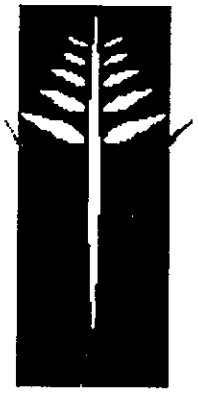
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GRAPE AND WINE RESEARCH AND DEVELOPMENT CORPORATION

FINAL REPORT

GWRDC Project UWS 98/1

Improved Management Strategy for Phomopsis on Grapevines

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1. EXECUTIVE SUMMARY

The Disease – Phomopsis cane and leaf spot disease of grapevines [caused by *Phomopsis viticola* (Sacc.) Sacc.] was formerly known as 'excoriose' and 'grape dead arm'. The use of the latter name has been discontinued because dead-arm-like symptoms have been associated with Eutypa dieback (caused by *Eutypa lata*). Phomopsis cane and leaf spot is an important disease in some viticultural regions of the world. The disease can be economically important in some grape growing areas in Australia either because of crop loss caused by the disease and/or because of the cost of spray programs applied for disease control. Since the beginning of organised research on this disease in Australia in 1991/92, severe symptoms of the disease have been found in vineyards in some districts of New South Wales and Victoria. The disease has also been observed in some vineyards in South Australia, Western Australia and Tasmania.

Previous research – Research overseas has indicated that most varieties of *Vitis vinifera* are susceptible to infection by *Phomopsis* although symptom severity and effects on vine growth can vary between varieties. Recommended practices for management of the disease have included use of disease-free planting material to prevent introduction of disease into new vineyards, removal of occasional diseased vines to prevent disease spread and establishment in new vineyards, removal of diseased canes or spurs from infected vines to reduce overwintering inoculum, treatment of established infected vines in late dormancy with eradicant fungicides to reduce the activity of overwintering pycnidia, and treatment of vines from budburst to flowering with protectant fungicides to prevent shoot and bunch infection during wet weather.

The major findings of past research on *Phomopsis* on grapevines in Australia were the recognition of different types of *P. viticola*, observations that *Phomopsis* Type 1 and Type 2 were mostly distributed in cool and warm viticultural regions respectively, definition of symptoms associated with *Phomopsis* Type 1 and Type 2, and an indication of the potential for dormant treatment of grapevines in addition to in-season spray programs to reduce disease incidence.

Although these observations helped to improve disease control, growers in some districts were still uncertain about the need for and the best approach to control. Further work was needed to provide grape growers with an appropriate disease management strategy.

Separation of the two types (or taxa) of the pathogen (*P. viticola*) appears to have an important bearing on the epidemiology and management of the disease on grapevines. Symptoms of Type 2 include bleaching, scarring and scabbing on dormant canes, leaf spots (small brown to black circular spots surrounded by yellow halos) and elongated scars on shoot stems. These symptoms are similar to those associated with infection by *P. viticola* in other parts of the world. Previous research in Australia has shown that Type 2 can cause significant reductions in the yield of grapevines and that in-season fungicide treatment programs can provide disease control. At present, only bleaching of dormant canes, and possibly some bud death, have been associated with Type 1. In laboratory and glasshouse tests, Type 1 appears to be less pathogenic than Type 2. To date, field studies have not indicated conclusively that fungicide treatments used to control Type 2 are also effective against Type 1. The distinction between the *Phomopsis* Type 1 and Type 2 is also based on

the size of alpha (α) conidia, characteristics of mycelial growth *in vitro* including pycnidial appearance, colour of the cirrhi (mass of conidia) and the rate of mycelial growth and production of conidia. The pectic enzyme profiles and optimum temperatures for conidial germination also support the separation of these Types.

This project was focused on the development of an improved management strategy for *Phomopsis* Type 2 because of its economic importance.

Project objectives - To develop an improved management strategy for *Phomopsis* Type 2 on grapevines through investigation of the efficacy of fungicide applications in the vineyard during dormancy to reduce carry over of inoculum, the assessment of the techniques (including long duration hot water treatment) used to eliminate *Phomopsis* from propagation materials, and the production of a brochure to help growers diagnose symptoms of *Phomopsis* and manage the disease.

Management of Phomopsis disease (Type 2) using dormant plus in-season spray applications – Potentially, a decrease in the carry over of disease from the dormant period to the new season should reduce the risk of disease. One of the primary objectives of this project was to study the effect of fungicide spray applications during vine dormancy on the incidence of *Phomopsis* on dormant canes, and on the development of disease on grapevine shoots and leaves in the following season. In the trials carried out during 1999/2000 on Chardonnay at Camden in New South Wales and on Sultana at Vinifera in Victoria, two applications of fluazinam (Shirlan®) were applied during dormancy. This was followed by three in-season applications of dithianon (Delan®) at 50-60% bud burst, 2 weeks and 4 weeks later. This treatment was compared with two other treatments, one of which received only in-season spray applications while the other was left untreated both at dormancy and in-season. Disease incidence on vines treated with dormant sprays of Shirlan® followed by in-season Delan® applications was significantly less than that on untreated vines and on vines treated only with in season sprays of Delan®. **Therefore, dormant treatments to reduce the carry over of disease into the new season, followed by in-season applications to reduce shoot and leaf infections, improve disease control.**

Improving quality of grapevine planting material – Hot water treatment is a standard procedure used by the grapevine industry to eliminate pathogens from planting material. Hence, a trial was carried out to examine the effects of long duration hot water treatment, which is employed in commercial practice, on the survival of *Phomopsis*. The treatment protocol used in the trial was similar to those used by the industry, the Australian Vine Improvement Association (AVIA) and the Victorian and Murray Valley Vine Improvement Association (VAMVVIA). Cuttings infected with *Phomopsis* were immersed in hot water at 50°C for 30 minutes in a hot water treatment tank. The treated cuttings were then transferred to cool down tanks. Proper controls were maintained during the trial [eg. no hot water treatment but cuttings held in water at ambient temperature for an equivalent time; no treatment (control) with cuttings showing *Phomopsis* symptoms held in cool storage]. The hot water treatment of the grapevine cuttings reduced the incidence of *Phomopsis* from over 75% to less than 1%. **Therefore, hot water treatment is an effective non-chemical way of reducing *Phomopsis* infection in grapevine propagation material. However, hot water treatment does not always eradicate the pathogen from planting material.**

Survey of nurseries – Scion cuttings, graftlings or rootlings of different grapevine varieties (31 varieties, 71 clones and 3635 cuttings or rootlings) were collected from three large-scale

commercial grapevine nurseries plus three smaller ones and Vine Improvement Associations in New South Wales, Victoria and South Australia. The presence of *Phomopsis* in these materials was determined by microscopic examination. Overall, the results showed that less than 0.6% of cuttings or rootlings were infected with *Phomopsis* Type 2 in relation to the source of the planting material. In comparison, the percentage incidence of *Phomopsis* in relation to grapevine variety was 8% in Sultana, 2% in Sauvignon Blanc, and 1% in Shiraz. A relatively low percentage of cuttings or rootlings was infected with other pathogens such as *Botryosphaeria obtusa* (0.3%) and *Botrytis cinerea* (0.2%). The incidence of these fungi in planting material in relation to grapevine variety was higher (eg. 11% *B. obtusa* in Red Emperor). Although this survey of nurseries in Australia was not meant to be comprehensive, the results indicated that **relatively low levels of planting material infected with *Phomopsis* were being used for propagation. However, the industry appeared to be moving toward improving the quality and consistency of propagation material by adopting and implementing new or improved management systems.**

Overall management strategy for *Phomopsis* Type 2 (based on studies in this and previous projects)

1. To minimise the risk of introducing *Phomopsis* into vineyards, use planting material that has been produced from cuttings that have been hot water treated at 50°C for 30 minutes and have been taken from healthy vines (ie. vines that do not have *Phomopsis* Type 2 or symptoms of disease caused by *Phomopsis* Type 2).

2. Before applying a vineyard spray program, establish whether a disease control program for *Phomopsis* Type 2, is needed. On some varieties and in some districts, the disease may not cause sufficient crop loss to warrant expenditure on control programs. Spray programs for the control of *Phomopsis* Type 2 are not required in vineyards where the pathogen is has not been detected.

3. Vineyards without a history of *Phomopsis* Type 2 should be monitored each season to ensure that they remain free of disease. For best results, monitoring for symptoms of disease on foliage should be conducted at least 3-4 weeks after conditions favourable for infection by *Phomopsis* Type 2 have occurred.

4. If a diseased vine is detected in a vineyard without a history of disease, prompt removal of the affected vine may be worthwhile to prevent the disease becoming established.

5. In vineyards with a history of *Phomopsis* Type 2, apply one fungicide spray 4 weeks before budburst followed by up to four in-season applications at 10-14 day intervals commencing at 30-50% budburst. The fourth spray may not be required unless wet conditions favourable for disease development continue. Sprays applied at budburst and 10-14 days later are most important for disease control in seasons when wet weather occurs in early spring.

6. Fungicides that provide control of *Phomopsis* Type 2 are:
   - fluazinam (Shirlan®) at vine dormancy and
   - dithianon (Delan®) and mancozeb (including Dithane®, Mancozeb®) during the vine growth season.

7. Before using fungicides for the control of Phomopsis Type 2, check their registration

status in each state. In some Australian states, mancozeb is not registered for *Phomopsis* control. A temporary permit for the use of Shirlan® was issued by the National Registration Authority (NRA) for 1998/99 and 1999/2000 with vineyard entry restrictions. The continued use of this fungicide will depend on final approval of registration by the NRA.

8. Where practical, reduce sources of inoculum by removing diseased canes or spurs from vines and the vineyard floor. This, in combination with fungicide treatment programs, will help to lower disease severity.

Delivery of information to industry – Presentations of the results of the project have been made to grape growers and other researchers by project staff at field days, seminars, industry and Research to Practice® training workshops in New South Wales, Victoria, South Australia and Western Australia. Information from the project has also been published in articles in Australian Grapegrower and Winemaker. Draft of a brochure on the management of *Phomopsis* has been prepared for use by the industry.

