Managing Sclerotinia shoot rot – a new disease of grapevines in South Australia



FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

PROJECT NUMBER: **SAR 01/04**

PRINCIPAL INVESTIGATOR: **Mrs Barbara Hall**

RESEARCH ORGANISATION:

South Australian Research and Development Institute

DATE: **September 2002**

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GWRDC Final Report

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By

Mrs Barbara Hall

South Australian Research & Development Institute

(SARDI)

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1. Abstract

Sclerotinia shoot rot, caused by the fungus *Sclerotinia sclerotiorum*, was initially found in South Australia in October 2000 on Cabernet Sauvignon vines in Eden Valley, approximately 50km North East of Adelaide. The base or stems of young shoots developed a pale brown rotted area, which girdled and killed the shoots. On some vines white fungal growth with sclerotia developed inside the rotted shoot. In Oct/Nov 2001, the fungus was also detected in a further 18 vineyards in the cooler grape growing areas of South Australia, affecting Cabernet Sauvignon, Shiraz, Pinot Noir, Riesling, Verdelho and Sauvignon Blanc.

Fungicides registered for use on grapes, either to control *Botrytis* or known to control Sc*lerotinia* on other crops, were tested to determine their protective or curative effect on the fungus. Evaluations undertaken on excised grape berries and treated shoots showed iprodione (Rovral®), fluazinam (Shirlan®), procymidone (Sumisclex®) and cyprodinil plus fludioxonil (Switch®) were effective at reducing the level of rot on berries and shoots when applied at recommended rates up to 7 days before infection. The same fungicides also reduced the level of rot on the berries when applied 1 and 3 days after inoculation.

2. Executive Summary

Sclerotinia shoot rot, caused by the fungus *Sclerotinia sclerotiorum*, was initially found in South Australia in October 2000 on Cabernet Sauvignon vines in Eden Valley, approximately 50km North East of Adelaide. In Oct/Nov 2001, the fungus was also detected in a further 18 vineyards in the cooler grape growing areas of South Australia, affecting Cabernet Sauvignon, Shiraz, Pinot Noir, Riesling, Verdelho and Sauvignon Blanc.

The disease appears as a pale brown rot, which develops either at the base of the shoot or at a node, and causes shoot death. Sclerotinia shoot rot reduces yield by killing infected shoots, and in some vineyards infected canes die, setting production back at least 2 years while a new cane is trained onto the wire.

A method of inoculating detached ripe grape berries was evaluated for preliminary investigations into the pathogenicity of the fungus and fungicide evaluation for disease control. Individual berries were surface sterilised and placed in small glass or plastic dishes in a humid tray (a tray containing wet chux covered with paper towel and enclosed in a plastic bag). The berries were inoculated with an agar plug of actively growing mycelium placed either on a wound site, or an unwounded berry. This technique was found to be successful, with infection occurring on the wounded berries after 4 days incubation in near 100% humidity.

All isolates of *S. sclerotiorum* tested from the different geographical regions infected the berries, however some did not infect all the berries in every test, indicating possible differences in virulence between the isolates. Berry age and size did not appear to affect the level of rotting found on the berries, nor did the age of the mycelia used in inoculation.

Fungicides registered for use on grapes, either to control *Botrytis* or known to control Sc*lerotinia* on other crops, were evaluated in 5 experiments using berries inoculated with the fungus. Fungicides were sprayed onto berries either before or after inoculation, and the berries incubated in near 100% humidity for 7 days. The fungicides iprodione (Rovral®), fluazinam (Shirlan®), procymidone (Sumisclex®) and cyprodinil plus fludioxonil (Switch®) were effective at reducing the level of rot on the berry when applied either up to 7 days before

or 3 days after berry inoculation. None of the fungicides completely controlled the fungus on all berries in all experiments.

Benomyl (Benlate®) was also tested, but found to be ineffective. Initially this was thought to be from resistance of *S. sclerotiorum* to the fungicides, however *in vitro* tests indicated that no resistance was present. Some control was achieved when 5 and 12 times the recommended rate was applied to the berries.

Potted vines were also sprayed with these fungicides, the shoots removed at 3 and 7 days after application, and pieces of agar with active fungal mycelium placed on the stems after wounding. After 7 days incubation at near 100% humidity, the inoculated stems of unsprayed shoots rotted and sclerotia formed. These tests confirmed that these fungicides were effective protectants.

Experiments were also undertaken in the greenhouse to establish whether artificial inoculation of shoots could be used to test efficacy of a range of fungicides. Unfortunately the inoculation techniques tested were not reliable, and the results were inconclusive.

