Development of Oil for the Control of Grape Powdery Mildew

FINAL REPORT to
GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

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CONTENTS

INDUSTRY SUMMARY 2
TECHNICAL SUMMARY 3
INTRODUCTION 5
GENERAL METHODS 6
Hydra Spray Unit 6
Bunch and Leaf Sampling and Assessment Methods 6
Products and Formulations 7
LABORATORY AND GLASSHOUSE EXPERIMENTS 8
Experiment 1 8
Experiment 2 and 3 10
Experiment 4 and 5 14
Experiment 6 15
FIELD EXPERIMENTS 16
Experiment 7 16
Experiment 8 and 9 17
Experiment 10 and 11 28
Experiment 12 32
Experiments 13, 14 and 15 36
Experiments 16 and 17 51
Experiment 18 63
Experiment 19 67
Experiment 20 and 21 71
Experiment 22, 23 and 24 79
Experiments 25 and 26 83
Experiment 27 91
Experiment 28 93
TECHNOLOGY TRANSFERS 95
RECOMMENDATIONS 96
ACKNOWLEDGEMENTS 97
REFERENCES 98
APPENDIX 99

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INDUSTRY SUMMARY

This work has shown that mineral oils control grape powdery mildew but they are not as effective as conventional fungicides such as the DMI's or sulphur.

Mineral oil was most effective when applied at 1% rate and in spray volumes of 1000 L/ha. At this rate and spray volume, powdery mildew on leaves was almost completely controlled whereas mildew on bunches was only controlled where the bunch was directly covered with spray.

Spray coverage was an important factor in the efficacy of oil applications and because of this oils are likely to control powdery mildew only when applied to either young vines, vines with exposed canopies or in vines where applications are made early in the season.

Limited work suggested that oils may be useful in controlling Light Brown Apple Moth larvae but further work is required on this aspect. Further work is also required on the possible carry over of unpleasant flavours into wine from grapes sprayed with oil.

Mineral oils are unlikely to be suitable for use on table grapes because of the incomplete control of powdery mildew and the likelihood of phytotoxicity arising from the need to apply oils at high spray volumes.

The main conclusions from this work are: -

- Mineral oils control powdery mildew
- Mineral oils are not as effective as conventional fungicides
- Spray coverage is important for effective control with oils
- Mineral oils are more effective when applied in high water volumes (1000 L/ha)
- Mineral oils are effective when applied at 1% rate but may be phytotoxic if applied at higher rates

Overall the results suggest that the use of mineral oils in viticulture may be limited particularly where a high degree of powdery mildew control is required. Future use of oils may be suited to areas where IPM programmes are in place and where a reduction of conventional fungicide use is desirable.

TECHNICAL SUMMARY

Twenty eight experiments were conducted in the glasshouse and in vineyards to evaluate the efficacy of DC Tron - a highly refined parafinic oil for the control of powdery mildew. Glasshouse studies on potted vines showed that 1% oil was the most effective concentration and that higher rates were likely to be phytotoxic. The glasshouse studies also showed that for oils to be effective, spray coverage needs to be optimum. As a result of this, a special "Hydra" sprayer was constructed which produced small spray droplets that were carried into the vine canopy in large volumes of air. This machine was used in most field experiments.

Various rates of oil and spray volumes were applied to Chardonnay, Columbard, Pinot Noir and Verdelho vines in a number of experiments. These confirmed that the 1% rate of oil was the most effective rate to use for powdery mildew control and that 1000 L/ha of water was the most efficient rate of spray to apply. Oil rates less than 1% were not effective whereas rates greater than this were phytotoxic. Also when the oil rate was kept constant and the spray volume varied, the most efficient water volume was 1000 L/ha. Spray volumes lower than this were less effective whereas volumes greater than this were phytotoxic to grapevines.

Overall these results showed that oil controlled powdery mildew but its efficacy depended on spray coverage. Control of powdery mildew on leaves was relatively easy to achieve whereas powdery mildew was only controlled on bunches that were near the outside of the canopy and exposed to the spray. Powdery mildew developed on bunches in the centre of canopies as well as on the bunches that were protected by leaf "shingleing". Good control of powdery mildew was achieved on young plantings (less than 4 years old) throughout the season whereas on older plantings, mildew developed as the canopy became denser and spray penetration to the centre of the canopy was reduced.

While oil at the 1% rate and sprayed at 1,000 L/ha controlled powdery mildew and reduced the incidence and severity of disease compared to the unsprayed treatments, the control achieved was not as great as that obtained with conventional fungicides such as the DMI's.

In addition the high spray volumes required to achieve a degree of control resulted in spray deposits accumulating around the stylar end of berries which produced unsightly deposits and scaring. As a result of this, oils are unlikely to be suitable for use on table grapes. The combination of oil and sulphur was not phytotoxic to Gamay vines when sulphur was applied to vines previously sprayed with oil. Also no adverse affects were detected in either taste or appearance of Red Globe vines sprayed with 1% oil but were observed at water volumes of 500 L/ha.

However, at higher rates of oil and spray volumes, oil appears to remove the bloom from berries and is unlikely to be suitable for use on table grapes. Although oil was not applied to table grapes just before harvest, dipping Sultana bunches in oil at the same rates used for spraying resulted in unsavoury after taste.

In 33 grape cultivars grown for wine, four applications of oil applied at 1% and in spray volumes of up to 600 L/ha did not cause any noticeable phytotoxicity when applied alone or before the application of sulphur.

A standard air blast sprayer was used to apply 1% oil in spray volumes of up to 800 L/Ha to a block of vines in a commercial vineyard. A similar number of vines were sprayed with a standard rate of Bayfidan using the same spray machine. Wine made from grapes sprayed with either oil or Bayfidan was tasted by independent panelists in a standard "blind" test. No difference was detected in taste or quality of wine made from Chardonnay grapes whereas "early dusty and musty aroma" was detected by some panelists in wine made from Cabernet Sauvignon grapes treated with oil. This suggests that further work on oil and wine quality is required.

Overall this work has shown that:-

- mineral oil controls powdery mildew
- mineral oils are not as effective as conventional fungicides
- spray coverage is important for effective control with oil
- mineral oil is most effective when applied in spray volumes of at least 1000 L/ha.
- mineral oils may be phytotoxic when applied at rates higher than 1%

INTRODUCTION

Powdery mildew caused by *Uncinula necator* is the most widespread and economically important fungal disease of grapes in Australia. The disease is found in all grape growing districts of Australia and costs the industry over $30 million annually. Although fungicides such as the demethylation inhibiting (DMI) materials such as Bayfidan, Rubigan, and Topas as well as sulphur control the disease, alternatives to these materials are needed. This is due to the development of resistance to DMI's overseas (Gubler *et al* 1996; Erickson and Wilcox 1997) and sulphur is phytotoxic in some seasons and can also cause residue problems if applied near harvest.

Non conventional chemicals have controlled powdery mildew on other crops (Ziv and Zitter, 1992) and preliminary experiments (Wicks and Magarey, unpublished data) showed that some of the materials have potential for use on grapes. Oils in particular were found to be effective on grape powdery mildew in laboratory and glasshouse tests which was not surprising as they have been used commercially for many years to control pests and diseases on a wide range of crops (Calpauzos 1966, Boubos et al 1994). Both mineral and vegetable oils controlled powdery mildew on grapes in glasshouse experiments (Azam *et al* 1995 and Wicks *et al* 1995) where oils were applied using hand held sprayers.

Preliminary experiments also showed that the efficacy of oil sprays was dependent on adequate spray coverage and it was considered that spray coverage from hand held application may differ from that achieved from commercial spray machines. Because of this, the objective of this project was to further evaluate oils, in this case mineral oils using field applications with non hand held spray machines.

In this report we describe the experiments undertaken to fine tune the use of mineral spray oils on vines particularly the efficacy of different oil concentrations, spray volumes, and spray regimes that include various combinations of oil in the spray program.

GENERAL METHODS

Hydra Spray Unit

Preliminary studies showed that the efficacy of oil was dependent on optimum spray coverage. To achieve this a new spray unit with improved coverage and distribution of spray droplets was used in trials during the 1996/97 and 1997/98 seasons. This sprayer was developed by Geoff Furness of SARDI, Dr Alan Fein formerly of University of Sydney, Department of Aeronautical Engineering (retired), and Vogt Engineers of Tarlee, South Australia. The two-head sprayer produces large air volumes with low velocity and high turbulence to provide improved spray coverage.

The sprayer, known as a "Hydra" (Furness, 1996) features two 500mm diameter axial fans with 6 broad chord blades rotating at 1,600 or 3,000 rpm, a HDPE plastic fan shroud, 8 hollow cone swing nozzles, and a 415 volt 3 phase AC electric drive. The turbulence created by the axial fans, combined with the converging airstreams from the 2 fans, gives greater spray penetration to the inner canopy of the vines. Additionally, the small droplet size created by the spray cloud passing through the fan and being subjected to high air shear forces provides more even spray coverage than conventional airblast spray units.

Bunch and Leaf Sampling and Assessment Methods

Bunches and leaves were assessed in the field and the laboratory for the incidence and severity of powdery mildew. In the field, 20-50 leaves or bunches were randomly selected from the middle vines of each plot. They were assessed *in situ* using a 0-10 rating scale developed by Dr RW Emmett of Sunraysia Horticultural Centre (Appendix 1). With laboratory assessments, 20-50 leaves or bunches were randomly harvested from each replicate and rated after examination under magnifying lamps using the same scale.

The incidence of powdery mildew is the percent of bunches or leaves with the presence of active lesions. The severity of powdery mildew is a measure of the mean bunch infection.

Data was analysed using the Analytical Software package STATISTIX V4.1, using general ANOVA to produce LSD (P=0.05).

Products and Formulations

The majority of the experiments involved the use of a C_{24} mineral oil developed by Ampol Rural called DC Tron Plus. DCT Plus is an highly refined, emulsified mineral spray oil that is slightly heavier than normal summer spray oils. This oil has been photoprotected with a patented additive package that prevents UV light induced breakdown of the oil, minimising phytotoxicity. In the 97/98 season a new formulation of DCT Plus was developed. This mineral oil is similar to DCT Plus however it incorporates a separate base oil and spreader additive, added to tank mixes at 0.08% to alleviate blending difficulties. Compared to DCT Plus mineral oil is slightly lighter, uses a different emulsifier and is more UV protected. Citrole oil was another oil used in field experiments, which is a highly refined paraffinic oil of unknown origin.

Rotam flowable sulphur and Thiovit were the 2 forms of sulphur used in field experiments. Rotam is a liquid sulphur which carries 800 g of sulphur per litre with particle size in the 1-3 micron range and a 90% plus suspendibility. Thiovit contains 800 g/Kg of sulphur in the form of a water dispersible granule.

Various DMI fungicides were sprayed to compare the efficacy with mineral oils. These included Topas (10% EC penconazole), Bayfidan (25% EC triadimenol) and Rubigan (12% EC fenarimol).

LABORATORY AND GLASSHOUSE EXPERIMENTS

Experiment 1

This glasshouse experiment was conducted to determine the most effective rate of DCT Plus in preventing powdery mildew infection on grapevine leaves.

Methods:

Trials were conducted on potted vines cv. Cabernet Sauvignon and cv. Chardonnay grown in a glasshouse at 21-25°C. Vines free of visible powdery mildew were randomly selected and allocated to 6 groups of 10 replicates. DCT Plus was sprayed once to run off with a hand sprayer using concentrations of 0.1, 0.5, and 1% on Cabernet Sauvignon vines. Chardonnay vines were sprayed twice with a hand sprayer at 0.5, 1, 2, 5 and 10%, once prior to inoculation with powdery mildew and again 17 days after inoculation. Additional treatments included distilled water, Citowett at 0.05% and an unsprayed control. Five fully developed leaves per vine were tagged and monitored during the trial.

Powdery mildew inoculum was produced by shaking 10 leaves vigorously in a beaker with 100 ml of distilled water for several minutes. The liquid was filtered through a fine sieve and poured into a hand sprayer. The vines were inoculated with this powdery mildew spore solution 4 days after spraying. Five leaves per vine were assessed after inoculation to determine the percent area of active powdery mildew.

Results & Discussion:

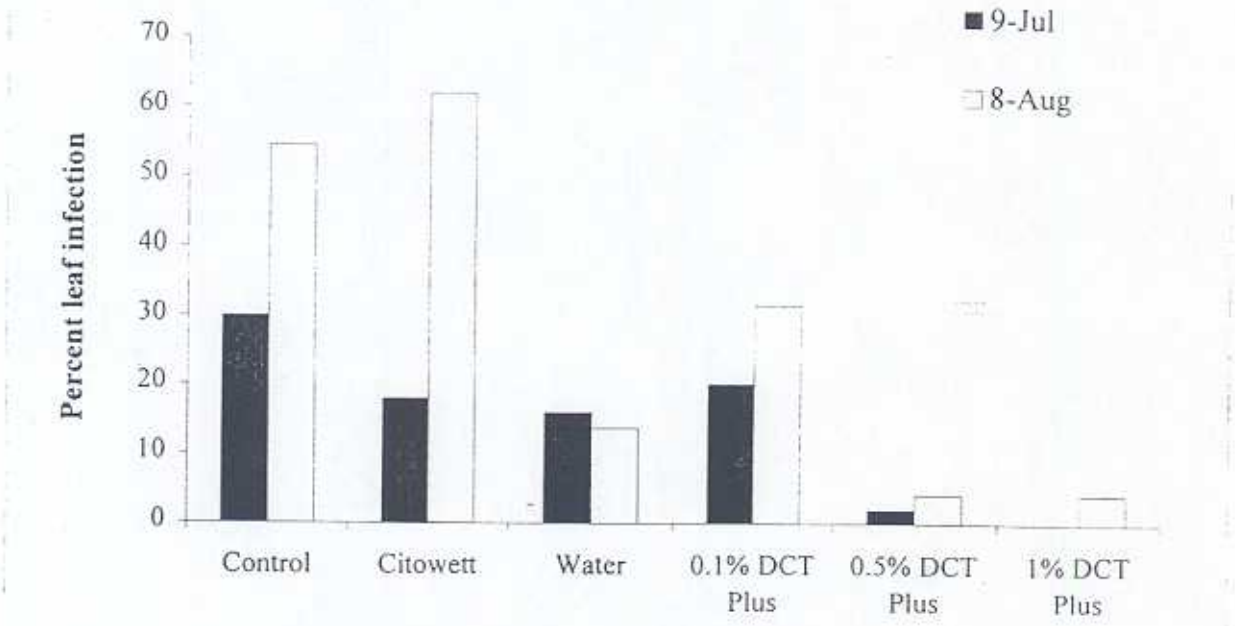
The incidence and severity of powdery mildew on Cabernet Sauvignon leaves increased during the month following inoculation in unsprayed, Citowett and 0.1% DCT Plus treatments (Fig. 1). Low incidence and severity of powdery mildew occurred in the higher DCT Plus rates.

The second trial on Chardonnay vines had to be terminated before powdery mildew could develop due to a severe two-spotted mite outbreak. Despite this, vines sprayed with DCT Plus at 5 and 10% developed severe marginal leaf burn and necrotic leaf spots after 2 applications.

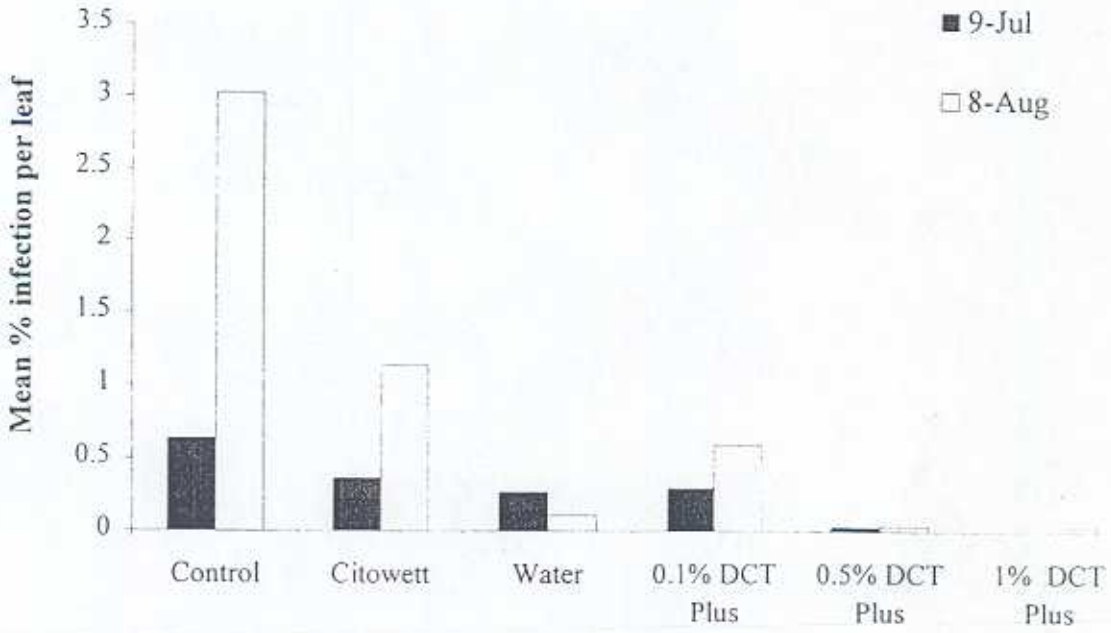
These studies confirm that rates of DCT Plus recommended for field trials in the 1996/97 season should be between 0.5 and 2%.

Figure 1 – Incidence (a) and severity (b) of powdery mildew on Cabernet Sauvignon leaves on glasshouse vines sprayed with DCT Plus prior to inoculation, July – August 1996.

(a) INCIDENCE



(b) SEVERITY



Experiment 2 and 3

Two experiments were undertaken to determine the most effective rate of DCT Plus for the eradication of powdery mildew on grapevine leaves.

Methods:

Experiment 2

Similar methods described in experiment 1 were used in this trial. However, vines with actively sporulating powdery mildew were selected and sprayed with DCT Plus to determine the effect on established lesions.

Results and Discussion:

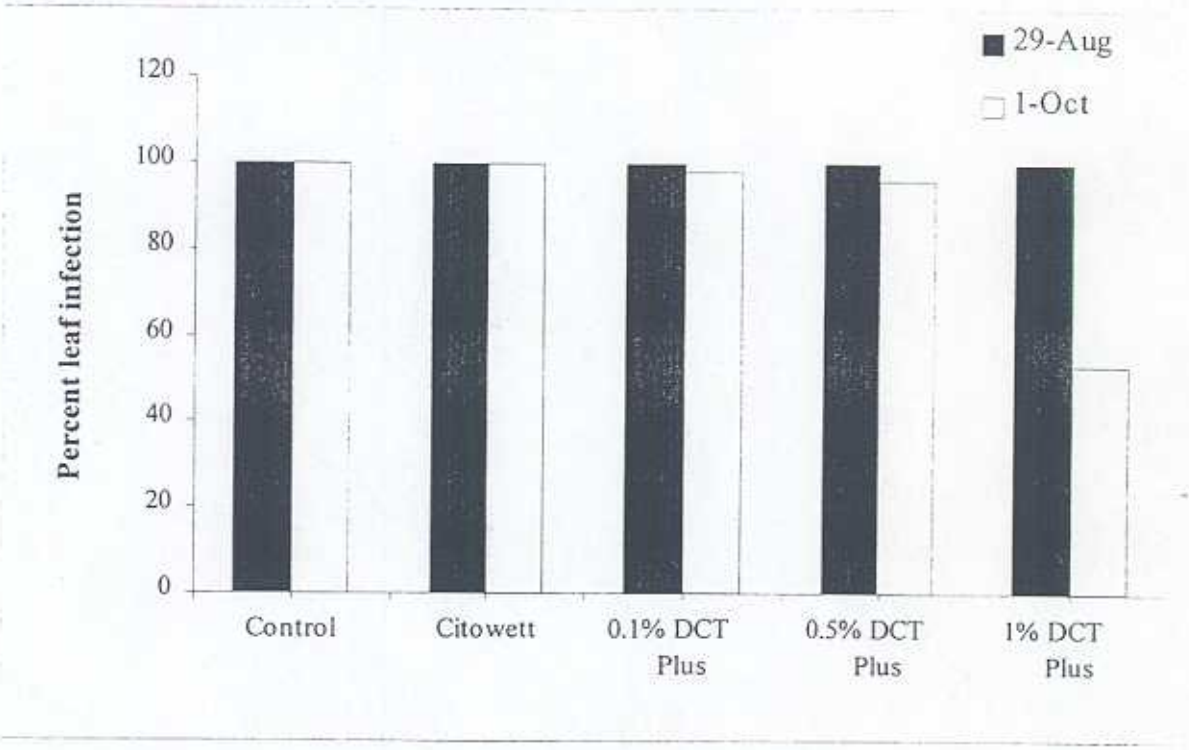
On Cabernet Sauvignon vines, single sprays did not reduce the incidence of powdery mildew 4 weeks after spraying except for the 1% DCT Plus where the number of infected leaves was reduced by nearly 50% (Fig. 2). Over this 4 week period the leaf area infected with powdery mildew increased in the control, Citowett and 0.1% DCT Plus treatments but decreased in both the 0.5 and 1% DCT Plus treatments.

A second experiment was started on Chardonnay vines but was not completed due to a mite infestation. DCT Plus was applied to vines at rates of 0.5, 1, 2, 5 and 10% and all rates eradicated powdery mildew. However, concentrations of 2% or higher caused marginal leaf burn.

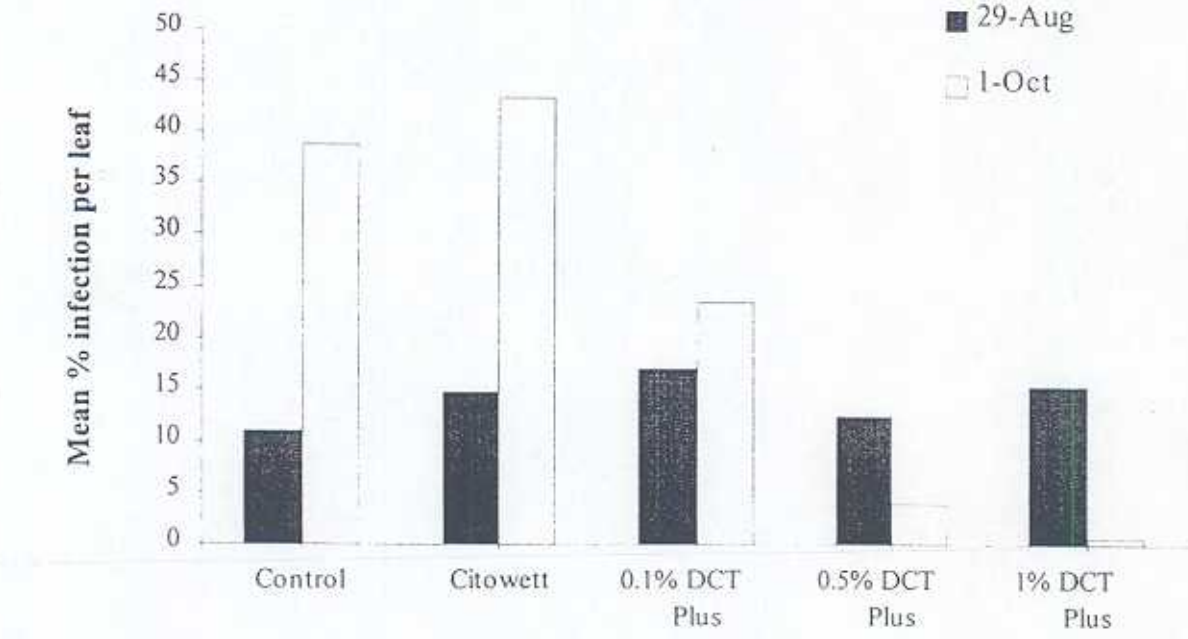
DCT Plus at 0.5% or below did not eradicate powdery mildew and the 2% and higher rates caused phytotoxicity on the leaves. As a result of this and the other laboratory and glasshouse studies it was decided to evaluate DCT Plus at a 1% concentration in field trials (1996/97 season), as this rate consistently reduced powdery mildew infections with minimal damage to the vines.

Figure 2 – Incidence (a) and severity (b) of powdery mildew on Cabernet Sauvignon leaves on infected glasshouse vines sprayed with DCT Plus, August – October 1996.

(a) INCIDENCE



(b) SEVERITY



Methods:

Experiment 3

Chardonnay leaves infected with powdery mildew were removed from inoculated potted vines and housed in a double petri dish containing water in the lower dish (Pearson and Gadoury, 1987). Leaves could be sustained in this manner for several weeks. Thirty five leaves were assessed for the level of infection using a 0-10 rating scale (Appendix 1) and randomly assigned to 7 groups of 5 single leaf replicates. DCT Plus at either 0.1, 0.25, 0.5, 0.75, 1 or 2% concentration was applied to leaves using a Potter Tower. An additional treatment of distilled water was applied to one group. The Potter Tower was set at 15 lb/in^2 with a 62 µl diameter nozzle and 3 ml of liquid sprayed per leaf.

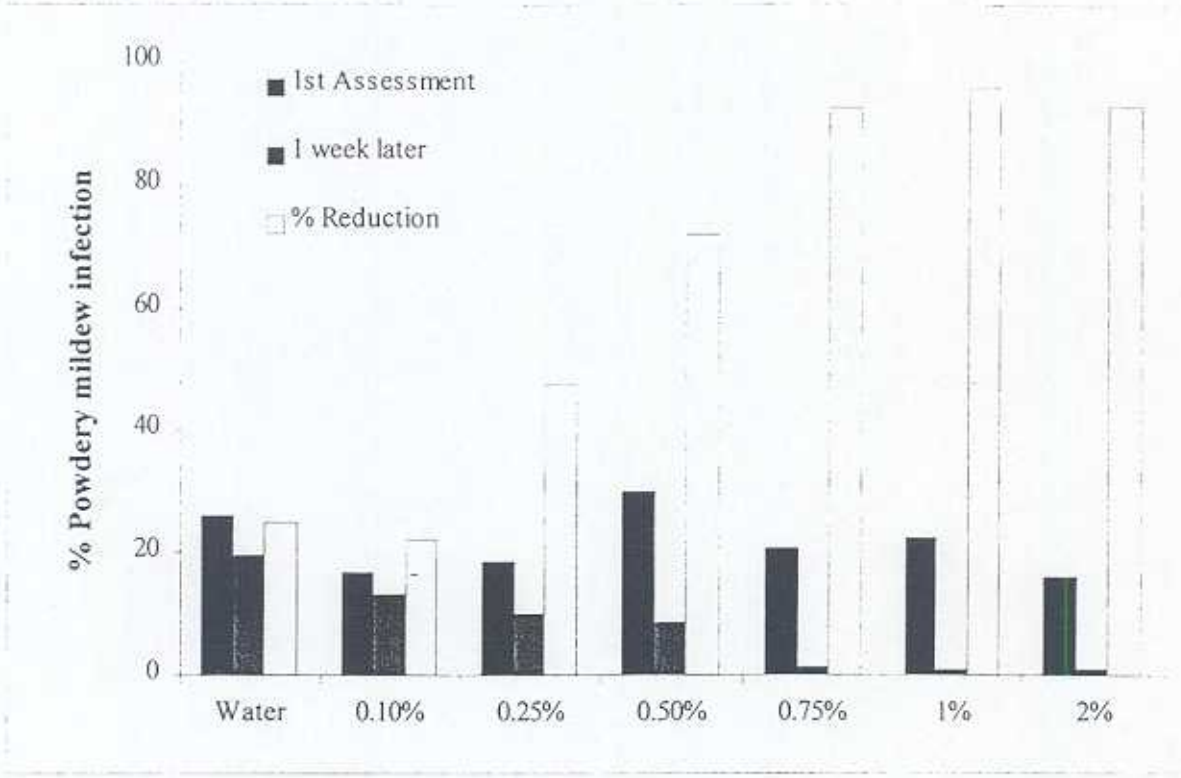
After 1 week each leaf was assessed again and the percent area of actively sporulating powdery mildew was determined. Any adverse effects of the DCT Plus applications were recorded at this time.

Results and Discussion:

The DCT Plus sprays flattened the mycelial growth of the powdery mildew lesions and caused lysis of mycelium on parts of the leaf where liquid had pooled after spraying. Necrotic spots occurred in these areas on several leaves sprayed with the 2% DCT Plus treatment. Fine spray droplets of solution beaded on the hyphae and evaporated with minimal effect to the mycellium.

The distilled water treatment reduced powdery mildew by 25% while 0.1% DCT Plus achieved 23% reduction (Fig. 3). DCT Plus at 0.25 and 0.5% reduced active sporulation of powdery mildew by 50 and 70% respectively. All rates of 0.75% or greater reduced sporulation by 95% or more but the 2% rate induced necrotic leaf spots. These results indicated that the 1% concentration was the optimum rate to use as it was effective on mildew and not phytotoxic.

Figure 3 – Percent reduction of powdery mildew on Chardonnay leaves treated with DCT Plus using a Potter Tower, October 1996.



Experiment 4 and 5

Two experiments were undertaken to determine the phytotoxicity of various rates of DCT Plus on Chardonnay grapevines.

Methods:

Potted Chardonnay vines were sprayed 3 times to run off with a hand sprayer at 7-10 day intervals. DCT Plus was applied to vines at 1, 5, and 10% in experiment 4 and a new formulation of DCT Plus was applied at 1, 2, and 4% in experiment 5. Replicates of 10 single vines per treatment were used. The vines were housed in a glasshouse at a temperature of 21-25°C.

Results & Discussion:

Experiment 4

Chlorotic leaf spots occurred on the leaves sprayed with 10% DCT Plus 3 days after the 2nd spray application. One week after the 3rd spray, necrotic leaf spots and marginal leaf burn were observed on vines treated at the 5 and 10% rates. As a result of this work, DCT Plus was not used in field trials during the 97 season at concentrations greater than 5%.

Experiment 5

A spray coverage of 100% was achieved on vines treated with the new formulations of DCT Plus. Water tension was reduced and complete coverage of the leaf surface was achieved, compared to spray deposits of DCT Plus 96 remaining in droplet form. Two days after the first spray application marginal leaf burning was observed on vines treated with 2 and 4% DCT Plus. At the third spray application all treatments sprayed with the new formulation of DCT Plus displayed necrotic leaf symptoms. As a result, a field trial was established to determine the effects of the new oil formulation at 1% on Chardonnay vines (Experiment 7).

Experiment 6

To determine the level of spray coverage and phytotoxic effects of a new formulation of DCT Plus on Sultana bunches treated at 1, 2, and 4%.

Methods:

Mature sultana bunches were sprayed once to run off with a hand sprayer, using a new formulation of DCT Plus oil at 1, 2, and 4%. Single bunch replicates were used of four bunches per treatment.

Results and Discussion:

The amount of coverage on the bunches was difficult to assess. Observations indicated that there was no difference in coverage between all three oil treatments. There was significant bruising on the bunches from handling resulting in indeterminable phytotoxicity effects from the oil.

FIELD EXPERIMENTS

Experiment 7

This field experiment was set up to compare the efficacy of two DCT Plus formulations and sulphur for the control of powdery mildew, and to determine whether any phytotoxic effects were caused by the new formulation of DCT Plus applied at 1%. The trial was conducted on Chardonnay vines, located at the University of Adelaide, Waite Campus.

Methods:

Old and new formulations of DCT Plus (1%) were compared with Rotam flowable sulphur (2 ml/L). All treatments were applied every 12 to 14 days to run off on Chardonnay vines using a Solo knapsack spray unit.

Results and Discussion:

Marginal leaf burning and necrotic leaf tissue developed on leaves treated with the new formulation of DCT Plus (1%) after the second spray application. The use of oils in this trial was abandoned due to the phytotoxic effects on the vines.

A new formulation of DCT Plus known as mineral oil was developed for field experiments in the 1997/98 season.

Experiment 8 and 9

These experiments evaluated the efficacy of spray programs of various concentrations of DCT Plus for the control of grapevine powdery mildew.

Methods:

Experiment 8

This trial was carried out on 5 year old vines cv. Chardonnay, located at the Lenswood Research Centre. The vines are planted 1.5 m apart at 3 m row spacings. Each row contained 40 vines trained to a single cordon vertical foliage system. DCT Plus at either 0.25, 0.5, 1 or 2.5% was applied on 5 occasions with the Hydra sprayer from December 4 1996 in spray volumes of 800-1300 L/ha (Appendix 3). Plots consisted of 8 vines, each replicated 4 times and arranged in a randomised block design with buffer rows separating treatment rows.

The incidence and severity of powdery mildew on bunches and the lower leaf surface was assessed on 4 occasions once the disease was detected in control vines. Bunches weight was also measured at harvest.

Results:

The incidence of powdery mildew increased rapidly in late December, the disease was detected in 5% of unsprayed bunches in early December and 100% in late January (Fig. 4a). Over the same period, the mean percent infection per bunch increased from 0% in the 1st assessment to 78% in the control plots and 37% on bunches treated with 2.5% DCT Plus in the final assessment (Fig. 4b). Bunch weights were not significantly different between treatments although bunches treated with the 2.5% rate of DCT Plus were 1-3 g less than those of the other oil treatments (Fig 5).

The incidence of powdery mildew on unsprayed leaves was 100% from mid December 1996 until the final assessment in March 1997 (Fig. 6a). On leaves sprayed with DCT Plus there was a rapid increase in the level of disease in December and then a decline in January, coinciding with three closely timed spray applications. Once spraying had ceased, the incidence increased to 80-100% leaves infected. The severity of powdery mildew remained low in the DCT Plus treatments (Fig. 6b), only increasing from 5 to 40% by the end of the trial. Severity of powdery mildew on untreated leaves increased rapidly from 1 to 60% over the assessment period. A small percentage of leaves in

the 1 and 2.5% concentrations of DC Tron Plus had phytotoxic damage on the leaf margins on the final assessment.

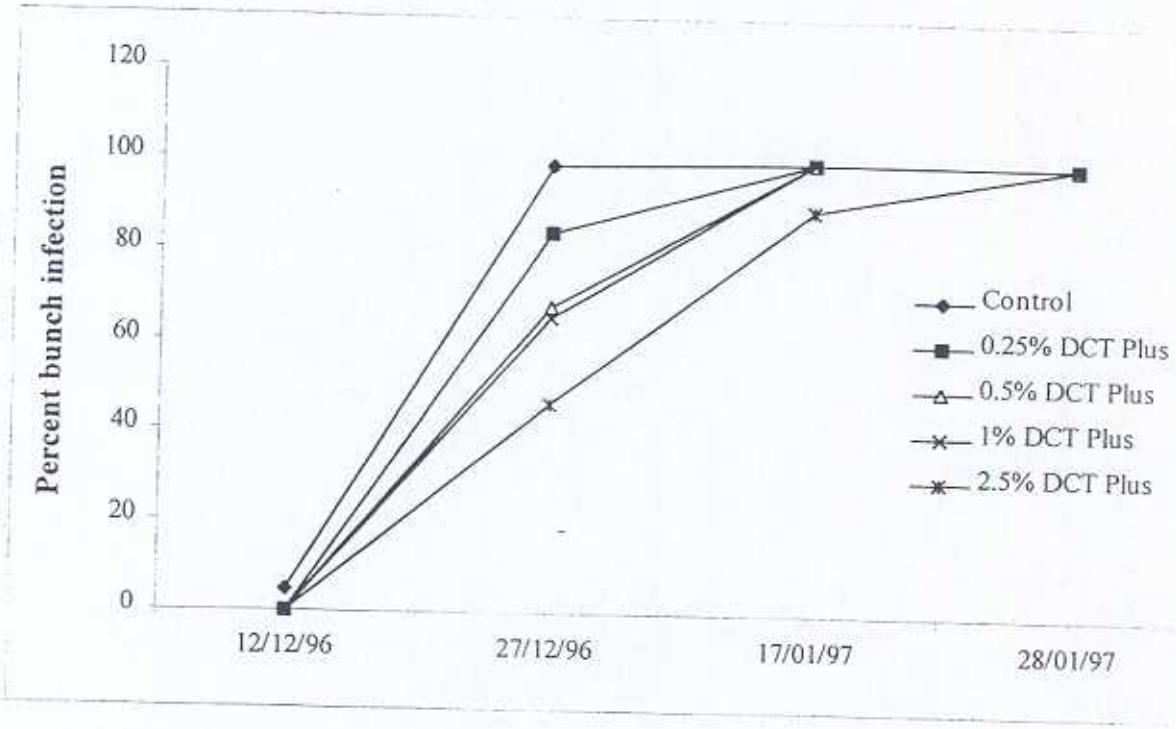
Discussion:

A full spray program of DCT Plus may have limited application in large canopy vines because although the oil controlled powdery mildew on bunches at rates of 0.5% and higher, once spraying ceased, infection developed to a level that was commercially unacceptable. Additionally DCT Plus at 2.5% caused marginal leaf burn and reduced the average bunch weight.

The incidence and severity of powdery mildew was lower on leaves than bunches due to better spray coverage on the leaves. Bunches inside the canopy received good spray coverage on the portion facing the outer canopy but limited coverage occurred on the portion facing the inner canopy and within the bunch. As the Hydra sprayer used in the trial only has 2 heads, their placement was critical to create the optimum turbulence and spray coverage. Further work is required to determine the correct placement of the heads for different canopy types. Additionally, shorter spraying intervals may reduce the incidence of powdery mildew in the vineyard and ultimately reduce the severity of the disease at harvest.

Figure 4 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches treated with DCT Plus, Lenswood 1996/97.