2. BACKGROUND TO THE RESEARCH

Introduction to *Phomopsis viticola* on Grapevines

General - Phomopsis cane and leaf spot disease of grapevines (caused by *Phomopsis viticola* (Sacc.) Sacc.) was formerly known as 'excoriose' and 'grape dead arm'. The use of the latter name has been discontinued, as similar symptoms are associated with Eutypa dieback (*Eutypa* sp.). Phomopsis cane and leaf spot is an important disease in some viticultural regions of the world (Reddick 1909; Hiura 1924; Taylor and Mabbitt 1961; Lal and Arya 1982; Bugaret 1984). The disease has been identified as a major problem in Eastern Europe (Machowicz-Stefaniak *et al.* 1991) and Australia (Nair *et al.* 1994, 2000). It is important economically in most of the grapevine growing areas in New South Wales, Victoria, South Australia, Tasmania and Western Australia either because of crop loss caused by the disease and/or because of the cost of spray programs applied for disease control. The first report of the disease in Australia was in 1911 in Mildura, Victoria, followed by a report of the disease in New South Wales in 1935. Since the beginning of organized research on this disease in Australia in 1991/92 (Nair *et al.* 1994; Merrin *et al.* 1995), severe symptoms of the disease have been found in a number of vineyards in New South Wales, Victoria, South Australia, Western Australia and Tasmania.

The present work is based on the findings of previous research (GWRDC projects DAN 8GW and DAN 94/1) on the cane and leaf spot disease of grapevines. The major findings of the past work were the recognition of different Types (or Taxa) of *Phomopsis viticola* showing preferential distribution in the warm and cool viticultural regions; definition of symptoms associated with Type 1 and Type 2 of *Phomopsis*; and, indication of the potential for dormant treatment of grapevines to reduce disease incidence. Although these observations have helped in improving disease control, further work was needed to provide grape growers with a disease management strategy.

The Pathogen - Two different types of *P. viticola* (Type 1 and Type 2) have been identified as the most important sources of disease in Australian vineyards (Merrin *et al.* 1995). Type 1 has been found primarily in cool climate or coastal areas and Type 2 in warmer inland areas, but both types have now been found together in inland vineyards in Victoria, New South Wales and South Australia. (Nair *et al.* 1994, 1998). Separation of the pathogen (*P. viticola*) into two Types appears to have an important bearing on the epidemiology of the disease on grapevines. The distinction between the types is also based on the size of α conidia, characteristics of mycelial growth *in vitro* including pycnidial appearance, colour of cirrhus and rate of mycelial growth and sporulation. The host response, pectic enzyme profiles and optimum temperatures for germination also support the separation of these taxa. Type 2 appears to be more virulent than Type 1 (Nair *et al.* 1998). Sergeeva *et al.* (2000) obtained further evidence for the higher degree of pathogenicity of Type 2 when compared with that of Type 1.

The pathogen produces over wintering, dark, eustromatic pycnidia in which two types of conidia are normally produced. These were termed alpha (α) and beta (β) conidia but were also called macro- and microconidia or stylospores respectively. α conidia of *Phomopsis* species are oval, elliptical or fusiform and usually biguttulate. β conidia are filiform, and mostly curved. The ratio of α:β conidia within a pycnidium varies greatly. Pycnidia that form solely α or β conidia are also found. α conidia are known to cause primary infection; however, β conidia are generally considered to be sterile and their function in disease development has

remained unknown. However, Sergeeva *et al.* (2000) reported recently that β conidia can germinate and infect grapevine leaves and therefore, play an important role in the epidemiology of the disease.

Table 2.1 Characteristics of α conidia of *Phomopsis* associated with grapevines (modified from Phillips 1999).

Species	Length x width (μm)	Shape	Guttulation	Reference
Phomopsis viticola	8-9 x 2	ellipsoidal	2-guttulate	Saccardo (1880)
Phomopsis viticola	8-10 x 3	elliptic-fusoid	2-guttulate	Pine (1958)
Phomopsis viticola	7-10 x 2-4	elliptic-fusoid	2-guttulate	Punithalingam (1979)
Phomopsis viticola	7.5-13.5 x 2-3	elliptical	-	Dias (1980)
Phomopsis viticola Type 1	4.8-7.2 x 1.4-2.2	ovoid	2-guttulate	Merrin *et al.* (1995)
Phomopsis viticola Type 2	8.0-11.8 x 2.0-3.2	elliptic-fusoid	multiguttulate	Merrin *et al.* (1995)

The pathogen *P. viticola* produces a sexual stage (perfect stage or teleomorph) belonging to the genus *Diaporthe*. Scheper *et.al.* (1997) reported a teleomorph of *P. viticola* from Australia and drew its relationship to the anamorph (asexual stage) of *P. viticola* (Type 1) *sensu* Merrin *et.al.* (1995). The species name *D. viticola* was given to this sexual stage found in Australia.

Infection of Grapevines - Primary infection occurs during wet weather in spring, when the pycnidia release spores that are washed or splashed onto nearby young shoots (Hewitt and Pearson 1988; Creecy and Emmett 1990). Successive cool, wet springs can lead to a build-up of the disease, but both types of *Phomopsis* can remain dormant in infected canes and spurs for a number of seasons when conditions in spring are dry and not conducive to disease spread. Infected canes and spurs may continue to produce pycnidia and spores for at least three seasons (Creecy and Emmett 1990). Dead canes may also produce spores for at least three years (Pearson 1990).

The Symptoms - Type 1 and Type 2 cause different symptoms on grapevines. While bleaching, scarring, and scabbing of dormant canes, leaf spots and elongated scars on shoot stems characterise infection by Type 2, to date, only bleaching (around the nodes) and sometimes flattish dark lesions with narrow dark borders on dormant canes have been associated with infection by Type 1. The leaf symptoms for Type 2 are small dark brown to black spots up to 1 mm in diameter, with yellow halos extending 2-3 mm beyond each spot. Diseased leaves are usually at the base of shoots that are often in the crown of vines. Severely infected leaves become distorted, turn yellow and fall. Diseased shoots have small black spots that gradually develop into dark brown to black elongated scars that join together, split open and cause scarring and scabbing. These lesions usually occur on the lower 2-3 internodes after an early season infection, but can also occur on petioles, tendrils, rachides, and bunches (Pine 1959; Taylor and Mabbitt 1961; Hewitt and Pearson 1988; Creecy and Emmett 1990). In severe cases, diseased flower and berry clusters shrivel and die, although berry infections are

less common in south eastern regions of Australia, where hot, dry summer weather reduces disease activity (Creecy and Emmett 1990). Reduced yield usually occurs when diseased shoots are girdled by lesions and become stunted, brittle and liable to break off near the base during the growing season (Moller *et al.* 1982). Loss of shoots early in the growing season can lower vine productivity by reducing potential bunch numbers. In winter, the weakened canes are more susceptible to frost damage and breakage at pruning time (Creecy and Emmett 1990). The loss of new or replacement canes can reduce yield in following seasons.

Spread of the Pathogen - *Phomopsis* spreads slowly within the vineyard from localised sources of infection. Previous research by project staff has highlighted the systemic nature of the disease. Type 2 appears to cause systemic infection in new shoots, progressing from basal internodes to the upper parts of one-year-old canes (Pine 1959; Nair *et al.* 1998). This discovery has an important bearing on the choice of chemical treatments for disease management and recommendations for eliminating the pathogen from grapevine propagation materials.

Long distance spread of the disease to new viticultural areas mostly occurs through the transfer of infected propagation materials such as bud wood, cane cuttings and nursery stock (Hewitt and Pearson 1988; Creecy and Emmett 1990). As well as introducing disease into the vineyard, infected material also reduces the rate of success of grafting and cutting propagation, and the fungus can kill grafted and other nursery stock (Willison *et al.* 1965; Hewitt and Pearson 1988). The use of 8-hydroxy quinoline sulphate (Chinosol®) as a disinfectant for the control of *Botrytis cinerea* on propagation material has been shown to reduce the viability of pycnidia of *Phomopsis* (Hewitt and Pearson 1988; Castillo-Pando *et al.* 1997) but for health and environmental reasons, this chemical is not widely used by the nursery industry. Previous studies on long duration hot water treatment (HWT) of grapevine cuttings and rootlings (30 minutes at 50°C) have shown that it can eradicate some fungi, insects, bacteria, nematodes and phytoplasmas (Orffer and Goussard 1980; Hamilton 1997; AVIA 2000). Anecdotal evidence has indicated that long duration HWT may also reduce the infection of *Phomopsis* in propagation material but this has not been confirmed by trials (Waite and May 1999).

Disease Management (chemical application).- Research has shown that it is difficult to eliminate *Phomopsis* from diseased vines, and in the past, highly toxic chemicals were used as dormant sprays (Taylor and Mabbitt 1961; Creecy and Emmett 1990). Currently no dormant treatment is registered for use in Australia. Trials in the USA have shown that high rates of lime sulphur applied to dormant grapevines can reduce the production of spores from over wintering pycnidia, and decrease the incidence and severity of the leaf and rachis phase of the disease. However, the extremely high rates of application required and cost of the chemical have made it a less competitive choice of treatment (Gadoury *et al.* 1994). Further trials in Australia and in other countries have studied the efficacy of other products as dormant treatments (Nair *et al.* 1998, 2000; Katz 1999).

