Strategies to control purple spot of asparagus

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Institute for Horticultural Development

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Department of Primary Industries
Primary Industries Research Victoria, Knoxfield Centre

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This report presents a summary of work conducted in Victoria during the period July 2001 – November 2004 by the asparagus pest and disease research team. This project has sought to address the needs of the southern Victorian asparagus industry with regard to the management of purple spot disease. This report has been restricted to the presentation of key findings and research highlights.

Contents

13. APPENDIX III Pests, Diseases, Disorders and Weeds of Asparagus in Southern Victoria

1. **MEDIA SUMMARY** (350 words)

Purple spot is a serious foliar disease of asparagus worldwide. In Australia, purple spot occurs in every growing region, prematurely defoliating crops thereby reducing the carbohydrate storage potential and yield of the asparagus crown. This project has sought to investigate management strategies for purple spot in southern Victoria, from seed health to the mature crop. Control of foliar diseases will contribute to the longevity of the asparagus crown and assist in achieving sustainable yields. Strategies have been developed which have resulted in heightened grower awareness of the disease and tangible outcomes that can be easily implemented on farm without compromising export and local market access. The following industry priorities have been addressed:

1. Management protocols to control purple spot disease at fern stage. Protocols were developed based on reviews of international literature and on farm field testing. Outcomes have been delivered to growers as a factsheet set including:
   - Disease identification, symptoms and conditions favouring disease.
   - Determination of a purple spot disease threshold (when to spray).
   - Disease risk analysis.
   - Cultural and chemical control strategies: methods and timing of fungicide applications and removal of volunteer seedlings.
   - Minor use permit applications for fungicides to control foliar diseases that will not compromise export or domestic market access ie no detectable chemical residues.
   - Promotes scouting as a first line of defence tool against disease.
2. Seed hygiene protocol.
   - Disinfestation of asparagus seed factsheet.
3. Nursery crown hygiene protocol.
   - Monitoring for disease in nursery crowns.
   - Keeping nursery crowns free of disease factsheet.
4. Tools to assist with the identification of major asparagus problems delivered to growers as a pocket guide “Pests, Diseases, Weeds and Disorders of Asparagus in Southern Victoria”.
5. Identification of the species of *Stemphylium* causing purple spot in Australia using DNA sequencing.
6. Note: An additional fungicide trial was conducted to control asparagus rust. This disease was first detected in May 2003 in Victoria. This trial was funded by Plant Standards, Victoria and is included in this report.

Recommendations included in this report provide asparagus growers with tools to manage a serious foliar disease and hygiene practices to minimise the impact of other diseases, especially exotic diseases, which threaten the viability of the Victorian asparagus industry. Future research is still a priority to keep abreast of pest and disease threats.

2. **TECHNICAL SUMMARY** (750 WORDS)

Purple spot (*Stemphylium vesicarium*) is a serious foliar disease of asparagus worldwide and impacts on the viability of Australian asparagus production regions. In Australia the disease is responsible for economic losses of up to 50% (epidemic levels) at harvest with growers unable to market spears due to unsightly lesions on the spear surface. This loss equates to approximately $10-$20 million annually. Increases in the severity of the disease are associated with extended periods of rainfall, fog or dew. As reported overseas and observed in Australia, purple spot causes premature defoliation of the fern reducing carbohydrate stores within the crown for the following harvest season. This economic loss is subtle but nonetheless very tangible. The residual fern debris persists through the harvest season and is the source of infection for emerging spears and volunteer seedlings.

This project was initiated by the Australian Asparagus Council (AAC) to develop control strategies for purple spot without jeopardising market access through chemical residue issues. In 1999 and 2000 the industry experienced two poor harvest seasons due to purple spot epidemics and suffered significant economic losses. During seven consecutive dry winters, the diseased fern debris did not decompose and thus allowed the disease inoculum to remain until spear production in each of the dry years. The severe disease reported in 1999 and 2000 was due to high rainfall, heavy fogs, high humidity and moderate temperatures. In 2001, 82% of respondents to an industry survey reported purple spot in their 2000 crop but had used no fungicides to control the disease. The project researched the issues that face the asparagus industry in controlling purple spot disease and investigated the epidemiology of the fungus *Stemphylium vesicarium*. The aim of the research was to provide growers with information about the disease and options to control it that were practical and cost effective. The *Stemphylium* species causing purple spot in Australia was identified using DNA sequencing and control options were delivered to growers as:

1. Management protocols for the control of purple spot disease. These protocols have been produced as part of a factsheet set.
2. Asparagus seed and nursery crown health protocols.
3. In addition, a pocket guide for growers, "Pests, Diseases, Weeds and Disorders of Asparagus in Southern Victoria" has been published. This has been an invaluable source of information about a range of asparagus problems and a useful on-farm identification tool.

Pre-Planting/Nursery

- Asparagus seed is a source of fungi that cause diseases of asparagus, in particular, *Fusarium moniliforme* and *Fusarium proliferatum* (external contaminants) which cause root and stem rots, *Botrytis* sp. (external contaminant), *Stemphylium vesicarium* (both an external and an internal contaminant) and the seed spoiler fungus *Penicillium* sp. A 10 minute alcohol dip controlled external but not internal contamination. All growers treated their seed when advised of the treatment protocol. Growers were advised to treat seed immediately before planting and buy certified seed free from *Stemphylium vesicarium*.
- A survey revealed first year nursery asparagus crowns were contaminated with fungal diseases such as F*usarium* root rots, *Phytophthora, Penicillium* Mould and purple spot (present on fern stalks attached to the crown). A soil survey revealed the presence of *Fusarium* fungi in both replant and new ground.

Established Crop

- Fern debris contains the *Pleospora* (overwintering) stage of *Stemphylium vesicarium*, the fungus which causes purple spot disease. The *Pleospora* stage was present in all sites surveyed in Victoria after mulching and bedforming of the crops. Infected fern debris provides the source of disease for spears and volunteer seedlings at harvest and post harvest new fern.
- Removal of asparagus fern debris is impractical on a large scale and fern debris does not decompose in dry conditions. Complete burial of the debris is impractical given the large amount of small pieces that still persist after slashing/mulching, wind rowing and burning.
- Soil amendments do not facilitate fern debris breakdown in dry conditions. Nitrogen does reduce the viability of the *Pleospora* stage by up to 62% but given the high level of infectious material present in the soil this is not enough to reduce disease.

- ❖ Fungicides used at harvest and applied to fern debris pre-harvest leave unacceptable chemical residues.
- ❖ Scouting for disease and calendar spray applications allow timely applications of protectant fungicides to control purple spot disease, but adequate coverage of the fern is critical. Systemic fungicides provide control of asparagus rust when applied at the earliest stage of disease development. The disease predictive model Tom-Cast did not provide an effective alternative to scouting and calendar spraying.
- ❖ Fungicides are most effective when applied by tractor mounted boom spray units. More investigation of helicopter spraying is required, but does provide an alternative application method under adverse weather conditions.

3. INTRODUCTION

Victoria is the leading state in Australia for the production and export of fresh asparagus, producing 89% of the national asparagus crop with a Gross Value of Production of $56 million (ABS: Agriculture 2002-03). The southern Victorian asparagus production region encompasses the Bairnsdale/Lindenow region through Warragul and the Kooweerup swamp up to Cranbourne. Asparagus is a perennial vegetable crop that under ideal conditions may produce for 15-20 years. Asparagus produces spears which arise from a woody crown with long fleshy roots. The early colonists introduced asparagus into Australia. During the early 1900s Thomas Roxburgh, a shipping agent, grew the first commercial asparagus on a 300-acre farm in Vervale. By the 1930's, Kooweerup and Dalmore were the major commercial production areas of asparagus in Victoria.

Victoria has a range of soils and climates suitable for asparagus production, including those in Kooweerup, East Gippsland and Lindenow in southern Victoria, and in the Mildura and Swan Hill districts of northwest Victoria. The sandy loams and warm climate in the Mildura and Swan Hill districts favour asparagus production between July and November, whereas the peaty loams and the cooler climate in the Kooweerup area support production between August and December. As a result, Victoria has a longer growing season for asparagus than most other production areas in the world. The asparagus season in Victoria also complements that of other states of Australia and helps provide a continuous supply of product.

In 2001, the Australian Asparagus Council (AAC) approached researchers at Department of Primary Industries for assistance in controlling purple spot disease of asparagus which had impacted economically in the previous two harvest seasons.

Purple spot disease of asparagus (*Asparagus officinalis* L.) spears and fern is caused by the fungal species *Stemphylium vesicarium* (Wallroth), teleomorph *Pleospora* sp. (Simmons). Purple spot was first recorded in Australia c 1975, but anecdotal evidence suggests this disease has been present in Australia for some years prior to this record. Over the last 20 years there has been an increase in the incidence of purple spot worldwide, thought to be as a result of increased production levels, the adoption of a no-till cultural program where infected asparagus fern debris is left on the soil surface and minimal or no use of fungicide spray programs. Purple spot incidence and severity has been exacerbated due to seven consecutive dry winters in which the diseased fern debris does not decompose.

Symptoms of the disease occur at two growth stages of the asparagus plant. At spear formation the disease causes purple-margined superficial lesions which when in high numbers and severity render the spear unmarketable. During epidemics, 50-90% of harvested spears can be infected (Hausbeck *et al*, 1999). The disease also occurs at fern stage, attacking the main stem and foliage causing premature defoliation. This defoliation can significantly decrease spear production in the following season due to reduced carbohydrate stores in the asparagus crown. Yield reductions of up to 50% have been experimentally demonstrated (Menzies *et al*, 1992).

A literature review (Cunnington and Pascoe, 2001) commissioned by the AAC, revealed that there were no fungicides registered in Australia for the control of purple spot on asparagus and indeed in a research survey 82% of respondents did not use fungicides on their farms. The review stated that whilst fungicidal control has been successfully achieved in other countries, further research was required to optimise control strategies including the use of fungicides and the adoption of appropriate cultural practices for Australian conditions. Research in the United States identified an effective protectant fungicide which required testing in Australia both for efficacy and for the establishment of a withholding period for use. Around the world, the three most commonly used fungicides are chlorothalonil, mancozeb and captafol. In New Zealand, Menzies *et al*., (1992) examined the differences between using chlorothalonil, mancozeb and captafol to control purple spot. All treatments reduced the amount of purple spot and it was noted that three sprays of captafol during January to March were as effective as weekly sprays between December and May for reducing purple spot. Meyer *et al*. (2000) found that under identical circumstances a significantly higher yield was obtained using chlorothalonil when compared to mancozeb. Note, any captafol residue is prohibited for the Taiwan export market so no further research was conducted on this fungicide in this current project.

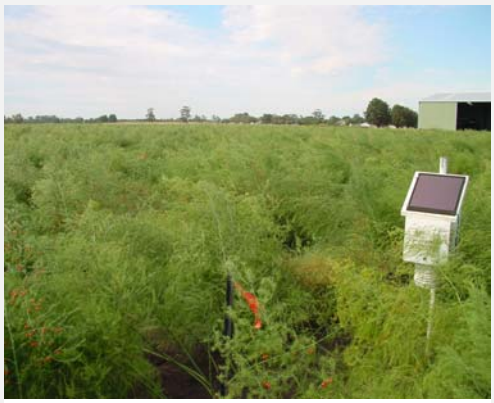
The primary aim of this project was to develop management strategies for the control of purple spot that encompassed the whole production cycle from seed to established fern and that did not compromise market access through chemical residue detection. Outcomes have included:

- Development of strategies to control purple spot
  1. Production of seed hygiene protocols
  2. Production of nursery crown hygiene protocols
  3. Production of protocols for the use of cultural and non-cultural strategies to control purple spot in the asparagus fern, fungicide use and removal of asparagus seedlings
- Production of a pest, disease, weed and disorders pocket guide to assist with identification in the field
- Identification of the species of *Stemphylium* responsible for purple spot in southern Victoria using DNA sequencing

Purple Spot Life Cycle in Asparagus

Purple spot lesions on spears.

Ascospores infect spears.



Lesions on ferns produce asexual spores (conidia).

Spores (conidia)

Ascospores inside asci produced in the black pseudothecia.

Black fruiting bodies (pseudothecia) form on dying fern.

Fern debris containing black overwintering fruiting bodies, pseudothecia.

4. MATERIALS & METHODS

Grower survey
The Australian Asparagus Council members were sent a survey on grower practices to assess whether any practice contributed to the incidence of purple spot disease and to assess the losses that could be attributed to the disease. A series of twenty-four questions were asked ranging from hectares grown, cultivar grown to pesticide usage. Seventy-five growers were sent survey forms and 45% responded.

Assessment of fern debris for the presence of Pleospora state of Stemphylium vesicarium
Four sites (7-year-old plants) were assessed for the presence of diseased fern debris after growers had slashed and burnt the dormant fern in July, 2001. The three sites consisted of areas 63 rows by 800 metres long. The areas were divided into 20 plots and 5 samples were collected in a circular pattern from each plot. Debris collected was moist incubated to determine if the *Pleospora* state of *Stemphylium vesicarium* was viable and then plated out onto Coon's agar and the resulting growth was scored positive or negative for the presence of sporulation.

Fungicide selection in-vitro
Ten fungicides were screened for efficacy against *Stemphylium vesicarium* in-vitro. A plug of *Stemphylium vesicarium* was placed on agar amended with 4 rates (ppm) of the fungicide, the label rate, a rate lower and higher than label and a control rate of 0ppm. There were three replicates of each treatment. The plates were incubated and the zones of inhibition were measured over a period of 6 days at 24 hourly intervals.

Fungicide spray trials
1. Fungicide spray trial (spears, 2001). To test fungicides for efficacy against purple spot disease of spears, four treatments with four replicates were applied using a backpack sprayer at two sites. Residue data was collected and sent to State Chemistry Laboratory for analysis.
2. Fungicide spray trial (fern, 2002). To test efficacy of 6 fungicide treatments replicated 4 times on two sites, fern was assessed for disease in June 2002. The Tom-Cast (adapted from FAST, Madden *et al*, 1978 and Monestinos *et al*, 1992) disease prediction model using temperature and leaf wetness in the modelling, was applied to this trial to test its ability to predict disease events.
3. Fungicide spray trial (fern, 2003). To test efficacy of 12 fungicide treatments replicated 4 times at one field site and to evaluate the Tom-Cast disease prediction model. Fern was assessed for disease in May 2003. Residue data was collected and analysed.
4. Fungicide spray trial (fern, 2004). To test efficacy of two fungicides at various rates and application intervals. Also crop scouting was evaluated as a method of reducing spray applications compared to calendar spray applications. Fern was assessed for disease in June 2004. Spears and soil were tested for fungicide residues.
    - ❖ An additional trial was conducted on methods of application; comparing helicopter spray application to standard tractor mounted boom spraying. A comparison of cost effectiveness was also conducted.
5. Rust fungicide spray trial (fern, 2004). To test efficacy of 16 fungicide treatments against asparagus rust and purple spot in Bairnsdale, Victoria. Treatments were applied at 14-day intervals. Ferns were assessed twice for disease incidence and severity. Spears and soil were tested for fungicide residues.

Debris treatment trials
1. Debris treatment trials conducted on Kooweerup site, 2002.
   Five soil amendments, control; mow, rake, burn and hill, control plus lime @500kg/ac, control plus lime @1000kg/ac, control plus liquid nitrogen 2 50L/hec and control plus 30% more hill height were replicated five times. Within these treatments, mesh bags containing diseased cladophylls (needles) and stem material were buried and removed at two time intervals during the harvest period. The buried debris was assessed for breakdown and *Stemphylium vesicarium* viability.
2. Debris treatment trials conducted on Kooweerup site, 2003
   Two trials were conducted, one to investigate complete removal of fern debris and the other to investigate soil amendments with ten treatments applied after mulching the fern in May, 2003. Spears

were assessed at harvest for beneficial effects of amendments on disease incidence, severity and yield. Mesh bags containing diseased fern debris were buried in the treatment plots and removed at two time intervals to assess effects of soil amendments on debris breakdown and *Stemphylium vesicarium* viability.

Disease and harvest assessments

1. Disease incidence and severity data collected from trial sites 2001
   Spears were assessed for purple spot over a three month harvest period at the two trial sites used for the fungicide trial (spears, 2001). Incidence, how many spears were infected per treatment, and severity, number of lesions per spear (rating 0-5 lesions = low, 6-10 lesions = medium, >10 lesions = high).
2. Disease and yield data collected from trial sites 2002
   Spears were assessed for purple spot over a three month harvest period at the two trial sites used for the fungicide trial (fern, 2002) and debris breakdown trial (2002). Thirteen harvest weeks were assessed.
3. Disease and yield data collected from trial sites 2003
   Spears were assessed for purple spot over a three month harvest period at the two trial sites used for the fungicide trial (fern, 2003) and debris breakdown trial (2003). Nine harvest weeks were analysed.

Seed and nursery crown health investigation

Two areas of concern for high health asparagus production were investigated.

1. Asparagus seed: Sixteen varieties of asparagus seed were sourced and tested for both external and internal diseases particularly the fungal diseases, purple spot, asparagus rust and Fusarium root rot. Various disinfestation techniques were trialed.
2. Nursery crowns: Crowns from six growers were tested for the presence of diseases particularly Fusarium root rot, purple spot, Phytophthora root rot and Penicillium storage rot. Soils from replant and new ground were also screened for asparagus diseases.

Identification of Stemphylium species using DNA sequencing

Isolates for this work were sourced from a collection of *Stemphylium* cultures collected from sites around Victoria. Pure cultures of *Stemphylium* were grown and PCR ready genomic DNA was extracted. The extracts were then PCR'd using glyceraldehyde-3- phosphate dehydrogenase primers. The resulting sequences were analysed and compared against GenBank sequences of *Stemphylium* species to differentiate between isolates and correctly identify the causal agent of purple spot in southern Victoria.

Statistical analyses

Various statistical analyses were used to analyse results depending on the trial. Statistical methods will be discussed on a trial by trial basis within the report.

5. RESULTS

Management strategies for the control of purple spot disease of asparagus.