Following concerns on controlling the disease by vineyard owners and managers, funds were provided for these initial studies to be undertaken in the laboratory and greenhouse to evaluate the fungicides. Only fungicides already registered on grapes were tested, and it would be valuable to test any new fungicides in the process of registration to determine if there are any of the new generation of fungicides with efficacy against the disease.

The results of this project provide grape growers with an immediate benefit with the knowledge of the available fungicides that can be used when the disease occurs again, however successful management of this disease will require investigations into the epidemiology of the fungus in relation to grapevines. While there is a reasonable amount of information on the epidemiology and management of the disease in annual crops such as vegetables, there is little information on the effects on perennial crops such as grapevines. There needs to be an understanding of how the fungus interacts with the grapevine, and what the long term effects on vine health and productivity may be.

3. Background

In October 2000, in a vineyard in the Eden Valley region, approximately 50km North East of Adelaide, a rot of young grapevine shoots cv. Cabernet Sauvignon was observed. The base of the shoots developed a pale brown area, which rotted and caused shoot death. Testing of the infected tissue showed the problem to be caused by the fungus *Sclerotinia sclerotiorum*, confirmed by Dr Michael Priest (NSW Agriculture, Orange). In Oct/Nov 2001, the fungus was also detected in a further 18 vineyards in the cooler grape growing areas of South Australia, affecting Cabernet Sauvignon, Shiraz, Pinot Noir, Riesling, Verdelho and Sauvignon Blanc (Hall *et al*, 2001, 2002).

Sclerotinia shoot rot appears as a pale brown rot, which develops either at the base of the shoot or at a node, and causes shoot death. The symptoms are superficially similar to those caused by *Botrytis*, but infection with *S. sclerotiorum* is characterised by the development of sclerotes within and on the affected shoots in the field. Sometimes several shoots per cordon are affected and in severely infected vineyards crop loss occurs from the death of cordons supporting the affected shoot. Sclerotinia shoot rot reduces yield by killing infected shoots. Tests have also shown that the fungus grows into the cane below the infected shoot. In some vineyards infected canes die, setting back production at least 2 years while a new cane is trained onto the wire.

S. sclerotiorum was recorded on grapevines in the Swan Valley, Western Australia, in 1987 (Shivas, 1987) and in California (Boland, 1994). A recent report also confirmed *S. sclerotiorum* as the cause of a shoot blight of grapevines in Chile in spring 2000 (Latorre 2001). In the past *S. sclerotiorum* had not been considered a significant pathogen of grapevines, however the fungus is a major pathogen of vegetable crops, weeds and some field crops worldwide.

In both South Australia and in the Margaret River region of Western Australia, the wet cool spring of 2001 caused an increase in both the incidence and severity of Sclerotinia shoot rot. Concerns raised by vineyard owners and managers in both regions initiated the investigations into possible control measures.

This project aimed to investigate the effect of Sclerotinia shoot rot over the 2001/2002 season, and to evaluate fungicides so preliminary recommendations could be offered to growers for the start of the next season.

4. Project Aims and Performance Targets

AIM: Information on effective inoculation method.

Performance Target: Determine the most effective inoculation method on potted vines by March 2002

AIM: Preliminary control measures determined.

Performance Target: Determine the eradicant and protectant activity of any registered fungicide by June 2002 and propose control measures to be field-tested in future work in the 2002/2003 season.

AIM: Information on spread of the disease

Performance Target: At last 2 vineyards monitored for spread of the disease within the vines and within the vineyard by April 2002.

5. Methods

Isolate collection.

Samples of vines with symptoms of Sclerotinia shoot rot were collected or received from various wine growing areas in South Australia in 2000, 2001 and 2002. A sample was confirmed as being infected with *S sclerotiorum* when the distinctive white mycelial growth and black sclerotes were observed after 7-10 days incubation in near 100% humidity at 22^{O}C. The black sclerotes were plated onto Potato Dextrose Agar (PDA) and clean cultures of the fungus which grew from the sclerotes were maintained on PDA for further testing.

Inoculation of potted grapevines.

Several methods were tested to inoculate shoots of various growth stages, from older partially lignified to young green shoots and leaf petioles, on potted grapevines cvs Cabernet Sauvignon, Shiraz and Chardonnay.

1. Shoots were wounded with a sterile scalpel, a plug of actively growing mycelia placed over the wound with a piece of grape berry, and wrapped with parafilm to seal the area. The pots and vines were placed in plastic bags with water to create near 100% humidity. Both bags and parafilm were removed after 48 hours.
2. Shoots were either cut with a sterile scalpel or pricked with a sterile needle, and tied with a cotton ball dipped in a solution of macerated mycelia. The plants were then placed in plastic bags or in a misting chamber for 48 hours before removing the cotton wool.
3. Shoots were wounded with a sterile scalpel and a plug of actively growing mycelia placed on the wound and sealed with parafilm. Vines were either left without further treatment or placed in plastic bags with water for 48 hours. The parafilm was not removed until the shoots had rotted.

