of potatoes stored in wooden bins over the dirt-floored area of the shed. Data is being further analysed to determine if there are any trends relating abundance of spores to the district, shed or activities in the shed.

This results of bioassays on shed dust and the sampling of air currents in sheds demonstrates the significant risk of contamination of seed potato stocks in potato sheds. The greatest risk is of contamination is with the silver scurf fungus (*H. solani*) because it is common in the shed dust and is also spread about sheds and cool stores as spores produced on diseased potatoes. This explains why silver scurf is the most common disease of seed potatoes. The data also shows the potential of the inadvertent contamination of seed tubers with pathogens such as the powdery scab fungus, for example, in apparently powdery scab 'free' districts. The results of this study indicate a need for potato growers to regularly clean shed floors during peak times in sheds to minimise the spread of dust throughout the shed and to physically separate sorting and storage areas. Concrete floors are essential if the shed is to be effectively cleaned.

### **Using DNA probes to detect pathogens in dust samples**

Powdery scab was detected in dust from one of the six sheds sampled in the Colac-Otway region using the bioassay technique. A number of the samples were also tested using a DNA based assay technique which is specific for DNA of the powdery scab fungus *Spongospora subterranea*. The tests were conducted by Robert Faggian who is currently developing DNA probes for the Brassica clubroot fungus, a fungus related to *S. subterranea* (HRDC Project VG99008). Although still in a development stage, this test confirmed the positive bioassay results but also detected *S. subterranea* in dust samples from the Colac district that had tested 'negative' with the bioassay. The advantage of the DNA test is that it takes only a fraction of the time and resources of the bioassay and is more sensitive. Research is underway in laboratories in Europe, Australia and New Zealand to develop quantitative tests.

### **Evaluating disinfectant treatments on different surface materials**

Previous experiments demonstrated the effect of several disinfectants on potato pathogens *in vitro*. In a second series of experiments, five disinfectant treatments were evaluated for their ability to disinfect four surface materials which were artificially contaminated with inoculum of the potato pathogens *Erwinia carotovora* pv. *atroseptica*, *Erwinia carotovora* pv. *carotovora*, *Ralstonia solanacearum*, *Fusarium trichotheciodes* and *Helminthosporium solani*, causing blackleg, bacterial soft rot, bacterial wilt, dry rot and silver scurf of potatoes, respectively. The surfaces tested were concrete, zincalume metal (used for shed walls and roofs), plastic (pot labels) and wood (matchsticks). Pathogens were coated on surfaces and treated with recommended rates of Phytoclean™ (quaternary ammonium compound), Biogram™ (phenol), Peratec 5 Sanitiser™ (peroxygen), Sodium hypochlorite @ 1000 ppm Cl (halogen) and 70 per cent ethanol (alcohol) for 10 minutes. Water was used as a control. The disinfection treatments were applied in both the presence and absence of organic matter (yeast extract for bacteria and peat extract for fungi).

Preliminary results of these tests were reported in Milestone 4. Further analysis showed that the recovery of viable potato pathogens was dependent on the type of organism and the type of surface, even when no disinfectant treatment was applied. On clean surfaces, very few viable bacteria were recovered in comparison to dirty surfaces. Viable fungi could be recovered from all surfaces, particularly from concrete and wood.

Further work is required to find a method of improving the recovery of viable bacterial cells from untreated surfaces in order to make any real comparisons of the relative effectiveness of each disinfectant treatment. In this study, 70 per cent ethanol was the best general purpose disinfectant. This contrasts with the results of *in vitro* suspension tests in which Biogram™ and Peratec 5 Sanitiser™ were the most effective disinfectant treatments, suggesting that different properties of each surface material, such as pH, interact with the disinfectants and affect their efficacy.

Overall, higher numbers of viable pathogens were recovered from dirty surfaces, suggesting that the efficacy of the disinfectants was reduced in the presence of organic matter. It is also possible that the particles of organic matter may have provided some protection to the pathogens, improving their survival. Disinfectants may also have reduced the adhesion of the pathogens to the surface allowing a greater recovery of viable pathogens.

Of the surfaces tested, both clean and dirty wood had the highest levels of recoverable colony forming units (cfu's) for all pathogens and disinfectant treatments. It is noteworthy that wood is itself an organic material, unlike concrete, plastic and metal. This indicates that wooden surfaces may be the most important source of contamination in the shed. Further research efforts in this area should concentrate on finding an effective cleaning and disinfection protocol for contaminated wooden surfaces.

Further testing is underway to develop a robust method of evaluating disinfectants on different surface materials. A thorough review of literature has raised a number of issues that need to be taken into consideration.

- Some bacteria produce a protective barrier, called a 'biofilm', which protects them from cleaning/disinfectant treatments. Bacteria are 10-100 times more resistant to biocides when attached to surfaces. Surfactants may be useful in cleaning surfaces, particularly where biofilms may be involved.

- Some pathogens, such as *Ralstonia solanacearum* (bacterial wilt), are able to produce enzymes, such as catalases, which break down peroxide-based disinfectants, thereby reducing the efficacy of these types of disinfectants. This problem can be overcome with the use of enzyme inhibitors.
- The presence of both soil and organic material significantly reduces the efficacy of some classes of disinfectant chemicals, particularly the halogen and quaternary ammonium products. Therefore, cleaning (i.e. removal of organic material) of surfaces is an essential step in the disinfection process.
- The pH of surfaces and of the water used to prepare disinfectant solutions can have a significant effect on the survival of pathogens and the efficacy of disinfectants. For example, available chlorine concentrations are dramatically reduced in water tending to alkaline pH.

Because of these problems, a greater emphasis will be placed on cleaning procedures prior to a disinfectant treatment. For some pathogens, effective cleaning procedures may eliminate the need for disinfectants. Nevertheless, it is important to know which class of disinfectant is effective against each pathogen on the different surfaces found in the shed environment. This includes information on the appropriate rate of application, time of exposure and factors that reduce efficacy (e.g. organic matter, pH, temperature). Growers need enough information to be able to use a particular class of disinfectant with confidence in relation to efficacy, safety of use and impact on the environment.

### Work in progress

- Improving tests for the efficacy of disinfectants on different surfaces. The use of osmotic buffers and tryptone to improve the survival of bacteria on different surfaces is currently being investigated.
- Developing a culturing technique to produce large quantities of spores of the black dot fungus *Colletotrichum coccodes*. It has been difficult to produce sufficient quantities of spores for experimental purposes. A 'lawn culturing' technique is showing promise.
- Testing the efficacy of disinfectants against the powdery scab fungus. Dolf de Boer recently attended the Powdery Scab Workshop in Aberdeen (July 2000) where he learned of a bioassay technique for the powdery scab fungus. This is being used to assess the effects of different disinfectant treatments on spore balls of this fungus.
- Comparing the disease risk of field soil and shed dust. Growers often ask 'What is point of cleaning up in the shed if I have the pathogens in the field soil?' Samples of field soil and shed dust from the same farm are being bioassayed for the presence of potato pathogens in order to determine the relative disease risk between the field and the shed. This will help determine what contribution shed dust could make to inoculum in the disease cycle on potato farms.
- Effective rates of disinfectants. So far, disinfectants have been tested at recommended label rates. Tests conducted so far suggests that some disinfectant treatments have not been effective at these rates. A range of different rates are currently being evaluated.
- Preliminary tests have identified strains of the silver scurf fungus that are resistant to the fungicide thiabendazole. Isolates of the silver scurf fungus baited from dust sample are being tested for resistance to this fungicide in order to determine the potential risk of spreading resistant strains within the shed environment.

### Evaluating the efficacy of disinfectants against *Rhizoctonia solani*

*Rhizoctonia solani* does not produce spores on artificial media and, although the fungus does produce sclerotia, they are not typical of those found in the natural environment. To overcome these constraints, potato tubers naturally affected with *Rhizoctonia solani* sclerotia (black scurf) were used as a convenient model for the evaluation of disinfectant treatments on an organic surface, representing an extreme situation in the potato shed. Tubers were immersed in disinfectant solutions for 2 minutes. Sclerotia of *R. solani* were then excised from the tuber skin, plated onto agar and radial growth of the fungus recorded after 48 hrs. Treatments included Formalin™ (1.4 per cent) (aldehyde), Biogram™ (1.5 per cent) (phenol), Sodium hypochlorite (8 per cent) (halogen), Oxine™ (0.5 per cent) (halogen), Peratec 5 Sanitiser™ (1 per cent) (peroxygen), Phytoclean™ (1 per cent) (quaternary ammonium), at rates recommended for 'dirty' surfaces, and water dip as an untreated control. Formalin™ and Biogram™ treatments almost completely inhibited the growth of moderately sized sclerotia. The remaining treatments resulted in slight to moderate reduction in growth compared with the untreated control. At five times the recommended rates, Biogram™ and Peratec 5 Sanitiser™ treatments were as effective as the standard Formalin™ treatment. However, the higher rate of Sodium hypochlorite and Phytoclean™ reduced growth by half that of the recommended rate, whereas treatment with Oxine™ at the higher rate was no better than the lower rate. Tests of solution have shown that available chlorine concentrations are considerably less than expected, perhaps because of the pH of the water used to dilute the chemicals. This may explain the poor efficacy experienced with the chlorine based treatments. Further experiments will compare the effects of time of exposure against rate of disinfectant for both *Rhizoctonia solani* and *Colletotrichum coccodes* (black dot) and will also examine the effect of water pH on the availability of chlorine in the chlorine disinfectants.

Formalin™ is not recommended for any purpose the potato sheds because of the potential hazards to human health. Biogram™ is not recommended for use on potato tubers because tests have shown that the chemical is very toxic to tuber sprouts at label rate. The disinfectant treatments described in this report are not registered for the treatment of seed potato tubers.

**Extension**

A paper relating to hygiene in the potato shed was presented at the Potatoes 2000 Conference, Adelaide, 1-4 August 2000.

Results of this project were presented to potato growers at Gippsland Seed Potato Growers Discussion Group, 9 August 2000, Trafalgar, Victoria and at the combined Processing Potato Growers and Seed Potato Growers Seminar Day, 10 August 2000, Bullarook, Victoria.

**Publications**

Edwards, J. and de Boer, R.F. (2000). Hygiene and disinfection in the potato shed. In 'Conference Proceedings of the Potatoes 2000 Australian Potato Research, Development and Technology Transfer Conference, Adelaide, South Australia, 31 July-3 August 2000'. Eds C.M. Williams and L.J. Walters. Pp. 59-62. (South Australian Research and Development Institute, Adelaide, South Australia).

Crump, N.S. and de Boer, R.F. (2000). Hygiene in the potato shed. Notes for Bullarook Growers Seminar, 10 August, Bullarook, Victoria.

## POWDERY SCAB RESISTANCE IN POTATO CULTIVARS

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Powdery scab of potato, caused by *Spongospora subterranea* f. sp. *subterranea*, is an important disease throughout the world where potatoes are intensively grown for seed, as fresh vegetables or for processing. Good progress has been made with identifying chemical methods for powdery scab control, using seed tuber treatments to prevent transmission of the disease to new crops and soil treatments to prevent infection from infested soil. New research has also shown that addition of boron to soil can reduce incidence and severity of powdery scab in heavily infested soil.

A third approach to powdery scab control has been to determine if potato cultivars and breeding lines differ in susceptibility to the disease. The first aim of this research was to provide potato growers with accurate information to assist crop management with respect to powdery scab (cultivar choice and the need for disease control strategies). After differences in reaction to the disease were noted, resistant germplasm has been identified and is being used in current breeding programs for development of new potato cultivars.

### Cultivar screening

Field trials over a 10 year period have tested the majority of potato cultivars available in New Zealand in disease nurseries where the soil is heavily infested with *S. subterranea*. Two cultivars, Gladiator (highly resistant) and Iwa (highly susceptible) have been included in all the trials as standards. All other cultivars that are commercially available in New Zealand have been tested, with each cultivar tested for at least two years. In each annual trial, harvested potato tubers from each cultivar are assessed for powdery scab severity, and each cultivar is given an average severity score, which is scaled each year (to allow for annual differences in disease severity) using the highly resistant and highly susceptible standards. Gladiator has the standard score of 8.8, while that for Iwa is 5.0. Cultivars with no disease will have a score of just over 9, while those with all tubers very heavily infected will have a score of 1.

The cultivars cover a broad spectrum of reaction to powdery scab (see accompanying Table), from very highly resistant (e.g. Swift, Gladiator and Red Rascal) to highly susceptible (e.g. Liseta and Asterix). Cultivars have been arbitrarily categorised (see Table) as very resistant (scores = 8), moderately resistant (scores 7-8), moderately susceptible (scores 6-7) and very susceptible (scores < 6)

### Relationship of root infection with tuber infection

We have recently completed a glasshouse experiment to determine if root infection of potato plants by *S. subterranea* is related to tuber infection. Fifteen cultivars representing the spectrum of response to the pathogen were examined for intensity of zoosporangium development in root cells and formation of root galls, after inoculation with standardised amounts of inoculum. In general, cultivars with heavy zoosporangium infection and extensive root gall formation were those that were most susceptible to tuber infection as assessed in field trials. Conversely, those with light zoosporangium infection and few root galls were those that were resistant to tuber infection in field trials. One cultivar (Swift) did not follow this pattern. This cultivar had heavy root infection and root galling, but is one of the most resistant cultivars to field-assessed tuber infection.

### Powdery scab resistance breeding

Identification of resistance in suitable potato germplasm has allowed crossing and selection for powdery scab resistance to be included in Crop & Food Research's potato improvement program. All new cultivars are likely to have resistance to the disease, or well characterised for reaction to *S. subterranea*. Resistance assessment will continue so that any changes in pathogen virulence can be detected. Possibilities for marker-assisted selection are being investigated.

Scaled average powdery scab severity scores for different potato cultivars in field trials in soil heavily infested with *Spongospora subterranea*. Score of 9 = highly resistant, 1 = highly susceptible. Cultivars assessed in at least two growing seasons.

Highly resistant	
Cultivar	Score
Swift	9.0
Vtn62-33-3	8.8
<b>Gladiator*</b>	<b>8.8</b>
Donald	8.7
Winston	8.6
Saxon	8.5
Red Rascal	8.4
Nortakah	8.4
Van Gogh	8.3
Toru	8.3
Moonlight	8.3
Harmony	8.3
Foxton	8.2
Snowden	8.2
Ilam Hardy	8.2
Stroma	8.2
Nadine	8.1
Fianna	8.1
Driver	8.0
Record	8.0

Moderately resistant	
Cultivar	Score
Russet Burbank	7.9
Ranger Russet	7.9
Nooksac	7.8
Innovator	7.7
Cliffs Kidney	7.7
Velox	7.6
Pacific	7.6
Valor	7.6
Rima	7.5
Croft	7.5
Jersey Benne	7.4
Waru	7.4
Tarago	7.4
Red King	7.4
Desiree	7.4
Pentland Dell	7.4
Maris Anchor	7.3
Majestic	7.3
Kaimai	7.2
Sebago	7.2
Kiwitea	7.2
Delcora	7.1
Lutetia	7.1
Dakota Red	7.1
Karaka	7.0
Katahdin	7.0

Moderately susceptible	
Cultivar	Score
Frisia	6.9
Bildstar	6.9
Tekau	6.9
White Delight	6.8
Wha	6.8
Jewel	6.7
Rua	6.7
Arran Banner	6.7
Fronika	6.6
Spunta	6.6
Hulda	6.6
Obelix	6.6
Tahi	6.5
Matilda	6.5
Atlantic	6.5
Epicure	6.4
Mondial	6.4
Shepody	6.4
Rocket	6.4
Frontier Russet	6.3
Victoria	6.3
Fanfare	6.3
Diamant	6.1
Red Star	6.1
Morene	6.1
Mona Lisa	6.0
Premiere	6.0
Yvonne	6.0

Highly susceptible	
Cultivar	Score
Kennebec	5.9
Concorde	5.9
Crebella	5.9
Rosa	5.9
Whitu	5.5
Agria	5.4
Draga	5.3
Ukama	5.1
Bright	5.1
<b>†waj</b>	<b>5.0</b>
Cardinal	4.9
Florissant	4.8
Liseta	4.6
Marco Polo	4.6
Asterix	2.6

\* = resistant standard

† = susceptible standard



## PT98015, DEVELOPMENT OF EXTREME RESISTANCE (IMMUNITY) TO COMMON SCAB DISEASE WITHIN CURRENT COMMERCIAL POTATO CULTIVARS

Principal investigator: Calum Wilson  
Project start: 01-Jul-98, finish: 31-Oct-01  
Organisation: University of Tasmania  
Contact phone: 03 6226 2638

### Technical summary

Common scab disease is the greatest economic constraint facing the Australian French potato processing industry and an important disease worldwide wherever potatoes are grown. Although not directly affecting tuber yields, disease lesions markedly reduce tuber value and require extra processing steps during French fry production. As a result, crops with severe disease are often rejected by processing companies and seed crops with moderate levels of disease will be downgraded to ware quality resulting in substantial losses to the producers. The frequency and severity of common scab in Australia (primarily Tasmania and parts of Victoria) is increasing. Current conservative estimates of losses due to this disease in Tasmania alone are in excess of A\$3.5 million per annum with greater losses forecast without appropriate control. This disease seriously threatens the sustainability of certain cropping areas for potato production.

Management of common scab disease has proven extremely difficult both in Australia and overseas. Past practices and current studies have utilised chemical and cultural control strategies and investigations into biological control have been attempted. Chemical control can be effective under conditions of low soil inoculum but is generally less useful where a high soil inoculum exists. Furthermore the costs associated with chemical applications add an additional burden to producers. Whilst offering a good short term management strategy, reliance on chemicals for disease control is seen as undesirable by industry and may limit future market opportunities. Similarly, cultural management strategies have had limited success in control of this disease. Most are difficult to implement within current cropping practices and may in time exacerbate other problems (e.g. increased irrigation at tuber initiation can increase powdery scab and black leg incidence; soil pH depression which limits the success of notation crops). Biological control has some potential but clear demonstration of cost effective control under commercial conditions is yet to be demonstrated.

Incorporation of durable resistance to the pathogen is an obvious long-term goal to improve sustainability of potato production. However, effective resistance is not present within current commercial cultivars. Also traditional breeding programs have significant weaknesses, requiring long time periods (in excess of ten years) to develop resistant cultivars with commercially suitable agronomic characteristics.

Use of plant tissue culture technologies, in the form of cell selection techniques offers a rapid method to obtain resistant clones of existing cultivars without the genetic re-assortment associated with breeding crosses. This makes it possible to retain the desirable agronomic characters and market acceptability of the original cultivar. This is now possible for this disease as in recent years a phytotoxin (thaxtomin) produced by the pathogen has been found which is fundamental to the development of common scab disease in potatoes. This project has utilised this toxin as a selection agent to select for resistant cell lines of current commercial cultivars.

The project has successfully developed a routine system for production of moderate quantities of highly pure thaxtomin required for cell selection studies. The techniques developed have delivered milligrams of bright orange crystals of thaxtomin. The identity of the extracts has been confirmed using mass spectroscopy and liquid chromatography have confirmed the identity of extract as being Thaxtomin A. A novel recrystallisation step in the extraction technique has been a key to recovery of highly pure (98 per cent) thaxtomin in useable quantities exceeding that of other researchers working with this toxin. This is significant as low purity samples could have had a significant effect on plant growth as the target molecule. Experiments examining possible elicitors of thaxtomin production did not clarify the reasons behind occasional variable yields of the toxin.

Following cell selection protocols a series of 20 toxin tolerant cell lines have been obtained. Three distinct phenotypes were observed within the selected callus lines.

1. Several cell lines (5 lines) showed a softer more friable callus than would be expected in unselected callus. These calli grew quickly on callus media which had facilitated rapid production of sufficient quantities callus for regeneration (and other) studies. However, some of these cell lines have proven difficult to handle during attempts at regeneration, due to sensitivity to abrupt changes in media resulting in tissue death. In some cell lines we believe that this is due to changes in osmotic potential of the media but in other cell lines it appears that there is sensitivity to changes in hormone concentration, particularly cytokinin. Sensitivity to changes in cytokinin levels presents a particular challenge, as this is central to the induction

of shoots from callus. Differences in plant hormone sensitivity are yet to be quantified in all cell lines but may point to a physiological basis for the Thaxtomin tolerance observed in some, but not all, cell lines.

2. One callus line was harder than normal but was much slower in growth. Osmotic sensitivity does not appear to be as prominent in this line.
3. The remaining 14 lines showed no phenotypic difference to unselected callus.

Despite initial sensitivity to changes in media, all cell lines have been successfully transferred to a thaxtomin free callus medium and are also maintained on a thaxtomin-containing medium.

In assays for maximal thaxtomin tolerance of selected lines, all tested lines tolerated (and grew) on media with ten times the selection concentration of thaxtomin (i.e. 22.5 mg/L). The selection level (2.25 mg/L) exceeds that likely to be found in naturally infected potatoes, so this greatly enhanced tolerance is pleasing and suggests that extreme resistance to thaxtomin has been selected within these lines. The control callus died at the normal selection concentration.

Regeneration of these cell lines has required significant level of experimentation of a range of media and culture conditions to ensure successful transfer from callus media to regeneration media. This has now been achieved but full regeneration will take a further few months culture.

Successful regeneration has not yet been achieved using standard media for thaxtomin tolerant cell lines. However significant progress toward this aim has been made. Cell lines have now all been successfully transferred onto regeneration media without adverse growth effects through careful manipulation of the transfer process, media and timing of transfers. Specific media combinations for each of the cell lines that result in the death of cultures have been identified. Notably, there are significant differences between different cell lines in media requirements.

The calli of all lines are all showing promising signs of differentiation prior to regeneration (including forming semi-structured lumps on callus, greening of callus, etc.).

New selections are continually being made (as younger callus has a greater regeneration efficiency) and it may be that now that likely specific media conditions are known that these younger calli can be habituated onto regeneration media faster.

That in recent experiments control (unselected) callus has also failed to regenerate has led us to believe that the current limitation may not be a direct consequence of the mutation and selection process but rather some fundamental media or growth room environmental factor.

To overcome this, duplicates of all cultures have been shipped to Prof. Conner (project partner chief Investigator) in New Zealand. Given that his laboratory routinely regenerates potato callus, one can assume that if it is a growth room effect inhibiting regeneration, that this should be overcome in Prof Conner's laboratory. These cultures will require a further 3-4 months before success of regeneration can be ascertained.

Regeneration is a time dependant process, and each experiment requires several months to determine outcomes. The requirement for extensive media studies has slowed progress toward the desired outcome of fully regenerated plants, however, we feel confident that the progress made and state of current cultures (growth dynamics and structures including 'greening' and semi-differentiation) and the multi-site trials should result in successful regeneration of toxin resistant plants within 3-4 months.

Additional studies have shown that exogenous and endogenous auxin ameliorates thaxtomin toxicity and conversely thaxtomin interferes with auxin activity. This has implications in the cell selection work, as alternative media had to be developed suitable for callus induction to avoid false tolerance reactions. Furthermore, this finding may link with glasshouse and field studies from the UK where foliar applied auxins reduced common scab disease. This provides a possible mechanism of thaxtomin toxicity and may assist in development of additional disease control strategies as has been suggested and trialed by researchers from the UK in the 1980's.

We also demonstrated that at least four distinct strain groups of pathogens exist in Tasmanian soil, at least two of which are novel species. Notably all pathogenic strains of the disease agent in Australia produce thaxtomin (which is essential for the successful application of the resistance generated in this project).

Lastly a brief study has shown that even within current commercial clones of Russet Burbank, significant difference in resistance to common scab disease exist. We are currently attempting to correlate this differences with tolerance to thaxtomin.

This project is the first successful selection of potato cultures with extreme resistance to the common scab toxin. Subsequent studies underway now should prove these lines to show extreme resistance to common scab disease and if agronomically sound should lead to commercial release of scab resistant clones of commercially important varieties.

**PT01001, CONTROL OF BLACK DOT IN POTATOES**

Principal investigator: Trevor Wicks  
 Project start: 01-Jul-01, finish: 30-Sep-04  
 Organisation: SA Research & Development Institute  
 Contact phone: 08 8303 9563

**Main objectives**

To develop management strategies to control the disease for both washed potato growers and seed growers.

**Summary of outcomes to date**

A survey of certified seed imported into the state was carried out to provide information on the incidence and severity of *C. coccodes* on potato seed tubers from the different seed producing regions in Australia. This was incorporated with data collected from similar surveys conducted in 1996 and 1997. The results showed that very few seed lots were unaffected by *C. coccodes*. The severity of the disease increased as the per cent of infected tubers increased. No correlation between external incidence or severity of *C. coccodes* and the internal incidence. Strong differences in disease levels were detected between different seed growers.

**Table: Detection of *C. coccodes* in seed tubers between 1996 and 2002**

$\frac{1}{2}$ # of seed lots	% of seed lots	97-98 # of seed lots	% of seed lots	96-97 # of seed lots	# of seed lots
17	60.5	37	81.0	17	64.6

Laboratory experiments have shown that volatiles released from defatted mustard seed meal from the cultivar *B. juncea* were inhibitory to the growth of *Colletotrichum coccodes* by 95 per cent and that as time of exposure increased the degree of inhibition increased. In addition hyphal radial growth was re-established within all fungi once the meal was removed, but the production of colony forming units (cfu's) was not.

The effects of nine synthetic and two biological fungicides as seed treatments on the viability of seed borne *C. coccodes* was investigated. Only three of the products tested inhibited *C. coccodes* by 100 per cent and of these only two (Maxim 'Fludioxonil' & Octave 'Prochloraz') provided 100 per cent inhibition for greater than 30 days. A further experiment is underway where six of the chemicals are being evaluated at either higher or lower concentrations.

**Summary of trials in progress**

Four field trials have been established to investigate the effects of 11 fungicides as seed treatments as well as the efficacy of the soil sterilant Metham Sodium on the viability of seed borne *C. coccodes*. Two were based in the Mallee region and two in the Adelaide Hills. In addition one of the Adelaide Hills trial site is evaluating the effect of Telone (1-3 Dichloropropene) as a replacement for the soil fumigant Methyl Bromide. Development of the disease on stem bases, roots and tubers will be assessed.

A field trial based in the Mallee region is evaluating the resistance of fourteen commercial and eight unreleased potato varieties to *C. coccodes*.

A pot trial evaluating the effects of the eleven fungicides as either seed treatments or soil treatment on the survival of seed borne *C. coccodes* and subsequent carry over to daughter tubers.

Two field trials have been established to monitor the development of *C. coccodes* in potatoes in the aim that a model can be developed to predict the potential incidence and severity of the diseases on tubers.

One in vitro trial has commenced to evaluate the effects of six different temperatures on the viability and growth rate of *C. coccodes*.

A survey of weed plants throughout the potato growing regions is being carried out to determine which alternative hosts may be a source of primary inoculum for *C. coccodes*. Fat Hen '*Chenopodium album*' and Silverleaf Nightshade '*Solanum elaeagnifolium*' have both been found to host *C. coccodes*.

**Summary of future aims**

Develop management strategies (rotations, irrigation, haulm desiccation or removal, time of harvest, fungicide timing, etc.) to reduce levels of *C. coccodes* in washed and seed potatoes.

Ascertain what soil populations of *C. coccodes* and other factors (temperature, soil type, potato variety) give rise to the disease.

Testing of new chemicals for *C. coccodes* control.

Evaluation of techniques for testing soil for *C. coccodes* levels.