Purple spot disease can be controlled at the fern stage by implementation of a fungicide spray program taking into account weather conditions and the physiological age of the fern, and by the non-chemical removal of sources of disease such as asparagus seedlings at harvest. If left uncontrolled, purple spot has the capacity to infect 100% of the crop every year of production. Considering that this is a perennial crop, the added disadvantage is that the disease is able to cycle with the host year in and year out without the necessity of an alternative host. Strategies must be put in place to break the disease cycle at the fern stage. Fungicides must be used to reduce the inoculum in the first instance and maintain the disease at a manageable level.

As a result of this project, management protocols were produced for seed hygiene, nursery crown hygiene and the management of purple spot at fern stage and published as factsheets based on the research outlined below. The publications are included as appendices to this report.

Purple spot lesions on spears.

Purple spot lesions on fern, Photo courtesy of DPI, Qld.

Overwintering pseudothecia on debris.

Figure 1 Purple spot disease symptoms

5.1. Grower Survey 2001

Materials and Methods

A survey was posted to the 75 growers listed in the Australian Asparagus Growers (AAC) database, with a response rate of 45%. The survey data did not include the incidence and severity of purple spot for the season 2001. Survey mailout included overleaf.

Results

- 82% of respondents reported purple spot in their harvested crops in 2000.
- 91% of respondents grow the cultivar UC157.
- 100% of respondents either slashed or mulched the senescent fern.
- All growers slashed or mulched between April and July of the fern-growing season.
- 15% of growers burnt the fern debris.
- 8% of growers added liquid nitrogen to their crops after removing fern.

- 6% of growers added urea to their crops after removing fern.
- 82% of growers used some form of pest control on their farm, predominantly for weed and insect control. Only three growers used fungicides to control purple spot.
- Estimates of dollar loss due to purple spot were up to $1500 per acre.

Conclusions

The survey data indicated that although growers had a purple spot disease problem, very few growers knew much about the disease and implications for their future yields. Estimated yield losses were very difficult to predict, as the growers were unaware of the potential yield loss that purple spot presented at the fern stage. There are no fungicides registered for use on asparagus for the control of purple spot so any use of fungicides indicated in the survey would have been off-label.

SURVEY OF CULTURAL GROWING PRACTICES FOR THE ASPARAGUS INDUSTRY, 2001.

As part of the Australian Asparagus Council and Horticulture Australia Ltd funded project "Keeping Australian Asparagus Green", this survey is designed to give researchers background into what has been happening in the asparagus crops over the last few years. It is important to discover what has changed over the years and why the disease "purple spot" caused by Stemphylium *has become so much of a problem.*

This survey is confidential and no information will be discussed without the permission of the growers involved. The information will be collected and processed and presented at a grower meeting in the near future.

Please feel free to add extra comments on the back of the pages.

Please circle ◯

(A) How big are your paddocks?

2000	5 acres	10 acres	20 acres	larger
2001	5 acres	10 acres	20 acres	larger

(B) How far apart are your crowns?

2000	9 inches	12 inches	more than 12 inches
2001	9 inches	12 inches	more than 12 inches

(C) How far apart are your rows?

2000	1 metre	1.5 metre	2 metre
2001	1 metre	1.5 metre	2 metre

(D) What variety are you growing?

2000	UC157	Mary Washington	other
2001	UC157	Mary Washington	other

(E) What is your soil type?

Sand	Sand/loam	Peat	Peat/sand	other

(F) Do you have "purple spot" (Stemphylium) on your farm?

2000 Yes No

Yield loss? **Yes** **No** **$ per 10 acres**

2001 Yes No

Yield loss? **Yes** **No** **$ per 10 acres**

1. Do you cut the fern and in what month?

2000	Yes	No	April	May	June	July
2001	Yes	No	April	May	June	July

2. Do you mulch?

2000	Yes	No
2001	Yes	No

Do you hill up after mulching?

2000	Yes	No
2001	Yes	No

3. Do you hill up as high as in the past?

2000	Yes	No
2001	Yes	No

4. Do you burn the fern debris and at what stage?

2000	Yes	No	Before mulching	Straight after mulching
2001	Yes	No	Before mulching	Straight after mulching

5. Do you add liquid nitrogen at mulching?

2000	Yes	No	50kg/hectare	100kg/hectare	more
2001	Yes	No	50kg/hectare	100kg/hectare	more

6. Do you add urea at mulching?

2000	Yes	No	rate?
2001	Yes	No	rate?

7. Do you spray for pests and diseases?

2000 Yes No

Fungal: What do you use and for what disease/s? Weeds: What do you use and for what weed/s?

Insects: What do you use and for what insect/s?

2001 Yes No

Fungal: What do you use and for what disease/s? Weeds: What do you use and for what weed/s?

Insects: What do you use and for what insect/s

If you have any queries regarding the research please contact:

Jane Moran 03 9210 9222, Gisele Irvine 03 9210 9222, Elizabeth Minchinton 03 9210 9222

5.2. Field survey to determine purple spot incidence.

Materials and Methods

Four sites (7-year-old plants) were assessed for the presence of diseased fern debris after growers had slashed and burnt the dormant fern in July 2001. At two sites the senescent fern was burnt, using gas burners and at two sites it remained unburnt.

Figure 2 Diseased fern debris visible on top of asparagus beds.

Results

A *Pleospora* sp. was isolated from the black fruiting bodies (pseudothecia) on the asparagus fern debris and after moist incubation, single ascospore isolation and growth on Coon's agar this was further identified as a *Stemphylium* sp. most probably *Stemphylium vesicarium*. *Stemphylium* sp. was isolated from 98% and 100% of debris pieces collected randomly from two sites, 800m long by 63 rows wide, in the burnt crops and from 99% and 98% of the debris pieces collected in the unburnt crops, sites were divided into 20 plots and 5 samples were collected in a circular pattern from each plot.

Conclusions

Burning the senescent fern may have reduced the volume of inoculum present but a high level of debris still remained on the soil surface containing viable fungus. This inoculum was present at harvest to infect spears, volunteer asparagus seedlings and new fern growth. It is very difficult to obtain an efficient burn due to the brittle nature of dead ferns and the damp, cool climatic conditions present in a Victorian winter. The gas burners are also not considered economically viable given the slow speed at which the burner has to travel and the cost of gas.

5.3. Fungicide selection in-vitro

Ten fungicides were screened for efficacy against *Stemphylium vesicarium* in-vitro.

Materials and Methods

Ten fungicides were selected on the basis of their efficacy against *Stemphylium* related diseases in vegetable crops both in Australia and overseas in particular the Unites States. In the US, chlorothalonil is routinely used to control purple spot and studies indicated the efficacy of other fungicides such as mancozeb. The fungicides represented various fungicide resistance management groups and were all registered for use on other crops in Australia (Table 1). A plug of *Stemphylium vesicarium* was placed on agar amended with 4 rates (ppm) of the fungicide, the label rate, a rate lower and higher than label and a control rate of 0ppm. The plates were incubated at 25^0C and the zones of inhibition were

measured over a period of 144 hours at 24 hourly intervals. The diameter of the inhibition zones was measured in millimetres.

Table 1 Fungicides trialed for efficacy in-vitro against *Stemphylium vesicarium*, 2001.

Fungicide	Group	Activity (manufacturers notes)	Registered in Australia
mancozeb	Y	Protectant	Y
azoxystrobin	K	Systemic	Y
fludioxonil& cyprodinil	L&I	Systemic/contact	Y
dichlofluanid	Y	Protectant/foliar	Y
chlorothalonil	Y	Protectant	Y
myclobutanil	C	Systemic	Y
metiram	Y	Protectant	Y
tebuconazole	C	Systemic	Y
copper/lime	Y	Protectant	Y
chlorothalonil	Y	Protectant	Y

Results

Two fungicides completely inhibited the growth of the fungus, tebuconazole and fludioxonil/cyprodinil, whilst the fungicide of most interest, chlorothalonil, shown to be effective in the US, did not reduce the growth rate significantly. Bordeaux mix (copper/lime) showed some efficacy but due to the removal of use of non-commercial Bordeaux on fruit trees due to the uncertain origin of copper (residue issues), it was discounted from further research.

Conclusions

The use of this in-vitro screening of fungicides is limited in value, as the most effective fungicide used in the US did not significantly inhibit the growth of the fungus. This method of screening does not take into account host pathogen relationships and the effect of protectant versus systemic fungicide activity. The two fungicides that showed most promise were further evaluated in the 2002 spray trial as well as chlorothalonil found to be most effective at controlling purple spot in the US.

5.4. Fungicide Spray Trials

5.4.1 Fungicide spray trial (spears, 2001). To test fungicides for efficacy against purple spot disease of spears and effects on yield at harvest.

Materials and Methods

There were 2 fungicides, dichlofluanid, phosphorous acid, 1 wetter/sticker (Nufilm) and one water control applied to spears at two sites within the Kooweerup region in a non-resolvable row column design with each treatment replicated five times. Treatments were applied using a single hollow cone nozzle by a Silvan 12v-knapsack sprayer at 600L/ha. The treatments were applied on the 19.9.01 and samples of spears were taken for residue testing at day-1, day 0, day + 1, day + 3, day + 5 and day + 7 and dichlofluanid at a further day + 9 and day + 14 on both sites. Only dichlofluanid and phosphorous acid were tested for residues.

Results

Table 2 Residue data State Chemistry Laboratories 2001. <n.nn result denotes concentration below the indicated limit of detection (LOD).

Treatment	Sample date	Residue (mg/kg)
Control	Day 0	<0.1 and <1
dichlofluanid	Day 0	2.5
phosphorous acid	Day 0	<1
Control	Day - 1	<0.1 and <1
dichlofluanid	Day + 1	1.8
phosphorous acid	Day + 1	<1
Control	Day + 3	<0.1 and <1
dichlofluanid	Day + 3	0.83
phosphorous acid	Day + 3	<1
dichlofluanid	Day + 5	0.12
dichlofluanid	Day + 7	<0.1
dichlofluanid	Day + 9	<0.1
dichlofluanid	Day + 14	<0.1

Residues of dichlofluanid were still being detected at an unacceptable level five days after applying the fungicide. Within this time period, no significant purple spot disease event occurred so it could not be ascertained whether the fungicides were effective at controlling the disease on spears.
Yields and disease events were measured during harvest at two sites. Two disease occurrences were observed in mid-October and late October but severity observed was low, 1-2 lesions per spear and the incidence was also low 0.2-0.5% of spears harvested per plot.

Conclusions

Residue levels of dichlofluanid were too high at harvest to warrant further investigation on applying fungicides at this time. Even if this fungicide had shown any degree of control further applications would have needed to be made posing additional residue issues. This study indicated the difficulty of applying treatments at harvest with the risk of chemical residues being detected. All further fungicide spray trials were conducted at the fern stage. At this stage of harvest five days would constitute a large economic loss as this period delivers high prices for the produce.
Weather conditions during harvest did not encourage the development of purple spot even with the amount of inoculum present in the soil. The rainfall was low and wind soon dried off dew that had settled on the spear surfaces. It is reasonable to suggest that when conditions do not favour purple spot then economic impact is slight.

5.4.2 Fungicide spray trial (fern, 2002). To test efficacy of six fungicide treatments including control, replicated four times on two sites. Fern was assessed for disease in June 2002. This trial was designed to also test efficacy of Tom-Cast disease prediction model using temperature and leaf wetness parameters.

Materials and Methods

The trial design was a non-resolvable row-column design with six treatments replicated four times. Two trial sites were used at Kooweerup, A1 (three year old crop) and A2 (six year old crop). Spray applications commenced 9th January 2002 and ceased on the 29th May 2002. Sprays were applied with a Silvan 12V-backpack sprayer at a rate of 600 litres of water per hectare and a dye was used to confirm adequate coverage of the fern. Two fungicides were used from the in-vitro fungicide screening, fludioxonil & cyprodinil and tebuconazole, one fungicide used effectively against purple spot in the US, chlorothalonil and a rotation of the three fungicides. All fungicides were applied at label rate.

In 1978, a computerised forecasting system called FAST was developed for *Alternaria solani*, a fungus that infects tomato, to identify weather periods favourable for disease development. In 1985, a modified FAST program called Tom-Cast was developed to assist in the management of anthracnose, leaf-spot and early blight in tomatoes. The Tom-Cast model does not include the rain model of FAST but uses the number of hours of leaf wetness in certain temperature ranges, a disease severity value (DSV), to predict when conditions are favourable for diseases to develop. The model has been used to predict four diseases including purple spot (*Stemphylium vesicarium*) overseas. Research in Michigan State in the US has shown that applications of chlorothalonil for control of purple spot in asparagus can be timed using disease severity values of 15 DSV. At this DSV interval it was shown that up to 1-2 sprays could be saved per season.
The Tom-Cast disease prediction model was used to predict when a purple spot disease event would occur using the parameters of leaf wetness and air temperature measured mid height in the fern at 15 DSV's. The disease severity value of 15 was used based on research from Michigan State in the US. The DSV was determined from set up of the weather station on the 16th January 2002. The first predicted spray application at 15 DSV's was on the 30th January 2002.
Fern was assessed for disease (defoliation percentage, 0%, 25%, 50%, 75% and 100%) in trial A1, June 2002 and number of diseased ferns. Further investigations of yield and effects on disease incidence and severity were conducted at harvest 2002.

TOMato foreCASTer
(Pitblado, 1992)

Mean temperature (^{0}C)	**Leaf wetness periods (hrs)**				
13-17	**0-6**	**7-15**	**16-20**	**21+**	
18-20	**0-3**	**4-8**	**9-15**	**16-22**	**23+**
21-25	**0-2**	**3-5**	**6-12**	**13-20**	**21+**
26-29	**0-3**	**4-8**	**9-15**	**16-22**	**23+**
Disease Severity Values (DSV's)	**0**	**1**	**2**	**3**	**4**

0 = conditions unfavourable for spore formation
4 = conditions highly favourable for spore formation
DSV's are added to 15 and a fungicide is applied

Table 3 Fungicides using to test for efficacy against purple spot 2002.

Fungicide	Rate	Application interval
Tom-Cast (fludioxonil & cyprodinil)	80g/100L	@ 15 DSV's
chlorothalonil (720)	2L/ha	7 day
fludioxonil & cyprodinil	80g/100L	14 day
tebuconazole	200ml/100L	14 day
alternate, chlorothalonil, tebuconazole, fludioxonil & cyprodinil	as above	14 days
control		7 day

The crop was assessed visually for disease at four time intervals during the spray program. Fern was destructively sampled and assessed for the presence of *Stemphylium vesicarium* on various parts of the fern. The bracts, in particular, were closely examined as they were the plant parts most likely to be colonised first. The fern was cut into three lengths, moist incubated for one week and then the bracts were examined microscopically.

Harvest 2002
Spears from the trials were assessed for incidence and severity of purple spot disease and an indicative yield over the three month harvest period. Severity was measured as the number of lesions per spear

and incidence as how many spears were infected in the treatments. Yield was measured by number and weight (kg) of saleable spears.

Results

Once the weather station was installed, the predictive modelling could be implemented. Disease severity values were calculated from the time of installation and at 15 DSVs, a spray application was made. The crop was also assessed visually at this time for the presence of purple spot.
The Tom-Cast model predicted four occasions when spray application should be made, a total of 19 spray applications were made on a calendar program every 7 days. Chlorothalonil was the only fungicide which prevented disease development and maintained cladophylls on the fern until late June 2002 (Figure 4). This fungicide is a protectant and therefore adequate coverage is required to all parts of the plant. There was an indication in the trials that where fungicide coverage was missed disease did develop, in particular at the tips of the fern. No other fungicide provided any level of disease prevention. No residues of chlorothalonil were detected at Limit of Detection (<0.05mg/kg) by State Chemistry Laboratory 80 days after the spray program ceased.
Stemphylium vesicarium was detected on fern bracts at the end of January 2002 but this detection was not associated with disease development. Purple spot was detected in the trials in April 2002 when small elliptical lesions formed on the stems and in the upper canopy (branches and cladophylls). Overwintering pseudothecia were also detected on damaged/senesced fern.

Table 3 Fungicide efficacy analysis 2002, trial A1. Estimated mean values

Fungicide	Diseased ferns %	Disease (defoliation)
Tom-Cast (fludioxonil & cyprodinil)	147.17	>50%
chlorothalonil	1.53	<50%
fludioxonil & cyprodinil	151.97	>50%
tebuconazole	131.63	>50%
chlorothalonil, tebuconazole, fludioxonil & cyprodinil (alternate)	138.06	>50%
control	125.05	>50%

Control treatment 2002

Figure 3

Chlorothalonil treatment 2002

Figure 4

Chlorothalonil treatment at slashing (needle retention) 2002

Figure 5

Harvest 2002
Severity and incidence of purple spot over the 2002 harvest period was low, and most infected spears had only one or two lesions which did not impact economically. Four periods of lesion development were observed, two in mid-August and two in October. Thirteen harvest weeks were analysed and only the control and chlorothalonil treatments were compared from the two trial sites.

Table 4 Total of four replicates yield (weight and number of spears) at two trial sites 2002 (This table represents total of all picks during harvest period).

Treatment	Trial A1(kg)	TrialA2(kg)	Trial A1 (spear no)	Trial A2 (spear no)
chlorothalonil	11.27	9.25	278	243
control	11.54	8.63	280	204

Conclusions

The purple spot fungus was detected on the bracts at least three months before disease development which indicates a very specific set of environmental conditions are required for this disease. The bracts on the fern provide an ideal saprophytic habitat for the fungus until conditions are conducive for lesion development. The only fungicide effective against purple spot in this trial was chlorothalonil applied at the maximum rate and application interval. Coverage of the fern with this protectant is essential as it was observed that where the fern was not sprayed ie tips, disease developed. Fungicide screening using in-vitro methods in this case did not provide useful efficacy data to be translated to field trials. Results also indicated that premature defoliation does occur in asparagus crops due to purple spot disease as this was the only foliar disease present and an effective fungicide was able to prevent defoliation. Growers were unaware of the premature defoliation effect possibly because purple spot had been present in crops for some time and there was no comparison to healthy crops.

The Tom-Cast predictive modelling did not effectively predict disease development despite predicting conducive conditions. Given the drying effect of winds which effectively removed all morning dews throughout the summer, high summer temperatures and low rainfall in 2002, it was not an unexpected result. Disease developed at the beginning of autumn which brought cooler temperatures and longer periods of dew, ideal for purple spot disease. Further research is required to better tailor the predictive modelling under different weather conditions and investigate the use of an effective fungicide in the model.