(a) INCIDENCE



(b) SEVERITY

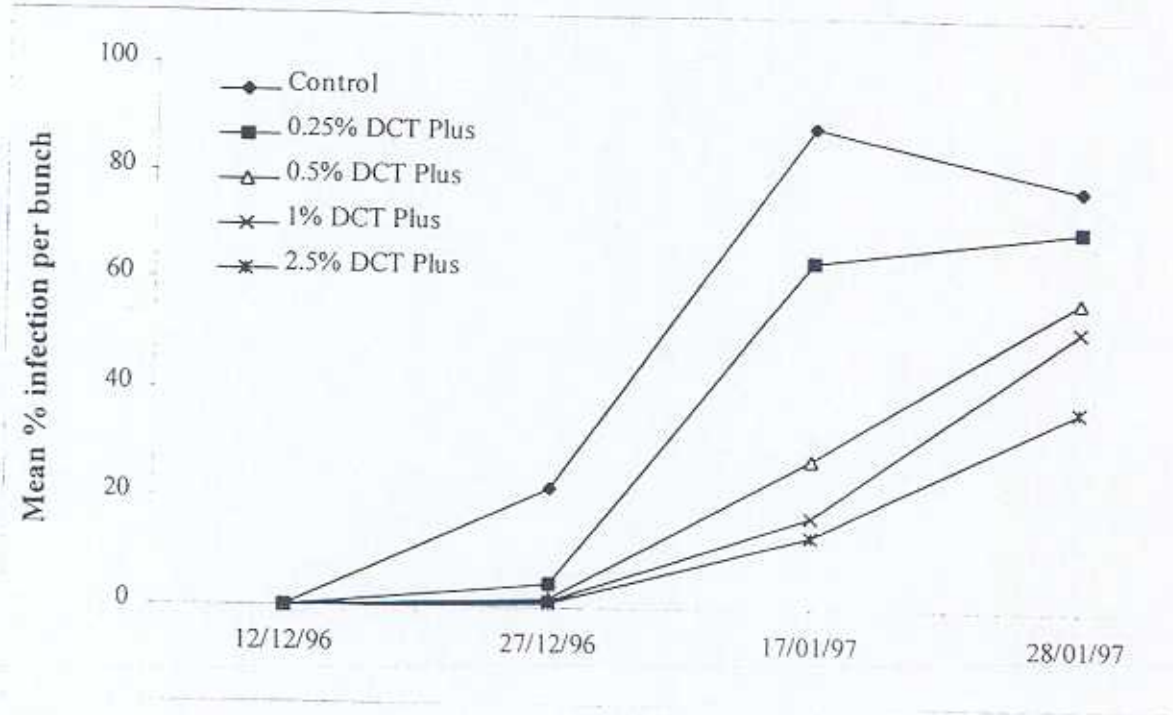


Figure 5 – Average weight of Chardonnay bunches at harvest treated with DCT Plus, Lenswood 1996/97.

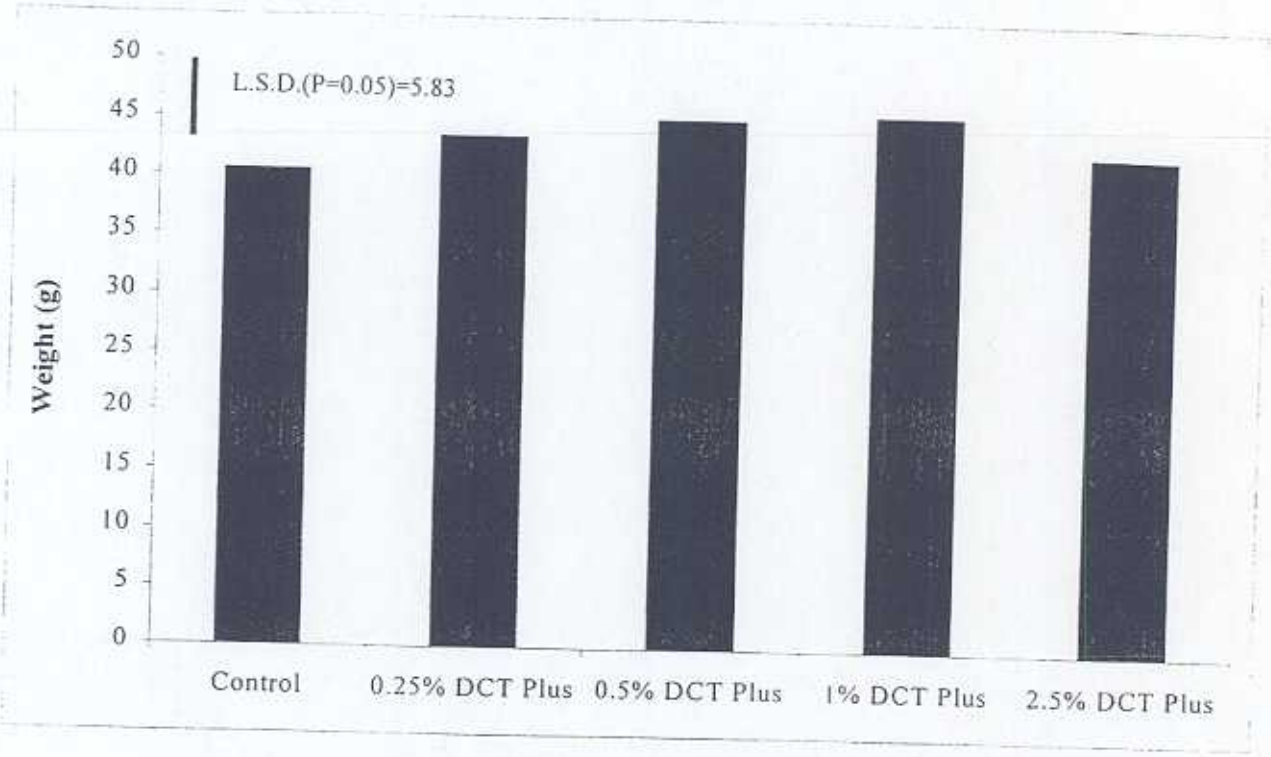
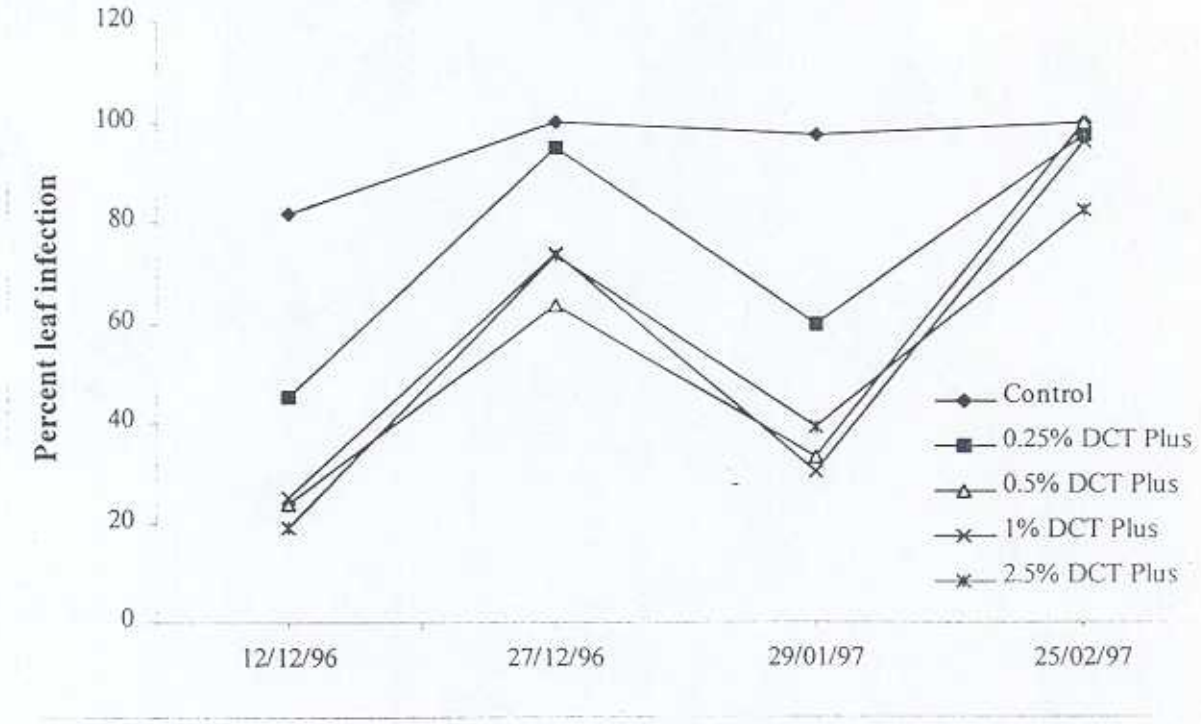
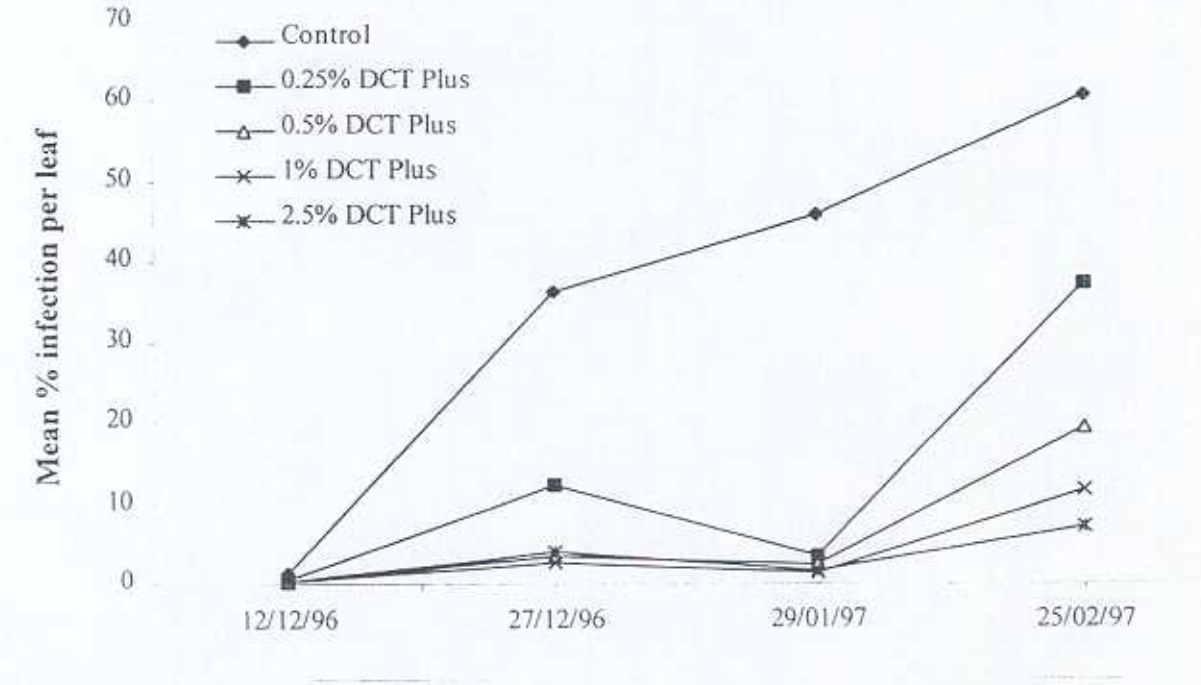


Figure 6 – Incidence (a) and severity (b) of powdery mildew on Chardonnay leaves treated with DCT Plus, Lenswood, 1996/97.

(a) INCIDENCE



(b) SEVERITY



Methods:

Experiment 9

In this experiment, treatments were applied to 5 year old vines cv. Pinot Noir, located on the Lenswood Research Centre. DCT Plus at concentrations of 1, 2.5 and 5% was applied with the Hydra spray unit using volumes of 450 to 1,300 L/ha (Appendix 4). These treatments were compared with Bayfidan applied at the recommended rate of 10 ml/100L. Treatments were applied to plots of at least 12 vines each replicated 3 times and arranged in a randomised block design.

The incidence and severity of powdery mildew on 50 bunches was assessed 4 times during the season, and 20 leaves were assessed once in February 1997.

Results and Discussion:

The incidence of powdery mildew in untreated bunches increased from 30% in late December to 90% in mid January and 100% at the final assessment in February 1997 (Fig. 7a). The incidence of disease was low in treated bunches until late January when it increased to 30% in the Bayfidan treatment and 90% in the 1% oil treatment. The severity of powdery mildew remained low in all the treatments throughout the trial except in the unsprayed plots (Fig. 7b). From mid January the mean bunch infection of powdery mildew in the untreated plots had rose from 10% to 45% by mid February.

The average bunch weights were significantly higher with Bayfidan and 1% DCT Plus than the other treatments (Fig. 8).

The incidence and severity of powdery mildew on leaves assessed at harvest showed that there was high infection in the untreated, 1% and 2.5% DCT Plus treatments whereas the incidence was low in the Bayfidan and 5% DCT Plus treatments (Fig. 9a). The severity was low in all treatments, particularly 5% DCT Plus and Bayfidan (Fig. 9b). The lower leaf surface had higher incidence and severity of powdery mildew than the upper leaf surface in all treatments, except on the unsprayed leaves. In this case the upper leaf surface had 10% higher infection than the lower leaf surface.

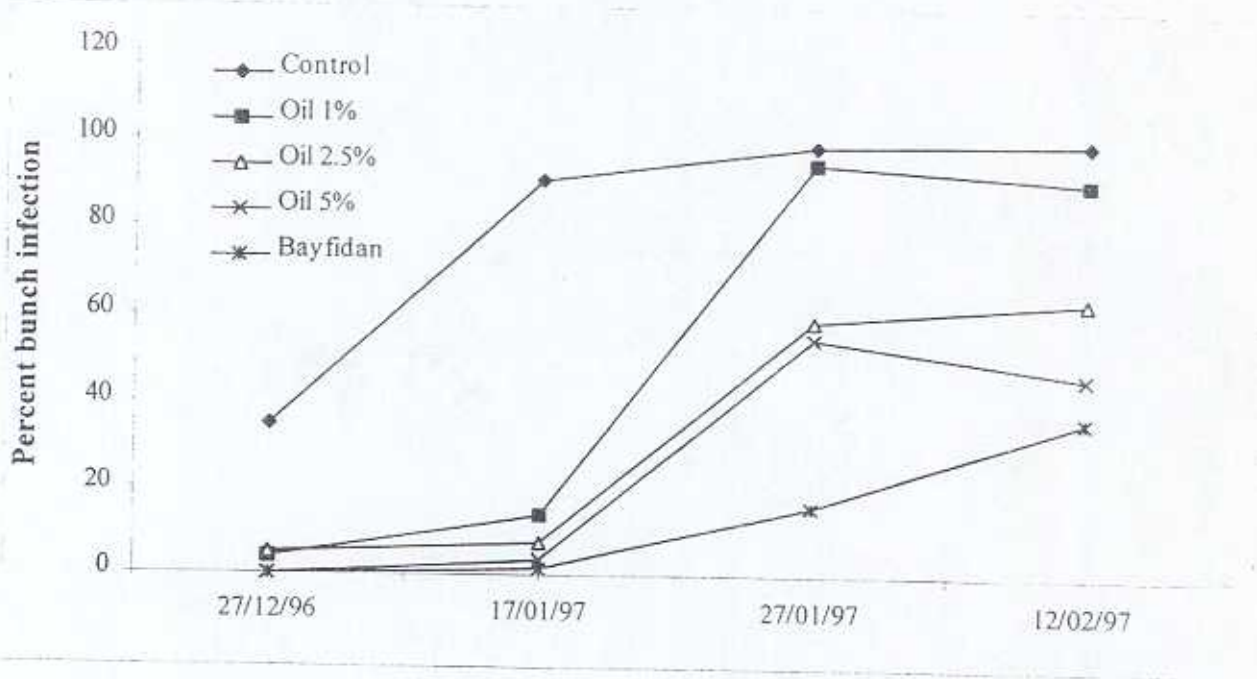
The area of necrotic leaf tissue caused by phytotoxicity was assessed on February 27, 1997 using a 0-5 rating scale. This does not include leaves which had died and dropped off the vine due to the high level of necrotic tissue. The treatments sprayed with 1 and 5% DCT Plus had 45 and 55% leaves respectively with phytotoxic damage (Fig. 10a). DCT Plus at 5% had an average of 8% necrotic tissue

per leaf compared to 5% at the lowest rate of oil (Fig. 10b). Bayfidan and control leaves exhibited minimal effects.

DCT Plus at 2.5 and 5% gave equivalent control of powdery mildew to Bayfidan, however those rates are unacceptable as they caused severe leaf burn and reduced the average bunch weight. Although the 1% rate had significantly higher incidence of bunch infection than Bayfidan, the severity was low enough to be marketable.

Figure 7– Incidence (a) and severity (b) of powdery mildew on Pinot Noir bunches treated with DCT Plus, Lenswood 1996/97.

(a) INCIDENCE



(b) SEVERITY

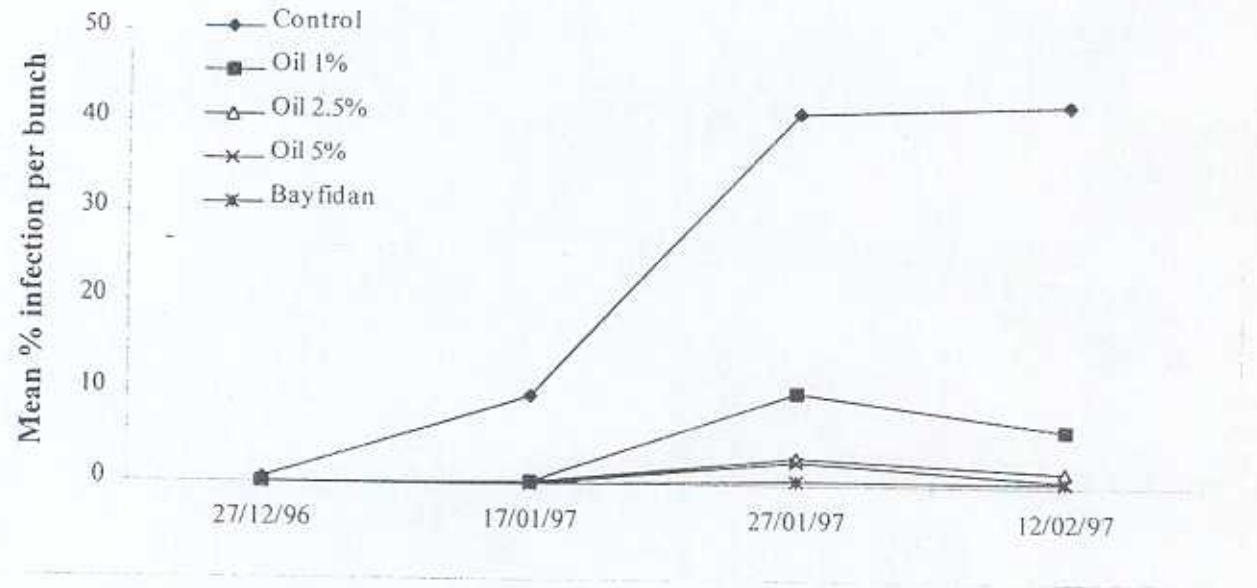


Figure 8 – Average bunch weight of Pinot Noir bunches treated with DCT Plus, Lenswood, February 1997.

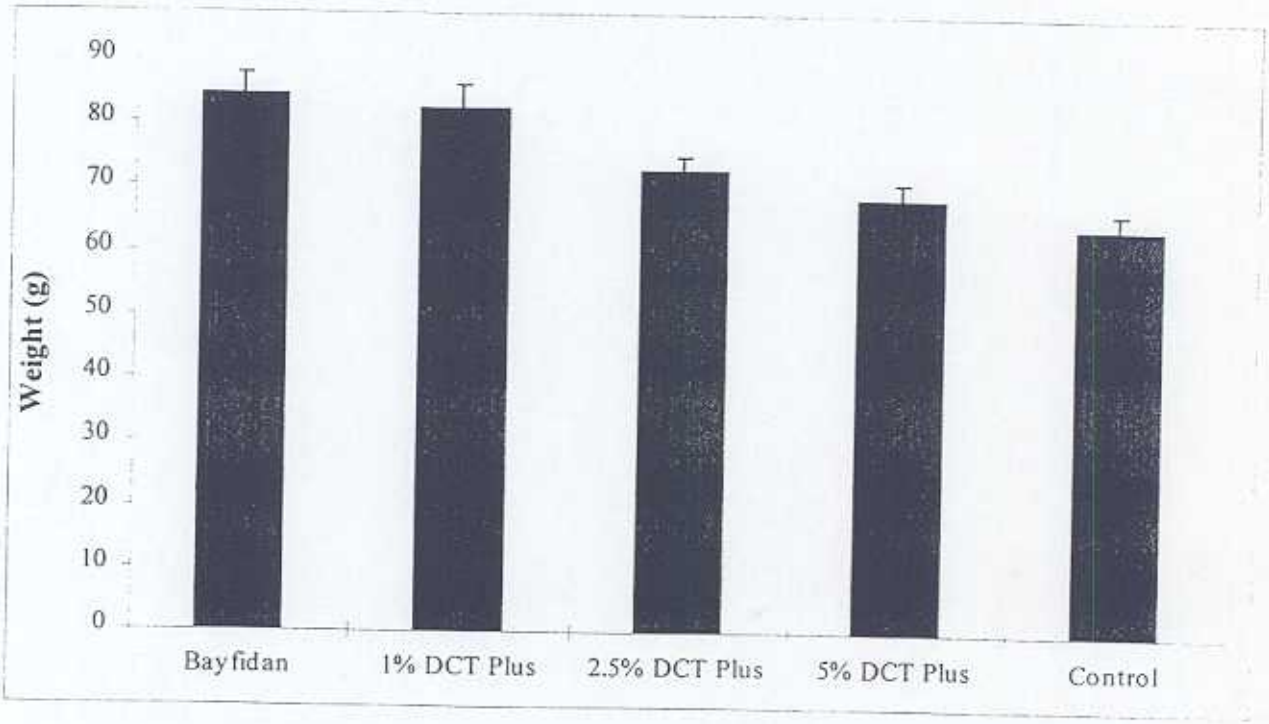
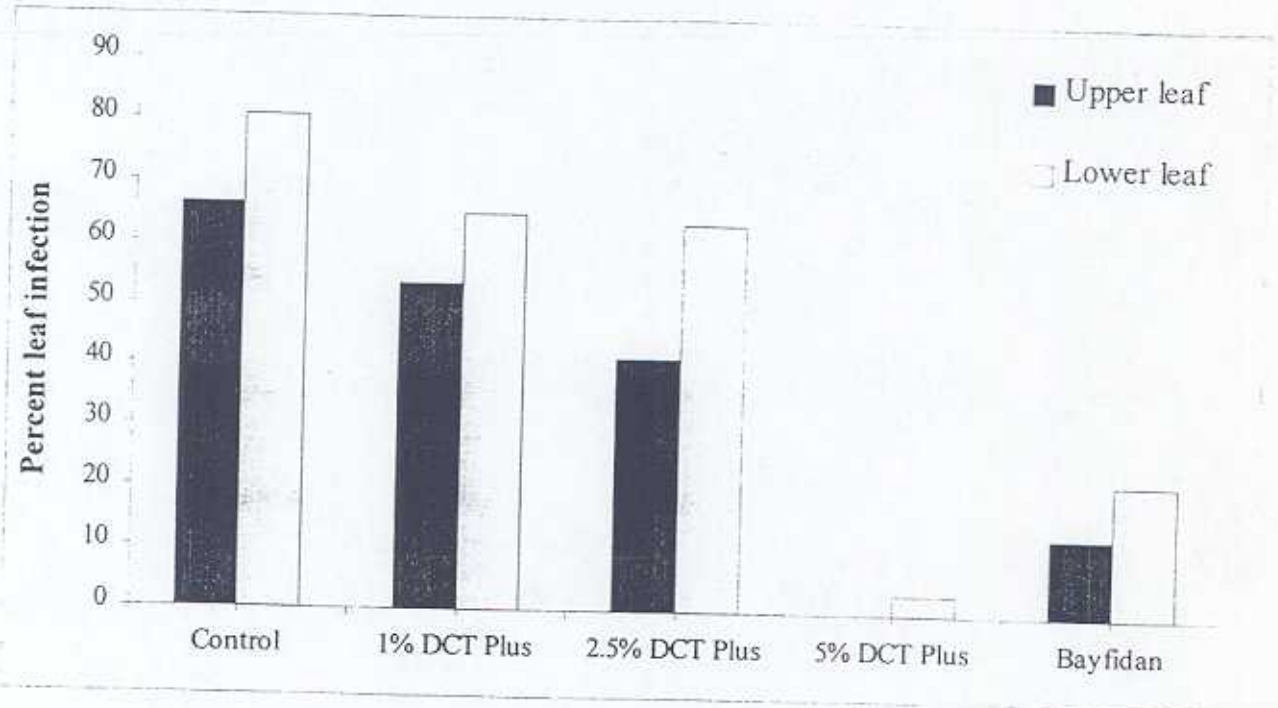


Figure 9 – Incidence (a) and severity (b) of powdery mildew on Pinot Noir leaves, upper and lower surfaces, Lenswood 1996/97.

Assessed: February 27 1997.

(a) INCIDENCE



(b) SEVERITY

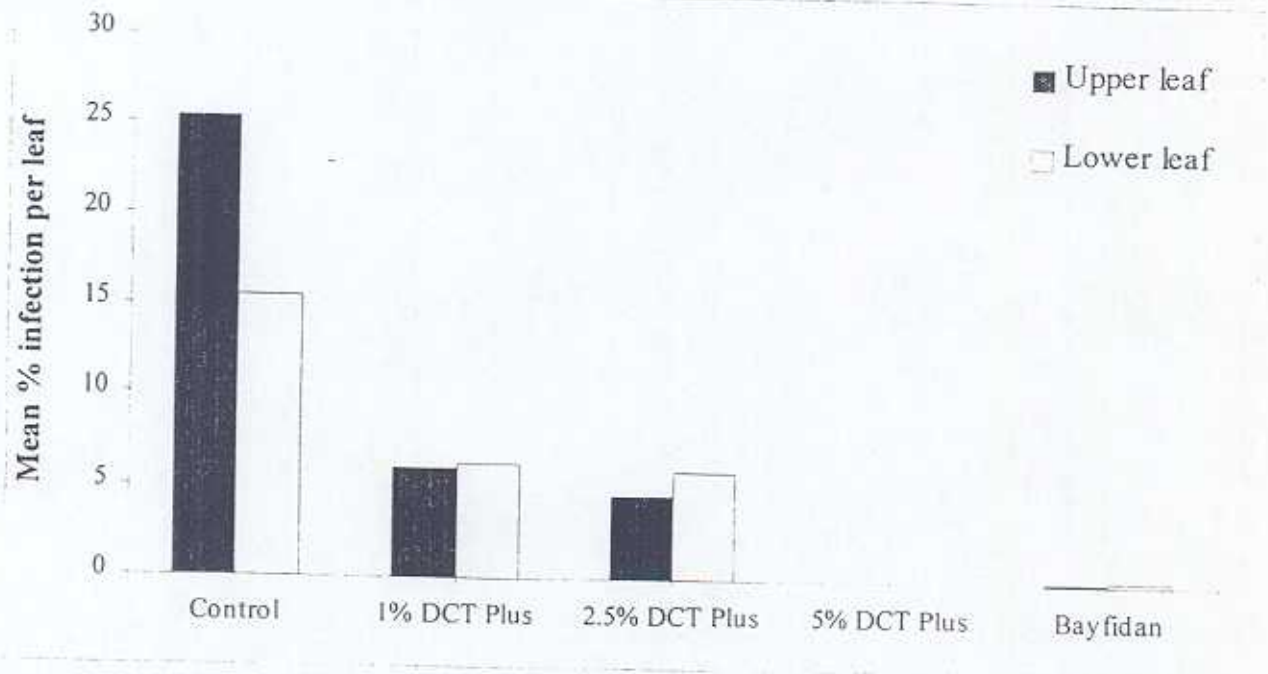
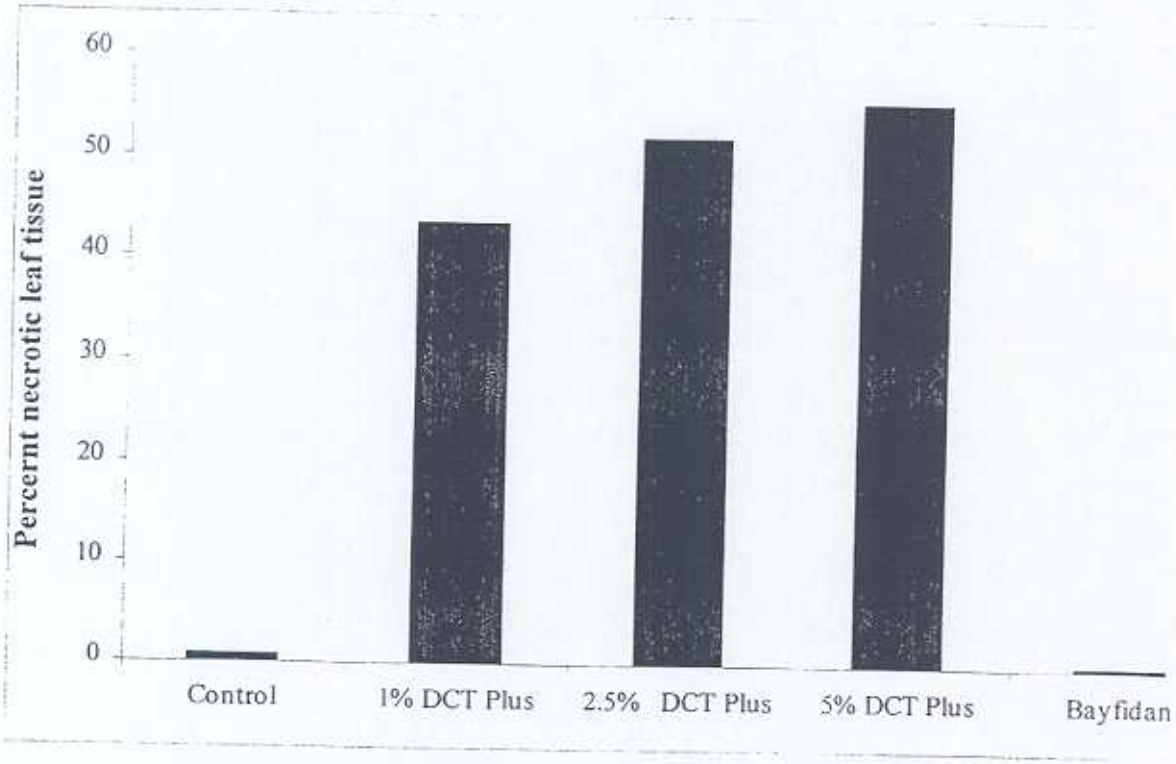
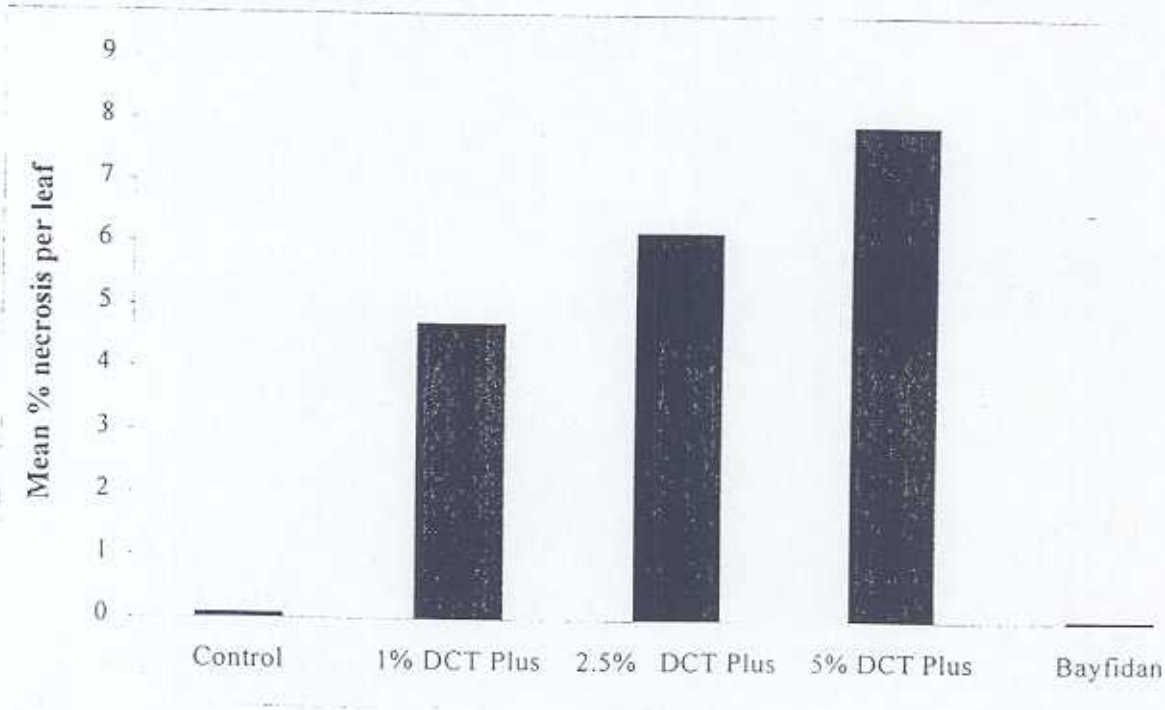


Figure 10 – Incidence (a) and severity (b) of necrosis on Pinot Noir leaves sprayed with DCT Plus, Lenswood 1996/97.

(a) INCIDENCE



(b) SEVERITY



Experiment 10 and 11

Two experiments were undertaken at the Nuriootpa Research Centre to compare the efficacy of DCT Plus and mineral oil applied at 1% for the control of powdery mildew.

Methods:

DCT Plus and mineral oil at 1% rate and a volume of 1000 L/ha was applied to 9 year old Riesling (Experiment 10) and 27 year old Chardonnay vines (Experiment 11) on 8 occasions from October 29, 1997 to January 19, 1998 (Appendix 5 & 6).

Between December 17 1997 and March 3 1998, 50 bunches per replicate were assessed on four occasions including harvest in the Chardonnay vines for the incidence and severity of powdery mildew.

Results:

Experiment 9

Powdery mildew was first detected in Riesling vines in late January 1998, but failed to spread throughout the trial. At the final assessment the incidence of powdery mildew on bunches was 7% and the severity rating was less than 0.2% (Fig. 11).

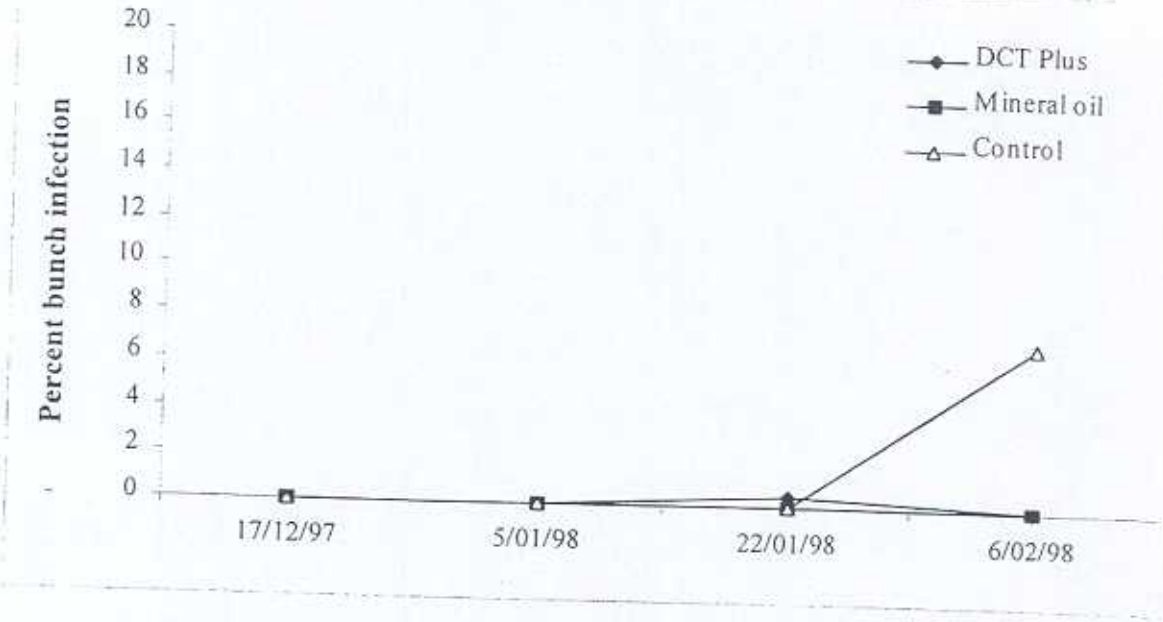
Experiment 10

The development of powdery mildew in Chardonnay vines was first observed on January 5 1998. The disease developed steadily during the season and by harvest the incidence of powdery mildew on untreated bunches was 100% (Fig 12a). However, the mean percent infection of powdery mildew on bunches was low throughout the season, ranging from 0% in all treatments in December to 5.8% on untreated bunches at harvest (Fig 12b).
Differences were observed at harvest between DCT Plus and mineral oil where the incidence of powdery mildew was 89 and 63% respectively.

Bunch weight was markedly increased in grapevines treated with mineral oil. Bunches weighed an average 84g whereas untreated and DCT Plus plots had an average bunch weight of 73g (Fig 13).

Figure 11 - Incidence (a) and severity (b) of powdery mildew on Riesling bunches, Nuriootpa 1997/98.