Data obtained in the previous project (Nair *et al.*1998) pointed to the possibility of reducing the incidence of *Phomopsis* by the application of a spray during vine dormancy (ie. 3-4 weeks before bud burst) followed by in-season spray applications (ie. 30-50% bud burst and later at 10 days, 3 and 5 weeks after bud burst). Fluazinam (Shirlan®) was found to be an effective fungicide for the dormant spray application and, it was suggested that fluazinam should be registered for use in managing *Phomopsis* on grapevines. The in-season applications of mancozeb (Dithane®) and dithianon (Delan®) appeared to be suitable for

reducing the disease. Currently mancozeb and dithianon are commonly used by growers depending on the appropriate regulations for chemical use in the different states

Disease Management (cultural practices) – Practices such as removing and destroying diseased and dead wood during pruning can reduce the carry-over of disease in an infected vineyard, but the trend towards mechanical-hedging and minimal pruning can increase disease inoculum and incidence and make effective control more difficult. Research trials in the USA showed that after two years of hedge pruning, the incidence of *Phomopsis* on infected vines increased significantly (Pscheidt and Pearson 1989a, 1989b, Pearson 1990).

Disease Management (resistant grapevine varieties) - Few, if any, cultivars of grapes are resistant to *Phomopsis* (Hewitt and Pearson 1988) but cultivars differ in their levels of susceptibility to infection. Pinot Meunier is the only variety in France that has been found to be almost resistant (Doazan 1974). Varieties infected by *Phomopsis* in Australia include: Chardonnay, Cabernet Sauvignon, Riesling, Shiraz, Sauvignon Blanc, Pinot Noir, Sultana (Thompson Seedless), Waltham Cross, Ruby Seedless and other table grape varieties (Creecy and Emmett 1990; Merrin *et al.* 1995).

3. PROJECT OBJECTIVES

(Disease management)

To develop an improved management strategy for *Phomposis viticola* (Type 2) on grapevines through:

- a fungicide application in the vineyard during vine dormancy to reduce carry-over of inoculum;
- hot water treatment to reduce spread of *Phomopsis* from planting materials; and,
- the production of a brochure to assist growers in diagnosis of symptoms caused by *Phomopsis* and in disease management.

4. PROJECT OUTCOMES

(improved disease management)

The major outcomes of the proposed project will be:

- improved management of *Phomopsis* in vineyards;
- improved quality of planting materials from nurseries; and,
- increased awareness of best practice for management of *Phomopsis* on grapevines through the production of a brochure for industry use.

5. MANAGEMENT OF *PHOMOPSIS* (TYPE 2) BY DORMANT AND IN-SEASON APPLICATIONS OF FUNGICIDES

Introduction

Currently, dithianon is the only agrochemical registered for control of *Phomopsis viticola* on grapevines in Victoria, New South Wales and South Australia. Dithianon is a protectant fungicide with multi-site activity. In vineyards with *Phomopsis* it is applied at 50% budburst and again at two weeks after budburst. If further wet weather occurs and conditions continue to favour disease spread, additional sprays may be required at two-week intervals until fruit set. In seasons when cool, wet weather results in high disease pressure in early spring, grape growers sometimes have difficulty achieving adequate control, especially in years with an early and uneven budburst.

In the past, highly toxic chemicals such as sodium arsenite and phenyl mercuric chloride (P.M.C.) were used in Australia as dormant winter treatments for *Phomopsis* on grapevines (Taylor and Mabbitt 1961; Creecy and Emmett 1990). These chemicals are no longer used and at the time when this project commenced, no dormant treatment or eradicant fungicide was registered for *Phomopsis* control in Australia

In 1994, the Grape and Wine Research and Development Corporation provided funding for a project titled 'Strategies to reduce the incidence of *Phomopsis* cane and leaf blight of grapevines'. Field trials were run to test the efficacy of dormant and early season treatments for reducing carry over and incidence of *Phomopsis*, to assess the effects of different types of *Phomopsis* on crop loss, and to increase grower awareness of *Phomopsis* disease. These vineyard trials were conducted in Robinvale, Vinifera and in the Yarra Valley (Victoria), in Padthaway and the Adelaide Hills (South Australia) and in Koraleigh and Griffith (New South Wales). They provided valuable information about the nature, distribution and management of *Phomopsis* in a number of Australian viticultural regions under a range of different climatic conditions (Nair *et al.* 1998).

It was established that *Phomopsis* Types 1 and 2, which normally occur seperately, could occur together in the same vineyard (eg. at Vinifera). The field trials showed that early season spray programs could provide effective disease control and increase vine yield. Initial results obtained from the dormant winter spray treatment trials were encouraging. However, a vineyard re-entry restriction specified by the National Registration Authority in the temporary permit issued for fluazinam made it necessary to test the efficacy of other chemicals such as mancozeb and dithianon as alternative dormant treatments (Nair *et al.* 1998, 2000).

In 1998, the Grape and Wine Research and Development Corporation and the Cooperative Research Centre for Viticulture funded another *Phomopsis* project, which allowed project staff to conduct further trials to determine the efficacy of dormant treatments.

Materials and Methods

Field trials to assess the efficacy of dormant and early season applications of fungicides for the control of *Phomopsis* were conducted at Vinifera, Victoria and, at Griffith and Camden, New South Wales. A total of five vineyard trials were conducted in 1998/1999 and 1999/2000.

Field trials at Vinifera, Victoria

The Sultana vines used in this study were over thirty years old, cane pruned on a narrow two-wire T- trellis, drip irrigated and had a history of infection with *Phomopsis* Types 1 and 2. In 1998/99, treatments were applied to a trial design (a 40 plot Youden Rectangle with two appended rows). This trial design was adopted to minimise any residual effects from treatments in previous seasons. Apart from the treatments, no other agrochemicals were applied to the trial site for the control of other diseases or pests apart from those listed below.

Treatments 1998

Treatments applied to vines in the *Phomopsis* dormant treatment trial are given in Table 5.1.

Table 5.1 Treatments applied to the *Phomopsis* trial at Vinifera, Victoria in 1998

Number	Dormant[1]			In season[2]
	Shirlan[3]	Delan[4]	D-C-Tron Plus[5]	Delan[6]
1	-	-	-	-
2	+	-	+	+
3	+	-	-	+
4	-	+	+	+
5	-	-	+	+
6	-	-	-	+

[1] Approximately 2 weeks before budburst; [2] 30-50% budburst, budbudrst + 9 days, budburst + 3 weeks, budburst + 5 weeks, budburst + 7 weeks, budburst + 10 weeks; [3] 100ml/100L; [4] 100g/100L; [5] 2L/100L (D-C-Tron Plus)

The dormant treatments tested were fluazinam (Shirlan® 500 g/L SC, Crop Care Australasia Pty. Ltd, Australia), emulsifiable petroleum oil (D-C-Tron Plus® 839 g/L EC, Ampol, NSW, Australia) and dithianon (Delan® 750 g/kg WP, Bayer Australia Ltd., NSW). The treatments were applied to four series of replicated plots either separately or in combination (Treatments two to five) at concentrations recommended by the manufacturers (fluazinam 500 ppm, emulsifiable petroleum oil 300 ppm and dithianon 750 ppm). These sprays were applied approximately two weeks before budburst on 27 August 1998, using pump-action 15L backpack sprayers with hollow-cone nozzles.

From 30-50% budburst, all previously treated plots and another set of plots (Treatment 6, which did not receive a dormant treatment), received five consecutive in-season treatments of dithianon (Delan® 750 g/kg WP) at 750 ppm. The first three of these sprays were applied by 15L backpack sprayer on 7 September (30-50% budburst), 16 September (9 days after budburst) and 30 September (3 weeks after budburst). After the third spray, the vine canopy had increased in size to the point where it was necessary to apply the last two applications of dithianon using a motorised spray unit. These were applied on 16 and 28 October (budburst and 5 weeks and 7 weeks respectively).

During each spray application, the vines were thoroughly sprayed from each side to the point of run off. When the last three in-season sprays were applied, the vines in the untreated control plots (Treatment 1) were sprayed with water using the same volume. Weather conditions at the time of each spray application were dry, and were either calm or with light winds.

Assessments – Incidence and severity of *Phomopsis* disease was assessed on leaves at the first six nodes and the first five internodes of the stems of fifteen shoots per plot (10 weeks after budburst, 20/11/98).. The assessment data were analysed statistically using Genstat 5.

Treatments: 1999

Treatments applied to vines in the second year of the trial are given in Table 5.2.

Table 5.2 Treatments applied to the *Phomopsis* trial at Vinifera, Victoria in 1999

Number	Dormant[1]		In season[2]
	Shirlan[3]	Oil[4]	Delan[5]
1	+	+	-
2	+	+	-
3	-	-	+
4	-	-	+
5	-	-	+
6	-	-	+
7	-	-	-

[1] 4 weeks before budburst and 3 weeks before budburst;
[2] 60% budburst, budburst + 2 weeks, budburst + 4 weeks, budburst + 10 weeks; [3] 100ml/100L; [4] 500ml/100L (Synertrol Horti Oil); [5] 100g/100L

A dormant treatment of fluazinam (Shirlan® 500 g/L SC, Crop Care Australasia Pty. Ltd., Australia), and emulsifiable botanical oil (Synertrol Horti Oil® 850 g/L EC, Organic Crop Protectants Pty. Ltd., NSW, Australia) was applied twice to a series of replicated plots (Treatment 2) at concentrations recommended by the manufacturers (fluazinam 500 ppm, emulsifiable Synertrol oil 300 ppm). The first spray was applied at approximately four weeks before budburst on 4 August 1999 and the second one-week later on 11 August 1999, using pump-action 15L backpack sprayers with hollow-cone nozzles. The adjuvant was changed from D-C-Tron Plus® (tested in 1998) to Synertrol Horti Oil® because research indicated that lighter oils may penetrate wood of canes and spurs more than heavy ones and increase efficacy. The change also minimised the risk of damage to shoots that were more advanced at the time of application, because phytotoxicity was observed in the previous season.

From 60% budburst, the plots that had received the two dormant treatments (Treatment 2), and another set of plots that did not receive any dormant treatments (Treatment 3), received three consecutive in-season treatments of dithianon (Delan® WP 750 g/kg, Bayer Australia Ltd., NSW) at the concentration recommended by the manufacturers (dithianon 750 ppm). The first spray was applied by backpack sprayer on 8 September (60% budburst), but the other

two applications were applied with a motorised spray unit on 20 September (2 weeks after budburst) and 5 October (4 weeks after budburst). The optional fourth spray of dithianon at 6 weeks after budburst was not applied because weather conditions remained dry. During each spray application, the vines were thoroughly sprayed from each side to the point of run-off. Weather conditions at the time of each spray application were dry, and were either calm or with light winds. The vines in the untreated plots were not sprayed with water this season.