There was too little disease in the 2002 harvest period to assess efficacy of the fungicide treatments and there were no differences in yield between treatments. The yield increases observed in the initial two weeks of harvest did not translate to any statistical differences.

Examination of the weather conditions indicated that conditions were not favourable for purple spot, as was the case in 2001. Rainfall was low and winds dried dew off the spear surfaces quickly each morning. No chlorothalonil residues were detected in produce 80 days after spraying ceased and this data will be used to support a permit application.

5.4.3 Fungicide spray trial (fern, 2003). To test efficacy of twelve fungicide treatments replicated four times at one field site. To also test efficacy of the Tom-Cast disease prediction model. Fern was assessed for disease in May 2003.

Materials and Methods

Twelve fungicides including a control were trialed at one site at Kooweerup in 2003. The trial design was a non-resolvable row-column design. Fungicides were applied using a Silvan 12V-backpack sprayer and applied at a rate of 600L water per hectare. A dye was also used to ensure adequate coverage of the fern. The spray program commenced on the 12th February 2003 and ceased on the 21st May 2003. Fungicides were applied according to label instructions ie label rates and resistance management guidelines.

Ferns were assessed for disease and percentage defoliation on the 27th May 2003. Assessments for the effect of the purple spot control on disease incidence and severity and yield were conducted at harvest 2003. Fern bracts were assessed for the presence of the purple spot fungus.

Spears were sent to State Chemistry Laboratory for fungicide residue testing at the beginning of harvest.

Table 5 Fungicides trialed for efficacy against purple spot 2003.

Fungicide	Rate	Application interval	Number of sprays
difenaconazole	500ml/ha	14 days	5 < =2 consec
azoxystrobin	200g/ha	14 days	4 < =3 consec
mancozeb	200g/100L	14 days	7
trifloxystrobin	10g/100L	14 days	4 < =3 consec
iprodione	500ml/ha	14 days	4 < =4 season
propiconazole	500ml/ha	14 days	4 < =5 season
chlorothalonil	2L/ha (active 720g)	7 days	14
chlorothalonil	2L/ha (active 720g)	14 days	7
chlorothalonil 15 DSV	2L/ha (active 720g)	DSV 15	3
difenaconazole 15 DSV	500ml/ha	DSV 15	3
chlorothalonil 20 DSV	2L/ha (active 720g)	DSV 20	2
control		7 days	14

Results

When chlorothalonil and difenaconazole were used with the Tom-Cast model there were three fungicide spray applications predicted at 15 DSVs and two applications at 20 DSV', whilst sixteen sprays of chlorothalonil were applied every seven days and eight sprays every fourteen days for control of purple spot throughout the season. Results show that the only fungicide to be significantly different in efficacy was chlorothalonil at seven day intervals compared to all other treatments. Difenaconazole, azoxystrobin, mancozeb, trifloxystrobin, chlorothalonil 7 days, chlorothalonil 14 days and iprodione are significantly better than the control. Propiconazole and the three DSV treatments are not significantly different from the control. Chlorothalonil applied on a calendar program controlled the disease in the fungicide trial but was not effective when used with the Tom-Cast modelling in 2003

Table 6 (1) Fungicide efficacy analysis 2003.
Regression analysis

Fungicide	Probability of having disease %
difenaconazole	60.78*
azoxystrobin	68.93*
mancozeb	54.82*
trifloxystrobin	63.09*
iprodione	68.28*
propiconazole	94.88
chlorothalonil (7 days)	17.24*+
chlorothalonil (14 days)	41.82*
chlorothalonil 15 DSV	84.62
difenaconazole 15 DSV	84.47
chlorothalonil 20 DSV	83.87
control	93.75

+ significantly different from all other treatments including those marked with an *.
* significantly different from the control.

The purple spot fungus was detected on fern bracts in February 2003 later than in 2002. There was no disease development associated with this detection. Disease was first detected in the trial site on the 30th April when small elliptical lesions were observed in the upper fern canopy and then on the stems within two weeks. Overwintering pseudothecia were observed on damaged/dead fern in April 2003.

Harvest 2003

The fungicide application treatments from the trial conducted on ferns in summer were assessed for efficacy against disease development at harvest and any effects on yield. Although it was not possible to harvest and weigh the asparagus spears from the trial, it was possible to measure the length and

diameter of unharvested spears. And so, a method of estimating spear weight was devised using a rough estimate of spear volume by assuming a spear to be cylindrical in shape. On two occasions, once early in the season (11.09.03) and later in the season (15.10.03), a large number of spears from one packhouse were weighed and the length and diameter of each spear was recorded. The relationship between the weight of the spears and their volume was estimated using regression analysis.
These equations were then used to estimate average spear weight in the spray trial. Only average weight of spears from three treatments was measured. The three treatments being chlorothalonil applied every 7 days and 14 days and the control. Analysis of variance of these weights showed no significant differences between treatments (Table 7).

Table 7 Yield based on average spear weight from spray trial 2003.
l.s.d 2.649

Fungicide	Yield means
chlorothalonil 7 days	29.70
chlorothalonil 14 days	29.93
control	32.15

Only nine harvest weeks were assessed due to cooler than normal weather conditions. Disease severity and incidence were low during the harvest period with one to two lesions per spear which did not impact economically. Incidence was also low with three periods of disease observed in October, the three disease events were preceded by a significant wetting event seven days before disease was observed (15-25 hours leaf wetness) accompanied by temperatures averaging 9.5^{o}C. Purple spot lesions were detected on volunteer seedlings on 8th October and despite the high disease pressure from these seedlings the disease did not develop to a great extent on spears. Due to the extent of disease it was not possible to detect differences between treatments.
No residues were detected on produce of any of the fungicides trialed at Limit of Detection 80 days after the spray program had ceased, chlorothalonil <0.1mg/kg (LOD). However residues of all fungicides were detected in soil after sampling on the 29th May 2003, chlorothalonil at the highest level but none exceeded MRL's set for produce. A follow up sample confirmed that the level of chlorothalonil had dropped to 0.2mg/kg by 19thAugust 2003 the commencement of harvest.

Conclusions

One fungicide treatment significantly reduced disease in the trial, chlorothalonil applied every 7 days. This treatment applied every 14 days also significantly reduced disease compared to the control but to a lesser extent. The control treatment indicated that as in 2002 there was significant premature defoliation of the fern due to purple spot. As was the case in 2002, the Tom-Cast model did not provide useful predictions for disease. The weather conditions in 2002 and 2003 were very similar: low rainfall, high temperatures and winds that dried dew off leaf surfaces quickly. Any significant rain event was soon followed by an extended dry period so disease did not develop. Although Tom-Cast has the potential to reduce the number of sprays required for control of purple spot based on reports from overseas, these experiments found that its usefulness was severely limited by weather conditions not factored into the model eg morning wind drying off of the fern. Accurate prediction requires more rainfall than occurred in 2002 and 2003. Given that disease did not develop until late April 2003, the spray program could have begun much later and therefore reducing applications and subsequent cost. Further studies were planned for 2004 to minimise the number of spray applications by better timing spraying ie using scouting as a tool to detect early disease development without compromising disease control.
Yield data did not provide any significant differences compared to the control, but overseas research suggests that there is a cumulative effect over several years. Another explanation is that disease developed at the end of the fern's life, that is the carbohydrate drawdown may have been completed late in the season therefore the yield loss would have been negligible. Further investigation into effects of disease on carbohydrate storage potential is required. Effects of treatments on disease incidence and severity could not be analysed due to minimal disease development. Since no fungicide residues of

chlorothalonil were detected in spears 80 days after the end of the spray program this further reinforces an application for a permit for use of this fungicide in asparagus.

5.4.4 Fungicide spray trial (fern, 2004). To test efficacy of two fungicides at various rates and application intervals. Also test efficacy of scouting as a method of reducing spray applications compared to calendar spray applications. Fern was assessed for disease in June 2004. Spears and soil were tested for fungicide residues.

Materials and Methods

Two fungicides of interest, chlorothalonil and difenaconazole were trialed at different rates and intervals. The trial design was a non-resolvable row-column design with fourteen treatments including control, replicated four times. Fungicides were applied using a Silvan 12V-backpack sprayer at a rate of 600L water per hectare. The spray program commenced on the 11th March as a calendar program based on 20 DSVs, the DSVs calculated from the end of harvest. The next parameter for application was after the observation of one lesion in the upper fern canopy in the trial site (refer to results for further explanation), this being on the 24th March. The spray applications ceased on the 11th May as the fern was too senesced for any fungicide to be effective. Fern bracts were assessed for the presence of the purple spot fungus.
Fern was assessed for disease on the 27th May 2004. The fern was in advanced senescence which made assessment difficult.
Spears and soil were collected from six treatments for residue testing at the beginning of harvest and sent to State Chemistry Laboratory for analysis.

Table 8 Fungicides and intervals used to test for efficacy against purple spot 2004.

Fungicide	Rate	Number sprays	Application interval
chlorothalonil	2L/ha	7	7 days @ detection
chlorothalonil	2L/ha	4	14 days @ detection
chlorothalonil	2L/ha	1	20 DSVs
chlorothalonil	1L/ha	7	7 days @ detection
chlorothalonil	1L/ha	4	14 days @ detection
difenaconazole	500ml/ha	4	14 days @ detection
difenaconazole	300ml/ha	4	14 days @ detection
chlorothalonil alt difenaconazole	2L/ha,500ml/ha	4	14 days @ detection
difenaconazole alt chlorothalonil	500ml/ha,2L/ha	4	14 days @ detection
chlorothalonil alt difenaconazole	1L/ha,300ml/ha	4	14 days @ detection
difenaconazole alt chlorothalonil	300ml/ha,1L/ha	4	14 days @ detection
chlorothalonil	2L/ha	5	14 days from 11th March
chlorothalonil	1L/ha	5	14 days from 11th March
control		9	7 days

Results

Fungicide efficacy.

Disease development was not observed until 20th May 2004 despite the detection of the purple spot fungus on fern bracts in February 2004. One lesion was detected in the upper canopy on the 25th March but disease did not develop. As previously observed in 2002 and 2003, purple spot disease prematurely defoliated the fern, however in 2004, weather conditions were unseasonably cool after an extremely hot period which effectively destroyed the top 15-20 cm of fern. The fern was almost half the height of previous years due to early maturation of the spears into fern after harvest shortening the internode length. Following the cool period during mid-late summer the fern entered early dormancy and was completely senesced by the end of the spray program. Tom-Cast predicted one spray application at 20

DSV's on the 11th March, this was the determining factor for commencing the calendar program. Disease did not develop from the Tom-Cast prediction as hot dry conditions followed the rain/wet events. Overwintering pseudothecia were observed on damaged/dead fern in April 2004.

Table 9 Analysis of fungicide efficacy based on average disease incidence 2004.

Fungicide	Rate	Application interval	Average disease incidence means %
1.chlorothalonil	2L/ha	7 days @ detection	25
2.chlorothalonil	2L/ha	14 days @ detection	0a
3.chlorothalonil	2L/ha	20 DSV's	75
4.chlorothalonil	1L/ha	7 days @ detection	75
5.chlorothalonil	1L/ha	14 days @ detection	25
6.difenaconazole	500ml/ha	14 days @ detection	25
7.difenaconazole	300ml/ha	14 days @ detection	0a
8.chlorothalonil alt difenaconazole	2L/ha,500ml/ha	14 days @ detection	25
9.difenaconazole alt chlorothalonil	500ml/ha,2L/ha	14 days @ detection	0a
10.chlorothalonil alt difenaconazole	1L/ha,300ml/ha	14 days @ detection	0a
11.difenaconazole alt chlorothalonil	300ml/ha,1L/ha	14 days @ detection	25
12.chlorothalonil	2L/ha	14 days from 11th March	0a
13.chlorothalonil	1L/ha	14 days from 11th March	25
14.control		7 days	100

This analysis was conducted by Dr Graham Hepworth. In summary, the results did indicate that both fungicides reduced disease significantly compared to the control. However the results of the treatments on disease incidence do not follow a pattern ie not all the chlorothalonil treatments gave the same level of control at the same rates and a lower rate of difenaconazole showed efficacy in one treatment and not another.

Residue testing results:

Chlorothalonil (2L/ha 7day)	<0.05mg/kg	LOD (spears)
Chlorothalonil (2L/ha 7day)	0.27-0.77mg/kg	LOD (soil), cumulative of four replicates
Difenaconazole (500ml/ha 14 day)	<0.03mg/kg	LOD (spears)
Difenaconazole (500ml/ha 14 day)	0.24-0.33mg/kg	LOD (soil), cumulative of four replicates

(highest rate of fungicide reported on only)

No chemical residues were detected at Limit of Detection in spears after the completion of the spray program. However, residues were detected in soil, but in the case of chlorothalonil this level was below set MRLs (Minimum Residue Limit) especially important for the export markets. In the case of difenaconazole, the residue level was above set MRLs, this was a cumulative amount of four replicates and if an average was taken (not an accurate result) the residue is still above the Japanese MRL of 0.02mg/kg at 0.06-0.08mg/kg. At this stage no more residue testing is being undertaken as the risk of soil entering into the export market on spears is almost negligible.

Trial site March 2004

Figure 6

Trial site April 2004

Figure 7

Conclusions

"Scouting involves the close scrutiny of the crop from the development of the fern until dormancy. Scouting will enable the grower to make an informed decision on when to begin a spray program."
This statement above was intended as the ultimate outcome from this trial in 2004, based on the development of a disease threshold. Due to the fact that disease did not develop in the crop until senescence, any conclusions as to the efficacy of any treatment are open for interpretation. Only incidence of disease could be measured as the fern was essentially dead when assessments were conducted. The results did indicate that both fungicides reduced disease significantly compared to the control. However the results of the treatments on disease incidence do not follow a pattern ie not all the chlorothalonil treatments gave the same level of control at the same rates and a lower rate of difenaconazole showed efficacy in one treatment and not another.
Disease development as in previous years, was dependent on weather conditions despite there being disease inoculum present on the fern in February. Scouting and the subsequent detection of one lesion in the fern in late March pre-empted the spray program but the disease did not develop further. This leads to the conclusion that the spray program commenced prematurely not only with the scouting treatments but also with the calendar program. Scouting still provides the most effective method of disease control as discussed in the spray trial conducted in Bairnsdale against asparagus rust where purple spot was also present and controlled after application of chlorothalonil at the disease threshold of two lesions per upper fern. Disease in the Kooweerup trial was not detected at threshold levels, two lesions per upper fern in ten plants in a crop, until 20th May when the fern was predominantly dormant. Any fungicide treatment at this stage would have had minimal effect which may explain the fairly inconclusive trial results. The Tom-Cast prediction of one spray application did not result in significant disease reduction and disease did not eventuate after the 20 DSVs had been reached. This particular disease prediction model does not appear to be effective as in Michigan State US, under the weather conditions experienced over the three years of trials, however, given a different set of conditions ie wet summers this model may be more applicable. More investigation is required into alternative modelling.
Fungicide residues were not detected in spears after the spray program, but there were residues found in soil. There is a minimal risk that soil may enter into the packaged product but it is unlikely as there are several critical areas of the operation where the produce is washed. However the effect of the fungicides on soil mycoflora is unknown and requires further examination.
Based on the residue data from this trial, the non-violation of MRLs 80 days after the end of the spray program and the results of the previous fungicide spray trials, a minor use permit is being sought for the use of chlorothalonil against purple spot of asparagus in Victoria.

❖ A demonstration was conducted on methods of application; comparing helicopter spray application to standard tractor mounted boom spraying. A comparison of cost effectiveness was also conducted.

A demonstration was conducted in March 2004 to assess two spray application methods and determine their cost effectiveness and other factors. This demonstration was designed to give growers an idea of how they could apply chemicals, especially fungicides. Based on research to date one fungicide has shown efficacy against purple spot disease, the fungicide is a protectant and so full coverage of the fern is essential. The fungicide would most likely be applied using tractor-mounted boom-sprayers, but in the event that tractors are unable to enter the paddocks due to wet conditions, a helicopter could be used. In this demonstration, water was used as the spray medium to ensure human safety. This fact must be taken into consideration as water with fungicide added will behave differently and in most cases will give better coverage of plant material due to the extra weight of the spray.
Water-sensitive paper was positioned at both the top and centre of ferns at 30 m intervals.

Figure 8 Helispraying and tractor boom spray demonstration, Kooweerup 2004.

(a) Helispraying was conducted on a paddock of mature asparagus in full fern. The height of the fern in 2004 was almost 50% less than in previous years due to weather conditions. Spray passes were made at different rates of water and nozzle ratings. The helicopter had a 100L capacity. The most effective rate that the helicopter applied was 60L of water per hectare using no.10 nozzles. Reinvestigation needs to be carried out on nozzle rating to get optimum coverage. One of the important factors observed was that the spray needed to be applied as close to the fern as possible. The other main observation made was that the helicopter should have a high carrying capacity to minimise time lost when refilling. The cost (based on prices May 2004):

If applying @ 60 L/ha	$55/ha
If applying @ 100 L/ha	$90/ha

NB: This application method would have to be carefully monitored for the possibility of contaminating water sources and therefore may not be applicable in certain regions.

(b) A tractor mounted boom spray was used to apply a rate of water that would adequately cover fern. The boom spray was tested at two rates, 250 L and 400 L per hectare of water. It was observed that

adequate coverage could be achieved using 250 L of water per hectare. The cost (based on prices May 2004):

If applying @250 L/ha	$52.90/ha (time plus chemical)
If applying @400 L/ha	Not significantly more than $52.90/ha (as above). Will depend on individuals water costs.

NB: These application rates will vary from grower to grower depending on equipment used eg size of nozzles and the cost of the chemical.

5.4.5 Rust fungicide spray trial (fern, 2004). To test efficacy of 16 fungicide treatments against asparagus rust and purple spot in Bairnsdale, Victoria. Treatments were applied at 14-day intervals. Ferns were assessed twice for disease incidence and severity. Spears and soil were tested for fungicide residues.

Materials and Methods

A fungicide spray trial was conducted at a site on a commercial asparagus farm in Bairnsdale, Victoria, for the control of asparagus rust (Refer "Asparagus Rust Matter of Facts"). Asparagus rust had been detected on this property in 2003 but due to the physiological age of the fern, ie almost dormant, no effective treatments could be applied. This trial was carried out as a supplement to the current foliar disease project (VX01024) and was partly funded by Biosecurity (formerly Plant Standards) Victoria. Sixteen treatments (Table 10) were applied to mature fern to test for efficacy against rust, to gather information about when to begin and end a spray program and gather information (photographs) on symptoms. Also residue data was collected to ensure that the fungicides found to be most effective did not compromise market access.