Any shoots showing symptomatic brown rotting were incubated in humid trays for 4-5 days to determine whether the characteristic white mycelial growth with black sclerotia of *S. sclerotiorum was* present.

Berry inoculation.

Ripe grape berries, either white or red varieties of table grapes, were surface sterilised by soaking in diluted White King Bleach with 1% available sodium hypochlorite, rinsed in demineralised water, dried in the laminar flow cabinet to maintain sterility and placed into sterilised welled trays or containers. The berries were inoculated by placing a 5mm plug of agar with actively growing mycelium over a wound made with a sterile needle on the side of the berry. The containers of inoculated berries were placed into humid trays, trays lined with wet chux covered with paper towel and sealed in a plastic bag to create conditions of near 100% humidity.

Fungicide application.

Fungicides were applied with a hand held atomiser to berries or potted vines and sprayed to the point of run-off. Citowett® was included as a wetter with all applications. The fungicides tested and rates of application are outlined in Table 1.

Table 1. Fungicides and rates applied to grape berries and potted plants

Fungicide	**Active ingredient**	**Rate per L of water (recommended rates in bold)**
Benlate®	benomyl	**0.4**, 0.5, 1 and 5 g
Teldor 500SC®	fenhexamid	**1** mL
Amistar WG®	azoxystrobin	**0.5**, 1g
Scala 400EC®	pyrimethanil	**2** mL
Bravo®	chlorothalonil	**2.6** mL
Shirlan®	fluazinam	**0.25** mL
Switch®	cyprodinil & fludioxinil	**0.8** g
Sumisclex 500®	procymidone	**0.75** mL
Rovral liquid®	iprodione	0.5, **1** mL
Flint 500WG®	trifloxystrobin	**0.15** g

Pathogenicity of isolates.

Experiment 1,2.

The pathogenicity of isolates of *S. sclerotiorum* from different regions of South Australian was tested by inoculating white table grapes with each of the 18 isolates collected, 4 berries

per isolate. The berries were assessed at 4 days after inoculation for the presence or absence of *S. sclerotiorum* on the berries. Control berries were wounded and inoculated with sterile agar. Any isolate that showed no or low infection was retested in a second experiment.

Berry inoculation technique.

Experiment 3.

This experiment was designed to determine whether *S. sclerotiorum* could infect berries that had not been wounded. For each of the 18 isolates of *S. sclerotiorum*, 4 white table grapes were inoculated after wounding, and 4 inoculated with no wounding. The berries were assessed 4 days after inoculation for the presence or absence of *S. sclerotiorum* mycelial growth.

Experiment 4.

The experiment was designed to determine whether the age of the *S. sclerotiorum* cultures used for inoculation, or the ripeness of the grape berries, were possible causes of the variation in the number of berries being infected in the previous experiments. Wounded berries from white table grapes were inoculated with plugs of mycelia taken from culture plates of 2 isolates either 2, 4 or 6 weeks old, using 8 large ripe berries and 8 small greener berries per age and isolate. The berries were assessed at 7 days after inoculation for the presence or absence of *S. sclerotiorum* mycelial growth.

Efficacy of fungicides applied to berries before infection.

Experiments 5-8

These experiments investigated the protectant activity of the 10 fungicides listed in Table 1 against infection by *S. sclerotiorum*. White (Experiments 5-7) or red (Experiment 8) table grape berries were sprayed to run off with each of the fungicides, and dried in the laminar flow to prevent contamination. Berries were sprayed with water and wetter as a control. At either 0, 1, 3 or 7 days after spraying, the berries were inoculated as previously described, eight berries per treatment. At least 2 isolates of *S. sclerotiorum* were tested in each experiment. The fungicides used and times of application are outlined in Table 2. The berries were assessed between 4 and 7 days after inoculation for the presence or absence of *S. sclerotiorum* mycelial growth.

Table 2. Protective spray applications – fungicides, rates and times of application, and isolates tested.

Experiment	Isolates	Fungicides	Rate	Days before inoculation
4	345, 348	Amistar, Benlate	0.5 and 1g/L	0
		Rovral	0.5 and 1mL/L	
5	345, 341	All listed in Table 1	Recommended (Table 1)	0
6	345, 341	All listed in Table 1 except Flint	Recommended (Table 1)	0
7	345, 271	All listed in Table 1 except Flint	Recommended (Table 1)	0
8	345, 350	Benlate, Shirlan, Switch, Rovral	1.0 g/L, 0.25 mL/L, 0.8 g/L, 1 mL/L	0, 3, 7

Efficacy of fungicides applied to berries after infection.