## PT98009, CHARACTERISATION OF AUSTRALIAN ISOLATES OF *PHYTOPHTHORA INFESTANS* AND PLANNING TO MANAGE NEW AND MORE AGGRESSIVE STRAINS OF THE FUNGUS

Principal investigator: Andre Drenth  
Project start: 01-Jul-98, finish: 30-Jun-00  
Organisation: CRC for Tropical Plant Pathology  
Contact phone: 07 3365 4772

### Technical summary

The aim of this project was to characterise Australian strains of *Phytophthora infestans* causing late blight of potatoes, in light of the development of new and more aggressive strains in North America and Europe, which are resistant to the fungicide metalaxyl and are causing major economic losses. Samples of diseased material were collected during the summers of 1998/99 and 1999/2000 from outbreaks of late blight in crops on the north coast of Tasmania and the Central Highlands region of Victoria where the disease traditionally occurs.

Twenty-eight isolates were successfully brought into culture from the Tasmanian late blight samples. However, the fungus was not successfully isolated and cultured from Victorian samples. Compared to reference isolates from overseas, the Tasmanian isolates grew rather poorly on different media and under different conditions which can account for difficulties in isolating and culturing the fungus. This observation is consistent with findings from overseas where isolates representing the old A1 mating type population are harder to culture than representatives of the new *P. infestans* population which grown readily in culture.

None of the isolates tested were found to have characteristics that were consistent with the strains presently found in Europe and North America. Of 24 of the Tasmanian isolates paired against tester strains of the A1 and A2 mating types, all were found to be A1 types. Of 2' isolates tested, all proved to be very sensitive to metalaxyl *in-vivo*. DNA fingerprinting with the RG-57 probe revealed that all of 20 isolates tested were identical and had a finger print pattern with a high level of homology to the old *P. infestans* populations which were found throughout the world prior to 1980. The proved to be closely related to the old US1.3 clonal line. The RG-57 fingerprint pattern for the 20 isolates varied slightly from pattern previously described for Australian isolates (AU-1 and AU-2) and were designated AU-3. The isozyme and DNA fingerprint pattern of these isolates provide evidence that the Australian isolates are somewhat different from the ones spread around the globe from Europe.

The characteristics of the Tasmanian strain is in line with field observations that late blight is a minor disease, occurring sporadically and locally in some districts, and readily controlled with foliar application of metalaxyl. The new strains overseas, which include both the A1 and A2 mating types, are proving to be more aggressive and adaptable, resistant to metalaxyl, able to survive in soil without a host for several seasons as oospores and require very costly spray programs which are less effective than metalaxyl. Evidence of new strains in Australia would include a breakdown in control with metalaxyl, a greater incidence and severity of outbreaks, an earlier start to epidemics and a more widespread occurrence of the disease.

Australia is one of the few countries in the world not to be affected by a serious late blight problem. In order to maintain this status, we must be informed and vigilant. Recommendation for further work include an assessment of the risk of introducing new strains into Australia, determining the likely scenario's for the potato industry should new populations of *P. infestans* occur and to develop contingencies to deal with possible incursions of the new strains of the fungus.

## **PT01040, PILOT COMMERCIAL CROP MONITORING FOR PESTS AND DISEASES IN WA SEED POTATO CROPS**

Principal investigator: Stewart Learmonth  
Project start: 01-Oct-01, finish: 30-Sep-02  
Organisation: Department of Agriculture Western Australia  
Contact phone: 08 9777 0000

### **Summary**

The occurrence of virus diseases in seed potato crops in WA has been at a low level based on recent regular testing, but is an ongoing threat to the supply of seed of reliable quality to the industry both in WA and the growing eastern states and overseas export markets. Apart from the aspect of seed borne virus, seed growers rate managing the insect vectors as the most important factor in producing crops with minimal virus level.

This project will introduce to seed growers in WA an interactive pilot pest and disease monitoring service. While virus vectors are the main target of the monitoring, other insects as well as diseases will be part of the service. For each grower involved in the project, selected crops will be monitored on a regular basis. Growers will be advised of results of the monitoring and, where action is required, it will be by mutual agreement of grower and Department of Agriculture staff.

All potato growers in WA have agreed to the need for and importance of this service and have contributed to a voluntary levy to fund this exercise for one year. Whether the service continues beyond this period will be decided after a review of the results of the first year.

## **PT00034, COMMUNICATING THE STRATEGIES TO MANAGEMENT POTATO VIRUS DISEASES FOR WESTERN AUSTRALIA POTATO CROPS**

Principal investigator: Stewart Learmonth  
Project start: 01-Dec-00, finish: 30-Jun-01  
Organisation: Agriculture Western Australia  
Contact phone: 08 9777 0000

### **Summary**

Potato leafroll virus (PLRV) has been an important issue for seed potato producers in WA and low levels of virus persist within this important segment of the WA potato industry. Tomato spotted wilt virus (TSWV) occurs in WA, but at very low levels only.

We aim to produce a video for distribution to all WA potato growers to emphasise the steps required to eliminate PLRV from the WA seed potato scheme. The video will cover virus sources, aphid monitoring, aphid management and crop roguing. The aims of the video on TSWV will be limited to identifying the symptoms and transmission, a reflection of the low incidence of this disease in WA.

The aims of the video will be complemented by separate self-funding by WA growers to test seed potatoes for virus and the promotion of regular monitoring of crops for aphids.

These approaches will lead to reduced levels of PLRV in WA seed potatoes to produce seed of consistent quality. It will enhance WA's reputation for quality export seed. It will also reinforce the confidence of commercial growers in WA of the virus status of their seed, thereby providing a major boost to the objective of reduced insecticide use in crops for human consumption by down grading the pest status of aphids.

## **PT00015, DEVELOPMENT OF GENETICALLY ENGINEERED VIRUS RESISTANT FRESH MARKET POTATOES**

Principal investigator: James Hutchinson  
Project start: 01-Jul-00, finish: 30-Jun-04  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### **Project progress/impact**

This project is a continuation of PT338 and PT97011. PT338 developed some of the platform technologies to genetically modify potato cultivars (primarily a knowledge of factors that influence adventitious shoot regeneration systems and Agrobacterium mediated gene transfer). PT97015 developed a population of transgenic lines of Sebago D, Crystal and 80-90-5 with resistance genes to Potato Leaf Roll Virus (PLRV), Potato Virus Y (PVY) and both viruses. These genes were demonstrated to be effective in glasshouse trials against both viruses. Field trials have established there is no agronomic penalty of transgenic lines compared to control lines, and for the single gene construct tested, that the resistance found in the glasshouse trials also can be found in the field.

The current project (PT00015) is:

- Using an improved virus resistance strategy to increase the percentage of plants resistant to PLRV and PVY.
- Incorporating recently released potato cultivars and advanced selections into the program.
- Developing strategies to remove the antibiotic selectable marker gene used in the production of transgenic plants.
- Evaluating a population of transgenic potato lines with a number of anti-microbial genes (and promoters) against Powdery Scab (*Spongospora subterranea*) and Common Scab (*Streptomyces scabies*).

When virus resistant lines are commercialised, their major impact will be to reduce the number of insecticide applications to control aphids. An important spin-off from this will be the full implementation of the ICM program for Potato Tuber Moth. There could be ramifications for the pathogen tested potato seed schemes, as their major reason for being is the provision of planting material free of PLRV and PVY.



## **PT98007, MANAGING BACTERIAL BREAKDOWN IN WASHED POTATOES**

Principal investigator: Trevor Wicks  
Project start: 01-Jul-98, finish: 30-Sep-02  
Organisation: SA Research & Development Institute  
Contact phone: 08 8303 9563

### **Report**

The objectives of this project were to evaluate strategies to minimise bacterial breakdown in washed potatoes.

### **Outcomes**

Sampling over several seasons showed that propensity of rot in potatoes collected from the field varied from 0 to 70 per cent and did not vary markedly between seasons. Once the tubers were immersed in water the incidence of rotting rose to near 100 per cent in all samples. Sampling of tubers along the washing line of several processing plants showed that most infection occurred at the initial wash and tumbling section. Levels of 4 to 6 x 10<sup>4</sup> cfu's of *Erwinia* were found in water samples collected at various points in the washing line and also in recycled water. The addition of sanitising agents reduced levels of bacteria in recycled water but were not effective when added to large volumes of water in dipping and tumbling tanks.

The use of sanitisers in final rinses did not control soft rot. The use of hot air to dry tubers after they passed from the tumbler was the most effective treatment. Other treatments such as air 'knives' are also being evaluated as systems to remove surface moisture from tubers and control breakdown.

## **PT98011, EFFECT OF CALCIUM NUTRITION ON DECAY OF SUMMER SOWN SEED POTATOES**

Principal Investigator: Greg Howell  
Project start: xxx, finish: -02  
Organisation: NSW Agriculture  
Contact phone: 02 6951 2528

### **Executive summary**

MS 7 - A soft rot prevention field day was held on January 24, 2002 in Berrigan NSW in conjunction with the Potato Breeding Program's processing variety evaluation field day. The field day was attended by processing and seed potato industry representatives however no growers, apart from the property owner, attended.

MS 9 - This milestone was not completed as its undertaking was conditional on MS 8 which was itself abandoned because there was no evidence that supplementary calcium fertiliser could protect harvested tubers from a normally managed ware crop from subsequent soft rot infection. Alternative management options are/were being investigated during the period assigned to MS9. We have found microbial antagonists to *Erwinia* which slow its growth *in vitro* and have found evidence that seed piece selection may be the mechanism by which the disease undergoes amplification on the farm.

## **PT97031, INNOVATIVE TRANSPORT AND DISEASE CONTROL SYSTEMS: POTATO EXPORTS TO ASIA**

Principal investigator: Alister Sharp  
Project start: 01-Jan-98, finish: 01-Jan-00  
Organisation: CSIRO Food Science & Technology  
Contact phone: 02 9490 8333

### **Technical summary**

Other than for short journeys, premium-quality potatoes have normally been exported from Australia in refrigerated containers. Like onions however, potatoes can be shipped to distant markets without refrigeration, provided they are handled appropriately, cured properly and kept dry during the journey. The challenge is to keep the surface of the produce dry during transport through changing climatic zones. As with onions, this can be done using fan-forced ventilation to ensure the load follows changes in ambient temperature during the journey. Unlike onions (that store best at low humidity), potatoes store best in the humidity range 90-95 per cent RH. Our aim was to adapt the Fantainer transport system, developed for onions, to make it suitable, reliable and economical for the shipment of potatoes.

Since no container can improve product quality but rather maintain it, it is essential that the Pot-Tainer be used as part of an integrated system that combines a modified Fantainer with a postharvest handling protocol. The Pot-Tainer combines several innovative features utilising newly available control equipment and sensors to maintain a high rate of air circulation. This keeps a uniform temperature within the stow, but also creates a high humidity within the load-space. The postharvest handling protocol rejects other than minor surface damage, and includes curing and/or fungicide treatment.

During this and a previous project we simulated several shipments to Asia in a container test facility at Food Science Australia. In this facility the ambient temperature can be varied to simulate temperatures encountered during a shipment from Australia through the tropics to Asia. We also monitored a commercial export shipment between Melbourne and Hong Kong.

The results from most shipments were very good, with progressive improvements made in the technology. However the need to follow the postharvest protocol was graphically illustrated when potatoes with far higher levels of damage than were acceptable were shipped, and curing was not undertaken. The outturn from this shipment was not acceptable despite the Pot-Tainer technology working well. This poor outturn was the result of the quality of the potatoes being below acceptable limits with regard to damage and disease control. It cannot be emphasised too strongly that the Pot-Tainer needs to be used as part of the integrated export system not as a stand-alone component.

The export protocol is proposed as a complete system to help ensure that potatoes can be exported in large quantities without the use of refrigeration. This will enable expansion of the industry in Australia and enable Australia to capture a much larger share of the rapidly growing Asian market.

**PT01020, EVALUATION AND COMMERCIALISATION OF COMMON SCAB RESISTANT CLONES OF COMMERCIAL POTATO VARIETIES**

Principal investigator: Calum Wilson  
Project start: 31-Aug-01, finish: 01-Oct-04  
Organisation: Tasmanian Institute of Agricultural Research  
Contact phone: 03 6226 2638

This project has only just begun in March 2002, continuing work from results of the previous project PT98015.

**PT98043, PREPARATION OF FIELD GUIDE AND REFERENCE BOOKS FOR PESTS, BENEFICIALS AND DISEASES OF POTATO CROPS**

Principal investigator: Paul Home  
Project start: 01-Jul-98, finish: 30-Jun-99  
Organisation: IPM Technologies Pty Ltd  
Contact phone: 03 9710 1554

No report available.

**PT99055, NATIONAL PCN MANAGEMENT STRATEGY**

Principal investigator: Gordon Berg  
Project start: 01-Feb-00, finish: 30-Sep-02  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

No report available.

**PT00019, MANAGEMENT OF TOMATO SPOTTED WILT VIRUS IN POTATOES**

Principal investigator: Calum Wilson  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: TAS Institute of Agricultural Research  
Contact phone: 03 6233 6841

No report available.

**PT01020, EVALUATION AND COMMERCIALISATION OF COMMON SCAB RESISTANT CLONES OF COMMERCIAL POTATO VARIETIES**

Principal investigator: Calum Wilson  
Project start: 31-Aug-01, finish: 01-Oct-04  
Organisation: Tasmanian Institute of Agricultural Research  
Contact phone: 03 6226 2638

No report available.

## **PT01042, POTATO PINK ROT CONTROL IN THE SOUTH EAST OF SOUTH AUSTRALIA**

Principal investigator: Trevor Wicks  
Project start: 26-Dec-01, finish: 31-May-02  
Organisation: SA Research & Development Institute  
Contact phone: 08 8303 9563

No report available.

## **VG98076, SCREENING POTATO AND VEGETABLE SOIL BORNE DISEASES THAT MAY BE CONTROLLED BY EUCALYPTUS LEAF MULCH - PILOT STUDY**

Principal investigator: Melita Shalders  
Project start: 01-Jul-98, finish: 30-Sep-99  
Organisation: Agronico Pty Ltd  
Contact phone: 03 6428 2519

No report available.

## **NEW ZEALAND POTATO, SWEET POTATO, TARO AND TUBEROUS VEGETABLE PROJECTS**

**Pathogen:** *Spongospora subterranea*

Research aim: Plant resistance  
Principal investigator: Russell Genet  
Institution: Crop & Food Research

**Pathogen:** *Spongospora subterranea*

Research aim: Marker assisted selection  
Principal investigators: Jeanne Jacobs, Russell Genet  
Institution: Crop & Food Research

**Pathogen:** *Spongospora subterranea*

Research aim: Improved detection and field management  
Principal investigator: Simon Bulman, Sandi Keenan, John Marshall  
Institution: Crop & Food Research

**Pathogen:** *Spongospora subterranea*

Research aim: Genetic engineering for resistance  
Principal investigator: Margy Gilpin, Tony Connor  
Institution: Crop & Food Research

**Pathogen:** *Phytophthora infestans*

Research aim: Development decision support system for disease management  
Principal investigator: Suvi Viljanen-Rollinson, Peter Jamieson, Peter Wright  
Institution: Crop & Food Research

**Pathogen:** *Alternaria solani*

Research aim: Develop disease prediction tool for decision support system  
Principal investigator: Suvi Viljanen-Rollinson, Peter Jamieson  
Institution: Crop & Food Research

**Pathogen:** *Phytophthora erythroseptica*

Research aim: Review importance in different potato growing areas of NZ  
Principal investigator: Suvi Viljanen-Rollinson, John Anderson  
Institution: Crop & Food Research

- Pathogens:** *Phytophthora erythroseptica*, *Pythium* spp., *Fusarium* spp.  
Research aim: Biological control (*Trichoderma*) biofumigation, soilborne pathogens  
Principal investigator: Lian Heng Cheah, Greg Tait  
Institution: Crop & Food Research
- Pathogens:** *Verticillium* spp.  
Research aim: Review importance in different potato growing areas of NZ  
Principal investigator: Suvi Viljanen-Rollinson, John Anderson  
Institution: Crop & Food Research
- Pathogens:** *Globodera rostochiensis*, *G. pallida*  
Research aim: Improved detection and quantification in soil using quantitative PCR  
Principal investigator: John Marshall, Sandi Keenan, Simon Bulman  
Institution: Crop & Food Research
- Pathogen:** *Meloidogyne fallax*  
Research aim: Pathogen biology and control in processing potatoes  
Principal investigator: John Marshall  
Institution: Crop & Food Research
- Pathogens:** Virus, bacterial, fungal, protozoan diseases  
Research aim: Pathogen-free seed potatoes  
Principal investigator: John Marshall, Sandi Keenan, Simon Bulman  
Institution: Crop & Food Research
- Pathogen:** *Erwinia carotovora*  
Research aim: Cultural control  
Principal investigator: Peter Wright  
Institution: Crop & Food Research
- Pathogen:** *Erwinia carotovora*  
Research aim: Plant resistance  
Principal investigator: Peter Wright  
Institution: Crop & Food Research
- Pathogens:** Potato LRV, potato virus Y<sup>N</sup>  
Research aim: Cultivar susceptibility, crop loss assessment  
Principal investigator: John Fletcher, Russell Genet  
Institution: Crop & Food Research
- Pathogen:** *Sclerotinia sclerotiorum*  
Research aim: Cultivar susceptibility in sweet potato  
Principal investigator: Peter Wright, Steve Lewthwaite  
Institution: Crop & Food Research
- Pathogen:** *Monilochaetes infuscans*  
Research aim: Cultivar susceptibility in sweet potato  
Principal investigator: Peter Wright, Steve Lewthwaite  
Institution: Crop & Food Research
- Pathogen:** Sweet potato feathery MV  
Research aim: Effects of NZ isolates on yield of local and imported varieties  
Principal investigator: John Fletcher, Steve Lewthwaite  
Institution: Crop & Food Research
- Pathogen:** *Phytophthora colocasiae*  
Research aim: Resistance selection methods for taro  
Principal investigator: Bob Fullarton  
Institution: HortResearch
- Pathogens:** Viruses  
Research aim: Elimination of viruses from vegetatively propagated tuberous crops  
Principal investigator: John Fletcher, Pam Fletcher  
Institution: Crop & Food Research

## APPENDIX 8. CAPSICUMS, TOMATOES, EGGPLANTS AND MELONS

### VG00069, INTEGRATED MANAGEMENT OF GREENHOUSE CUCUMBER AND CAPSICUM DISEASES

Principal investigator: Len Tesoriero  
 Project start: 01-Oct-00, finish: 31-Mar-04  
 Organisation: NSW Agriculture  
 Contact phone: 02 -46406300

#### Summary

Plant diseases cause significant losses to greenhouse-grown cucumbers and currently require a high and recurring chemical use for their control. Although capsicums grown in protected structures do not appear to have major disease problems to date, there are a number of threatening diseases that are likely to emerge over time as this sector of the industry expands and as short crop rotations allow pathogen levels to build-up. To date there have been no systematic or targeted surveys to identify all the important diseases occurring in Australian greenhouse cucumber and capsicum crops. Many important diseases have been detected through passive surveillance but only after significant losses were incurred and the pathogen responsible had been spread widely. An example was the detection of the important disease, Black Root Rot of cucumbers in the mid-1980s. Passive surveillance has also uncovered a number of diseases with complex etiology which require further research to determine or confirm the pathogens involved, as well as the predisposing environmental conditions. Several root rot complexes of cucumbers and capsicums fit into this category. Finally there are a number of important diseases that occur on these crops overseas that have not been detected in Australia. For example there are two seed-borne virus diseases (cucumber green mottle mosaic and squash mosaic) of cucumbers that have not been targeted in Australia as their symptoms are vague but they reduce production significantly. Targeted surveillance and diagnostic activities in this project will clarify the occurrence, distribution and importance of diseases as well as gather environmental and cultural information that will assist with our understanding of the root rot complexes. Knowledge of the presence or absence of certain diseases will further enhance the industry's capacity to access export markets. Updated knowledge of the industry's crop health status will enable the dissemination of valid and current photographic and technical information in the form of factsheets, diagnostic cards and industry workshops. Better grower awareness and understanding of diseases is seen as a key to reducing unnecessary chemical pesticide use.

Phase two of the project will develop and evaluate integrated disease management strategies in greenhouse trials on NSW stations (Gosford & EMAI) and on-farm. There has been a rapid development and availability of biological control products worldwide, yet many of these products have not been objectively evaluated for efficacy. Nor have they been trialed as part of integrated crop management systems for Australian conditions. There are also a number of gaps in the existing pesticide registrations that will be highlighted by this project. The frequent picking of these crops combined with reduced levels of chemicals washing off due to the protected environment increases the risk of produce exceeding maximum residue limits. Other factors threatening the sustainability of this industry are the proximity of the greenhouse structures to urban development and an increasing awareness of occupational health and safety issues. This exacerbates the need to develop integrated (chemical, cultural and biological) management strategies for diseases.

#### Milestone report 2: Update understanding of diseases threatening the greenhouse cucumber and capsicum industries

##### *Disease surveys*

Twenty-six properties were surveyed in NSW (Sydney Basin, Gosford, Picton, Coffs Harbour, Milton and Sunrasia) and seven in South Australia (Virginia). Further state records were obtained from relevant government authorities. Records from Victoria and Tasmania are yet to be received. Results are listed in Tables 1 and 2.

In NSW surveys coincided with the commencement of the winter 2001 crop. Many growers had commenced using coco peat as a root substrate. This provided an opportunity to access and compare root diseases (rots, damping-off and wilts) in four media: coco peat; sawdust; compost mix; and NFT. Several *Pythium* species and *Fusarium oxysporum* were the major root pathogens detected. Pathogenicity assays with isolates of these fungi demonstrated that dual infections caused more rapid onset and severity of wilt symptoms when compared with either pathogen alone. This interaction is the subject of further experiments. Taxonomic studies are also ongoing to determine the species of *Pythium* and the subspecies of *F. oxysporum* involved with diseases.

Excess root zone moisture was found to be a common factor associated with higher incidence and severity of *Pythium* rots and wilts. Certain farms using higher irrigation rates in coco peat and compost media suffered significant losses. An experiment at the National Centre for Greenhouse Horticulture, Gosford showed a strong correlation between NFT and *Pythium* root infection that resulted in almost a complete plant loss. Plants growing in coco peat bags were largely unaffected.

The fungal disease, Gummy stem blight, was commonly found associated with longitudinal splitting of lower stems. This often resulted in wilting and death of mature plants. The longitudinal splits were likely to have been caused by a combination of rapid plant growth and large diurnal temperature ranges.

The fungi *Alternaria alternata* and *A. cucumerina* were detected on leaf spots in NSW and SA. These are the first Australian records of a leaf spot disease caused by *A. alternata*. Since no fungicides are specifically registered for these diseases in Australia, the NSW greenhouse growers' association and the NSW vegetable IDO were contacted to seek a permit or an extension to the label registration of azoxystrobin (Amistar ®).



## **INVESTIGATION OF CAPSICUM GENETIC RESISTANCE TO TOMATO SPOTTED WILT VIRUS, TOSPOVIRUS SEROTYPE IV AND BACTERIAL SPOT DISEASE.**

Des McGrath, QDPI

The objectives of this work are to: confirm genetic resistance to TSWV and identify virus strains; undertake glasshouse study of virus transmission; undertake genetic analysis of host resistance; identify DNA markers linked to resistance; identify at least 10 uniformly resistant BC2 or BC3 lines and evaluate in field plots; produce resistant hybrids and evaluate in Western Australia and Queensland; hold grower evaluation field days of resistant hybrids and release several resistant hybrids to industry.

## **VG98110, SURVEY OF GEMINIVIRUSES IN NORTHERN AUSTRALIA**

Principal investigator: Ali Rezaian  
Project start: 01-Jul-98, finish: 30-Jun-01  
Organisation: CSIRO Plant Industry  
Contact phone: 08 8303 8634  
Ali Rezaian <Ali.Rezaian@csiro.au>

### **Abstract**

The occurrence of geminiviruses in Australia was studied using a mixed DNA probe capable of detecting a range of distinct geminiviruses. The only geminivirus species detected was Tomato leaf curl virus (TLCV) which is spread across a vast geographical region of far northern coastal Australia, an area inhabited by the Australian indigenous biotype of *Bemisia tabaci*. The newly introduced silverleaf whitefly, *B. tabaci* biotype B, forms high population densities in the eastern coastal region of Queensland and is approximately 150 km from the nearest known TLCV infected area. The viral host range appeared to be narrow and of 58 species of crop plants and weed species inoculated by whiteflies, only 11 became infected, including 5 that did not show foliar symptoms. A DNA fragment of 694 nts including the complete C4 open reading frame (ORF), the overlapping N-terminus part of the C1 ORF, and the viral iterons involved in replication, was amplified from 11 TLCV field isolates and sequenced. Sequence analysis revealed an overall sequence variation of up to 14 per cent in this region as well as the presence of distinct viral iterons, suggesting independent replication.

## VG00065, CONTINUED DEVELOPMENT OF MANAGEMENT STRATEGIES FOR WESTERN FLOWER THIRPS AND TOMATO SPOTTED WILT VIRUS IN VEGETABLES

Principal investigator: Roger Jones  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: Department of Agriculture  
Contact phone: 08 9368 3269

### Milestone: 5 'Outcomes of second field experiment on impact of granular insecticides on WFT and TSWV', Brenda Coutts, David Cousins and Roger Jones

It is likely that insecticides applied to the soil at transplanting will prove more effective than foliar sprays in decreasing spread to crops from TSWV-infected source plants. This is because plants are then insecticide protected from the beginning and the systemic chemical can tackle the first nymphal thrips phase which is the only one that can acquire TSWV.

Two field experiments were done, one with lettuce and another with capsicum. Of the three thrips vector species only onion and tomato thrips were present in the lettuce experiment, but western flower thrips were also present in the capsicum experiment. The aim of these two experiments was to assess the effectiveness of the insecticidal soil drench thiamethoxam (Actara at 500 g/ha) in suppressing TSWV in lettuce and capsicum by controlling its thrips vectors.

#### Lettuce field experiment

The 2001/02 lettuce TSWV control experiment was located at Medina Research Station.

The experimental design consisted of 5 treatments, each with 8 replicate plots arranged in a randomised block design. Oat buffers were sown around each plot to help limit TSWV spread in between them. The 5 treatments were:

- thiamethoxam to tomato infector plants only
- thiamethoxam to tomato infector plants and lettuce plants
- thiamethoxam to lettuce plants only
- no insecticide to tomato infector and lettuce plants
- no tomato infector plants introduced and no insecticide to lettuce plants

The separate treatments to infector (tomato) and recipient (lettuce) plants provided information on the relative importance of targeting control at a) virus acquisition by thrips from TSWV-infected source plants versus b) virus transmission to healthy plants. Each plot had 6 introduced TSWV infector foci, each focus consisting of 2 TSWV-infected tomato transplants and 2 flowering marigold transplants. The marigold plants were present to boost thrips numbers. Each plot contained 48 healthy lettuce variety Raider plants. The insecticide used, thiamethoxam, was applied as a soil drench to tomato infector and lettuce plants at transplanting. It was not applied to the marigold plants

To determine the numbers of thrips vectors present during the experiment, weekly sampling of marigold flowers started one week after transplanting of the lettuce. Two marigold flowers were collected from each plot on each occasion. Two TSWV vectors, tomato thrips (*F. schultzei*) and onion thrips (*T. tabaci*), were present in the marigold flower samples, but no WFT were found. Because insecticides were not applied to the marigolds, there was no relationship between thrips numbers or species and insecticide treatment. Largest mean numbers of thrips (26 thrips/flower) were present in the 1<sup>st</sup> week (29 November 2001) after transplanting, numbers decreasing to 1 thrip/flower in the 4<sup>th</sup> week (19 December 2001) before increasing again to 13 thrips/flower in the 5<sup>th</sup> and 6<sup>th</sup> weeks. Mean daily temperatures during this time ranged from 13 to 32°C.