The rationale for this work was that rust would have additional impact on the health of asparagus combined with purple spot disease and that research was required to find effective fungicides for both diseases. The farm chosen for the trial consisted of 4 paddocks of various aged crops harvested at different times. The site that was chosen was in close proximity to a severely infected crop. At the time of setting up, no rust pustules were observed in the trial, however, rust was detected on the 14th April and purple spot was detected at the two lesion per upper fern stage at the first spray application.
Sixteen treatments were applied by a backpack sprayer @ 600L water /ha (Table 10);

Table 10 Fungicides trialed for efficacy against asparagus rust 2004.

Treatment number	Treatment	Rate	Application interval
1	mancozeb/copper	400g/100L	14 days
2	tebuconazole	290ml/ha	14 days
3	myclobutanil	25ml/100L	14 days
4	pyraclostrobin	40ml/100L	14 days
5	chlorothalonil	1.5L/ha	14 days
6	propiconazole	600ml/ha	14 days
7	metiram	300g/100L	14 days
8	difenaconazole	500ml/ha	14 days
9	trifloxystrobin	10g/100L	14 days
10	spiroxamine	60ml/100L	14 days
11	propiconazole/chlorothalonil		14 days alternated
12	difenaconazole/chlorothalonil		14 days alternated
13	tebuconazole/chlorothalonil		14 days alternated
14	metiram/chlorothalonil		14 days alternated
15	myclobutanil/chlorothalonil		14 days alternated
16	control		14 days

Rust in concentric rings on fern stem (severely infected crop adjacent to trial site), Bairnsdale, 2004.

Rust pustules on fern stems, Bairnsdale, 2004

Figure 9 Asparagus rust symptoms 2004.

The fungicides were applied every 14 days from 25th March 2004 until the 1st June 2004, giving a total of 5 sprays.
The trial design was a resolvable row-column design, replicated in both directions. There were 4 reps, each with 6 rows by 6 columns of each of the 16 treatments (15 and 1 control) randomly assigned to the experimental units, plots. Each plot consisted of three spray rows and measures were taken from the middle spray row. Specifically, each spray row consisted of four crowns, and incidence and disease severity was measured from three ferns per crown ie a total of 12 ferns per plot were assessed for disease incidence and severity. Incidence was calculated as the percentage of ferns infected per plot, out of the total of twelve ferns per plot. Disease severity was calculated as the mean number of rust pustules per fern in a plot. The treatments were assessed twice, on the 11th May and on the 22nd June. The trial site was also affected by purple spot disease which was not studied specifically in this trial but was assessed using defoliation percentage as a scoring scale.

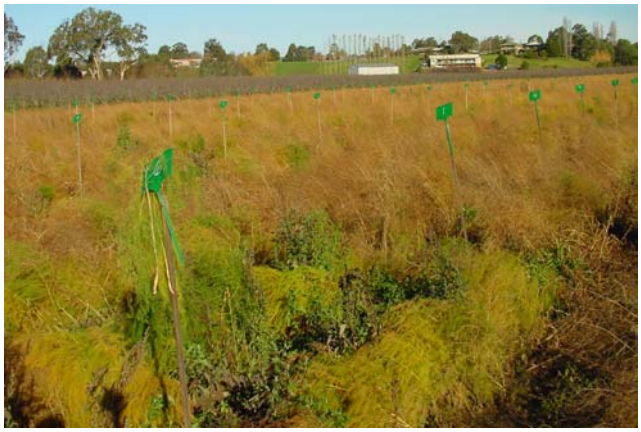


Figure 10 Trial site, Bairnsdale 2004 (note fern in the foreground sprayed with chlorothalonil has not been defoliated).

Results

Asparagus rust

Rust was detected in the trial site on the 14th April 2004 at low to medium severity across the whole trial site (based on a severe infection observed in an adjacent crop). Purple spot disease was also present. The method of analysis used for the incidence data at both assessment times was logistic regression. This was appropriate for two reasons; the data are binary and the assumption of constant variance necessary for a valid ANOVA was not met by these data. At time 1, tebuconazole, difenaconazole and propiconazole were shown to be effective against rust when compared with the control. These results are not presented in this report. The other fungicides were not different from the control. The addition of chlorothalonil made no statistical difference to the effectiveness of any of these fungicides.

The data for time 2 are presented in Table 11. The means for incidence are the expected proportion (%) of disease for each treatment. At time 2, trifloxystrobin, tebuconazole with chlorothalonil, myclobutanil, difenaconazole with chlorothalonil and propiconazole both with and without chlorothalonil reduced rust significantly when compared to the control. Surprisingly, in this trial, myclobutanil with chlorothalonil did not show a significant difference at the 5% level in the incidence of rust when compared to the control. The severity data at time 2 were analysed using ANOVA after being log transformed so that the constant variance assumption could be met. Both the log means and the means backtransformed to the original scale are presented in Table 11.

Table 11 Analysis of fungicide efficacy,rust trial 2004.
Incidence at time 2
Means which are signficantly different from each other at the 5% level have a different letter.
* is different at 5% level
** is different at 10% level

Treatment No	Treatment	Incidence(%)	Log(Severity Score)	Average Severity Score ^
1	mancozeb/copper	52.2	0.036b	1.037
2	tebuconazole	0.0 *	-2.303a	0.100
3	myclobutanil	12.6 **	-1.390a	0.249
4	pyraclostrobin	41.8	-0.134b	0.875
5	chlorothalonil	70.9	0.271b	1.311
6	propiconazole	5.0 **	-1.307a	0.271
7	metiram	60.5	0.227b	1.255
8	difenaconazole	0.0 *	-2.303a	0.100
9	trifloxystrobin	16.7 **	-0.942b	0.390
10	spiroxamine	62.6	0.346b	1.413
11	propiconazole/chlorothalonil	4.2 **	-1.676a	0.187
12	difenaconazole/chlorothalonil	4.2 **	-1.989a	0.137
13	tebuconazole/chlorothalonil	8.4 **	-1.320a	0.267
14	metiram/chlorothalonil	50.1	0.021b	1.021
15	myclobutanil/chlorothalonil	46.0	-0.119b	0.888
16	control	58.4	0.418b	1.518
LSD(5%)		--	1.00	N/A

^ where 0 is healthy ferns and 1 is 1-2 pustules per fern.

Spears and soil were tested for chemical residues at the State Chemistry Laboratory, Queensland University of Technology and Hill Laboratories and results are included in this final report (Table 12). A minor use permit has been submitted for the use of the effective fungicides. Information on withholding periods is essential so growers know when to stop a spray program and not compromise market access.

Table 12 Residue data from fungicides used for efficacy against asparagus rust 2004.
All residues at LOD (limit of detection)

Fungicide	Residue analysis (mg/kg) at LOD	Less than set MRL's
mancozeb/copper	<0.05	Y
tebuconazole	<0.016 (LOQ)	Y
myclobutanil	<0.02	Y
pyraclostrobin	<0.02	Y
chlorothalonil	<0.05	Y
propiconazole	<0.03	Y
metiram	<0.05	Y
difenaconazole	<0.03	Y
trifloxystrobin	<0.016 (LOQ)	Y
spiroxamine	<0.016 (LOQ)	Y

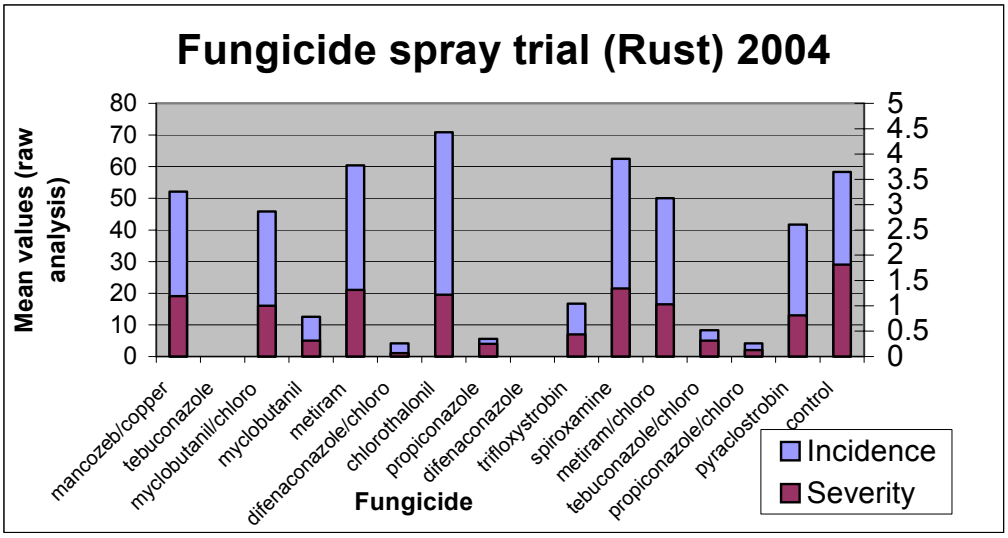


Figure 11: Comparison between severity and incidence at fungicide spray trial, Bairnsdale, 2004.

Purple spot

One fungicide, chlorothalonil effectively reduced purple spot, supporting previous research on the management of purple spot (HAL project VX01024). Fungicide efficacy was assessed by percentage defoliation.

Table 13 Comparisons of fungicide efficacy on purple spot 2004.
Means assigned the same letter are not significantly different at the 5% level

Fungicide	Defoliation(%)	Number of sprays (chlorothalonil)	(total)	Application interval
difenaconazole/chlorothalonil	31a	2	5	28 days
pyraclostrobin	49ab		5	14 days
chlorothalonil	53abc	5	5	14 days
myclobutanil/chlorothalonil	54abc	2	5	28 days
propiconazole/chlorothalonil	55abc	2	5	28 days
metiram/chlorothalonil	65bc	2	5	28 days
tebuconazole/chlorothalonil	74bc	2	5	28 days
difenaconazole	78c		5	14 days
mancozeb/copper	100d		5	14 days
tebuconazole	100d		5	14 days
propiconazole	100d		5	14 days
control	100d		5	14 days
l.s.d	25.3			

Conclusions

- *Three fungicides were effective in reducing the incidence and severity of asparagus rust but were all DMI fungicides from the fungicide activity, Group C. This has implications for resistance build up within the rust population and therefore any spray program should be formulated with this in mind ie keeping the number of applications to a minimum per season.*

  NB If rust builds resistance to one Group C fungicide then the disease will not be controlled by Group C fungicides. (Source: BayerCropScience product label)

  Based on the results of this fungicide trial, more research is required to tailor spray programs for the foliar diseases, purple spot and rust, to ensure that spraying is cost effective and does not compromise resistance management. The cost ($Aus) of applying fungicides proven effective against rust in the USA and in trials conducted in Victoria was estimated at:

  (based on retail prices May 2004)

Tebuconazole @ 290ml/ha	*$30.14/ha*
Difenaconazole @ 500ml/ha	*$84.15/ha*
Propiconazole @ 600ml/ha	*$40.42/ha*

  A cost analysis on the three effective fungicides suggests there is a range of chemical costs so can some fungicides be applied at lower rates reducing cost?

  Note: The spray applications were at 14 days intervals, the protectant fungicides trialed may require a 7 day spray application to be effective. Will growers have the ability to apply fungicides at 7 day intervals? Further research is required.

- *Treatments containing chlorothalonil reduced purple spot disease. In addition, a 14 day application of pyraclostrobin also reduced disease but in all previous trials, strobilurin fungicides were not effective against purple spot. The applications containing chlorothalonil were applied either at 14 day or 28 day intervals significantly reducing the defoliation effect of purple spot on the asparagus fern. Chlorothalonil alternated with difenaconazole appeared to have an enhanced efficacy over chlorothalonil alone. Chlorothalonil applied every 28 days significantly reduced the number of sprays required for disease reduction, but may not achieve the level of control required. A disease threshold was established for the spray program against purple spot (refer Factsheet 5).*

5.5. Debris Treatment Trials

Current practice for debris removal is to slash, or mulch in some instances, the dormant fern with a hay mower, windrow six rows into one and then burn the windrow with a flamethrower. Observations were made that there was still significant debris left on the soil surface (Figure 12).

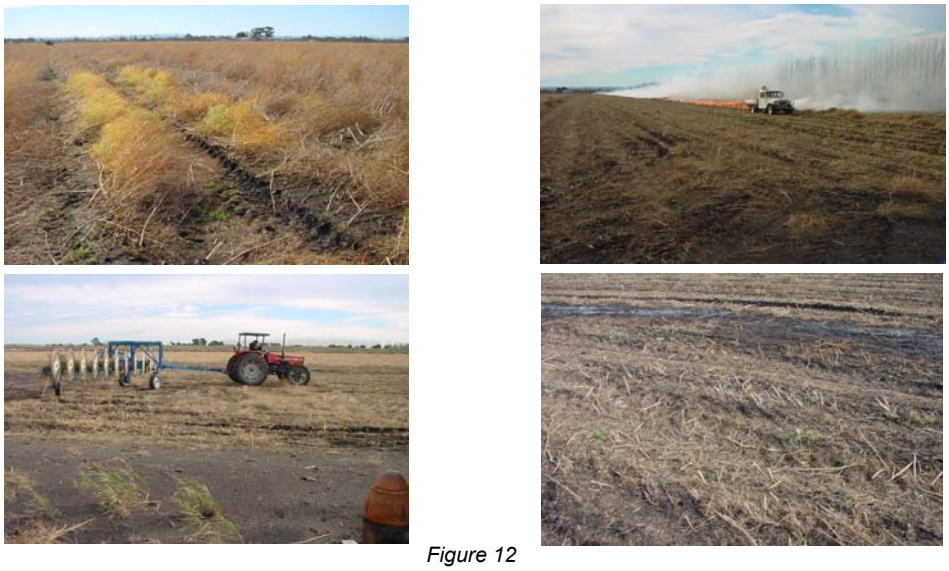


Figure 12

Current fern debris removal strategies, Kooweerup 2002. Debris treatment trials conducted on Kooweerup site, 2002.

5.5.1 Debris Treatment Trial 2002.

Debris treatment trials conducted on Kooweerup site, 2002 to examine the effects of different treatments on yield and disease in the subsequent harvest.

Materials and Methods

Five soil amendments (Table 14) were applied to the trial site, replicated five times. Two mesh bags each containing diseased cladophylls (needles) and stem material were buried in each treatment plot and removed at two time intervals during the harvest period, August and November. The buried debris was assessed for breakdown and *Stemphylium vesicarium* viability. Yield and disease incidence and severity were measured at harvest.

Table 14 Soil amendments applied to trial site, 2002

Treatment	
(A) Mow, rake, burn, add hot lime @1000kg/acre, hill	(Hot lime GBA)
(B) Mow, rake, burn, hill and add hot lime @1000kg/acre	(Hot lime GBA)
(C) Mow, rake, burn, add liquid nitrogen @50L/ha, hill	(Liquid N)
(D) Mow, rake, burn, add hot lime @500kg/acre, hill	(Hot lime GBA)
(E) Control, mow, rake, burn and hill	

Disease incidence and severity were assessed at harvest by harvesting each plot and scoring the level of disease (low=<5 lesions/spear, medium=6-10 lesions per spear, high=>10 lesions per spear). Yields were also measured between the trial treatments by harvesting and measuring the weight and number of spears per plot. This method was less than ideal as the product harvested was only a representation of the day's pick because the area had already been commercially harvested early that morning.

Results

Any differences between the effect of the treatments on fungal viability could not be analysed due in part to the techniques used for assessing the debris bags because the replicates were pooled. When the debris was subjectively assessed for breakdown, very little decomposition had taken place even by the second assessment in November. A 5-10% decomposition percentage was observed across all treatments. Given the low incidence and severity of the disease, three disease events of low incidence and low severity, no differences in the effect of the different treatments could be seen.
There were no significant differences between the treatments in terms of yield (Table 15). Due to the difficulty in obtaining adequate sample size another method of measuring yield will be investigated for the following year's trial.

Table 15 Yield of spears from the five soil amendment treatments, 2002.

Treatment	Mean Number of spears	Mean Weight of spears (g)
A	143.2	37.65
B	152.6	38.92
C	145	39.23
D	151.2	38.63
E	146.4	37.19
l.s.d (5%)	23.74	3.987

Conclusions

The rainfall in 2002 was below average during winter and spring in the Kooweerup region. These environmental conditions may have hindered the activity of the hot lime and nitrogen amendments. As the disease did not develop to any economic extent no conclusions could be made as to the efficacy of

the treatments in reducing disease. Observations of the extent of decomposition of the debris indicated that it was very resistant to breakdown in the soil given low soil moisture.

5.5.2 Debris treatment trials conducted on Kooweerup site, 2003

Materials and Methods

Two trials were conducted, one scoping trial to investigate complete removal of fern debris and the other to investigate soil amendments, with eleven treatments including control (Table 16) applied after slashing the fern in May, 2003. Spears were assessed at harvest for efficacy of amendments on disease incidence, severity and yield. Mesh bags containing diseased fern debris were buried in the treatment plots and removed at two time intervals to assess effects of soil amendments on debris breakdown and *Stemphylium vesicarium* viability. Yield was assessed using a different method than for the 2002 trial. The diameter and height of spears were measured and a formula was developed to calculate average spear weight.

Table 16 Debris treatment trial, 2003.

Treatment Number	Treatment	Rate
1	Control (slash, burn, hill)	
2	GBA hot lime before hilling (1)	1 ton/ac
3	GBA hot lime before hilling(2)	2 ton/ac
4	Chlorothalonil on debris prehill	2l/ha
5	Chlorothalonil on debris pre and post hill	2L/ha
6	Chlorothalonil posthill	2L/ha
7	Liquid N pre hill	100L/ha half strength
8	Liquid N pre and post hill	100L/ha half strength
9	Liquid N post hill	100L/ha half strength
10	Watered	20L/row=12.5mm
11	Dry composted chicken manure pre hill	10kg/rep =3278kg/ha

The complete removal of fern was conducted after the grower had slashed the fern. This scoping trial left the researchers in no doubt that this method of reducing diseased fern is impractical due to the scale of the task and lack of machinery to perform the task adequately. The amount of small pieces of fern and needle litter left with visible pseudothecia was still considerable and given that this debris showed little or no decomposition at harvest, would provide a significant source of disease.