Experiment 9

This experiment investigated the eradicant activity of seven fungicides against *S. sclerotiorum* infection. White table grape berries were inoculated as previously described with isolate 345 and 350. At 1 and 3 days after inoculation, eight berries of each isolate were sprayed to run off with Benlate, Teldor, Switch, Rovral, Shirlan, Sumisclex or Amistar at the recommended rates listed in Table 1. Berries were sprayed with water and wetter as a control. Berries were allowed to dry after the fungicide application before being resealed in plastic bags for further incubation. When sprayed at 3 days after inoculation, the berries were assessed for the presence of *S. sclerotiorum* mycelium or any rotting on the berries prior to the fungicide application. All berries were assessed again at 7 days after inoculation for the presence or absence of *S. sclerotiorum* mycelium.

Susceptibility of isolates to Benlate.

Experiments 10-12

White table grapes berries were used in these experiments to determine whether any of the isolates were susceptible to Benlate, as the control achieved in initial test results were very variable. In Experiment 10, berries were treated with either 1 g/L Rovral or 1 g/L Benlate, allowed to dry, then 8 berries were inoculated with each of 4 isolates of *S. sclerotiorum*. Experiment 11 tested 16 isolates, inoculating 8 berries with each isolate after spraying with

the recommended rate of 0.4g/L Benlate. In this test, 7 isolates of *S. sclerotiorum* showed a reduction in infection on the Benlate sprayed berries, and in Experiment 12 these were used to inoculate berries sprayed with 0.4, 1 or 5g/L Benlate using 8 replicate berries per treatment. All berries were assessed after 6 or 7 days incubation in near 100% humidity for the presence or absence of mycelial growth of *S. sclerotiorum*.

Experiments 13-15

All isolates were tested for resistance to Benlate *in vitro* by plating plugs of actively growing mycelia onto PDA amended with various concentrations of benomyl. Experiment 13 tested 7 isolates on PDA amended with 0. 0.5, 1,5,10, 50 and 100 ppm a.i. benomyl, experiment 14 tested 6 isolates on PDA amended with 0, 0.1, 0.5, 1, 5, 10, 50 and 100 ppm a.i. benomyl, and experiment 15 tested 17 isolates on PDA amended with 0. 1 and 10 ppm a.i. benomyl.

Efficacy of fungicides applied to potted plants before inoculation.

Experiments 16, 17

Potted grapevines, cvs Chardonney, Cabernet Sauvignon and Shiraz, were sprayed to runoff with either 1.0 g/L Benlate, 0.25 g/L Shirlan, 0.8 g/L Switch, 1 mL/L Rovral or demineralised water mixed with wetter using a hand held sprayer. At 1, 3 and 7 days after spraying, shoots were removed from the plants and inoculated with plugs of actively growing mycelia (isolate 345) by placing the plug on a shoot or leaf petiole after wounding either with a sterile scalpel or sterile needle. After 8-10 days incubation in near 100% humidity, the shoots were assessed for presence of absence of rotting with mycelia and sclerotia at the wound sites.

This experiment was repeated using Shiraz and Cabernet Sauvignon, with shoots removed at 3 and 7 days after treatment, inoculated and incubated in humid trays for 7 days before assessment.

Experiment 18

Potted vines cv Cabernet Sauvignon, 4 vines per treatment, were sprayed to run off with 1.0 g/L Benlate, 1 mL/L Rovral, 0.8 g/L Switch or water using a hand held sprayer. Shoots were inoculated at 1 and 3 days after spraying by placing plugs of actively growing mycelium with a piece of grape berry over wounds and sealing with parafilm, before being placed in plastic bags with water for 48 hours. Any shoots showing symptoms of rotting were inoculated in

humid trays at near 100% humidity to confirm the presence of *S. sclerotiorum* mycelia and sclerotes.

6. Results /Discussion

Isolate collection.

Sclerotinia shoot rot was reported on 26 occasions from 15 grape growing areas, infecting 6 different cultivars (Table 3). Samples were submitted from 21 of these reported occurrences, the presence of *Sclerotinia* confirmed and 17 isolates collected and maintained.