(a) INCIDENCE



(b) SEVERITY

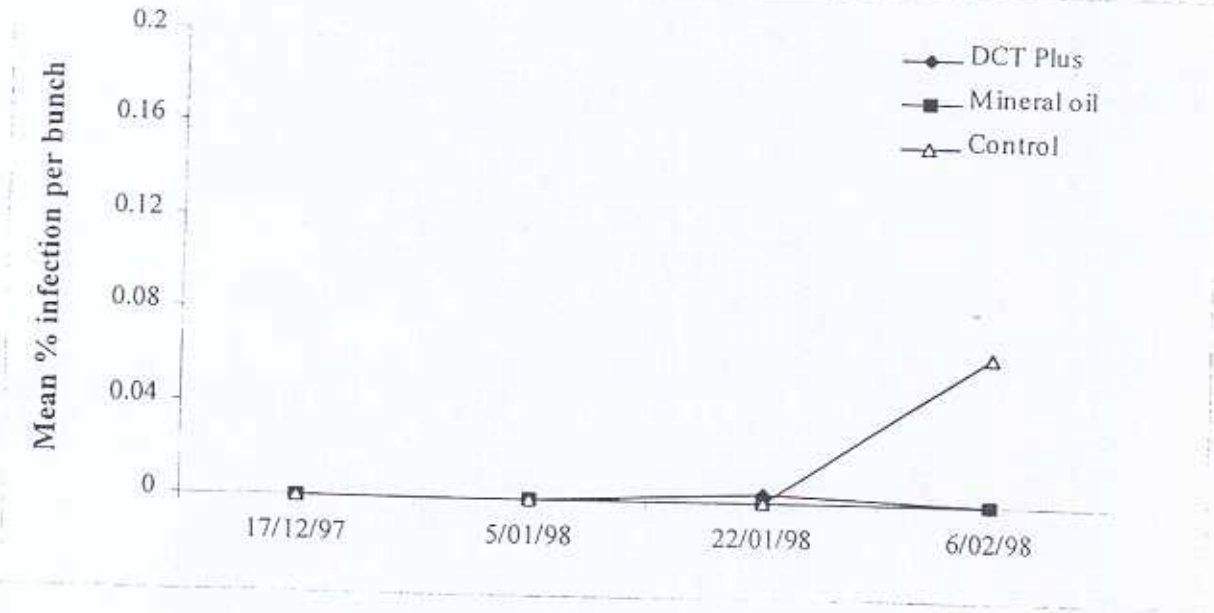
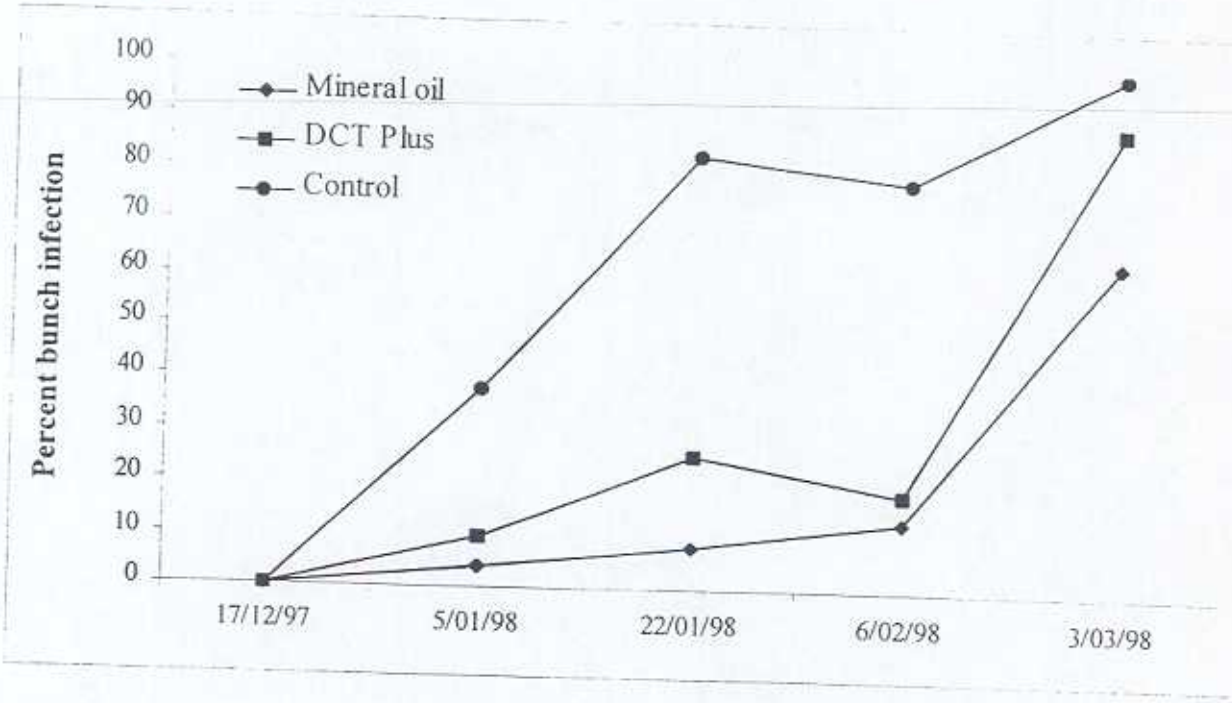


Figure 12 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches, Nuriootpa 1997/98.

(a) INCIDENCE



(b) SEVERITY

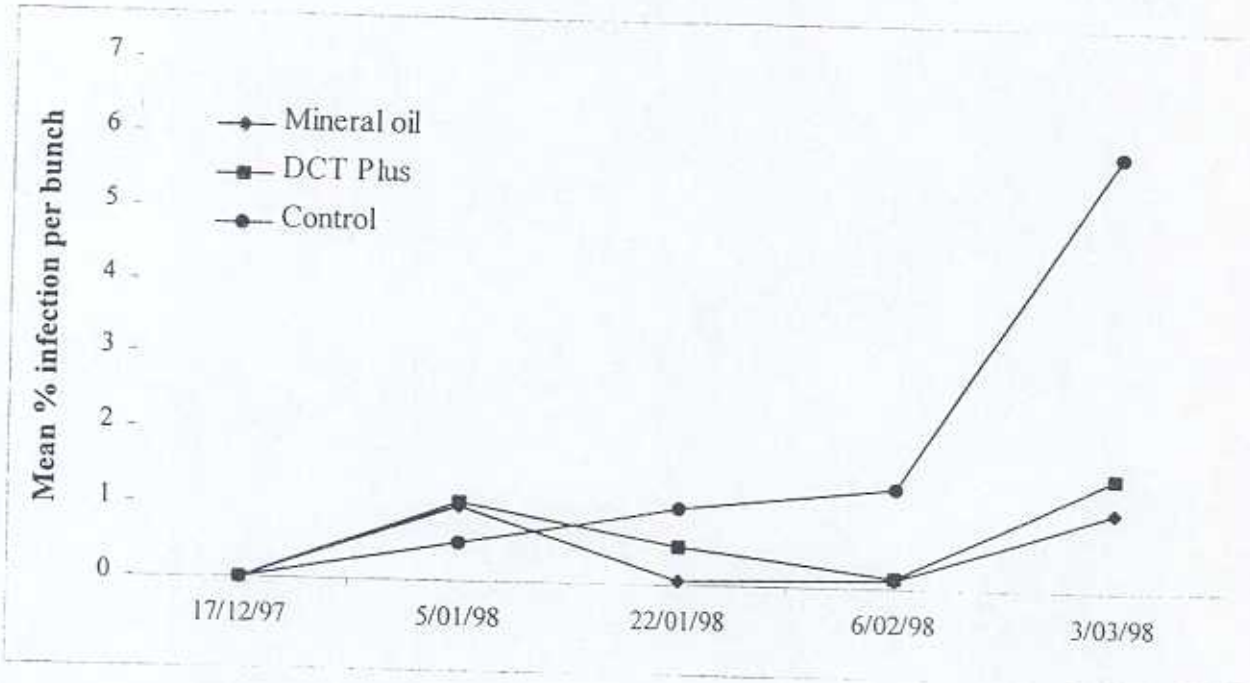


Figure 13 – Average weight of Chardonnay bunches at harvest treated with DCT Plus and mineral oil, Nuriootpa 1997/98.

Assessed: 4th March 1998.

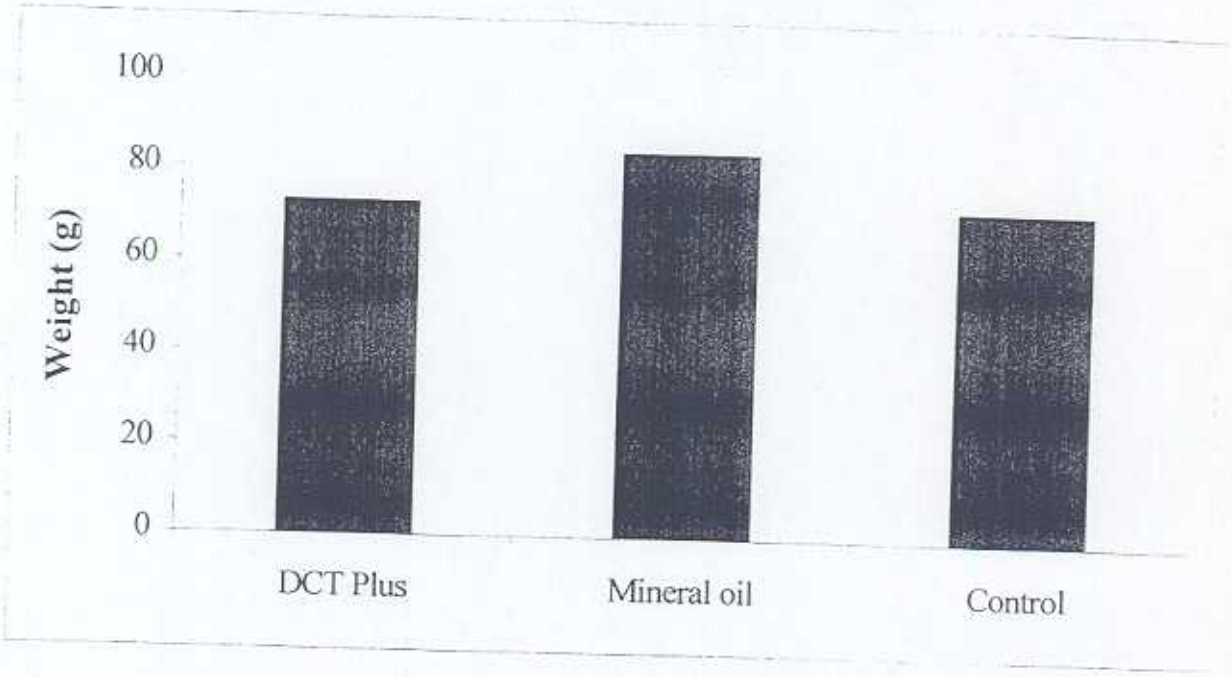
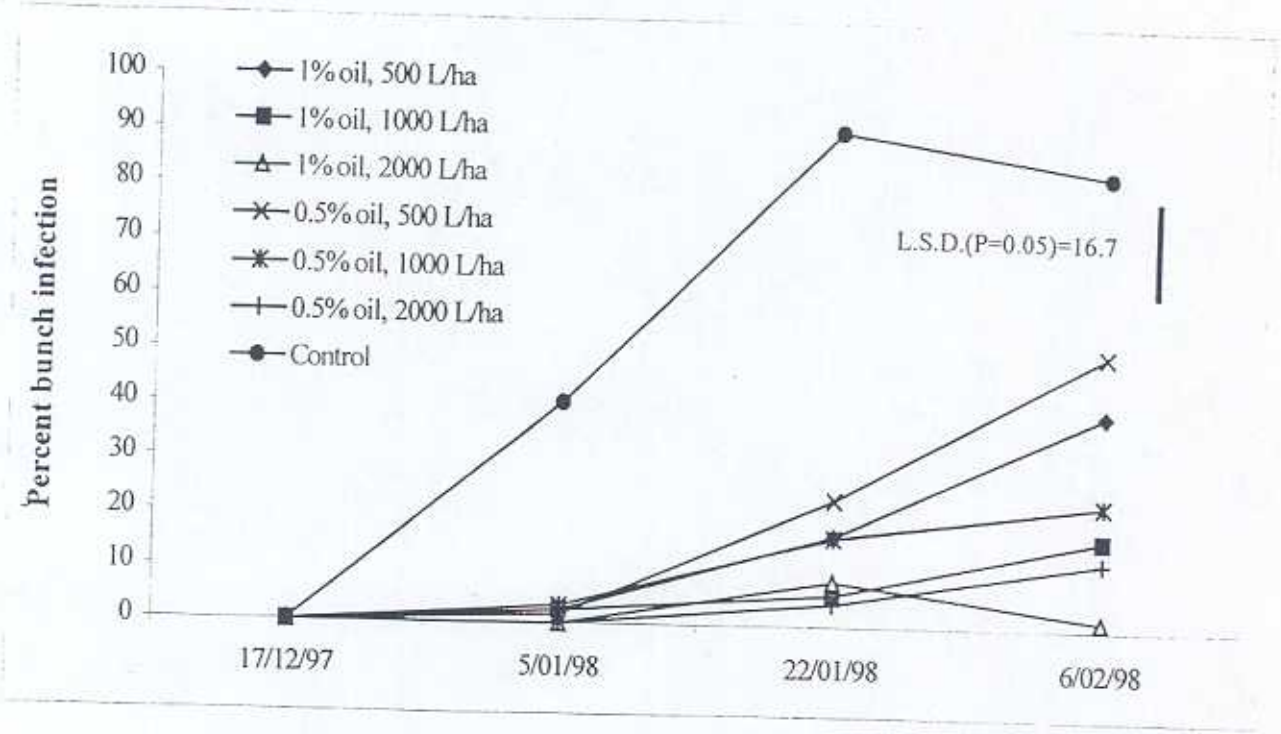


Figure 14 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches, Nuriootpa 1997/98.

(a) INCIDENCE



(b) SEVERITY

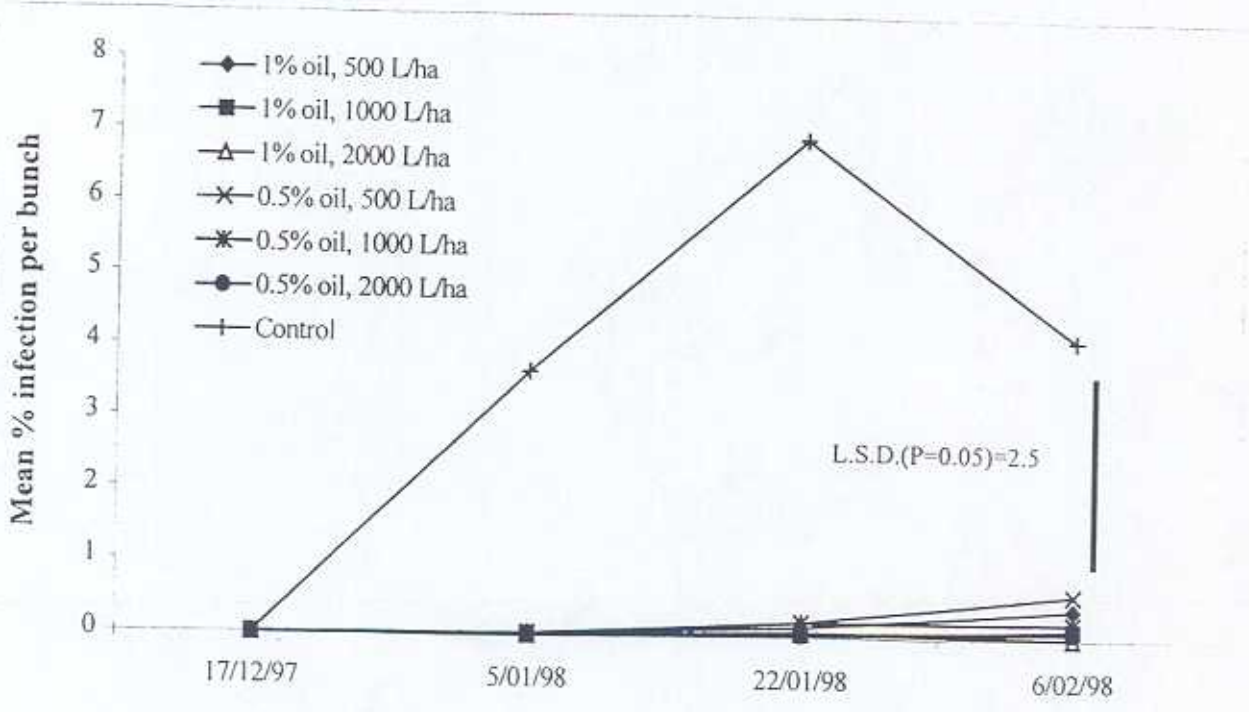
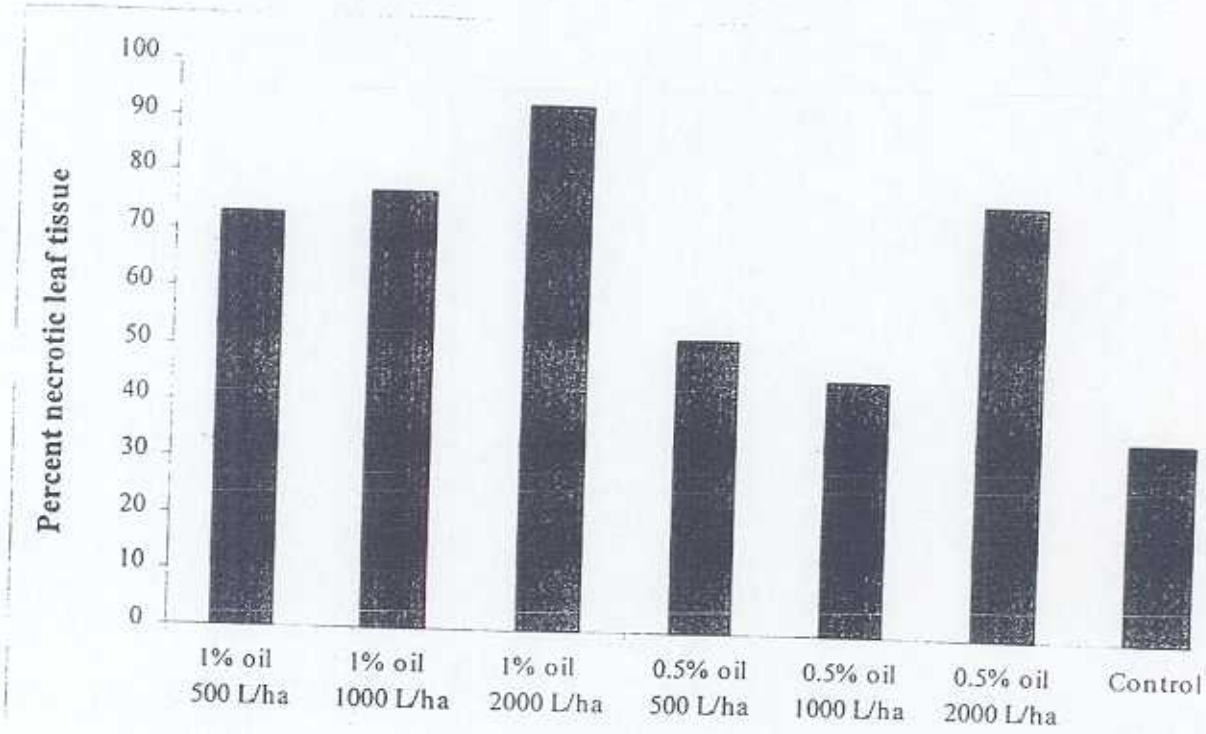


Figure 15 – Incidence (a) and severity (b) of necrosis on Chardonnay leaves, Nuriootpa 1997/98.

Assessed: 4th March 1998.

(a) INCIDENCE



(b) SEVERITY

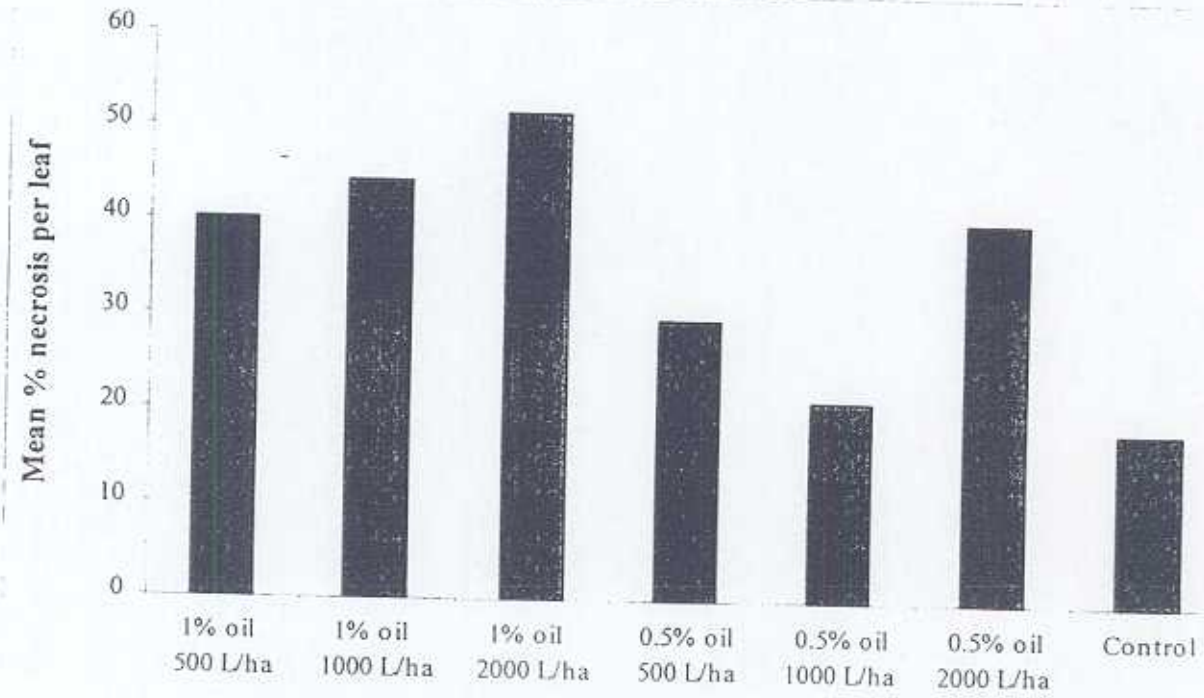
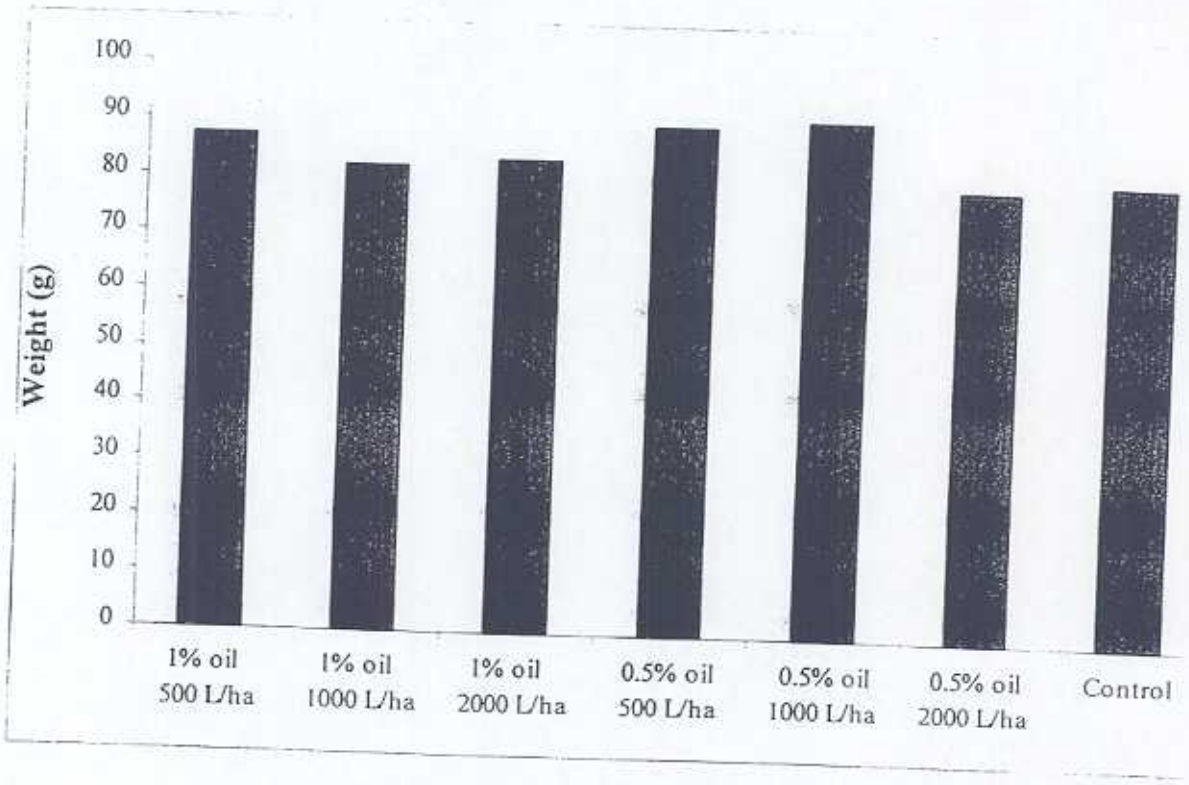


Figure 16 – Average weight of Chardonnay bunches at harvest, Nuriootpa 1997/98.

Assessed: 11th March 1998.



Experiment 12

Chardonnay grapevines located at the Nuriootpa Research Centre were sprayed to determine the efficacy of 0.5 and 1% mineral oil applied at different spray volumes for the control of powdery mildew.

Methods:

Mineral oil at 0.5 and 1% was applied to 4 year old Chardonnay vines using the Hydra sprayer at water volumes of 500, 1000, and 2000 L/ha. Sprays were applied on 9 occasions at intervals of 7 to 21 days between October 29 1997 and February 4 1998 (Appendix 7).

Treatment plots consisted of 9 vines with 6 replications. Buffer rows separated the treatment rows to reduce the amount of spray drift.

The incidence and severity of powdery mildew was assessed 4 times on 20 bunches per replicate between December 17 1997 and February 6 1998. Phytotoxicity and powdery mildew on 20 leaves per treatment plot were assessed at harvest along with yield on March 11, 1998.

Results and Discussion:

Powdery mildew increased rapidly on untreated bunches where the incidence of the disease increased from 40% in early January to 90% in late January (Fig 14a). In the spray treatments the incidence of powdery mildew gradually increased between December and February from 0 to 1.5% on bunches sprayed with 1% mineral oil at 2000 L/ha and 1 to 50% on bunches treated with 1% mineral oil at 500 L/ha. The severity of infection remained low all season with the untreated vines having the highest rating of 4 at harvest.

Phytotoxicity on leaves increased with spray volume and mineral oil concentration (Fig 15). Assessment errors or sunburn damage, which was present throughout the trial may have caused the high incidence and severity level measured on untreated leaves.

At harvest average bunch weight was similar in all the treatments with no differences being detected between different rates and concentrations (Fig 16).

Experiments 13, 14 and 15

Three field trials were undertaken at various locations to determine the influence of spray volume on the efficacy of mineral oil for the control of powdery mildew.

Methods:

Experiment 13

DCT Plus at 1 and 5% was applied to mature Verdelho vines in a commercial vineyard at Padthaway using a rate of 100 L/ha. Sprays were applied by a unit built by Greentech Australia with hydraulic spray heads using the same design principles as the Hydra unit (Appendix 8).

Each treatment was applied to 3 rows, with 3 panels in the centre of each row being left as an unsprayed control. Bunches were assessed for incidence and severity of powdery mildew on three separate occasions between November 25 1996 and March 17 1997. Water sensitive papers were placed in treated and untreated plots during the 3rd spray, November 25 1996 to measure the amount of spray deposit penetrating the vine canopy.

Results & Discussion:

Powdery mildew did not develop in the Verdelho bunches until early 1997. The incidence and severity of powdery mildew remained lower in the unsprayed plots than treated plots, until after February where a sharp increase in the level of disease developed (Fig. 17). There were no differences between treatments during the trial, however in March the incidence and severity of powdery mildew in unsprayed bunches was significantly higher than treated bunches.

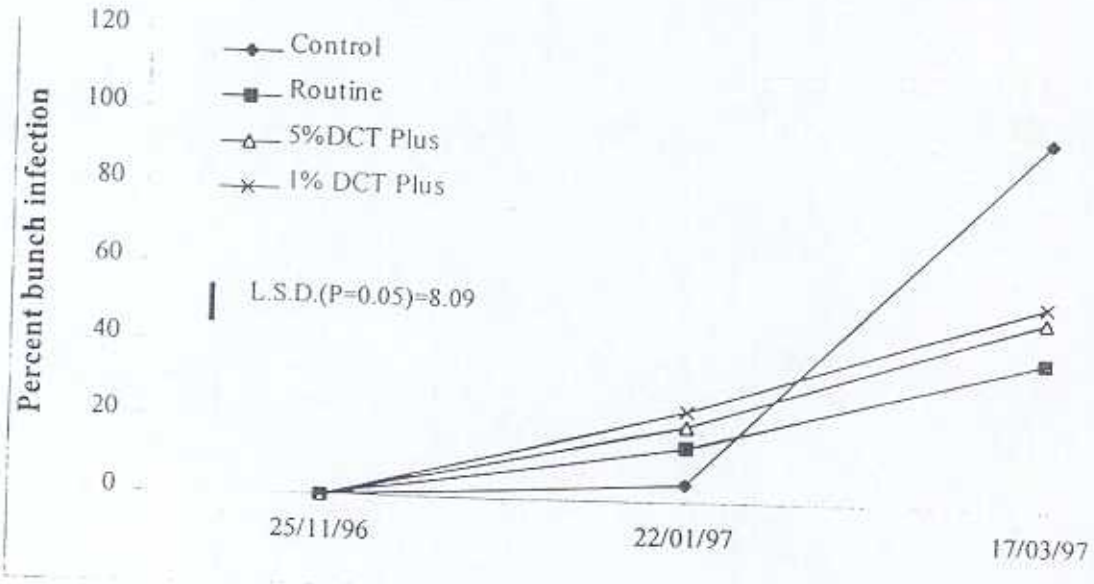
Spray deposits on water sensitive paper were very high on the side exposed to the outer canopy which had a dense covering of fine droplets. The side facing the inner canopy received variable coverage, most with less than 10%. Papers in the buffer rows received minimal coverage indicating a very small amount of drift.

Spray penetration in the vines was very good even with the use of low (100 L/ha) volumes of water. DCT Plus at 1 and 5% were as effective as the routine spray application despite spray intervals of 20-22 days. The coverage of leaves and bunches by the oil is a critical factor in the effectiveness of the

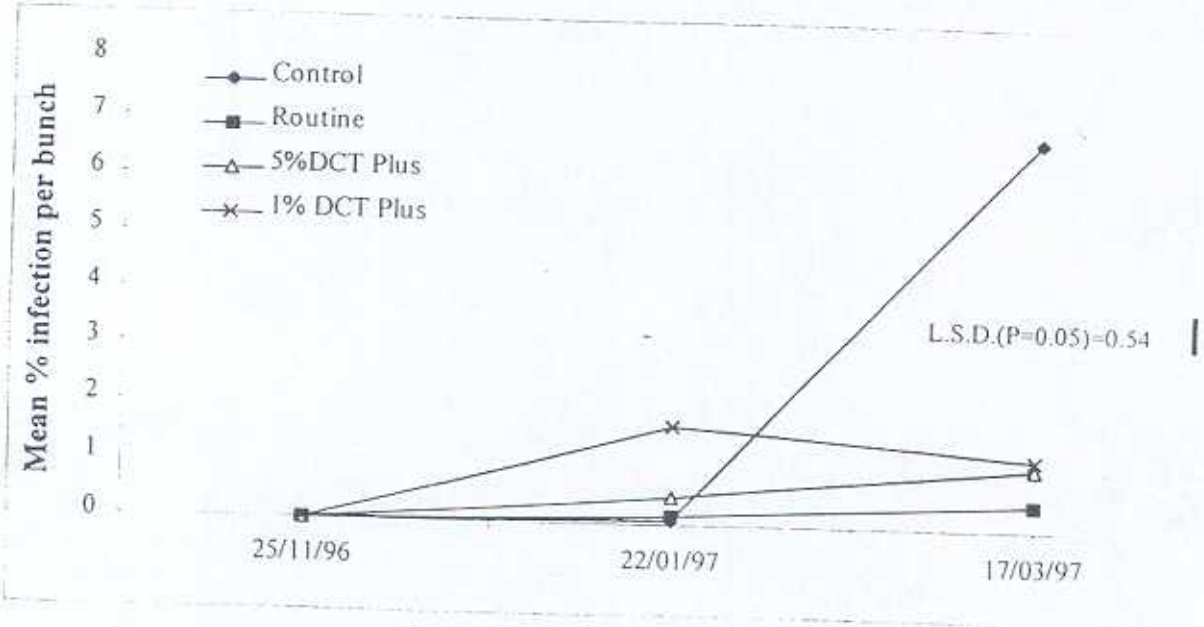
spray application. The spray unit used in the trial had 5 heads, 2 either side of the row and 1 above, this allowed for a highly turbulent airflow within the canopy and greater spray penetration.

Figure 17 – Incidence (a) and severity (b) of powdery mildew on Verdelho bunches treated with DCT Plus at 100 L/ha, Padthaway 1996/97.

(a) INCIDENCE



(b) SEVERITY



Methods:

Experiment 14

Mature Chardonnay vines located at the Nuriootpa Research Centre were sprayed with DCT Plus at 1% using the Hydra spray unit. Sprays were applied using water volumes of 100, 200, 500, 1000 and 1500 L/ha on 4 occasions at intervals of 6 to 19 days, between November 15 and December 23 1996 (Appendix 9).

Treatments were arranged in a completely randomised design with 5 replicates each containing 9 vines per treatment. A buffer row separated each treated row. The level of powdery mildew on bunches was assessed on 3 occasions between December 1996 and early January 1997 and leaves were assessed once in December 1996. An additional assessment of senescence and leaf phytotoxicity using a 0-5 rating scale was conducted on March 5 1997.

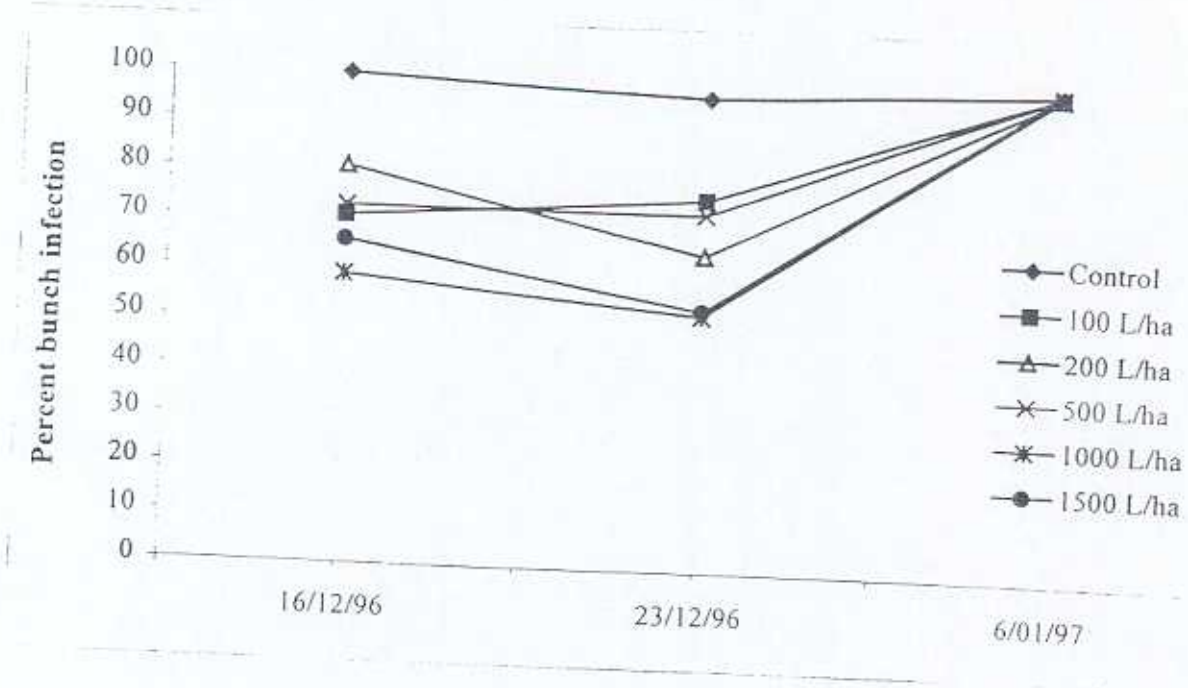
Results and Discussion:

At the first assessment in mid December, all unsprayed bunches were infected with powdery mildew (Fig. 18a). Vines treated with 100 and 200 L/ha of DCT Plus had 60 and 80% of bunches infected respectively in mid December, which increased to 100% by January 6, 1997. The severity of powdery mildew also increased rapidly after the last spray application on December 23 1997 (Fig. 18b). Bunches sprayed with 1000 and 1500 L/ha had significantly less disease than the control and 100 L/ha treatment (Fig. 19).

Leaves treated with higher volumes of DCT Plus had significantly lower incidence and severity of powdery mildew than the control and 100 L/ha treatment (Fig. 20). The level of senescence of leaves followed the same trends as the early assessment of powdery mildew (Fig. 21). The vines sprayed with 500 to 1500 L/ha of 1% DCT Plus had healthier leaves and less dead tissue per leaf.

Figure 18 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches sprayed with 1% DCT Plus at different spray volumes, Nuriootpa 1996/97.

(a) INCIDENCE



(b) SEVERITY

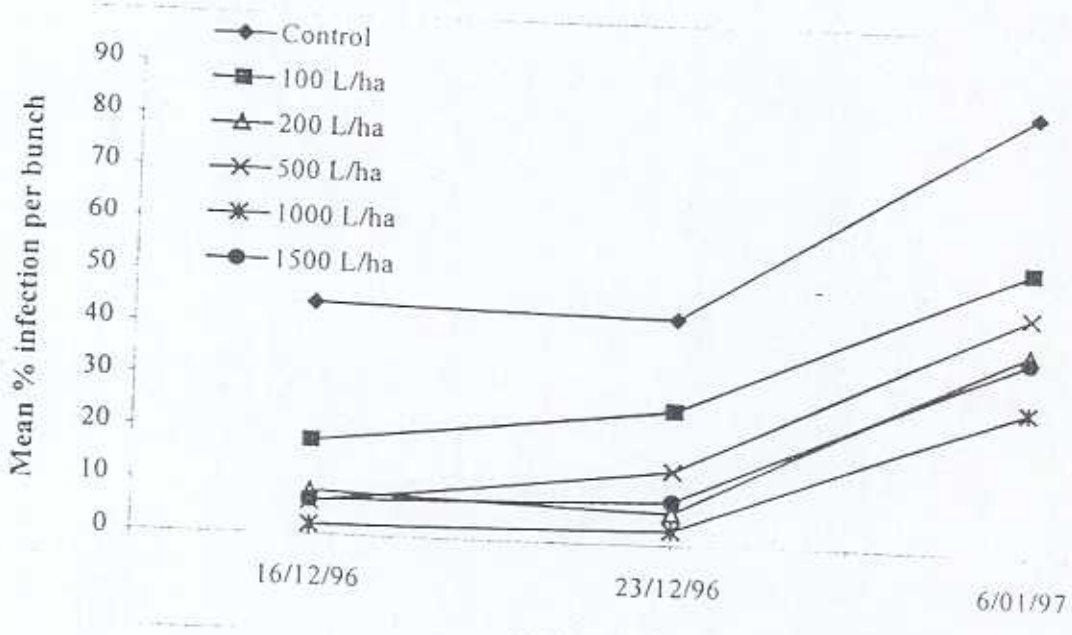


Figure 19 – Effects of increasing volumes of DCT Plus on the development of powdery mildew on Chardonnay bunches, Nuriootpa - December 16, 1996.