Assessments - The incidence and severity of *Phomopsis* disease on the leaves at first 6 nodes and on the first 5 internodes of stem of fifteen shoots per plot were assessed (10 weeks after budburst). The assessment data were again statistically analysed using Genstat 5.

Field trials at Camden, New South Wales

The trial site at Camden, New South Wales was chosen because of its history of severe *Phomopsis* infection in the sixteen year old Chardonnay vines. The vines trained on a vertical shoot position trellis, had a dense canopy and were overhead irrigated. Although the vineyard was in a designated Phylloxera area, the pest was not detected in a monitoring survey carried out in 1998/99. Sprays were applied to run off using pump action backpack sprayer with hollow cone nozzles. The weather was calm and clear during the application.

Treatments 1998

Treatments applied to vines in the *Phomopsis* dormant treatment trial are given in Table 5.3.

Table 5.3 Treatments applied to the *Phomopsis* trial at Camden, New South Wales in 1998

Number	Dormant[1]			In season[2]
	Shirlan[3]	Delan[4]	Oil[5]	Delan[4]
1	-	-	-	-
2	+	-	+	+
3	+	-	-	+
4	-	+	+	+
5	-	-	+	+
6	-	-	-	+

[1] Approximately 2 weeks before budburst; [2] 30-50% budburst, budbudrst + 9 days, budburst + 3 weeks, budburst + 5 weeks, budburst + 7 weeks, budburst + 10 weeks; [3] 100ml/100L; [4] 100g/100L; [5] 2L/100L (D-C-Tron Plus)

Assessments: The incidence and severity of *Phomopsis* disease on the leaves at the first six nodes and on the first five internodes on the stems of fifteen shoots per plot were assessed on 10 October 1998 (10 weeks after budburst). The data were statistically analysed by Analysis of Variance and the levels of significance expressed at $P<0.05$.

Treatments 1999

Table 5.4 Treatments applied to the *Phomopsis* trial at Camden, New South Wales in 1999

Number	Dormant[1]			In season[2]
	Shirlan[3]	Delan[4]	Oil[5]	Delan[4]
1	-	-	-	-
2	+	-	+	+
3	+	-	-	+
4	-	+	+	+
5	-	-	+	+
6	-	-	-	+

[1] Approximately 2 weeks before budburst; [2] 30-50% budburst, budbudrst + 9 days, budburst + 3 weeks, budburst + 5 weeks, budburst + 7 weeks, budburst + 10 weeks; [3] 100ml/100L; [4] 100g/100L; [5] 2L/100L (Synertrol Horti Oil)

Assessments: The methods of assessment were the same as for the 1998 trial (given above).

Field Trial at Griffith, New South Wales

The trial was carried out at the research station of New South Wales Agriculture, Griffith on vines of the variety Shiraz that were approximately 30 years old. The spray treatments and the timing of application of fungicides were similar to those used at Camden, New South Wales (1998).

Results and Discussion

Field trials at Vinifera, Victoria

(First year - 1998/1999)

The effects of the treatments on incidence and severity of *Phomopsis* disease on internodes and leaves are presented in Tables 5.5 and 5.6 respectively. The figures shown in the tables are the back-transformed means and the lower case letters indicate significant differences (ie. means with a lower case letter in common are not significantly different at the P=0.05 level, as assessed by the LSD comparison of the means on the transformed scale). All treatments reduced disease incidence and severity in comparison to the untreated control. No significant differences were detected between the dormant treatments of Shirlan®, D-C-Tron Plus® or Delan® (which were all followed by in-season Delan® treatments) and the in-season Delan® only treatment.

Table 5.5. Incidence and severity of Phomopsis disease on internodes of Sultana grapevines at Vinifera, Victoria in 1998/1999.

Dormant treatment	In season treatment	%Internodes diseased	% Internode area diseased	% Missing leaves
Untreated control	Untreated control	46.1 b	1.24 b	0.11 b
None	Delan®	0.4 a	0.00a	0.00 a
D-C-Tron Plus®	Delan®	0.9 a	0.01 a	0.00 a
Delan®/D-C-Tron Plus®	Delan®	0.3 a	0.00 a	0.00 a
Shirlan®	Delan®	0.3 a	0.01 a	0.00 a
Shirlan®/D-C-Tron Plus®	Delan®	0.2 a	0.00 a	0.00 a

LSD (P=0.05); ® Registered trade name

Table 5.6. Incidence and severity of Phomopsis disease on leaves of Sultana grapevines at Vinifera, Victoria in 1998/1999.

Dormant treatment	In season treatment	% Leaves diseased	% Leaves area diseased	% Missing leaves
Untreated control	Untreatyed control	86.1 b	2.06 b	5.10 b
None	Delan®	8.7 a	0.03a	1.51 a
D-C-Tron Plus®	Delan®	8.9 a	0.04 a	1.00 a
Delan®/D-C-Tron Plus®	Delan®	8.2 a	0.03 a	1.22 a
Shirlan®	Delan®	6.0 a	0.02 a	0.41 a
Shirlan®/D-C-Tron Plus®	Delan®	3.7 a	0.02 a	1.19 a

LSD (P=0.05); ® Registered trade name

Climatic conditions had the greatest effect on the outcome of the trial in 1998/99. In the preceding year (1997), conditions in early autumn and spring were unusually dry. In 1998, the total rainfall in the Swan Hill district for the months of August and September was 3.6 mm and 17.6 mm respectively, substantially less than the long term averages of 38 mm and 33 mm. Budburst was approximately one week earlier than usual and was also more uneven than in previous years. This, in part, was due to a combination of higher than average daily temperatures and moderate overnight temperatures in the first week of September. An outcome of the early budburst was that the dormant treatments were applied at two weeks instead of the projected three weeks before budburst.

Low levels of phytotoxicity were observed on some early leaves of vines that had been treated with a dormant spray of D-C-Tron Plus® alone or in combination with other chemicals as dormant sprays. The first symptoms, which were not severe enough to stunt shoot growth, were noted on 16 September (approximately 3 weeks after the dormant treatments were applied). At the time of application of the dormant spray, some buds were more advanced than others and those that were approaching budburst would have been more vulnerable to damage from the oil.

Climatic conditions prior to and during the period of the field trial were unfavourable for *Phomopsis* infection, and resulted in low levels of over wintering inoculum and subsequent disease expression. Rains on 10 and 11 September (at approximately 50-60 % budburst) initiated an early *Phomopsis* infection on the untreated emerging shoots, as did further rains on 2 and 3 October (budburst and 4 weeks). However the rainfall total of 17.6 mm for September in the Swan Hill district was nearly 50% below the long-term average of 33 mm, so disease pressure was less severe than in previous years. The October total of 30.6 mm was close to long-term average. No further rains occurred that significantly affected the development of the disease prior to assessment on 20th November 1998 (9 weeks after budburst). The period between budburst and the time of assessment had days with relatively high temperatures, some as high as 30-33°C which were well above the Swan Hill district averages of 18, 22 and 24°C for September, October and November respectively. These temperatures reduced disease activity and therefore the risk of infection occurring on the developing bunches.

To adequately test the efficacy of the treatments, the trial needed to continue for a further season, preferably one with normal patterns of rainfall. The long-term average rainfall for the Swan Hill district is 347 mm per annum, with the majority of rain falling during winter

and spring. Although this annual rainfall figure is low compared to many other viticultural regions in Australia and overseas, because the months of August, September and October receive the highest amounts of rainfall, there is often the risk of *Phomopsis* primary infections occurring when the vines are most susceptible.

(Second year - 1999/2000)

The results for 1999 are presented in Tables 5.7 and 5.8. As previously, the figures shown in the tables are the back-transformed means and the lower case letters indicate significant differences (ie. means with a different lower case letter are significantly different at the P=0.05 level, as assessed by the LSD comparison of the means on the transformed scale). This season there were significant differences in the analysed data between the dormant and in season treatments and the in season treatment alone. There were also differences between the treatment and the untreated control.

Table 5.7. Incidence and severity of Phomopsis disease on leaves of Sultana grapevines at Vinifera, Victoria in 1999/2000.

Dormant treatment	In season treatment	% Leaves diseased	% Leaf area diseased	% Missing leaves
Untreated control	Untreated control	95.3 c	5.85 c	5.98 b
None	Delan®	60.0 b	1.03 b	0.34 a
Shirlan® / Synertrol	Delan®	30.0 a	0.28 a	0.34 a

LSD (P=0.05); ® Registered trade name

Table 5.8. Incidence and severity of Phomopsis disease on internodes of Sultana grapevines at Vinifera, Victoria in 1999/2000.

Dormant treatment	In season treatment	% Internodes diseased	% Internode area diseased	% Missing internodes
Untreated control	Untreated control	82.8 c	5.68 c	0.36 b
None	Delan®	26.8 b	0.78 b	0.00 a
Shirlan® / Synertrol	Delan®	10.9 a	0.21 a	0.00 a

LSD (P=0.05); ® Registered trade name

Although unusually dry climatic conditions had influenced the outcome of the trial in the previous season, conditions in the spring of 1999 were quite different. In 1999, the total rainfall in the Swan Hill district for the months of August and September was 65.9 mm and 29.8 mm respectively, a large increase from the previous spring and nearly 25 mm more than the long term average of 71 mm for the two months. Budburst was again at least one week early and very uneven, which in combination with the increased early season disease pressure, resulted in a higher level of disease on all the trial plots than in the previous season.

Rain on 4 September (at approximately 40% budburst) and again on 29 and 30 September (3 weeks after budburst) initiated early *Phomopsis* infections on any untreated emerging shoots, as did further rains on 10 October. Dry conditions along with daily temperatures ranging up to 36°C in the period after flowering were likely to have inhibited *Phomopsis* infection on the bunches.