The lettuce plants were inspected for TSWV symptoms weekly, starting 2 weeks after transplanting. Initially, symptoms were confirmed as being due to TSWV by testing samples by ELISA, but subsequently symptoms were so typical that counts only needed to be done visually. On the final assessment date, 8 weeks after transplanting, the incidence of TSWV was 62 per cent in the control treatment involving no insecticide applied to either tomato infector or lettuce plants (Fig. 1). This level of infection was significantly greater ( $P < 0.001$ ) than that in the control treatment that had no tomato infector plants or applied insecticide (19 per cent TSWV) and in the treatments where insecticide was applied to tomato infector plants only (22 per cent TSWV), to lettuce plants only (19 per cent TSWV) and to

both (11 per cent TSWV). The most effective treatment was application of insecticide to both tomato infector plants and lettuce plants, the 11 per cent TSWV level found being significantly smaller than the levels in all other treatments ( $P < 0.001$ ).

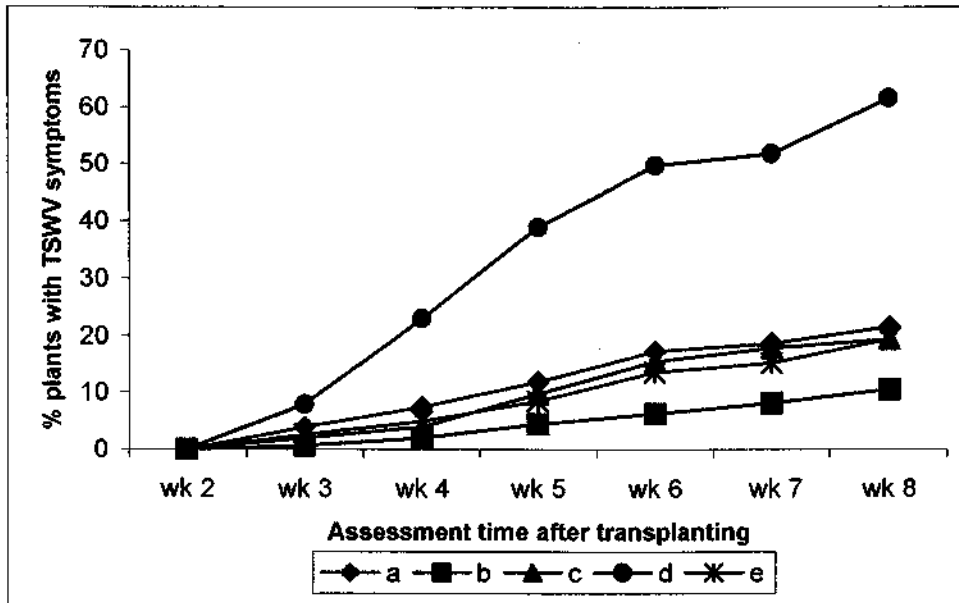


Figure 1. Effect of thiamethoxam soil drench on spread of TSWV in lettuce variety Raider. Treatments: a) thiamethoxam to tomato infector plants only; b) thiamethoxam to tomato infector and lettuce plants; c) thiamethoxam to lettuce plants only; d) no insecticide to tomato infector or lettuce plants; e) no tomato infector plants present or insecticide used.

The spread that occurred in control plots with no tomato infector plants and no insecticide applied to lettuce plants (19 per cent TSWV) indicates the extent of spread of TSWV in between plots. The difference (43 per cent) between the TSWV spread in these plots and the spread in plots with no insecticide applied to tomato infector or lettuce plants (62 per cent) indicates the extent of spread of TSWV from within plot sources. The overall ratio of external to internal spread was therefore 1:2.3. Within plots with insecticide applied to tomato infector plants alone, the lettuce recipient plants would still have received thrips from external untreated infected sources within other plots. The 22 per cent infection in them versus the 19 per cent in plots without infector plants suggests that treating the infector plants alone was very effective in decreasing TSWV spread, with a 40 per cent reduction in TSWV spread attributable to this treatment.

### Capsicum field experiment

The capsicum field experiment was located at South Perth. The experimental design and treatments were identical to those of the lettuce field experiment, except that each plot had one introduced TSWV infector focus consisting of 3 TSWV infected tomato plants and 14 marigold plants, the focus being surrounded by 50 healthy capsicum plants. Due to poor growth of capsicums at one side of the experimental area the plots within 2 replicates were removed, so the data presented are for 6 replicates.

To determine the numbers of thrips vectors present during the experiment 10 capsicum flowers were sampled each week. Three TSWV vectors, tomato thrips (*F. schultzei*), onion thrips (*T. tabaci*) and western flower thrips (*F. occidentalis*), were present in the flower samples.

The TSWV isolate used to infect the tomato transplants was found to be very severe and resulted in early death of the infector plants. By four weeks after capsicum transplanting, most plots had one or two tomato infector plants left and by 15 weeks all tomato infector plants had died. The capsicum plants were individually sampled and tested fortnightly for presence of TSWV, starting three weeks after transplanting. In plots where TSWV was present, individual plants showing symptoms were tagged and the numbers of infected plants recorded within each plot.

By 15 weeks after transplanting, spread of TSWV infection was still much lower than in the lettuce trial only reaching 4.4 per cent in the plots with tomato infector plants and no insecticide applied (Fig. 2). When insecticide was applied to the capsicums only and tomato infector plants were present, there was a 3.6 per cent TSWV level. Plots with insecticide applied to the tomato infector plants only or to both the tomato infector and capsicum plants had 2 per cent

TSWV spread. Plots with no tomato infector plants and no insecticide had 1.3 per cent TSWV, this representing the extent of spread between, as opposed to within, the plots.

The levels of infection at 15 weeks after transplanting were not significantly different between treatments (at  $P < 0.05$ ) due to the overall low level of infection in the experiment presumably resulting from the tomato infector plants dying out early. However, Figure 2 does indicate an early effect of suppression of spread from treating the tomato infector plants before they died out, which subsequently resulted in delayed spread of TSWV.

This experiment will continue until the end of April 2002.

## VX99037, MANAGEMENT OF VIRUS DISEASES AND BACTERIAL BLOTCH OF MELONS

Principal investigator: Denis Persley  
Project start: 01-Feb-00, finish: 01-Feb-03  
Organisation: QLD Department of Primary Industries  
Contact phone: 07 3896 9375

### Project aims

The objective of this work is to define the spectrum of strains of Bacterial Spot and other diseases present by both pathological characteristics and molecular techniques. Previous work has surveyed melon and other cucurbit crops in the Burdekin, Bowen and Bundaberg regions usually as part of HRDC supported projects on the development of virus resistant melon and pumpkin germplasm. In those surveys, high disease levels were frequently found and the viruses involved identified by ELISA serology. A high incidence of both zucchini yellow mosaic (ZYMV) and papaya ringspot viruses (PRSV) were found, particularly during the main and latter parts of the production periods. Reflective mulch slowed virus spread in zucchini and melons, and this information, along with data on transmission and crop hygiene has been presented in extension articles with a view to minimising the impact of virus. However, virus remains a major limiting factor in cucurbit production in north Queensland.

Relatively little work has been done in the increasingly important production areas west of the Great Divide. Virus diseases are recognised as a significant constraint on production and growers will benefit from research to understand and combat the problem in their specific environment. Crucial to the project will be determining how the virus overwinters and spreads. In addition, work will be aimed at developing an integrated control program including the evaluation of new aphidicides which should be useful in limiting virus transmission.

PRSV, ZYMV and other potyviruses are also present in the USA, and have been the focus of plant breeding and disease management programs for some time. The information available from such programs may be useful in Australia, and this project aims to bring growers up to date with the latest information in cucurbit virus research.

### Progress

Additional pathogenicity testing (as recommended in the previous report) has shown that the majority of Aac isolates conform to the existing groups of watermelon and honeydew melon infecting isolates (WHI) or rockmelon, watermelon and honeydew melon infecting isolates (RWHI). These two groupings continue to correspond well with the two established DNA fingerprint groups, with WHI isolates routinely producing a distinctive high molecular weight band at ca. 750 bp, while RWHI isolates produce a low molecular weight band at ca. 450 bp when analysed by rep-PCR (DNA fingerprinting). As previously mentioned, only two isolates appear not to fit easily within the two groups described. Isolate HLM 244 is pathogenic on cucumber as well as melons, while GRS 1237 appears to be pathogenic on pumpkin and melons, but not on cucumber, zucchini or squash. Both of these isolates have the characteristic low molecular weight band associated with the RWHI group.

DNA fingerprinting revealed a wide range of diversity, with the 27 isolates of *Fusarium* spp. analysed producing 11 unique genotypes. Of these all 5 of the *Fusarium oxysporum* isolates collected between 1969 and 1971 corresponded to one genotype, Fon, while only two isolates collected in the last 2 years were Fon. The remaining 20 isolates were dispersed between the other 10 genotypes. The significance of this diversity is not yet clear.

Due to the wide range of genotypes determined by DNA fingerprinting, it was decided to test to a broad range of *Fusarium* spp. isolated from melons, against a small range of melon varieties. Preliminary results indicate that six isolates of *Fusarium oxysporum* are pathogenic on seedless watermelons only, having little or no effect on seeded watermelon varieties. Of the remaining pathogenic *Fusarium oxysporum* isolates seven out of 10 appear to be much more severe on seedless watermelons than seeded watermelons. Interestingly, these pathogenicity groups seem to correspond well with the genotypes described above. Unfortunately the number of isolates included in this study was not sufficient for any conclusions to be reached, however the range of diversity shown by these isolates indicates that further investigation is warranted. Proposals for further work in this area are currently being prepared.

## **VG00026, DEVELOPMENT AND IMPLEMENTATION OF INTEGRATED PEST MANAGEMENT SYSTEMS IN EGGPLANT AND CAPSICUM**

Principal investigator: John Brown  
Project start: 01-Mar-01, finish: 28-Feb-04  
Organisation: QLD Department of Primary Industries  
Contact phone: 07 4783 0401

### **Project aims**

In this project, we are proposing to: collate the currently available information; develop management strategies for other pests present in eggplant and capsicum (this may mean adjustment to the management strategies developed for major pests, as these can cause minor pests to become more significant); extend the IPM systems to producers via group activities, including on-farm demonstrations (slight modifications will be needed between regions and evaluate the performance of these systems and their adoption over time, adjusting the strategies where necessary).

### **Progress**

The first part of the project involved the distribution of a questionnaire to growers in all of the production areas. This included WA but no responses have been received from this area to date. The aim of the questionnaire was to identify the current insect pest problems and management practices and a final questionnaire at the end of the project will be used to gauge the acceptance or change in these management practices as a result of this project. Work in other projects on some of the insect pests that occur in these crops has been by addressed by a number of researchers and their results are being extended into these management systems. Work to date has involved evaluating parasite/predator numbers on aphids and the first stage in developing a monitoring system in Capsicum. Findings have identified that beneficial insects of 8 per 100 leaves are sufficient to control an averaged aphid population of 6 per leaf. Growers should also be prepared to scout their crops twice weekly and examine 100 plants for approximately 6000 plants. It is an aim of this year's work to refine this scouting method and this may reduce the number of plants required to be examined.

Results in Eggplant studies have identified egg laying sites and field identification of eggs. Also the use of pheromones in trapping moths as an indication of pest pressure/presence is still being evaluated. Eggs are laid mainly on the small developing fruit (between 1-5 cm). The tip of the calyx is the preferred site though they are laid on the fruit stem through to the calyx tip. The eggs are white at first and within 1-2 days develop red stripes from the top down the sides. These eggs emerge within 5 days at approximately 25°C.

## VG99034, UNDERSTANDING THE CAUSES OF SUDDEN WILT OF CAPSICUM

Principal investigator: Graham Stirling  
 Project start: 01-Jan-00, finish: 31-Mar-03  
 Organisation: Biological Crop Protection Pty Ltd  
 Contact phone: 07 3202 7419

### Project aims

Sudden wilt is a major disease of capsicums in the dry tropics of Queensland and in the Bundaberg district. The exact causes and conditions that predispose plants to infection are not clearly understood. Several fungi have been associated with the syndrome and it is believed stressed plants succumb most rapidly.

### Progress

Disease development was studied in six crops during the main capsicum growing-season (April-November 2000). Crops were selected soon after planting and roots were sampled regularly during the life of the crop. Two untreated and two methyl bromide-treated crops were sampled in Bundaberg and one untreated and one metham sodium-treated crop at Bowen. The first signs of root rotting were observed 6 weeks after planting at Bowen and at 7 weeks in Bundaberg. Symptoms were usually seen only in fine roots at this stage, but in one of the fields in Bowen large roots arising from the crown were also rotted. These early signs of infection were only seen in untreated fields, suggesting that fumigation with either methyl bromide or metham sodium delayed the onset of root rotting. *Fusarium* and *Pythium* were the potential pathogens most commonly isolated from fine roots during these early stages of crop growth.

The amount of root rotting in crops at Bundaberg was greater at 14 weeks than at 7 weeks but levels of infection did not increase markedly as crops matured. Less than 5 per cent of fine roots in all four fields were rotted at 14 weeks and rotting extended to large roots in only one of these fields. Aboveground symptoms of sudden wilt were not observed. At Bowen, the level of root rotting increased with time, so that by the time the sampled crops were being harvested, plants that did not exhibit aboveground symptoms had lost between 20 and 38 per cent of their large roots due to root rot. In the non-fumigated field where root rotting was observed at 6 weeks, plants showing symptoms of sudden wilt were scattered spasmodically across the field 5 weeks later. About 80 per cent of the large roots on these plants were rotted. These results indicate that soil-borne pathogens begin to damage fine roots between 4 and 8 weeks after planting, with early infections being most severe in non-fumigated crops. During the 2000 season, the disease often remained at relatively low levels until crops were harvested, but sometimes it progressed rapidly into large roots, resulting in severe damage to the whole root system. The reasons for these differences in disease development have not yet been determined, but soil temperature and moisture and the complexity of the soil biological environment are possibly involved.

There is considerable circumstantial evidence to suggest that sudden wilt is most severe during periods of high temperature. Previous outbreaks of the disease (e.g. the spring of 1997) were associated with high temperatures, while the disease is more common in crops that mature during autumn and spring than those that mature in winter. Since soil temperatures under plastic mulch in Queensland capsicum-growing areas often reach 34-37°C during spring, summer and autumn, the pathogenicity of *Pythium*, *Fusarium*, *Rhizoctonia* and *Macrophomina* was determined at temperatures that typically occur in the field. In the first of these experiments, two isolates of each fungus were inoculated onto 6 week-old capsicum plants during mid summer when the average daily maximum temperature in pots was about 35 °C. *Fusarium*, *Rhizoctonia* and *Macrophomina* were not pathogenic to capsicum under the test conditions, as above-ground symptoms were not observed and symptoms on roots were limited to a few minor brown lesions near the point of inoculation. In contrast, plants inoculated with either isolate of *Pythium* began to wilt within 3 days of inoculation. After 1 week, root systems were severely rotted and they did not recover during the course of the experiment. One isolate (SW82) was particularly damaging, reducing the top dry weight 4 and 7 weeks after inoculation by about 50 and 60 per cent respectively.

A further experiment was done with three isolates of *Pythium* in March/April 2001, under temperatures that were similar to the previous experiment. The two isolates used in the previous experiment again caused wilting and severe root rotting, while the third isolate was also pathogenic. However, symptoms were observed at much lower inoculum densities than in the first experiment and occurred in plants that were not damaged during the inoculation procedure. Results of initial taxonomic studies suggested that two of the isolates were *P. myriotylum* and one was *P. aphanidermatum*.

**VG98006, DEVELOPING AN IPM STRATEGY TO REDUCE TOMATO SPOTTED WILT VIRUS IN THE DRY TROPICS**

Principal investigator: Dale Abbott  
Project start: 01-Jul-98, finish: 30-Jun-01  
Organisation: Bowen Crop Monitoring Services Pty Ltd  
Contact phone: 07 4786 6100

No report available.

**VG98135, EVALUATING THE IMPACT OF R&D ON INTEGRATED PEST MANAGEMENT IN THE PROCESSING AND FRESH TOMATO INDUSTRIES**

Principal investigator: Harley Juffs  
Project start: 21-Dec-98, finish: 28-Apr-99  
Organisation: Harley Juffs & Associates Pty Ltd  
Contact phone: 07 3263 2930

No report available.

**VG98136, HEAT TREATMENT OF TOMATOES FOR NEW ZEALAND - COMMERCIAL PROTOTYPE DEVELOPMENT**

Principal investigator: Rod Jordan  
Project start: 01-Jan-99, finish: 30-Jul-02  
Organisation: QLD Department of Primary Industries  
Contact phone: 07 3406 8555

No report available.

**VG99061, IMPROVED CONTROL OF FUNGAL STORAGE ROTS OF JAPANESE SQUASH**

Principal investigator: Frank Hay  
Project start: 01-Oct-99, finish: 01-Mar-00  
Organisation: TAS Institute of Agricultural Research  
Contact phone: 03 6430 4907

No report available.

**VX99003, INTEGRATED PEST MANAGEMENT OF SILVERLEAF WHITEFLY AND THE GEMINIVIRUSES IT TRANSMITS**

Principal investigator: Paul De Barro  
Project start: 01-Jul-99, finish: 30-Jun-03  
Organisation: CSIRO Entomology  
Contact phone: 07 3214 2811

No report available.



## **VG00025, MONITORING OF TOSPOVIRUSES BY REAL TIME POLYMERASE CHAIN REACTION**

Principal investigator: Ralf Dietzgen  
Project start: 01-Jul-00, finish: 30-Jun-02  
Organisation: QLD Department of Primary Industries  
Contact phone: 07 3365 4968

No report available.

## **VX99029, MONITORING AND DIAGNOSTIC AIDS FOR PREDICTING AND MANAGING SOIL-BORNE DISEASES IN FRESH TOMATOES**

Principal investigator: Graham Stirling  
Project start: 01-Jan-00, finish: 31-Dec-02  
Organisation: Biological Crop Protection Pty Ltd  
Contact phone: 07 3202 7419

No report available.

## **NEW ZEALAND CAPSICUM, TOMATO, AND SQUASH PROJECTS**

### **Pathogen:**

Research aim: Pesticide residues in capsicum  
Principal investigator: Hari Krishna  
Institution: Crop & Food Research

### **Pathogens:**

***Pythium* spp.**  
Research aim: Pathogen control in hydroponic tomatoes  
Principal investigator: Hari Krishna  
Institution: Crop & Food Research

### **Pathogen:**

***Sclerotinia sclerotiorum***  
Research aim: Biological control using *Trichoderma* and *Coniothyrium*  
Principal investigator: Alison Stewart  
Institution: Lincoln University

### **Pathogens:**

***Colletotrichum coccodes*, *Fusarium* spp., *Sclerotinia sclerotiorum***  
Research aim: Pathogens and environmental conditions causing storage rots of squash  
Principal investigator: Lian Heng Cheah, Bruce Bycroft  
Institution: Crop & Food Research

### **Pathogens:**

**Watermelon MV 2, zucchini YMV**  
Research aim: Disease epidemiology, management and control in squash  
Principal investigator: John Fletcher, Tim Herman  
Institution: Crop & Food Research, FruitFed Supplies Ltd.

## APPENDIX 9. CARROTS, CELERY AND BEETROOT

### VG98011, INTEGRATED MANAGEMENT OF PYTHIUM DISEASES OF CARROTS

Principal investigator: Elaine Davison  
Project start: 01-Oct-98, finish: 01-Oct-02  
Organisation: Department of Agriculture  
Contact phone: 08 9368 3215

#### FINAL REPORT AND TECHNICAL SUMMARY, ELAINE DAVISON AND ALLAN MCKAY

##### The cause of cavity spot and other *Pythium* diseases of carrots in Australia

Cavity spot disease of carrots is caused by *Pythium* spp. *P. violae* and *P. sulcatum* are the most important causes of cavity spot worldwide. *P. sulcatum*, but not *P. violae*, causes this disease in Western Australia. A survey of *Pythium* spp. associated with carrot crops in eastern and southern Australia showed that *P. sulcatum* was the most widespread pathogenic species, occurring in all states and isolated from most regions. *P. violae* was recovered from two regions, one in Victoria and one in South Australia, but both in the River Murray basin. This is the first record of *P. violae* from carrots in Australia.

The diversity of *P. sulcatum* isolates, as shown by DNA analysis, suggests that it is a cosmopolitan species that may occur on native Australian Apiaceae.

A small survey of carrot crops in Victoria and South Australia showed that the incidence of cavity spot varied from 0 to 79 per cent, and was more common in the crops from Victoria than those from South Australia.

##### Cultural methods for controlling cavity spot and other *Pythium* diseases

###### *Host range and rotation*

The major hosts of *Pythium sulcatum* are members of the carrot family (Apiaceae). Grasses (barley, maize, oats, rye and wheat) used for wind protection, and un-related vegetables, are not infected.

In an experiment on a badly infested site at the Medina Research Station, carrots were planted after one, two or three broccoli crops. There was a significant reduction in the incidence and severity of seedling infection by *P. sulcatum* when carrots followed broccoli. At harvest this was associated with decreased forking and increased root length, resulting in an increase in export yield. There was a decrease in the incidence and severity of cavity spot in two of the three plantings where carrots followed broccoli, but these results were inconsistent. Oospores of *P. sulcatum* are able to survive for at least 21 months in the absence of a host.

###### *Solarisation*

Solarisation is a cultural method for controlling soil-borne diseases where soil is heated by solar energy. Its potential to reduce cavity spot was assessed in experiments that determined the survival of *P. sulcatum* and *P. violae* at elevated temperatures. Isolates of *P. violae* failed to survive for 2 hr at 35°C while *P. sulcatum* survived for 2 hr at 45°C, and 6 hr at 42.5°C. In the field it is unlikely that temperatures achieved by solarisation will be high enough to reduce the inoculum potential of *P. sulcatum*, although these temperatures may be sufficient to reduce the inoculum of *P. violae*.

##### Chemical methods for controlling cavity spot and other *Pythium* diseases

In a field experiment on a badly infested site, cavity spot control was attempted with a number of commercially available chemical and microbial formulations. Seedling harvests showed that *Pythium* infection was only reduced in the metalaxyl treatment. At the final harvest there was no significant reduction in the incidence or severity of cavity spot in any treatment although Amistar<sup>®</sup> is worthy of further work.

A survey was carried out to determine whether there was evidence of enhanced breakdown of the fungicide metalaxyl on sites where it has been used in the past. Metalaxyl was added to soil samples from carrot properties in South Australia, Tasmania and Western Australia and the half-life determined by chemical analysis. The half-life varied from less than 1 day to 43 days, compared with a published value of 70 days. Enhanced breakdown of metalaxyl appears to be a widespread problem.

### Varietal tolerance to cavity spot

Identification of carrot varieties tolerant to cavity spot, that are also suitable for export production, is an important part of integrated disease control. Between 1999 and 2001 further variety screening was carried out in a cavity spot disease nursery at the Medina Research Station in Western Australia. Three farm trials were also planted in Victoria to confirm the relative cavity spot tolerance of varieties. Many of the most cavity spot tolerant varieties identified did not produce the high root quality demanded by export markets. The variety Stefano combines the characters of moderate yield and cavity spot tolerance with high root quality. Stefano has become established as the industry standard variety throughout Australia.

## VG98100, INVESTIGATIVE STUDY INTO IMPROVING CARROT SEEDLING ESTABLISHMENT AND DISEASE MANAGEMENT

Principal investigator: Trevor Wicks  
Project start: 01-Dec-98, finish: 30-Nov-99  
Organisation: SA Research & Development Institute  
Contact phone: 08 8303 9563

### Aims

To determine the cause of carrot seedling losses in SA that regularly occur during November to May.

### Outcomes

A survey of SA carrot growing areas found most damping off was caused by the fungus *Alternaria radicina*. It was found on plants and in soil in 9 of the 10 carrot growing areas in South Australia. *Alternaria* is seed borne and of 35 seed samples tested, 83 per cent were contaminated with the fungus. Existing seed treatments are only partially effective. The *Alternaria* fungus survives in the soil for at least 8 years. High soil levels of *Alternaria* were found in areas such as the Riverland.

## VG00014, MANAGING ALTERNARIA BLIGHT IN CARROTS

Principal investigator: Trevor Wicks  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: SA Research & Development Institute  
Contact phone: 08 8303 9563

### Aims

To effectively control *Alternaria* by evaluating seed treatments, foliar sprays of fungicides to control seed infection in the field and soil drenches to control seedling damping off.

### Outcomes to date

*Alternaria* infected carrots at all stages: infecting seedlings, petiole and crowns and cold storage carrots. Steaming and hot water treatments controlled seed borne disease completely, but germination was slightly reduced. Girdling of crowns of mature carrots is caused by *Alternaria*, field trials have shown that Amistar and Rovral drenches applied four weeks before harvest controlled infections on maturing carrots. Shade house and field trials showed drenches and foliar sprays of Amistar, Rovral and Sumisclex applied 6 to 8 weeks after planting also controlled foliar infections.

Further studies on the *Alternaria* species associated with carrots has shown *Alternaria radicina* is the main pathogen with *A. carotiincultae* and *A. arborescens* also causing disease on foliage, carrot flowers, seeds and crowns.

### Future directions

Development of more effective seed treatments.  
Evaluation of fungicides applied to seed crop to reduce seed infection in the field.  
Trial fungicides for use as foliar treatments to control seedling damping off.  
Evaluate irrigation and tillage practices before planting carrots to reduce soil levels of *Alternaria*.

## IMPROVING THE RELIABILITY AND CONSISTENCY OF PROCESSING BEETROOT PRODUCTION.

Heidi Martin, QDPI.

South-east Queensland supplies 90 per cent of Australia's processed beetroot, worth \$33m PA. The industry is at a crossroad. Soil borne diseases (*Aphanomyces*, *Rhizoctonia* and *Pythium*) are dramatically affecting warm season crops. Early infections reduce plant stands and prune root growth. Late infections attack developing beets, ruining quality and increasing processing costs. Badly affected crops are bypassed. Additionally, the industry currently depends on two beet varieties, a vulnerable position. Unless solutions are developed, the industry will soon be unprofitable, and close down.

The industry needs practical systems for managing these diseases, and broader varietal options. It must consolidate and then extend reliable production windows beyond the current August-November boundaries. This urgent project runs from October 2000 to October 2003.

### Progress

First round of experimental work completed, reported to industry and discussed at field walks

After consultation with industry at a meeting in November 2000, fungicide and beetroot varietal assessment work was given top priority for the first year of this project.

Two fungicide trials and two variety trials were completed during the 2001 production season. Each trial type was planted on-farm at two different times during the season, to ensure that treatments were evaluated under different environmental conditions and disease pressures. Thirty-two beetroot varieties and 36 fungicide treatments were assessed in these experiments. The first trials were planted in March and harvested in August. The second trials were planted in June and harvested in October and November.

In the early fungicide trial, one fungicide (Hymexazol) greatly surpassed the current industry standard treatments for control of soil-borne seedling diseases. On the basis of these results an application for a minor use permit has been lodged with the National Registration Authority. In the early varietal assessment, nine of the thirty-two varieties evaluated were equal to or superior to the current standard commercial types in yield, disease tolerance and physical characteristics. Samples of these varieties were provided to the Golden Circle cannery for further assessment.

Two irrigation efficiency trials have also been conducted on-farm during the 2001 season. These trials aimed to investigate the relationship between irrigation distribution, yield and disease incidence.