Table 3. Locations and cultivars of reported occurrences of and Sclerotinia shoot rot, with collection date and isolate number of cultures confirmed and maintained

Location	Variety	Confirmed	Date collected	Isolate
Eden Valley	Cabernet Sauvignon	✓	Oct 2000	271
Eden Valley	Shiraz	✓	Nov 2001	337
Birdwood	Cabernet Sauvignon	✓	Nov 2001	338
Eden Valley	Cabernet Sauvignon	✓	Nov 2001	339
Penola	Cabernet Sauvignon	✓	Nov 2001	340
Kangarilla	Sauvignon Blanc	✓	Nov 2001	341
Eden Valley	Pinot Noir	✓	Nov 2001	342
Eden Valley	Shiraz			
Eden Valley	Pinot Noir	✓	Nov 2001	
Eden Valley	Shiraz	✓	Nov 2001	
Eden Valley	Shiraz			
Eden Valley	Riesling			
Mt Pleasant	Riesling			
Kangarilla	Cabernet Sauvignon	✓	Nov 2001	343
Padthaway	Cabernet Sauvignon	✓	Nov 2001	344
Eden Valley	Cabernet Sauvignon	✓	Nov 2001	345
Eden Valley	Cabernet Sauvignon	✓	Nov 2001	346
Wrattonbully	Cabernet Sauvignon	✓	Nov 2001	347
Wrattonbully	Shiraz	✓	Nov 2001	348
Kangarilla	Pinot Noir	✓	Nov 2001	349
Mt Benson	Cabernet Sauvignon	✓	Nov 2001	350
Eden Valley	Cabernet Sauvignon	✓	Nov 2001	351
Chapel Hill	Verdelho	✓	Nov 2001	352
Kangarilla	Cabernet Sauvignon	✓	Nov 2001	353
Kangaroo Island	Cabernet Sauvignon	✓	Jan 2002	
Kangaroo Island	Sangiovese			

Inoculation of potted grapevines.

All the inoculation techniques proved effective, however consistent infection was difficult to achieve, with only a few of the inoculations working at any one time. The young shoots were the most easily infected, however as they were rather fragile, they often died from the wounding.

Pathogenicity of isolates.

All isolates caused infection of wounded berries, however some consistently infected all berries, whereas others were more variable (Table 4).

Table 4. Percent of berries infected after inoculation with various isolates of *S. sclerotiorum*.

Isolate	**% berries infected**	
	Experiment 1	**Experiment 2**
Control	0	0
271	25	100
337	75	75
338	0	50
339	0	50
340	100	-
341	0	75
342	50	50
343	100	100
344	50	100
345	0	100
346	100	100
347	100	-
348	100	-
349	100	-
350	100	-
351	100	-
352	100	-
353	100	-

Berry inoculation technique.

Wounding berries encouraged infection, and berries that were not wounded were less likely to become infected with *S. sclerotiorum* (Table 5). Neither the age of the culture used for

inoculation nor the size or ripeness of the berry appeared to affect the level of infection obtained when inoculating with wounding (Table 6).

Table 5. Percent of berries infected with *S. sclerotiorum* with and without wounding.

Isolate	**% berries infected**	
	wounded	**not wounded**
271	50	0
337	75	0
338	50	0
339	50	0
340	75	25
341	50	50
342	50	25
343	75	0
344	100	25
345	100	50
346	100	0
347	100	0
348	75	75
349	25	25
350	100	50
351	100	75
352	100	25
353	25	25

Table 6. Percent of berries infected with differently aged cultures, and different size and ripeness of berries.

Isolate	**Culture age**	**% large ripe berries infected**	**% small firmer berries infected**
341	6 weeks	62.5	50
	4 weeks	71.4	100
	2 weeks	87.5	62.5
345	6 weeks	87.5	87.5
	4 weeks	87.5	87.5
	2 weeks	50	87.5

Efficacy of fungicides applied to berries before infection.

Shirlan, Switch, Rovral and Sumisclex were the most effective fungicides at reducing the level of berry rot from *S. sclerotiorum* when applied up to 7 days before inoculation (tables 7-11). However they did not provide complete control in every experiment.

Table 7. *Experiment 4.* Percent of berries infected with *S. sclerotiorum* after treatment with fungicides immediately before inoculation.

Isolate	**Fungicide**	**% berries infected**	
		0.5 g or mL/L	**1.0 g or mL/L**
345	Control (water)	86.7	
	Amistar	100	62.5
	Benlate	80	68.75
	Rovral	0	0
348	Control	100	
	Amistar	87.5	56.25
	Benlate	6.25	0
	Rovral	18.75	25

Table 8. *Experiment 5.* Percent of berries infected with *S. sclerotiorum* after treatment with fungicides immediately before inoculation.