(a)

(b)

(c)

Figure 13
(a) Applying soil amendments trial 1.
(b) Complete removal scoping trial
(c) Debris left on ground after removal.

Results

Stemphylium vesicarium had not lost viability due to any of the treatments by the first time interval in August. By the second assessment in early December, viability had been reduced in some treatments (Table 17). Liquid nitrogen pre and post hilling, chicken manure pre hilling and chlorothalonil pre and post hilling all reduced the viability of the fungus significantly, but there was still enough inoculum to cause a disease event. The analysis conducted on this trial was an analysis of percentage viability. Analysed by REML algorithm rather than ANOVA as the trial design was not balanced.

Table 17 Analysis of the effects of soil amendments on debris breakdown 2003 (viability).
(p=0.05)
Means assigned the same letter are not significantly different at the 5% level

Treatment	Treatment name	Mean
0	Control (slash, burn, hill)	90.62a
1	GBA hot lime before hilling(1)	87.50a
2	GBA hot lime before hilling(2)	87.50a
3	Chlorothalonil on debris prehill	87.50a
4	Chlorothalonil on debris pre and post hill	45.83b
5	Chlorothalonil posthill	62.50a
6	Liquid N pre hill	87.50a
7	Liquid N pre and post hill	37.50b
8	Liquid N post hill	87.50a
9	Watered	84.38a
11	Dry composted chicken manure pre hill	45.83b

Although it was not possible to harvest and weigh the asparagus spears from the trial, it was possible to measure the length and diameter of unharvested spears. Therefore, a method of estimating spear weight was devised using an estimate of spear volume assuming a spear to be cylindrical in shape. On two occasions, once early in the season (11.09.03) and later in the season (15.10.03), a large number of spears from one packhouse were weighed and the length and diameter of each spear was recorded. The relationships between the weight of the spears and their volume were estimated using regression analysis.

This relationship was then used to estimate average spear weight in the debris trial (Table 18). Analysis of variance on these weights showed significant differences between the treatments in the debris trial. For the spray trial (discussed earlier), only spears from three treatments were measured. Using analysis of variance on these weights showed no significant treatment differences.
Note that we are not presenting actual weights because the relationship between the length, diameter and weight changes during the season.

Table 18 Yield of spears from treatments 2003.
Means assigned the same letter are not significantly different at the 5% level

Treatment	Treatment name	Spear weight (av estimated)
0	Control (slash, burn, hill)	28.44a
1	GBA hot lime before hilling(1)	26.86a
2	GBA hot lime before hilling(2)	29.44a
3	Chlorothalonil on debris prehill	27.36a
4	Chlorothalonil on debris pre and post hill	27.39a
5	Chlorothalonil posthill	28.50a
6	Liquid N pre hill	27.03a
7	Liquid N pre and post hill	28.59a
8	Liquid N post hill	28.83a
9	Watered	28.49a
11	Dry composted chicken manure pre hill	30.57b
l.s.d		1.927

The only treatment that significantly increased yield was the application of chicken manure at a rate of 3278kg/ha (1.3ton/ac).
There was little disease development during the harvest of 2003, with low incidence and severity (one to two lesions per spear) recorded at three time intervals in October 2003. These disease events were preceded 7 days before by a significant wet event (15-25 hours leaf wetness) accompanied by temperatures averaging 9.5^0C. Volunteer seedlings were collected and assessed for purple spot. The seedlings were found to be infected early in October with lesions and potentially provided high disease pressure to the emerging spears. The harvest period was shorter due to cooler weather and disease did not impact economically.

Conclusions

Only one soil amendment, composted chicken manure at 3278kg/ha, had any effect on reducing the viability of Stemphylium vesicarium under dry cool conditions. This reduction still allowed for almost 40% spore viability which given the amount of diseased debris present in the soil is high enough to initiate disease. All treatments should be trialed under wet conditions to determine the effects of nitrogen and hot lime in the soil and the effects of these treatments on the soil microflora under more normal conditions.
As the disease was minimal and did not impact economically no treatment could be assessed for its effect on reducing disease development on spears. Volunteer seedlings were observed with purple spot lesions early October, and these seedlings remained on the beds providing inoculum through the harvest period. Given the high disease pressure from the volunteer seedlings, there would have been more disease development on spears if conditions had been conducive to purple spot.

5.6. Seed Hygiene

Materials and Methods

Seed from sixteen different asparagus varieties was imported into Australia to test for diseases that may be carried into the growing cycle. As per International Seed Testing Authority protocols 400 seed (95% confidence level that <1% is infected) from each lot were either surface sterilised with ethanol or left untreated and then plated onto Coon's agar to test for external and internal fungal pathogens. Three seed lots that had been treated by the suppliers with a seed dressing were subjected to an extra water rinse treatment before plating out. A scoping trial was conducted utilising a steam air seed sterilising unit with three treatments, 48^oC/30 minutes, 52^oC/30 minutes and 56^oC/30 minutes. The seed lots used were known to be contaminated with *Stemphylium vesicarium* and *Fusarium* spp. (previous seed health study, Table 19). A separate scoping trial was conducted on the effect of different treatments on seed pathogens using 70% ethanol, 70% methylated spirits (commercial) and 1% NaOCl. The seed used for this scoping trial was a commercial UC157 lot imported by an asparagus grower.

Results

A total of 41 fungi and yeast species were isolated from the seed lots. Of particular interest (Table 19), *Stemphylium vesicarium* was isolated from 5 out of 16 seed samples, as an external contaminant in 4 seed lots and an internal contaminant in 2 samples. *Fusarium moniliforme* was found in 8 of the 16 samples as an external contaminant but was not found internally. Similarly, *Fusarium proliferatum* was isolated as an external contaminant of 5 seed samples but was not found internally and *Fusarium oxysporum* was isolated as an external contaminant from 1 seed lot. *Botrytis* sp. was isolated in 7 samples and in one sample was an internal contaminant. *Penicillium* spp. were isolated from all seed lots and in 7 instances this contaminant was internal. Germination was not compromised significantly by the ethanol treatment (Table 20); the advantage of the disinfestation treatment was to decrease the amount of post emergent contamination. Therefore this study suggests that a 10 minute agitated soak in 70% alcohol (eg methylated spirits) will rid seed of most fungal contaminants (Table 22). However, a

percentage of internal seed contaminants eg *Stemphylium vesicarium*, *Botrytis cinerea*, *Penicillium* spp. and *Aspergillus niger* were not controlled by the 70% ethanol treatment.

Table 19 Summary of mycoflora pathogenic to asparagus isolated from 16 asparagus seed lots, 2003.

Fungus (asparagus pathogens or spoilage fungi)	Number of seed samples with,		Highest Infection Level	Pretreated Seed health (3 lots)	Control with Surface Sterilisation?
	Internal Infection %	External Infection %	%	Infection %	
Botrytis cinerea	1	7	0.5	0	NO
Fusarium moniliforme	0	8	4.8	0	YES
Fusarium proliferatum	0	5	1.0	1	YES
Fusarium oxysporum	0	1	0.25	0	YES
Stemphylium vesicarium	2	4	0.5	0	NO
Penicillium spp.	7	16	17.25	2	NO
Aspergillus niger	4	11	41.25	0	NO

Table 20 Germination trial results, untreated and treated asparagus seed.

Assessments	Untreated	Treated (70% ethanol/10 minutes)
% germination	98%	95.8%
% radicle death (contaminated)	9%	1.7%
% post-emergence contamination	98%	9.7%

The two seed lots treated with steam air at three temperatures were plated out to assess for disinfestation and germination. Results (Table 20 and 21):

Table 21 Steam air treatment of two seed lots, 2003.

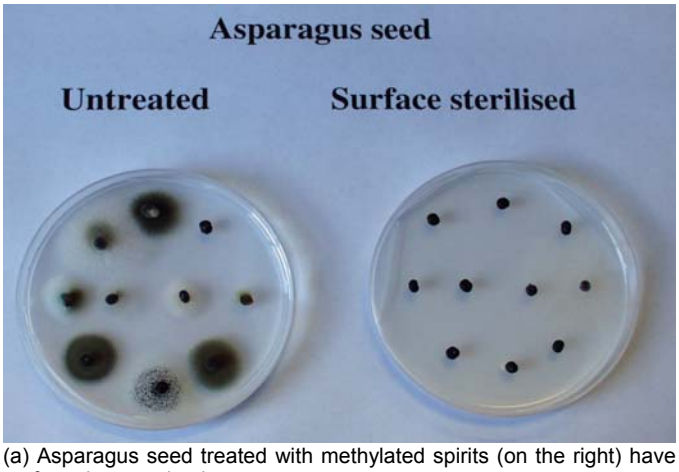
Treatment	Control untreated average %		48°C/30 minutes		52°C/30 minutes		56°C/30 minutes	
Seed Lot	D	E	D	E	D	E	D	E
Botrytis cinerea	0.25	0.5	0	0	0	0	0	0
Fusarium moniliforme	2.5	0.5	0	0.25	0.25	0	0	0.25
Fusarium proliferatum	0	0.25	0	0	0	0	0	0
Fusarium oxysporum	0	0	0	0	0	0	0	0
Stemphylium vesicarium	0.25	0.5	0	0	0	0	0	0
Penicillium spp.	8	10.5	5.5	1	1.75	0	0.25	0
Aspergillus niger	25	13.5	10.75	3.25	15.5	0.5	6	0.25

Steam air treatment reduced and in some instances eliminated internal and external fungal contaminants from seed (Table 21). However, in one instance, *Fusarium moniliforme* was not eliminated with the steam air treatment whereas it was controlled by ethanol disinfestation (Table 21). Germination trials were conducted with all seed lots treated in the steam air trial but significant drying out of the seeds occurred during incubation. It did appear that germination was not compromised although this was not tested statistically, the test would need to be repeated to satisfy ISTA (International Seed Testing Authority) standards as values were out of the acceptable tolerance range.

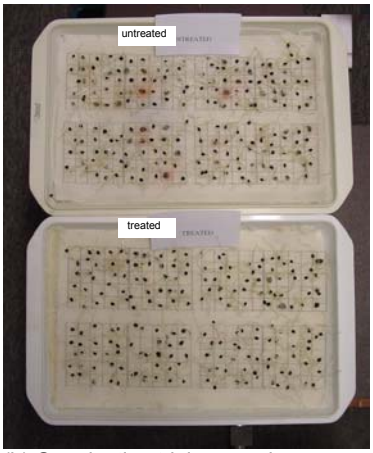
Table 22 Effect of ten minutes of 70% ethanol, NaOCl and methylated spirits seed disinfestation treatments on pathogenic fungi of asparagus seed, 2003.

Treatment	Control	NaOCl	Ethanol	Methylated Spirits
Botrytis cinerea	7.75	0	0	0
Fusarium moniliform	1	0	0	0
Fusarium proliferatu	0.75	0	0	0
Penicillium spp.	77.25	0.25	0	0
Aspergillus niger	22.75	0.25	0	0

70% commercial methylated spirits provided the same disinfestation control as that of 70% laboratory grade ethanol (Table 22).



(a) Asparagus seed treated with methylated spirits (on the right) have no fungal contamination.



(b) Germination trial comparing treated to untreated.

Figure 14 (a) Asparagus seed treatment and (b) germination.

Conclusions

Seven asparagus fungal pathogens were isolated from asparagus seed. These pathogens have the ability to damage the seed or transmit via the seed diseases that limit production. Stemphylium vesicarium., Fusarium spp.*, Penicillium* spp.*, Aspergillus* spp. *and Botrytis cinerea were present on seed and in some instances, for example Stemphylium vesicarium, were under the seedcoat. The spoilage fungi for example Penicillium* spp. *have the potential to affect germination rates of seed.*
A wide range of seed borne pathogens on asparagus seed can be controlled with a 10-minute dip in 70% alcohol. However, control of Stemphylium vesicarium present internally in seed requires different treatments and further work needs to be undertaken to identify the most effective disinfestation protocols. A scoping trial showed that steam air treatment does have potential to reduce seed pathogens without affecting germination at 52^{o}C for 30 minutes (Table 21). The scoping trial on the efficacy of different seed disinfestation treatments showed that methylated spirits provides equivalent control to ethanol. Methylated spirits is readily available over-the-counter and is cheaper than laboratory grade ethanol. Seed hygiene protocol produced and distributed to growers (Factsheet No 1).

5.7. Nursery Crown Hygiene

Materials and Methods

First year nursery crowns ie planted from seed 8-12 months earlier, were collected from six different growers. The crowns were collected from coolrooms or nursery beds and tested for the presence of asparagus fungal diseases. Plant residues and soil from one replant paddock and two ploughed pasture paddocks were also tested for *Stemphylium vesicarium.*

Results

New ground		No *Stemphylium vesicarium*. *Fusarium* sp. detected.
Replant ground	-	No *Stemphylium vesicarium*. *Fusarium* sp. detected.
1.Crowns	-	*Phytophthora* sp. and *Fusarium* sp. detected.
2.Crowns	-	*Fusarium* sp. detected.
3.Crowns	-	*Stemphylium vesicarium, Fusarium* sp. and *Penicillium* sp. detected.

4.Crowns - *Stemphylium vesicarium* and *Fusarium* sp. detected.
5.Crowns - *Stemphylium vesicarium* and *Fusarium* sp. detected.
6.Crowns - *Stemphylium vesicarium* and *Fusarium* sp. detected.

Four out of six crown lots tested were found to be infected with *Stemphylium vesicarium* which causes purple spot disease on the ferns and spears. All crowns were infected with *Fusarium* sp. which was isolated from root rots. One crown lot was infected with *Phytophthora* sp. Both replant and new ground were found to contain *Fusarium* sp.

Conclusions

Nursery crown health was compromised by the presence of the three foliar and soil-borne fungi. These fungi are responsible for the major diseases, purple spot, Fusarium root rot and stem rot and Phytophthora spear rot. Stemphylium vesicarium was present as overwintering pseudothecia on fern stubble left on the crowns after they were lifted from the soil, indicating that the fern had become infected at fern stage. The soil-borne Fusarium and Phytophthora fungi may have been present in the soil before the asparagus was planted but in the case of Fusarium, may also have been seed-borne. Fusarium was detected in both new and replant soils, indicating that this fungus can be found in soil without a history of asparagus production.
This investigation highlights that crowns are not being produced under high hygiene conditions and measures must be taken to improve this. Timely fungicide spray applications for foliar diseases, use of registered soil treatments for Phytophthora disease and monitoring for nutrient deficiencies can assist in preventing disease. Nursery crown hygiene protocols produced and distributed to growers (Factsheet No.2).

5.8. Using DNA sequencing to further identify which *Stemphylium* sp. is the causal agent of purple spot of asparagus in Victoria

Using DNA sequencing, we established that the causal organism isolated from purple spot lesions is *Stemphylium vesicarium* and not *Stemphylium botryosum* (some longstanding confusion between the species and associated purple spot disease).

Materials and methods and results

Isolates for this work were sourced from a collection of *Stemphylium* cultures collected from sites around Victoria. Pure cultures of *Stemphylium* were grown and extracted for PCR ready genomic DNA. The extracts were then PCR'd using glyceraldehyde-3- phosphate dehydrogenase primers. The resulting sequences were analysed and compared against GenBank sequences of *Stemphylium* species to differentiate between isolates and establish the causal agent of purple spot in southern Victoria.

The results of this work are summarised in a paper submitted for publication to Australasian Plant Pathology, 2004 as follows:

Purple spot of asparagus caused by *Stemphylium vesicarium* in Victoria
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Abstract. Purple spot of asparagus is a disease of increasing importance in Victoria and Australia. Glyceraldehyde-3-phosphate dehydrogenase sequences revealed the causal agent of purple spot of

asparagus to be *Stemphylium vesicarium*, rather than the often-reported *S. botryosum*. Implications for disease control are discussed.

Purple spot of asparagus (*Asparagus officinalis*), also known as asparagus leaf spot, stemphylium leaf spot and "summer burning" of asparagus, is a common disease occurring in most parts of the world where asparagus is commercially grown. In Victoria, purple spot occurs in the majority of growing regions and causes extensive economic loss at harvest and compromises the photosynthetic potential of the plant by prematurely defoliating the fern.

Two species of fungus are reported in the literature to cause purple spot of asparagus. These are *Stemphylium vesicarium* and *Stemphylium botryosum*. Both species have been recorded on asparagus in Australia (herbarium DAR, VPRI and BRIP records), but this association in Australia has not been noted in the scientific literature. *Stemphylium vesicarium* has been identified as the cause of purple spot of asparagus in New Zealand (Menzies *et al*., 1992) and South Africa (Thompson & Uys, 1992), while *S. botryosum* has been recorded from Europe (Elena, 1996; Leuprecht, 1988).

Species in this group of *Stemphylium* can be very difficult to identify, but recent molecular studies have shown that *S. vesicarium* can be differentiated from *S. botryosum* by glyceraldehyde-3-phosphate dehydrogenase (GPD) gene sequences, which have been shown to be much more variable than the ribosomal RNA internal transcribed spacer regions (Câmara *et al*. 2002). However, it was found that GPD sequences would not differentiate *S. vesicarium* from the similar species *S. herbarum* and *S. alfalfae*. To determine the identity of the causal agent of purple spot in Victoria, the GPD gene from seven *Stemphylium* isolates (Table 1) was sequenced using the methods described by Câmara *et al* (2002). Comparison with GenBank sequences revealed all sequences to be identical to *S. vesicarium* (as well as *S. herbarum* and *S. alfalfae*). These sequences have been deposited on GenBank (Table 5.7.1).

This brief study has provided the first DNA sequence data from *Stemphylium* species causing purple spot of asparagus. The GPD sequences were identical with sequences on GenBank for *S. vesicarium*, *S. herbarum* and *S. alfalfae*. This similarity was discussed by Câmara *et al*. (2002) who suggested that these three taxa could be conspecific, and that the morphological characters used to differentiate these species, ie. conidial septum development and slight differences in conidial ornamentation, were not useful. Although all the isolates used by Câmara *et al*. were from legume hosts, Câmara's study has shown that GPD sequences do not differentiate isolates within this species group. Therefore GDP sequences cannot be used to differentiate isolates derived from different host families, ie. Fabaceae (legumes) and Liliaceae (eg. asparagus).