First round of disease surveys on four sites completed and reports prepared.

Disease surveys were completed at each of the two fungicide and variety field trial sites. This involved monitoring the crop every two to three days for five to six weeks after planting to evaluate field losses due to disease pressure in the early growth stages of the crop. Additional disease assessments were made on each of the four trial crops at harvest to determine the impact of disease on the final marketable quality of the beets. Fungi isolated from the survey samples have been retained in a culture collection and their pathogenicities will be established in future experimental work.

Throughout the production season an additional eighteen beetroot samples have been received by the laboratory for diagnostic testing. Isolates from these diagnostic samples have also been retained and added to the collection of survey isolates.

Collaborative links have been made with Dr Paul Scott (University of Queensland, Gatton) who is developing a molecular diagnostic system for soil-borne plant pathogens. Isolates of *Pythium* spp. collected during the disease surveys have been passed on to Dr Scott who will use DNA fingerprinting technology to identify the species involved.

Field soil samples, collected from paddocks with a history of beetroot diseases are currently being indexed for disease in a glasshouse bioassay. This work has only recently commenced and it is anticipated that it will continue into the next growing season, with soil samples being collected from numerous sites around the district. Fungal isolates obtained from this work are being retained in the culture collection.

Fumigation/Biofumigation/Organic Amendments/Crop Rotation/Biologicals trials are being developed. Individual growers adopt a wide range of practices on their farms. Little is known about the best management strategy for minimising losses due to soil-borne diseases in the longer term. The project team has suggested to the industry that a permanent bed trial investigating treatment effects in the longer term, be established at a site for the remainder of the project. The specific treatments to be compared have not been decided but will focus on the above options (fumigation, biofumigation, organic amendments, crop rotations, biological control products, nutrition) and this will require additional consultation with the individual growers. This concept will be discussed with the growers and an experimental plan will be formulated and provided to the industry for comment and approval.

The importance of plant spacing was identified by several growers as worthy of further investigation, particularly for baby beets. A field trial will be established at Gatton Research Station for this purpose. Information on the optimum plant population necessary for maximum yield and quality is required.

In addition to the proposed trial work, survey work and disease indexing work with field soils collected from around the district will continue into 2002. Isolates from this work will be placed in the culture collection, and eventually will be tested for pathogenicity. *Pythium* spp. will continue to be provided to Dr Paul Scott.

## VG99020, IMPROVED CONTROL OF NEMATODES IN CARROT PRODUCTION

Principal investigator: Frank Hay  
Project start: 01-Jun-00, finish: 30-Sep-03  
Organisation: TAS Institute of Agricultural Research  
Contact phone: 03 6430 4907

### MILESTONE 4 SECOND SEASON'S TRIALS SUCCESSFULLY ESTABLISHED

Frank Hay, Elaine Davison, Allan McKay, Greg Walker, Deborah Keating, Lila Nambier, Tony Pattison, Jennifer Cobon, Jackie Nobbs

#### Pot trials initiated to establish threshold densities of principal nematodes

Preliminary pot trials have been initiated in different States to determine threshold density of *Pratylenchus penetrans* and of *Meloidogyne* spp. Further pot trials will be conducted in 2002 pending isolation of specific nematodes and maintenance of colonies in the greenhouse.

#### Plots established to determine relationship between initial population and damage

A trial consisting of 42 plots has been established in a commercial crop in Tasmania to relate population density of *Pratylenchus* spp. early in the season to yield and quality of carrot. A further trial is being established to monitor the relationship between *Meloidogyne* spp. and yield/quality in Western Australia.

#### Population dynamics of nematodes monitored in crops

Population dynamics of several different species of nematodes have been monitored in 2000/2001 season at several sites in different States and will continue to be measured as part of other trials during 2001/2002.

#### Pot trials established to determine host range of nematodes

A pot trial is underway to investigate the host range of *P. penetrans* on 10 fallow species, including grasses and legumes in Tasmania. Various pot trials have been initiated in other States to investigate cover crops and biofumigant species for control of *Meloidogyne* spp. Further pot trials are to be established to determine host range of *Meloidogyne* spp. and other nematode species (pending isolation and maintenance of colonies in the greenhouse).

#### Monitoring of nematodes in crop rotations after carrot begun

Further monitoring of nematode populations is continuing. However, many of the nematodes found in carrot soils have wide host ranges so it is expected that many of the crops currently used in rotations would act as hosts. More effort is being directed into pot trials to identify plant species which are non-hosts.

#### Field trial to examine efficacy of nematicides established

Field trials have been initiated in Western Australia and South Australia to determine efficacy of a range of nematicides.

#### Progress

Progress on the project has generally been good. One of the major outcomes has been a more detailed understanding of what plant-parasitic nematodes are present in carrot growing regions of Australia, and which species are causing reduced yield and quality. This information is important not only from the standpoint of the grower and agronomist, but also potentially for continued access of Australian carrots into overseas markets. Future work on the project is generally towards developing improved management strategies e.g. better understanding of damage thresholds for particular nematode species and quantification of their effects on yield/quality and identification and testing of suitable rotation crops and chemical controls. It is envisaged that some aspects such as pot trials to determine threshold populations of nematodes, will now need to be ongoing throughout the life of the project. This is due to the difficulty and time-consuming nature of isolating and bulking up pure cultures of particular nematode species for use in pot trials. However, this is not expected to impact on the final outcomes of the project. There have been some staff changes during the last year. Julie Stanton has left QDPI and Tony Pattison and Jennifer Cobon will be continuing the Queensland part of the project. Ms Deborah Keating has taken leave from Agriculture Victoria and her part of the project will be continued by her co-investigators Lila Nambier and Gordon Berg. At present the project is on track for meeting further milestones. A more detailed summary of progress in the project follows.

### Tasmania survey of crops 2000/2001 season

Results of a survey of carrot fields on the North West Coast of Tasmania have been collated. Preliminary results presented in the previous milestone report indicated that *Pratylenchus* are the main species associated with cropping soils in the Northern regions of Tasmania. *Pratylenchus* were present on 28 of 33 farms surveyed at an average population density of 106/400 mL soil in carrot crops up to 5 weeks old (Table 1). Stunt nematodes (*Tylenchorhynchus* spp. and *Merlinius brevidens*) occurred on 14 farms and at an average population density of 11/400 mL soil early in the season (Table 1). Other genera occurred at low population density (on average less than 5/400 mL soil). *Paratylenchus*, stunt nematodes and *Helicotylenchus* are not known as significant parasites of carrots, especially at the low population densities observed. Second stage juveniles of cyst nematode (*Heterodera* spp.) were observed in soil extracts from 3 farms. However, there were no cysts observed on carrot root samples taken at the time of sampling and *Heterodera* J2 were not obtained from root extractions, indicating that the species was not *H. carotae*, a known parasite of carrot in other countries. It is likely that the *Heterodera* J2 observed in Tasmanian carrot fields are *H. trifolii*. *H. trifolii* is widespread in pastures in Tasmania and the J2 observed in this study were probably survivors from pasture rotations or surviving on clover weeds growing in the crop.

Fixed specimens of some genera of nematodes from 17 farms were sent to Dr Jackie Nobbs, SARDI to identify to species. *P. crenatus*, *P. neglectus*, *P. thornei* and *P. penetrans* were confirmed on 14, 4, 2 and 1 out of 17 farms respectively. A stunt nematode from one farm was identified as *Merlinius brevidens*. Second stage juveniles of *Meloidogyne* were identified as *Meloidogyne fallax* from 2 (possibly 3 of the farms). Further confirmation of this will be carried out this season. Up until now it has been assumed that the only *Meloidogyne* species in Tasmania was *M. hapla*. *Meloidogyne fallax* was first described from the Netherlands (Karssen, 1996) and has recently been reported in at least 6 sites in South Australia (Nobbs *et al.* 2001). It is thought this nematode has been in Australia for many years and is likely to be widespread, so it is not considered a quarantine issue at this point. The presence of this nematode in Tasmania will be of concern to local growers as it can be particularly damaging to carrot and potato crops at higher population densities, causing a blistered appearance to the surface of the tuber.

**Table 1. Mean, maximum and minimum number of nematodes extracted per 400 mL soil from 33 Tasmanian carrot crops up to 5 weeks in age (November 2000 to February 2001)**

	<i>Pratylenchus</i>	<i>Paratylenchus</i>	Stunt <sup>1</sup>	<i>Heterodera</i>	<i>Meloidogyne</i>	<i>Helicotylenchus</i>
Average	106.1	4.5	11.4	1.0	2.5	0.4
Maximum	627.0	40.1	76.0	17.9	12.0	5.8
Minimum	0	0	0	0	0	0
No. of farms at which present	28	8	14	3	5	1

<sup>1</sup> Includes *Tylenchorhynchus* spp. and *Merlinius brevidens*.

**Table 2. Identification of nematode species present in carrot fields in Tasmania (2000/2001)**

Farm and location	<i>P. crenatus</i>	<i>P. neglectus</i>	<i>P. thornei</i>	<i>P. penetrans</i>	<i>M. fallax</i>	<i>M. brevidens</i>
1. (Heybridge)	+					
2. (Sprent)		+			+	
3. (Kindred)	+					
4. (Somerset)	+			+		
5. (Forth)		+				
6. (Penguin)		+	+		?	
7. (Wesley Vale)	+					
8. (Sulphur Creek)	+	+			+	+
9. (Penguin)	+					
10. (Sulphur Creek)	+					
11. (Burnie)	+					
12. (Sassafrass)	+					
13. (unknown)	+		+			
14. (Cressy)	+					
15. (Kindred)	+					
16. (Thirstane)	+					
17. (Sassafrass)	+					
Total number	14	4	2	1	2(3?)	1

**Tasmania field trial**

Results of a field trial established in a commercial field last year have been analysed. *Pratylenchus* was the predominant plant parasitic species at the site, with two species present (*P. neglectus* and *P. thornei*). Part of the field was subdivided into 42 plots and population density was measured at three times during the season. One hundred carrots were harvested from each plot at the end of the season and categorised according to anomaly and weighed. Carrots were graded on a 0-5 scale (Belair and Parent, 1996) ranging from 0 (healthy and marketable) to 5 (severely stunted and unmarketable).

Regression analysis showed some negative relationships between *Pratylenchus* population densities at some times of the year and size and shape of carrots (Table 3). Increasing numbers of *Pratylenchus* were associated with reduced plant density, decreased weight of healthy marketable carrots (category 0-1), increased weight of misshapen carrots (category 3), increased weight of small carrots, and decreased short cracks, constrictions and forking. However, nematode numbers were a poor predictor of the weight of carrots in these categories, indicating that other factors may play a role in causing such anomalies in carrots.

**Tasmania field trial 2001/2002**

A field trial has been established on a commercial carrot crop to investigate relationship between nematode numbers and yield and quality of carrot. A site has been chosen with *Pratylenchus* spp. at high numbers in some locations. Forty two plots (7 x 6 m) have been established and soil samples are currently being processed to provide a base count of nematodes early in the life of the crop. Further samples will be taken to monitor the population dynamics of nematode species during the season. Carrots will be harvested from each plot at the end of the season, weighed and scored for anomalies.

**Tasmania 2.4 pot trials**

Preliminary pot trials have been initiated to determine the relationship between nematode numbers and yield/quality of carrots, and in association with project OT98004 to assess host range of *Pratylenchus penetrans*. Pot trials in Tasmania have fallen behind schedule due to the difficulty in obtaining pure populations of nematodes from the field. More effort will be directed this season into isolating and bulking up populations of different species in the greenhouse for use in pot trials later in 2002.

**Table 3. Statistical significance ( $P=$  ) of the relationship between nematode numbers (log (nematode numbers +1)) and weight of carrots in different categories.**

	Feb 27 <i>Pratylenchus</i> / gram dry wt. root	Feb 27 <i>Pratylenchus</i> / 400 mL soil	Apr 3 <i>Pratylenchus</i> / 400 mL soil	Apr 26 <i>Pratylenchus</i> / 400 mL soil
Plants/m row	0.77	0.03* (-) <sup>1</sup>	0.29	0.39
Average carrot weight	0.69	0.13	0.84	0.60
Category 0-1 <sup>2</sup>	0.97	0.05* (-)	0.77	0.40
Category 2-5	0.64	0.83	0.18	0.31
Total fresh weight of 100 carrots	0.46	0.10* (-)	0.89	0.49
Category 0	0.77	0.20	0.34	0.68
Category 1	0.71	0.01* (-)	0.11	0.84
Category 2	0.72	0.58	0.21	0.80
Category 3	0.59	0.03* (+)	0.13	0.18
Category 4	0.41	0.84	0.25	0.79
Category 5	0.42	0.76	0.15	0.97
Small carrots	0.20	0.05* (+)	0.02* (+)	0.04* (+)
Twisted	0.38	0.60	0.46	0.65
Long cracks	0.89	0.44	0.62	0.56
Short cracks	0.55	0.03* (-)	0.07* (-)	0.38
Constriction	0.09* (-)	0.30	0.24	0.52
Forked	0.09* (-)	0.14	0.27	0.11
Other	0.66	0.35	0.93	0.67

<sup>1</sup> Increasing numbers of *Pratylenchus* were either negatively associated (-) or positively associated (+) with measured parameter.

<sup>2</sup> Carrots were categorised according to Belair and Parent (1996), on a scale of 0 (carrot with no anomalies) to 5 (severely stunted).



## South Australia progress

Nematode levels were monitored and yields of carrots and incidence of defects were assessed on three farms under conventional or organic management. Production of non-defective carrots was lowest at the organically-managed farm, due to a high incidence of undersized and galled carrots. The most important carrot defects were galling, hairy roots, splitting, swollen tips, forking and undersized carrots. Nematodes with high multiplication rates over the carrot growing season were *Meloidogyne javanica*, *Hemicyclophora saueri*, *Pratylenchus neglectus*, *Helicotylenchus* spp., *Scutellonema brachyurum* and *Paratrichodorus* spp. Metham sodium used at 300 L/ha was inadequate to provide effective control of nematodes, especially in early season crops. At planting, mid-season and at harvest levels of *M. javanica* were correlated with incidence of galled carrots, and were variously associated with incidence of forked, tip-swollen, stubbed, hairy, constricted, split and substandard carrots. At harvest, levels of *H. saueri* were correlated with incidence of substandard carrots, and with hairy, constricted, forked, tip-swollen, stubbed and split carrots, suggesting that this nematode may also be a significant, and previously unreported, cause of carrot production loss in South Australia. The correlations between at planting levels of *H. saueri* and incidence of split (both a conventional and newly described type of split) and constricted carrots were particularly strong. Incidence of undersized carrots was correlated with at harvest levels of *P. neglectus*. Conventional methods of extracting nematodes were reliable where high nematode levels existed at planting, however, they were unreliable for detecting *M. javanica* following soil fumigation until 14-17 weeks after planting.

One paper has been submitted to Australasian Plant Pathology - (Walker, G.E. Associations between carrot defects and nematodes in South Australia).

## Victoria introduction

Following the completion of the first year of project work there were some clear conclusions that could be summarised.

A variety of nematodes, both previously recorded and non-previously recorded as pests on carrots were found within carrot paddocks. The most significant nematodes found were *Meloidogyne hapla*, *Meloidogyne javanica*, *Pratylenchus neglectus*, and *Pratylenchus crenatus*. The remaining nematodes identified are thought to be of less significance, such as *Helicotylenchus* spp, *Heterodera schachtii*, *Paratrichodorus* spp, *Pratylenchus* spp., and *Tylenchorhynchus* spp.

*Heterodera schachtii* (Beet cyst) was found to be a problem on broccoli and was investigated as a possible indirect problem to carrots. Broccoli is used in rotation with carrot crops to reduce the soil load of *Pythium* spp. attacking subsequent carrot crops. A population study was completed on this nematode over a carrot crop. Numbers of *H. schachtii* dropped significantly over the course of the carrot crop, proving it to be a poor host of this nematode.

Two species of root knot nematode (*Meloidogyne hapla* and *Meloidogyne javanica*) were extracted from damaged roots of carrots. These two species were the only nematode found to be causing any significant damage to carrots in Victoria.

The two species of root knot nematode (*Meloidogyne hapla* and *Meloidogyne javanica*) were found in all carrot growing regions of Victoria. The regions are Mornington Peninsula (Somerville), Gippsland (Warragul), East Gippsland (Longford), Dandenong Ranges (Silvan) and Murray Valley (Robinvale, Nangiloc).

## Victoria nematode species within carrot paddocks

Following on from Year 1 investigations, species identification of nematodes found in carrot paddocks were completed after the submission of slides to Dr Jackie Nobbs. From the slides positive identification were made for Stunt nematode (*Merlinius brevidens*) and root lesion nematodes (*Pratylenchus neglectus* and *Pratylenchus crenatus*). *Merlinius brevidens* has not been previously recorded on carrots in Victoria or elsewhere in the world. After monitoring stunt nematode population dynamics over the carrot crop, this nematode is not thought to be a concern in carrots. Both species of *Pratylenchus* have been previously recorded on carrots in Victoria, however from the population studies for these nematodes there was little evidence to suggest these nematodes were causing problems to the crops monitored. Some species of spiral nematodes (*Helicotylenchus* spp.) mounted on slides could not be identified to species level due poor specimen presentation.

A new record of root knot nematode has been made since the last milestone report. A population of *Meloidogyne hapla* has been identified by PCR from a paddock in Warragul (Gippsland). Victoria now has records of root knot nematode in every carrot growing region. *Meloidogyne hapla* and *Meloidogyne javanica* are still the only species of root knot nematode recorded in Victoria from the surveys conducted during this project.

### **Victoria precision sampling study**

The experimental design incorporated comparison between the traditional 'Zigzag' or 'W' shaped method and a 'Stratified' or 'Grid' method (as currently used for Potato Cyst Nematode sampling). The grid method is thought to be more statistically correct by biometricians as it gives every piece of soil an equal and unbiased opportunity to be sampled. A soil corer of 2 cm diameter and 30 cm depth was used for sampling. Originally a plot of 100 X 100 m was to be used. Unfortunately the grower had planted more of the paddock being sampled than thought and the plot was reduced in size to 100 m X 30 M. The plot was randomly chosen and the sampling intensities were repeated 4 times. Sampling intensities were 10, 20, 40 and 60 cores. A representative subsample from each sampling intensity will be processed by the Whitehead tray method. Statistical analysis is yet to be completed.

From the results it is hoped that an appropriate sampling intensity will be identified and a preferred method of sampling chosen. This will give designated samplers a suitable sampling method and will result in more accurate nematode forecasting. Following the completion of this study, a campaign to encourage growers to do regular pre-plant nematode tests will be undertaken. Special thanks must go to Collin Gazzola of L Gazzola and Sons for the use of his paddock and for his continued support of this project. It is greatly appreciated.

### **Victoria optimisation of a culturing protocol**

The majority of the work to be completed within the second year of this project will revolve around *Meloidogyne hapla* and *Meloidogyne javanica*. At least three individual studies into threshold density, carrot variety susceptibility, and host range trials have been planned. In order to carry out these studies adequate amounts of egg masses and juveniles will need to be available. Good culturing and extraction techniques will need to be developed.

A nematode nursery has been set up to maintain all populations of *Meloidogyne* spp. collected from all carrot growing regions of Victoria. Not all regions recorded both species of Root Knot nematode, but all populations have been retained for future studies that may incorporate population virulence studies, sub species identification, or studies into the effect of control strategies for each regional population.

The current culturing methods rely on the use of tomato seedlings (*Lycopersicon esculentum*) under favourable glasshouse conditions to maintain a high population status. Conditions for maintenance of Root Knot nematode may vary depending on the population, species, glasshouse facilities, external seasonal factors and host plant. For the various populations of *Meloidogyne hapla* and *Meloidogyne javanica* collected from the Victorian carrot growing regions, we have optimised the conditions for culturing and maintenance of these nematodes according to the following conditions:

- Populations maintained on seedlings of tomato (*Lycopersicon esculentum*) and Impatiens (*Impatiens* spp.).
- Three week old Impatiens seedlings and 4 leaf stage tomato seedlings are inoculated with either juveniles (J2) or cuttings from previously infected root material.
- Seedlings are maintained in 6 inch plastic pots under glasshouse conditions.
- Glasshouse temperatures are set between 18-25°C. Optimal temperature is approximately 25°C and is especially important during Winter months.
- Watering as required by hand to avoid over-watering.
- Re-inoculation of fresh seedlings should occur every 3 months.
- Individual populations are maintained in separate trays to avoid splash contamination and water run-off from each pot is collected and autoclaved.
- Light regime is set at natural lighting conditions (10-12 hours light per day).

### **Victoria carrot threshold density study**

This study will be completed in pot trials under glasshouse conditions. After surveying some of the Victorian carrot growers, five of the most commonly planted carrot varieties will be used to determine any variation in threshold levels for 2 populations of Root Knot nematode. The carrot varieties selected are; Stefano, Senior, Murdoch, Red Hot, and Viking. All are Nantes varieties except for Red Hot which is an Imperator. The two nematode populations are *Meloidogyne hapla* and *Meloidogyne javanica*, both populations originated from carrots on a property at Silvan, Victoria. Five different levels of inoculum will be used 0, 10, 20, 40 and 80 nematodes/100 g soil.

Previously published literature regarding the pest-host interaction of root knot nematode and carrots has shown that the threshold level may be very low (< 5 nematodes/100 g soil). Our sampling intensities have been adjusted to accommodate this theory. Each possible combination will be repeated 3 times for this study in a randomised block design. Pot size will be 8 inch. An appropriate soil mixture will be sourced from literature or from a recommendation by a soil mix company. Data loggers will be used to monitor soil moisture and temperature differences during this study. Sampling will be done at harvest, assuming an average cropping season of 112 days.

### **Victoria carrot variety susceptibility study**

Carrot has long been known as a very susceptible host for *Meloidogyne* spp. This study aims to investigate any varying level of tolerance from ten of the most commonly grown carrot varieties in Victoria. The population of *Meloidogyne hapla* and *Meloidogyne javanica* from Silvan, Victoria will be chosen for this study. The study may be widened to include all root knot nematode populations collected from all Victorian carrot growing regions, if results from the initial trial are significant.

This study will be carried out in pots under glasshouse conditions. The ten varieties of carrots will be: Stefano, Senior, Murdoch, Red Hot, Viking, Mojo, Havana, Bastille, Red Sabre, and Richardo. These varieties will be subjected to extremes of nematode infection to determine any difference in tolerance level. The soil inoculation intensities will be 0, 5, and 50 nematodes/100 g soil. Pot size will be 8 inch. An appropriate soil mixture will be sourced from literature or from a recommendation by a soil mix company. Data loggers will be used to monitor soil moisture and temperature differences during this study. Sampling will be done at harvest, assuming an average cropping season of 112 days. Each possible combination will be repeated 3 times for this study in a randomised block design.

### **Victoria host range susceptibility study**

Both *Meloidogyne hapla* and *Meloidogyne javanica* have wide host ranges. The range of hosts include many vegetables, fruit, ornamentals and pasture species. The level of host susceptibility recorded can vary with species of plant, species of nematode, climatic conditions, soil type, and crop management.

This study aims to determine levels of host susceptibility to the Silvan population of *Meloidogyne hapla* and *Meloidogyne javanica*. Plant species selected for this study were chosen from crops that are currently rotated with carrots by Victorian growers, or from crops thought suitable for inclusion as rotation crops (i.e.: crops that would most likely be adopted into the existing rotation plan by Victorian growers, if shown to be significant)

The plant species that may be chosen for this study are: Canola, Broccoli (*Brassica oleracea*), Egg plant (*Solanum integrifolia*), Oats (*Avena sativa*), Annual Rye grass (*Lolium rigidum*), onion (*Allium cepa*), Sorghum (*Sorghum* spp.) beans (*Phaseolus vulgaris*), Sundan grass (*Sorghum sydanense*) and Rye corn (*Secale cereale*). The soil inoculation levels will be 0, 5, and 50 nematodes/100 g soil. Sampling will only be made at harvest. Each crop will vary with its harvest date. An average date will need to be chosen after the length of cropping for each of the hosts has been determined. Data loggers will be used to monitor soil moisture and temperature differences during this study. Each possible combination will be repeated 3 times for this study in a randomised block design. Pot size will be 8 inch

### **Victoria publication of project work in grower magazine**

A brief article outlining the results of year one and future ambitions of the Victorian section of this project will be published in the next edition of a new Victorian grower magazine, VegMatters. The publication is due to be distributed in December 2001. VegMatters is a magazine published by Natural Resources and Environment and is edited by the Vegetable extension team, VegCheque. All vegetable growers that pay a levy receive the magazine.

### **Western Australia**

The 0.25 hectare nematode infested site at Medina Research Station, developed as part of this project, will be used for two experiments over summer 01/02. It is planned to seed both experiments in December 2001.

One of the field experiments is designed to examine in detail the relationship between numbers of root knot nematode (*Meloidogyne*) and carrot yield and quality. Assessment of sampling protocol for sandy soils will also be carried out in conjunction with this experiment.

The second experiment at the Medina site will be a nematode control experiment. Some of the treatments to be included in this trial are: Nemacur® (fenimaphos), metham sodium, Furadan® (carbofuran) and Telone® (1,3 dichloropropene).

Additional details of nematode sampling was conducted. A number of soils were screened for carrot cyst nematode (*Heterodera carotae*) an important pathogen of carrot in some other countries. This was found to be absent from carrot soils in Western Australia.

#### **Queensland survey of Queensland carrot fields**

Five carrot fields were sampled in the Fassifern Valley on November 21, 2001. Soil was examined for plant parasitic nematodes from five fields and roots of carrots were examined from four fields. No plant parasitic nematodes were detected in two fields. Lesion nematodes (*Pratylenchus* sp.) were detected in soil from two farms, however, was not detected in the roots of carrots on any farms. Spiral nematode (*Helicotylenchus dihystera*) was detected in the soil from one farm and in the roots of carrots from another location.

#### **Queensland identification of *Meloidogyne* species**

Three *Meloidogyne* specimens from Victoria were identified to species using the PCR technique. One specimen was *M. hapla* and two specimens were *M. javanica*. Ten specimens from Western Australia were all identified as *M. hapla*.

#### **Queensland screening rotation crops**

Six commercial brassica cultivars were evaluated for resistance to *M. javanica*. A commercial variety of radish (*Raphanus sativa* cv. Weedcheck) has shown good resistance to *M. javanica* in pot trials. This cultivar is also reputed to have biofumigation potential. Further evaluation of the resistance of Weedcheck to other *Meloidogyne* and *Pratylenchus* species found in carrot producing areas throughout Australia is underway. The possibility of the biofumigation from the incorporation of leaf residue of Weedcheck for management of soil borne carrot disease will also be investigated. Two species of *Pratylenchus* have been collected from South Australia and are currently being established on cultures in the laboratory. An isolate of *M. hapla* is expected to be established shortly.

#### **Queensland nematicide efficacy**

A pot trial has commenced evaluating the efficacy of NemaCur 400, NemaCur 240 GS, Rugby 100 G, Rugby 240 GS and Vydate 240 L for control of *M. javanica* in carrots. Five carrot seedlings grown in 1.5 kg of sandy soil were inoculated with 2,500 eggs. Nematicides equivalent to 10 µg/g soil was applied to the soil five days later. Carrots are to be harvested eight weeks after nematicide application.