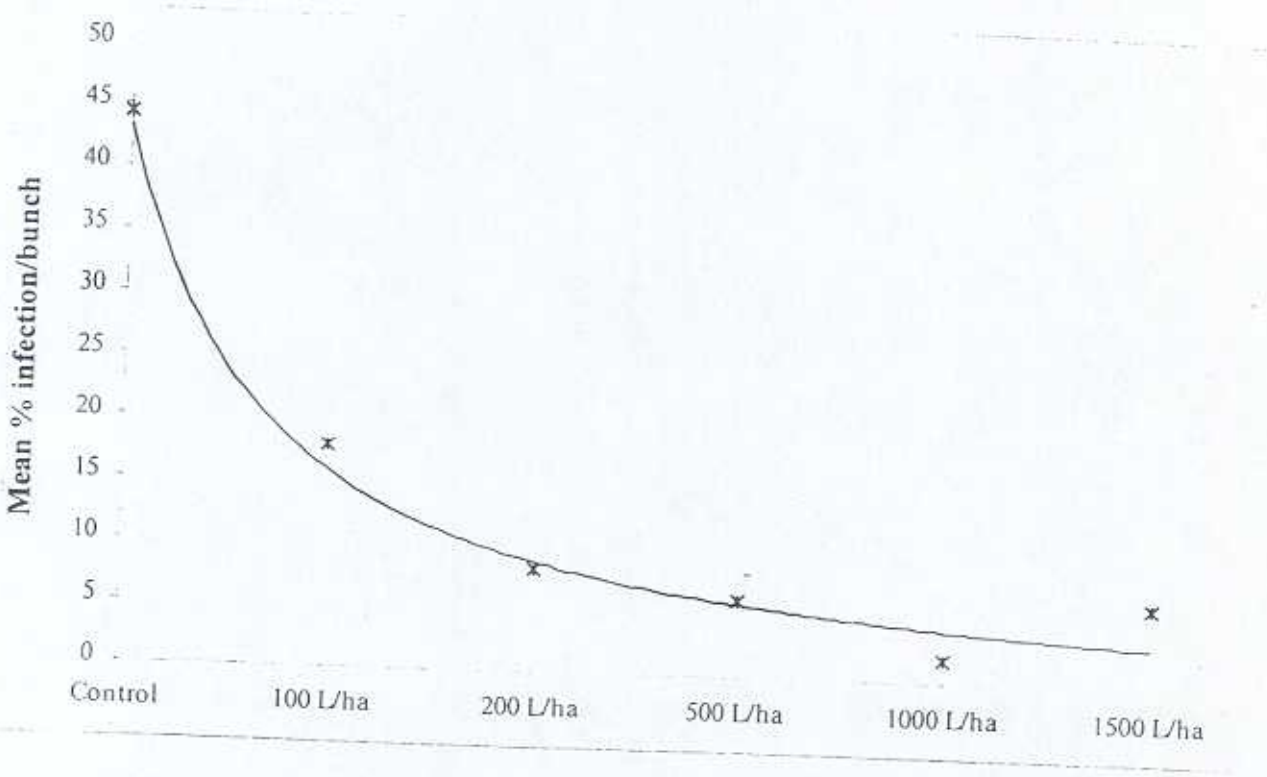
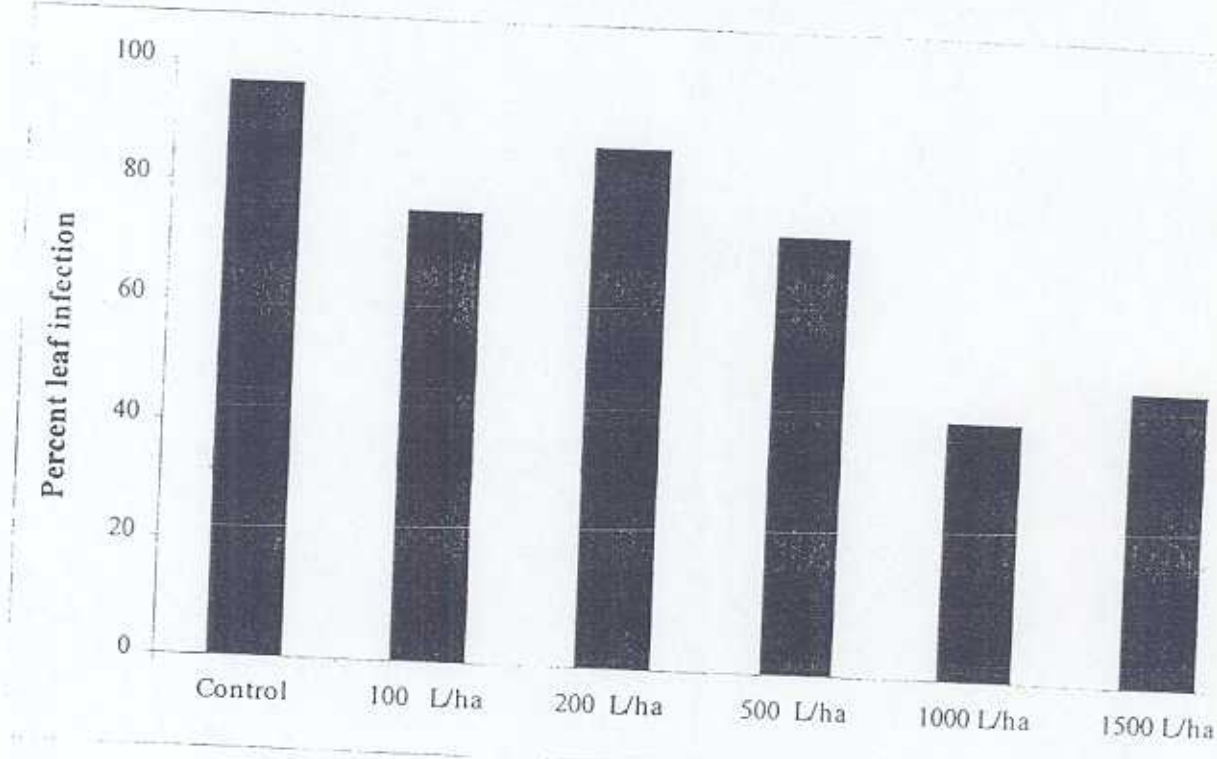


Figure 20 – Incidence (a) and severity (b) of powdery mildew on Chardonnay leaves treated with 1% DCT Plus at different spray volumes, Nuriootpa 1996.

Assessed: 16 December 1996.

(a) INCIDENCE



(b) SEVERITY

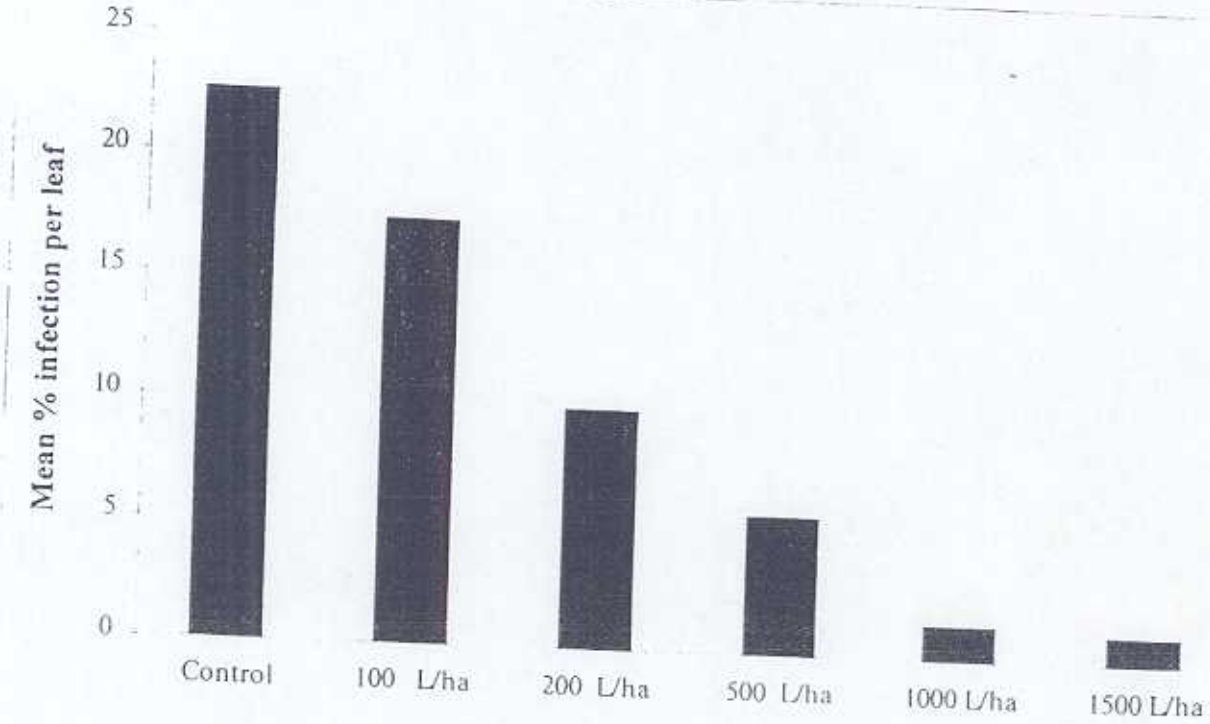
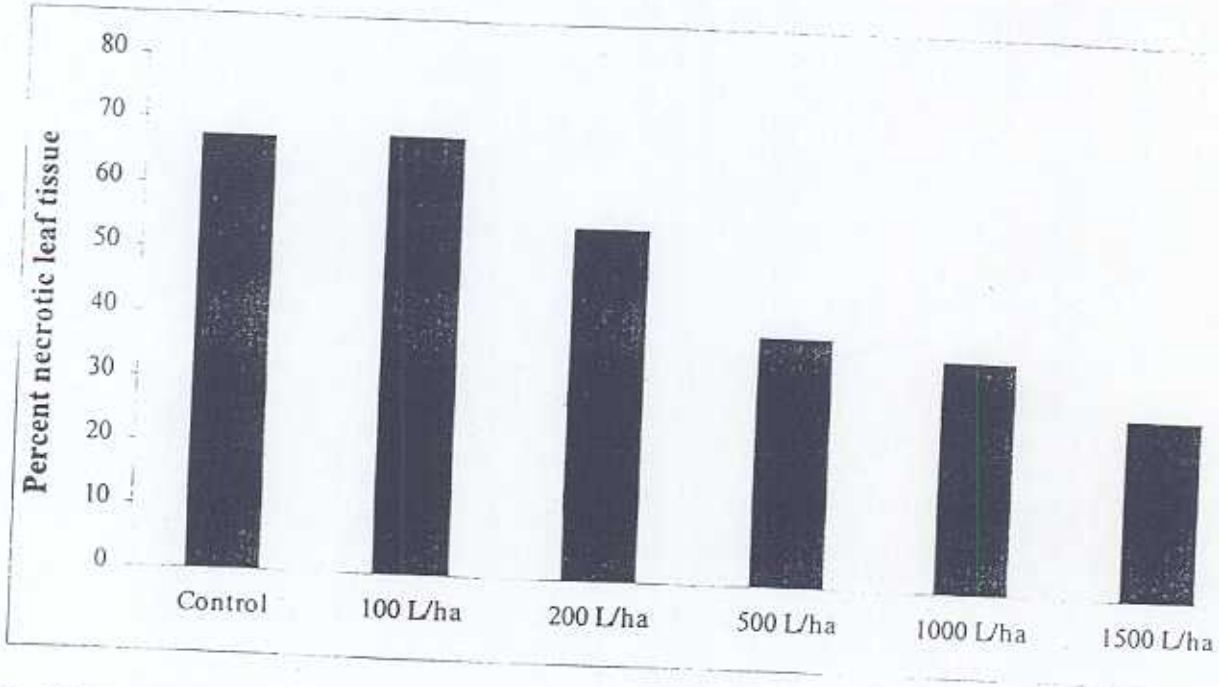


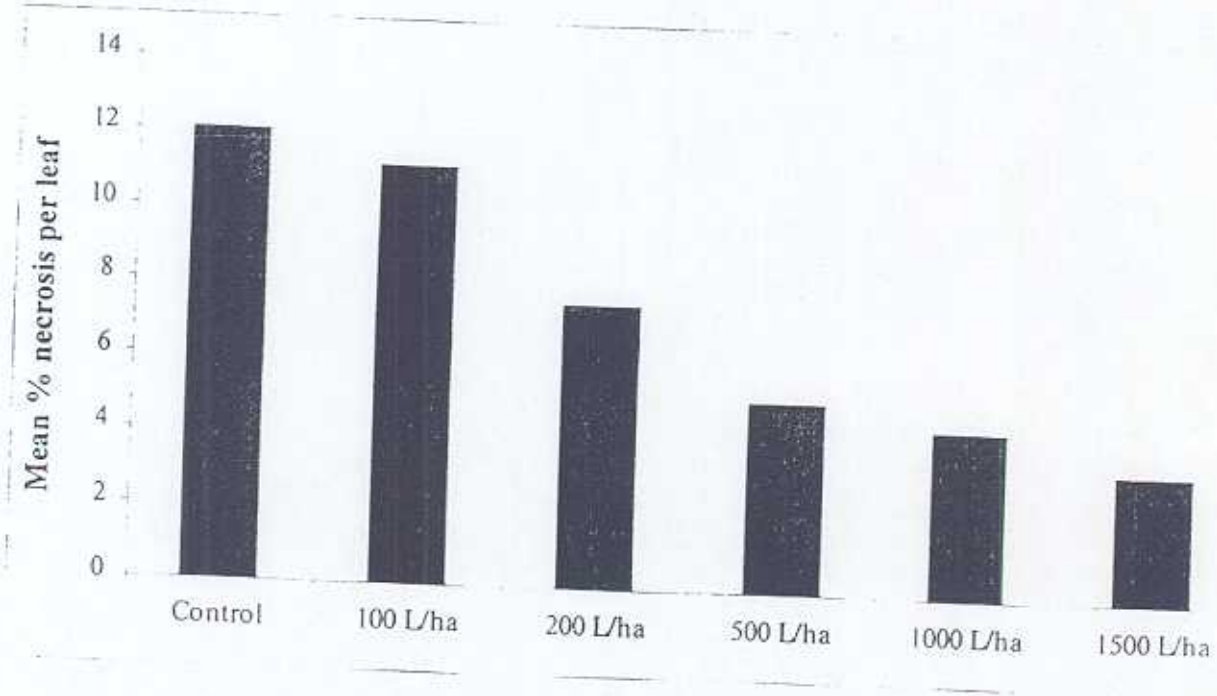
Figure 21 – Incidence (a) and severity (b) of necrotic leaf tissue on Chardonnay vines treated with 1% DCT Plus at different spray volumes, Nuriootpa 1996/97.

Assessed: March 5 1997.

(a) INCIDENCE



(b) SEVERITY



Methods:

Experiment 15

Mineral oil (1%) was applied to Chardonnay vines located at the Lenswood Research Centre using spray volumes of 500, 1000, 1500, and 2000 L/ha. Vines were sprayed on 10 occasions at intervals of 6 to 14 days between November 6 1997 and February 4 1998 (Appendix 10).

Plots consisted of 8 vines each replicated 4 times and arranged in a randomised block design with buffer rows separating treatment rows to minimise spray drift.

The incidence and severity of powdery mildew on 25 bunches per replicate was assessed on 5 occasions at 2 week intervals from December 2 1997 to February 2 1998. Powdery mildew infections, and phytotoxicity damage was assessed on 50 leaves per replicate at harvest. Leaf assessments involved analysing each side of the vine separately to determine any relationship between phytotoxicity damage and sunlight length.

In this experiment the effect of various rates of mineral oil on Light Brown Apple Moth (LBAM) was also tested. This was done by attaching LBAM egg masses each of approximately 50-100 eggs to the upper surface of leaves, which were then sprayed on two separate occasions. Once the oil was dry the egg masses were collected and placed onto a diet medium for three weeks. The number of larvae that hatched from the egg masses in each spray treatment was recorded.

Results and Discussion:

The level of powdery mildew on unsprayed bunches increased rapidly between December 2 1997 and January 2 1998, with incidence levels of 0 and 100% respectively. By the final assessment on February 2 1998 all treatment plots were heavily infected with mildew (Fig 22a). The severity of powdery mildew was influenced by spray volumes where rates of 500 and 2000 L/ha had a mean percent bunch infection of 73 and 16% respectively (Fig 22b).

Powdery mildew development on Chardonnay leaves followed the same trend as on bunches both the incidence and severity of powdery mildew increased with increasing spray volume (Fig 23).

Significant differences in bunch weight were present between bunches treated with oil at 1500 L/ha and untreated. Weights ranged from 50 g in untreated plots up to 81 g in plots treated at 1500 L/ha. Bunch weight was similar in all treated plots (Fig . 24).

Phytotoxicity on leaves was present in all treatments sprayed with 1% mineral oil. The incidence and severity of necrotic leaf tissue increased with spray volume, ranging in severity from 26 to 60% on vines sprayed with 500 and 2000 L/ha respectively (Fig 25).

The number of Light Brown Apple Moth larvae that hatched from egg masses sprayed with all rates of mineral oil was greatly reduced compared to untreated egg masses (Table 1). This result indicates that oil may have potential as a control measure for LBAM.

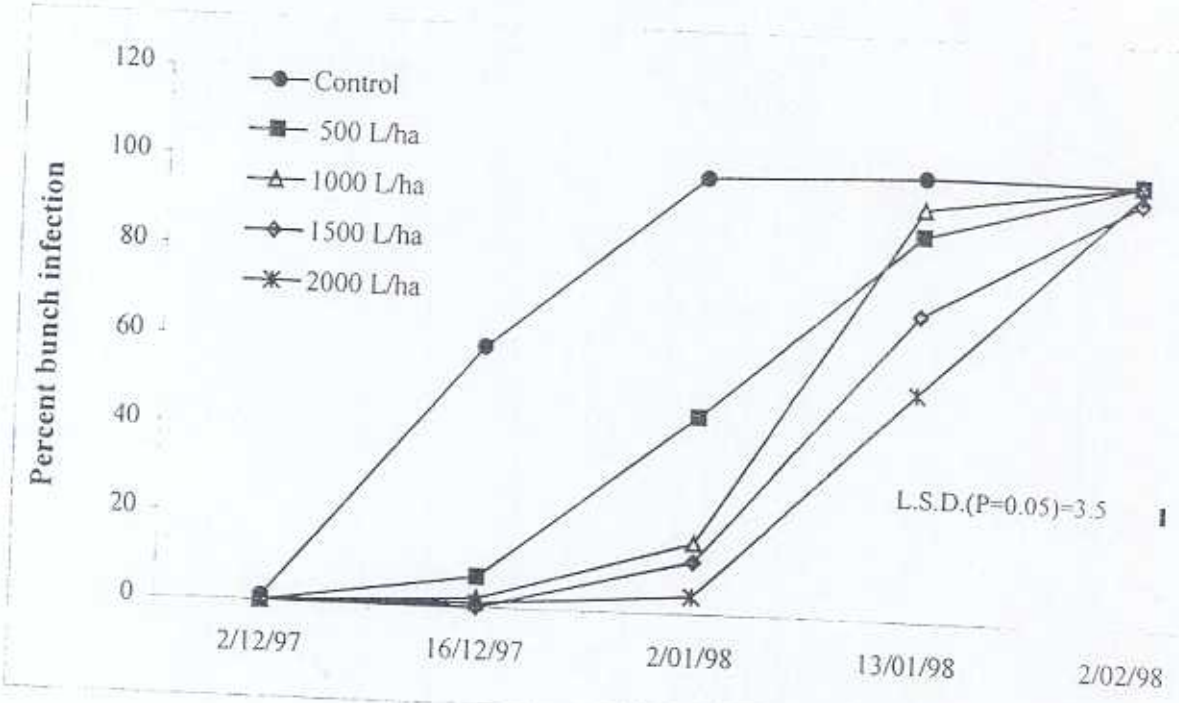
The results of this experiment and others focusing on spray volume show conclusively that spray volume is critical in the use of oils to control powdery mildew. From these studies it appears that spray volumes of at least 1000 L/ha are required for adequate control but there is a fine balance as spray volumes higher than this increase the likelihood of phytotoxicity from the oil when spray residues accumulate along the leaf margins.

Since this work was initiated, two overseas publications Northover and Schneider 1996, and Dell *et al* 1998 have reported on the efficacy of oils for the control of grape powdery mildew. The degree of control in these overseas reports was greater than we achieved but may be explained by the high volume of spray applied. For example in the report from California treated vines were sprayed by hand. In this case hand spraying may have provided good spray coverage on bunches, even those situated inside the canopy. With the report from Canada, disease incidence and severity is reported only on leaves and it is disappointing that none is presented on the degree of control on bunches.

Never the less their data supports that obtained in the South Australian experiments in that mineral oil provides excellent control of powdery mildew on sprayed leaves.

Figure 22 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches, Lenswood 1997/98.

(a) INCIDENCE



(b) SEVERITY

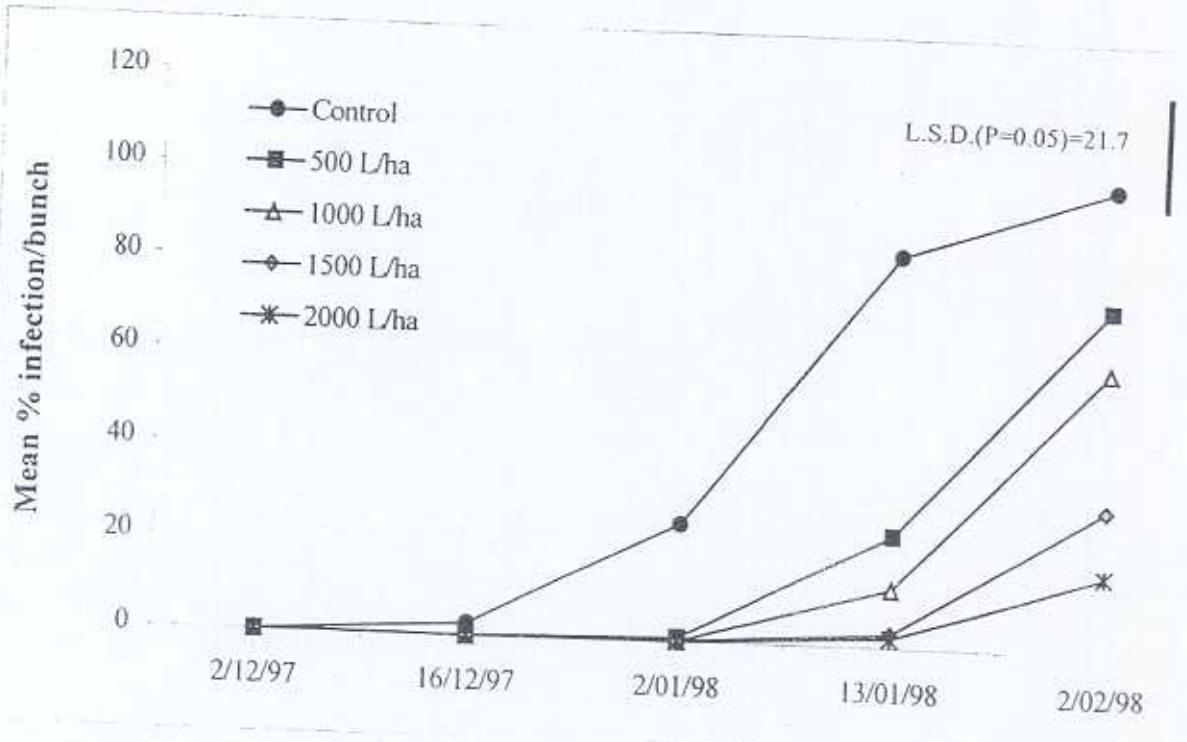
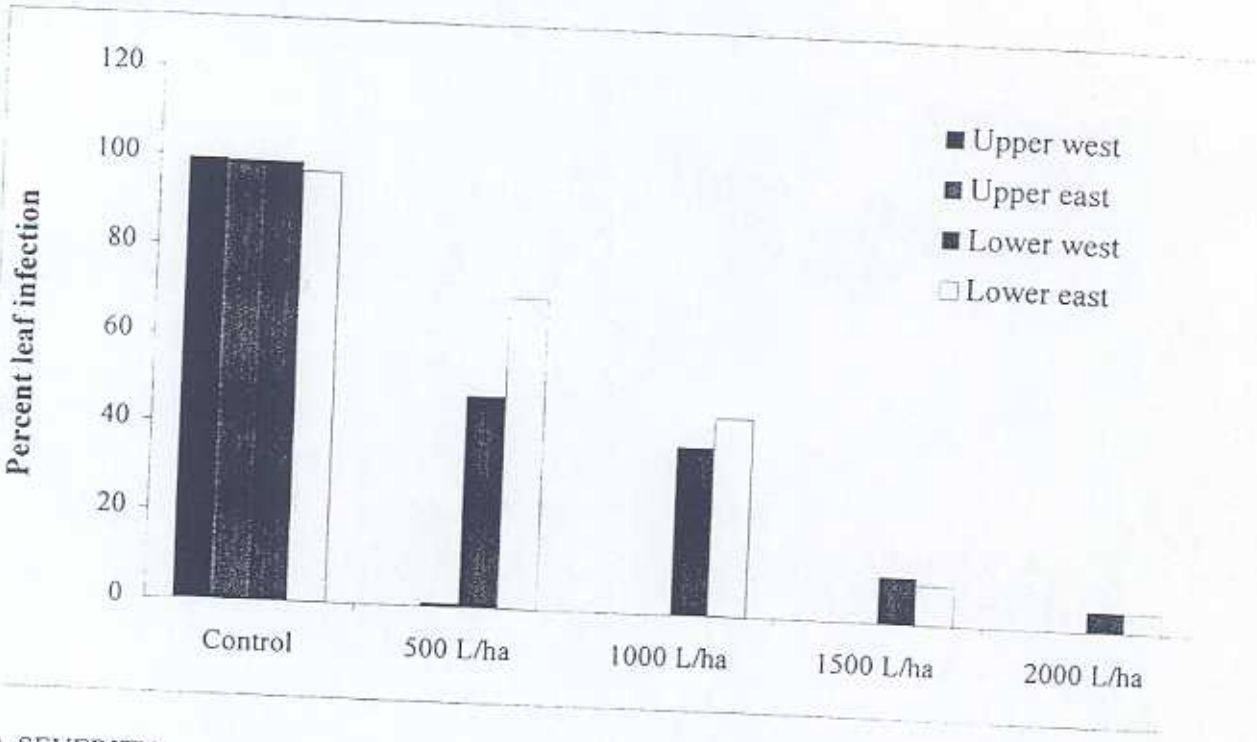


Figure 23 – Incidence (a) and severity (b) of powdery mildew on Chardonnay leaves, sprayed with various rates of mineral oil, Lenswood 1997/98.

Assessed 9th February 1998.

(a) INCIDENCE



(b) SEVERITY

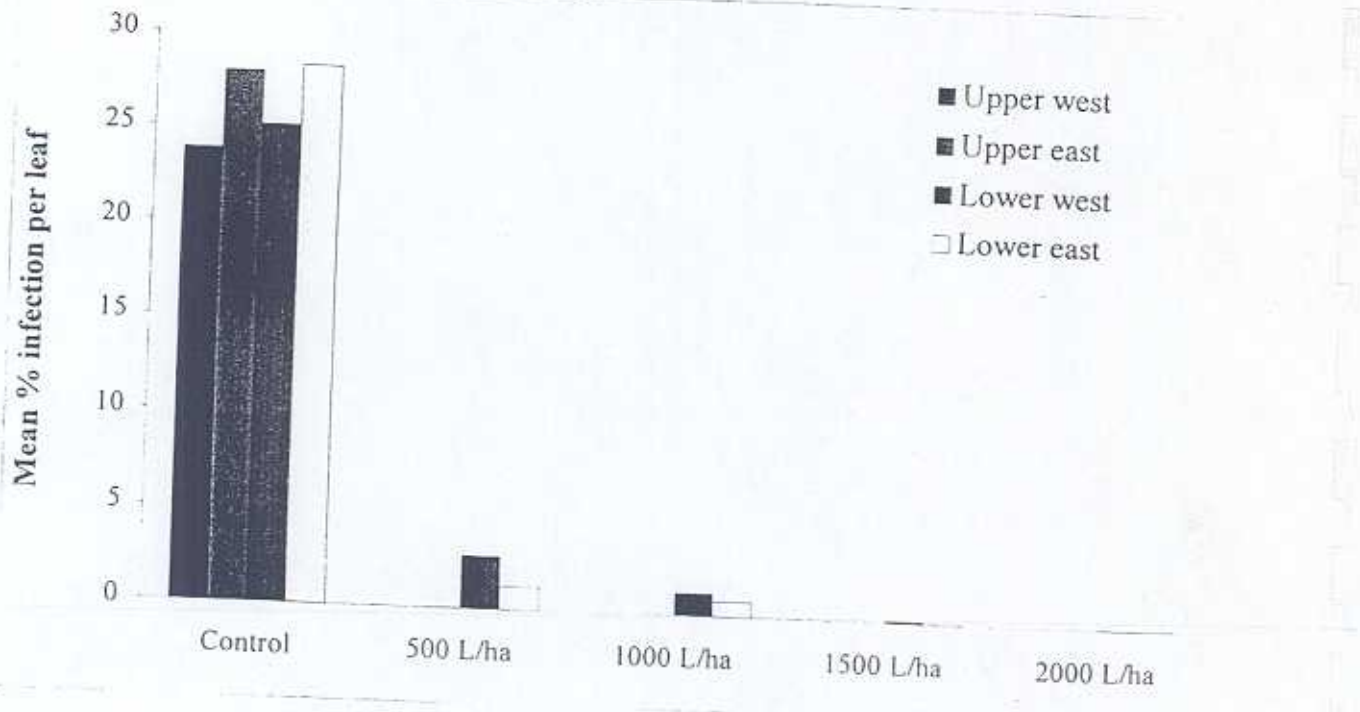


Figure 24 – Average weight of Chardonnay bunch at harvest treated with 1% mineral oil at different spray volumes, Lenswood 1997/98.

Assessed: 5th March 1998.

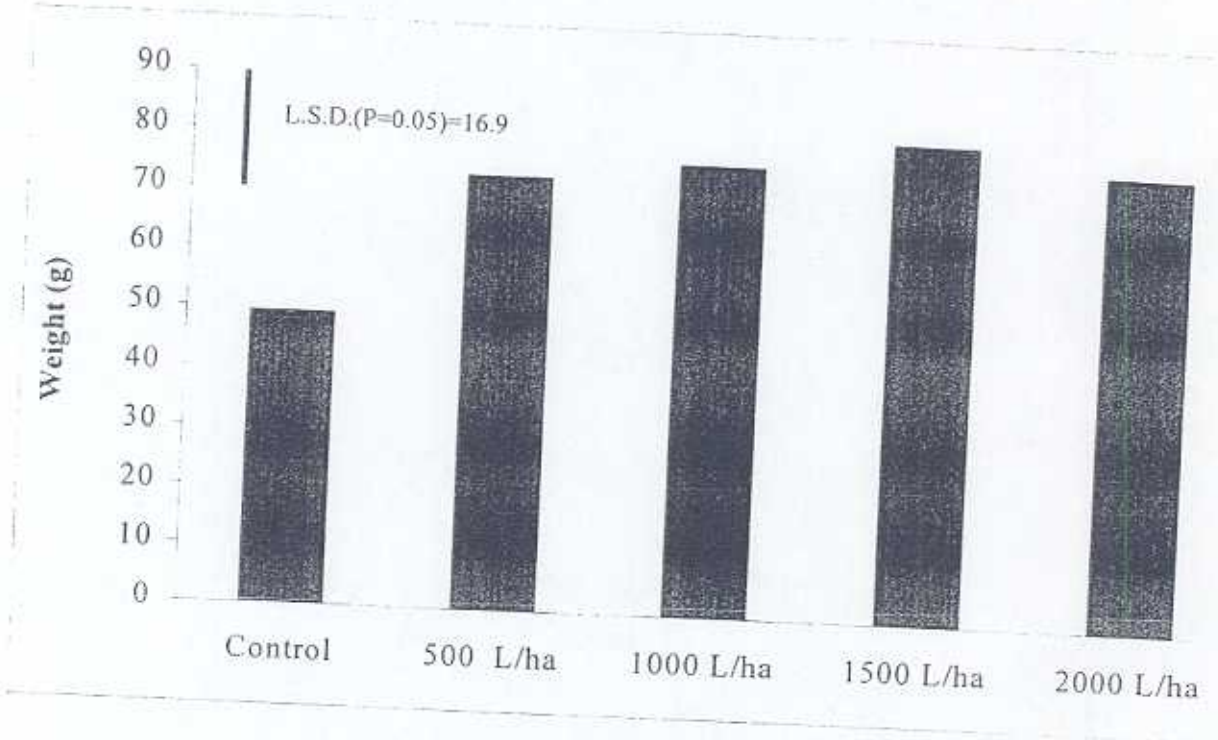
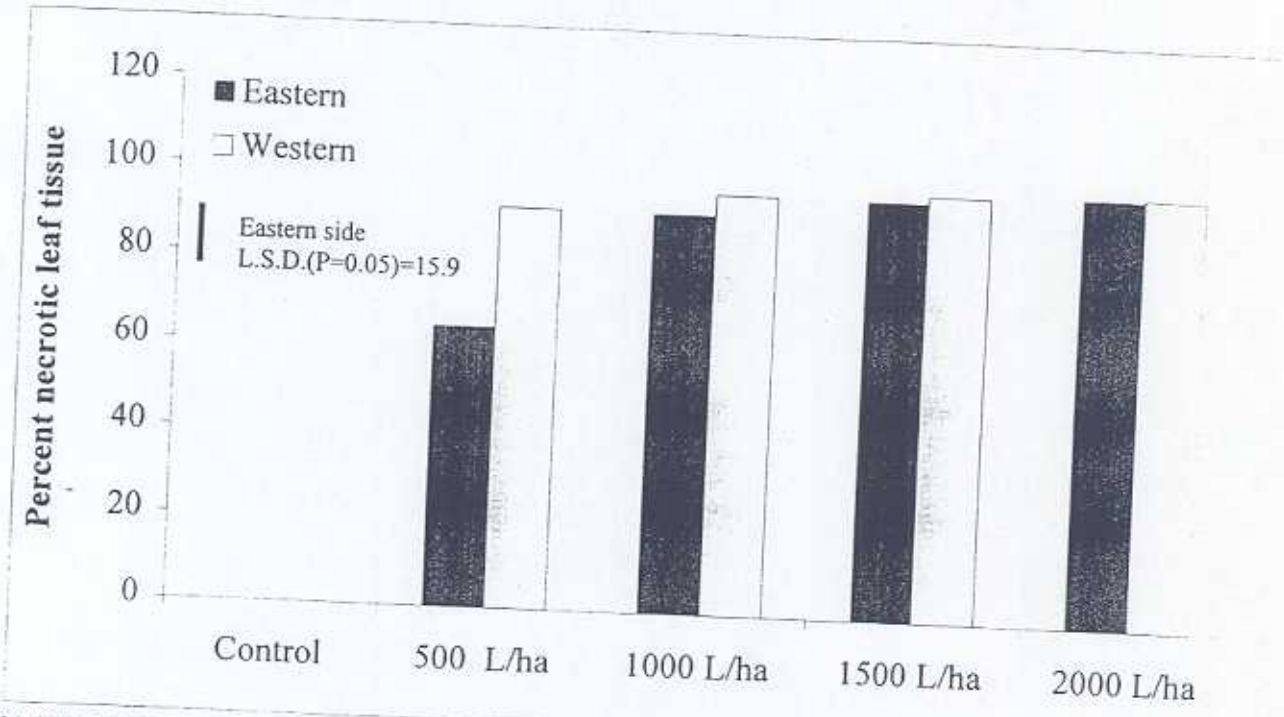


Figure 25 – Incidence (a) and severity (b) of necrosis on Chardonnay leaves sprayed with 1% mineral oil at different spray volumes, Lenswood 1997/98.

Assessed: 9th February 1998.

(a) INCIDENCE



(b) SEVERITY

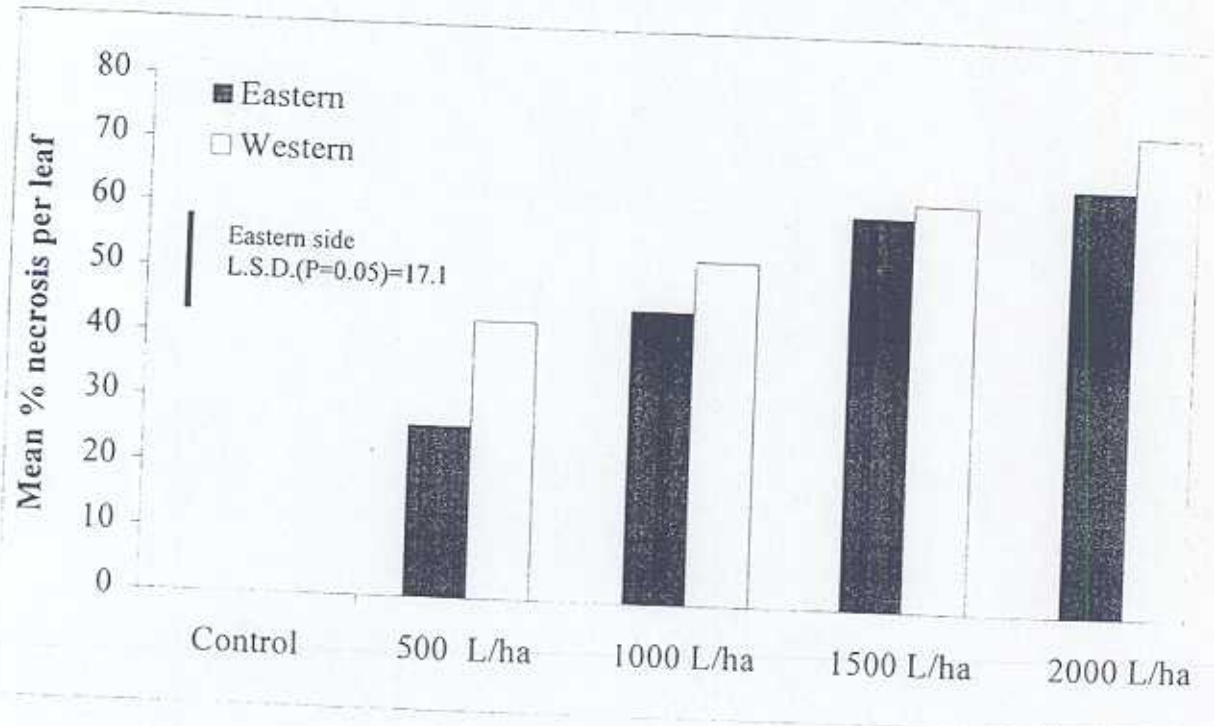


Table 1 – Effect of 1% mineral oil sprayed at various application rates on LBAM egg hatch, Lenswood 1997/98.

Oil Treatment	Experiment 1		Experiment 2	
	No. Egg Masses	No. Larvae	No. Egg Masses	No. Larvae
Control	20	79	20	180
500 L/ha	19	1	20	79
1000 L/ha	21	1	20	59
1500 L/ha	20	24	20	39
2000 L/ha	19	29	20	36

Experiment 1 – 3rd December 1997

Experiment 2 – 23rd January 1998

Assessed 3 weeks after treatment

Experiments 16 and 17

This experiment was conducted at the Nuriootpa Research Centre to compare the efficacy of DCT Plus and mineral oil applied at similar rates and spray volumes using either the Hydra experimental spray unit or a commercial airblast spray unit.