The differentiation of *S. vesicarium* from *S. botryosum* is important as these two species have different biological properties that may affect disease management. In particular, *S. botryosum* takes 8 months to form fertile ascospores (at least in culture) compared to as little as 3 months for *S. vesicarium*. As most growers have adopted a no-till cultural program, the ascomata of *S. vesicarium* in the fern debris from the previous season are the primary source of inoculum. Given the speed with which fertile ascomata are produced by *S. vesicarium*, infection of spears and volunteer seedlings has been observed at the beginning of harvest. Therefore, as a preventative management strategy, the debris should be buried quickly and deep enough to prevent ascospore dispersal, and long enough to facilitate decomposition.

References

Câmara MPS, O'Neill NR, van Berkum PB (2002) Molecular phylogeny of *Stemphylium* spp. based on ITS and glyceraldehyde-3-phosphate dehydrogenase gene sequences. *Mycologia* **94:** 660-672.

Elena K (1996) First report of *Stemphylium botryosum* causing *Stemphylium* leaf spot of asparagus in Greece. *Plant Disease* **80:** 342.

Leuprecht B (1988) *Stemphylium*, an important disease of asparagus. *Gemuse Munchen* **24:** 235-236.

Menzies SA, Broadhurst PG, Triggs CM (1992) *Stemphylium* disease of asparagus (*Asparagus officinalis* L.) in New Zealand. *New Zealand Journal of Crop and Horticultural Science* **20:** 427-433.

Thompson AH, Uys MDR (1992) *Stemphylium vesicarium* on asparagus: a first report from South Africa. *Phytophylactica* **24:** 351-353.

Table 23 Stemphylium vesicarium specimens from asparagus used to obtain glyceraldehyde-3-phosphate dehydrogenase *partial gene sequences*.

Specimen	Habit	Location	GenBank Accession
VPRI (1)	Fern	Kooweerup, Vic.9 May 2002	To be added
VPRI (2)	Fern	Nar Nar Goon, Vic.,9 May 2002	To be added
VPRI (4)	Debris	Kooweerup, Vic.,12 July 2001	To be added
VPRI (6)	Roadside volunteer	Kooweerup, Vic.,15 May 2002	To be added
VPRI (8)	Debris	Cranbourne, Vic. 17 July 2001	To be added
VPRI (9)	Fern	Clydebank, Vic., 30 December 2001	To be added
VPRI (10)	Fern	Mildura, Vic.,1 May 2002	To be added

Conclusions

The causal agent for purple spot of asparagus in Victoria is Stemphylium vesicarium, not Stemphylium botryosum as is sometimes recorded in the literature. The identification of the causal agent of purple spot as Stemphylium vesicarium highlights the advantages of DNA sequencing as a tool to further explore idiosyncrasies of different but closely related fungal species. This study identified Stemphylium vesicarium as the causal agent of purple spot of asparagus. This particular species exhibits early maturation in culture which translates to the early expression of disease in the field. As discussed in the above study, the management of purple spot disease in the asparagus crop requires the cycle of ascospore production to be interrupted by burying debris sufficiently to facilitate decomposition, or at best eliminated from by removing the carry-over inoculum on the fern with the use of fungicides.

6. DISCUSSION

The results presented in this report are a culmination of three years of trials on the cultural and chemical control of purple spot under southern Victorian conditions. At present the southern Victorian asparagus industry has few management tools for the control of purple spot disease. There are no fungicides registered for use against purple spot and if available fungicide use would be restricted for use at fern stage only. This project investigated control measures utilised overseas, in particular United States and management protocols for asparagus crop hygiene were developed based on trial results. The protocols are presented as a series of factsheets. In addition, a pocket guide to assist growers in the identification of major pests, diseases, disorders and weeds of asparagus was produced. This guide has an added benefit as it also includes up-to-date information on three new diseases which have recently been detected in Australia.
The information contained in the management protocols is of benefit to the industry only if the uptake is universal. Due to falling asparagus prices and other economic pressures on growers over the past three years, adoption of fungicide spray programs may be seen as an additional cost which some small growers may not be able to meet. It is therefore imperative that the Australian Asparagus Association is seen to actively endorse the outcomes of this research.
The following project outcomes are discussed:

- Purple spot disease cycles with the asparagus plant and therefore does not require alternative hosts for continuity. The most critical disease management periods which can be targeted from a practical farm

management position are at fern stage and during harvest when volunteer seedlings provide another source of disease inoculum.

1. Implementation of a fungicide spray program at first detection of disease at fern stage (fungicides must not be applied to spears). Chlorothalonil is a broad-spectrum protectant fungicide which gives control of purple spot disease at fern stage but this was the only fungicide found to be effective at controlling the disease in this project. This is not an ideal scenario for fungal resistance management. Therefore spray applications must be timed such that a minimal number of applications are applied at a disease threshold that offers control, cost effectiveness and does not compromise market access ie no residues present in produce at harvest. (Refer application for a minor use permit for chlorothalonil, September 2004).
2. Use of non-chemical methods to remove volunteer asparagus seedlings at harvest. Herbicides can not be applied at harvest and so seedlings must be removed mechanically. This operation poses problems as emerging spears may also be removed. Future research is aimed at preventing seed formation therefore eliminating the seedling weed problem.
3. Mulching fern debris finely to facilitate decomposition. Current practice amongst many growers is to slash and leave the large ferns in the paddock. Complete removal of fern is impractical as the disease inoculum is present not only on the large stems but also on the small needles which fall to the ground in great numbers. Research showed that fern debris including needles does not breakdown in the short period of time before harvest and no soil treatments assisted in decomposition to any significance. This is due in part to dry winters with lower than average rainfall and the short period of time that the debris remained in the soil before harvest, an average of 2 months. A return to average or above average rainfall would assist in the breakdown of debris and reduce disease inoculum. Mulching the fern as finely as possible allows more penetration of microbes and more exposure to moisture.
4. The disease prediction model Tom-Cast did not assist with timing of spray application. In the first year of research modelling reduced the number of spray applications but subsequent testing of the model against several disease severity values did not show any benefits compared to scouting and late season calendar spray programs. The Tom-Cast model was shown to be of benefit to growers in Michigan State, US. Under their conditions, the period of fern growth before it is covered with snow is shorter, late June –September compared to December – end May in southern Australia. The shorter fern stage allows a narrower window to gather disease severity values which allows fewer sprays to be applied.
5. Scouting provided a more reliable method of purple spot disease detection, and spray applications could be applied at a disease threshold. This reduced the number of application compared to a calendar spray program without compromising disease control. During the three years of research purple spot disease did not develop until very late in the fern cycle and therefore few sprays were required. However, wet summer conditions will be more favourable to disease development.

- Implementation of seed and nursery hygiene measures will prevent most diseases entering into a new crop. However, contaminated machinery and persons moving from a diseased area to a clean area can initiate a disease situation as diseases such as purple spot can carry over on fern debris which may be carried into a new crop. Treating seed will lower the risk of diseases entering the crop and not compromise germination but will not eliminate all seedborne diseases. Further examination of seed treatments such as steam air needs to be undertaken. Suppliers also need to be made aware of the disease status of their seed before exporting and importers may request a seed disinfestation protocol be conducted on the seed before import.
- Three fungicides, tebuconazole, propiconazole and difenaconazole were found to control asparagus rust in a trial. The fungicides were applied before symptoms of rust were visible but adjacent to a severely infected paddock. Within two weeks rust symptoms were visible at the trial site. The fungicides were alternated with chlorothalonil which controls purple spot and were effective when applied every 28 days, reducing the number of sprays to three compared to a 14 day spray program of 6 sprays. These three fungicides are from the same fungicide resistance management group C. Further research is required to find alternating fungicides to lower the risk of resistance developing in the rust population. These

fungicides may also be applied at the first symptoms of rust ie scouting (Hausbeck per comm) but due to the speed at which rust develops this would have to be investigated further. The three fungicides do not control purple spot.

7. TECHNOLOGY TRANSFER

A range of technology transfer media has been used during this project. These have included presentations at grower meetings, annual reports to industry, monthly project up-dates to the AAC steering committee, poster presentation at conference, scientific paper, factsheets, articles in newsletters and a field demonstration. Details below:

Industry publications

Irvine, G.C. et al (2002). "Project Notes" a summary of project research for the year 2001-2002.

Irvine, G.C. et al (2003). "Project Notes" a summary of project research for the year 2002-2003.

Irvine, G.C. et al (2004). "Project Notes" a summary of project research for the year 2003-2004.

VegCheque "Matter of Facts" pest and disease publications for asparagus industry. Stemphylium (purple spot) of asparagus, Asparagus Rust and Garden Symphilid.

Irvine, G.C. et al (2004). "Pests, diseases, weeds and disorders of asparagus in southern Victoria"

Scientific paper

Cunnington, J.H., Irvine, G.C. (2004) submitted. "Purple spot of asparagus caused by *Stemphylium vesicarium* in Victoria". Australasian Plant Pathology.

Conference and seminar presentations

Irvine, G.C. (2003). Poster presented at the International Plant Pathology Conference, New Zealand, February 2003, "Strategies to control purple spot of asparagus in southern Victoria, Australia".

Irvine, G.C. (2002). Asparagus Growers of Sunraysia, Annual General Meeting. Oral presentation on Stemphylium project and pests and diseases of asparagus in Victoria and threats posed by diseases recently detected in Queensland.

Irvine, G.C. (2004). Grower seminar, Mareeba, Queensland. Oral presentation on *Stemphylium* project and general information regarding Victorian compared to Queensland asparagus growing practices.

Irvine, G.C. (2002). Presentation at AAC Annual General Meeting, July 2002

Irvine, G.C. (2003). Presentation at AAC Annual General Meeting, July 2003

Irvine, G.C. (2004). Presentation at AAC Annual General Meeting, July 2004

Field demonstration

Kooweerup, Victoria (March, 2004). Method of application demonstration. Helicopter and tractor boom spray. Assisted by VegCheque.

Research up-dates and general correspondence (Australian Asparagus Council (AAC))

1. AAC meeting (project proposal to AAC Steering committee) at DPI Knoxfield, 18th May 2001.

2. AAC meeting (Proposal put to grower steering committee) at Jo Vizzari's, 28th May 2001.

3. Extension meeting, guest speaker Dr Ed Nigh from University of Arizona, at Kooweerup, 14th June 2001.

4. AAC meeting (Dr Nigh and Bill Jeffery) at DPI Knoxfield, 19th June 2001.

5. AAC meeting (AAC General), research presentation at Kooweerup, 13th September 2001.

6. AAC meeting (AAC Steering committee), research presentation at Kooweerup, 18th February 2002.

7. Ongoing discussions with Dr Cheah (Crop and Food, NZ), Dr Bob Davis (DPI, Queensland) and Biosecurity Victoria, with regard to threat of incursion of asparagus diseases from Queensland.

8. AAC Steering committee meeting, research presentation at Kooweerup, 18th March 2002.

9. AAC meeting: 8th April 2002, presentation given on progress of trials. Article requested for AAC newsletter. Article produced and emailed to AAC.

10. AAC meeting: 13th May 2002, *Stemphylium* project up-date given and info on "field bindweed" given by G. Irvine and Brian Brewer, Elders.

11. AAC meeting: 16th July 2002, AAC AGM. Guest speaker organised, Dr Bob Davis, Queensland DPI spoke about his experience with asparagus diseases in Queensland and Northern Territory.

12. AAC meeting: 22nd August 2002, meeting held at Masonic Hall, Kooweerup for all asparagus growers to discuss urgent chemical residue issues.

13. AAC meeting: 2nd September 2002, follow up meeting to discuss chemical residue issues by working group.

14. AAC meeting: 9th September 2002, *Stemphylium* project up-date given.

15. AAC meeting: 14th October 2002, *Stemphylium* project up-date given.

16. AAC meeting: 11th November 2002, Dr Peter Taylor from CPA gave presentation on potential chemical degradation trials for AAC.

17. AAC meeting: 9th December 2002. Dr Cheah gave presentation to AAC re HAL project on new diseases of asparagus which have occurred in the North of Australia. Stephanie Andreata, Veg-Cheque extension officer was present and passed on apologies from G. Irvine.

18. Discussions with Dr Cheah (Crop and Food, NZ), Dr Bob Davis (DPI, Queensland) and Plant Standards Branch, Victoria, with regard to threat of incursion of asparagus diseases from Queensland, produced a draft proposal to HAL which was accepted and to start in September 2002. Communication has begun with Heidi Martin, researcher on Dr Cheahs' new asparagus project at DPI, Queensland.

19. AAC committee meeting; 10th February 2003, Veg Cheque attended.

20. AAC committee meeting; 11th March 2003, *Stemphylium* project up date.

21. Visit and extension, 8th April 2003, Christine Horlock, researcher from DPI Queensland on new HAL project for control of rust and other diseases.

22. AAC committee meeting; 14th April 2003, *Stemphylium* project up date.

23. AAC committee meeting; 12th May 2003, Veg Cheque attended.

24. AAC committee meeting; 10th June 2003, Project up-date.

25. Ongoing correspondence with Biosecurity Victoria to secure asparagus rust trial funding, Chemical Standards Victoria and Ruth McGowan, State Coordinator of the Horticulture Residue Management.

26. AAC committee meeting; 14th July 2003, *Stemphylium* project up date.

27. "Project notes 2002-2003" including all relevant research results was presented at the AAC AGM on July 22nd, 2003.

28. AAC committee meeting; 11th August 2003, *Stemphylium* project up date.

29. AAC committee meeting; 8th September 2003, *Stemphylium* project up date.

30. AAC committee meeting; 13th October 2003, *Stemphylium* project up date including report on seed testing.

31. Ongoing correspondence with new Veg Cheque extension officer Neville Fernando and production of "Matter of Facts" with Craig Murdoch of Veg Cheque.

32. Asparagus rust was detected in the Kooweerup growing region and this necessitated a response from DPI for information to be extended to growers. There have been two meetings with growers in 2003 relaying up-to-date research findings and photographs of rust to help growers identify rust on their properties.

33. AAC committee meeting; 10th November 2003, *Stemphylium* project up date.

34. AAC committee meeting; 8th December 2003, *Stemphylium* project up date.

35. AAC committee meeting; 9th February 2004, *Stemphylium* project up date.

36. AAC committee meeting; 16th March 2004, *Stemphylium* project up date.

37. AAC committee meeting; 13th April 2004, *Stemphylium* project up date.

38. AAC committee meeting; 10th May 2004, *Stemphylium* project up date.

39. AAC committee meeting; 17th May 2004, Emergency session discussing the rust detection in Kooweerup.

40. Ongoing correspondence with Veg Cheque extension officer Neville Fernando and production of "Matter of Facts" with Craig Murdoch of Veg Cheque.

41. A project proposal was submitted for consideration to HAL to research asparagus rust in southern Victoria. This proposal was unsuccessful in attracting HAL funding.

42. Advice provided to the AAC regarding implementation of an Industry Order (compulsory levy). This levy system was voted on and did not eventuate therefore the current voluntary levy system will remain.

43. "Project notes 2003-2004" including all relevant research results was presented at the AAC AGM on July 20th, 2004. Pocket guide for identification of pests, diseases, weeds and disorders of asparagus in southern Victoria was distributed to industry members.

44. AAC committee meeting; 16th August 2004, *Stemphylium* project up date and presentation of a commercial contract to undertake asparagus rust research for 2004-2005.

8. RECOMMENDATIONS

The outcomes of this research have immediate implications for the control of both purple spot and asparagus rust in Victoria. The recommendations that follow are practical solutions to disease issues that have an economic impact on asparagus production. Some recommendations will incur financial outlays that have not previously been required, but faced with the losses in saleable product and yield, these financial outlays are necessary to achieve sustainable cropping. Success of the recommendations depends on wide acceptance and adoption of the protocols within the industry and ongoing support from the Department of Primary Industries.

Of major concern, research has highlighted the lack of alternate fungicides to control purple spot and asparagus rust. At present there is only one effective fungicide against purple spot and three fungicides from the same fungicide activity group effective against rust. This scenario poses risks of resistance developing in the disease organisms. With the increasing pressure to decrease pesticide use, this is an added complication for vegetable industries. Reducing the number of fungicides applied to crops by implementing scouting and further research into disease predictive modelling will prolong the life of the existing fungicides. There are however investigations required into biocontrol treatments and new groups of fungicides.

Scout for Disease (first line of defence, proactive)

- Scouting for purple spot is essential for the timing of sprays. Scouting should be carried out during fern stage and particularly after rainfall and high humidity conditions. The threshold for this disease is the presence of two lesions within the upper half of a fern. The disease appears to distribute evenly across a paddock so the presence of the lesions on up to 10 ferns appears to be predictive of the status of the whole paddock.

Implement fungicide spray program (reactive to scouting)

- There are no fungicides currently registered for use on asparagus for purple spot disease in Australia. A minor use permit is being sought to allow the use of a protectant fungicide that showed promise in field trials. Timing and good coverage of fern with protectants is critical. The fungicide may be applied by tractor boom (helicopter spraying may also be an option). Based on field trials the first application must be applied as soon as the disease threshold (2 lesions in upper half of fern canopy) is reached and regular applications must be made. A minor use permit will contain details of spray application rates and withholding periods. TEST FOR RESIDUES after any treatment program. (Refer Quality Assurance for Asparagus, a Veg Cheque production, 2002)
- There is one protectant fungicide that adequately controls purple spot based on field trials. However, the reliance on a single protectant fungicide is not ideal as chemical resistance may rapidly build up in the *Stemphylium* population.

Cultural control practices (proactive, good farm management)

- Treat all new seed (refer to Asparagus Factsheet No 1 Seed Health).

- Treat nursery crowns if disease is detected (refer Asparagus Factsheet No 2 Nursery Crown Health).
- Disease carried on dormant fern debris at the end of the growth cycle is the source of disease for the spears at harvest and the next fern stage (which may begin early in October in a young crop). This debris does not breakdown during dry winters (approx 80 days) due to lack of soil moisture. Growers are advised to remove as much fern debris as is practicable, which will reduce but not eliminate the disease due to the presence of diseased small branchlets and needles. To aid decomposition, deep-bury small pieces of debris. Where practical, a final bedform should be carried out to make sure that most of the debris is kept under the soil.
- At harvest, volunteer asparagus seedlings are alternative hosts for purple spot fungi which can infect the emerging spears. Control these seedlings by manually weeding or lightly cultivating the sides of the beds. This will eliminate the majority of the seedlings.
- There are no disease tolerant cultivars recorded to date.
- To date there are no biological control agents available to control purple spot.
- Minimise damage to fern as purple spot forms overwintering structures on dying fern before disease development is observed in the healthy fern.