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## VG01016, DEVELOPING AND COMMUNICATING MANAGEMENT STRATEGIES FOR CONTROLLING CARROT VIRUS Y

Principal investigator: Roger Jones  
 Project start: 01-Jul-01, finish: 30-Jun-02  
 Organisation: Department of Agriculture  
 Contact phone: 08 9368 3269

### MILESTONE 2 'OUTCOMES OF NATIONAL SURVEYS FOR CVY IN CARROT CROPS DETERMINED.'

Lindrea Latham (WA), Roger Jones (WA), Violetta Triacevski (VIC), Dennis Persley (QLD), Calum Wilson (TAS), Len Tesoriero (NSW), Robin Coles (SA)

#### (a) National surveys of carrot crops for carrot virus Y

Surveys of carrot crops were undertaken in WA, VIC, NSW, SA, TAS and QLD. One hundred leaf samples were collected at random from each crop by walking through it and sampling every five paces the nearest shoot to the tip of the boot. The samples were transported to the laboratory and tested for carrot virus Y (CVY) by enzyme-linked immunosorbent assay (ELISA) using suitable virus specific antisera. The results from the surveys in the different states are tabulated below.

**Table 1. Incidence of CVY in carrot crops in Australia in 2001/2002**

	% of carrot crops infected with CVY	% of carrot growing properties infected with CVY	Range of % CVY incidence within infected crops
WA	19	27	1-68
VIC	54	71	Not determined
SA	56	56	2-98
NSW	63	83	10-100
QLD	24	60	1-3
TAS	7	7	3

Infection with CVY was found to be alarmingly widely distributed in national carrot crops often occurring at very high incidences. Highest proportions of infected properties (> 50 per cent) were found in VIC, SA, NSW and Qld. Highest infection incidences within individual crops (> 50 per cent) were in WA, SA and NSW). Victorian incidences not determined but of similar magnitude. These very high levels of infection are cause for concern for the national carrot industry.

#### (b) Literature review on carrot crop virus problems internationally completed and any potential exotic disease threats to Australia identified.

In different parts of the world, more than 30 viruses are known to infect plants in the apiaceae family, to which carrot belongs. Of these, 10 are recorded infecting carrot naturally in the world: carrot motley dwarf virus (CMDV), CVY, celery mosaic virus (CeMV), parsnip yellow fleck virus (PYFV), arabis mosaic virus, carrot cryptovirus, carrot thin leaf virus, carrot mosaic virus, carrot mottle mimic virus and carrot yellow leaf virus. Of these, only the first four viruses cause serious and economically damaging losses to carrot production. Three of these four serious viruses, (CVY, CMDV and CeMV), are already known to occur in Australia but PYFV has not as yet been found here.

PYFV causes significant losses in carrot crops in the United Kingdom and in seed crops of carrot in the Netherlands. In carrot, the disease is actually caused by two viruses that are spread together in a semipersistent manner by the aphids *Cavariella aegopodeii* and *C. pastinaceae*. Of these aphids *C. aegopodeii* is known to occur in Australia but neither virus is known to occur. Virus source plants must contain a helper virus, anthriscus yellows virus (AYV) before aphid vectors will transmit the complex. Thus only plant species that are infected with both viruses simultaneously act as sources for virus transmission to healthy plants. The only known wild hosts of the damaging complex of both viruses are wild chervil (*Anthriscus sylvestris*) and the weed cow parsley (*Heracleum sphondylium*). Carrots are immune to AVY so PYFV does not spread from plant to plant within carrot crops, and all infections observed in carrot are primary infections with PYFV.

The threat from PYFV to Australia's carrot industry would appear to be small as the virus is not transmitted through seed. Therefore its introduction would require importation of live infected plant material. Also, both viruses would need to be present together before the disease would spread into carrot or other cultivated apiaceae species such as celery and parsnip.

**(c) Seed transmission and summary of alternative reservoir hosts completed**

**(i) Seed transmission**

Viruses that infect other crops related to CVY and belonging to the same virus group, members of the Potyviruses, are sometimes transmitted at low levels through seed. It is therefore very important to determine if introduction of CVY to new sites could be occurring through inadvertently sowing infected carrot seed stocks. We have already determined that some carrot seed crops within seed production areas in Australia are heavily infected (> 90 per cent) with CVY so infection of seed stocks is likely if seed transmission does occur.

Seed was harvested from carrot plants with known CVY-infection growing in the glasshouse. The seed was germinated in moist paper towels and the radicles from every seedling tested by ELISA for CVY. In initial tests, transmission through seed to seedlings was detected at 0.1 per cent. At this level, keeping in mind that many thousands of carrots seeds are planted per hectare, then CVY seed transmission is capable of introducing many infection foci/crop. Hence contamination of seed stocks is potentially a serious threat for carrot growers and may explain the widespread distribution of this virus throughout Australia.

In WA some CVY-infected carrot crops are flowering now. Further tests for seed transmission will be done on seed collected from them so as to provide more information on this key issue.

**(ii) Alternative hosts**

It is important to determine if there are any alternative CVY reservoir hosts to carrot crops or volunteer carrots so that any sources of CVY can be eradicated from the vicinity of crops to reduce the virus reservoir. In WA, the only widespread apiaceous weed growing in carrot growing areas is perennial wild fennel (*Foeniculum vulgare*). This grows prolifically along roadside verges and at the edges of carrot crops. Over 1000 new leaf shoots of wild fennel were collected from 25 sites around the Perth metropolitan area. Samples were tested by ELISA for CVY in the laboratory but none was detected. This indicates that fennel is not a reservoir of CVY so carrot itself seems to be the only infection source.

**1. Next steps**

**Field trials**

**(a) Screening for resistance to carrot virus Y in carrot varieties**

Twenty varieties of carrot currently available to local growers were exposed in the field to high CVY disease pressure. This was achieved in small replicated plots using CVY-infected transplants from the glasshouse to provide a uniform virus source. To confirm virus presence and determine percentage incidence, shoots were collected from 50 carrot plants within each plot of each variety and tested by ELISA for CVY. This percentage infection result provided a measure of relative susceptibility. Fifty carrot roots were harvested from each plot and assessed for amount of disfiguration caused by infection. This provided a measure of relative sensitivity to the virus. The results from this experiment are still being processed although initial indications are that there seems to be no natural resistance to CVY in currently cultivated carrot species and that roots are similarly disfigured regardless of variety.

**(b) Effect of time of infection with carrot virus Y on yield and quality losses in carrot**

Before this work, although yield and quality loss information was available from pot trials, no information was available on the impact of time of infection with CVY on yield and quality losses of carrots under field conditions. In a field experiment, small numbers of CVY-infected carrot plants were introduced to replicated plots of carrots to act as virus sources. There were also control plots with no introduced infection sources. Individual plants that became infected at different growth stages during the growing season were harvested. Equal number of plants from healthy and infected plots (up to 50/date) were harvested for each assessment date. Measurements of carrot length, crown width, total yield and distortions were taken from each plant. Paired plant comparisons using Chi-squared tests are currently being done. Field observations confirm what was observed in the glasshouse that early infection results in severe knobby symptoms in carrot roots and renders the carrot unmarketable, however delayed infection results in milder symptoms.

**(c) Carrot yield loss due to infection with carrot virus Y**

Before this work, although yield loss information was available from pot trials, none was available on the impact of infection with CVY on yield losses of carrots under field conditions. In a replicated field trial, different numbers of CVY-infected carrot plants were introduced into carrot plots as virus sources. There were also control plots with no introduced infection sources. Percentage CVY infection within plots was then determined by testing samples by ELISA. Large aphid populations were present at the time of seeding the experiment and, unfortunately, within three to four weeks much of the experiment was swamped with CVY infection so that regardless of whether source plants were introduced or not, most plots eventually became 100 per cent infected with CVY. One hundred carrots were harvested from each plot and measurements of carrot length, crown width, total yield and distortions were taken from each plant and total yield determined. The number of carrots with CVY that were unmarketable from each plot was determined. Despite the swamping with CVY infection, the experiment is likely to give useful results because plots became fully infected at different times. Results are currently being processed.

**(d) Victorian field trials**

The roles of different individual aphid species as CVY vectors will be assessed through detailed field monitoring of aphid populations and CVY incidence in carrot crops. The monitoring is being done by using suitable yellow sticky traps and water traps. Flying aphids are being caught on fine nets downwind of heavily infected crops and placed on individual test plants to determine which species are transmitting CVY.

**Interstate visits**

Dr Violetta Traisevski of Knoxfield, Victoria visited Perth on the 27 and 28 of November 2001. During her visit we had meetings with the WA CVY team (Lindrea Latham, Roger Jones, Allan McKay, and Lisa Smith) working on project VG01016 and discussed current and future work. She also visited field trial sites at Medina Research Station, and carrot growing properties suffering economic losses from CVY infection. Her visit was highly productive with greater understanding reached on carrot growing and CVY problems in the two states. A number of issues regarding different sampling and testing procedures used in different laboratories were also resolved.

**2. Communication and extension activities****Book contributions**

Latham L.J., Jones R.A.C. (2001) Carrot Virus Y. In *Compendium of Umbelliferous Diseases* (Ed M Davis, R Raid) APS Press pp. 53.

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**Newsletter/magazine/newspaper articles**

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Latham L. (2000). News from Western Australia: Celery mosaic virus and carrot virus Y: In *'The control of celery mosaic virus - Newsletter February 2000'*. (Ed V. Traicevski) pp. 5.

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## **VG01017, EXTENSION OF AN INTEGRATED MANAGEMENT STRATEGY FOR CELERY MOSAIC VIRUS IN CELERY CROPS IN WESTERN AUSTRALIA**

Principal investigator: Lindrea Latham  
Project start: 01-Jan-02, finish: 30-Jun-02  
Organisation: Department of Agriculture  
Contact phone: 08 9368 3266

### **Summary**

Celery mosaic virus (CeMV) causes a damaging disease of celery. The virus is transmitted by aphids causing symptoms of plant stunting, severe leaf vein clearing and leaf up-curling in celery plants. Shelf life is reduced and both yield and quality impaired. All currently grown celery varieties are susceptible. Build up and spread of CeMV infection is favoured by continuous cropping all year round. The sowing of new crops next to old ones favours rapid spread of CeMV infection from old to new plantings and gradual build up of infection levels over time. The situation is made worse where different celery growers' properties are in close proximity. The virus is now widespread and severely threatening the Western Australian celery industry. Growers have become so desperate to reduce infection levels that some have been forced into a celery free period on their properties. Technology transfer of measures to address the CeMV issue will be developed for Western Australian celery growers in collaboration with the WA CeMV Working Group. A number of cheap and effective control strategies that growers can employ to reduce the incidence of CeMV in their celery crops will be extended as an integrated package. A range of technology transfer tools will be used to achieve maximum uptake by growers

## **VG01043, IMPROVED CARROT AND CELERY CULTIVARS THROUGH BIOTECHNOLOGY**

Principal investigator: James Hutchinson  
Project start: 01-Jul-2001, finish: 30-Jun-05  
Organisation: DNRE Agriculture Victoria IHD Knoxfield  
Contact phone: 03 9210 9222

### **Project progress/impact**

Two important findings from the HAL, AusVeg and DNRE project 'Management of celery mosaic virus' (VG97013) were that effective control would require either a break in the production cycle or the planting of resistant cultivars. A break in production does not fit in with current industry practice and presently no CeMV resistant cultivars exist.

The project 'Sustainable carrot production: Workshops and development of priorities' (VG99029) established some R&D priorities for the carrot industry. Concerns about Carrot Virus Y (CVY) and the fungal disease Cavity Spot (*Pythium sulcatum*) were important issues raised by growers.

Gene transfer has a proven track record to generate virus resistant plants and the potential to enhance fungal resistance.

The aims of this project are to:

- Develop required platform technologies to genetically modify carrot and celery germplasm using marker genes.
- Design, prepare and assess gene constructs to control CeMV, CVY and Cavity Spot.
- Report to industry on the potential of gene transfer to solve important problems.



## **VG99005, QUALITY WASH WATER FOR CARROTS AND OTHER VEGETABLES: INSURANCE FOR CLEAN FOOD MINIMISING ENVIRONMENTAL IMPACT**

Principal investigator: Martin Mebalds  
Project start: xxx, finish 03-May-01  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### **MILESTONE REPORT**

#### **Summary**

The aim of this project is to minimise the amount of water used on farm to wash vegetables. This will be achieved through the delivery of best practice protocols for the treatment of wastewater. The first stage of the project involved characterising the quality (microbial and chemical) of source water and wastewater from various growing districts. Whilst chemical contamination was found to be minimal, the presence of plant pathogens and faecal indicator bacteria in several samples indicated a potential problem, and suggested the need for water treatment. The second phase of the project-starting with milestone four-involved investigating on farm water treatment systems. We found that a series of settling ponds may improve water quality, although not all settling ponds systems operate efficiently. From phases one and two we have been able to develop industry guidelines, which are the focus of this milestone.

#### **Description**

Provisional recommendations formulated for water treatment. Completed analysis of water treatment effects on physical and chemical parameters.

#### **Criteria**

Completed water treatment analysis. Consult with IDOs on results and formulate provisional recommendations for water treatment. Published results and provisional recommendations reported through industry magazines and newsletter.

#### **Explanation of milestone delay**

This milestone was delayed for several reasons. Firstly, project leader Martin Mebalds was unavailable for the project from October 2000 to November 2001, as he was assigned to a higher duties position during this period. Therefore, during this period there was only one staff member (Andrew Hamilton) available to work on the project. Also, from July to October 2001 Andrew Hamilton took leave without pay to fulfil study commitments. Arrangements were made to replace him during this period, but due to administrative reasons this did not occur. Thus, the project was un-staffed during this period. However, both Martin Mebalds and Andrew Hamilton are back on the project and arrangements are currently being made to employ an additional full-time staff member (using funds saved during previous staff absences), which will assist in bringing the project back in line with the original schedule.

#### **Development of industry guidelines**

The provisional industry guidelines have been completed and are attached. These guidelines have been circulated to the industry development officers for comment. The guidelines address several important issues relating to the re-use of vegetable wash-water for both washing and irrigation. These include: contamination of food, crop protection, treatment technologies and environmentally friendly disposal of waste-water. The guidelines not only draw on our research, but also on international research, particularly in relation to the agronomic and environmental effects of pesticides in irrigation/waste water.

#### **Communication through industry magazines**

To date two articles have been published in industry magazines, and arrangements are currently being made for another publication that will present a summarised version of the guidelines for the industry. Since the last milestone, the second edition of the 'In the Wash' newsletter has been published and distributed to growers.

***Completed water treatment analysis***

In the previous milestone report, preliminary results on the effectiveness of waste-water treatments (settling ponds and sand filters) on three farms were presented. It was stated the final analyses would be completed by this milestone. These analyses have been completed and they were used in the development of the attached industry guidelines. The results of the studies of the various systems can best be appreciated by reading the guidelines and milestone four.

The results from the carrot waste-water survey have also been statistically analysed and are currently being prepared for publication in a scientific journal. The survey results were also used in the development of the guidelines. Since the last milestone, source and wastewaters from two Western Australian and two South Australian farms were analysed and added to the survey database.

**VG00054, DEVELOPMENT OF AN INTEGRATED PEST MANAGEMENT PROGRAM FOR CELERY (DETAILS TO BE COMPLETED)**

Principal investigator: Tom Schreurs  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: Celery Growers Association  
Contact phone:

No report available.

**NEW ZEALAND CARROT PROJECTS**

**Pathogens:** *Pseudomonas viridiflava, P. marginalis*  
Research aim: Pathogen characterisation, elucidation of cold-tolerant pathogenicity  
Principal investigator: Scott Godfrey, John Marshall  
Institution: Crop & Food Research

**Pathogen:** *Meloidogyne sp.*  
Research aim: Control for improved quality  
Principal investigator: John Marshall  
Institution: Crop & Food Research

## APPENDIX 10. BRASSICAS

### VG98080, READY REFERENCE GUIDES FOR THE BRASSICA INDUSTRY

Principal investigator: Caroline Donald  
Project start: 01-Jul-98, finish: 30-Jun-00  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

#### Media and technical Summary

The project VG 98080 resulted in the production of 'A field guide to pests, diseases and disorders of vegetable brassicas'.

The guide, an 85 page, full colour, laminated pocket book covers everything from pests (with built in scale to size drawings), to beneficial insects, diseases, nutritional disorders, genetic and physiological disorders and environmental and chemical disorders of the vegetable brassicas. It is the first fully comprehensive field guide currently available for Brassica crops.

Over 1000 copies (one per grower) have been distributed free of charge to growers of vegetable brassica crops nationally. Non-levy paying sectors of the industry (e.g. researchers, chemical reps, consultants, etc.) can purchase a copy through the Crop Health Services bookshop (03) 9210 9365.

A survey was distributed with each field guide to determine grower satisfaction with the finished product. 166 surveys had been returned at the time of preparation of this report. The response was overwhelmingly positive with at least 98 per cent of growers circling 'adequate', 'excellent' or 'good' for each of the 7 questions relating to the quality and quantity of written and photographic material.

Most (96 per cent) growers believed that the publication would 'probably' or 'definitely' be a useful reference for themselves or others on the farm and 95 per cent of growers reported that production of this publication had 'probably' or 'definitely' been a good way to use levy money.

Many growers (26 per cent) reported that they would have liked to have had chemical recommendations for each pest or disease included in the guide, however, as registrations for chemicals differ in the various States and change regularly, this was not considered practical by the authors at the time of production. Inclusion of this information would also have increased the size of the booklet far beyond 'pocket sized'.

Demand for a similar publication was greatest for lettuce, followed by curcubits (pumpkin, zucchini, cucumber and melons), alliums (onions and leeks) and potatoes.

## **VG01024, IMPROVED MANAGEMENT OF BLACK ROT OF BRASSICAS**

Principal investigator: Len Tesoriero  
Project start: 01-Jul-01, finish: 01-Mar-04  
Organisation: NSW Agriculture  
Contact phone: 02 4640 6406

### **Summary**

Black Rot is the most destructive disease of Brassica crops world-wide. Significant losses have been experienced across three production districts in SE Australia over the last few years. Virtual complete crop losses have been experienced. Litigation has been threatened on at least two occasions. Spread of the causal bacterium, *Xanthomonas campestris*, has been attributed to an increase in the international trade in seed. World trade in seed has escalated with the high demand for new cultivars with superior marketing attributes. There are significant risks of introducing undesirable bacterial strains and races, especially since very low initial infection levels in seed can translate to considerable field losses. Losses occur because bacteria multiply and spread rapidly under favourable conditions that occur during seedling production, transplanting operations and field production. Current bacterial detection techniques in seed are labour intensive, time consuming and therefore expensive. This project proposes to develop and validate a superior detection technique that is quicker, cheaper, more sensitive and with the potential to distinguish different bacterial strains and races. Seed disinfection protocols will be reviewed after the comparison of a chemi-thermal technique with currently used methods. Disease management guidelines for Black Rot will be established for the seed, seedling and field phases of production. These activities will ultimately give the industry greater yields and quality assurance, and reduce the risks of spreading Black Rot with the industry supply chain.

## **VG99008, A RAPID DIAGNOSTIC TEST FOR CLUBROOT**

Principal investigator: Caroline Donald  
Project start: 01-Jul-99, finish: 30-Jun-02  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### **MILESTONE REPORT 4**

#### **Determine economic threshold (level at which treatment is justified) for clubroot**

##### ***Relevance to industry***

For the first time worldwide, an accurate diagnostic probe is available to the Australian brassica industry. This information, together with knowledge of factors such as pH, soil moisture content, varietal resistance, and others, will allow diagnostic laboratories and researchers to accurately predict the amount of viable clubroot inoculum in soil and the severity of disease in subsequent crops.

##### ***Summary of progress against milestone***

DNA extraction from soil has been refined, this has allowed consistent and accurate clubroot testing.

TaqMan primers and probes have been designed and an assay optimised for soil detection.

TaqMan standard curves have been developed for resting spore dilution series.

Clubroot inoculum concentration has been estimated before planting at several trial sites around Australia.

A new project has been initiated to develop an on-farm diagnostic kit for Australian brassica growers.

##### ***Criterion 1. Quantitative method of PCR for clubroot developed***

A diagnostic test for clubroot was commercially released through Crop Health Services at the Institute for Horticultural Development in 2001. Commercial release of the test followed many months of laboratory testing to ensure that the test is robust and reliable. A key element of this research included work to improve the purity of DNA that can be extracted from soil samples, as impure DNA can be responsible for false negative test results. A method was developed to produce purer DNA from soil by removing enzyme-inhibiting substances such as

phenolic compounds. Over 50 different soils from around Australia were tested, and consistent PCR (polymerase chain reaction) amplification of the soil DNA was achieved on every occasion.

The commercial clubroot diagnostic test, coupled to the improved DNA extraction procedure has now been adapted for use with the TaqMan system for quantitative PCR. This process will enable researchers to estimate the number of spores in a sample rather than providing a simple positive/negative test outcome. The TaqMan system uses specially labelled molecular probes to quantify the amount of target DNA in a sample, which can then be correlated to the concentration of target organisms. Two TaqMan primers (primer 1: CGCTGCATCCCATATCCAA and primer 2: TCGGCTAGGATGGTTCGAAA) and a TaqMan probe (FAM-CGCACGTACCCGGTTCACATGG-TAMRA) were designed and optimised for the detection of clubroot DNA in soil.

The new TaqMan assay was calibrated with dilution series of resting spores in solution and with dilution series of spores in soil to produce standard curves. The standard curves provide the means to extrapolate the concentration of clubroot spores in field soil. The assay was able to reliably detect concentrations ranging from  $10^8$  to  $10^2$  resting spores per gram of soil.

From previous research carried out at IHD, and numerous international studies, it is known that visible clubroot symptoms only develop once the concentration of resting spores in soil reaches  $10^3$  spores per gram, while yield reduction occurs when spore concentrations exceed  $10^4$ - $10^5$  spores per gram. These concentrations are well within the discernible range of the TaqMan assay, and therefore can be determined accurately using the standard curves.

#### ***Criterion 2. Severity of disease predicted for trial sites in each State***

Soil samples were collected from a number of plots in each of three trial sites in Victoria, two in Tasmania, Western Australia and Queensland and one in New South Wales. The samples were subjected to TaqMan analysis and the concentration of spores in soil estimated using the standard curves. The molecular data will be aligned to disease assessments made of the trial plants at harvest. The combination of soil inoculum concentration and subsequent crop disease levels will enable the development of preliminary disease risk curves from which researchers can estimate the likely disease risk from a future test outcome.

#### ***Criterion 3. Trial crops monitored - Eventual yield loss compared with predicted***

The trial crops are currently being monitored and will be harvested/assessed in late April.

#### **Additional achievements relevant to milestone**

A new project has been initiated with Horticulture Research International (Wellesbourne, England), funded by the UK Department of the Environment, Food and Rural Affairs, to develop an on-farm test kit for clubroot. The kit would enable growers to carry out preliminary on-farm soil tests to determine whether more accurate, laboratory-based molecular testing is required. The clubroot diagnostic assay developed in the current HAL-funded program is now recognised as the 'gold standard' for clubroot detection world-wide. Australian researchers have been asked to collaborate in this project which will combine UK experience in the development of 'do it yourself' test kits with Australian clubroot diagnostics to produce a 'do it yourself' kit for clubroot.

#### **The next steps**

Disease development and eventual yield loss from trial crops will be assessed and compared with that predicted by the quantitative diagnostic test. Preliminary disease risk ratings will be determined to enable researchers to estimate potential yield loss from a soil test result.

#### ***Communication/extension activities***

Media releases and a 1 page article in 'Clubroot - Galls and All' (the project newsletter of the national clubroot project) have been published to advertise the commercial availability of the clubroot diagnostic test.

#### ***Additional commercialisation/intellectual property issues***

Advice is being sought from Agriculture Victoria Services Ltd to protect existing IP during any collaboration with the UK group.

## **VG00044, TOTAL CROP MANAGEMENT OF CLUBROOT IN BRASSICA VEGETABLES**

Principal investigator: Caroline Donald  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### **Progress against milestone criteria**

#### ***Research team meet and collate available results and information from each State***

- Meeting of researchers together with HRDC brassica commodity group held in the first year of the project. Research results from each state were reviewed and research goals for the project were developed.
- A second meeting is planned for July 2002 to review progress towards these goals and develop a publication and 'extension' strategy for the final year of the program. It will be important to optimise dissemination of results and ensure that results remain available to growers in a published form after the completion date of the project.

Research goals were identified by the brassica commodity group at the initial meeting. Several of these priorities form the basis for milestone criteria 2 and 3. Progress follows each goal. The remaining research goals and progress toward the completion of these have been included at the end of this report.

#### ***Appropriate management strategies for each region determined***

##### ***Research goal 1: 'Produce simple - grower friendly management strategies and thresholds (including hygiene practices and guidelines)'***

A guide to the production and management of clubroot in vegetable brassicas has been distributed to brassica growers nationally. This document contains interim recommendations for the control of clubroot in pamphlet format. New field sites have been established in Victoria (4), Western Australia (2), Queensland (2), Tasmania (2) and New South Wales (1) to correlate soil spore load and symptom expression. Soil samples have been taken from numerous plots within each site for quantitative PCR analysis (to determine the number of spores in the soil). These sites have been planted with brassicas and will be monitored for disease expression. These results will be used to develop predictive management recommendations (i.e. Custom recommendations for a particular quantitative test result).

Writing of a best practice manual for the production of brassica seedlings is underway. This manual includes topics such as reusing plastic trays, water quality, simple strategies for a clean nursery, disinfection, etc.

##### ***Demonstration groups formed in each state to participate in hands on demonstrations, discussions and plan individual control strategies. Outcomes published in local industry newspapers***

##### ***Research goal 2: 'Conduct on farm demonstrations of complete treatment 'unit' (banding machine with transplanter)'***

A modified transplanter designed to incorporate liquid and/or granular products into the planting row at transplanting was built for the project, however, problems with the Victorian Workcover Authority prevented the use of this machine in field trials and demonstrations during the first year of the project. These problems have since been rectified and the Authority has approved the current model of the machine. In spite of this set back in the formation of demonstration groups in each state, the unit has been used for trial work and demonstrations in Tasmania and Victoria and a similar unit used in Western Australia. Trials (but no formal demonstrations) have continued in New South Wales and Queensland using older models of the machine. These machines differ from the new machine in that treatment and transplanting must be conducted separately.

**Other achievements - Progress against research goals not listed as milestone criteria**

**Research goal 3: 'Develop a DNA process to quantify the number of spores in a soil sample and detect only viable resting spores'**

Quantitative method developed (project VG 99008). Trial sites established to correlate spore load and symptom expression (see above). Field trial underway to confirm how long DNA can be detected by PCR following soil fumigation to kill resting spores. Trials conducted in the glasshouse indicate that the DNA from dead spores is likely to degrade quickly. It would therefore be unnecessary to add another step (and associated additional costs) to the PCR test to ensure only viable spores are detected.

**Research goal 4: 'Continue to trial new products for clubroot control as they become available'**

New fungicidal active included in current season's trials in Victoria and Queensland. This product has recently been registered in New Zealand for clubroot control and the company has expressed interest in pursuing registration in Australia. Data from current trials will be used to hasten the registration process should it proceed.

**Research goal 5: 'Investigate cultivation practices to minimise clubroot, e.g. Leaching spores to below root zones, use of long fallows and irrigation methods'**

Field trial (currently in second of two years) established to determine the effect of radish bait crops, crop rotation and long fallows on the number of spores in the soil.

Glasshouse trials have been conducted to determine the effect of various irrigation practices on the movement (both vertically and horizontally) of resting and zoospores of *P. brassicae* through soil. Soil samples have been collected from these trials and prepared for PCR analysis.

**Research goal 6: 'Investigate the effects of temperature and moisture on clubroot development'**

Chinese cabbage is currently being used as a model plant in trials being conducted in growth chambers. The effect of temperature and humidity on disease development is determined by weekly assessment of plant roots for a period of 10 weeks.