Fungicide and rate	**% berries infected**	
	isolate 345	**isolate 341**
Control (water)	100	100
Benlate (0.4 g/L)	100	75
Teldor (1 mL/L)	100	100
Amistar (0.5 g/L)	87.5	62.5
Flint (0.15 g/L)	100	100
Scala (2 mL/L)	100	100
Bravo (2.6 mL/L)	62.5	100
Shirlan (0.25 mL/L)	0	62.5
Switch (0.8 g/L)	62.5	0
Sumisclex (0.75 mL/L)	0	37.5
Rovral (1 mL/L)	0	37.5

Table 9. *Experiment 6.* Percent of berries infected with *S. sclerotiorum* after treatment with fungicides immediately before inoculation.

Fungicide and rate	**% berries infected**	
	isolate 345	**isolate 341**
Control (water)	50	75
Benlate (0.4 g/L)	50	0
Teldor (1 mL/L)	37.5	62.5
Amistar (0.5 g/L)	50	50
Scala (2 mL/L)	50	62.5
Bravo (2.6 mL/L)	12.5	37.5
Shirlan (0.25 mL/L)	0	12.5
Switch (0.8 g/L)	0	75
Sumisclex (0.75 mL/L)	0	62.5
Rovral (1 mL/L)	0	100

Table 10. *Experiment 7.* Percent of berries infected with *S. sclerotiorum* after treatment with fungicides immediately before inoculation.

Fungicide and rate	**% berries infected**			
	isolate 345		**isolate 271**	
	Mycelia	**Sclerotes**	**Mycelia**	**Sclerotes**
Control (not sprayed)	100	100	100	100
Control (water)	100	100	100	100
Benlate (0.4 g/L)	100	100	100	100
Teldor (1 mL/L)	87.5	0	87.5	37.5
Amistar (0.5 g/L)	100	12.5	100	0
Scala (2 mL/L)	62.5	0	100	100
Bravo (2.6 mL/L)	100	62.5	100	37.5
Shirlan (0.25 mL/L)	0	0	0	0
Switch (0.8 g/L)	0	0	0	0
Sumisclex (0.75 mL/L)	0	0	0	0
Rovral (1 mL/L)	0	0	0	0

Table 11. *Experiment 8.* Percent of berries infected with *S. sclerotiorum* after treatment with fungicides at 0, 3 and 7 days before inoculation.

Fungicide and rate	**% berries infected**					
	isolate 345			**isolate 350**		
	0 days	**3 days**	**7 days**	**0 days**	**3 days**	**7 days**
Benlate (1.0 g/L)	25	37.5	37.5	12.5	25	28.6
Shirlan (0.25 mL/L)	0	0	12.5	0	0	0
Switch (0.8 g/L)	0	0	0	0	0	0
Rovral (1 mL/L)	12.5	0	0	0	0	0
Control (water)	100	100	100	100	100	100

Efficacy of fungicides applied to berries after infection.

Shirlan, Switch, Rovral and Sumisclex were also effective in controlling infection of berries when applied up to 3 days after inoculation (Table 12). Many of the berries were already infected, and the fungicides not only prevented the rot from spreading, but also killed the fungus in the berry, as no mycelial growth or sclerotial formation was observed on the berries after further incubation.

Table 12. *Experiment 9.* Percent of berries infected with *S. sclerotiorum* after treatment with fungicides at 1 and 3 days after inoculation.

Fungicide and rate	**% berries infected**					
	isolate 345			**isolate 350**		
	1 day	**3 days before treatment***	**3 days**	**1 day**	**3 days before treatment***	**3 days**
Control (water)	100	100	100	100	100	100
Benlate (0.4 g/L)	100	87.5	75	62.5	62.5	75
Teldor (1 mL/L)	100	100	100	37.5	75	100
Amistar (0.5 g/L)	87.5	75	87.5	87.5	62.5	75
Shirlan (0.25 mL/L)	25	100	0	0	12.5	0
Switch (0.8 g/L)	12.5	100	0	0	50	0
Sumisclex (0.75 mL/L)	12.5	87.5	0	25	62.5	25
Rovral (1 mL/L)	25	87.5	0	25	75	0

*Berries were assessed for the level of rot before the 3 days after inoculation fungicide treatment was applied.

Susceptibility of isolates to benomyl.

None of the isolates tested showed resistance to benomyl (Tables 16-18) however Benlate was not effective at controlling the rot on the berries unless applied at 2-12.5 times the recommended rate of 0.4 g/L (Table 13-15).

Table 13. *Experiment 10*. Percent of berries infected with *S. sclerotiorum* after treatment with fungicides immediately before inoculation.

Isolate	**% berries infected**		
	Control	**Benlate 1g/L**	**Rovral 1g/L**
337	75	12.5	0
343	75	75	0
346	50	50	0
348	25	37.5	12.5

Table 14. *Experiment 11*. Percent of berries infected with *S. sclerotiorum* after treatment with Benlate at 0.4g/L immediately before inoculation.