Methods:

Experiment 16

DCT Plus at 1% was applied to mature Chardonnay grapevines with the Hydra spray unit or a Hardi SPV direct nozzle airblast spray unit. Two rows consisting of 37 vines were sprayed with each spray unit with a buffer row separating the 2 treatments plots. Oil was applied on 6 occasions between November 15 1996 and January 16 1997 at intervals of 8 to 16 days (Appendix 11). The trial was not replicated to reduce the likelihood of drift.

The incidence and severity of powdery mildew on 25 bunches per row were assessed on 3 occasions from mid December 1996 to late January 1997. On January 7 1997, 100 bunches per row were harvested, weighed and assessed for powdery mildew, another 100 bunches were assessed for mildew on January 31 1997. The incidence and severity of powdery mildew was assessed on 25 leaves per row on December 17 1996.

Fluorescent dye was sprayed on 1 row by both spray units on January 15 1997. Twenty five leaves and bunches were harvested from 4 sites within the canopy; upper, inner, north side, and south side These were visually assessed under UV light to determine the level of spray coverage using a rating scale developed by Geoff Furness (Loxton Research Centre). Water sensitive papers were randomly placed in the vines at the same time to determine the spray penetrations of the two spray machines.

Results and Discussion:

The incidence and severity of powdery mildew on bunches increased rapidly between December 17 1996 and January 7 1997 (Fig. 26). By the final assessment there was no significant difference between the severity of disease in bunches sprayed by either unit.

Bunches sprayed by the Hardi unit had a significantly higher average weight than those untreated or treated with the Hydra sprayer (Fig. 27).

The incidence and severity of powdery mildew on leaves was slightly lower on those sprayed with the Hardi unit than the Hydra unit (Fig. 28), however this difference was not statistically significant.

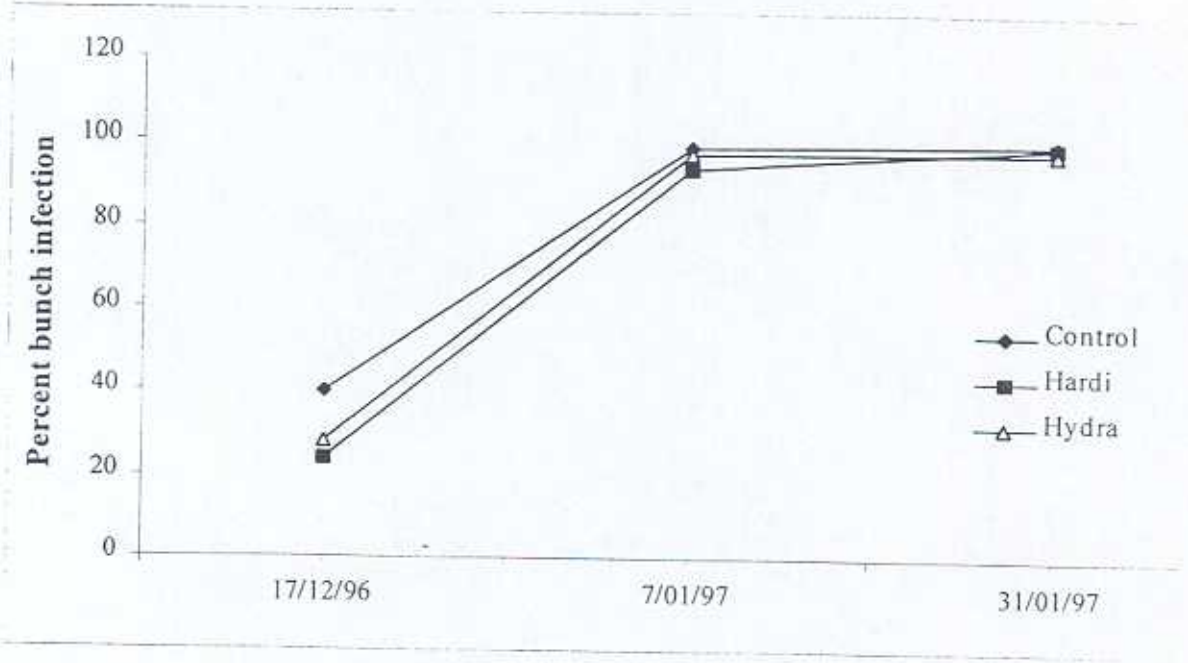
Fluorescent dye showed that the Hydra spray unit achieved 95% coverage on the outer portion of bunches as compared to 40% coverage by the Hardi spray unit (Fig. 29). Both units failed to cover the bunch completely as the berries on the unexposed side of the bunch received only 15% coverage by the Hydra and 2% by the Hardi. The Hydra spray unit produced greater coverage on the lower leaf surface than the Hardi (Fig. 30), particularly in the centre of the vine. Similar coverage of the upper leaf surface was achieved by both spray units however the Hydra had greater penetration of the inner canopy and the Hardi had higher coverage on the top of the canopy.

Using water sensitive paper the spray coverage produced by the Hardi sprayer in the outer canopy showed large droplet sizes and good coverage on the exposed half of the paper but limited deposits on the half facing the centre of the vine. The inner canopy received lighter coverage on both halves. The Hydra had finer deposits and better coverage of both sides of the paper but, as with the Hardi sprayer, less deposits in the inner canopy.

Previous results have indicated that with oil sprays, improved coverage increases the control of powdery mildew, however in this trial the better spray coverage produced by the Hydra sprayer compared to the Hardi sprayer did not significantly improve control. A possible explanation for this may relate to the larger droplet size produced by the Hardi unit. Laboratory experiments conducted in 1996 found that powdery mildew mycelium on leaves were flattened by the large droplets of oil suspension. The fine droplets sprayed by the Hydra may have been too small to flatten mycelial growth, therefore levels of infection were not reduced.

Figure 26 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches treated with the Hardi spray unit or with the Hydra spray unit, Nuriootpa 1996/97.

(a) INCIDENCE



(b) SEVERITY

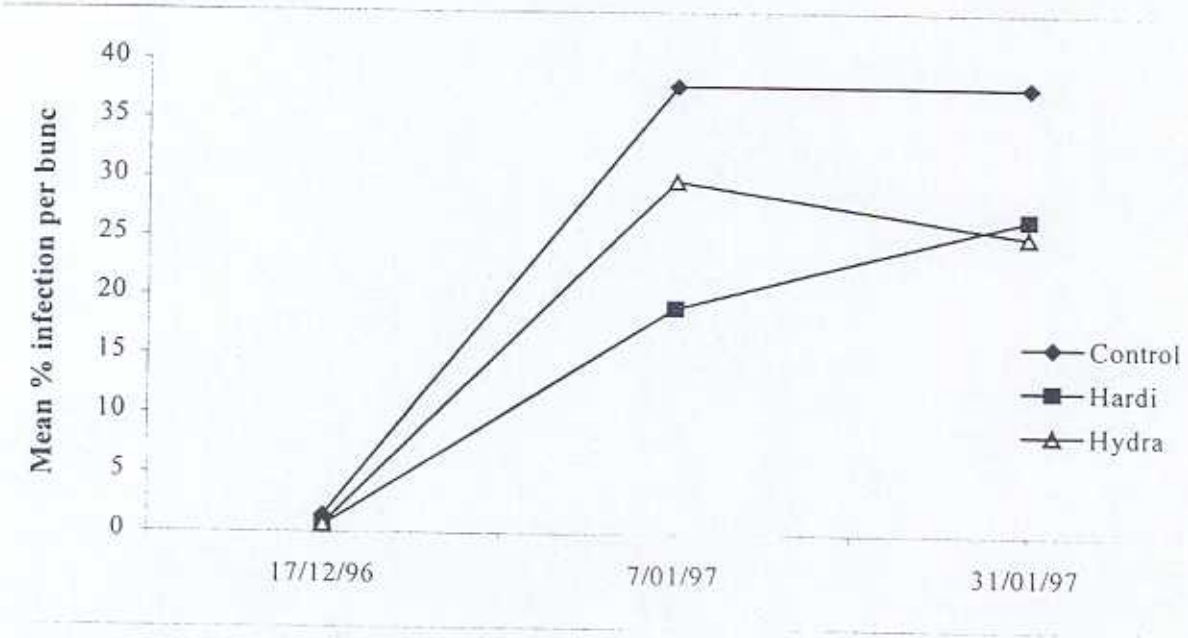


Figure 27 – Average weight of Chardonnay bunches, Nuriootpa 1996/97.

Assessed January 7 1997.

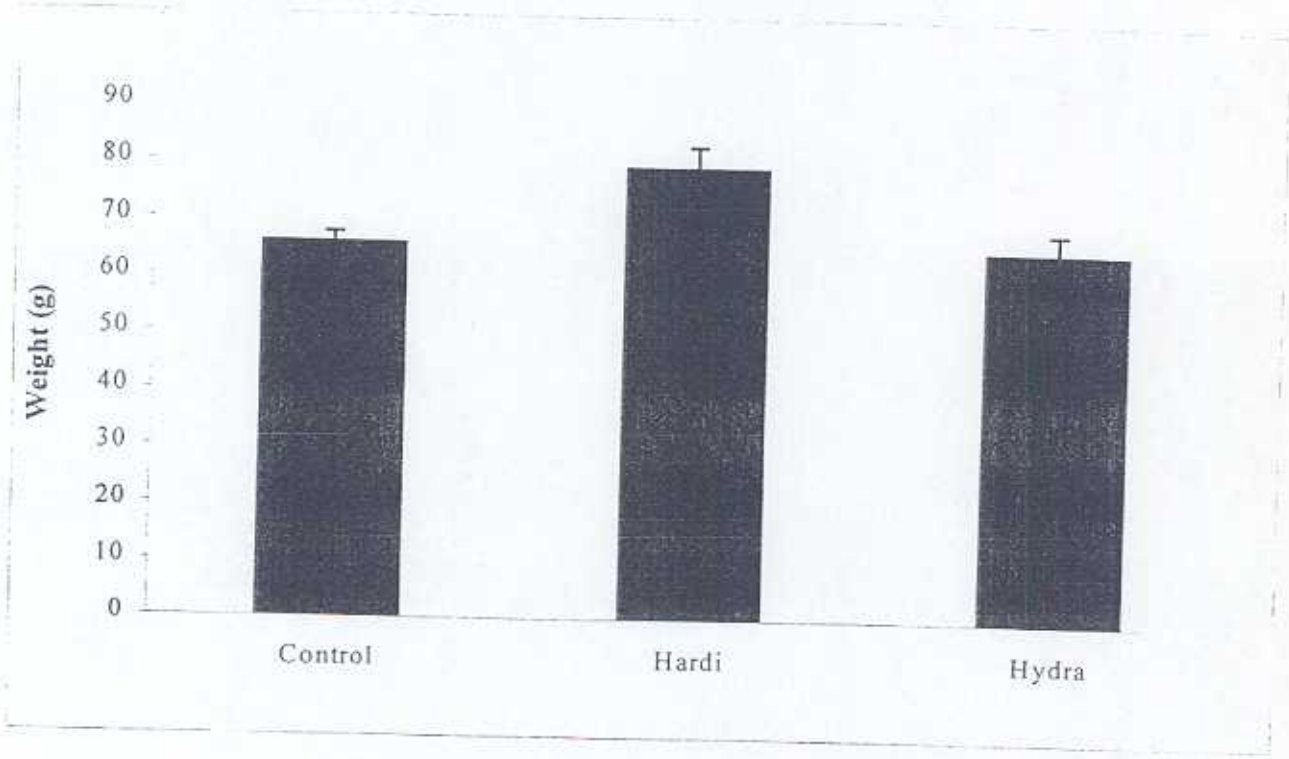
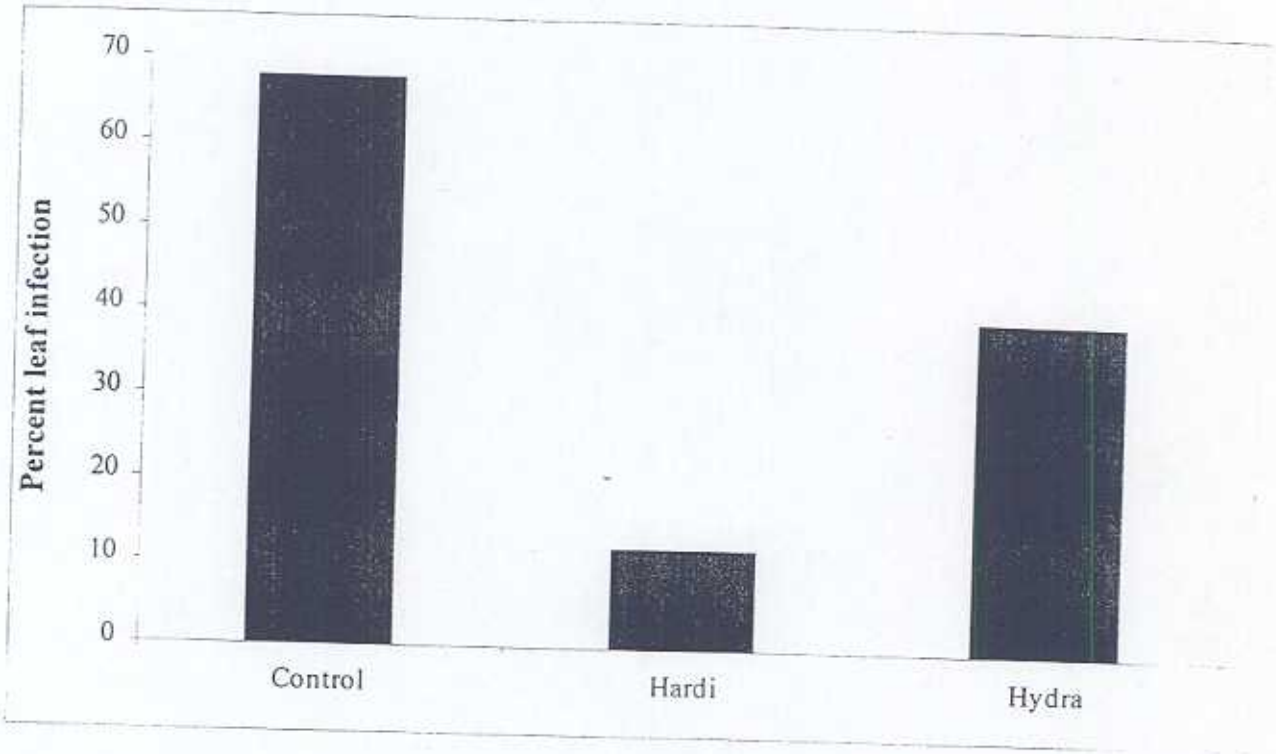


Figure 28 – Incidence (a) and severity (b) of powdery mildew on Chardonnay leaves sprayed with the Hardi spray unit or the Hydra spray unit, Nuriootpa 1996/97.

Assessed : December 17 1996.

(a) INCIDENCE



(b) SEVERITY

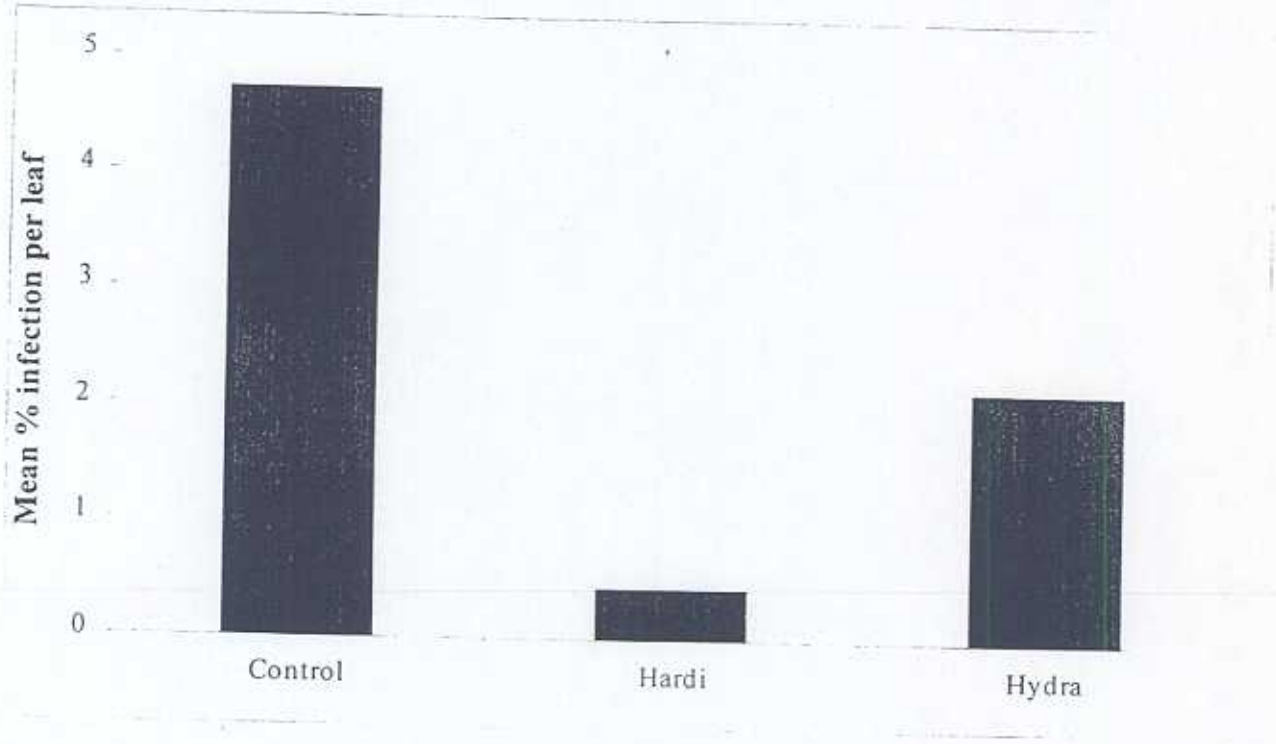


Figure 29 – Visual assessment of fluorescent dye coverage on Chardonnay bunches.

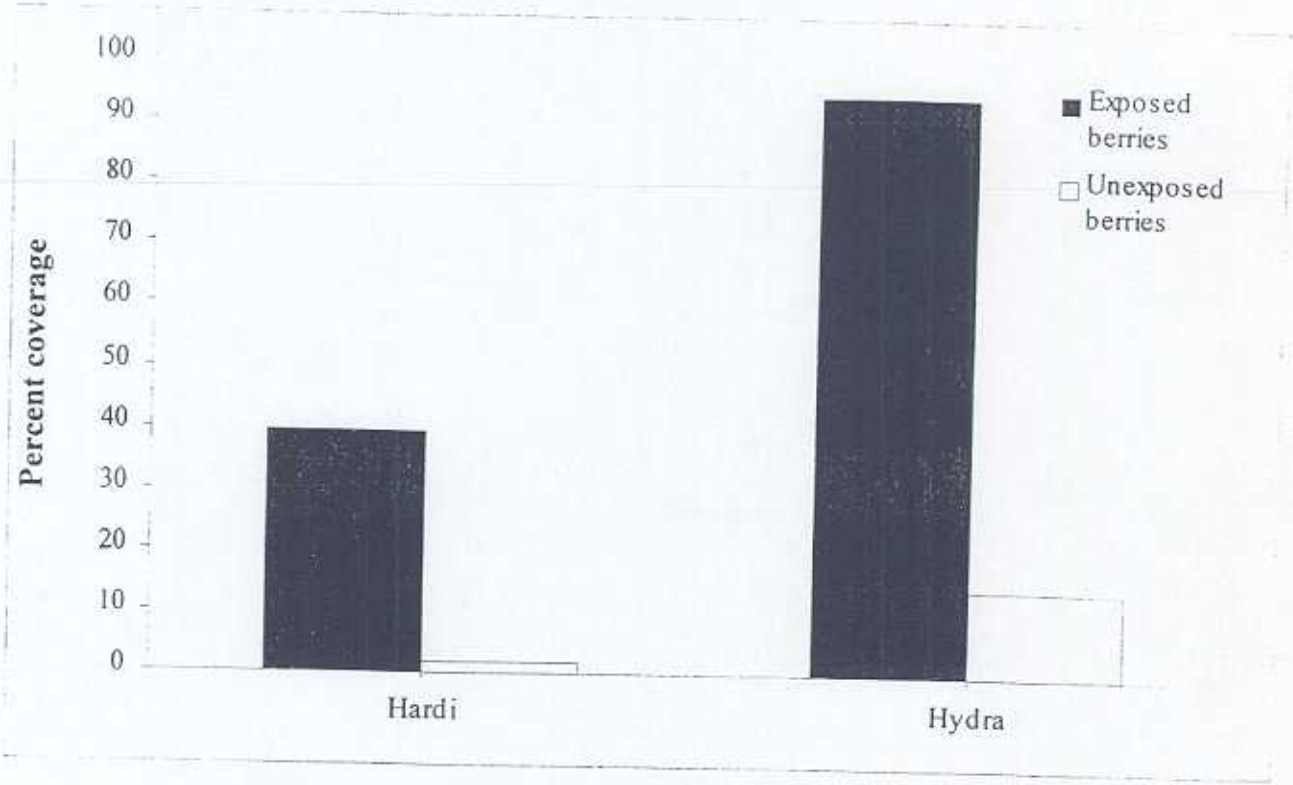
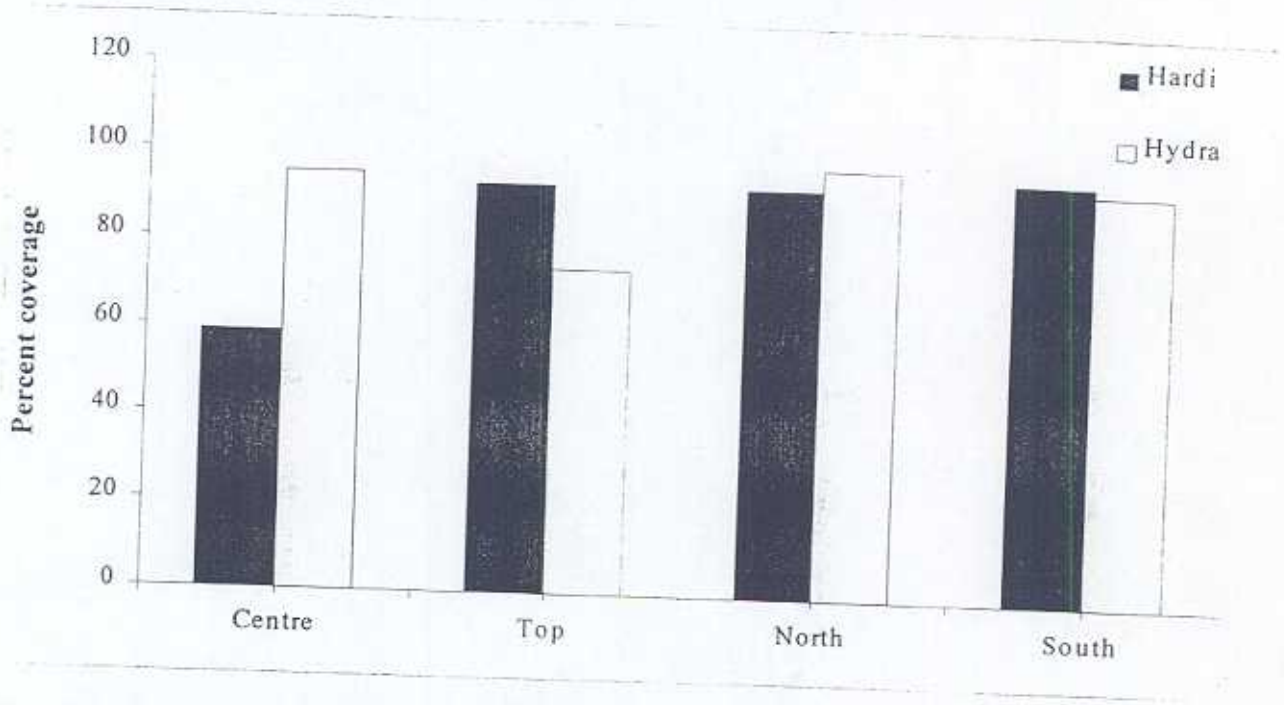
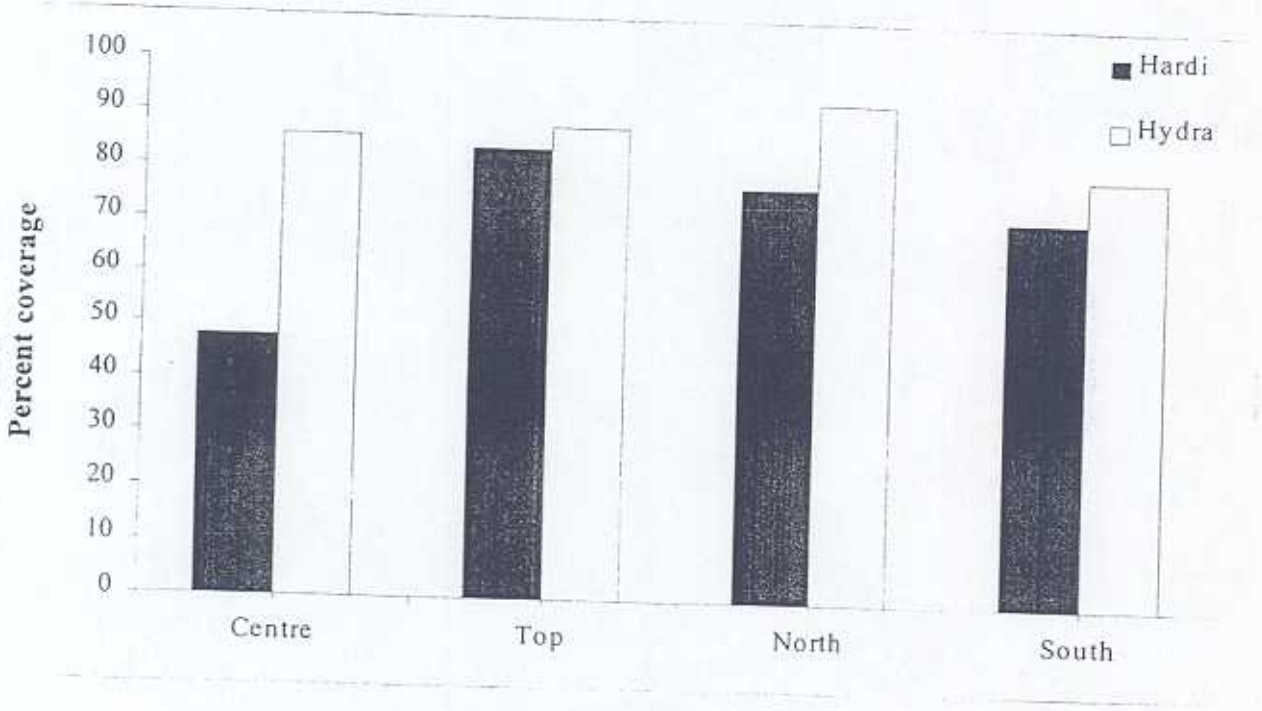


Figure 30 – Visual assessment of fluorescent dye coverage on Chardonnay leaves.

Upper leaf surface



Lower leaf surface



Methods:

Experiment 17

Mineral oil at 1% was applied to mature Chardonnay grapevines with the Hydra spray unit or a Hardi SPV direct nozzle airblast spray unit. The oil was applied on 10 occasions between October 29 1997 and January 9 1998 at intervals of 7 to 13 days (Appendix 12).

The incidence and severity of powdery mildew on bunches was assessed on 4 occasions at 2 week intervals from December 17 1997.

Fluorescent dye was sprayed on 1 row of Chardonnay vines by both spray units on February 12 1998. Twenty five leaves and 10 bunches were harvested from 5 sites within the canopy; north, south, centre, top north, and top south. These were visually assessed under UV light to determine the level of spray coverage using a rating scale developed by Geoff Furness. Water sensitive papers were randomly placed in the vines at the same time to determine the spray penetrations of the two spray machines.

Results and Discussion:

Powdery mildew incidence on bunches increased steadily between December 17 1997 and February 6 1998 (Fig 31). However the variation in the incidence of powdery mildew was so great that no significant differences were detected between treatments. At the final assessment the severity of the disease was significantly less on bunches sprayed with the Hydra unit compared to the Hardi unit.

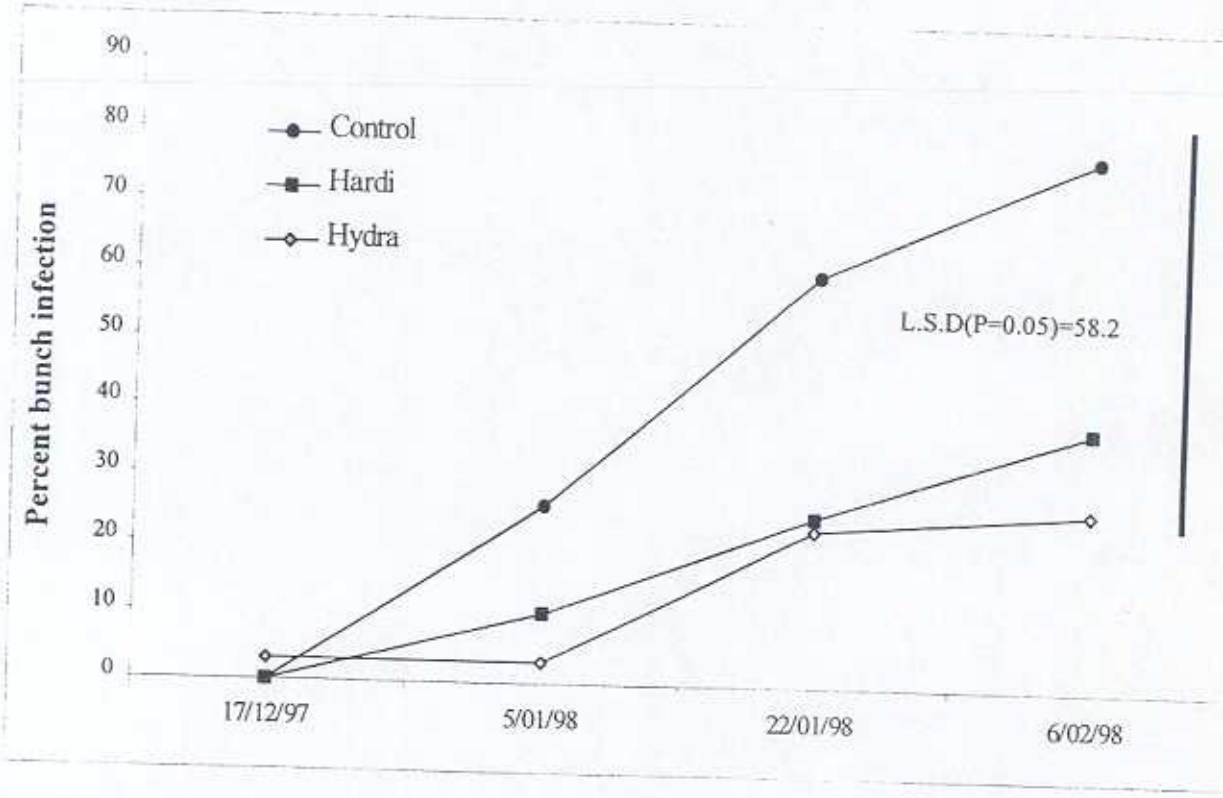
The Hydra spray unit produced greater coverage on the lower leaf surface than the Hardi spray unit (Fig 32), particularly in the centre of the vine. Similar coverage of the upper leaf surface was achieved by both spray units however the Hydra had greater penetration in all areas of the canopy. Fluorescent dye coverage showed that the Hydra spray unit achieved 100% coverage on bunches located inside the canopy compared to 82% coverage by the Hardi spray unit (Fig 33).

The spray coverage by the Hardi spray unit on water sensitive paper on the inner canopy showed large droplet size and good coverage. The Hydra spray unit provided excellent coverage to the inner canopy, due to the finer deposits produced by this machine.

Spraying at volumes of 1000 L/ha favours the complete coverage of grapevines. This was demonstrated by the hydra spray unit where almost all sprayed leaves and bunches had 100% coverage of spray with fluorescent dye.

Figure 31 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches, Nuriootpa 1997/98.

(a) INCIDENCE



(b) SEVERITY

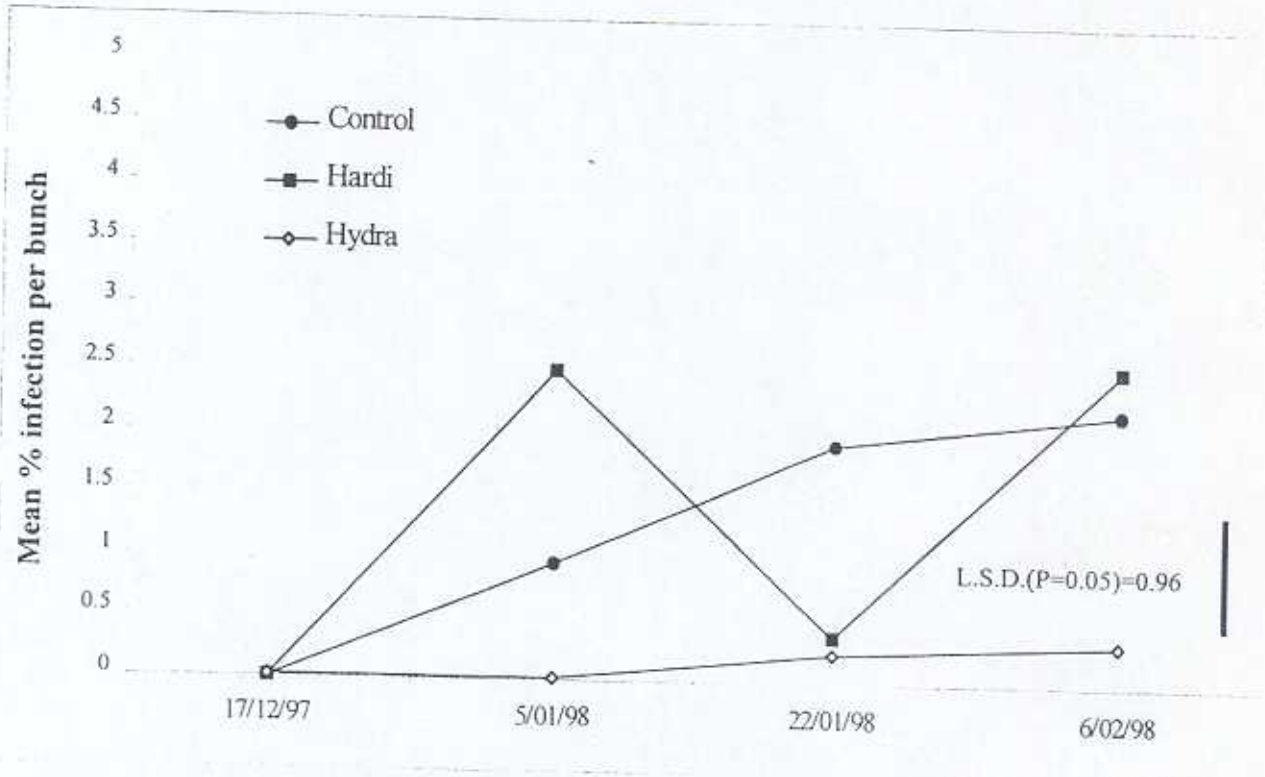
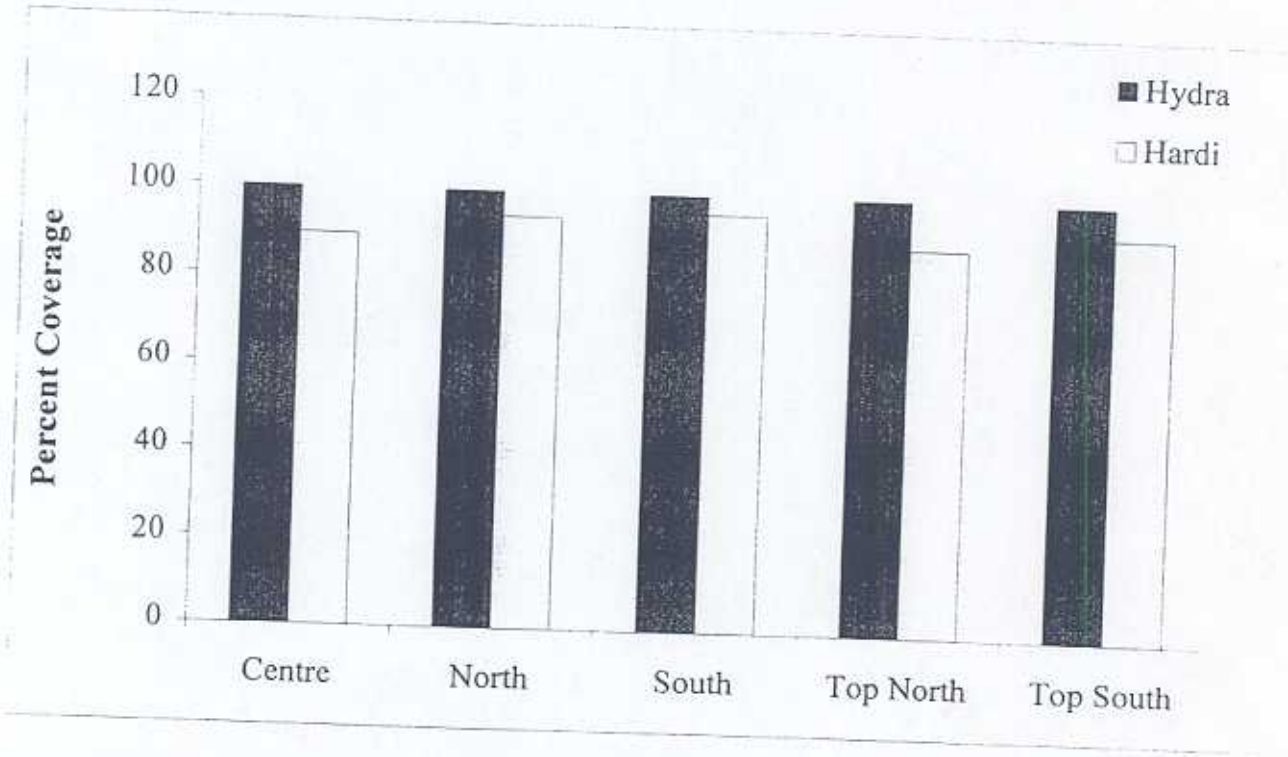


Figure 32 – Visual assessment of fluorescent dye coverage on Chardonnay leaves, Nuriootpa 1997/98.

Assessed: 13th February 1998.