**Research goal 7: 'Identify isolates of clubroot present in each state, screen varieties for resistance to clubroot'**

Root collections continue from recently infected properties. The pathotype of *P. brassicae* is determined by screening against the European Clubroot Differential series.

Screening of resistant varieties is ongoing, as new varieties become available.

**The next step (priorities for 2002/03)**

In spite of the set back, resulting from negotiations with workcover (re machinery design), the project is on target to meet all future milestones and will be completed by the agreed date (June 30, 2003). As a result of the meeting conducted with the HRDC brassica commodity group and the on farm demonstrations, seminars and trials detailed in this milestone report, it is clear that extension must be the primary focus for the project in the coming year. The amount of time dedicated to extension activities including field days, seminar evenings, machinery demonstrations, newspaper articles and publications, will be increased to ensure that the impact of the research is optimized in the final year of the project.

Other key research activities will include the development of hygiene protocols for all aspects of the production of brassica seedlings and publication of these results as a best practice manual. Industry training sessions for seedling producers will also be conducted (as detailed in Milestone 5).

Work will also continue towards the registration of a new fungicidal active and the identification of resistant vegetable brassicas.



**Communication/extension activities**

- Donald, E.C., Porter, I.J. and Lancaster, R.A. (2001). Band incorporation of fluazinam (Shirlan) into soil to control clubroot of vegetable brassica crops. *Australian Journal of Experimental Agriculture* 41: 1223-1226.
- Donald, E.C., Lawrence, J.M. and Porter, I.J. Evaluation of a fluorescent staining technique as an indicator of pathogenicity of resting spores of *Plasmodiophora brassicae*. *Australasian Plant Pathology* (In Press).
- Donald, E.C., Porter, I.J. and Lancaster, R.A. (2002). Strategic application of lime, fertilisers and fungicides for improved control of clubroot. *Cruciferae Newsletter*. Nr. 24.
- Donald, C. and Porter, I. Clubroot - Galls and All. Issue 10.

**Extension activities**

- Tasmania - Machinery demonstration/seminar (Harvest Moon and Forthside Vegetable Research station), 13 December 2001.
- Victoria - Machinery demonstration, 2-3 May and 30 November 2001.
- Queensland - Clubroot committee meeting and clubroot seminar 9 August, 2001.

## **VG01015, SURVEYING VEGETABLE BRASSICA CROPS FOR VIRUS DISEASES IN WESTERN AUSTRALIA**

Principal investigator: Lindrea Latham  
Project start: 01-Jul-01, finish: 30-Jun-02  
Organisation: Department of Agriculture  
Contact phone: 08 9368 3266

### **Summary**

Several viruses cause damaging diseases of vegetable brassica crops worldwide resulting in substantial economic losses. Both yield and quality are seriously affected. In Australia four viruses are known to infect brassica crops, beet western yellows virus (BWYV), broccoli necrotic yellow virus (BNYV), cauliflower mosaic virus (CaMV) and turnip mosaic virus (TuMV). All four are spread by aphids. Symptoms of virus disease in plants infected with them are often misdiagnosed as being due to genetic defects, herbicide damage, nutritional problems, etc. The importance of these viruses to broccoli, brussel sprouts, cabbage, cauliflower and chinese cabbage crops is undoubtedly being underestimated because of these misdiagnoses. Crop surveys are an excellent way of gathering information on the presence and prevalence of viral disease. This project will collect information on the occurrence of BWYV, BNYV, CaMV and TuMV in different brassica crops in WA and combine the information obtained from the surveys with published information on virus-induced yield and quality losses from overseas to provide an estimate of economic loss. This project will also devise a 'best bet', integrated disease management strategy for the control of virus diseases in vegetable brassicas. Control of virus diseases will enhance reliability of production of high quality brassicas that meet market expectations and improve export prospects.

## **VG01082, AN INVESTIGATION ON HEAD ROT DISEASE OF BROCCOLI CROPS GROWN FOR PROCESSING**

Principal investigator: Hoong Pung  
Project start: 01-Jul-01, finish: 30-Sep-02  
Organisation: Serve-Ag Research  
Contact phone: 03 6427 0800

### **Background**

In Tasmania, the primary cause of broccoli head rot disease is not known. In studies conducted elsewhere, bacteria were often found to be the main cause of broccoli head rot on crops exposed to warm and humid conditions. In contrast, head rot is more prevalent on crops grown under cold and wet conditions in Tasmania. Preliminary trial studies conducted recently in Tasmania have shown that fungicides may help reduce the incidence of head rot. This suggests that there may be pre-disposing causes to bacterial invasion of damaged florets. There also appears to be anecdotal evidence that certain pesticide sprays may accentuate the disease.

- The objective of this project is to determine the primary cause of head rot on broccoli produced for processing. A better understanding of the primary cause of head rot in Tasmania is essential for the industry to develop strategies for managing the disease. The outcomes of this project will benefit the processing companies and their growers. The knowledge and subsequent management strategy developed in this project will also flow on to the fresh market sector of the broccoli industry.

### **Work undertaken to date and outcomes**

- Bacteria and fungi isolated from head rot, identified, and tested for pathogenicity.
- Pesticides and adjuvants commonly used in broccoli crops were tested for surfactant activities.
- Preliminary studies indicate that damage to the waxy surface of flower head as a result of natural surfactant produced by *Pseudomonas* bacteria or synthetic surfactant in spray wetting agents will predispose the head to bacterial invasion. Fungi such as *Botrytis* and *Fusarium* did not appear to require damage for invasion.

### **Technology transfer**

Regular updates given to R & D managers of the processing companies as project findings become available.

### **Funding**

- This is a one-year project study funded by the processing companies, Simplot Australia Pty Ltd and McCains Food (Aust) Pty Ltd, with matching funds from Horticulture Australia Ltd.

## VG01042, GENETICALLY ENHANCED BRASSICA CULTIVARS FOR IMPROVED PEST AND DISEASE CONTROL AND SHELF LIFE. PART 2

Principal investigator: James Hutchinson  
Project start: 01-Jul-2001, finish: 30-Jun-2005  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### Project progress/impact

This project is a continuation of VG98085, which had the main objective of developing some of the platform technology to genetically modify important vegetable brassica cultivars. The long objectives of the research are to develop cultivars with enhanced resistance to Clubroot, Diamondback Moth and with extended shelf life.

There were four major outcomes from VG98085;

- (1) Reliable and reproducible adventitious shoot regeneration systems were established for 29 cultivars (broccoli 8, Brussels sprout 3, cabbage 3 and cauliflower 15). There is considerable variation in the way cultivars regenerate, with an order of magnitude difference between the worst and best cultivars.
- (2) Agrobacterium mediated gene transfer systems were developed for some broccoli and cauliflower cultivars, however the transformation frequency is very low and requires improvement. In excess of 21,000 explants were processed resulting in 105 transgenic lines.
- (3) A number of gene constructs were prepared with different anti-microbial genes, a proteinase inhibitor gene and a gene associated with cytokinin biosynthesis. These have been transferred to a number of cultivars, including Marathon (broccoli), Atlantis and Plana (cauliflower) and Pak Choi (Chinese cabbage). This material is in various stages of assessment in glasshouse trials.
- (4) Some transgenic lines with potential against Clubroot and Diamondback Moth have been identified.

The new project (VG01042) will:

- Evaluate the existing population of transgenic lines in more detail.
- Develop protocols to regenerate and transform inbred parental lines using the marker gene *gusA*. Material will be provided by Henderson Seeds.
- Take advantage of the recent developments with *Arabidopsis thaliana*. This is the first plant to have its genome sequenced, is a close relative of the vegetable brassicas, is a host to Clubroot and Diamondback Moth and importantly has, well defined genetic stocks and a 12 week seed to seed life cycle. These attributes make *Arabidopsis* an ideal plant to study problems associated with vegetable brassicas. This aspect of the project is will be offered as a PhD studentship. Details have yet to be finalised, but will most likely used micro arrays to study changes in gene expression after infection with Clubroot [with the aim to isolate some potential resistance genes] or to study foliar senescence to improve shelf life.

The major impact of this research will be to either, reduce the number of insecticide and fungicide applications to crops and/or further enhance the ICM programs being developed for Clubroot and Diamondback Moth. Improved shelf life of broccoli and Chinese cabbage will assist improve domestic and export markets.

**VG99006, INTEGRATED PEST MANAGEMENT 'RESEARCH TO PRACTICE' FOR BRASSICAS**

Principal investigator: Anita Chennell  
Project start: 01-Jul-99, finish: 30-Jun-02  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

No report available.

**NEW ZEALAND BRASSICA PROJECT**

**Pathogen:** *Plasmodiophora brassicae*  
**Research aim:** Chemical and biological control  
**Principal investigator:** Lian Heng Cheah  
**Institution:** Crop & Food Research

## APPENDIX 11. ENHANCED BREAKDOWN OF CHEMICALS AND BIOCONTROLS

### VX00012, ENHANCED METALAXYL BREAKDOWN AND ITS IMPLICATION IN AUSTRALIAN HORTICULTURE

Principal investigator: Hoong Pung  
Project start: 01-Jul-00, finish: 31-Dec-01  
Organisation: Serve-Ag Pty Ltd  
Contact phone: 03 6427 0800

#### Background

The use of metalaxyl in vegetable and potato crops is expected to increase, as it has often been found to provide the most effective fungicide treatment for the control of *Pythium*, *Phytophthora* and downy mildew diseases in vegetables, as well as pink rot and late blight diseases of potatoes. Based on overseas experience, the enhanced metalaxyl breakdown is likely to develop further through its regular use across a range of vegetable and potato crops. Unless a good understanding, and the proper use, of metalaxyl is promoted to the relevant industries, the efficacy of metalaxyl against the major diseases may be severely affected.

#### Objectives

The objectives and outcomes of this project will be as follows:

- Obtain an overall perspective of this potential threat to the Australian vegetable and potato industries by reviewing current information and research that has been carried out on enhanced metalaxyl breakdown in Australia and overseas.
- Raise the awareness of growers and industry on the proper use of metalaxyl.
- Improve the management of metalaxyl usage and disease control practices.
- Provide a better understanding of the development of metalaxyl breakdown.

#### Outcomes

- Biodegradation by soil micro organisms, is the most important factor in reducing metalaxyl persistence in soils.
- Enhanced degradation of metalaxyl has been reported in sites that have a history of consecutive years of metalaxyl soil applications.
- Metalaxyl degradation varies with soil type, environmental and management conditions.
- Cultural practices may influence the persistence of metalaxyl in soil.
- Apart from degradation, there are additional factors that may influence metalaxyl persistence and efficacy.
- Final report completed and available from Horticulture Australia Ltd. It contains detailed reference information on degradation of metalaxyl and other factors affecting the persistence of metalaxyl.
- Key information from this project published in an information flyer for distribution to the relevant industry.

## **HG98034, ENHANCED BIODEGRADATION OF SOIL-APPLIED PESTICIDES PROJECT HG98034**

Principal investigator: John Matthiessen  
Project start: 01-Feb-99, finish: 31-Jan-03  
Organisation: CSIRO  
Contact phone: 08 9333 6641

### **MILESTONE 8 REPORT JOHN MATTHIESSEN AND BEN WARTON**

#### **1. Devise appropriate robust bioassay technique**

A bioassay technique to test for residues of metham sodium in soil was tested. The technique utilised the potent herbicidal nature of MITC, the active toxin produced by metham sodium, by attempting to germinate cress seeds in the presence of soil suspected of containing MITC. Cress seeds were used due to their relatively rapid germination rate of approximately two days.

An obvious drawback with such a test is the fact that it takes two days to receive a result. In order to use the test effectively, the grower would take a sample of relevant soil and add cress seeds to it. Two days later the assessment of cress germination would be made. But a sample the following day would also be taken in case the soil is only one day away from being residue-free. This process would continue until significant germination was achieved, at which point the soil would be suitable for crop use (indeed would have been suitable two days previously!).

All of this is time-consuming and convoluted, and it is not difficult to envisage reluctance on the part of growers to adopt such a technique. As a result we have devised a simpler more direct analytical method, that tests specifically for enhanced biodegradation of metham sodium. At this stage, preliminary work has confirmed the soundness of the chemical process involved in the testing procedure.

We envisage that in practical operation it would operate similar to the test kit for swimming pool pH, with a vial containing the soil sample to which the reagents are added, attached to a simple chart with colour gradations ranging from pale to intense, as a semi-quantitative measure (a more intense colour would indicate more severe enhanced biodegradation).

A second vial could also be attached, to which is added a virgin soil of similar type as a reference. A test kit like this could be either commercialised and eventually marketed to growers (or horticultural consultants) to enable them to monitor their soil for enhanced biodegradation, perhaps before every metham sodium application. Preferably, however, it would be so inexpensive that it could be provided at no charge or at a nominal fee, perhaps by the manufacturer or agent. This would serve to encourage best-practice, sustainable use of metham sodium.

A large amount of work will be required to develop this concept to the point where it can be used on-farm. Therefore it has been written into a new proposal centred around development of sustainable use practices for metham sodium, which is in a full proposal currently before Horticulture Australia.

#### **2. Standardise bioassay against analytical benchmarks**

#### **3. Test bioassay in laboratory and field**

For the reasons described above, these two sections of the milestone were deemed not relevant.

#### **4. Update of long term enhanced biodegradation induction experiment**

As described in Milestone 6, a long-term experiment is being conducted to study conditions related to the induction of enhanced biodegradation of metham sodium on two soils, a coarse sand and a sandy loam. Soils were amended to pH values of 4.8, 5.8, 6.8 and 7.8 with calcium carbonate (lime), and are being treated at intervals of 1, 2, 3, 6, and 12 months with metham sodium. The results obtained to date in the sandy soil show induction of enhanced biodegradation in high pH soil after one-, two-, and three-monthly treatments.

It is unclear whether the main factor causing the induction of enhanced biodegradation is the elevated pH or the elevated concentration of calcium in the soil. Calcium, just to complicate matters, is an important microbial

nutrient! So it could be that the calcium is promoting the bacterial population either together with or separately from pH.

To answer this question, a parallel experiment was commenced in which the sandy soil was amended to pH values of 4.8, 5.8, 6.8 and 7.8 with magnesium carbonate. After 10 monthly metham sodium treatments, there was no sign of enhanced biodegradation. This suggests that in fact, enhanced biodegradation of metham sodium in high pH soils may be due, at least in part, to the presence of high concentrations of calcium in the soil. The observation may also explain why researchers overseas have reported that enhanced biodegradation of metham sodium is inconsistent, occurring in some apparently 'suitable' soils but not others.

A second confirmation of the influence of pH versus calcium on enhanced biodegradation has also been commenced. This time, the sandy soil was amended with calcium chloride, because it does not change the pH as does calcium carbonate, to give a calcium concentration equivalent to that in the soil amended to pH 6.8 with calcium carbonate. That soil completely degraded MITC within 24 hours of application after 8 treatments (see Milestone 6 report). This experiment is continuing, and a conclusive result is not yet available.

### Publications, workshops, conferences

Warton, B. and Matthiessen, J.N. (2001). Persistence of metham sodium in sandy soil - relationship to treatment history. *Potato Grower*, July, pp. 14-15.

Warton, B., Matthiessen, J.N. and Roper, M.M. (2001). Enhanced Biodegradation of Metham Sodium - A Particularly Severe Example and the Organisms Responsible. *Biology and Fertility of Soils* 34: 264-269.

Matthiessen, J.N. Enhanced biodegradation of metham sodium soil fumigant. *Potato Australia* 12: 29.

Warton, B. and Matthiessen, J.N. (2001). Enhanced biodegradation of the soil fumigant metham sodium in Australia. *Australian Entomological Society 32nd AGM & Scientific Conference*, Sydney.

Matthiessen, J.N. and Robertson, L. (2001). Enhanced microbial degradation of soil-applied pesticides. *Australian Entomological Society 32nd AGM & Scientific Conference*, Sydney.

Warton, B. and Matthiessen, J.N. (2001). Factors affecting the enhanced biodegradation of metham sodium. *Processing Tomato Grower*, November, pp. 25-26.

Warton, B. and Matthiessen, J.N. (2001). Balancing pesticide degradation rates - fate of metham sodium fumigant in soil. *18th Conference of Residue Chemists*, Canberra, 40-44.

Warton, B. and Matthiessen, J.N. (2001). Effect of soil pH on enhanced biodegradation of metham sodium. *Potato Grower*, October, pp. 17-18.

Ben Warton presented a paper (listed above) on enhanced biodegradation of metham sodium at the national 18th Conference of Residue Chemists in Canberra in October 2001.

John Matthiessen attended the Australian Entomological Society 32<sup>nd</sup> AGM and Conference in Sydney and presented a paper on enhanced biodegradation of metham sodium, and a review paper on the general issue of enhanced biodegradation of soil-applied pesticides.

The third issue of the 'How Degrading' newsletter was produced and sent out. The mailing list now exceeds 600. There has been increasing international interest generated.



## **VX00013, BIOFUMIGATION - OPTIMISING BIOTOXIC BRASSICA ROTATIONS FOR SOIL-BORNE PEST AND DISEASE MANAGEMENT**

Principal investigator: John Matthiessen  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: CSIRO Entomology  
Contact phone: 08 9333 6641 Project VX00013

### **MILESTONE 4 REPORT ASSESSMENT OF BRASSICAS FOR BIOFUMIGATION, JOHN MATTHIESSEN AND BEN WARTON**

#### **Chemical profiling of brassica tissues - relating ITC production to GSL profile**

The work reported in the Milestone 2 & 3 reports on correlating isothiocyanate (ITC) and glucosinolate (GSL) profiles in the large number of diverse *Brassica* samples has now been written up and has been published in the *International Journal of Agricultural & Food Chemistry*. The information is being used in an ongoing process by Dr Stuart Gowers, the *Brassica* breeder at Crop & Food CRI in New Zealand, to enhance his selection process.

The methodology developed to directly measure ITCs released from *Brassica* tissue is being used routinely to profile many hundreds of samples regularly sent by Dr Gowers, as well as for tissues from plants grown in our own field experiments and those of John Kirkegaard in Canberra. As mentioned in the previous report, we are capturing enormous cost-effective extra benefits in this project from the gas chromatograph purchased with HA funds for the enhanced biodegradation of metham sodium project (HG98034).

#### **Toxicity evaluation of various ITCs**

The analyses of the toxicity of pure methyl, 2-phenylethyl, propenyl and benzyl ITC, and hydrolysing mustard seed meal tissue, and metham sodium, both *in vitro* and *in vivo*, using the whitefringed weevil bioassay system, have been completed. Toxicity has been assessed at a range of temperature (5, 10, 15, 20°C), and the *in vivo* assessments have been carried out in the presence of three contrasting soil types (sand, loam, peat) to determine the effect of these key variables on the performance of these major biofumigant ITCs.

The results are currently being analysed and indications are that the results will show quite different behaviours of various ITCs in contrasting types in soil. It also appears that work published a few years back by US researchers examining the contact toxicity of various ITCs may not correlate well with vapour toxicity, especially in soils of high organic matter content. These various findings will have implications for the selection process for the type of ITCs that may give the best biofumigation effect under different soil conditions.

These assays have proven more time-consuming than originally envisaged, which has delayed the initial plan to bioassay a range of *Brassica* tissues *in vivo*. However, with indications that different ITCs were behaving uniquely in contrasting soils, it was considered better to focus mainly on pure compounds of contrasting characteristics (notably ensuring that multiple aliphatic and aromatic ITCs were examined), as almost all *Brassica* tissue contains mixtures of ITCs. Assays with more than the one type of plant tissue or with mixtures of ITCs will be held over for the future.

#### **Analysis and toxicity screening of different and new brassicas**

The close collaboration with fodder *Brassica* breeder Dr Stuart Gowers at the New Zealand Crop & Food CRI at Lincoln in evaluating the biofumigation potential of new lines of brassicas continues as an ongoing activity. Samples from each field plot evaluation series are sent to us and are analysed for ITCs, and screened for toxicity using the standard whitefringed weevil bioassay. Many of the lines tested are either new crosses made by Dr Gowers or imported lines that he accesses as he utilises the results we provide to make selections designed to maximise biofumigation capacity and stabilise the crosses.

Similar analyses and testing are ongoing in the collaboration with Drs John Kirkegaard (CSIRO Plant Industry, Canberra) and Steve Akiew (QDPI, Mareeba) who, as mentioned in the last report, are working on a ACIAR project to utilise biofumigant brassicas in tropical agriculture in the Philippines.

#### **Analysis of ITCs released into soil by Brassica tissue**

The methods developed during the previous milestone period for detection of ITCs in soil were used for analysis of ITCs in field soils under brassicas (fodder rapes and mustard) sown in early winter 2001. Samples were taken periodically during growth of these crops, plus small plots of some high-GSL canola and mustard lines provided

by Drs Kirkegaard (CSIRO Canberra) and Mark Potter (SARDI, Adelaide). (Sampling of soil following incorporation of the plants is dealt with in the next section).

The technique is also being used in collaboration with John Kirkegaard to measure ITC release as brassica tissue breaks down in soil in laboratory experiments to measure the effects of degree of tissue disruption and the effects of moisture on ITC release. Similarly, we are collaborating with Dr Brendan Smith, from John Kirkegaard's team at CSIRO, Canberra to measure the diffusion of 2-phenylethyl ITC into soil from point releases.

### Field assessment of various brassicas

Farmer collaborator, Keith Taylor, a potato grower at Busselton, WA sowed several hectares of Wrightson Seeds' BQMulch and AgSeeds' Fumus in winter 2001 in a loam soil. Soil and plant samples for ITC analysis and biomass production were taken periodically during growth and a major series of experimental treatments was applied in early October to assess the effect of various incorporation strategies on ITC release.

The incorporation studies were based on work carried out by John Kirkegaard and Matt Morra (University of Idaho) in Canberra, which indicated that tissue disruption at the cellular level may have a major influence on the amount of ITCs released as a 'flush'. We pulverised the above ground tissue of the brassicas with a mulcher and then rapidly incorporated the mush into the soil with a rotary hoe. Comparative treatments included rotary hoeing the tops in, removing the tops to a 'clean' area of soil and rotary hoeing them in, and rotary hoeing the root remnants.

Various simulated irrigation treatments were applied over all the incorporation treatments. Samples of soil for ITC analysis were taken at various intervals after treatments were applied, extending over an almost three-week period. Almost 700 soil samples were taken and the last of them are at present being run through the GC for ITC detection. A massive amount of data has been generated. Once the analyses are complete, the process of interpreting the information to determine treatment effects will begin.

### Effect of biofumigation on suppression of *Pythium*

One of the great problems in assessing the impact of treatments on soil pests and diseases is the great unpredictability and patchiness in the distribution of the organisms in the soil. This makes on-farm trials notoriously difficult to interpret. What is needed is an area where manipulations can be undertaken to build up a pest or disease to a uniformly high level for experimental purposes.

With advice from Dr Elaine Davison of the Department of Agriculture Western Australia, we have begun a large field trial to assess the effect of *Brassica* biofumigants and incorporation methods on suppression of *Pythium sulcatum*, the cause of cavity spot disease of carrots in WA. The trial is being carried out at the Department of Agriculture (DAWA) field station at Medina, where a *Pythium* 'nursery' has been promoted.

A sacrificial carrot crop was grown in spring-summer 2001-2002, with the aim of building up a *Pythium* infection. No chemical anti-fungal treatments were applied. The crop was sampled systematically in early January 2002 to assess the level and uniformity of the *Pythium* infestation. The carrots were then removed and the land will lie fallow until winter 2002 sowing of brassicas, followed by various incorporation treatments and soil samples for ITCs, before sowing the carrot crop to be used to bioassay the effects later in 2002.

### Publications, conferences, workshops

Matthiessen, J.N. and Learmonth, S.E. (2001). Management of a soil insect pest with fumigant - a challenge to the adoption of IPM. *Australian Entomological Society 32nd AGM & Scientific Conference, Sydney*.

Matthiessen, J.N. and Shackleton, M.A. (2001). Utilisation of unique attributes of larval whitefringed weevil for bioassaying toxicity of pure and plant-derived fumigant compounds. *Australian Entomological Society 32nd AGM & Scientific Conference, Sydney*.

Matthiessen, J.N. Biofumigation - optimising biotoxic *Brassica* rotations. *Potato Australia* 12:24.

Warton, B., Matthiessen, J.N. & Shackleton, M.A. (2001). Glucosinolate content and isothiocyanate evolution - two measures of the biofumigation potential of plants. *Journal of Agricultural & Food Chemistry* 49: 5244-5250.

The 14<sup>th</sup> issue of the 'Biofumigation Update' was compiled and distributed in November 2001. The mailing list for the newsletter currently stands at almost 550. It is now also available on the CSIRO Entomology Web site.

John Matthiessen attended the Australian Entomological Society 32<sup>nd</sup> AGM and Conference in Sydney and presented papers on issues related to management of soil-borne pests and diseases, and methodologies in research on measuring biofumigation effects.

## **EVALUATING BIOFUMIGATION FOR SOILBORNE DISEASE MANAGEMENT IN TROPICAL VEGETABLE PRODUCTION.**

**Steve Akiew, QDPI**

The project proposes to achieve the following objectives: identify candidate brassicas suitable for use as biofumigants in tropical vegetable production systems in the Philippines and north Queensland.; evaluate the suppressive potential of the candidate Brassica species, varieties and their various plant parts; identify the biocidal compounds responsible for suppression and demonstrate a correlation between concentrations of these in the tissues and the degree of pest suppression; identify factors which influence the efficiency of biocide release from the incorporated Brassica tissues; evaluate the most promising Brassica species/varieties in the field and develop protocols for the most effective strategies to improve field efficacy based on above; evaluate effectiveness in commercial and small scale farmer fields as a component of integrated disease management based on combined strategies including disease resistance/tolerance, non-host crop rotation and solarisation; extend the existing Biofumigation Network (about 700 recipients) to include a research and extension network in south-east Asia and the Pacific region to facilitate the development and transfer of this new technology.

### **Progress**

Field work has not yet commenced.

## VG00048, DEVELOPMENT OF BIOLOGICAL CONTROLS FOR SCLEROTINIA DISEASES OF HORTICULTURAL CROPS IN AUSTRALASIA

Principal investigator: Ian Porter  
Project start: 01-Jul-00, finish: 30-Jun-03  
Organisation: Agriculture Victoria  
Contact phone: 03 9210 9222

### MILESTONE REPORT

#### Biological agent monitoring studies commenced

Previous field trials in Australia had shown that disease control levels obtained with two biological controls agents (*Trichoderma* spp, *Coniothyrium minitans*) were not as good as those obtained in New Zealand. This could be due to either poor survival of the biocontrol agents in the new commercial formulations being developed, or lack of survival of the biocontrols in the warmer soil conditions experienced at the time of application in Australian soils. The lack of survival could also be due to the lower levels of organic matter found in Victorian soils where disease occurs.

To address these issues, biological studies evaluated: i) the optimum conditions for biocontrol growth; ii) population densities required to maintain biocontrol effect; and iii) new formulations and application regimes for effective biocontrol effect. In addition, glasshouse and field studies are currently evaluating the use of organic soil amendments to either inhibit/kill sclerotia or to change soil conditions so microbial control is enhanced.

#### Laboratory studies

At Lincoln University in New Zealand, a considerable amount of time was spent optimising spore production capabilities of *Trichoderma* spp. The range of temperature/pH/light and nutrient regimes for optimum spore production was determined. In addition, a major task included mass production of inoculum of *C. minitans* and *Trichoderma* spp. for subsequent formulation by Agrimm for the Sclerotinia trials in Australia.