In 1999/2000, the climatic conditions were more typical for the region and more favourable for *Phomopsis* primary infection, subsequent disease expression and higher levels of overwintering inoculum. Both treatments reduced disease incidence and severity, but significant differences were detected between the dormant treatments of Shirlan® followed by in-season Delan® sprays, and the in-season Delan® only treatment.

The carry over of *Phomopsis* inoculum from 1999 to 2000 was 38% in the dormant treatment (Table 5.9)

Table 5.9. Carry over of *Phomopsis* from one season to the next on Sultana grapevines at Vinifera, Victoria.

Treatment		Level of carry over of inoculum (%)	
Dormant	In-season	June 1999	June 2000
Untreated	Untreated	58	100
Shirlan® / Synertrol	Delan®	58	38
Untreated	Delan®	58	85

Field trials at Camden, New South Wales

(First year - 1998/1999)

Significant differences in percent incidence of *Phomopsis* were not seen between the dormant and the in-season treatments (Table 5.10). However, incidence of the pathogen in the untreated controls was significantly less than in the treated series

Table 5.10. Incidence of Phomopsis disease on leaves and internodes of Chardonnay grapevines at Camden, New South Wales in 1998/1999.

Dormant treatment	In-season treatment	% Leaves diseased	% Internodes diseased	% area of internodes diseased
Shirlan®	Delan®	0 a	0 a	0 a
Shirlan®/D-C-Tron® Plus	Delan®	0 a	0 a	0 a
Delan®/D-C-Tron® Plus	Delan®	0 a	0.3 a	0.5 a
None	Delan®	0 a	0.6 a	0.5 a
D-C-Tron®	Delan®	0 a	1 a	2 b
Untreated	Control	3 b	31 c	8

P<0.05; ® Registered trade name

(Second year - 1999/2000)

The results indicated that there were no significant differences in the incidence of *Phomopsis* on leaves between the dormant and the in-season treatments (Table 5.11). However, significant differences were obtained on incidence of the disease on internodes between the dormant treatments of Shirlan® + Synertrol Oil® and the in-season Delan® only treatment.

Table 5.11. Incidence of Phomopsis disease on Chardonnay grapevines at Camden, New South Wales in 1999/2000.

Dormant	In-season	% Leaves diseased	% Internodes diseased
None	None	3 a	8 a
Shirlan®(1%)/Synertrol®	Delan®	0.6 b	0 b
Shirlan® (2%)	Delan®	0 b	0 b
Untreated	Delan®	3 a	6 a

P<0.05; ® Registered trade name

The carry over of *Phomopsis* inoculum from the dormant period in June 1999 to the dormant period in June 2000 was significantly reduced (Table 5.12). There was a 25-30% reduction in carry over inoculum as a result of the dormant spray application compared to a 10% following the in-season applications alone. There was a 100% carry over of inoculum in the untreated series.

Table 5.12. Carry over of *Phomopsis* from one season to the next on Chardonnay grapevines at Camden, New South Wales.

Treatment		Level of carry over of inoculum (%)	
Dormant	In-season	June 1999	June 2000
1% Shirlan® + Synertrol Oil®	Delan®	100	75
2% Shirlan®	Delan®	100	70
Untreated	Delan®	100	90
Untreated	Untreated	100	100

® Registered trade name

Field trial at Griffith, New South Wales

Year - 1998/1999

Dormant treatments of Shirlan® with or without D-C-Tron® Plus or Delan® with D-C-Tron® Plus followed by in season treatments of Delan® significantly reduced the incidence of *Phomopsis* compared with in season treatments only, dormant treatment of D-C-Tron® Plus and in season and untreated control. Dormant treatment of Shirlan® followed by in season treatment of Delan® was the most effective in reducing the incidence of the disease (Table 5.13)

Table 5.13. Incidence of Phomopsis disease on Shiraz grapevines at Griffith, New South Wales in 1998/1999.

Dormant	In-season	% Leaves diseased	% Internodes diseased
Shirlan®	Delan®	1 a	11 a
Shirlan®/D-C-Tron® Plus	Delan®	7 b	10 a
Delan®/D-C-Tron® Plus	Delan®	13 c	19 a
None	Delan®	22 d	33 b
D-C-Tron® Plus	Delan®	23 d	31 b
Untreated	Control	44 e	51 c

$P<0.05$; ® Registered trade name

6. SURVEY OF NURSERIES TO DETERMINE THE INCIDENCE OF *PHOMOPSIS VITICOLA* (TYPE 2) IN PLANTING MATERIAL

Introduction

Control of *Phomopsis viticola* in grapevine planting material is a very important way to prevent spread of the disease into new vineyards (Bugaret 1986; Simon 1993). In the last decade large numbers of new vineyards have been established in Australia. During this time, there are also indications that the incidence of *P.viticola* (Type 2) has increased in some viticultural regions. While most State vine improvement schemes and many nurseries have adopted procedures to minimise the incidence of pathogens in grapevine planting material, little is known about the effects of these procedures on the incidence of *Phomopsis* (Waite and May 1999).

This chapter reports the results of a survey of Australian nurseries and grapevine improvement schemes that was conducted in 1999 to determine the incidence of *P. viticola* and other fungal pathogens in grapevine planting material. The procedures currently used by and nurseries and vine improvement schemes to minimise the incidence of *P. viticola* and other fungal pathogens in planting material are also discussed.

Materials and methods

Nurseries surveyed - Three large-scale commercial grapevine nurseries and three smaller nurseries were surveyed in each of the States of New South Wales, Victoria and South Australia. Vine improvement associations in Victoria and South Australia were also surveyed. A letter was sent to nurseries and managers of vine improvement associations seeking participation and explaining survey procedures.

Collection and handling of samples - Thirty to fifty dormant scion cuttings, rootlings, or graftlings of susceptible grapevine varieties [eg. Sultana (Thompson Seedless), Red Globe, Chardonnay, Shiraz and Cabernet Sauvignon] were sampled at random from vine improvement associations and nursery stocks by project staff from Agriculture Victoria or New South Wales Agriculture. Where available, various numbers of cuttings and rootlings from other varieties were also sampled. After collection, the propagation material of each variety from each source was packed in heavy-duty polyethylene bags. A 6 mm hole was made in each bag to allow air exchange. The material was then placed in cool storage at 1°C (+/-1°C) for no more than six weeks, before it was packed in polystyrene containers and sent to laboratories at the Hawkesbury Campus, University of Western Sydney, Richmond, NSW or at the National Wine and Grape Industry Centre, Wagga Wagga, NSW.

Laboratory examinations - At the laboratories, the samples were placed in plastic bags with wet paper towels and incubated in a humid environment at 25°C for 14-20 days. Fungal growth on each cutting, rootling or graftling was examined microscopically for the presence of pathogens, including *Phomopsis viticola* (Taxon 1 and Taxon 2), *Botryosphaeria* spp. including *B. obtusa and B. ribis*), *Botrytis cinerea, Pestolotia* sp. and other fungal

contaminants (*Alternaria* sp.). After assessment, all propagation material was autoclaved and/or treated in accordance with interstate importation permits before it was discarded.

Nursery management of propagation material - When the samples were collected, profiles of the management of sampled propagation material were compiled with the assistance of nursery staff. At most nurseries, propagation material was managed using a step-wise process that included treatments to reduce contamination by plant pathogens (summarised in Table 6.1). However, the application of the steps and treatments in the process varied between nurseries.

Compilation of results - The incidence of *Phomopsis viticola* and other pathogenic fungi in the propagation material was examined in relation to the source, grapevine variety and treatments applied in nurseries. Confidential reports on the incidence of fungi in individual samples were forwarded to the managers concerned who provided those samples. To ensure confidentiality, the nurseries that were surveyed have not been identified in this report.

Results

The sequence of standard treatments (Table 6.1) for one year old cuttings consists in brief of hydration, a Chinosol® treatment, cool storage, re-hydration and hot water treatment. The treated cuttings are disbudded, grafted/callused, potted and grown in a glasshouse or planted in a field nursery. A program of irrigation, nutrient application and pest and disease management is used. The rootlings (two year old rooted vines) go through a process (Table 6.1) which involves trimming, washing and hydration followed by short duration hot water treatment (HWT). Some are also treated with a Chinosol® spray. The treated rootlings are then packed and placed in cool storage and later for vineyard establishment or re-planting.

Table 6.1 – Sequence of standard treatments applied to grapevine planting material by nurseries[1]

Cuttings (one year old)	1	Cuttings collected and graded or purchased from VIA
	2	Hydration in chlorinated water (5-7 ppm)
	3	Chinosol® treatment (dip)
	4	Cool storage at 1-2°C
	5	Rehydration / leaching for up to 18 hours
	6 a	Hot water treatment (1) at 50°C for 30 minutes or
	6 b	Hot water treatment (2) at 52°C to 55°C for 5 minutes
	7	Disbudding, then grafting and/or callusing of material
	8	Potted and placed in glasshouse or planted out in field nursery
	9	Application of irrigation, fertiliser and spray program for pest and disease control
Rootlings (two year old)	10	Rooted plants lifted, trimmed, graded, washed and hydrated
	11	Hot water treatment (2)*:
		52°C to 54°C for 3-5 minutes (VIC) * or
		55°C for 5 minutes (SA) * or
		51.5°C to 54.5°C for 3-5 minutes (NT) *
	12	Packed for distribution or sale
	13	Chinosol® treatment (spray)
	14	Cool storage at 1-2°C
	15	Rootlings sold for vineyard establishment

[1] Refer to Table 6.4 for incidence of fungi in relation to treatment sequence

* Hot water treatment of 54°C (+/- 1°C) for 5 minutes or 50°C (+/- 1°C) for 30 minutes is now a national quarantine requirement for vine planting material that will be moved interstate.