Isolate	**% infected Control**	**% infected Benlate**
271	100	62.5
337	100	87.5
338	100	100
339	100	100
340	62.5	37.5
341	100	87.5
342	100	50
343	100	100
344	100	100
345	87.5	87.5
346	100	100
347	87.5	87.5
348	100	100
349	62.5	37.5
350	100	75
353	100	100

Table 15. *Experiment 12*. Percent of berries infected with *S. sclerotiorum* after treatment with Benlate at various rates immediately before inoculation.

Isolate	% berries infected			
	Control	**Benlate 0.4 g/L**	**Benlate 1g/L**	**Benlate 5g/L**
271	75	75	62.5	0
340	75	75	37.5	25
342	100	100	100	25
345	87.5	75	25	0
348	62.5	0	12.5	0
349	25	0	0	0
350	100	62.5	62.5	0

Table 16. *Experiment 13*. Percent inhibition of growth of *S. sclerotiorum* on PDA amended with benomyl compared to growth on non-amended PDA.

Isolate	Percent inhibition (ppm benomyl)					
	0.5	**1**	**5**	**10**	**50**	**100**
271	100	100	100	100	100	100
337	100	100	100	100	100	100
338	100	100	100	100	100	100
339	100	100	100	100	100	100
340	100	100	100	100	100	100
342	100	100	100	100	100	100
343	100	100	100	100	100	100

Table 17. *Experiment 14*. Percent inhibition of growth of *S. sclerotiorum* on PDA amended with benomyl compared to growth on non-amended PDA.

Isolate	Percent inhibition (ppm benomyl)						
	0.1	**0.5**	**1**	**5**	**10**	**50**	**100**
271	0	C*	100	100	100	100	100
337	0	0	0	100	100	100	100
338	0	C	100	100	100	100	100
339	0	C	100	100	100	100	100
340	0	C	100	100	100	100	100
341	0	0	0	0	100	100	100

* C = contaminated, no measurement taken.

Table 18. *Experiment 15*. Percent inhibition of growth of *S. sclerotiorum* on PDA amended with 1 or 10 ppm benomyl compared to growth on non-amended PDA.

Isolate	**% inhibition 1ppm**	**% inhibition 10ppm**
271	100	100
337	100	100
338	100	100
339	100	100
340	100	100
341	100	100
342	100	100
343	100	100
344	100	100
345	95	100
346	100	100
347	100	100
348	100	100
349	100	100
350	92	100
351	100	100
353	100	100

Efficacy of fungicides applied to potted plants before inoculation.

Switch was the only fungicide to provide complete control in both experiments using excised shoots (Table 19, 20). Rovral also provided good control, but results were variable with Shirlan and Benlate. Experiments where grape vine shoots were inoculated without excising were not successful, as the inoculation techniques did not give consistent infection so no conclusions could be drawn from the results.

Table 19. *Experiment 16*. Percent of inoculation sites on shoots infected with *S sclerotiorum* after treatment with fungicides at 1, 3 and 7 days before shoot removal and inoculation.

Fungicide and rate	**% inoculation sites infected**								
	Chardonnay			**Shiraz**			**Cabernet Sauvignon**		
	1 day	**3 days**	**7 days**	**1 day**	**3 days**	**7 days**	**1 day**	**3 days**	**7 days**
Benlate (1.0 g/L)	0	0	0	0	0	0	0	0	0
Shirlan (0.25 mL/L)	0	0	25	0	0	0	0	0	0
Switch (0.8 g/L)	0	0	0	0	0	0	0	0	0
Rovral (1 mL/L)	0	0	75	0	0	0	0	0	0
Control (water)	75	50	100	50	25	75	25	50	75

Table 20. *Experiment 17*. Percent of inoculation sites on shoots infected with *S sclerotiorum* after treatment with fungicides at 3 and 7 days before shoot removal and inoculation.

Fungicide and rate	**% inoculation sites infected**		**% inoculation sites infected**	
	Shiraz		**Cabernet Sauvignon**	
	3 days	**7 days**	**3 days**	**7 days**
Benlate (1.0 g/L)	67	0	61	55
Shirlan (0.25 mL/L)	12.5	27	29	19
Switch (0.8 g/L)	0	0	0	0
Rovral (1 mL/L)	12.5	0	0	0
Control (water)	100	89	94	100

7. Outcomes/Conclusion

Four fungicides, Switch, Shirlan, Rovral and Sumisclex, were found to have both eradicant and protectant activity against Sclerotinia shoot rot when tested on berries and excised shoots. Unfortunately a method of inoculation that provided consistent infection on growing shoots was not found, so these fungicides could not be tested on in ground vines.