At IHD in Victoria, a laboratory experiment was conducted to determine the range of temperature conditions for survival of five commercial biocontrol agents, including the two isolates from NZ. The optimum temperature conditions for growth and sporulation were between 15°C and 25°C. A laboratory assay was also developed for monitoring the survival of biocontrol isolates in the soil.

#### Field studies

Population dynamics of the two biocontrol agents from NZ were monitored in the transplant nursery and in the field in North Canterbury NZ. This involved the use of a strain specific molecular marker and detailed population counts at regular intervals during the course of the experiment. From this work the minimum population threshold of each biocontrol agent required to maintain effective biocontrol effect was predicted.

Field evaluation of single and multiple applications of *C. minitans* and *Trichoderma* spp. was conducted in a field trial in North Canterbury NZ. This trial identified the best application regime for both biocontrols agents and these treatment regimes, applied in two new formulations (potting mix and transplant immersion), will be evaluated in the Australian trials this season.

#### Second year field trials established

In total 8 field trials have been conducted in Victoria and Tasmania during the 2001/2002 season.

Two field trials are being established in Bacchus Marsh to evaluate improved biocontrol technology, chemical treatments (including mustard meal, urea, calcium cyanamide) and organic soil amendments for control of Sclerotinia of lettuce. The new biocontrol formulations developed in NZ will be compared to four other commercial biocontrol products from Australia, Germany and USA.

Four field trials are being conducted in Tasmania to evaluate cultural, chemical, biocontrol products and biofumigants crops (mustard, canola, and broccoli) for control of *Sclerotinia* disease in lettuce.

Two field trials have been established in Werribee to investigate the use of disease-based threshold criteria for determining the best timing for application of Sumisclex sprays. In these two sites and the one in Bacchus Marsh, an improved method of applying Sumisclex that earlier in the project resulted in significant improvements in lettuce drop control will be further evaluated.

#### Progress against research goals not listed as milestone criteria

Ten *Sclerotinia minor* isolates were tested *in vitro* for their sensitivity to procymidone (Sumisclex). Preliminary results showed that all isolates were sensitive to doses of procymidone recommended for field use. This result suggests that recent reported losses of effectiveness of procymidone in lettuce crops may be due to poor application by growers or enhanced soil breakdown of the fungicide.

In a pot study completed in Tasmania, defatted mustard seed meal, urea, and calcium cyanamide showed potential for reducing sclerotia levels in the soil. The defatted mustard seed meal and urea were particularly effective in destroying the sclerotia of *Sclerotinia minor*.

In a pot trial in Tasmania, the brassica plants, canola (BQ-Mulch), mustard (FUMUS) and rocket, were susceptible to *Sclerotinia* wilt at the early seedling stage. Seedlings of broad bean, beet, onion, spinach, tatsoi and mizuna, were relatively tolerant to *Sclerotinia*. A better understanding of crop susceptibility to *Sclerotinia* will enable growers to determine the suitability of crops for use in rotations as part of *Sclerotinia* disease management.

#### The next step (priorities for 2002/03)

The project is on track and has achieved all milestones. Development of a biological control strategy for *Sclerotinia minor* is still of high priority as there are no new chemicals besides procymidone (Sumisclex) in Australia that are sufficiently effective to control *Sclerotinia*. More trials are required, however, before wider spread adoption of biocontrols can be accepted by industry. Therefore, efforts for the remainder of the project will be directed towards improving formulation technology, product delivery and field effectiveness of biological controls.

New trials will also focus on evaluating soil amendments (organic and chemical) that either inhibit/kill sclerotia in the soil or change soil conditions so microbial control is enhanced. Organic soil amendments will also be evaluated for their suitability as a food source to enhance the activity of promising biocontrol agents. There will also be wider evaluation and adoption of the improved method to apply Sumisclex this season because of the larger scale of field trials that are being conducted throughout Victoria and Tasmania. In addition, potential new treatments, including chemicals, biofumigant crops and crops tolerant to *Sclerotinia*, will be evaluated in field trials for improved management of *Sclerotinia* diseases.

#### Communication/extension activities

##### *Extension activities*

Project findings were presented at a Tasmanian vegetable extension day held at Devonport on 15 August 2001. This was well attended by Tasmanian growers, industry representatives and researchers.

Up-to-date project findings were discussed at regular meeting with growers, farm managers, and consultants who assisted with the field trials in Tasmania.

Research outcomes were presented to growers and consultants by the principal investigator and Prof. Alison Stewart at two grower's meetings held in Victoria (Cranbourne and Werribee) in October 2001.

##### *Papers*

A. Stewart, N. Rabeendran, I.J. Porter, T.M. Launonen and J. Hunt (2001). Biological control of *Sclerotinia* disease of vegetables using *Coniothyrium minitans* A69. Plant Pathology Conference, 24-27 September 2001, pp. 337.

**VG01087, SUPPRESSIVE SOILS FOR BIOLOGICAL CONTROL OF ROOT-KNOT  
NEMATODES ON VEGETABLE CROPS**

Principal investigator: Graham Stirling  
Project start: 01-Jan-02, finish: 31-Dec-04  
Organisation: Biological Crop Protection  
Contact phone: 07 3202 7419

No report available.

## APPENDIX 12. EXTENSION

### AUSTRALIAN VEGETABLE INDUSTRY COMMUNICATION CHANNELS

Report by the Australian Vegetable Industry Development Officers

Wednesday, 12 June 2002

#### DRAFT Version 3.0

AusVeg and Horticulture Australia Limited consider communication a vital ingredient in successful R&D projects. This document is designed as an aid to assist researchers in developing their communication strategies as well as assist in communicating with industry during R&D projects.

#### AUSTRALIAN VEGETABLE IDO COMMUNICATION CHANNELS

The Vegetable Industry Development Officers (IDOs) have been developing communication channels throughout the vegetable industry. These channels have been developed to the stage where considerable benefit may be gained by utilising them. Please note that all databases are confidential and will not be provided.

##### 1.1 Articles in Vegetable IDO State newsletters

Vegetable IDO newsletters are sent to all registered vegetable growers and many other stakeholders in the industry in Australia and most are published quarterly (Tasmania bi-monthly). Articles must be grower focused, be provided electronically, 200 to 250 words and preferably contain at least one picture. Contact the IDO in your state to discuss use of article/s and coordination with other IDO's. The spaces in these newsletters are limited thus use of articles is at the discretion of the IDO in each state.

Note: Articles can be translated into Vietnamese resulting in potential increased readership of 80 Khmer or 600 Vietnamese growers in SA.

##### 1.2 Direct mail out to all vegetable growers

There are approximately 4,400 growers on the Australian vegetable industry database. The IDO in each state can facilitate mail outs at cost recovery (Number of growers: Western Australia - 800, South Australia - 1300, New South Wales - 1000, Tasmania - 700, Victoria - 600, and Queensland - 2000).

##### 1.3 Targeted mail outs

The Australia vegetable IDOs can assist with targeted mail outs. Currently all IDOs can target mail to an ever increasing percentage of growers. Table 1 outlines the Vegetable IDO targeting capabilities at the 1<sup>st</sup> October 2001.

Table 1. Vegetable IDO target communication capabilities (as of 1<sup>st</sup> December 2001)

State	Growers that can be targeted					
	GO	%	Crops grown %	AM	GO	%
WA		60	60			100
SA		65	60			100
NSW (Database currently being built)		60	60			100
Queensland and Northern Territory.		100	100			100
Victoria		50	50			100
Tasmania		95	95			100

**Commodity Groups** are the groupings used when reviewing project proposals. The six groups are brassica vegetables, leafy vegetables, root vegetables, other vegetables, export, and processing.

**Areas of interest** are areas that growers may express an interest in that are not specific to one crop. Areas of interest currently being used include local market, marketing, industry profitability, resource sustainability, quality assurance/ minor use chemicals, cool chain/ supply chain, Automation/ equipment development, and industry communication.

#### **1.4 Workshops and meetings**

The IDOs can offer advice when planning meetings and/or workshops with growers and other stakeholders. Meetings can be targeted to crops, location, areas of interest, etc. depending on the research project. Contact IDOs in each state to organise.

- **Western Australia**

WA has a wide geographic spread of growers across eleven (11) growing regions. Most regions specialise in a couple of crops, which can assist regional R&D meetings to be targeted to growing areas. Most regions are a long distance from Perth with an average distance from Perth of 840 km. Two of the main production regions are located close to Perth (Wanneroo and Baldivis). The distances from Perth for the other main production areas are: Kununurra (3640 km); Carnarvon (900 km); Myalup (150 km); Manjimup (300 km); and Albany (410 km).

- **South Australia**

The majority of growers (approximately 1,200) are based 30 to 40 km north of Adelaide. The second major concentration of growers are situated ninety km south of Adelaide. Growers are also situated in the Adelaide Hills region, Riverland and lower South East, although numbers of growers in these areas have reduced in recent years. A wide range of crops and production methods with the largest concentration of green house structures in Australia.

- **New South Wales**

NSW has a wide geographic spread of growers and can roughly be divided into eight (8) growing regions, including the Sydney Basin. There are growers, however located outside of these growing regions. The majority of regions specialise in a few crops.

- **Queensland**

Qld has a wide geographic spread of growers all throughout the South East Corner and up the East Coast. There are 12 major growing regions with many growers scattered in between. Most regions grow a variety of commodities.

- **Northern Territory**

Vegetables are produced around Darwin and Katherine. Major crops include Asian vegetables, capsicums and cucurbits.

- **Victoria**

There are five major production regions in Victoria. The two regions with the largest production and number of growers are located near Melbourne (Werribee and South East Melbourne). The distance from Melbourne of the other three regions is: East Gippsland (280 km), Swan Hill (350 km), and Mildura (550 km).

- **Tasmania**

Three main growing regions NW, NE and Northern Midlands with minor cropping activity in the south. Meetings and workshops can be targeted to specific regions or specific crops or commodity groups.

#### **1.5 E-mail services**

As electronic communication is efficient and effective, the Vegetable IDOs have been developing this communication medium. All IDOs can communicate electronically with a percentage of the growers. Growers with e-mail are generally considered early adopters and targeting research outcomes to this group may greater assist with communication, technical transfer and adoption of outcomes.



The vegetable IDOs can also target e-mail communication as outlined for mail outs in table 1. Contact your state IDO to discuss specific project communication in this manner. The current IDO e-mail communication capabilities are outlined in table 2.

**Table 2. Vegetable IDO electronic communication capabilities (as of 1 December 2001)**

REGION	Growers on e-mail	Stakeholders on e-mail (excluding growers)	Current services
WA	112 growers (15 per cent of growers)	190 stakeholders	<ul style="list-style-type: none"> <li>•IDO News</li> <li>☐Guiding Meaningful Opinions Newsletter</li> <li>☐Minor essentials newsletter &amp; Information</li> <li>•Irrigation and water news</li> <li>☐Sweet corn ear</li> <li>☐Vegetable web page list</li> </ul>
SA	40 growers	70 stakeholders	<ul style="list-style-type: none"> <li>•IDO News</li> <li>☐Guiding Meaningful Opinions Newsletter</li> <li>☐Minor essentials newsletter &amp; Information</li> <li>☐Western Flower Thrips information</li> <li>•SA Brassica Newsletter</li> <li>☐Vegetable web page list</li> </ul>
NSW	40 growers	100 stakeholders	<ul style="list-style-type: none"> <li>•IDO News</li> <li>☐Guiding Meaningful Opinions Newsletter</li> <li>☐Minor Essentials newsletter &amp; Information</li> </ul>
QLD and NT			<ul style="list-style-type: none"> <li>•IDO News</li> </ul>
VIC	40 growers	60 stakeholders	<ul style="list-style-type: none"> <li>•IDO News</li> </ul>
TAS			<ul style="list-style-type: none"> <li>•IDO News (Not yet)</li> <li>☐Getting Results posted on TFGA Website</li> </ul>

### 1.6 Australian vegetable industry web site

In the near future the Australian vegetable industry web site will be operating and information can be submitted through the IDO network. The website is a joint initiative of the Potato & Vegetable industries and has funding from the respective grower levies. The site will be organised into crop areas with a vegetable IDO responsible for information in each crop. Responsibilities are outlined in table 3.

**Table 3. Vegetable IDO responsibility areas on the vegetable and potato industry web site**

Crop area	Contact	Crop area	Contact
Brassica	Craig Feutrill	Carrots	David Element
Sweet corn	Alison Anderson	Pumpkin, marrow and zucchini	Samantha Heritage
Lettuce and celery	Patrick Ulloa	Beans, green peas	Roger Tyshing

### Commercial and other vegetable communication channels

There are a number of commercial, government, and grower organisations that communicate with industry.

#### Australia

- Good Fruit and Vegetables
- ABC Rural Radio
- National Marketplace News (Editor: 03 5149 7066)
- Vegetable Platter column for Good Fruit & Vegetables on a monthly basis. Articles for this column must not be simple research outputs but have a grower focus. Articles should be ready (written or dot points) with a picture or photo. Coordinates by the SA IDO.

**Western Australia**

- WA Grower magazine including WA VegeLink published quarterly. (Articles must be grower focused and contain pictures.). Magazine sent to all vegetable growers in WA and other stakeholders. Distribution 1600 (Contact Linda Manning on 08 9434 2628). To place articles in the VegeLink section refer to information in section 1.1 of this document.
- Market news (Editor: Fresh Finesse, 08 9388 2775)

**South Australia**

- The Grower magazine, quarterly (plus) articles under the VegLink Banner - posted to 9,000 SA growers (not just Vegetable Growers) Contact: Cindie Lange, on 08 8372 5230. To place articles in the VegeLink section refer to information in section 1.1 of this document.

**New South Wales**

- Articles in the NSW Farmers' Association Horticulture Report (sent to NSW Farmers' horticulture members). NSW Farmers' Association also has a radio station. (Contact Liz Chamberlain on 02 8251 1700).
- Articles in NSW Agriculture's 'Vegie Bites' newsletter (sent to all vegetable growers in NSW that request the newsletter). Articles must be grower focussed and preferably with a picture. (Contact Tony Napier on 02 6951 2611).
- The Land newspaper (Editor: 02 4560 4444)

**Queensland**

- Queensland Fruit and Vegetable News: This is the magazine of Queensland Fruit and Vegetable Growers and it distributed to every grower in Queensland. If you would like to include an article in this publication please have your story ready (written or dot points) with a picture or photo and contact Shannon Mackay at QFVG on ph 08 89833233 or e-mail smackay@qfvg.org.au.

**Northern Territory**

- The Northern Territory Horticulturalist is published bi-annually. If you would like to include an article in this publication please have your story ready (written or dot points) with a picture or photo and contact Rod Hollingsworth at the Northern Territory Horticulture Association on ph 08 89833233.

**Victoria**

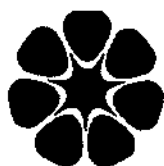
- DNRE publishes the Vege-matters newsletter. For further information contact Sarah Barry 03 9210 9222.

**Tasmania**

**IDO contact details**

<p>David Ellement (WA)                      Phone: 08 9456 4077                      Fax: 08 9455 2096                      Mobile: 0408 941 318                      E-mail: ellement@inet.net.au                      MP 96, Market City,                      280 Bannister Rd, Canning Vale, WA, 6155</p>	<p>Craig Feutrill (SA)                      Phone: 08 8568 1824                      Fax: 08 85681834                      Mobile: 0418 831 089                      E-mail: cfeutrill@adam.com.au                      158 Melrose Street, Mount Pleasant, SA, 5235</p>
<p>Patrick Ulloa (VIC)                      Phone: 03 9738 0574                      Fax: 03 9738 0573                      Mobile:                      E-mail: pulloa@vgavic.org.au                      PO Box 4126, Knox City, Vic, 3152</p>	<p>Samantha Heritage (QLD and NT)                      Phone: 07 3213 2425                      Fax: 07 3213 2480                      Mobile: 0408 135 042                      E-mail: sheritage@qfvg.org.au                      PO Box 19, Brisbane Market, Qld, 4106</p>
<p>Alison Anderson (NSW)                      Phone: 02 9746 1865                      Fax: 02 9746 1865                      Mobile: 0409 383 003                      E-mail: alison.anderson@bigpond.com                      PO Box 1, Sydney Markets, NSW, 2129</p>	<p>Roger Tyshing (TAS)                      Phone: 03 6331 6377                      Fax: 03 6331 4344                      Mobile: 0438 943 984                      E-mail: tfga.rtyshing@bigpond.com                      PO Box 193, Launceston, Tas, 7250</p>

## EXAMPLES OF EXTENSION MATERIAL PRODUCED IN THE NORTHERN TERRITORY FOR ASIAN VEGETABLE GROWERS



# Northern Territory Government

Department of Business, Industry & Resource Development

### SNAKE BEAN SOIL AND ROOT PROBLEMS

An information paper prepared by Barry Condé, Rex Pitkethley and Isagani Arao Arao, Plant Pathology Branch, NT DBIRD-Primary Industry, Darwin, NT.

#### INTRODUCTION

There are several conditions that can cause only death of snake beans (or as Vietnamese growers call it, 'early die') in the Top end of the Northern Territory. Some are lack of basal fertiliser, poor drainage, root knot nematode and Fusarium wilt.

#### LACK OF BASAL FERTILISER

Firstly, if basal fertiliser is not applied to the soil before planting the snake beans, the young seedlings will soon run out of mineral nutrients especially phosphorus and nitrogen because Darwin soils are so poor. The plants will become pale, stop growing and die when very young. This is particularly a problem in land which has not been planted previously. The solution to this is to make sure that the recommended general fertiliser is applied as a basal application to the soil before the crop is planted.

#### WATERLOGGING

A second cause of early death of snake beans in Darwin is waterlogging. If the soil is not ripped deeply enough and has a hard layer at shallow depth, the poor drainage will cause the plants to be waterlogged with the roots sitting in water. Roots become damaged due to anaerobic (low oxygen) conditions and the damaged roots are invaded by the water-loving fungus, *Pythium* sp. The solution is to make sure that deep ripping is a part of the soil preparation for snake bean growing.

#### ROOT KNOT NEMATODES

A third type of 'early die' snake beans found in Darwin in the last 10 years or so with the popular Green Pod Koahsiung variety is when they are infected by root knot nematodes, *Meloidogyne* spp. Snake beans in common with other legumes have nitrogen fixing (*Rhizobium*) nodules on their roots. The *Rhizobium* bacteria fix nitrogen from the air into a form that is used by plants. These nitrogen fixing nodules are small, a millimetre to several millimetres in diameter. The root knot nematode galls begin small, but grow very large so that the roots become quite distorted with very large galls. Leaves on affected plants turn yellow, drop off or die, and plants eventually die early. For control measures see separate information sheet on root knot nematodes.

#### FUSARIUM WILT

Fusarium wilt is the fourth type of 'early die' symptom was seen in the Darwin snake bean growing areas from 1999. This is caused by the fungus *Fusarium oxysporum* f. sp. *tracheiphilum* (E.F. Smith) Snyder and Hansen. Fusarium wilt affected plants appear similar to root knot in that leaves turn yellow and either die or fall off and plants die. The above ground symptoms are more sudden than for root knot nematode. The distinguishing feature of Fusarium Wilt on snake beans is that the internal water conducting tissues on affected plants are a dark brown colour. Fusarium wilt was reported previously in Australia on cowpea in 1948 and, on snake bean in 1957 in Queensland. Once a field is infected with Fusarium wilt, the resting spores or chlamydospores of the fungus ensures that the soil remains infective for more than 20 years. There are no chemicals or cultural controls for Fusarium wilt. DPIF Plant Pathology Branch in cooperation with Horticulture Division and NTHA – Asian Vegetables Group is testing 30 – 60 varieties of snake beans in glasshouse infection tests. It is hoped that a suitable cultivar with resistance of Fusarium wilt can be found for growing on infested farms.

# Agnote

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## GRAFTING SNAKE BEANS TO CONTROL FUSARIUM WILT

B. Condé, I. Arao-Arao, R. Pitkethley - Plant Pathology Branch and G. Owens - Horticulture Division, Darwin

### Introduction

Fusarium wilt is a serious problem of snake beans grown in the Darwin area. It is caused by a soil-borne fungus, *Fusarium oxysporum* f.sp. *tracheiphilum*, which infects plants through the roots, especially if plants are damaged by implements or are infected by root knot nematode. The fungus is also seed-borne.

### Symptoms

Infected plants quickly wilt and collapse, often within 24 hours. In some cases this may happen over a period of two to three days. Symptoms usually appear when plants flower and begin to set fruit. Diagnosis of Fusarium wilt involves slicing the tap root, stem and branches with a sharp knife. Infected plants have a reddish brown discolouration of the vascular or water conducting tissues (towards the centre) of the root and stem. The discolouration in some cases reaches the branches.

### Control

Fusarium wilt was first reported in 1999 in Darwin and appears to have spread to most farms. The disease can be controlled by:

1. Using seed harvested from healthy plants and by adopting hygienic practices aimed at preventing the disease from entering the property if it is known to be free of the disease. This will sustain production unless the disease is introduced.
2. Using resistant varieties. However, no suitable and commercially acceptable resistant variety is known at present.
3. Grafting onto resistant cowpea rootstock. Snake beans can then be produced in an area infested with Fusarium wilt. This Agnote describes the technique of grafting.

### Onto what do you graft?

A variety of cowpea called *iron* is resistant to snake bean Fusarium wilt in Darwin and can be used as the rootstock for snake beans. It is important to use a definitely known resistant variety of cowpea rather than any cowpea. Samples of *iron* cowpea seed are available from DBIRD Primary Industry, Bemimah Farm.

### Grafting

Rootstock cowpeas (*iron* cultivar) are generally sown in pots (or commercially, in seedling trays) two to three weeks before the scion snake beans. When the scion snake bean seedlings have reached a height of about 300 mm proceed as follows:

1. Cut off the top 100 mm of each snake bean plant and then trim into a wedge shape (see Figure 1).
2. Remove leaves from the snake bean scion to minimise moisture loss.
3. Cut off the *iron* cowpea rootstock at the height where it is the same thickness as the snake bean scion. Discard the top portion.
4. Split down the centre of the remaining rootstock stem to the same depth as the scion wedge already prepared (about 15-20 mm).
5. Make the graft by inserting the scion into the split rootstock stem, ensuring that the sides are making good contact. The graft can be held in position by binding it with grafting tape, or better still, by using commercially produced grafting clips.

Grafted plants need to be staked to prevent them breaking until the grafts are sufficiently strong.

Prevent newly grafted plants from drying out by growing in a shade house with mist irrigation or by staking and placing a plastic bag over each graft. Alternatively, cover the whole tray with a plastic bag to prevent air currents from drying out the graft union. The bags can be removed after three to five days and the plants allowed to harden. After about two weeks, the grafting tape or grafting clips can be removed.

As with all grafted plants, the grafted area must be kept above the soil or mulch level when planting out, otherwise the plant may become infected with Fusarium wilt. It is essential to keep all parts of the plant secured onto trellises or stakes to prevent contact with the soil. Constant attention needs to be given to the removal of side shoots of the cowpea root stock coming from below the graft union.

One more advantage of grafting snake beans onto *iron* cowpea is that the *iron* cowpea root stock is also resistant to the root knot nematode which can also devastate snake bean crops.

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Agnote 807  
Tháng TB 2002

## GHÉP ĐUỖ ĐUỖA ĐỂ TRÁNH BỆNH HÉO KHÔ (FUSARIUM WILT)

B. Condé, I. Arao-Arao, R. Pitkethley - Plant Pathology Branch và G. Owens - Horticulture Division, Darwin.

### GIỚI THIỆU

Bệnh héo khô là bệnh nghiêm trọng của đậu đũa trồng ở vùng Darwin. Bệnh gây ra bởi một loài nấm (*Fusarium oxysporum* f.sp. *tracheiphilum*), sinh sản trong đất, cây nhiễm bệnh qua rễ, đặc biệt khi cây bị thiệt hại do sên và chom vùi các đống cỏ hoạc cây bị bệnh phù (nematode). Bệnh cũng lây qua hột.

### DIỄN TIẾN

Cây nhiễm bệnh héo và chết nhanh chóng, thường trong vòng 24 tiếng. Trong vài trường hợp cây có thể kéo dài tới hai - ba ngày. Dấu hiệu thường xuất hiện khi cây ra hoa và bị đậu trái. Chẩn đoán bệnh héo khô bằng cách dùng dao bén cắt xéo rễ chính, thân cây và các nhánh. Rễ và thân cây bị bệnh có màu nâu đỏ - các tuyến đen (gần gốc) rễ và thân cây. Trong vài trường hợp sên đẻ màu này lên tới các nhánh cây.

### KIỂM CHẾ

Bệnh héo khô lần đầu tiên được báo cáo tìm thấy ở Darwin vào năm 1999 và được coi như lan truyền tới hầu hết các nông trường. Bệnh có thể kiểm chế bằng cách:

1. Sử dụng hột giống tốt của những cây khỏe và thực hành theo những cách hợp vệ sinh ở phòng gieo bệnh lây lan vào nông trường nếu nông trường trước đây là chổ bệnh, nhiễm bệnh. Điều này sẽ duy trì được sản lượng cho tới khi bệnh xuất hiện.
2. Sử dụng giống kháng bệnh. Tuy nhiên, cho tới nay chưa có loài giống nào kháng bệnh mà thích hợp và được chấp nhận cho trồng mới.
3. Ghép vùi giống kháng bệnh là cowpea. Sau đó cây đậu đũa có thể mang đi trồng - chế độ bệnh héo khô. Tất cả Agnote này miêu tả phần pháp ghép đậu đũa.

### GHÉP VỚI GIỐNG GÌ?

Giống cowpea có tên Iron là loài kháng bệnh héo khô trên đậu đũa ở Darwin và có thể sử dụng làm giống ghép đậu đũa. Xác định đúng giống cowpea kháng bệnh héo khô là điều quan trọng, không phải loài cowpea nào cũng kháng bệnh. Mọi hột Iron cowpea được cho miễn phí ở Bộ Nông Nghiệp DBIRD, Bemimah Farm.

### GHÉP CÂY

Iron cowpea được trồng trong chậu (hoạc trong các vỉ, vùi sẵn trong đất) hai tới ba tuần trước khi trồng đậu đũa ở ruộng ngoài. Khi cây đậu đũa cao khoảng 300 mm làm theo những bước sau:

1. Cắt ngọn cây đậu 100 mm và xén theo hình cái nêm (xem hình 1)
2. Tia lá trên ngọn đậu ở hột chôn sâu một chút.
3. Cắt cây cowpea - chiều cao mà nửa thân cây có cùng một kích thước với ngọn đậu. Bỏ phần ngọn cowpea đó đi.
4. Chèn dục gốc thân cây cowpea với chiều sâu bằng với hình nêm của ngọn đậu (khoảng 15- 20 mm).
5. Ghép chúng với nhau bằng cách nhét phần ngọn vào ổ rãnh chèn của phần gốc, sao cho hai mặt tiếp xúc sát với nhau. Dùng ghép có thể giã bằng băng nhả (grafting tape), hoạc tốt hơn là dùng kẹp (grafting clips) được bán phổ biến.

Cây mới ghép phải được xếp ở nơi tránh gây ô nhiễm cho tới khi mới ghép thật lành mạnh.

Tránh cho các cây ghép không bị khô bệnh cách đặt chúng trong nhà lưới với vòi tưới nước phun sương hoặc trùm bao nhựa qua khỏi mặt ghép. Hoặc có thể trùm nguyên vỉ bệnh bao nhựa để tránh gió làm khô các mặt ghép. Bao nhựa có thể tháo ra hai tới ba ngày sau khi ghép, và cây cũng sẵn sàng để tháo làm quen với nắng. Hai tuần sau, kính hoặc bảng nhựa có thể tháo ra.