® Registered trade name

The results showed that up to 6.5% of cuttings or rootlings were infected with *P. viticola* - Type 2 (Table 6.2). *Botryosphaeria obtusa* and *B. ribis* occurred in 1.7% and 0.06% of cuttings or rootlings respectively. *Botrytis cinerea* and *Pestalotia* sp. were also found in 0.2% and 0.1% of cuttings or rootlings.

The percentage occurrence of *P. viticola* (Type 2) in relation to grapevine variety was 8% (Sultana), 6% (Marroo Seedless), 2% (Sauvignon Blanc) and 1% (Shiraz) (Table 6.3).

Maximum incidence of *P. viticola* (Type 2) was seen in plant material that was not treated with hot water (Table 6.4). Also, with one exception, this material was not treated with Chinosol®.

Table 6.2 Incidence of *Phomopsis viticola* (Taxon 2), *Botryosphaeria obtusa*, *B. ribis*; *Botrytis cinerea* and *Pestalotia* sp. in grapevine cuttings and rootlings in relation to source of plant material

State	Region	Number of cuttings or rootlings surveyed	Percent cuttings or rootlings with Pv2*	Bo*	Br*	P*	Bc*
New South Wales	Central	480	0.6	<.01	0	0	0
	South-East	25	0	0	0	0	0
	South-West	277	6.5	< 0.1	0	0	0
Victoria	North-West	1449	0.6	0.3	0.06	0.1	0.2
South Australia	Riverland	510	0	0	0	0	0
	South-East	300	0	0	0	0	0*
	Southern	594	0	1.7	0	0	0
_____	_____	Total = 3635	_____				

*Pv2 = *Phomopsis viticola* (Taxon 2) Bo = *Botryosphaeria obtusa*;
Br = B. *ribis* P = *Pestalotia* sp. Bc = *Botrytis cinerea*

The survey included a total of 31 varieties, 71 clones and 3635 cuttings or rootlings. The results showed that less than 0.03% of cuttings or rootlings were infected with *P. viticola* in relation to the source of the planting materials (Table 6.2). However, the percentage occurrence of *P. viticola* in relation to grapevine variety was 8% (Sultana), 6% (Marroo Seedless), 2% (Sauvignon Blanc) and 1% (Shiraz) (Table 6.3).

Table 6.3. Incidence of *Phomopsis viticola* (Taxon 2), *Botryosphaeria obtusa*; *B. ribis*; *Pestalotia* sp. and *Botrytis cinerea* in grapevine cuttings and rootlings in relation to variety4

Grapevine variety	Number of clones surveyed	Number of cuttings or rootlings surveyed	Per cent cuttings or rootlings with Pv2*	Bo*	Br*	P*	Bc*
Cabernet Franc	1	50	0	2	0	0	0
Cabernet Sauvignon	10	616	0	0	0	<0.1	0
Calmeria	1	10	0	0	0	0	0
Carina	1	22	0	0	0	0	0
Centennial Seedless	1	8	0	0	0	0	0
Chardonnay	4	215	0	0	0	0	0
Chenin Blanc	1	8	0	0	0	13	0
Colombard	1	21	0	0	0	0	0
Crimson Seedless	1	59	0	0	0	0	0
Emperor	1	9	0	11	0	0	0
Flame Seedless	1	123	0	0	0	0	0
Grenache	1	200	0	0	0	0	0
Marroo Seedless	1	17	6	0	0	0	0
Mataro	2	56	0	0	0	0	0
Menindee Seedless	1	72	0	0	0	0	1
Merbein Seedless	1	23	0	0	0	0	0
Merlot	4	342	0	0	0	<0.1	0
Muscat Gordo	1	11	0	9	0	0	0
Petit Verdot	1	38	0	0	0	0	0
Pinot Gris	1	31	0	0	0	0	0
Pinot Noir	3	84	0	2.3	0	0	0
Red Globe	1	124	0	3.2	0	0	0
Rhine Riesling	5	350	0	0	0	0	0.3
Ruby Seedless	1	10	0	0	0	0	0
Sauvignon Blanc	4	168	2	0	0	0	0
Sangiovese	1	25	0	0	0	0	0
Semillon	4	103	0	0	0	0	0
Shiraz	9	482	1	0	0	0	0
Sultana	4	288	8	4	0.3	0	0
Sunmuscat	2	63	0	0	0	0	0
Voignier	1	7	0	0	0	0	0

* *Pv2* = *Phomopsis viticola* (Taxon 2) *Bo* = *Botryosphaeria obtusa*; Br = B. *ribis* *P* = *Pestalotia* sp. *Bc* = *Botrytis cinerea*

Table 6.4. Incidence of *Phomopsis viticola* Taxon 2, *Botryosphaeria obtusa*; *B. ribis*; *Pestalotia* sp. and *Botrytis* cinerea in grapevine cuttings and rootlings in relation to treatments applied by vine improvement associations and/or nurseries.

Cuttings or rootlings surveyed (No.)	Treatment Sequence*															Cuttings or rootlings with:		
	Cuttings									Rootlings								
	1	2	3	4	5	6 a	6 b	7	8	9	10	11	12	13	14	*Phomopsis viticola* Taxon 2 No. of samples tested (%)	*Botryo-sphaeria spp.*	*Botrytis cinerea*
1132	+	+	-	+												27 (2)	+	
112	+	+	+	+														
300	+	+	+	+	+													
174	+	+	-	+	-	+												
18	+	+	+	+	+	+												
50	+	+	-	+	-	-	+											
52	+	+	-	-	+	-	-	+	+	+	+						+	
33	+	+	+	-	+	-	-	+	+	+	+							
60	+	-	-	-	-	-	-	+	+	+	+	-	+			1 (2)	+	+
60	+	+	-	+	-	-	-	+	+	+	+	-	+					
30	+	+	+	+	-	-	-	+	+	+	+	-	+					
60	+	+	+	+	+	-	-	+	+	+	+	-	+			2 (3)		
300	+	+	+	+	-	-	-	-	-	-	-	-	+	-	+			
50	+	-	-	+	-	-	-	+	+	+	+	-	+	-	+			+
121	+	-	-	+	-	-	-	+	+	+	+	-	+	-	+			
92	+	-	-	-	-	-	-	+	+	+	+	+	+	-	+			
100	+	+	-	+	-	-	-	+	+	+	+	-	+	-	+			
20	+	+	-	+	-	-	+	+	+	+	+	-	+	-	+			
30	+	+	+	+	-	-	-	+	+	+	+	-	+	-	+			
30	+	+	-	+	+	-	-	+	+	+	+	+	+	-	+			
50	+	+	+	+	+	-	-	+	+	+	+	-	+	-	+			
361	+	+	-	+	-	+	-	+	+	+	+	+	+	-	+		+	+
100	+	+	+	-	+	-	-	+	+	+	+	-	+	+	+			
50	+	+	-	+	+	+	-	+	+	+	+	+	+	-	+		+	
100	+	+	+	+	+	-	-	+	+	+	+	-	+	+	+			
150	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+			
3635																		

* Refer to Table 6.1 for treatment sequence definition.

Chinosol® treatment + present - absent

Hot water treatment

® Registered trade name

Discussion

The survey reported here was not comprehensive and did not cover all of the grapevine planting material that is produced and sold in the Australian industry. It included a total of 31 varieties, 71 clones and 3635 cuttings or rootlings. The survey did, however, give an overview of the incidence of *P. viticola* in propagation material from three States in 1999. While most propagation material was free of *Phomopsis,* some infected material was still being collected for propagation, despite industry protocols which specify that only healthy, symptomless material should be selected from well maintained vineyards that have been inspected and treated with appropriate fungicide programs (AVIA 2000).

During the survey, all vine improvement associations and nurseries were very supportive and were willing to supply information and samples of propagation material for assessment. The industry appeared to be committed to improving the quality and consistency of grapevine propagation material by adopting and implementing new or improved management systems. This was reflected in the very low levels of *Phomopsis* and other fungi observed in the propagation materials from the nurseries.

The incidence of other fungi such as *Alternaria, Aspergillus* and *Penicillium* on some samples appears to be related to post-treatment handling and storage procedures. Waite and May (1999) reported poor vigour, higher than expected mortality and deterioration of hot water treated material, particularly rootlings, in cold storage in the 1998 season.

Treatment regimes applied during the production of propagation material varied considerably between vine improvement associations and nurseries (Table 6.4). In one state, treatment with 8-hydroxyquinoline sulphate (Chinosol®) was a standard practice. In other states, some nurseries did not use Chinosol® for occupational, health and environmental reasons. At the time of the survey, some nursery managers were also concerned about the use of long duration hot water treatment (HWT) at 50°C for 30 minutes because of unacceptable mortality rates (Hamilton 1997; Waite and May 1999). Some nursery managers treated their rootstock material but not their scion material. On the other hand, in at least one vine improvement association and some large nurseries, HWT at 50°C for 30 minutes was standard practice for all *Vitis vinifera* and rootstock material. Protocols for the nursery industry, which have been established by the Australian Vine Improvement Association (AVIA) from 1996 to 2000, advise that HWT should be carried out at accredited facilities with calibrated equipment, accurate temperature monitoring and strict hygiene procedures in place. Management techniques that minimise the stress and impact on the viability of the treated material include hydration prior to the HWT, and careful handling before, during and after treatment. The material should be healthy and fully dormant at the time of treatment. Many nursery managers also indicated that grafting and/or planting of the treated material should be undertaken as soon as possible after HWT. Prolonged periods of cool storage after HWT were not recommended.