Upper leaf surface



Lower leaf surface

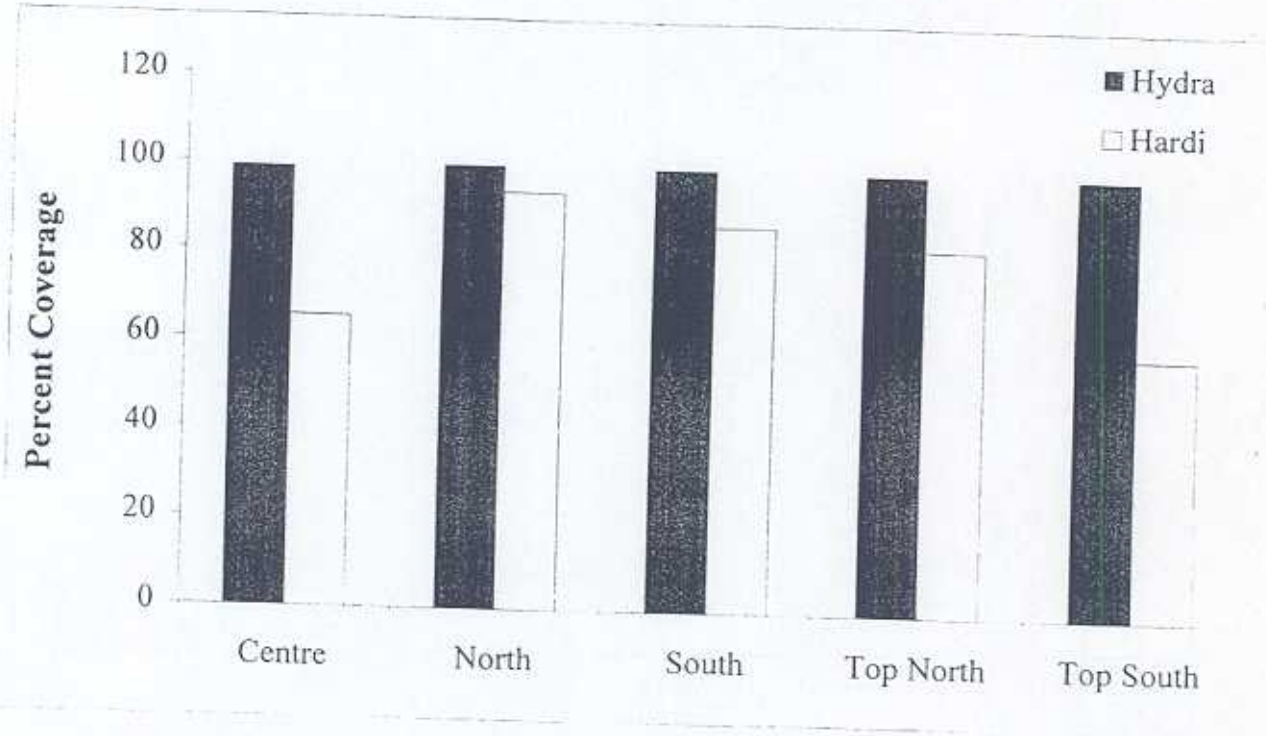
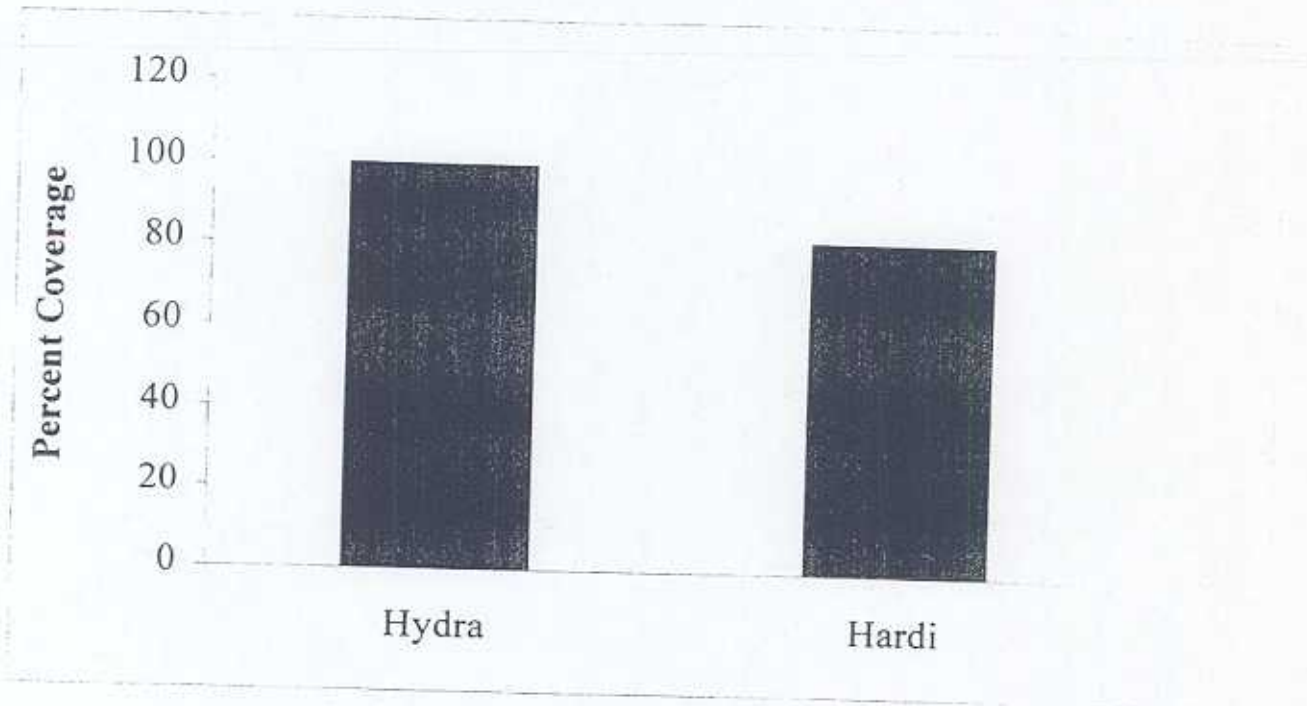


Figure 33 – Visual assessment of fluorescent dye coverage on Chardonnay bunches, Nuriootpa 1997/98.

Assessed: 13th February 1998.



Experiment 18

The efficacy of various DMI fungicides and oils for the control of powdery mildew were evaluated on young Chardonnay vines located at the Lenswood Research Centre.

Methods:

Bayfidan, Rubigan, Topas, Citrole oil (1%) and mineral oil (1%) were sprayed to the point of run off on 5 year old Chardonnay vines. A Solo motorised backpack spray unit was used to apply sprays on 7 occasions at volumes of 229 to 781 L/ha from November 6 1997 (Appendix 13). The treatments were arranged in a randomised block of 5 reps each containing 8 vines.

The incidence and severity of powdery mildew on bunches was assessed 5 times at 2 week intervals between December 2 1997 and February 10 1998. Powdery mildew levels and phytotoxicity damage on leaves was assessed once on March 6 1998.

Results and Discussion

Powdery mildew was first detected in Chardonnay vines on December 16, 1997 and from then it spread rapidly with more than 80% of untreated bunches being infected by late January (Fig 34a). Topas and Bayfidan provided significantly better control of powdery mildew on bunches, with 0 and 2.4% infected respectively, at the final assessment.

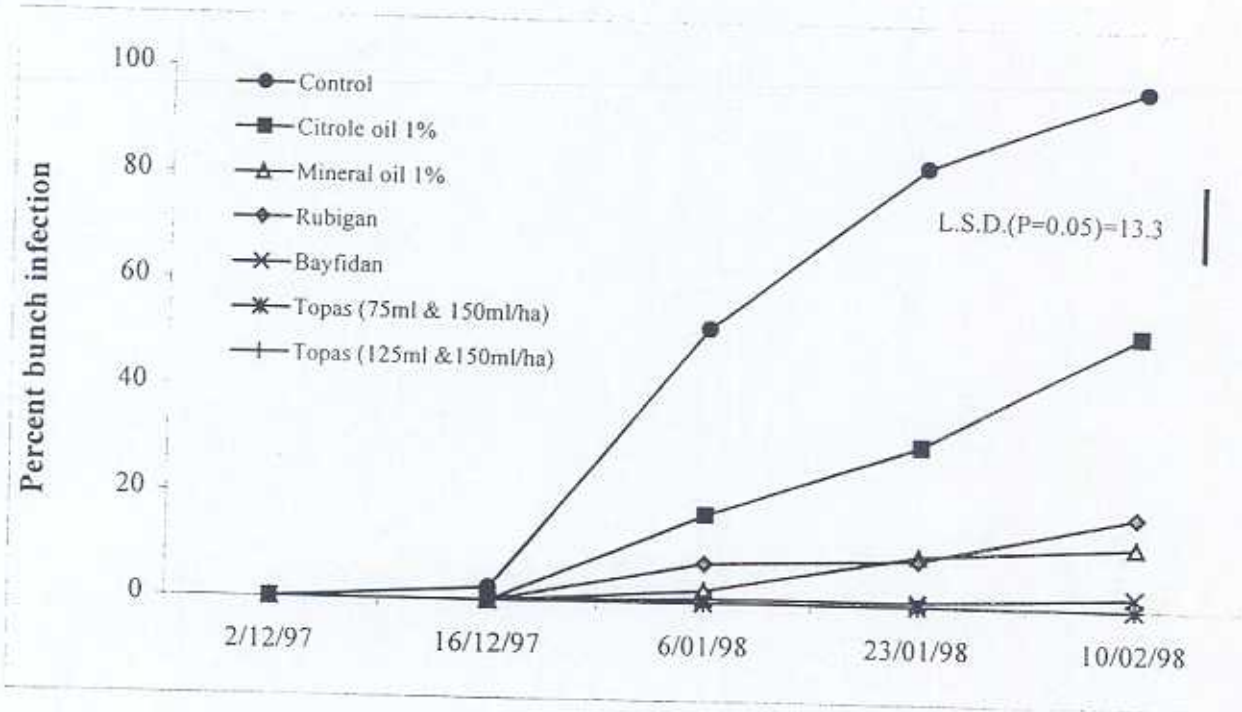
The severity of powdery mildew on bunches remained low in the sprayed treatments during the season. At harvest there was a significant difference in the severity of powdery mildew between spray treatments and the control (Fig 34b).

Powdery mildew was assessed on leaves at harvest, four weeks after the final spray application. Powdery mildew was predominant on the upper surface of the leaves, with 92% of the untreated leaves infected. Severity remained low in all treatments with a maximum rating of 10 on untreated leaves (Fig 35).

Necrotic leaf tissue was detected in all spray treatments. Phytotoxic damage was severe only in grapevines treated with mineral oil with an incidence of 76% and a mean percent leaf infection of 42 (Fig 36).

Figure 34 – Incidence (a) and severity (b) of powdery mildew on Chardonnay bunches, Lenswood 1997/98.

(a) INCIDENCE



(b) SEVERITY

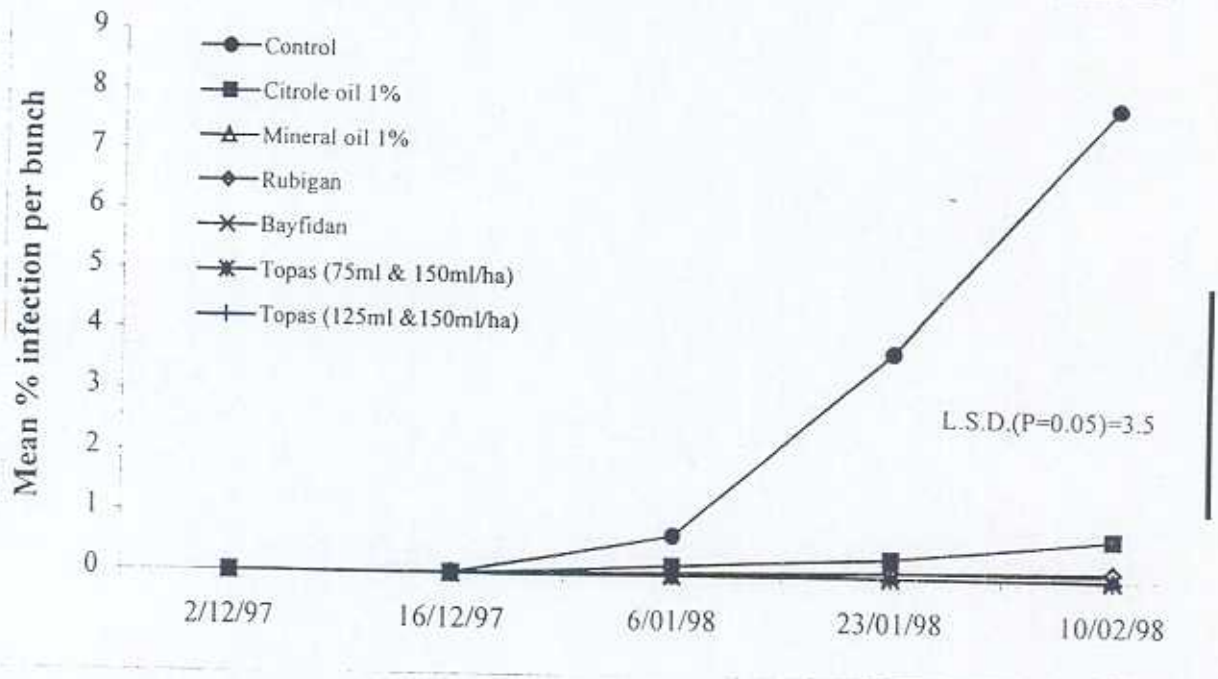
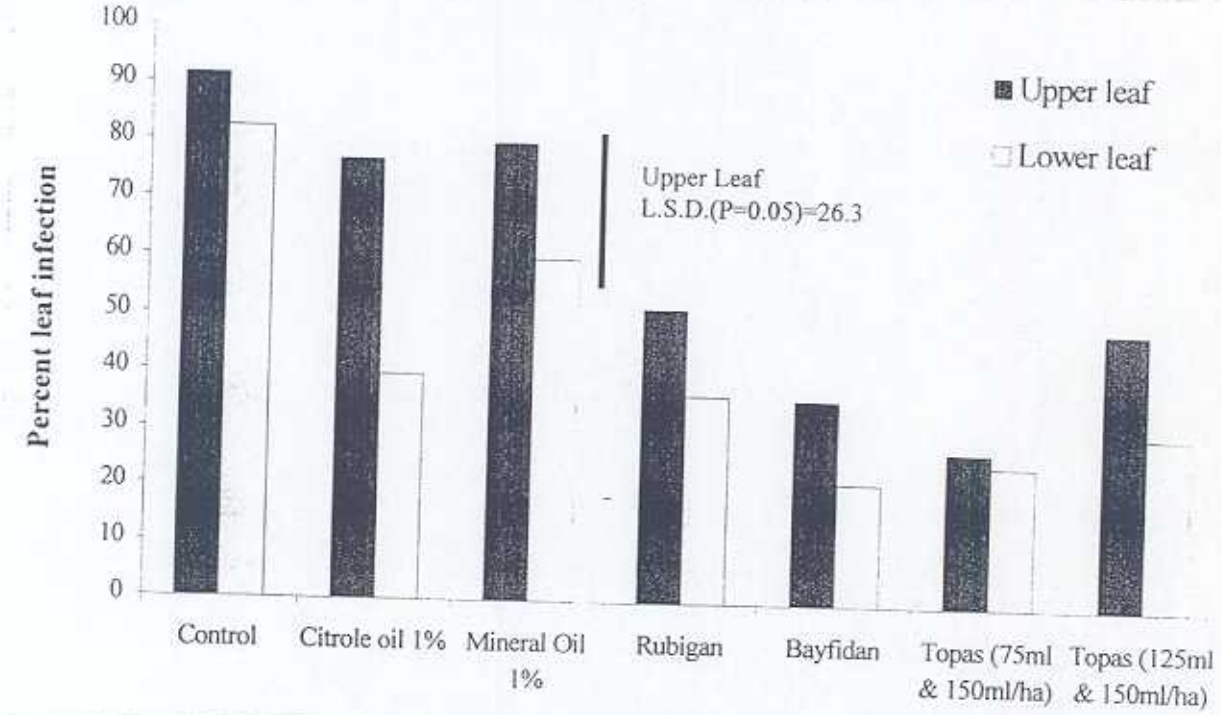


Figure 35 – Incidence (a) and severity (b) of powdery mildew on Chardonnay leaves, Lenswood.

Assessed: 6th March 1998.

(a) INCIDENCE



(b) SEVERITY

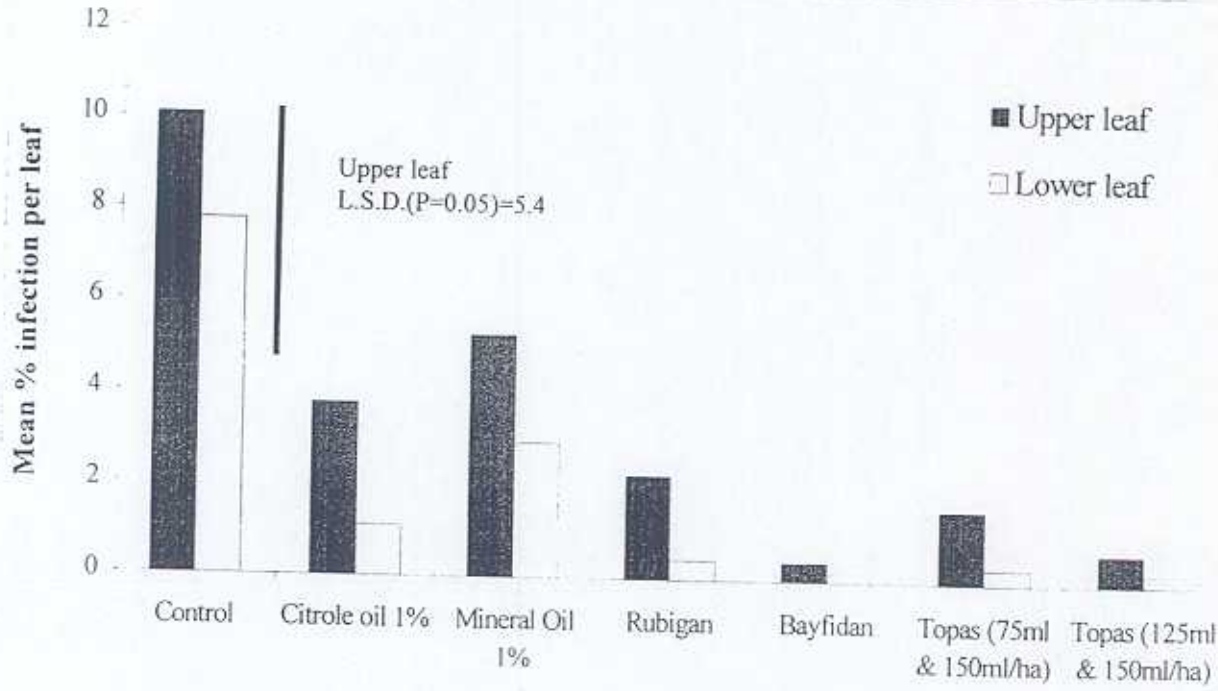
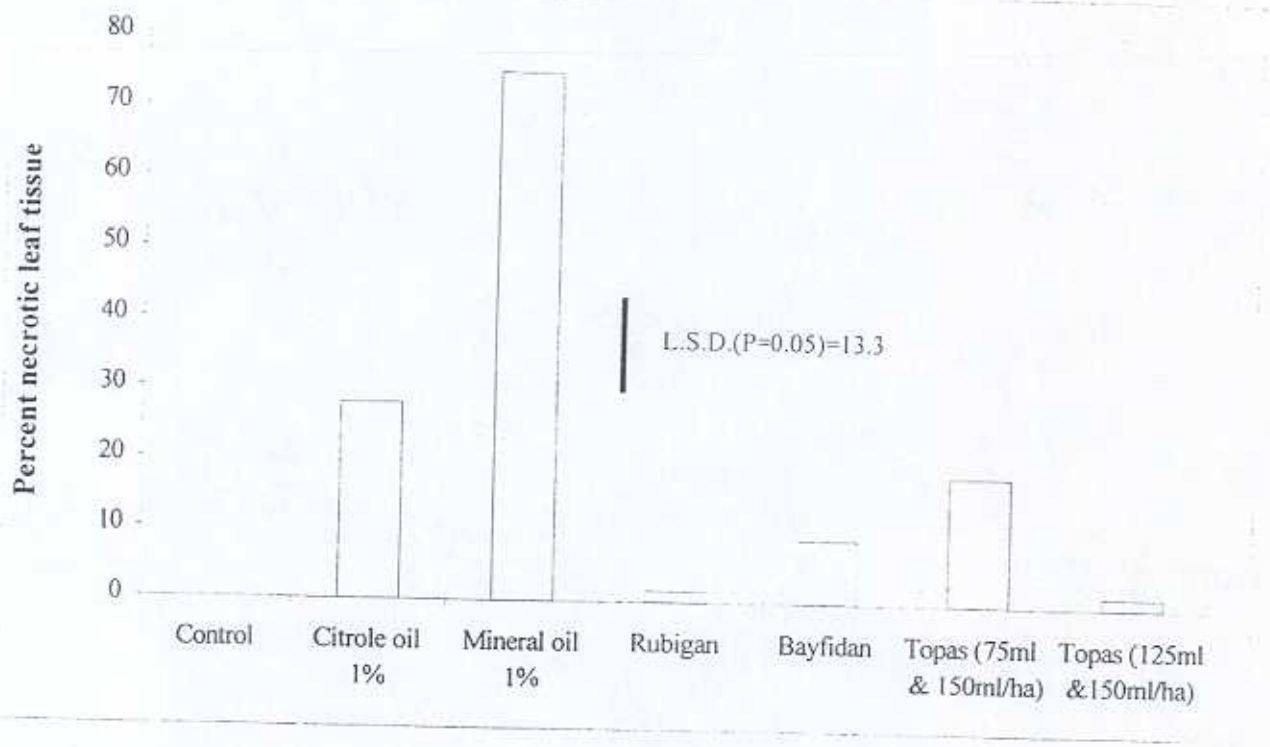


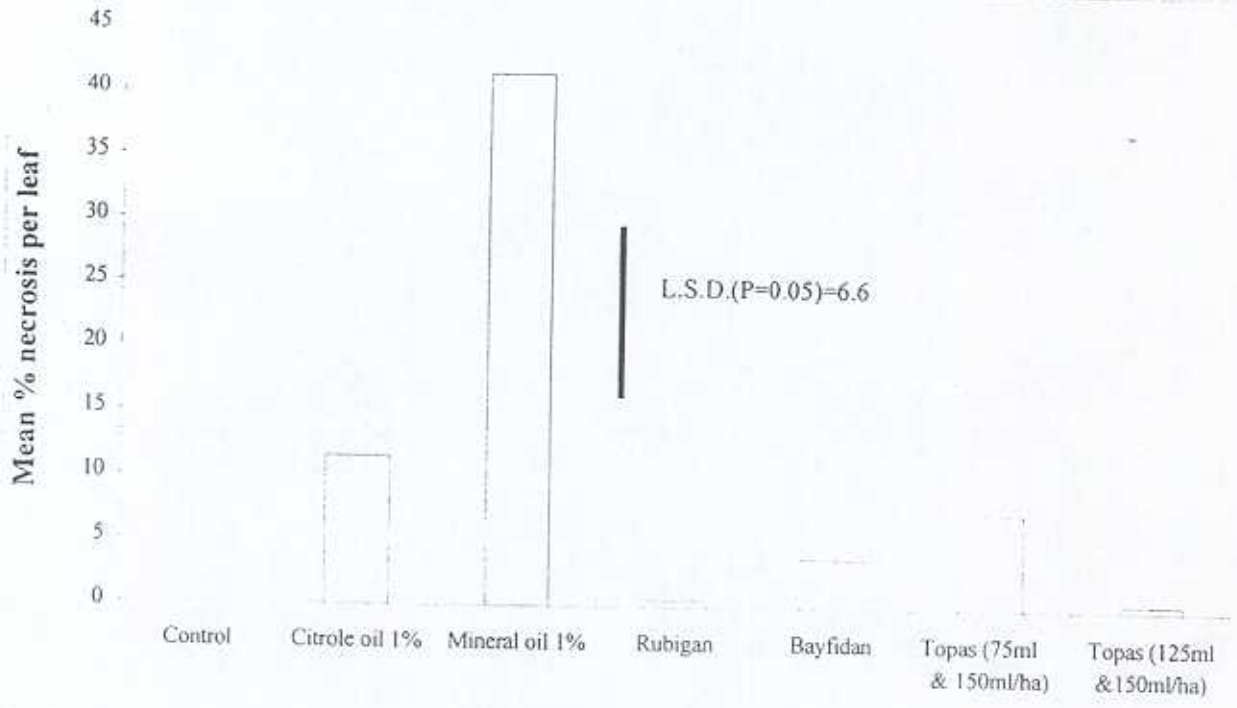
Figure 36 – Incidence (a) and severity (b) of necrosis on Chardonnay leaves, Lenswood.

Assessed: 6th March 1998.

(a) INCIDENCE



(b) SEVERITY



Experiment 19

The efficacy of different combinations of Topas and mineral oil spray regimes for the control of powdery mildew were assessed on Verdelho vines located at the Nuriootpa Research Centre.

Methods:

Various combinations of 1% mineral oil and Topas, either applied alone or alternatively (Table 2), were sprayed on 10 year old Verdelho vines. Sprays were applied on 7 occasions at intervals of 9 to 14 days between November 7 1997 and January 9 1998 at 1000 L/ha (Appendix 14).

Treatment plots consisted of 6 vines each replicated 4 times and arranged in a randomised block design with buffer rows separating treatment rows.

The onset of an early colonisation of powdery mildew throughout the trial required the buffer rows to be sprayed with Topas three times from November 13 to December 10 1997.

The incidence and severity of powdery mildew on bunches was assessed at 2 week intervals beginning November 21 1997. Bunches located in buffer rows were assessed for powdery mildew every 2 weeks beginning at the second assessment.

Results and Discussion:

Powdery mildew was well established throughout the Verdelho vines when the first spray was applied on November 7 1997, the incidence of disease in untreated plots was 77%. The incidence and severity of powdery mildew was greatly reduced in all treated plots by the third spray application. The best result was seen on the buffer rows that were sprayed with Topas, which had a 75% reduction in the incidence of powdery mildew over 2 weeks (Fig 37a).

By the start of February the incidence of powdery mildew was high in all treatment plots however the severity remained low (Fig 37b). Mineral oil alone suppressed powdery mildew compared to the control, but it was significantly less effective than any treatment that included Topas.

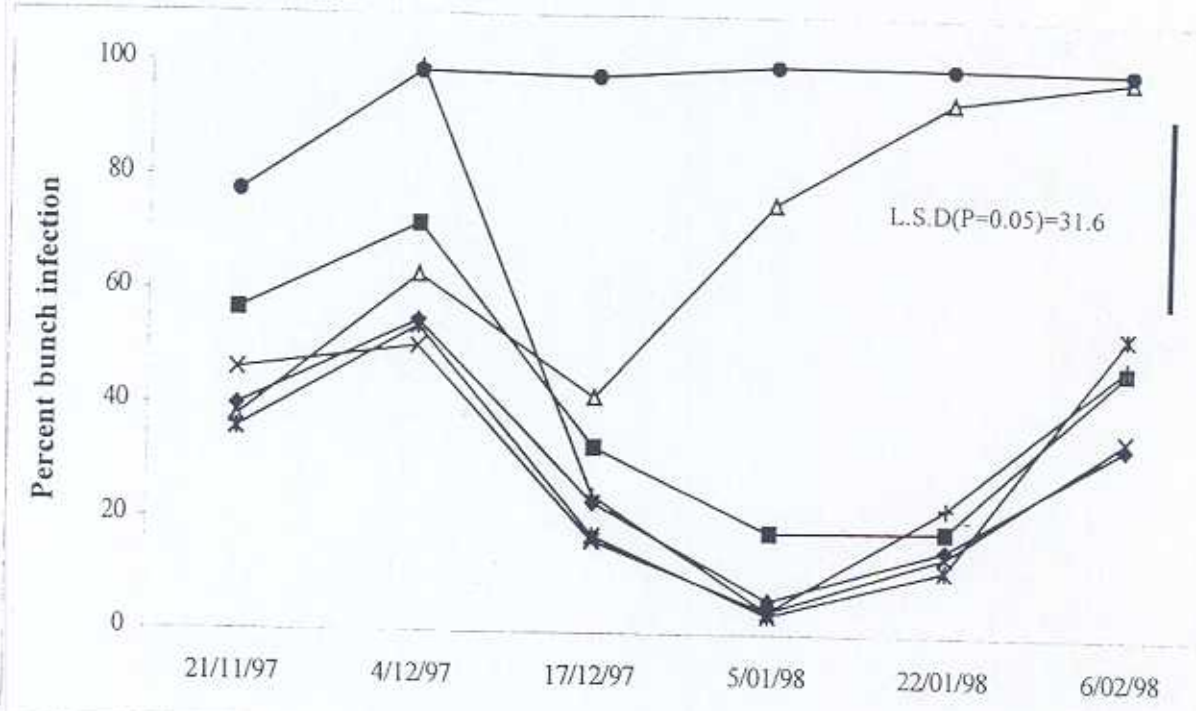
The severe powdery mildew infection in the untreated rows was reflected in the bunch weight where the average weight of untreated bunches was 16 g, compared to average weights between 65 and 75 g in alternate Topas and oil treated plots (Fig 38).

Table 2 - Spray regime for Verdelho vines, Nuriootpa 1997/98.

Treatment	7/11/97	17/11/97	27/11/97	10/12/97	19/12/97	29/12/97	9/1/98
1	Topas	Oil	Topas	Oil	Topas	Oil	Bayfidan
2	Oil	Oil	Topas	Topas	Topas	Oil	Bayfidan
3	Oil	Oil	Oil	Oil	Oil	Oil	Oil
4	Oil	Topas	Topas	Topas	Oil	Oil	Bayfidan
5	Oil	Topas	Topas	Topas	Oil	Oil	Bayfidan
6	-	-	-	-	-	-	-
7	-	Topas	Topas	Topas	-	-	-

Figure 37 – Incidence (a) and severity (b) of powdery mildew on Verdelho bunches, Nuriootpa 1997/98.

(a) INCIDENCE



(b) SEVERITY

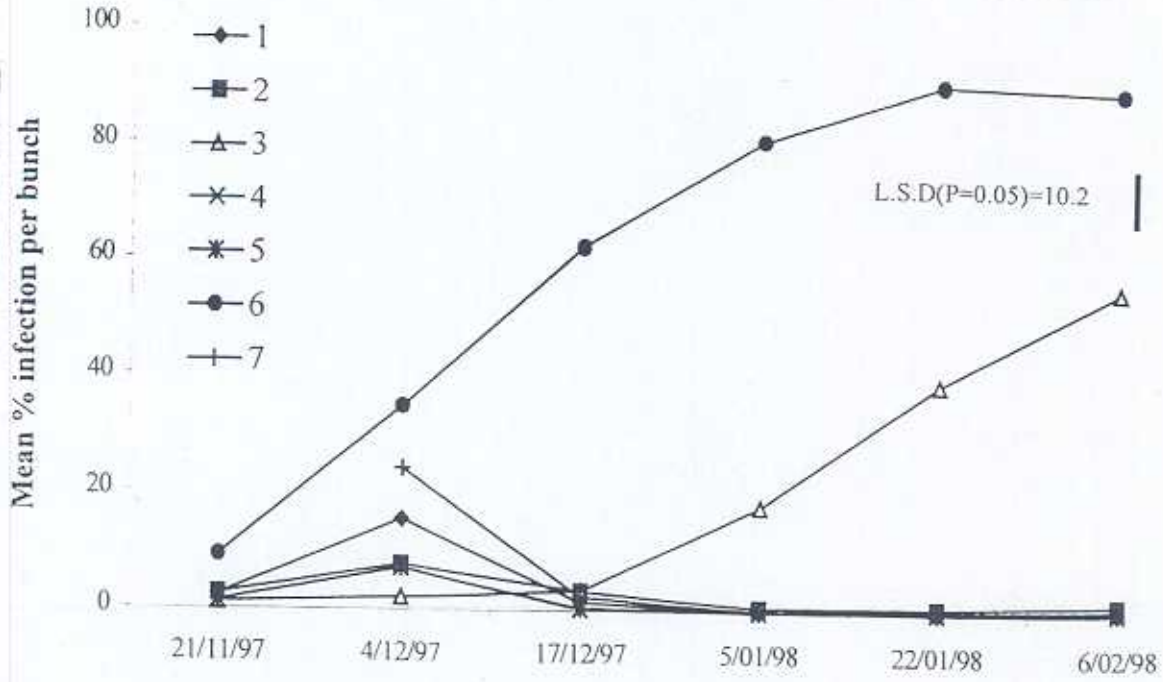
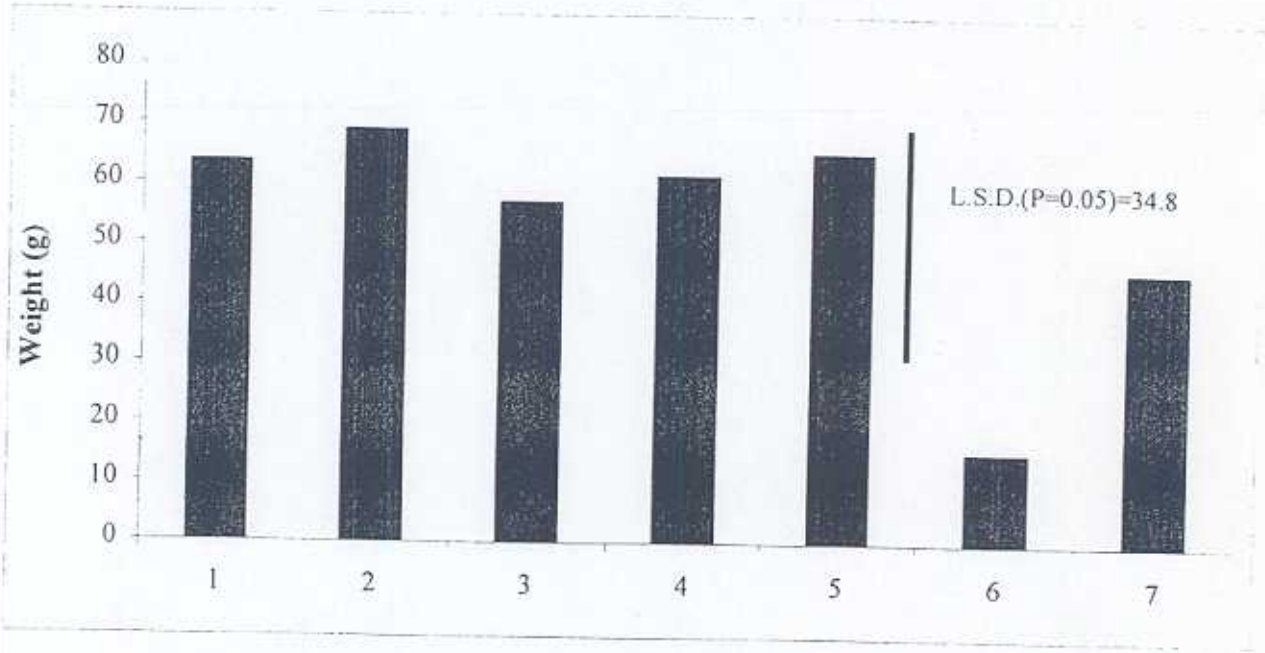


Figure 38– Average weight of Verdelho bunches, Nuriootpa 1997/98.

Assessed: 3rd March 1998.



Experiment 20 and 21

Two trials were undertaken to compare Bayfidan at quarter and half the recommended rates either alone or together with DCT Plus for the control of grapevine powdery mildew.

Methods:

Experiment 20

Spray treatments were applied to mature Verdelho vines located at the Nuriootpa Research Centre. Treatments included an unsprayed control, Bayfidan which was applied at 2.5 and 5 ml/100L, quarter and half the recommended rates respectively, 2.5 ml/100L Bayfidan with 1% DCT Plus and 1% DCT Plus alone. Each treatment containing 8 vines was replicated three times, and arranged in a randomised block design, separated by unsprayed buffer rows.

The Hydra spray unit was used to apply sprays on 6 occasions from November 15 1996 to January 16 1997 with intervals of 8 to 16 days between applications (Appendix 15). The volume applied increased from 330 L/ha from mid November 1996 to 915 L/ha in January 1997.

Twenty five bunches per plot were assessed for incidence and severity of active powdery mildew on 3 separate occasions between December 16, 1996 and January 31 1997. On January 31 1997, 50 bunches were randomly harvested, and weighed from each plot.

Results and Discussion:

Nearly all bunches in the control and 1% DCT Plus treatments were infected with powdery mildew at the time of the 1st assessment in mid December (Fig. 39a). By mid January more than 90% of bunches in each treatment were infected with powdery mildew. There was no significant difference between the severity of disease on untreated bunches and those treated with 1% DCT Plus (Fig. 39b). The addition of DCT Plus to quarter the recommended rate of Bayfidan did not improve the performance of the standard fungicide.

Bunch weights in all Bayfidan treatments were significantly higher than those unsprayed or treated with 1% DCT Plus (Fig. 40). The addition of DCT Plus to Bayfidan did not increase the average weight of bunches compared to those treated with quarter and half rate Bayfidan.

The control, 1% DCT Plus, and quarter rate Bayfidan with DCT Plus treatments all had significantly higher incidence of powdery mildew on leaves than the other Bayfidan treatments (Fig. 41a). The severity of powdery mildew on Verdelho leaves was low in all treatments, 0-1.2% (Fig. 41b).