Cũng như các loại cây ghép khác, khi trồng mặt ghép phải đặt giữa trên đất hoặc trên lớp nhựa, nếu không thì cây có thể bị nấm bệnh héo khô. Vết nứt và các nhánh đậu lên lưới hoặc giàn đỡ giúp cho chúng không dễ dàng là vật cản trở. Theo dõi tình trạng xuyên và cắt bỏ những nhánh mọc ra khỏi mặt ghép.

Một ích lợi khác của việc ghép đậu đũa với gốc Iron cowpea là loại Iron cowpea cũng kháng bệnh rỉ sắt, là bệnh cũng có thể tàn phá các vụ mùa đậu đũa.



# Northern Territory Government

Department of Business, Industry & Resource Development

## MOSAIC VIRUSES CAN CAUSE SEVERE DAMAGE TO CUCURBIT CROPS

An information paper prepared by Barry Condé and Isagani Arao Arao, Plant Pathology Branch, NT DBIRD-Primary Industry, Darwin, NT.

### The viruses

Mosaic viruses can cause severe loss of production of cucurbits and severe economic loss to cucurbit farmers in the Top End of the Northern Territory. 100 per cent infection of cucurbit crops is not uncommon. Two viruses belonging to the Potyvirus group are the cause of mosaic virus diseases in the Top End. The cucurbit strain of papaya ringspot virus (PRSV-W) previously known as WMV - 1 or watermelon mosaic virus strain 1 has been known to cause problems to cucurbits since 1977. A second potyvirus, zucchini yellow mosaic virus (ZYMV) has also been the cause of mosaic virus diseases since 1989.

### Crops affected

The mosaic viruses are known to affect zucchini, squash, cucumber, long melons, smooth luffa, watermelon, rock melon and gramma or pumpkins such as butternut, jap and other Asian types.

### Symptoms

These diseases are called mosaics because the leaves have a mottled or mosaic pattern of light and dark green instead of the normal dark green colour. Leaves may also be distorted, bubbled or very narrow (especially in zucchini). Fruit found on green/black zucchini and butternuts after virus infection is often distorted with bubbles and is unmarketable. Golden squash and golden zucchini fruit on plants after infection have colour break where the yellow colour is replaced to a greater or lesser degree by green colour.

### How are the viruses spread

Aphids spread the mosaic viruses in a nonpersistent manner. This means that the virus can be picked up by the insect on its stylet or mouthparts in only a few seconds, and also injected into a healthy plant in a matter of only a few seconds. The virus is retained in the aphid for only a short time, i.e. a matter of minutes to hours. Virus vector specificity is low for most of the potyviruses. This means that many species of aphids can transmit the cucurbit mosaic viruses. However, in the Top End, the cotton aphid, *Aphis gossypii* is the most common aphid on cucurbits, and so is the most important vector of the mosaic viruses. These viruses are not spread by mites, leafhoppers, whiteflies or other insects, or in the soil or by fruit moved from farm to farm, or on equipment. The only spread is by the aphids. As aphid transmission is nonpersistent, spread generally occurs from nearby inoculum sources. Aphids are often overlooked because they mostly increase in numbers on the undersides of the leaves, usually as wingless insects. As the aphids increase in numbers, the population pressure causes winged aphids to develop. It is these winged aphids that are responsible for the bulk of the spread of the viruses to nearby plants and also long distances for up to several kilometres in the wind to new areas.

### Management

All new growth on a plant infected with the virus disease becomes infected with the virus. Unlike fungal diseases such as powdery mildews, downy mildews, rust and leafspots which can be controlled with fungicide sprays, there is no way a virus-affected plant can be sprayed to control the disease. Since brief feeding probes of only a few seconds is all that it needs for aphids to inoculate new plants with the virus, the virus is able to spread to new plants before the insecticide kills the aphid. Colonisation of a plant is not necessary for the aphid to inoculate the plant with the virus. However, it is important for plants to be kept free of aphids so that winged aphids on these possibly infected plants will not take flight and spread the virus to new plants.

The virus can come into a farm from an aphid blown in from an infected plant several kilometres away. Nothing can be done to prevent an infectious aphid from being blown several kilometres away onto a healthy cucurbit crop. Even if the healthy crop is protected with an aphid insecticide, the aphid will transmit the virus to the plant before it is killed. It is important to constantly monitor the cucurbit crops for any plants showing symptoms of mosaic virus, and to rogue these infected plants out straight away so that they do not become new sources of virus for further infections. In practice, most of the virus spread seen on farms in recent years comes from within a few hundred metres, from infected previous crops on the farm, infected cucurbits such as jap gramma in the



house garden or infected crops on a neighbour's farm. A point to remember is that mosaic virus infection which begins as one or a few plants in a crop if left unchecked, will increase in amount with each successive planting of cucurbits until the infected crop becomes uneconomic to produce because of large losses. Ideally non-sequential planting should be made to ensure breaks in virus build-up. However, this may not be practicable for the farming system, and also because new infections may come in from nearby farms.

It is most important to make sure that cucurbit plants in the house garden are not infected by virus. Otherwise they will become a source of virus for cucurbit crops. If infected, they should be pulled out and burnt. Any old or previous crops with virus infections will become sources of virus for new planting. Infected plants should be pulled out and burnt so that aphids can not feed on them. Cucurbit crops should be inspected regularly for aphids especially under the leaves. The crops should be sprayed regularly with an insecticide effective against aphids. This will ensure that aphids die before that can breed up in numbers to produce winged forms that can spread mosaic viruses. It is important also for neighbours to co-operate in keeping their plants free of aphids by regular sprays and rouging out and disposing of infected plants to remove sources of virus for each other.

#### **Who to contact**

If you are going to plant cucurbits and are not sure of the mosaic virus risk or if you think that you have a mosaic virus problem on your cucurbits, phone Barry Condé on 8999 2265 or Isagai Arao Arao on 8999 2247 in Plant Pathology (fax 8999 2312), or Kim Bui at NTHA on 8983 3233 (mobile 0419 901 554).



# Northern Territory Government

Department of Business, Industry & Resource Development

## ROOT KNOT NEMATODE

An information paper prepared by Barry Condé, Rex Pitkethley and Isagani Arao Arao, Plant Pathology Branch, NT DBIRD-Primary Industry, Darwin, NT.

### Introduction

Plant Pathology has recorded root knot as a significant disease of vegetables in the Northern Territory and in Darwin area since 1964. With the increase in Asian and South East Asian population in Australia and in Darwin, snake beans, bitter melon, luffa and other Asian vegetables have been grown by Vietnamese and other Asian growers in the Darwin rural area to meet the needs of this market. As a consequence, Plant Pathology has recorded increasing and severe problems of root knot disease on snake beans and other Asian vegetables since 1988.

Two root knot nematode species have been identified from the Top End (area from Darwin to Katherine) of the NT, *Meloidogyne incognita* (Kofold & White) Chitwood and *M. javanica* (Treub) Chitwood. One of the most widely grown and severely affected crops has been snake bean, *Vigna unguiculata* (L.) Walp. ssp. *sesquipedalis* (L.) Verdc. Both species of *Meloidogyne* have been identified from snake bean. Some other Asian vegetables affected by root knot nematode are okra, *Abelmoschus esculentus* L. bitter melon, *Momordica charantia* L. angled luffa (sinqua), *Luffa acutangula* (L.) Roxb., smooth luffa, *L. cylindrica* (L.) M. Roemer and sweet basil, *Ocimum basilicum* L. At this stage it is not known which of the two species of *Meloidogyne* affects which crops; further investigations by Plant Pathology Branch will be done to determine this. Usually the first crop on new soil is not affected by root knot. When crops are grown on the same land the next season, they are often devastated by root knot. One practice some Asian growers have adopted is to grow crops on new land each season to avoid the root knot nematode problem. Also, many Asian growers are leasing blocks of land.

In the early 1980's, rockmelons dominated the vegetable horticulture industry in the Top End. A cultivation procedure was developed by Horticulture, DPIF. It involved growing a green manure crop of forage sorghum (Pacific Seeds male sterile, 'Sudax-ST6') or pearl millet and discing it into the soil to improve the soil organic matter and structure before planting the crop. The crops were planted under black plastic mulch, using fertigation through bi-wall irrigation system. Although commercial rockmelons are very susceptible to both species of *Meloidogyne*, the melons had no root knot problems during this time.

Since the late 1980's, Asian vegetables have been grown by Vietnamese and other Asian growers in the Darwin rural area. They have not grown green manure crops to improve the soil structure because they tended to grow vegetables all year round, and green manure crops appeared to be a non-productive crop, and in general, do not grow on black plastic mulch. Many of their crops have been severely affected by root knot nematode causing them large losses.

In recent times, ginger growers in Australia and overseas claimed that applications of mulch of sawdust and chicken manure to improve the crop nutrition had a side benefit of controlling the root knot nematode. This claim was confirmed by Nematologists. Earlier research with pineapples in Hawaii before World War II demonstrated that applications of mulch of plant waste gave very good control of the root knot problem in the pineapples. However, with the emphasis on chemical control of insects during the war, the importance of this Hawaiian research was lost for some time and there was an emphasis on use of various chemicals to control root knot and other nematodes. It was only in the last ten to fifteen years when there has been a trend to use less chemicals in agriculture that the use of mulches and green manure crops has come to the fore.

The growing of bulky green manure crops of Sudax sorghum and discing in to improve the soil organic matter and structure had an unintentional side benefit of effective control of root knot nematode in the rockmelon crops in the early 1980s. Literature indicates that it is the act of breaking down of the plant organic matter that controls the nematodes and that it is fungal fraction of the microflora which is more important. The procedure of growing a bulky green manure crop over the wet season and incorporating into the soil by discing is now being recommended to growers of Asian vegetables as a means not only of controlling root knot but of also improving their soil.

### Symptoms

Leaves on root knot affected plants turn yellow, drop off or die and plants will eventually die. The specific diagnostic symptom is the root galls or knotted roots which can vary from very small to large malformations. Ornamental crops such as Heliconia and ginger can be affected by root knot nematodes.

### Control recommendations

Root knot nematode can be managed effectively on large horticultural plantings by the incorporation of large amounts of plant organic matter into the soil in the form of green manure crops or plant waste prior to growing the crop. For large areas, growing the green manure crop and incorporation into the soil is a more efficient means of control. With long-growing or semi-perennial crops such as Heliconia or ornamental ginger, regular incorporation of large quantities of plant organic matter (mulch) is a more practical means of control. In parts of the Philippines, the trap crop plant, *Crotalaria spectabilis* (Roth) is used commercially for effective management of root knot nematode. This has been trialed once in Darwin and could be useful in home garden or small holding situations where incorporation of bulk organic material is impracticable. Plant Pathology Branch is continuing its investigations into root knot nematode and its control.



# Northern Territory Government

Department of Business, Industry & Resource Development

## BASIL SOIL AND ROOT PROBLEMS

An information paper prepared by Barry Condé, Rex Pitkethley and Isagani Arao Arao, Plant Pathology Branch, NT DBIRD-Primary Industry, Darwin, NT.

### Introduction

This information paper will discuss three types of soil and root problems of sweet basil and other plants. These are cultural problems, root knot nematode and Fusarium wilt and crown rot. In some cases the information is incomplete and a clearer picture will emerge with further investigations.

### WATERLOGGING AND SEVERELY PRUNED PLANTS

Basil needs to be kept moist. However, constantly waterlogged conditions with poorly drained soil and excessive irrigation, and sometimes plastic mulch will lead to death of many plants. The solution to this problem is to regulate the watering, and ensure good drainage. Another problem encountered is where the basil plants have been severely pruned too close to the plant base when harvesting. The plant root system can not cope with such a greatly reduced shoot system and so dies. The solution to this is to make sure that the plants are not pruned too severely when harvesting.

### ROOT KNOT NEMATODE

Sweet basil plants can be severely affected by root knot nematode. Affected plants have the characteristic root galling. It has not been determined whether *Meloidogyne incognita* or *M. javanica* or both species are the cause of this problem on sweet basil. Root knot nematode is not usually a problem on previously uncropped land because the nematodes are usually in low numbers. The problem emerges after the second or third crop on the land, with nematode numbers building up successively with each crop. For control, see separate information sheet on root knot nematode.

### FUSARIUM WILT AND CROWN ROT

Fusarium wilt and crown rot of sweet basil is caused by the fungus *Fusarium oxysporum* f.sp. *basilci*. Seed of sweet basil was mass produced in the 1980's and early 1990's in countries where labour was inexpensive. Seed was harvested from Fusarium infected plants and sent through out the world, thus spreading the disease in the 1980's and 90's. Fusarium infected sweet basil stops growing, leaves become chlorotic (paler), the plant wilts and leaves drop off. Necrotic streaks appear on the stem and the growing tip becomes necrotic. Then the plant dies. Basil Fusarium is unusual in that it combines both a wilt and a necrotic crown rot phase. As well as the initial spread into a locality in infected seed, once a crop is infested the soil remains infective for twenty years or more through the chlamydospores or resting spores. The disease is also spread in infested soil clinging to footwear, vehicle tyres, agricultural implements and on root vegetables such as shallots, spring onions and yam beans. The disease is unusual in that it can also be spread aerially by spores produced on the stems of infected plants. This was demonstrated in glasshouses in Italy. If the soil on a farm is uninfected, Fusarium wilt certified free soil should be used to prevent the crop being infected. If the soil is already infected with the disease, a Fusarium tolerant or resistant variety should be grown. Nufar F1 a highly tolerant/resistant hybrid sweet basil developed in Israel is marketed and used widely in Canada and USA. Seed of this Nufar F1 cultivar is available from Eschol Springs Nursery, Gingin, Western Australia. This Nufar F1, UH sweet basil (from Hawaii) and '5170' cultivars are being tested for reaction to the Fusarium wilt in the Plant Pathology glasshouse and on growers properties in co-operation with NTHA - Asian Vegetables Communications Officer and Horticulture Division.

Vietnamese and Thai growers grow other basil as well as the sweet basil. These are apparently known Asian basil and Thai basil. It is unclear what effect the Fusarium disease has on Asian and Thai basil; this will be further investigated by Plant Pathology Branch in co-operation with NTHA - Asian vegetables Group and Horticulture Division.

## APPENDIX 13. DISEASES OF NURSERY STOCK

### NURSERY DISEASE ISSUES

#### Diseases spread on infected nursery stock in Queensland

Bob Davis QDPI

There are several large and many small nursery operations servicing the vegetable industries of Queensland. The larger operators generally have no major recurring disease issues since these operations have adequate facilities to hygienically produce transplants. The adequacy of these facilities across nurseries in Queensland varies from ISO standard to 'wing-and-a-prayer' type shows.

**Brassica** transplants can suffer from downy mildew infections emanating from nurseries. Generally nurseries with open sheds suffer most, particularly during periods of extended leaf wetness (from overhead watering and dews) in cooler months. Downy mildew lesions are often the sites of subsequent *Pythium* spp. infections in the field. *Pythium* damping off can be a sporadic problem in nurseries and some losses continue into the field. Rarely do we see much *Rhizoctonia* that we can attribute to nursery infections. Clubroot has become an issue from time to time here, but there has been no evidence that infected plantings were linked to Queensland nurseries. This disease is currently topical in several areas in Queensland and there is certainly increased pressure being placed on nursery operators to supply Clubroot-free transplants.

**Lettuces** are usually problem-free as transplants here. In some cases, particularly with the upright Cos-types, *Botrytis* and *Sclerotinia* can be transferred from nurseries. Some minor problems occur from time to time with viral infections commencing in nursery stock.

**Tomato and Capsicum** diseases sometimes can be attributed to infected nursery stock. In recent years bacterial canker has been traced to infections in the nursery. *Alternaria* stem infections are common in poorly managed nurseries. In fact, in most cases, capsicum and tomato diseases in nurseries can be attributed to either poor nursery management or infected seedlots.

**Cucurbit** seedlings, in particular watermelon, rockmelon and honeydew are particularly susceptible in the nursery stages to bacterial fruit blotch infection. This can commence from infected seeds and continue into the field to harvest. Seed companies are now addressing this disease in countries they are sourcing seed from.

As a general rule, there are no major unaddressed nursery disease issues in Queensland. Most nursery operators are aware of how to manage their facilities so that conditions in and around nursery sites do not lend themselves to disease outbreaks. Watering is usually well managed and chemicals are deployed to prevent the more common damping-off diseases.

#### NSW- nursery plant quality

Andrew Watson, NSW Agriculture

I work in an area that does not use transplants for vegetable production so I don't have first hand experience with seedlings. Lettuce growers near us use direct seeding at planting. Growers are always suspicious of the quality of seedlings and in NSW the diseases claimed to be associated with batches of seedlings are commonly black rot, mildews and viruses are issues especially TSWV in tomatoes and lettuce seedlings.

There are concerns expressed by the quality of seed that seedling producers receive. They currently buy seed by number however the germination rate is not taken into consideration when the price is worked out. This is an issue for the seedling producers. The other main concern of the seedling producer is that seed dressings for them are a hindrance to germination and they prefer seed free of such dressings. This may indicate that more research should be done on seed dressings but probably seed companies have been handling this in the past.

There seems to be room for some routine pathogen testing from these nurseries as part of their quality assurance program. Who undertakes this role? Do they already do this?

## Distribution of virus infected seedlings from vegetable nurseries in WA

Lindrea Latham, DAWA

In WA in recent years a number of virus disease outbreaks have been attributed to local vegetable seedling nurseries.

The two most notable virus outbreaks were:

1. Tomato spotted wilt virus in tomato and capsicum seedlings
2. Lettuce big vein virus in lettuce seedlings

Both have resulted in the widespread distribution of the virus and in the case of LBBV long term contamination of lettuce growing areas.

Integrated disease management strategies have been developed for both of these diseases.

Nurseries, in general, have been reluctant to adopt strategies that will prevent future problems as it usually involves increased costs.

## Diseases in Vegetable Nursery Stock in the Northern Territory

Barry Condé, DBIRD-PI, NT

There are few vegetable seedling nurseries in the Northern Territory. As a consequence, there are few disease problems associated with vegetable nurseries. Two disease situations come to mind, both associated with growing tomatoes. Firstly, tomato seedlings are regularly grafted onto either resistant tomato or resistant wild Malay eggplant rootstock to protect the tomatoes from bacterial wilt. Secondly, the serious tomato disease, tomato leaf roll caused by Australian tomato leaf curl geminivirus (TLCV-Au) can infect tomatoes directly or indirectly through a symptomless infection of the wild Malay eggplant rootstock originating in the vegetable nursery.

## Diseases spread on infected nursery stock in Tasmania

Lisa Gibson, DPIWE

Tasmania has some vegetable crops grown from transplant stock, most of the larger crops are seed sown. Seedlings of brassicas such as cauliflower, cabbage, broccoli, brussel sprouts and pumpkins, silver beet, parsley, lettuce, leeks, celery are grown for transplant. The vegetable nursery industry set up in Tasmania has developed a good hygiene and management system to assist in disease control.

In the past diseases such as lettuce big vein virus and anthracnose of lettuce, as well as sclerotinia, bacteria diseases of brassicas and septoria leaf spot of celery were problems for nursery growers. *Botrytis* can be a problem from time to time for some nurseries depending on their set up, but this again is addressed with good hygiene management systems in the majority of situations.

The issue of seedling transmitted diseases goes hand in hand with seed transmitted diseases. Tasmania has a 'growing' vegetable seed industry of high standard and great quality. The vegetable seed growers want good clean seedlings supplied, but nurseries also need to start off with clean seed. So there is a pressure placed on both suppliers to keep the system clean!

Seed supplied to nurseries from seed companies has already been treated with hot water and any other treatment for specific disease control. Majority of nurseries have adopted good sterilisation and seed cleaning techniques internally as well. From speaking to industry there appears to be no current disease issues for nurseries.

Clubroot is the largest disease threat to brassica growers, with current trials being carried out for its management, as part of the national project. However it doesn't appear to be an issue at the nursery stage.

**Disease spread in nursery stocks in Victoria**

Nigel Crump, Department of Natural Resources, Knoxfield

<b>Disease</b>	<b>Host</b>
Downy mildew	Brassica, lettuce
Botrytis	Brassica, lettuce
Phythium and Phytophthora	Brassica and others
Rhizoctonia	Brassica and others
Bacterial canker	Tomatoes
Bacteria/Pseudomonas	Leek

**Issues associated with disease spread in nursery stocks**

- The location of nurseries in vegetable production areas and the risk of disease
- The development of fungicide resistance particularly for diseases such as botrytis that have limited management strategies
- The need for hygiene standards to prevent disease
- Do seed assurance schemes have a role in the reduction diseases in nursery stocks?

## **APPENDIX 14. FUTURE DIRECTIONS**

### **ROLE OF PRIVATE INDUSTRY IN VEGETABLE PATHOLOGY RESEARCH AND EXTENSION**

Dr Hoong Pung, Serve-Ag Research

Serve-Ag Pty Ltd was established over 25 years ago. The company now operates from 19 sites throughout Australia, employing one of the largest teams of technical staff in Australian agriculture. Its capability is based on the technical expertise, cooperation and commitment of its specialists. Serve-Ag has an independent Research Division, which is one of the largest private research providers in Australian agriculture. Research areas covered include crop management systems, plant pathology, plant nutrition, pest and weed management, post-harvest systems, and disease diagnostics.

The company's focus is on integrating quality advice, research and technology. Hence, our activities in R&D and implementation of new technologies are an essential and important part of the core business of the company. Our research activities or projects are usually driven by our clients' need to better understand, precisely monitor, and efficiently manage production to meet quality standards, remain profitable, and maintain their natural resources. We make it our business to take up the challenges that face our clients in primary industries, and provide solutions to their problems.

Research studies are often conducted in close liaison with other Serve-Ag divisions, utilising the available technical expertise to ensure that the outcomes are relevant to the primary industry. Some of Serve-Ag's other services and capabilities include integrated crop agronomy, group training, enterprise management support, plant sap analysis, soil nitrate testing, crop nutrition plans, farm mapping, design & layout, irrigation design, monitoring & scheduling, environmental monitoring and water management. These linkages are important, as disease management is only one component of the whole crop management system and are often interconnected with or influenced by other crop management practices such as nutrition and irrigation.

The role of a private research provider could compliment services provided by large educational institutions and government organisations and vice versa. In vegetable pathology research, most projects are currently being conducted in collaboration with government institutions, which includes CSIRO, Crop and Food Research Pty Ltd (NZ), Lincoln University (NZ), Queensland Department of Primary Industry, Queensland's Department of Natural Resource, Victoria Agriculture, New South Wales Agriculture, Tasmanian Institute of Agricultural Research, Tasmanian Department of Primary Industry, Water and Energy, Institute of Agricultural Research and University of Tasmania.

Most of the research studies conducted by Serve-Ag could be classified as applied research, where most trials are conducted on farm properties. By the nature of our customer driven service, our success is measured by generating research outcomes that can be applied rapidly to solve industry problems. Government institutions, which generally serves the public interest, however, are better equipped and have greater resources to conduct non-applied research, which requires long term commitments, and is essential in laying the foundations of further development and applications of new knowledge and technology. Private research providers, like Serve-Ag, which serves the primary industry sector, are in a unique position to help develop, adapt, and apply new technologies, which originate from government institutions.

For example, the rapid development and adoption of the Folicur-lime super application method for onion white rot control by Serve-Ag, helped to secure the viability of the onion industry in Tasmania in the short-term, while a biocontrol method investigated by the Tasmanian DPIWE may help provide an alternative strategy for sustainable management of the disease in the future. This is an example of applied research versus basic research, and the synergy of contributions by the private and public research organisations.



## COLLABORATION BETWEEN HORTICULTURE AUSTRALIA LTD AND NEW ZEALAND (OR OTHER COUNTRIES)

Fiona Benyon, HA

The horticultural industries in Australia and New Zealand, particularly vegetable, potato, stone fruit and avocado industries have driven the establishment of collaborative research and development to achieve industry-focused outcomes. This drive was a direct result of the Trans Tasman Horticultural Conference held around 1997. Horticulture Australia Ltd (HAL) facilitates this industry-driven collaboration, by attaching New Zealand industry contributions (as Voluntary Contributions), provided the outcomes of the project will benefit Australian industries. In addition, HAL can match New Zealand Government Funds as Voluntary Contributions (VCs), because there is an identified benefit for Australia. This is also applicable to other countries, but acceptance of an overseas VC by HAL is determined on a case by case basis by the Board of HAL.

The Australian Government decided that HAL cannot match Australian Commonwealth, State or Local Government Funds because this revenue source is considered to be Australian Taxation Funds.

Horticulture Australia Ltd's primary objective is to deliver research and development outcomes for industry in the most efficient and effective manner possible. Research skills within Australia and New Zealand (and other countries) may differ and HAL seeks to fund research providers that can deliver the most efficient outcomes for industry. Projects may involve research providers in one or more countries. HAL recognises that researchers are already collaborating internationally and HAL's intention is to build on the expertise in Australia and fund collaborative projects wherever possible.

The Australian and New Zealand Potato and Vegetable industries have established a working party to determine common priority R&D areas to initiate research. Researchers can also identify areas for collaboration and apply for funding through the normal CDP/FP process. Funding has not been reserved specifically for this program.

Horticulture Australia Ltd sees the diminishing pool of scientific resources worldwide as a significant problem and is seeking to address this through encouraging young people to choose a career in horticultural science. The Australian Society of Horticultural Science is assisting in this endeavour. How can young people be encouraged to choose horticultural pathology as a career path?

HAL has received the following proposals for collaborative Australian/New Zealand R&D in potato and vegetable pathology:

VG00048 Development of biological controls for *Sclerotinia* diseases of horticultural crops in Australasia  
PI: Dr Ian Porter (Agriculture Victoria), Dr Phillip Keane (La Trobe University), Dr Hoong Pung (Serve-Ag Research), Mr Frank Ruffo (Bacchus Marsh), Mr Andrew Watson (NSW Agriculture)  
PI (NZ): Dr Alison Stewart, Lincoln University  
Status: current project, started 1/7/00, due for completion 30/6/03.

PT01019 Prediction and molecular detection of soil borne pathogens of potato  
PI: Dr Nigel Crump, Dr Dolf de Boer, Mr Robert Faggian (IHG, Knoxfield)  
Status: Australian project only to operate in conjunction with PT01031, approved March 02.

PT01031 Enhanced detection of PCN and bacterial wilt to improve market access for the Australia and New Zealand Potato Industries  
PI: Mr Robert Faggian, Dr Gordon Berg, Dr Dolf de Boer, Dr Ian Porter (Agriculture Victoria)  
PI (NZ): Dr John Marshall, Crop and Food Research  
Status: To Board for consideration.

VG01096 Stop the Rot- managing onion white rot in spring onions  
PI: Dr Ian Porter, Agriculture Victoria  
PI (NZ): Dr Alison Stewart, Lincoln University  
Status: To Board for consideration.

**Some points to consider in developing proposals for Horticulture Australia Ltd funding**

1. All proposals require a Background Summary. This is a review of past and current research that justifies why this research proposal should be funded.
2. All projects are to include a Comprehensive Literature Review as part of Milestone 2. This is also to be included in the Final Report.
3. Pathology proposals need to identify the impact of the disease on the industry in terms of its Dollar Value and identify the Dollar Return to growers if the disease is controlled.
4. Ensure that the research is appropriate to the problem, with practical outcomes for industry.
5. Remember that your proposal is being assessed by industry for its relevance and outcomes.

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