One vineyard in Eden Valley was monitored in spring 2001, and infected vines tagged. Little spread was observed within the vineyard after the initial infection. These vines will be visited again in spring 2002 to determine if the disease in still present. Monitoring of 2 vineyards was not undertaken due to time constraints. One vineyard in Mt Benson, monitored by consultants, had continual new infections into January 2002, most likely due to the continual wet weather experienced in that region.

This investigation provides growers with preliminary recommendations for the control of Sclerotinia shoot rot. As some of the fungicides tested showed eradicant properties against *S. sclerotiorum*, it is likely that growers can wait until they see the first signs of disease before treating, particularly in dry weather when the fungus is less active. However this will require close monitoring, as the disease progresses very quickly and it would be advisable to provide control before the formation of the sclerotes, which would aid in reducing carryover inoculum for future seasons.

8. Recommendations

Future research is required to understand the epidemiology of the fungus and it's relationship to the grapevine. Understanding the conditions required for its development and spread will assist in predicting possible future outbreaks, so control measures can be implemented before further spread and loss of productivity.

The long-term effect of infection by *S. sclerotiorum* on the vine also needs investigation, as the fungus was able to be isolated from living canes under the affected shoots. It is not known if this would become a possible source of further infection.

Appendix 1: Communication

The results of this work were communicated at Research to Practice meetings in Robe and Coonawarra. A fact sheet was produced and has been distributed electronically to growers, companies and consultants, and at Research to Practice workshops (Appendix 5).

An article has been produced in the Viticare newsletter (Appendix 5), and results will be presented at the 8th International Congress for Plant Pathology, incorporating the 14th Biennial Australasian Plant Pathology Conference, in Christchurch NZ in Feb 2003 (abstract in Appendix 5).

Appendix 3: References

Boland GJ and Hall R (1994) Index of host plants of *Sclerotinia sclerotiorum*. *Canadian Journal of Plant Pathology* **16**: 93-108

BH Hall, RL McMahon and TJ Wicks (2002) First Report of *Sclerotinia sclerotiorum* on grape (*Vitis vinifera)* in South Australia. *Australasian Plant Pathology* (in press)

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BH Hall and RL McMahon (2001) Two new disease of grapes reported in South Australia. In "Proceedings of the 13th Biennial APPS Conference, Cairns" p231

Latorre BA and Guerrero MJ (2001) First Report of Shoot Blight of Grapevine Caused by *Sclerotinia sclerotiorum* in Chile. *Plant Disease* **85:** 1122

Shivas R (1989) Fungal and Bacterial pathogens of plants in Western Australia. *Journal of the Royal Society of Western Australia* **72:**1-62.

Appendix 4: Staff

- Barbara Hall (SARDI – Horticulture Pathology)
- Catherine Hitch (SARDI – Horticulture Pathology)
- Robyn McMahon (SARDI – Horticulture Pathology)
- Trevor Wicks (SARDI – Horticulture Pathology)
- SARDI colleagues

Appendix 5: Communications

Abstract for ICPP conference:

Sclerotinia shoot rot of grapevines.

B.H. Hall, R.L. McMahon, C.J. Hitch and T.J. Wicks
South Australian Research and Development Institute (SARDI), Plant Research Centre, GPO Box 397, Adelaide, SA 5001
Email: hall.barbara@saugov.sa.gov.au

Sclerotinia sclerotiorum (Lib.) de Bary was recovered from rotting grapevine shoots (*Vitis vinifera* L) cv. Cabernet Sauvignon in a vineyard in South Australia, October 2000. In Oct/Nov 2001, the fungus was also detected in a further 14 vineyards in the cooler grape growing areas of South Australia, affecting Cabernet Sauvignon, Shiraz, Pinot Noir, Riesling, Verdelho and Sauvignon Blanc. Symptoms included a pale brown rot, which developed either at the base of the shoot or at a node, and caused shoot death. Sometimes several shoots per cordon were affected and in severely infected vineyards crop loss also occurred from the death of cordons supporting the affected shoot. These symptoms were superficially similar to those caused by *Botrytis*, however sclerotes developed in and on the affected shoots in the field. Fungicides known to control either *Sclerotinia* or *Botrytis* were tested to determine their protective or curative effect on the fungus. Initial evaluations undertaken on excised grape berries indicated iprodione (Rovral), fluazinam (Shirlan), procymidone (Sumisclex) and cyprodinil plus fludioxonil (Switch) were effective when applied immediately before infection. The same fungicides also eradicated the fungus on the excised berries when applied 1 and 3 days after inoculation. Benomyl (Benlate) also gave control, but results were variable, as some isolates were resistant to benomyl. Tests on inoculated shoots are underway to evaluate the fungicides on grapevines.