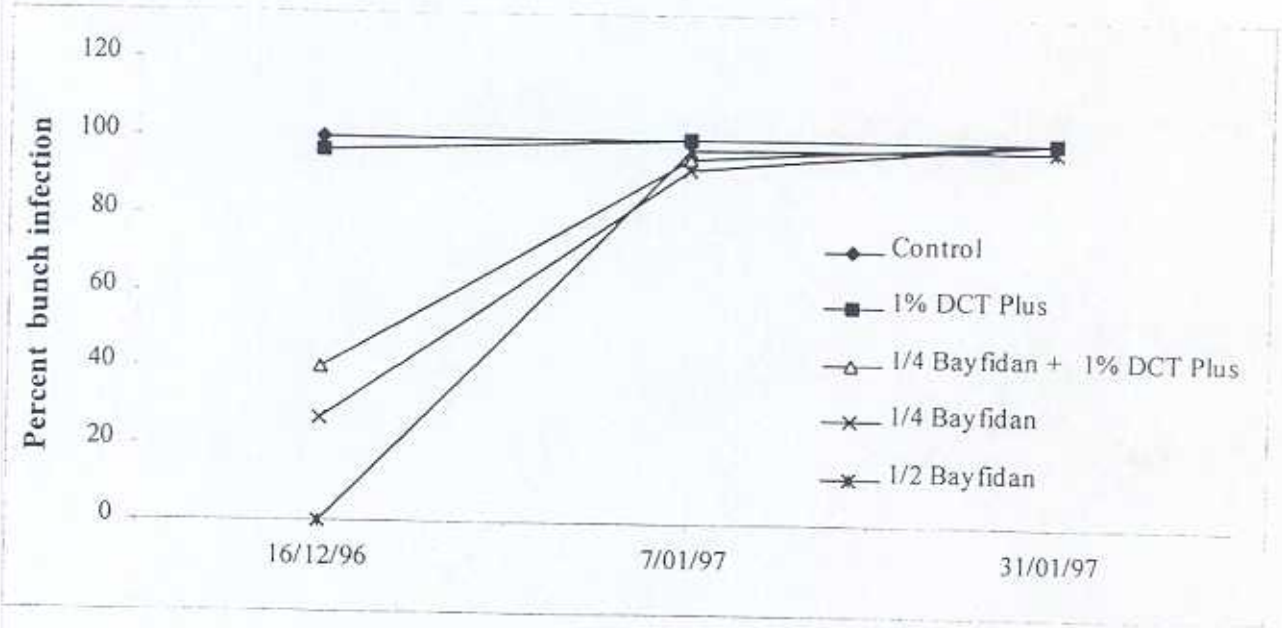
Although fungicide resistance has not occurred in Australia, there is always the risk that it will occur as it has in Europe and USA (Gubler *et al* 1996). DCT Plus was added to low rates of Bayfidan to determine if the oil enhanced the efficacy of the low rate of Bayfidan.

The use of a tank mixture of DCT Plus and Bayfidan did not improve the performance of the reduced rate of fungicide. Bayfidan at half the recommended rate was effective in controlling powdery mildew in leaves and bunches despite a high incidence level of disease.

Unlike Bayfidan, DCT Plus does not have a systemic mode of action and relies on spray coverage for disease control. The Verdelho canopy was very dense with over hanging canes that made effective spray penetration difficult to achieve. The results indicate that oil does not enhance the uptake of Bayfidan into leaf tissue but does improve powdery mildew control over DCT Plus alone.

Figure 39 – Incidence (a) and severity (b) of powdery mildew on Verdelho bunches treated with Bayfidan and DCT Plus, Nuriootpa 1996/97.

(a) INCIDENCE



(b) SEVERITY

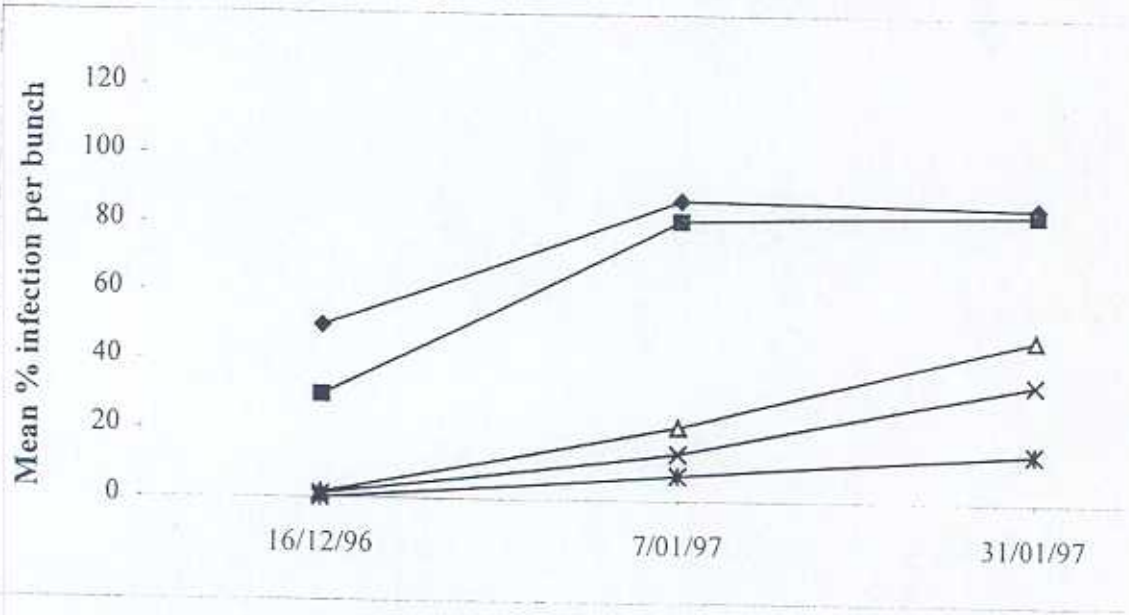


Figure 40 – Average weight of Verdelho bunches treated with Bayfidan and DCT Plus, Nuriootpa 1996/97.

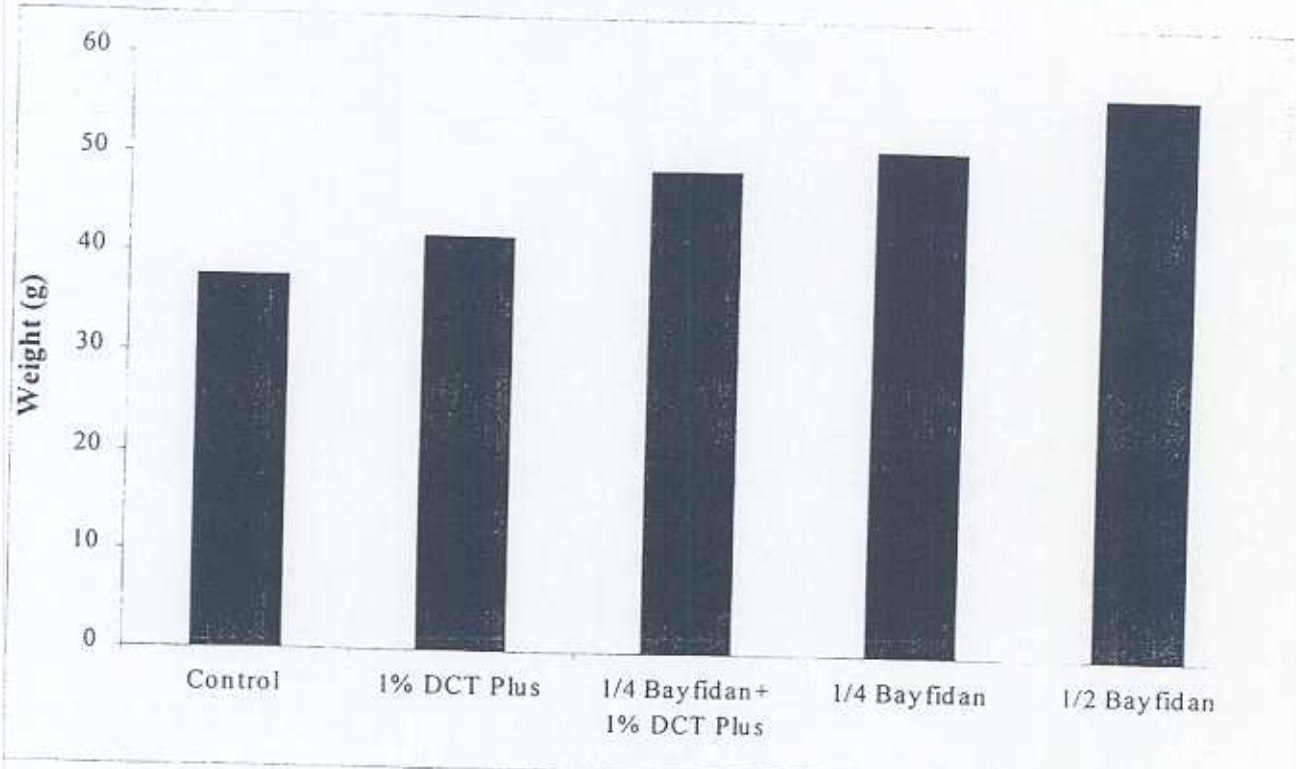
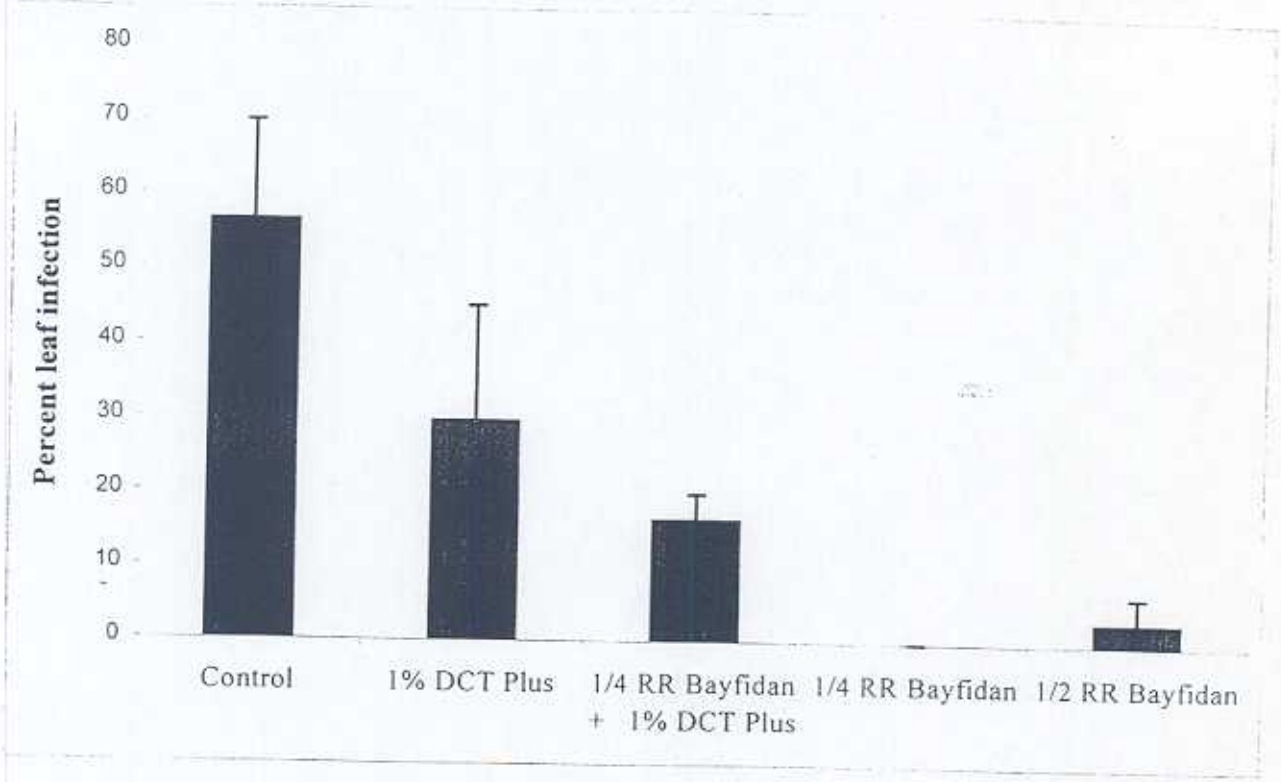
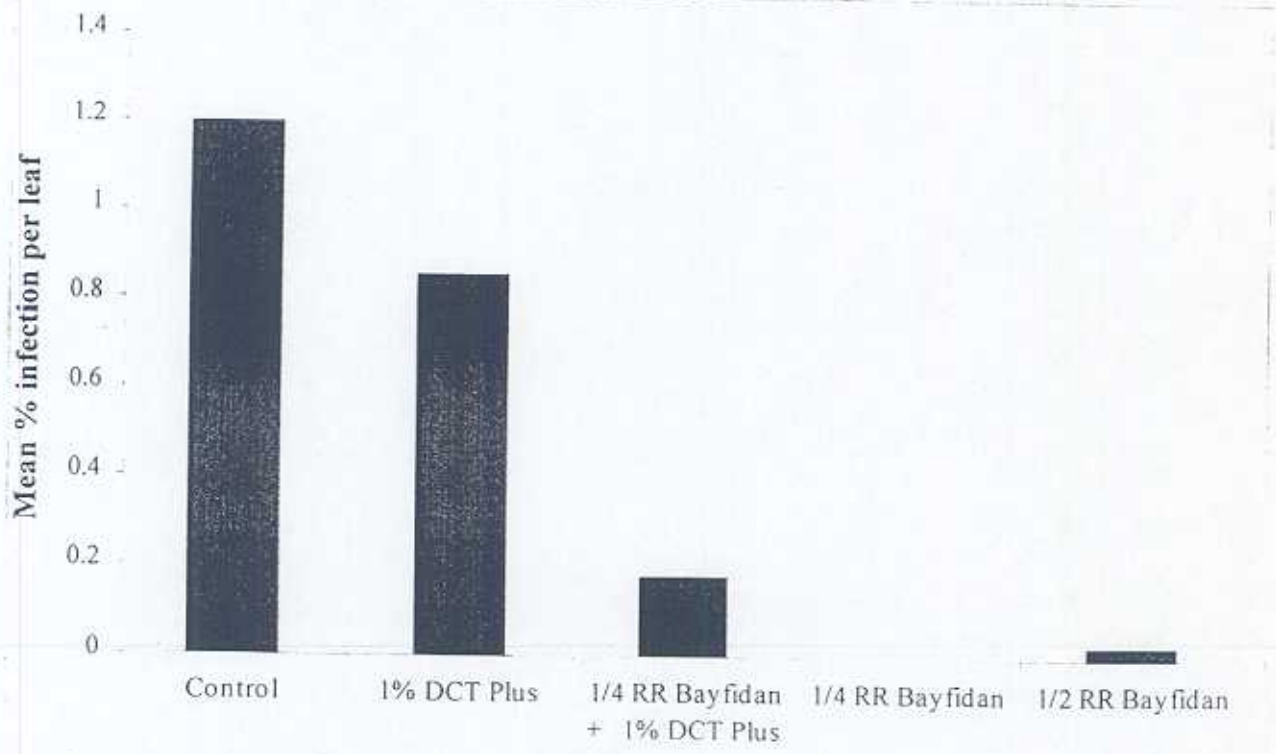


Figure 41 – Incidence (a) and severity (b) of powdery mildew on Verdelho leaves, Nuriootpa 1996/97.

(a) INCIDENCE



(b) SEVERITY



Methods:

Experiment 21

Sprays were applied to mature Columbard vines located at the Loxton Research Centre. Vines were trellised to either a single wire or tee trellis and spur or cane pruned. Treatments were replicated 4 times with each replicate consisting of 8 vines and arranged in a completely randomised design. Unsprayed buffer rows separated treatment rows.

The treatments consisted of an unsprayed control, Bayfidan, which was applied at 2.5 and 5 ml/100L, quarter and half the recommended rates respectively, 2.5 ml/100L Bayfidan with 1% DCT Plus and 1% DCT Plus alone (Appendix 16).

Each treatment was applied 5 times between October 21 1996 and January 2 1997. Due to delays in the arrival of the Hydra spray unit, a Solo motorised knapsack spray unit was used for the 1st application. As a result the volume applied on the 1st spray was approximately 1,200 L/ha as compared to 300 L/ha on the 2nd spray and 780 L/ha by the final spray.

Leaves and bunches were harvested and assessed in the laboratory on February 5 1997 for the incidence and severity of powdery mildew.

Results and Discussion:

The incidence of powdery mildew ranged from 40% on bunches treated with half rate Bayfidan to 95% in the unsprayed bunches (Fig. 42a). The severity of powdery mildew was low, with less than 5% infection on the unsprayed bunches (Fig. 42b). Although a slight reduction in the number of bunches infected in the half rate Bayfidan treatments was observed, neither the reduced rates of Bayfidan or the Bayfidan/DCT Plus mixture significantly reduced the level of control. The incidence of powdery mildew in the untreated bunches and those treated with 1% DCT Plus was similar, however with DCT Plus the bunch infection was significantly lower (Fig. 42b).

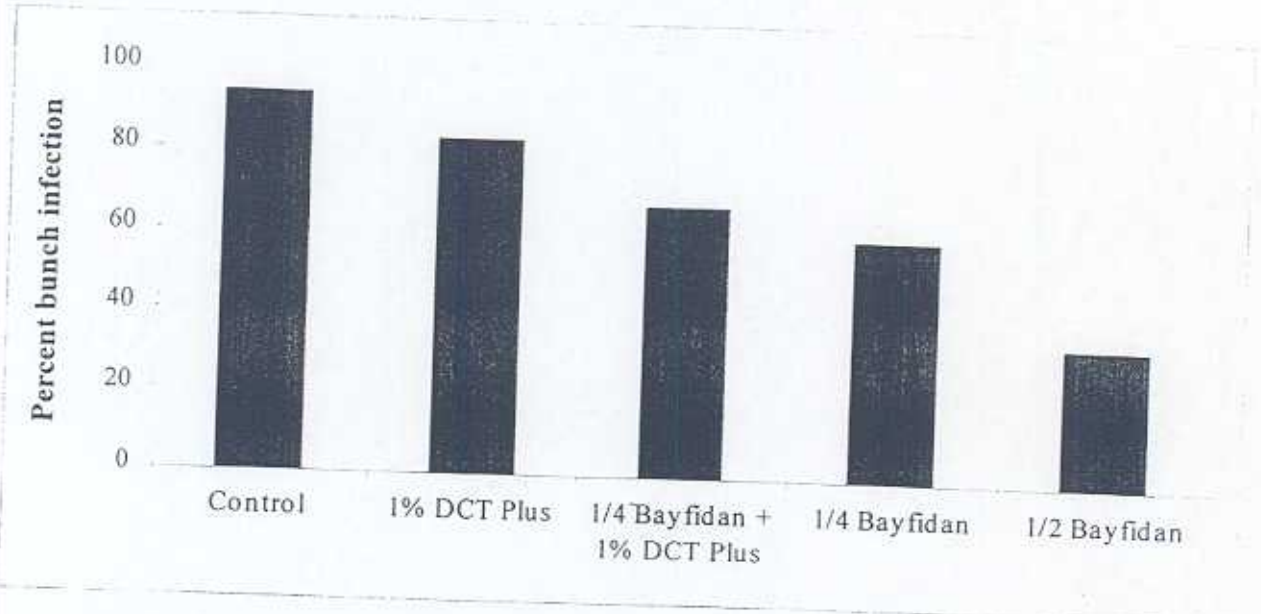
All treatments significantly reduced the severity of powdery mildew on leaves compared to the unsprayed plots, however there was no difference in the incidence of disease (Fig. 43).

In this trial, the addition of 1% DCT Plus to quarter the recommended rate of Bayfidan gave better control than oil alone but was equivalent to quarter the recommended rate of Bayfidan alone.

Figure 42 – Incidence (a) and severity (b) of powdery mildew on Columbard bunches treated with DCT Plus and Bayfidan, Loxton 1996/97.

Assessed: February 5 1997.

(a) INCIDENCE



(b) SEVERITY

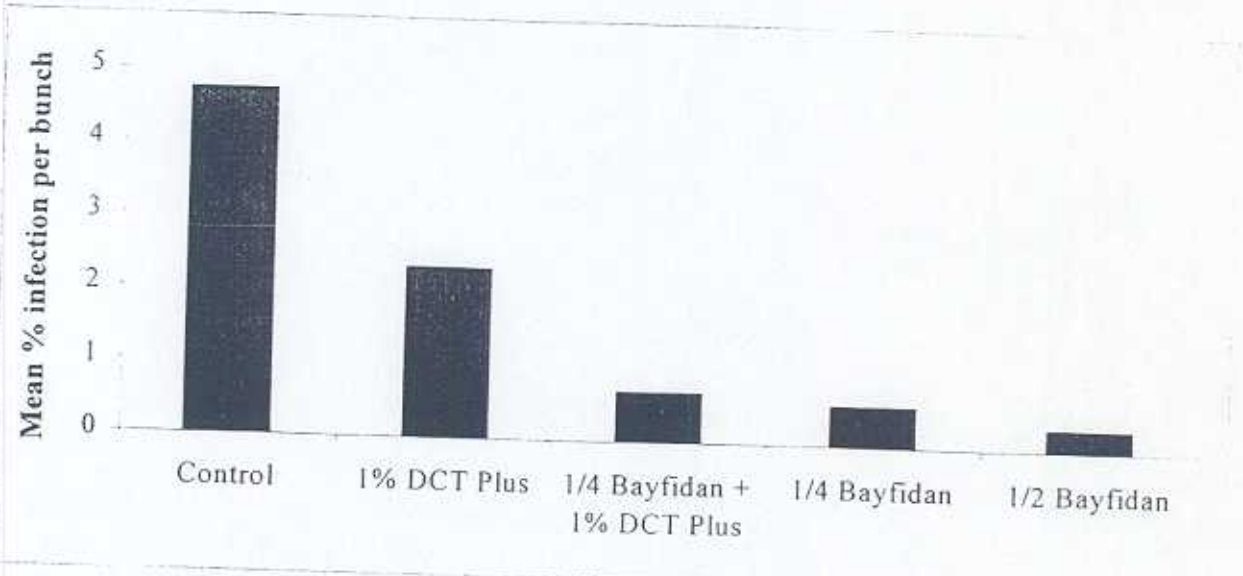
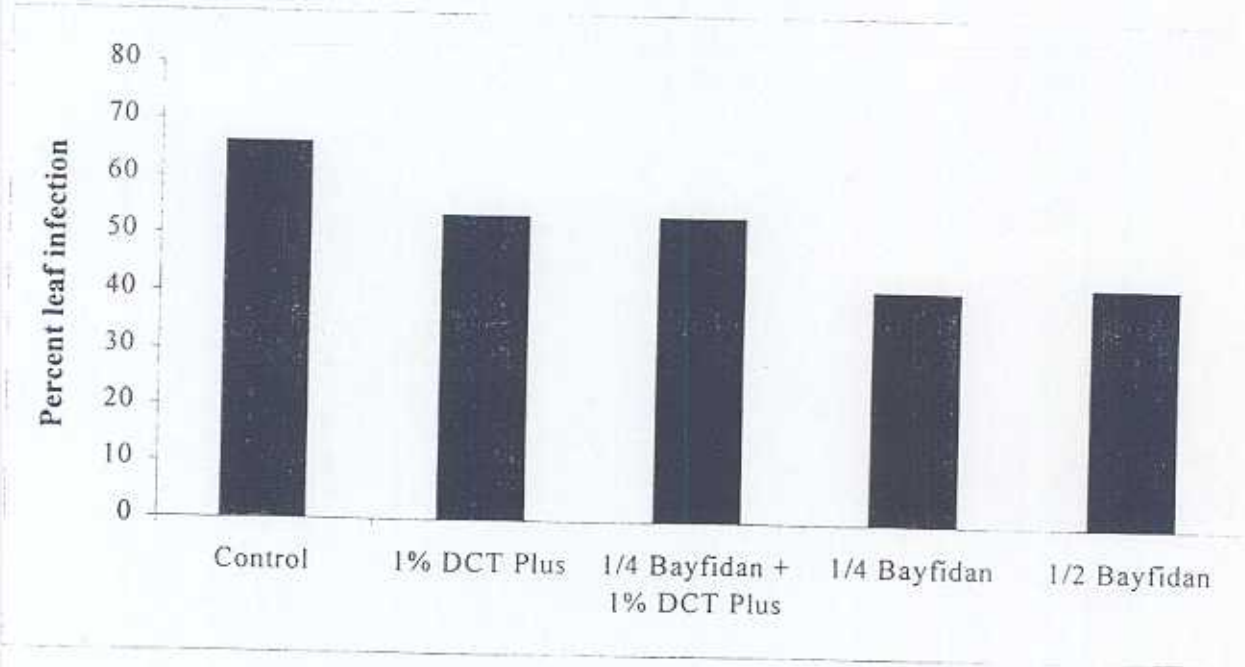


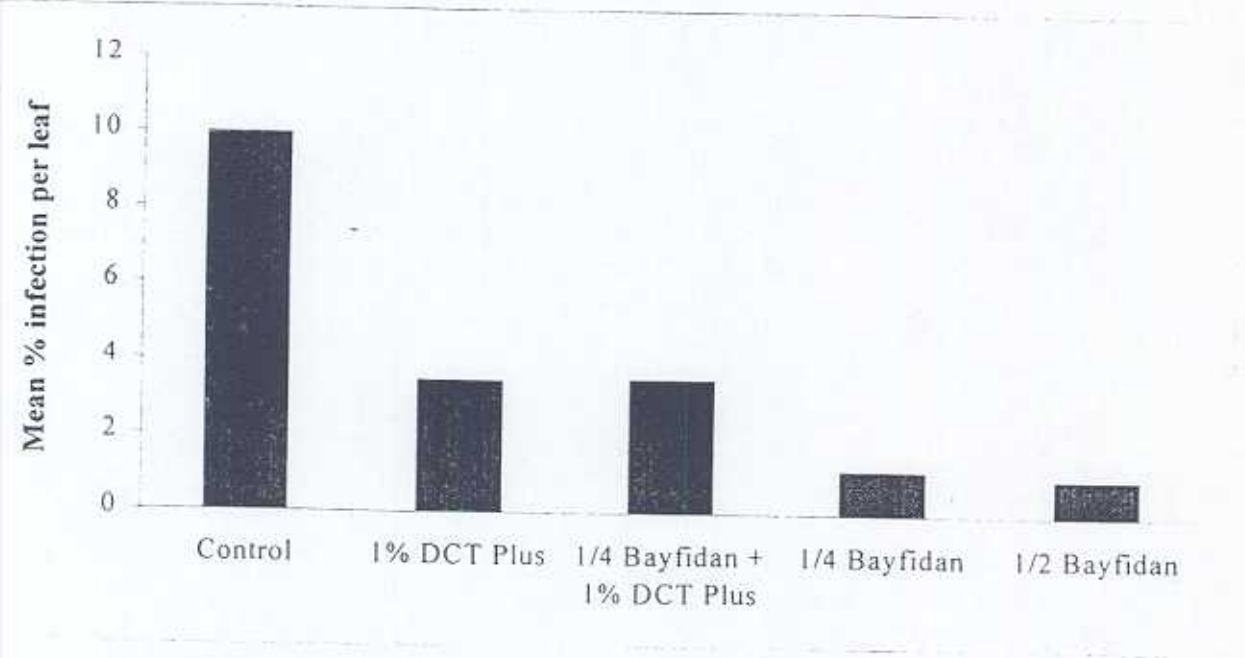
Figure 43– Incidence (a) and severity (b) of powdery mildew on Columbard leaves treated with DCT Plus and Bayfidan, Loxton 1996/97.

Assessed: February 5 1997.

(a) INCIDENCE



(b) SEVERITY



Experiment 22, 23 and 24

Three trials were undertaken at the Nuriootpa Research Centre to assess any adverse reactions of incorporating oils into fungicide programs used on table grapes.

Methods:

Experiment 22 & 23

Mineral oil (1%) was applied to Red Globe and Gamay grapevines using the Hydra spray unit on 3 occasions during flowering followed by 4 Bayfidan sprays. Oils were applied at 9-12 day intervals using either 500 or 1000 L/ha (Appendix 17).

The incidence and severity of powdery mildew on bunches was assessed 3 times at 2 week intervals from December 17 1997. Phytotoxicity and yield was also assessed on Gamay vines at harvest.

Results and Discussion:

Experiment 22

Phytotoxic damage was observed on Red Globe bunches that were sprayed with Bayfidan. This appeared as rings of brown coloured residue and scar tissue on the skin at the stylar end of individual berries.

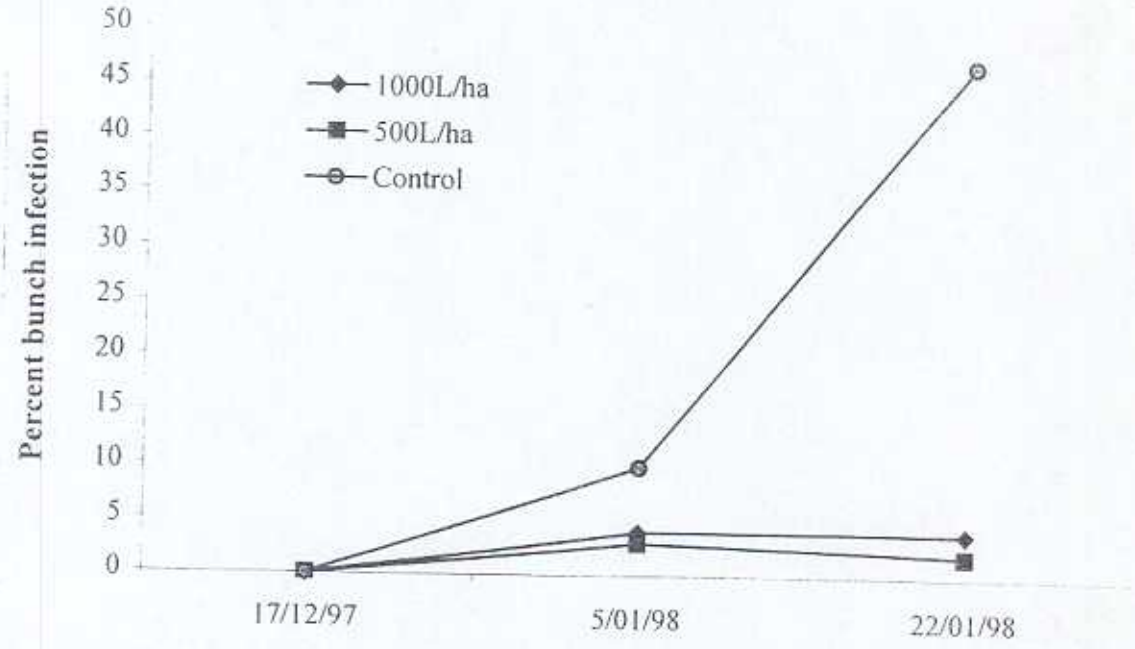
Experiment 23

Forty seven percent of bunches in the untreated plots were infected with powdery mildew compared to 4% or less in the treated plots (Fig 44). No phytotoxicity was observed on the Gamay berries but a similar amount of sunburn was present on berries in each treatment.

Bunch weight was similar between all treatments. The mineral oil/Bayfidan treatments had an average bunch weight of 78 g whilst untreated bunches weighed 71 g (Fig 45).

Figure 44 – Incidence (a) and severity (b) of powdery mildew on Gamay vines, Nuriootpa 1997/98.

(a) INCIDENCE



(b) SEVERITY

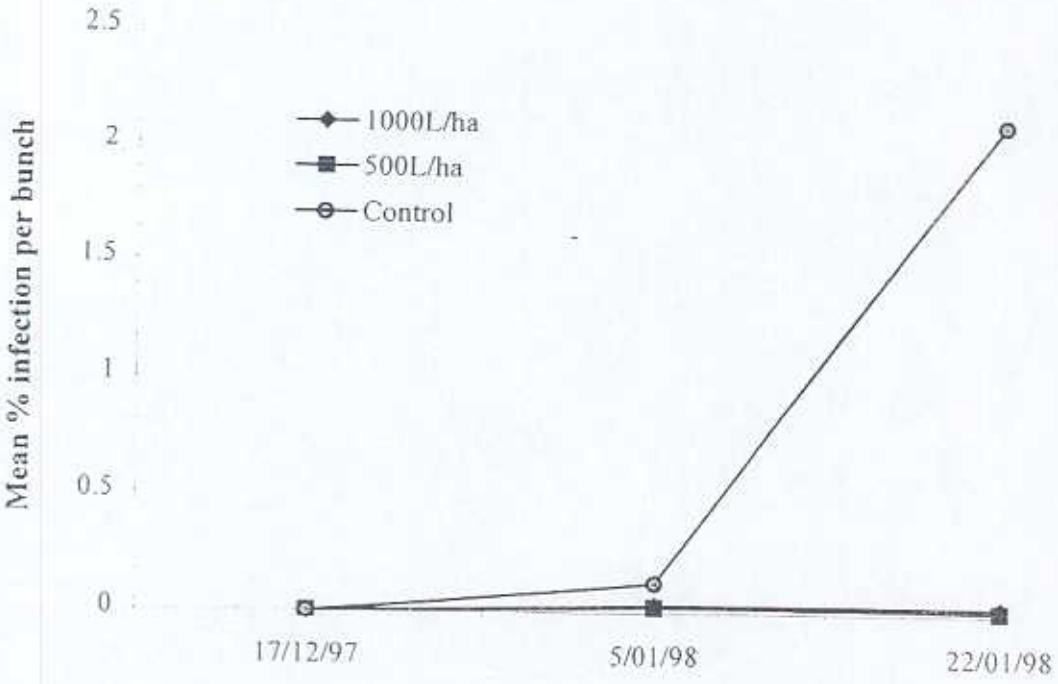
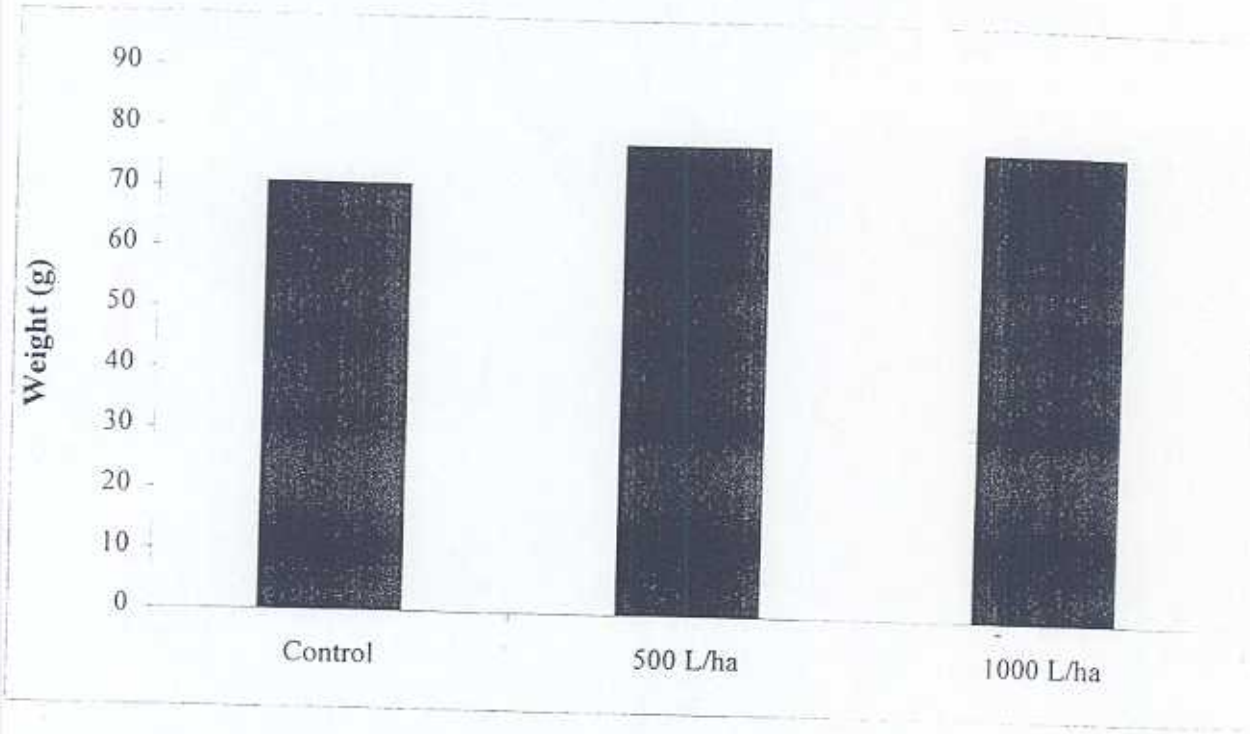


Figure 45 – Average weight of Gamay bunches at harvest, Nuriootpa 1997/98.



Methods:

Experiment 24

DCT Plus at 1% was applied on 6 occasions to 2 rows of Gamay vines located on the Nuriootpa Research Centre using the Hydra spray unit. In each row two panels of vines were left unsprayed (Appendix 18). The day after the 5th and 6th applications, January 8 and 16 1997, sulphur (300g/100L) was sprayed at 370 L/ha onto 1 row of vines including the 2 untreated panels.

Phytotoxicity damage using a rating scale of 0 to 5, was assessed on leaves and bunches in each plot 2 weeks after each sulphur application and again in mid February.

Results & Discussion:

Extended periods of hot weather occurred in January and February 1997 (Appendix 22). Eighteen days over 30°C occurred between the 1st sulphur application to the last assessment in February but no adverse effects developed when sulphur was applied to leaves previously sprayed with DCT Plus. Vines sprayed with only 1% DCT Plus or sulphur did not exhibit any phytotoxic reactions on leaves or bunches.

Experiments 25 and 26

Two experiments were undertaken to determine if applications of DCT Plus had any detrimental effect on the taste and appearance of table grapes.

Methods:

Experiment 25

DCT Plus (1%) was applied with the Hydra spray unit at 500 L/ha on 6 occasions to 1 row of mature Red Globe grapevines (Appendix 19). To compare the taste and appearance of berries sprayed with DCT Plus an extra 6 panels of vines were sprayed with Bayfidan, a conventional fungicide.

In late March, 100 bunches were randomly harvested from treated and untreated vines and divided into 5 batches of 20 bunches each. Each batch was stored in a lined crate with sulphur storage pads at 0°C for 5 months. After storage one bunch from each treatment was selected at random and 11 assessors individually rated taste and appearance on 0-4 scale; 0 = poor to 4 = excellent.

Results and Discussion:

The difference between treatments on the quality of grapes after storage was not significant. A few bunches from the Bayfidan and oil treated bunches were infected with Penicillium, but the majority of bunches were still in good condition. There was no difference in weight of bunches pre and post storage (Table 3).

Although the results were extremely variable in the taste and appearance test, no adverse affects were apparent in the taste and appearance of bunches treated with DCT Plus compared to those treated with the conventional fungicide Bayfidan (Table 4).

Table 3 – Pre and post storage weights of table grapes.

Treatment	Pre-storage weight (kg) 27/3/97	Post-Storage weight (kg) 26/8/97	Difference
Bayfidan	8.8	8.8	0
Bayfidan	5.1	5.1	0
Bayfidan	6.82	6.82	0
Bayfidan	5	5	0
Bayfidan	6.8	6.8	0
DC Tron Plus	7.34	7.34	0
DC Tron Plus	8.22	8.18	0.04
DC Tron Plus	4.44 (15 bunches)	4.44	0
DC Tron Plus	6.9	6.9	0
DC Tron Plus	8.46	8.46	0

Table 4 - Taste and appearance of Red Globe bunches treated with DC Tron Plus 1% and Bayfidan.