Recommendations for further research

- Further research is required into the stopgap cultural methods of reducing infected fern until the fungicide spray programs are fully implemented and effective ie. early removal of fern, methods of fern removal other than mulching. These control methods are deemed unnecessary if the fungicide program is successfully implemented.
- Further work on disease predictive modelling.
- Investigate controls for other diseases which threaten the Victorian asparagus industry.
- Further investigate new fungicides for resistance management.
- Investigate disease resistant varieties.
- Investigate biocontrol and other treatments as foliar treatments and soil amendments for enhancing debris decomposition.

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Lavinia Zirnsak DPI, Victoria, Darren Russell-Croucher (Victoria)

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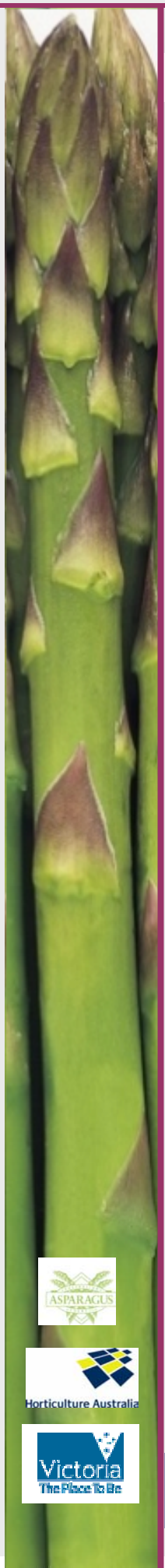
11. **APPENDIX I** Asparagus Factsheets 1- 5

12. **APPENDIX II** Asparagus "Matter of Facts"

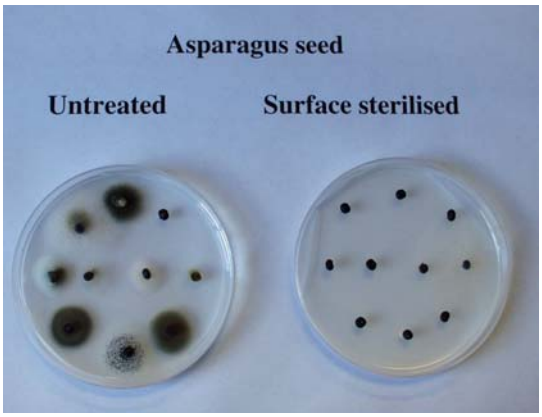
13. **APPENDIX III** "Pests, Diseases, Disorders and Weeds of Asparagus in Southern Victoria"

DEPARTMENT OF PRIMARY INDUSTRIES

Asparagus Factsheet



Facts: Seed Health No 1



Asparagus seed treated with methylated spirits (on the right) have no fungal contamination.

Asparagus seed can be infected with disease-causing fungi such as *Fusarium* and *Stemphylium* and the storage rot fungus *Penicillium* which may affect germination in storage and cause disease when planted.

When seed is imported:

1. Treat all seed just before sowing by soaking and agitating the seed for 10 minutes in 7 parts methylated spirits and 3 parts water. Air dry seeds. Do not treat seeds before storage.
2. Store seed when not in use at 4°C and about 25%-35% humidity. It is important to use seed as soon as possible as germination rates can fall over an extended period of time.

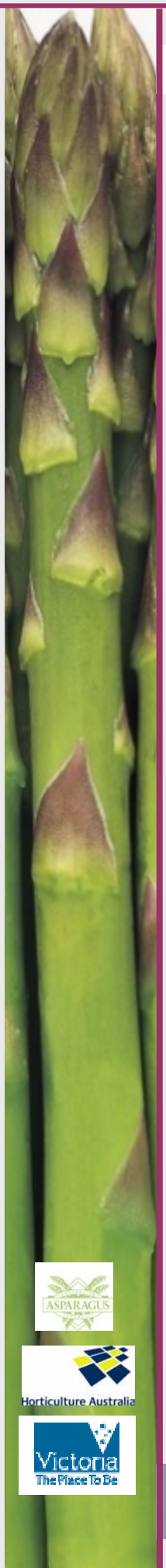
* The rule: once seeds have dried (cured) to the correct moisture level (by weight), store in sealed, air-tight containers like glass jars or doubled Ziploc bags, unless you have the kind of precisely-controlled storage (cold, low humidity) conditions employed by seed companies. Generally, in the home or small farm environment, paper envelopes, cloth bags or cardboard boxes are not suitable for long-term storage.

Mould:

Seeds frequently rot if not dried to the correct moisture level prior to being sealed in glass or plastic. Rule of thumb – if condensation appears on the inside of the container within a few hours of the seed being stored, then further drying is required. Stay right on this one because damp seeds (above 12% seed moisture) will decay (and die) very quickly!

DEPARTMENT OF PRIMARY INDUSTRIES

Asparagus Factsheet



Facts: Nursery Crown Health — No 2

Sources of pests and diseases?

Seeds
Crowns
Established crops
Fungi already present in soil
Headlands (insects and snails/slugs)
Machinery
Border trees (windbreaks) and weeds
Irrigation (timing) and excessive rainfall

Asparagus crowns infected with Fusarium rot.

* Nursery crowns can be infected with disease-causing fungi such as *Fusarium* (root rot), *Stemphylium* (purple spot) and *Phytophthora* (spear rot). These fungi carry over on the crowns into the main production area.
* Diseases include, damping-off of seedlings due to root rot, rotting of spears and stems and the development of purple spot lesions.
* *Fusarium* and *Stemphylium* can be seed-borne and *Fusarium* can be found in soils with no history of asparagus.
* Storage diseases caused by *Penicillium* (blue mould) can occur if crowns are stored incorrectly in coolrooms after lifting. This can further compromise the overall health of the plant.

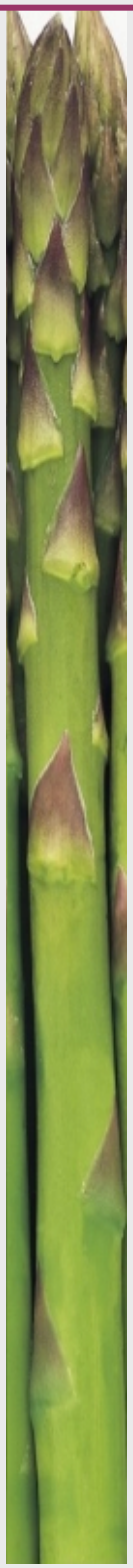
**** Can seedlings be economically produced in greenhouses and planted directly into permanent production paddocks? ****

- Treat all seed and store seed when not in use. (see Fact Sheet 1)
- Inspect seedlings for root rots and purple spot. Control weeds in crop and on headlands. Check for pests and diseases at regular intervals and get positive identification of the pests and diseases found. Apply pesticides when required. Plant directly into permanent paddocks or direct seed into nursery crown paddocks and lift after one year.
- When lifting crowns avoid damage to roots.
- Treat crowns in storage with a registered fungicide. Ideally do not store for long periods in coolrooms. Do not stack more than three crowns deep and keep dry (high humidity can promote rot).
- Wash dirt off crowns and then treat with a registered fungicide in suspension before planting out.

DEPARTMENT OF PRIMARY INDUSTRIES

Asparagus production in southern Victoria

Factsheet No 3



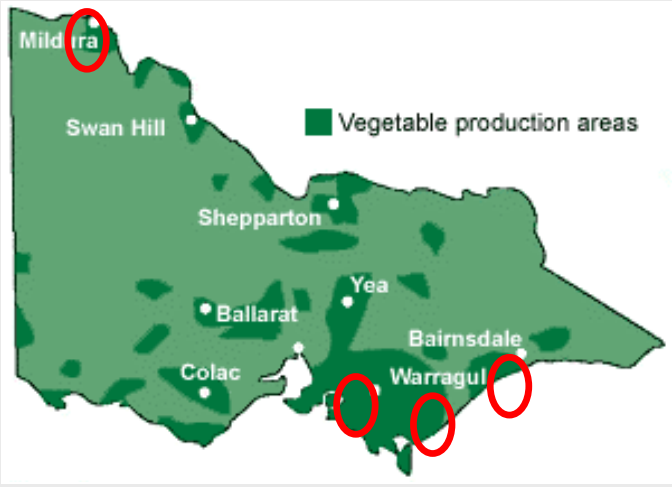
History and Asparagus Production Facts

Asparagus is a perennial vegetable crop that under ideal conditions may produce for 15-20 years. Asparagus produces spears which arise from a woody crown with long fleshy roots. The early colonists introduced asparagus into Australia. During the early 1900s Thomas Roxburgh, a shipping agent, grew the first commercial asparagus on a 300 acre farm in Vervale. By the 1930's, Kooweerup and Dalmore were the major commercial production areas of asparagus in Victoria.

Victoria has a range of soils and climates suitable for asparagus production, including those in Kooweerup, East Gippsland and Lindenow in southern Victoria, and in the Mildura and Swan Hill districts of northwest Victoria. The sandy loams and warm climate in the Mildura and Swan Hill districts favour asparagus production between July and November, whereas the peaty loams and the cooler climate in the Kooweerup area support production between August and December. As a result, Victoria has a longer growing season for asparagus than most other production areas in the world. The asparagus season in Victoria also complements that of other states of Australia and helps provide a continuous supply of product.

In the early days, white blanched asparagus spears - harvested just as the tips emerge from the soil by cutting the spears close to the crown - were mainly destined for the processing and canning factories. Over the years the industry changed to meet changing consumer demand from white asparagus to green asparagus, which is harvested when the spears are 25-30 cm above the soil surface. Speciality demand has recently increased production of white asparagus under polythene tunnels which exclude light.

Most asparagus planted in Australia is the California hybrid UC157 which produces a premium spear of uniform size, length and overall appearance. However, additional varieties are grown in specific regions, such as Mary Washington in southern Victoria and Ida Lea in northwest Victoria. New varieties have enabled growers to increase the numbers of harvests sometimes twice a year. An average harvest season involves up to 60 separate picks. Harvesting is done by hand or with mechanical aids to transport pickers along the rows.



Major asparagus production areas in Victoria 2004.

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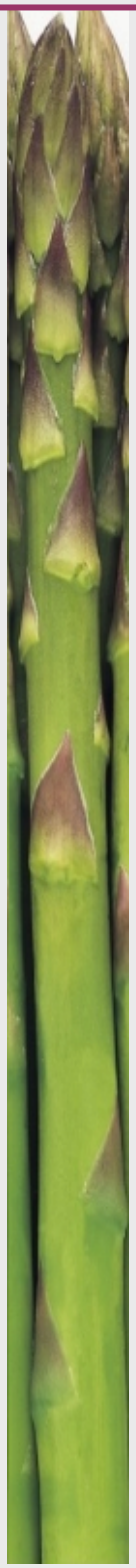
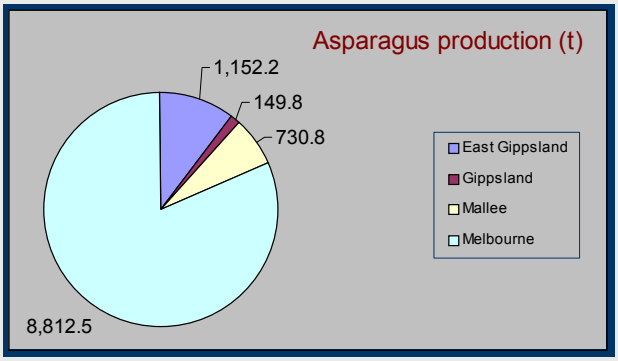


Regional Production Statistics

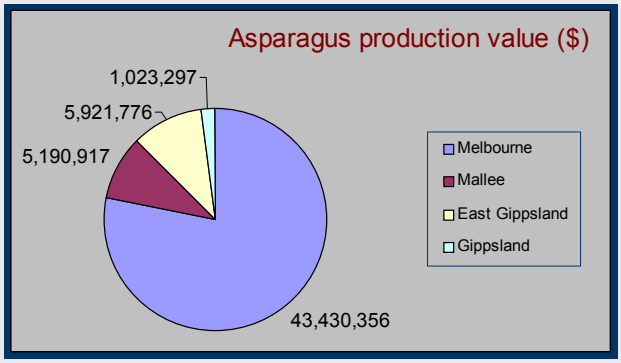
Victoria is the leading state in Australia for the production and export of fresh asparagus, producing 89% of the national asparagus crop with a Gross Value of Production of $56 million (ABS: Agriculture 2002-03). The asparagus production region encompasses the Bairnsdale/Lindenow region through Warragul and the Kooweerup swamp up to Cranbourne.

Production of fresh asparagus in Australia has grown steadily over the past decade to 12,223 tonnes in 2002/03 (ABS 2003). Total area planted to asparagus in Australia for 2003 was 2,286 ha, with 72% in Victoria. Within Victoria, southern growers in the Melbourne/Gippsland region account for about 92% of annual production – 9,964 tonnes in 2002/03 (ABS 2003).

There are 69 growers in the southern Victorian region. Approximately 20 growers based in the Victorian Mallee region produce 1200 tonnes annually. Asparagus is sold off farm to either processors, packing houses or at produce markets. One main processor and several packing houses sell fresh and processed asparagus to supermarkets and other retailers. Two large packing houses account for most asparagus exports, although there are up to 20 packing houses operating throughout southern Victoria.



Graph 1: Source ABS 2003



Graph 2: Source ABS 2003

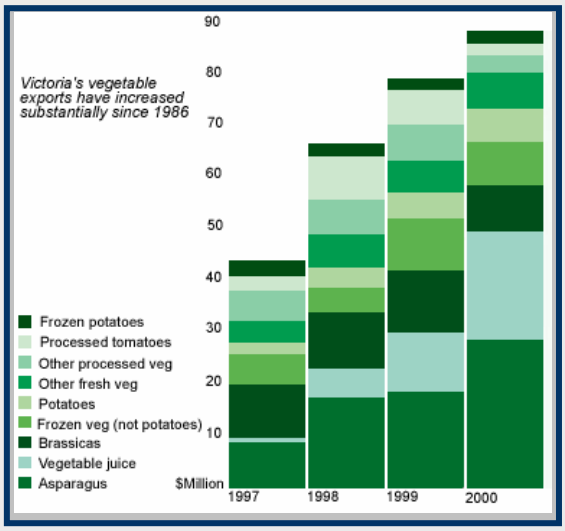
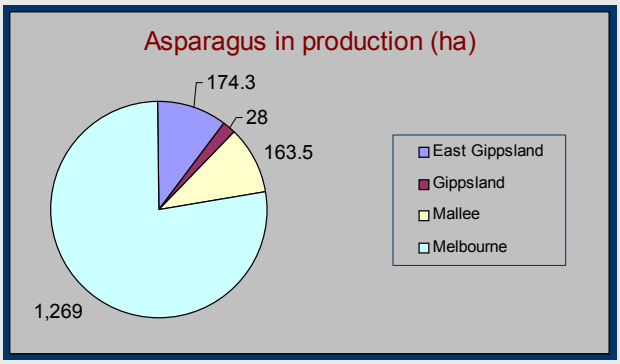
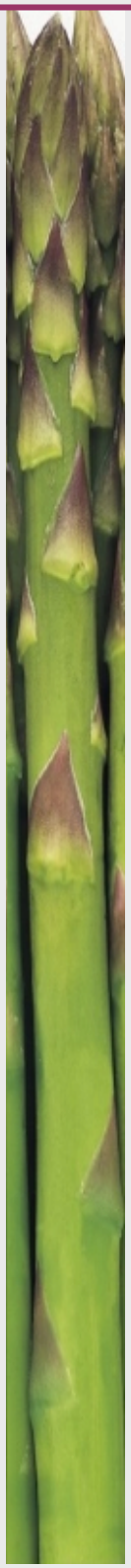


Table 1: Source ABS 2000.



Graph 3: Source ABS 2003



Cultural Practices

Direct seeding

Seed is treated with an ethanol rinse before planting either in nursery fields or occasionally into glasshouse facilities. During the following winter the one-year-old seedlings, known as crowns, are dug and stored until transplanting into permanent beds in spring.

Seedling transplant

Seedlings may be raised in a glasshouse and transplanted into nursery beds or permanent beds. These transplants are planted into furrows 15-20 cm deep with roots draped over an internal mound.

Crowns

One-year-old crowns are planted in spring in furrows which are gradually filled in during the first growing season. Crowns must be of high health and ideally not carry foliar disease such as purple spot or root disease such as Fusarium root rot. These fields are allowed to stand for 1-2 years as non-bearing asparagus. Harvesting begins in the second year but often does not extend for more than 8 weeks so as not to stress the new crowns.

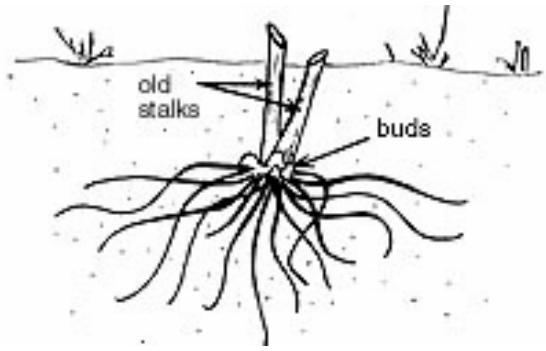
Variety

Currently UC157 (a male/female F1 hybrid) is the variety most suited to southern Victoria, with other small plantings of Ida Lea, Mary Washington, Atlas and purple varieties. UC157 is also used in the production of white asparagus grown under polythene tunnels.