7. EFFECTS OF HOT WATER TREATMENT ON THE INCIDENCE OF *PHOMOPSIS VITICOLA* IN GRAPEVINE CUTTINGS

Introduction

Long distance spread of *Phomopsis viticola* (Sacc.) Sacc. into new viticultural areas mostly occurs through the transfer of infected propagation materials such as bud wood, cane cuttings and nursery stock (Hewitt and Pearson 1988; Creecy and Emmett 1990). As well as introducing disease into the vineyard, infected material also reduces the rate of success of grafting and cutting propagation, and the fungus can kill grafted and other nursery stock (Willison *et al.* 1965; Hewitt and Pearson 1988). The use of 8-hydroxy quinoline sulphate (Chinosol®) as a disinfectant for the control of *Botrytis cinerea* on propagation material has been shown to reduce the viability of *Phomopsis* pycnidia (Hewitt and Pearson 1988; Castillo-Pando *et al.* 1997), but for health and environmental reasons, this chemical is not widely used by the nursery industry. Previous studies on long duration hot water treatment (HWT) of grapevine cuttings and rootlings (30 minutes at 50°C) have shown that it can eradicate some fungi, insects, bacteria, nematodes and phytoplasmas (Orffer and Goussard 1980; Hamilton 1997; AVIA 2000). Anecdotal evidence has indicated that long duration HWT may also reduce the infection of *Phomopsis* in propagation material but this has not been confirmed by trials (Waite and May 1999).

This section reports the results of studies on the effects of hot water treatment (30 minutes at 50°C) on survival of *P. viticola* in grapevine cuttings.

Materials and Methods

In line with standard industry practice, the grapevine material for the trial was selected when the vines were fully dormant, as dormancy has a significant impact on the effect of HWT on viability of cuttings and rootlings after treatment. As a rule of thumb,full dormancy is at least one month after leaf-fall and at least one month before budburst (AVIA 2000). Basal cuttings from grapevines (*Vitis vinifera* cv. Sultana and cv. Waltham Cross) with symptoms of *Phomopsis viticola* were collected from commercial vineyards in the Mid-Murray region near Swan Hill, Victoria. Vines in one vineyard were infected with *P. viticola* Type 1 and Type 2, while those in the other vineyard were infected with *P. viticola* Type 2.

A limited number of cuttings were available for use in the trial, due to low levels of disease carry over from 1998. An unusually dry and warm spring and early summer in the previous growing season had resulted in an absence of symptoms on the one-year-old dormant canes.

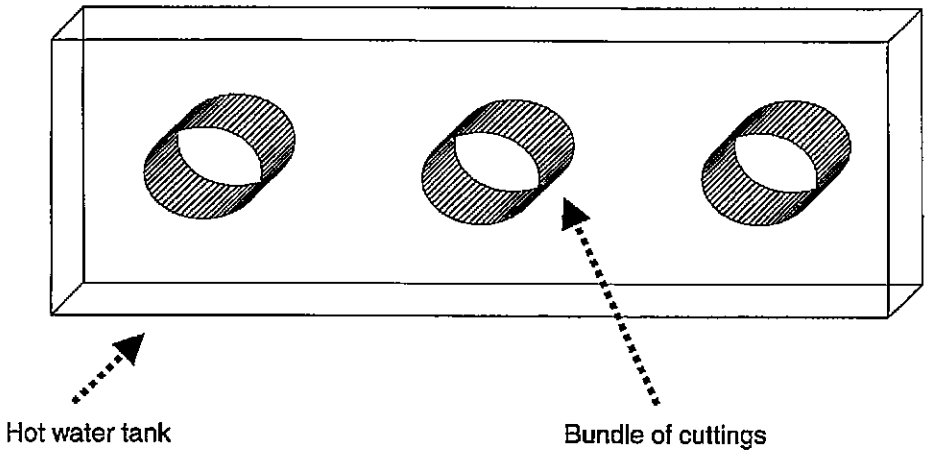
The cuttings were hydrated in clean water at ambient temperature for three hours and then drained. To prevent deterioration, the cuttings were stored in heavy-duty polyethylene bags and maintained in a moist condition at around 95 to 98 percent relative humidity, but without the presence of free water. The bags were closed but were not airtight, as each had a 6 mm hole to allow some air exchange. The cuttings were then placed in cool storage at 1°C (+/- 1°C) until the HWT was applied. A HWT trial protocol that involved similar treatment

methods to those used by industry, was produced in consultation with the Australian Vine Improvement Association (AVIA) and the Victorian and Murray Valley Vine Improvement Association (VAMVVIA).

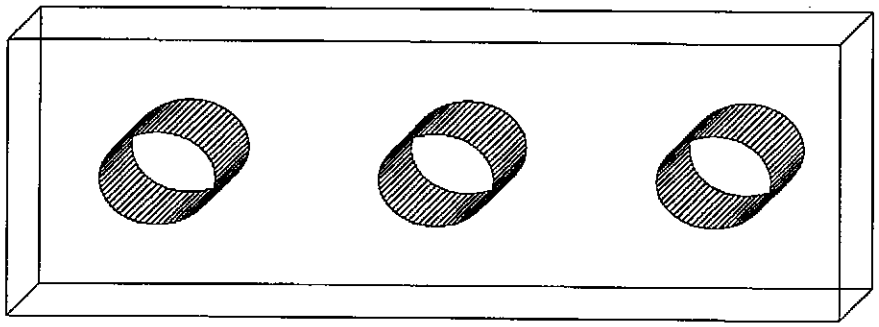
Bundles of cuttings were exposed to HWT or control treatments and this was replicated three times. Non-HWT cuttings were processed identically to those that were treated, except that the HWT phase was omitted. In addition, some cuttings were not treated except for exposure to the initial three-hour hydration. These cuttings were used to see whether the submersion of non-HWT cuttings in water for an equivalent amount of time to that of the HWT ones would have any effect on *Phomopsis*.

Fig. 7.1. Diagrammatic representation of the treatments in the hot water treatment trial.

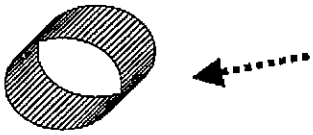
1. **Hot water treatment:** Cuttings with symptoms of *Phomopsis* disease were immersed in hot water at 50° C for 30 minutes. The treated cuttings were then transferred to a cool down tank for 10 minutes. After draining, the cuttings were placed in cool storage at 1 °C (+/- 1°C).



2. **No hot water treatment:** Cuttings with symptoms of *Phomopsis* disease were immersed in water at ambient temperature for 30 minutes and then transferred to a cool down tank for 10 minutes. After draining, the cuttings were placed in cool storage at 1 °C (+/- 1°C).



3. **No treatment control:** Cuttings with symptoms of *Phomopsis* disease without treatment were placed in cool storage at 1° C (± 1^0 C).



The HWT material in the each of the first two treatment runs consisted of 100 Waltham Cross and 50 Sultana cuttings, which were labelled and made into two bundles and one bundle of 50 respectively. Each of these bundles was then combined with a bundle of 50 Cabernet Sauvignon cuttings to create 3 composite bundles of 100 cuttings. This was done to simulate the industry recommendation that cuttings in each run should be treated in bundles of 100. The Cabernet Sauvignon cuttings were used as "dummies," because there were insufficient Sultana and Waltham Cross cuttings to provide the number required in the treated and non-HWT groups of each replicate. Each bundle of cuttings was tied securely and labelled. The third run was made up of one bundle of 50 Sultana cuttings but two bundles each with 37 Waltham Cross cuttings. One hundred and fifty Cabernet Sauvignon cuttings and 26 Chardonnay cuttings were used as "dummies" in this run to make up each of the bundles to 100 cuttings.

Similar numbers of Sultana and Waltham Cross cuttings were prepared and used simultaneously for the three non-HWT replicates. Lower numbers of cuttings were used for the untreated replicates (50, 42 and 41, for runs 1, 2 and 3 respectively) because of the limited availability of diseased cuttings.

VAMVVIA's accredited HWT equipment was used in this work. To minimise the possibility of transferring disease from the *Phomopsis*-infected cuttings to any subsequent batches of material that were to be HWT, the trial runs were conducted at the end of each week. After the trial run the tanks were emptied, rinsed, refilled and heated to 60°C to disinfest them.

Bundles of cuttings to be HWT were placed in a cage and temperature probes were placed beside each bundle. These probes monitored the temperature in the tank every five minutes and relayed this information to a calibrated data-logger, which provided a permanent record of the temperatures applied to each batch of cuttings. The tank temperature was maintained at 50°C (+/- 1°C). Pre-season calibration and testing of the HWT and cool down tanks and equipment showed that there was minimal variation in temperature between different positions in the tanks. After the cuttings were secured in the cage and lowered into the heating tank, the temperature was returned to the minimum allowable (49°C) in less than two minutes. The 30-minute treatment was timed from this point onwards. Non-HWT cuttings were immersed simultaneously in tubs of clean water at a mean ambient temperature of 13.8°C for the same time and removed from the tubs when the HWT cuttings were lifted from the HWT treatment tank. The HWT cuttings were immersed in the cool-down tank containing chlorinated water (5-7ppm) at an ambient temperature for ten minutes, followed by the non-HWT cuttings for an equivalent period of time.

After draining, the cuttings were stored at 1°C (+/-1°C) in heavy-duty polyethylene bags in a moist condition, but without the presence of free water. Each bag had a small 6mm hole to allow some air exchange. The cuttings were then incubated in a humid environment at 25°C for 14-20 days and assessed for the presence of *P. viticola* Type 1 and Type 2.

Results

Long duration HWT (30 minutes at 50°C) of the grapevine cuttings reduced the level of *Phomopsis* (Taxon 2) infection from over 75% to less than 1% (Table 7.1.) As the percentage of untreated and non-HWT cuttings with *Phomopsis* was similar (74% and 76% respectively), submersion of the non-HWT cuttings in chlorinated water did not affect the survival of the pathogen.

Table 7.1. Incidence of *Phomopsis viticola* in hot water treated (HWT), not hot water treated (non-HWT) and untreated cuttings.