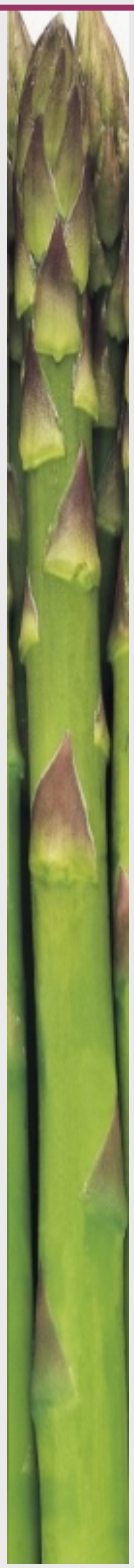
Harvesting

Asparagus can be harvested the second year after planting, but the duration of this cut is significantly shorter than subsequent years so as not to stress the young plants' reserves. Traditionally asparagus is harvested in spring, ferns grow in summer and the plant becomes dormant during winter. Fresh asparagus is usually hand-harvested by specialised pickers at above 20 cm and the interval between picks will depend on the weather conditions, predominantly the air/ground warmth. By October, most paddocks are being harvested daily. After harvest, the spears are washed, cooled, trimmed and graded. The spears can then be stored before export or delivery to domestic markets.

Spears ready for harvest



An asparagus plant showing buried crown in relation to emerging spears.



Purple spot disease of asparagus

Scientific Name

- *Stemphylium vesicarium*

Symptoms

- This fungal disease attacks both the fern and the spears. Purple spot affects spears in wet cool springs producing purple lesions which, in large numbers, make spears unmarketable. The disease also affects the fern, with lesions that develop throughout the fern canopy leading to premature defoliation.

Conditions favouring disease

- Twelve hours or more of rain or wetness (dew) are required for infection at temperatures ranging from 10 – 20°C. Severity is increased with high humidity.

Source and spread of disease

- Purple spot can be seedborne. The pathogen may be on or under the seed coat. Volunteer asparagus seedlings host the fungus in spring providing spores to infect spears. Fern debris carries the overwintering stage of the fungus. Nursery crowns can be a source of disease as there is always fern debris left after the tops are slashed before transplanting. Crowns must be disease free before transplanting. Scouting at the fern stage of every crop is essential, to detect the disease early and allow timely application of fungicides. Controlling purple spot enhances fern vigour and the production of highly marketable spears.
  NB: Fungicides are not applied to spears.

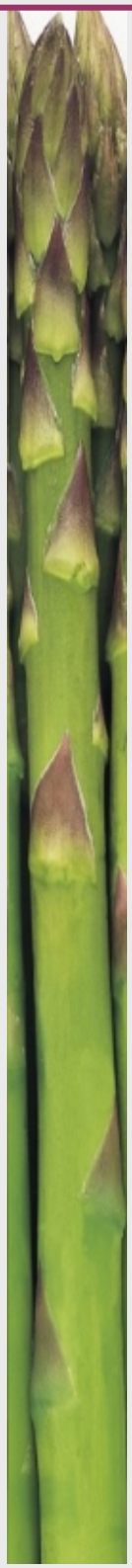
Survival of disease

- The fungus overwinters on fern debris left over from the previous season. Spores produced from the overwintering stage infect emerging spears in spring. At the end of harvest, fern develops and purple spot fungal spores can be found "resting" on the fern bracts until environmental conditions are right for germination and development of disease in the fern, usually in autumn. The disease results in premature defoliation of the fern which reduces the carbohydrate stores in the crowns. However with high summer rainfall accompanied by high humidity, purple spot can develop early in summer. There are some variations to the fungal disease scenario that arise. Young crops that produce fern in spring are more at risk from early infection.

Spears infected with purple spot (Photo by D.Johnson, USA).

Fungicide treated fern (righthand side of photograph) compared to defoliated untreated fern (trial site).

Fungicide treated fern surrounded by defoliated fern (trial site).



Disease threshold

- Scouting for this disease is essential for the timing of sprays. Scouting should be carried out during fern stage and particularly after rainfall and high humidity conditions. The threshold for this disease is the presence of two lesions within the upper half of a fern. The disease appears to distribute evenly across a paddock so the presence of the lesions on up to 10 ferns appears to be predictive of the status of the whole paddock.

Chemical control

- There are no fungicides currently registered for use on asparagus for purple spot disease in Australia. A minor use permit is being sought to allow the use of a protectant fungicide that showed promise in field trials. Timing and good coverage of fern with protectants is critical. The fungicide may be applied by tractor boom (helicopter spraying may also be an option). Based on field trials the first application must be applied as soon as the disease threshold is reached and regular applications must be made. A minor use permit will contain details of spray application rates and withholding periods. TEST FOR RESIDUES after any treatment program. (Refer Quality Assurance for Asparagus, a Veg Cheque production, 2002)

Chemical use in resistance management

- There is one protectant fungicide that adequately controls purple spot based on field trials. However, the reliance on a single protectant fungicide is not ideal as chemical resistance may rapidly build up in the *Stemphylium* population.

Cultural control practices

- Treat all new seed (refer to Asparagus Factsheet No 1 Seed Health).
- Treat nursery crowns if disease is detected (refer Asparagus Factsheet No 2 Nursery Crown Health).
- Disease carried on dormant or damaged fern debris at the end of the growth cycle is the source of disease for the spears at harvest and the next fern stage (which may begin early in October in a young crop). This debris does not breakdown during dry winters (approx 80 days) due to lack of soil moisture. Growers are advised to remove as much fern debris as is practicable, which will reduce but not eliminate the disease due to the presence of diseased small branchlets and needles. To aid decomposition, deep-bury small pieces of debris. Where practical, a final bedform should be carried out to make sure that most of the debris is kept under the soil. Minimise damage to ferns during the growing season.
- At harvest, volunteer asparagus seedlings are alternative hosts for purple spot fungi which can infect the emerging spears. Control these seedlings by manually weeding or lightly cultivating the sides of the beds. This will eliminate the majority of the seedlings.
- There are no disease tolerant cultivars recorded to date.

Biological controls

- To date there are no biological control agents available to control purple spot.

References and Web sites:

1. UC Pest Management Guidelines: http://www.ipm.ucdavis.edu
2. Rutgers IPM Vegetable Fact Sheets: http://www.aesop.rutgers.edu
3. Cornell Vegetable Team: http://www.nysaes.cornell.edu
4. MSU Crop Advisory Team: http://www.ceenet.msue.msu.edu
5. University of Minnesota Extension: http://www.extension.umn.edu

DEPARTMENT OF
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Vegetable Matters-of-Facts

Based on research funded by the Australian Asparagus Council,
Horticulture Australia Limited and Department of Primary Industries -Victoria

VegCheque
extension for the vegetable industries

Number 8
October
2003

Asparagus

Stemphylium (Purple Spot) of Asparagus

Main controls:

- Chemical fungicides
- Crop scouting
- Weed control
- Seed treatment
- Disease forecasting
- Remove fern debris

What is "Stemphylium" (Purple Spot)

Stemphylium of asparagus (also known as Purple Spot) is caused by the fungus *Stemphylium vesicarium*. Purple Spot is a major worldwide disease of asparagus.

Losses from this disease are from spotting of spears which reduces marketability. Repeated defoliation of ferns can reduce yield in following crops. The disease has caused severe problems for Southern Victorian asparagus growers in recent years.

Typical symptoms

Infected **spears** have elliptical sunken, purplish spots with brown centres which lead to rejection of product.

Asparagus **fern** infected with Purple Spot has brown spots with dark purple margins.

Black **over-wintering** structures appear as the fern dies back and these are the main source of infection for newly developing spears in spring.

More about Purple Spot

- The primary source of the disease is from infected fern debris from the previous crop.
- Infection occurs through natural openings and wounds on the newly emerging spears.
- Purple Spot can be severe during a cool, wet growing season. Twelve continuous hours of leaf wetness are necessary for infection.
- Purple Spot over-winters on fern debris.

In spring, spores released from last year's infected fern debris are spread by wind and water to the new spears.

Horticulture Australia

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"Strategies to control Stemphylium (Purple Spot) of Asparagus"

HAL Project: VX 01024

Results to date

Seed treatment

Stemphylium, Fusarium and *Botrytis* (disease-causing fungi) were detected on asparagus seed.

A simple treatment to consider is to soak seed for 10 minutes in 7 parts methylated spirit and 3 parts water. This will rid seed of most fungal diseases. Unfortunately, *Stemphylium* can also be an internal infection and cannot be adequately controlled by surface sterilisation.

Crown testing

Random tests showed that 4 out of 6 one-year-old crown lots were infected with *Stemphylium* and all were infected with *Fusarium* root rot.

Decay of fern debris

Asparagus fern is very slow to decay in cold dry soil. Other methods to accelerate decomposition need to be developed.

Fungicide trials

In trial conditions, only the fungicide chlorothalonil provided a level of protection from disease at the green fern stage.

NOTE: Chlorothalonil is not registered for use on Asparagus

Future work

- Test low-toxicity fungicides for use in disease management to avoid chemical resistance developing.
- Test use of hot lime to aid decomposition of fern debris.
- Can crop scouting help growers.
- Disease forecasting from weather data.

Contact

Gisele Irvine or Martin Mebalds (seed testing)
DPI-Knoxfield, (03) 9210 9222

Weblinks used to prepare this information :

http://www.apsnet.org/online/feature/asparagus/top.htm

http://pearl.agcomm.okstate.edu/plantdiseases/f-7646.html

http://www.extension.umn.edu/distribution/horticulture/components/1861a.html

http://attra.ncat.org/attra-pub/PDF/asparagus.pdf

http://www.anrcatalog.ucdavis.edu/pdf/7234.pdf

http://commserv.ucdavis.edu/CEImperial/Aspar_03.pdf

For more information please contact your local VegCheque officer.

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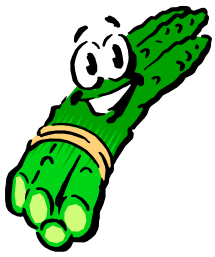
Bruce Fry	South West Vic	5233 5510
Craig Murdoch	Melbourne	9210 9222

Controlling Stemphylium (Purple Spot)



Current methods

The control of Purple Spot involves a combination of crop management practices and well-timed chemical treatments.

Chemical Control:

In trials, the fungicide chlorothalonil was effective in controlling Purple Spot on the fern. Other effective chemicals are needed to reduce the danger of the disease becoming resistant to chlorothalonil.

NOTE: Chlorothalonil is not registered for use on Asparagus

Disease Forecasting:

Purple Spot can occur whenever weather conditions are right. Twelve hours of leaf wetness are necessary for infection. Crop scouting for purple spot on green fern is recommended after prolonged wet conditions.

For new plantings, consider orienting the block so that wind can blow along the rows and dry the foliage quickly.

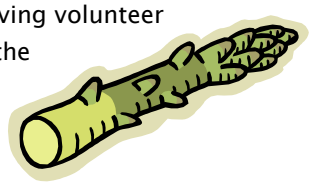
Removing Fern Debris:

Burying or burning asparagus debris will help reduce infectious material and air-borne spores, even if the debris does not decay before harvest.

However total removal of fern debris is difficult and it is likely that enough infectious material will survive to infect emerging spears.

Weed Control:

Volunteer asparagus seedlings can become infected during the harvest season and are a source of disease. Mechanically removing volunteer seedlings can help control the spread of disease.



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DEPARTMENT OF
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Vegetable Matters-of-Facts

VegCheque
extension for the vegetable industries

Number 10
November
2003

Asparagus

Garden Symphilid

(Scutigerella immaculata)

- Description
- Behaviour
- Symphilids in Victoria
- Control methods


Suspected symphilid damage on an asparagus spear 2003

Description

The **Garden Symphilid**, (also known as Symphylan in the USA), are small, white, soft-bodied "centipede-like" animals, 3-7 mm long with 12 pairs of legs and a pair of antennae. They are found mainly in moist open structured soils often associated with crop debris. Symphilids are sensitive to light and are very active when exposed.

Symphilids in Victoria

The garden symphilid was recently reported causing problems in a Victorian asparagus crop. The pest has since been found on a large numbers on widely dispersed properties. Symphilids feed on sprouting seeds and underground stems of seedlings, weakening or killing plants.

In asparagus, the pest feeds on the crown and the base of spears. Infested areas are usually confined to small patches of a field where the crop appears stunted or has been destroyed.

Asparagus growers have been aware of this pest for at least 15 years, and they only appear to be a problem in dry years when they move from other hosts to the asparagus crowns deeper in the soil.

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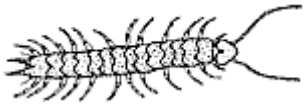
Symphilid behaviour

Adult symphilids usually stay in the top 50 cm of soil and can live for several years. Generations are produced continuously under warm, moist conditions taking about 3 months to develop from egg to adult. In the spring they feed on young plant roots near the soil surface.

Symphilids are unable to burrow, instead travelling through pores, cracks or burrows made by earthworms. High populations are more common in well structured clays than in sandy soils.

Symphilids move vertically in the soil profile in response to temperature and flooding, returning to colonise the same area each year so infestations only spread slowly.

High summer temperatures and dryness cause symphilids to burrow down to the moist subsoil where they feed on decaying organic matter. Moderate spring/autumn temperatures or flooding will cause them to return to the surface where they can damage crops.



Websites used to prepare this fact sheet :

http://www.ofrf.org/publications/Grant%20reports/99.53.15.VanHorn.Fall99.IB12.pdf
http://www.ipm.ucdavis.edu/PMG/r734301311.html
http://www.ento.psu.edu/extension/factsheets/garden_symphylan.htm
http://www.ent3.orst.edu/smartkey/pagelist.cfm (see Symphylan)
http://info.ag.uidaho.edu/keys/plates/plate01.htm
http://oregonstate.edu/Dept/entomology/ranb/symp.html
http://ippc2.orst.edu/potato/symphylans.pdf
http://mint.ippc.orst.edu/symphcycle.htm
http://mint.ippc.orst.edu/symphfact.pdf
http://pbesa.ucdavis.edu/ESApdfs/UmbleX.pdf
http://wlapwww.gov.bc.ca/vir/pp/ipm/insects/symphyla.html
http://zzyx.ucsc.edu/casfs/research/Cultivar191.pdf

For more information please contact your local VegCheque officer.

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Sally-Ann Henderson	Northern Vic	5051 4500
Bruce Fry	South West Vic	5233 5510
Craig Murdoch	Melbourne	9210 9222

Control methods

Given the perennial nature of asparagus plantings, no effective symphilid control measures have yet been identified as appropriate for established Victorian asparagus crops.

Control of garden symphilids in other crops involves applying preventative treatments before planting. No rescue treatment can be used effectively while the crop is growing.

In other parts of the world, high populations of symphilids have been managed using a combinations of methods including tillage, flooding, drying, natural enemy conservation, crop rotation, cover crop management, organic matter management, time of planting, biofumigants and pesticides.

Because symphilids can retreat deep into the soil, chemical treatments may simply act as repellents, useful for protecting plants in the short-term such as during their early development.

Numerous naturally occurring organisms prey on symphilids in the field including true centipedes, predatory mites, predacious ground beetles, and various fungi; however, little is known about their ability to control symphilid populations.

For more information contact :

Gisele Irvine - Asparagus scientist

or Gary Darcy - Plant Standards

at DPI-Knoxfield, (03) 9210 9222

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DEPARTMENT OF
PRIMARY INDUSTRIES

Vegetable Matters-of- Facts

VegCheque
extension for the vegetable industries

Number 12
February
2004

Asparagus

Asparagus Rust

(Puccinia asparagi)

- **Rust disease of asparagus is caused by the fungus *Puccinia asparagi*.**
- **Rust is only a problem on fern not the spears.**
- **Infected fern is defoliated reducing the potential yield of next seasons crop.**
- **First detected in Queensland in 2000 and in Victoria in 2003**

Infection and symptoms

Infections of asparagus rust begin in spring from over-wintering spores on crop debris. Rust has several visual spore stages known as the orange, red and black spore stages. Visual symptoms of infection start in spring/summer with light green pustules on new emerging fern which mature into yellow or pale orange pustules.

In early to mid summer when conditions are warm and moist, the orange spores spread to new fern growth producing brick red pustules on stalks, branches and leaves of the fern. These develop into powdery masses of rust-red coloured spores which reinfect the fern.

Infected fern begins to yellow, defoliate and die back prematurely. In late autumn and winter the red-coloured pustules start to produce black spores and slowly convert in appearance to a powdery mass of jet-black spores. This is the over-wintering stage of the fungus and the source of the next seasons infection.

Victoria
The Place To Be

Control Stratagies

Complete eradication of the disease is not feasible as rust spores are spread by wind. However rust can be controlled with proper fern management.

- Scout for early signs for rust and implement fungicide spray program
- Volunteer and other unwanted asparagus plantings must be destroyed to control infection sources.
- Extra care should be taken with hygiene as spores can be spread on clothing and equipment.
- Be aware of current quarantine restrictions.

NOTE:
Removal of debris will reduce the amount of infectious material but will not eliminate all source of disease.

For more information contact:

Gisele Irvine DPI-Knoxfield- Vic
(03) 9210-9222

or

Dean Beasley DPI-Stanthorpe-Qld
(07) 4681-1255

Websites used to prepare this fact sheet:

http://www.ipm.msu.edu/CAT01_veg/V05-16-01.htm
http://www.ipm.msu.edu/CAT03_veg/V05-07-03.htm#5
http://www.dpi.qld.gov.au/health/4238.html

For more information please contact your local VegCheque officer.

Neville Fernando	Gippsland	5152 0600
Sally-Ann Henderson	Northern Vic	5051 4500
Bruce Fry	South West Vic	5233 5510
Craig Murdoch	Melbourne	9210 9222

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DEPARTMENT OF
PRIMARY INDUSTRIES

Purple Spot Disease Risk Analysis
(Southern Victorian Production Region)

Production	Fern	Remove Fern	Scout for disease[A]	Disease (2001-2003)	Treatment[B]
Main	December	June	December-June	April	At threshold
Summer	March	July	March-July	April	At threshold
Young	September	June	September-June	October	At threshold
Nursery	November	June	November-June	April	At threshold
Glasshouse	From planting		Fern stage		At threshold

[A] Always scout for disease during fern stage.

[B] Threshold (2 lesions /upper canopy of fern on ten plants), see lesion circled in photograph.

NB: Treatment applications must finish end of May (fern dormancy), allowing sufficient withholding period before harvest (refer minor use permit (application pending)). TEST FOR CHEMICAL RESIDUES in produce.

Contact PIRVic, Knoxfield for more information on research findings, HAL Project VX01024 "Strategies to control purple spot of asparagus"
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