Treatment	Run No.	Date	Total No. of Cuttings	No. of Infected Cuttings	Infected Cuttings (%)
A. HWT:	1	16/07/99	150	0	0
	2	30/07/99	145	3	2
	3	06/08/99	124	0	0
	Total No. Cuttings =		419	Mean % infected =	0.7
B. No HWT:	1	16/07/99	150	123	82
	2	30/07/99	150	124	83
	3	06/08/99	124	77	62
	Total No. Cuttings =		424	Mean % infected =	75.6
C. No Treatment:	1	16/07/99	50	47	94
	2	30/07/99	42	35	83
	3	06/08/99	41	18	44
	Total No. Cuttings =		133	Mean % infected =	73.7

$P<0.01$

The incidence of *Phomopsis* in HWT cuttings of Sultana and Waltham Cross was similar (2% and 0.3% respectively, Table 7.2), indicating that the effects of HWT do not appear to be variety dependent. The incidence of *Phomopsis* in untreated and non-HWT cuttings of the different varieties and from different sources was variable (Table 7.2).

Table 7.2. Incidence of *Phomopsis viticola* in hot water treated (HWT), not hot water treated (non-HWT) and untreated cuttings of grapevines, cv Sultana and Waltham Cross from different sources.

Treatment	Run No.	Date	Source of Sultana	Total No. of Cuttings	Infected cuttings		Source of Waltham Cross	Total No. of Cuttings	Infected cuttings	
					No.	%			No.	%
A. HWT:	1	16/07/99	Vinifera	10	0	0	Nyah	100	0	0
			Lake Boga	20	0	0				
			Nyah	20	0	0				
	2	30/07/99	Vinifera	25	0	0	Nyah	100	1 a	1 a
			Lake Boga	20	2	10 a				
	3	06/08/99	Vinifera	50	0	0	Nyah	74	0	0
					Mean	2			Mean	0.3
B. No HWT:	1	16/07/99	Vinifera	10	10	100 b	Nyah	100	85 b	85 b
			Lake Boga	20	19	95 b				
			Nyah	20	9	45 c				
	2	30/07/99	Vinifera	25	8	32 d	Nyah	100	91 b	91 c
			Lake Boga	25	25	100 b				
	3	06/08/99	Vinifera	50	18	36 d	Nyah	74	59 c	80 b
					Mean	68			Mean	85
C. No Treatment:	1	16/07/99	Vinifera	3	3	100 b	Nyah	33	30 d	91 c
			Lake Boga	7	7	100 b				
			Nyah	7	7	100 b				
	2	30/07/99	Vinifera	15	13	87 e	Nyah	12	7 e	58 e
			Lake Boga	15	15	100 b				
	3	06/08/99	Vinifera	27	8	30 d	Nyah	14	10 e	71 e
					Mean	86			Mean	74

P<0.05

Discussion

In this study, long duration hot water treatment (30 minutes at 50°C) reduced the survival of *P. viticola* in grapevine cuttings, but did not eliminate the pathogen. Despite this, HWT still appears to be an effective, non-chemical way of reducing *Phomopsis* infection in grapevine propagating and planting material. Hot water treatment is also a recognised means of eliminating or reducing the titre of a wide range of other grapevine pathogens and pests, such as crown gall, bacteria, nematodes, phylloxera and phytoplasmas. Arguably, the material that was used in this study represented a 'worst case' scenario because diseased cuttings (ie. with symptoms of *Phomopsis)* were specifically selected. The recommended practice is to select propagation material from healthy, well maintained vines with no symptoms of

disease, and from vineyards where both inspections and an appropriate fungicide program have been completed.

Our study has shown that hot water treatment for 30 minutes at 50°C is a practice that should be an important part of a *Phomopsis* disease management strategy.

8. TECHNOLOGY TRANSFER

Delivery of information to industry:

Presentations of the results of the project have been made to grape growers and other researchers by project staff at field days, seminars, industry and Research to Practice® training workshops in Queensland, New South Wales, Victoria, South Australia and Western Australia.

Information from the project has also been published in articles in Australian Grapegrower and Winemaker. A brochure on the management of *Phomopsis* has also been produced for use by the industry. (A penultimate version of the brochure is attached to this report).

Nair, N.G., Emmett, R.W., Wicks, T.J., Clarke, K., Sergeeva, V., Castillo-Pando, M. and Creecy, H. (2000). Dormant spray application facilitates management of *Phomopsis* on grapevines. The Australian Grapegrower and Winemaker Annual Technical Issue **438a**: 71-73.

9. RECOMMENDATIONS

Overall management strategy for *Phomopsis* Type 2-

1. To minimise the risk of introducing *Phomopsis* into vineyards, use planting material that has been produced from cuttings that have been hot water treated at 50^0C for 30 minutes and have been taken from healthy vines (ie. vines that do not have *Phomopsis* Type 2 or symptoms of disease caused by *Phomopsis* Type 2).

2. Before applying a vineyard spray program, establish whether a management program for the control of *Phomopsis* Type 2 is needed.

3. Vineyards without a history of *Phomopsis* Type 2 should be monitored each season to ensure that they remain free of disease. For best results, monitoring for symptoms of disease on foliage should be conducted at least 3-4 weeks after conditions favourable for infection by *Phomopsis* Type 2 have occurred.

4. If a diseased vine is detected in a vineyard without a history of disease, prompt removal of the affected vine may be worthwhile to prevent the disease becoming established in the vineyard.

5. In vineyards with a history of *Phomopsis* Type 2, apply one fungicide spray 4 weeks before budburst followed by up to four in-season applications at 10-14 day intervals commencing at 30-50% budburst. Sprays applied at budburst and 10-14 days later are most important for disease control in seasons when wet weather occurs in early spring. The fourth spray may not be required unless wet conditions favourable for disease development continue. (Note strategy 2 given above)

6. Fungicides that provide control of *Phomopsis* Type 2 are:
(1) fluazinam (Shirlan®) at vine dormancy and
(2) dithianon (Delan®) and mancozeb (including Dithane®, Mancozeb®) during the vine growth season.

7 Before using fungicides for the control of *Phomopsis* Type 2, check their registration status. A temporary permit for the use of Shirlan® was issued by the National Registration Authority (NRA) for 1998/99 and 1999/2000 with vineyard entry restrictions. The continued use of this fungicide will depend on final approval of registration by the NRA. In some Australian states, mancozeb is not registered for *Phomopsis* control.

8. Where practical, reduce sources of inoculum by removing diseased canes or spurs from vines and the vineyard floor. This, in combination with fungicide treatment programs, will help to lower disease severity.

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APPENDIX 1

Phomopsis Brochure

Introduction

- *Phomopsis* can be a serious disease of grapevines in some viticultural regions in Australia.
- There are two types of *Phomopsis* – Type 1 and Type 2.
- Type 2 can cause crop loss.
- The importance of Type 1 is uncertain and is the subject of current research.

Symptoms caused by Type 2

Grapevine tissue	Symptoms of infection by Type 2
Dormant cane	• Elongated, brown, cracked scars • Bleached areas with black specks
Green shoots[1]	• Small black streaks develop into dark brown to black elongated scars mostly on lower parts of shoot
Leaves[2]	• Small, brown to black spots with a yellow halo • Leaf stem may have brown to black lesions • Severely diseased leaves may turn yellow and fall prematurely
Bunches	• Symptoms uncommon in Australia • Brown to black scars on bunch stems • Bunches shrivel • Occasionally ripe berries darken and develop black specks on surface

[1] and [2] symptoms appear 10 – 30 days after infection

Other symptoms confused with those of Type 2

- Bud and rust mite damage (distortion and stunting of leaves, yellow leaf spots; marks and scars on shoots but these do not elongate)
- Black spot (leaf spots are brown-purple and larger than those caused by *Phomopsis* and more circular and roughened)
- Mild frost damage (distortion of leaves, bleaching of canes and restricted shoot growth)
- Spray speckle (leaf spots, no distinct yellow hallo around necrotic area)
- Sucking insects (leaf spots may be associated with leaf veins; entire leaf may be crinkled and discoloured)
- Bleaching of canes can be associated with other causes (e.g. physiological, *Botrytis*, *Botryosphaeria*)

Symptoms caused by Type 1

Grapevine tissue	Symptoms of infection by Type 1
Dormant cane	• Bleached areas with black specks
Green shoots	• No symptoms
Leaves	• No symptoms
Bunches	• No symptoms

Management strategy for Type 2

- In general, if there is no previous history of *Phomopsis* Type 2 in the vineyard, chemical application will not be required.
- In particular, if a vineyard has no previous history of *Phomopsis*, apply chemicals only if rainfall occurs at budburst.
- Spray only localized parts of the vineyard showing symptoms of *Phomopsis*.
- If rainfall occurs early in the season, the new growth in vineyards with the disease should be protected.
- If a vineyard has a history of *Phomopsis*, apply four sprays at 10-14 day intervals, commencing at 30-50% budburst. The fourth spray may not be required unless wet conditions continue and the disease is severe.
- Research has shown that one application at dormancy (3-4 weeks before budburst) followed by the in-season applications as mentioned above provides effective control of *Phomopsis* (Type 2).

- Chemicals that may provide control of *Phomopsis* (Type 2) are:

Shirlan® - dormant spray

Mancozeb®, Delan®, Captan® — in-season spray

These chemicals should only be applied after checking registration status in the relevant state and strictly adhere to the directions for use and safety advice.

Other *Phomopsis* management practices

- Minimise the risk of introducing *Phomopsis* with planting material. Use only healthy planting material selected from vines that do not have *Phomopsis* or that has been hot water treated at 50^0C for 30 minutes or treated with Chinosol® for *Botrytis* control.
- Reduce the source of inoculum where practical (e.g. pruning out severely infected canes and removing prunings from the vineyard floor)

Phomopsis Type 1

- Type 1 is not known to cause economic damage
- There are no chemicals currently registered for use on Type 1
- Research is under way to determine whether the current chemicals and strategies used for the control of Type 1 are warranted for the control of Type 1

Photographs

Photographs in the brochure will include the following.

Phomopsis (Type 2)

- Grapevine leaf infected with *Phomopsis*.
- Grapevine bunches infected with *Phomopsis*.
- Green shoots infected with *Phomopsis*.

Phomopsis (Type 1)

- Bleached canes with *Phomopsis*.

Other symptoms commonly confused with those of Type 2

- Bud and rust mite damage
- Black spot
- Mild frost damage