Appearance

Treatment	Number of Responses (%)				
	Poor				Excellent
	0	1	2	3	4
Bayfidan	45	27	18	9	0
Bayfidan	0	9	9	18	63
Bayfidan	0	45	18	36	0
DC Tron Plus	9	36	27	18	9
DC Tron Plus	9	18	27	45	0
DC Tron Plus	0	0	36	36	27

Taste

Treatment	Number of Responses (%)				
	Poor				Excellent
	0	1	2	3	4
Bayfidan	18	27	36	9	9
Bayfidan	18	18	27	27	9
Bayfidan	9	0	45	36	9
DC Tron Plus	18	9	27	27	18
DC Tron Plus	0	18	18	54	9
DC Tron Plus	9	27	18	45	0

Methods:

Experiment 26

This trial was conducted in 20 year old Sultana vines located at the Loxton Research Centre. The vines were minimally pruned and trellised to either a single wire or tee trellis. DCT Plus was applied at 1 and 2% while Bayfidan was applied at the recommended rate of 10 ml/100L. Treatments were replicated twice with each replicate containing 28 vines. An unreplicated control row was separated from the treatments by an unsprayed buffer row.

Five sprays were applied between October 21 1996 and January 2 1997, the first application was applied by hand using a Solo motorised knapsack spray unit at a volume of 2000 L/ha. The remaining sprays were applied with the Hydra spray unit at 400 L/ha on November 12 1996 to 1,200 L/ha on January 2 1997 (Appendix 20).

The incidence and severity of powdery mildew on leaves was assessed on 3 occasions between November 1996 and January 1997. Powdery mildew levels on bunches were assessed once in early January. The vines were severely affected by frost early in the growing season and bunch development was reduced. Subsequently there were not enough bunches to conduct a replicated taste and appearance assessment of each treatment. An alternative untreated Sultana block was harvested and the bunches dipped or sprayed with either Bayfidan or 1% or 2% DCT Plus. Four lots of 20 bunches per treatment were stored at 0°C in lined crates with sulphur pads for approximately 8 weeks. After this time they were rated by a panel of 10 different assessors for appearance and taste. Appearance was rated on a 0-4 scale where 0 = would not purchase grapes to 4 = would buy in preference to any other. Taste was also rated on a 0-4 scale where 0 = did not like the taste of the grapes to 4 = preferred the taste of these grapes to any other.

Results:

Powdery mildew did not develop on any bunches or leaves treated with Bayfidan (Fig. 46 & 47). DCT Plus at 2% significantly reduced both the incidence and severity of bunch infection compared to DCT Plus at 1% and the untreated leaves and bunches. Powdery mildew bunch infection on untreated vines remained low until late December then rapidly increased to 80% by early January.

Although the appearance of bunches treated with DCT Plus rated highly for appearance, the taste of the grapes rated very poorly (Table 5). Untreated bunches rated poorly for appearance but were

preferable in taste. Similarly bunches treated with Bayfidan had the preferred taste and a more appealing appearance.

Discussion:

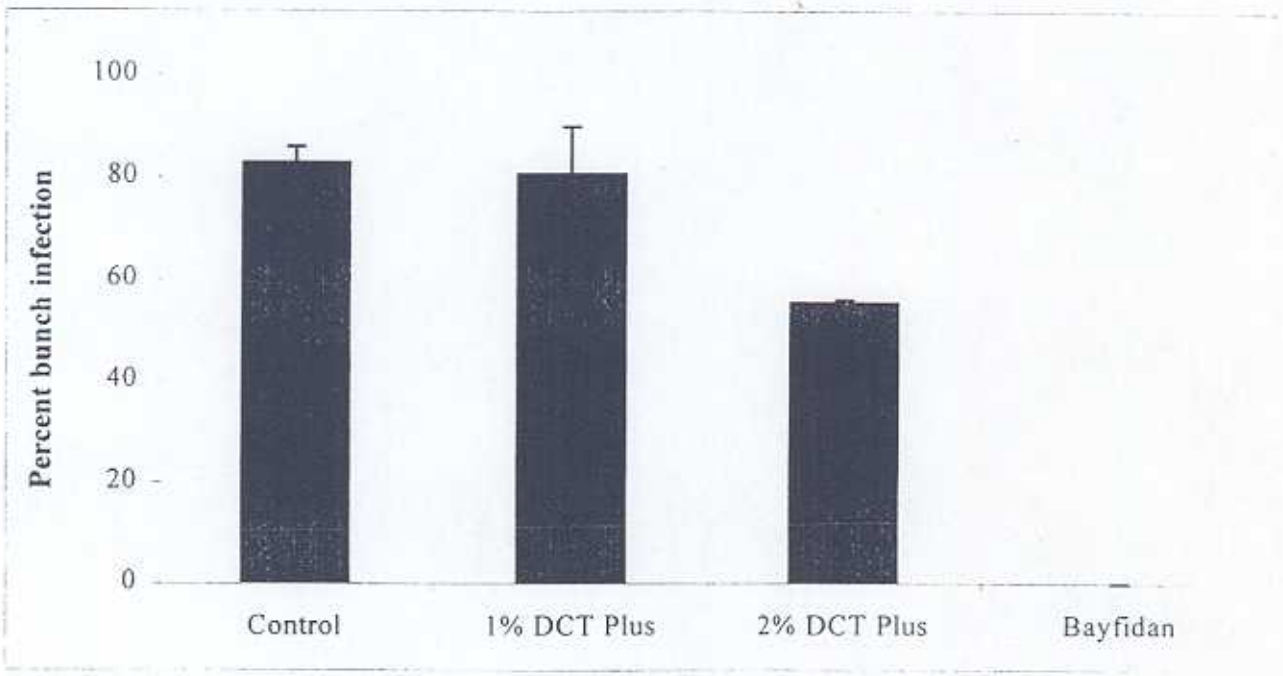
The results of the taste and appearance tests conducted in this trial are only a guide as the sultana bunches used were not of a commercially acceptable standard due to low brix and powdery mildew infection. Additionally by using bunches that were not sprayed with DCT Plus during the season, a "worse case scenario" was simulated by dipping bunches in a solution prior to storage.

Oil removes the bloom of the berry, so bunches treated by dipping or spraying all had the shiny appearance which appeals to some people. However the taste of the dipped berries rated poorly due to the oily or chemical taste and aftertaste. From observations of other experiments, this chemical aftertaste was not obvious in berries taken from bunches sprayed with the Hydra sprayer, therefore this experiment should be repeated to determine whether the taste is present after correct oil application.

Figure 46 – Incidence (a) and severity (b) of powdery mildew on Sultana bunches treated with DCT Plus and Bayfidan, Loxton 1996/97.

Assessed: January 2 1997.

(a) INCIDENCE



(b) SEVERITY

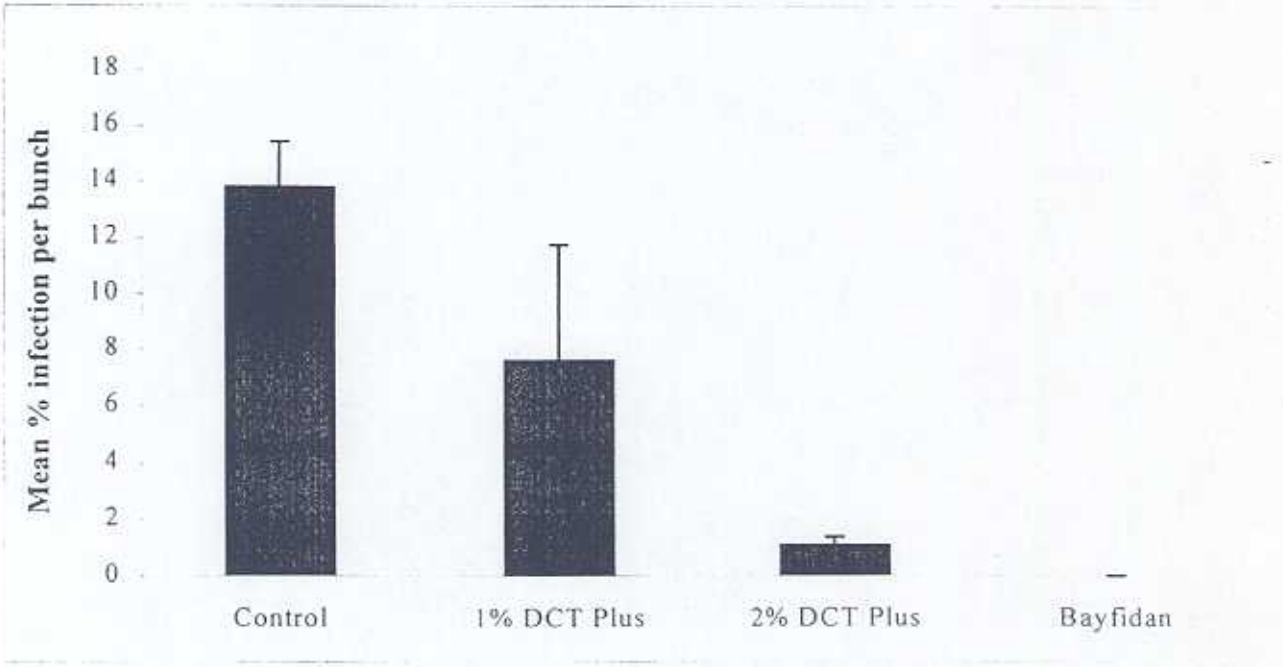
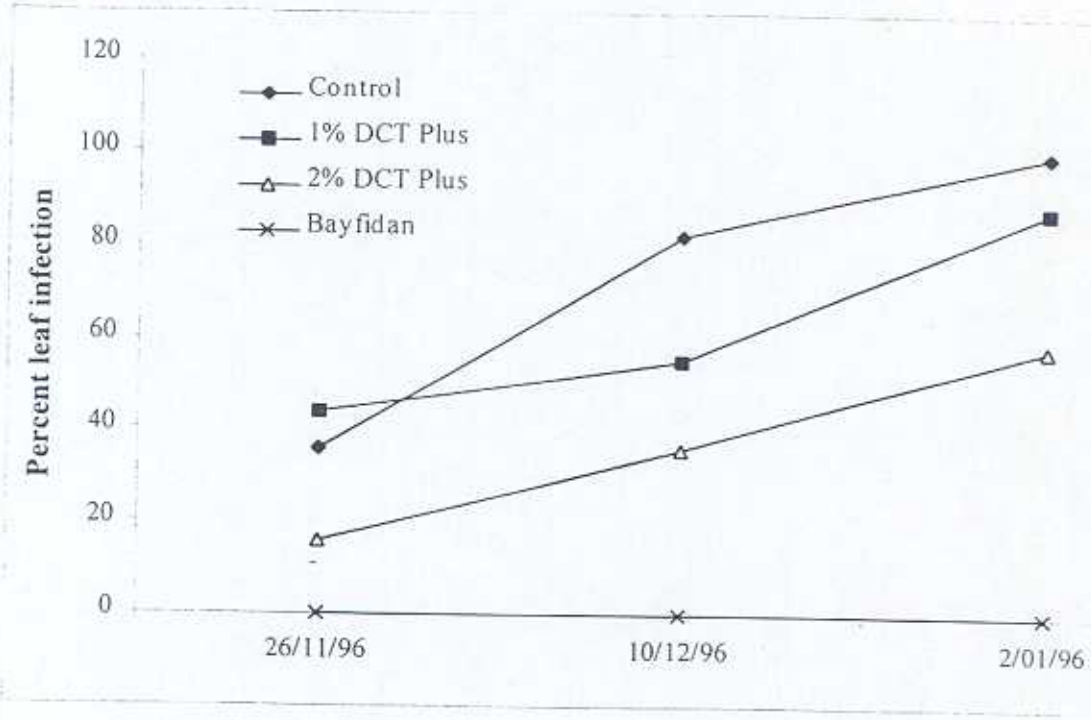


Figure 47– Incidence (a) and severity (b) of powdery mildew on Sultana leaves treated with DCT Plus and Bayfidan, Loxton 1996/97.

(a) INCIDENCE



(b) SEVERITY

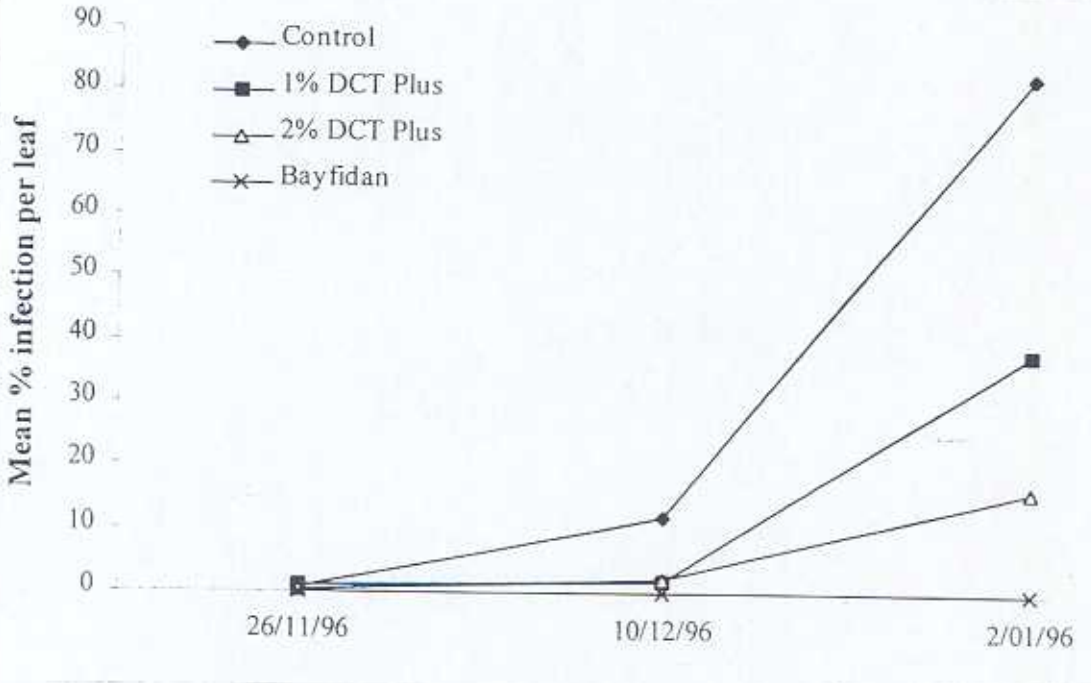


Table 5 - Taste and appearance evaluation of Sultana storage trial, Loxton, 1997.

TASTE

Treatment	Number of Responses (%)				
	Poor				Excellent
	0	1	2	3	4
Control	20	-	40	20	20
Bayfidan	-	10	60	10	20
0.5% DCT Plus	60	20	20	-	-
1% DCT Plus	80	-	10	10	-
2% DCT Plus	80	-	10	10	-

APPEARANCE

Treatment	Number of Responses (%)				
	Poor				Excellent
	0	1	2	3	4
Control	50	20	30	-	-
Bayfidan	10	-	50	20	20
0.5% DCT Plus	10	10	50	20	10
1% DCT Plus	-	-	50	30	20
2% DCT Plus	20	-	50	10	20

Experiment 27

This experiment was undertaken to determine if any wine or table grape cultivars were sensitive to applications of DCT Plus with and without sulphur.

Methods:

The experiment was conducted at the Loxton Research Centre in a rootstock variety trial where 33 cultivars were planted on 4 different rootstocks (Table 6). This trial was not replicated, as it was an observation trial. DCT Plus at 1% was applied with the Hydra spray unit to the entire block, excluding 8 vines in the middle of each row that were left as unsprayed control vines.

Four sprays were applied, between November 12 and January 2 1997 where 270 to 600 L/ha was used respectively at intervals of 14 to 23 days (Appendix 21). Sulphur (300g/100L) was applied 3 times to vines at 370 L/ha previously sprayed with DCT Plus. The level of powdery mildew and phytotoxic damage on leaves and bunches was assessed on 4 occasions throughout the season.

Results & Discussion

Powdery mildew was observed on leaves in control plots on November 26 1996 and continued to develop in treated and untreated leaves and bunches until the final assessment on February 12 1997. One hundred percent infection had occurred on bunches and leaves of some varieties by early January. No phytotoxicity was observed on the leaves or bunches of any variety. The additional spray applications of sulphur did not cause any phytotoxic damage on leaves or bunches but did slightly reduce the incidence of powdery mildew infection on some varieties.

As DCT Plus does not have a systemic mode of action it relies on the spray coverage of bunches and leaves to control powdery mildew. The large canopy size of the rootstock vines prevented effective spray penetration particularly in the inner canopy. This was evident in the lack of control of powdery mildew even in the vines sprayed with sulphur.

Table 6 - Rootstock variety trial, Loxton 1996/97.

Row	Variety	Observation of disease#
11	Merlot	+++
	Tinta Maderia	+++
	Carina	+++
12	Chardonnay	+++
	Frontignac	+++
	Montils	+
13	St. Macaire	+
	Valdigvie	+
	Mondeuse	+
14	Cabernet Franc	+++
	Tarrango	+++
	Femao Pires	+++
15	Cabernet Sauvignon	+++
	Grenache	+++
	Shiraz	+++
16	Zinfandel	+++
	Chenin Blanc	+++
	Riesling	+++
17	Doradillo	+++
	Gordo	+++
	Pedro Ximenez	+++
18	Mataro	+
	Currant	+++
	Palomino	+
19	Sultana	+++
	Trebbiano 64	+++
	Malbec	+++
20	Ruby Cabernet	+++
	Barbera	+
	Columbard	+
21	Sauvignon Blanc	+
	Rubi Red	+++
	Traminer	+++

+ = low levels of powdery mildew, +++ = high levels of powdery mildew.

Experiment 28

This experiment was carried out to determine if adverse residues or off flavours carried over into wine following the application of oils.

Methods:

Both DCT Plus and a vegetable oil Synertrol were applied at 1% on three occasions to mature Chardonnay and Cabernet Sauvignon vines in a commercial vineyard using a standard air blast sprayer utilising up to 800 L/ha. The last spray applied at least 28 days before harvest. The standard treatment of Bayfidan at the recommended rate was applied to adjacent rows of vines of each cultivar and used as the standard control.

At harvest at least 30 Kg of grapes from each treatment were transported to the Plant Research Centre where pH, titratable acidity and brix were determined before the juice was processed into wine.

Wine was matured in bottles for at least six months before it was assessed by independent tasting panels. Bottles of each wine were opened and checked for any wine making fault or bottle taint by an experience oenologist. Bottles were mixed and then placed back into the bottles which were gassed with CO_2. Triangle tests were conducted to determine whether sensory differences existed between the samples. 30 mls of each wine was poured into XL5 international testing glasses and covered with a watch glass. All wines were served at room temperature and tested at 20°C. The red wines were tasted under sodium lamps to mark possible colour differences. Panellists consisted of experienced oenologists and those with a strong interest in wine. All had experience in triangle testing.

Results and Discussion

Analysis of the juice pH, acidity and brix showed no significant difference between grapes sprayed with mineral or vegetable oil or Bayfidan.

Similarly with the wine, no significant differences were detected between treatments in wine made with Chardonnay. With Cabernet Sauvignon however many panellists commented on the "green herbaceous unripe character" in the DCT Plus treated wine compared to the control. Other commented on the "earthy, dusty, musty aroma" compared to the control. With the Synertrol oil only 2 panellists referred to differences between the control and oil treatment.

Although powdery mildew assessments showed no significant different in the incidence and severity of disease between the treatments, it is always possible that some berries and bunches in the oil treatment were infected with mildew and those may have been responsible for imparting "off" flavours into the wine rather than the oil. Ough and Berg (1979) have reported as little as 3% powdery mildew on bunches can reduce wine quality by inducing unsatisfactory flavours.

Overall it appeared that DCT Plus oil produced a slight perceptible sensory affect in red wine which suggests that further work is required in this area.

TECHNOLOGY TRANSFERS

Results of this project have been presented at various "IPM Research to Practice" workshops conducted throughout South Australia, Western Australia and Tasmania during 1997 and 1998.

In addition results have been presented at grower meetings in Coonawarra, McLaren Vale and the Adelaide Hills as well as to scientific audiences at presentations at the Waite campus of the University of Adelaide.

Preliminary results have also been presented in articles in the Australian Grape Grower and Winemaker and the Annual Reports of the Grape and Wine Research and Development Corporation.

Details of some of this research were presented to a worldwide scientific audience at the Downy Mildew and Powdery Mildew Workshop held in Loxton, March 1998.

The results of this project have also been presented on several occasions to the Crop Protection Manager and other staff of Caltex Australia Petroleum Pty Ltd and to Mr. Peter Hayes of the Grape and Wine Research Development Corporation and senior staff of the technical section of Southcorp Wines.

A final article presenting the main findings of this project is in preparation for the Australian Grape Grower and Winemaker as well as a scientific article for the Australian Journal of Grape and Wine.

RECOMMENDATIONS

These results have shown that oil controls powdery mildew when applied at 1% and in spray volumes of at least 1000 L/Ha. The control achieved is not as great as that obtained with conventional fungicides such as the DMI's or sulphur. Oils were found to be unsuitable for use on table grapes but will provide adequate control of powdery mildew when applied at high spray volumes to young vines and to mature vines with exposed canopies.

Further studies are required to determine: -

- the efficacy of oils when applied at low spray volumes but using new spray technology to improve spray coverage
- the efficacy of oil when applied to different canopy styles
- the compatibility of oils with other spray materials used on vines as either tank mixes or foliar applications
- possible chronic effects of oil sprays on yield
- effect of late season application of oil on residue and wine quality
- effect of oils on insect pests such as mites, LBAM and predators

ACKNOWLEDGEMENTS

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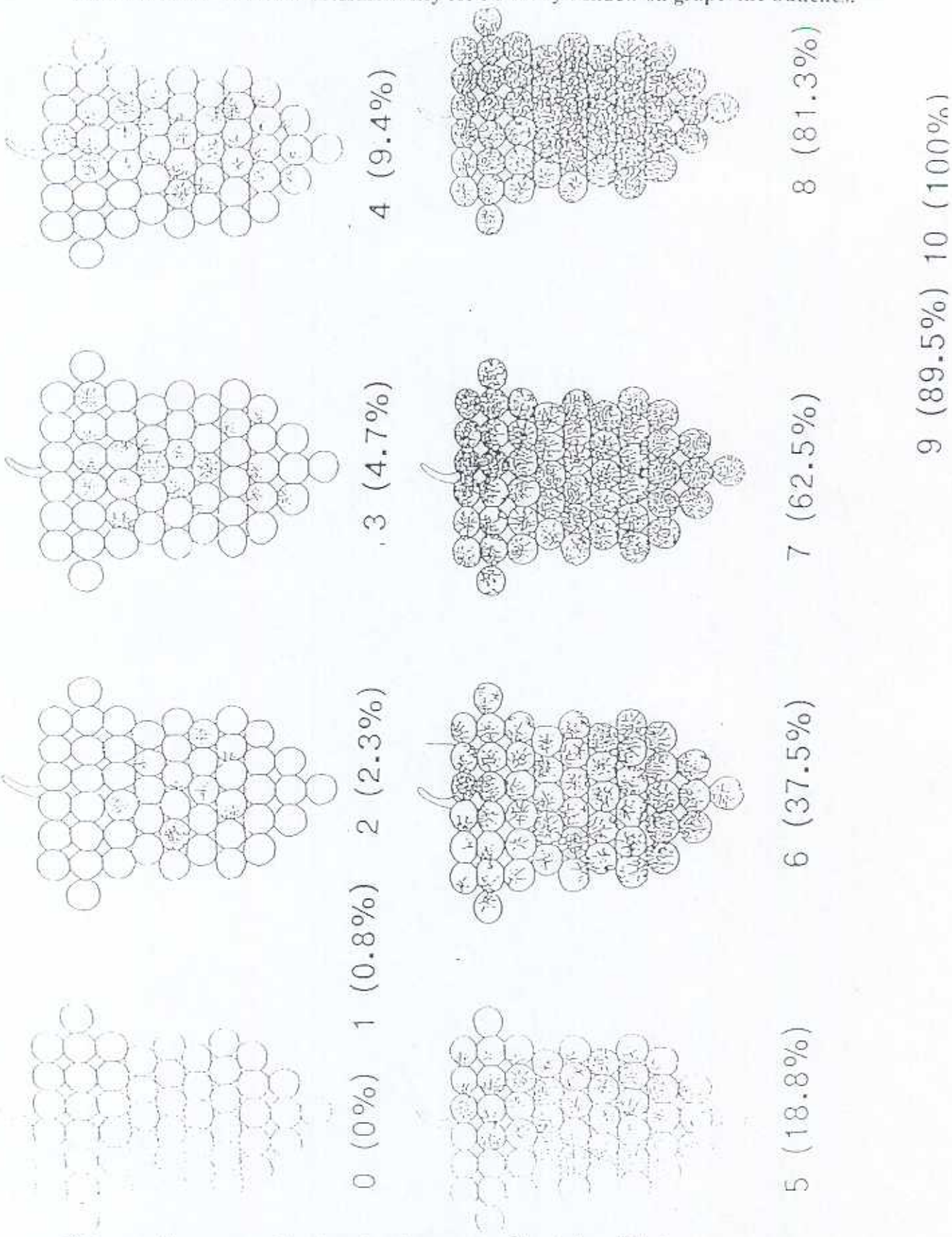
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APPENDIX 1 – Disease assessment key for Powdery Mildew on grapevine bunches.



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APPENDIX 1 – Disease assessment key for Powdery Mildew on grapevine leaves.

APPENDIX 1 (Cont.) – Incidence and severity rating of powdery mildew.

INCIDENCE

$$\text{No. bunches or leaves infected} = \frac{\text{Total No.} - \text{Total No. with Rating 0}}{\text{Total No. bunches or leaves}} \times 100$$

SEVERITY

$$\text{Mean \% Infection/Bunch or leaf} = \frac{(R1x0.8)+(R2x2.3)+\ldots\ldots+(R9x89.5)+(R10x100)}{\text{Total No. Bunches or Leaves}}$$

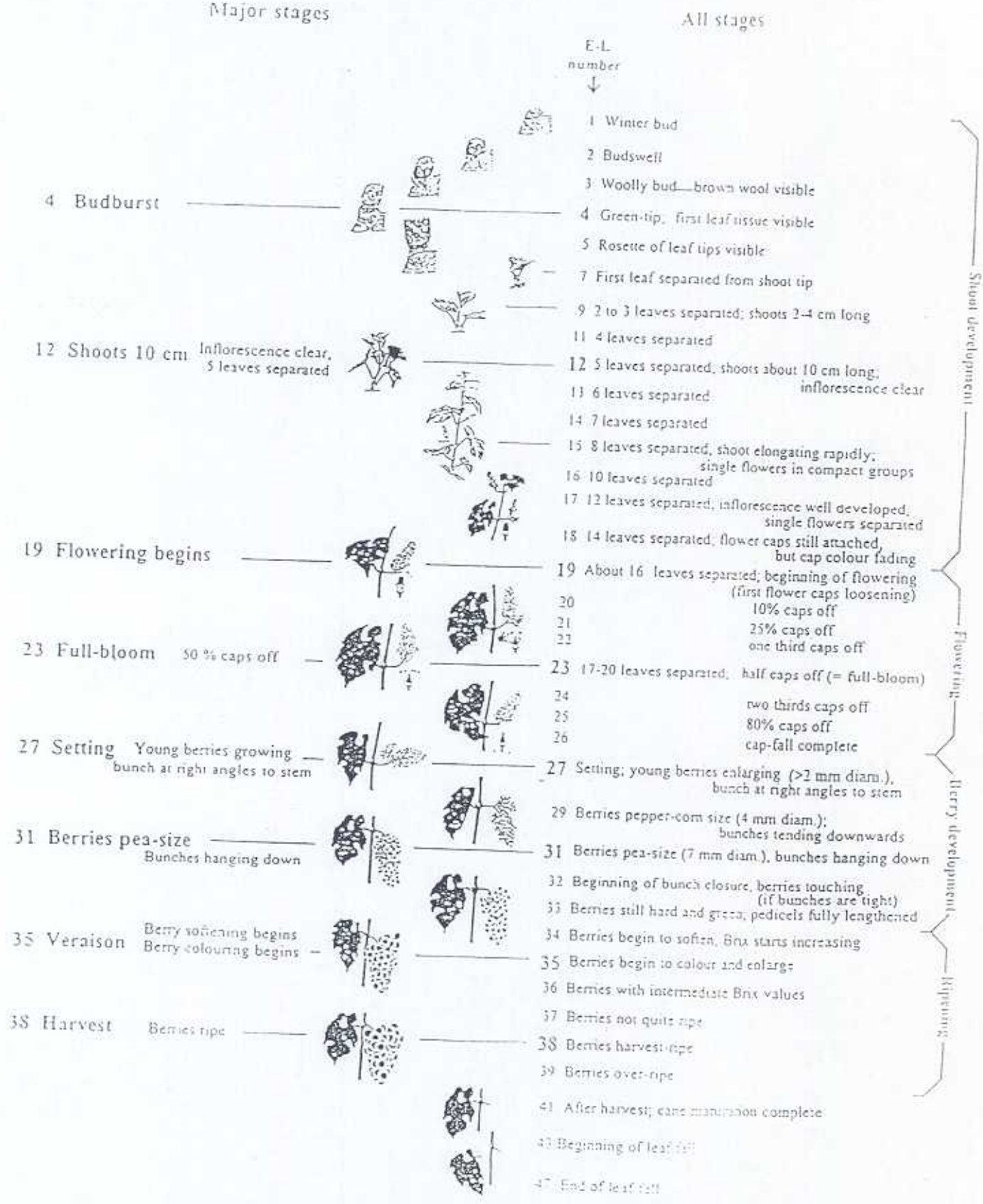
(Refer to previous page – Disease Assessment Key)

R1 = Number of bunches or leaves per vine rated as having a disease level of 1.

R2 = Number of bunches or leaves per vine rated as having a disease level of 2.

.....etc.

APPENDIX 2 – Grapevine Growth Stages



Adapted from Eichhorn and Lorenz (1977) by B.G.C., 1995.

APPENDIX 3 – Chardonnay spray records, Lenswood 1996/97.

Date	Days between spraying	Growth Stage	Treatment	Average L/ha#
4/12/96	-	25	0.25% DCT Plus 0.5% DCT Plus 1% DCT Plus 2.5% DCT Plus	870
19/12/96	15	29	0.25% DCT Plus 0.5% DCT Plus 1% DCT Plus 2.5% DCT Plus	885
27/12/96	8	32	0.25% DCT Plus 0.5% DCT Plus 1% DCT Plus 2.5% DCT Plus	780
9/1/97	11	33	0.25% DCT Plus 0.5% DCT Plus 1% DCT PJus 2.5% DCT Plus	1350
23/1/97	14	35	0.25% DCT Plus 0.5% DCT Plus 1% DCT Plus 2.5% DCT Plus	1390

= Average of all treatments applied on that day.

APPENDIX 4 – Pinot Noir spray records, Lenswood 1996/97.

Date	Days between spraying	Growth Stage	Treatment	Average L/ha#
4/12/96	-	25	DCT Plus 1% DCT Plus 2.5% DCT Plus 5%	850
			Bayfidan	900
19/12/96	15	29	DCT Plus 1% DCT Plus 2.5% DCT Plus 5%	950
			Bayfidan	450 *
27/12/96	8	32	DCT Plus 1% DCT Plus 2.5% DCT Plus 5%	1,110
			Bayfidan	630 *
9/1/97	11	33	DCT Plus 1% DCT Plus 2.5% DCT Plus 5%	1,270
			Bayfidan	1,250
23/1/97	14	35	DCT Plus 1% DCT Plus 2.5% DCT Plus 5%	1,290
			Bayfidan	1,250

= Average of all treatments applied on that day.
* = Reduced coverage due to gusting wind conditions at time of spraying

APPENDIX 5 – Riesling spray records, Nuriootpa 1997/98.

Date	Days between spraying	Growth Stage	Treatment	L/ha
29/10/97	-	15	DCT Plus (1%) Mineral oil (1%)	600 600
5/11/97	7	16	DCT Plus (1%) Mineral oil (1%)	500 500
17/11/97	12	19	DCT Plus (1%) Mineral oil (1%)	500 500
24/11/97	7	25	DCT Plus (1%) Mineral oil (1%)	1000 1000
10/12/97	16	27	DCT Plus (1%) Mineral oil (1%)	1000 1000
19/12/97	9	29	DCT Plus (1%) Mineral oil (1%)	1000 1000
29/12/97	10	31	DCT Plus (1%) Mineral oil (1%)	1000 1000
19/1/98	21	34	DCT Plus (1%) Mineral oil (1%)	1000 1000

APPENDIX 6 – Chardonnay spray records, Nuriootpa 1997/98.

Date	Days between spraying	Growth Stage	Treatment	L/ha
29/10/97	-	16	DCT Plus (1%) Mineral oil (1%)	400 400
5/11/97	7	17	DCT Plus (1%) Mineral oil (1%)	500 500
17/11/97	12	23	DCT Plus (1%) Mineral oil (1%)	500 500
24/11/97	7	25	DCT Plus (1%) Mineral oil (1%)	1000 1000
10/12/97	16	27	DCT Plus (1%) Mineral oil (1%)	1000 1000
19/12/97	9	29	DCT Plus (1%) Mineral oil (1%)	1000 1000
29/12/97	10	31	DCT Plus (1%) Mineral oil (1%)	1000 1000
19/1/98	21	34	DCT Plus (1%) Mineral oil (1%)	1000 1000

APPENDIX 7 – Chardonnay spray records, Nuriootpa 1997/98.

Date	Days between spraying	Growth Stage	Treatment	L/ha
29/10/97	-	13	Mineral oil (1%) Mineral oil (1%) Mineral oil (1%) Mineral oil (0.5%) Mineral oil (0.5%) Mineral oil (0.5%)	500 500 500 500 500 500
5/11/97	7	15	As above	As above
17/11/97	12	17	As above	As above
27/11/97	10	19	Mineral oil (1%) Mineral oil (1%) Mineral oil (1%) Mineral oil (0.5%) Mineral oil (0.5%) Mineral oil (0.5%)	500 1000 2000 500 1000 2000
10/12/97	13	23	As above	As above
19/12/97	9	27	As above	As above
29/12/97	10	31	As above	As above
19/1/98	21	33	As above	As above
4/2/98	16	35	As above	As above

APPENDIX 8 – Verdelho spray records, Padthaway 1996/97.

Treatment	23/9/96	14/10/96	4/11/96	26/11/96	17/12/96	6/1/97
5% DCT Plus 100 L/ha	-	√	√	√	√	√
1% DCT Plus 100L/ha	-	√	√	√	√	√
Routine Sprays 100 L/ha	Sulphur Bayfidan Citowett	Sulphur Rubigan Citowett	Sulphur Citowett	Sulphur Citowett	Sulphur Citowett	Sulphur Citowett

APPENDIX 9 – Spray records.

Date	Days between spraying	Growth Stage	Treatment	L/ha
15/11/96	-	17	DCT Plus (1%) DCT Plus (1%) DCT Plus (1%) DCT Plus (1%) DCT Plus (1%)	1 - 145 2 - 290 3 - 578 4 - 1011 5 - 1445
28/11/96	13	23	As above	As above
17/12/96	19	29	As above	As above
23/12/96	6	31	As above	As above

APPENDIX 10 - Chardonnay spray records, Lenswood 1997/98.

Date	Days between spraying	Growth Stage	Treatment	L/ha
6/11/97	-	14	Mineral oil (1%) Mineral oil (1%) Mineral oil (1%) Mineral oil (1%)	500 500 500 500
12/11/97	6	15	As above	As above
20/11/97	8	16	As above	As above
2/12/97	12	19	As above	500 1000 1500 2000
12/12/97	10	23	As above	As above
23/12/97	11	27	As above	As above
6/1/98	14	31	As above	As above
15/1/98	9	32	As above	As above
23/1/98	8	33	As above	As above
4/2/98	12	35	As above	As above

APPENDIX 11 – Chardonnay spray records, Nuriootpa 1996/97.

Date	Days between spraying	Growth Stage	Treatment #	L/ha
15/11/96	-	16	Hardi	-
			Hydra	440
28/11/96	13	25	Hardi	440
			Hydra	530
11/12/96	13	27	Hardi	440
			Hydra	530
23/12/96	12	31	Hardi	440
			Hydra	530
8/1/97	16	32	Hardi	615
			Hydra	650
15/1/97	7	33	Hardi	650
			Hydra	680

APPENDIX 12 – Chardonnay spray records, Nuriootpa 1997/98.

Date	Days between spraying	Growth Stage	Treatment	L/ha
29/10/97	-	15	Hydra Hardi	400 405
5/11/97	7	17	Hydra Hardi	500 500
17/11/97	12	19	Hydra Hardi	500 500
27/11/97	10	22	Hydra Hardi	1000 1000
10/12/97	13	26	Hydra Hardi	1000 1000
19/12/97	9	29-31	Hydra Hardi	1000 1000
29/12/97	10	32	Hydra Hardi	1000 1000
9/1/98	11	33	Hydra Hardi	1000 1000

APPENDIX 13 – Chardonnay spray records, Lenswood 1997/98.

Date	Days between spraying	Growth Stage	Treatment	L/ha
6/11/97	-	14	Topas (75 & 150ml/ha)	234
			Topas (125 & 150 ml/ha	244
			Bayfidan (100ml/ha)	255
			Rubigan (20ml/ha)	234
			DCT Plus 97 (1%)	317
			Citrole oil (1%)	229
19/11/97	13	16-17	Topas (75 & 150ml/ha)	366
			Topas (125 & 150 ml/ha	372
			Bayfidan (100ml/ha)	334
			Rubigan (20ml/ha)	368
			DCT Plus 97 (1%)	354
			Citrole oil (1%)	293
2/12/97	13	27	Topas (75 & 150ml/ha)	390
			Topas (125 & 150 ml/ha	312
			Bayfidan (100ml/ha)	364
			Rubigan (20ml/ha)	468
			DCT Plus 97 (1%)	328
			Citrole oil (1%)	338
11/12/97	9	29	Topas (75 & 150ml/ha)	364
			Topas (125 & 150 ml/ha	520
			Bayfidan (100ml/ha)	625
			Rubigan (20ml/ha)	703
			DCT Plus 97 (1%)	520
			Citrole oil (1%)	572
23/12/97	12	31	Topas (75 & 150ml/ha)	520
			Topas (125 & 150 ml/ha	520
			Bayfidan (100ml/ha)	625
			Rubigan (20ml/ha)	729
			DCT Plus 97 (1%)	364
			Citrole oil (1%)	364
7/1/98	15	32	Topas (75 & 150ml/ha)	667
			Topas (125 & 150 ml/ha	729
			Bayfidan (100ml/ha)	781
			Rubigan (20ml/ha)	781
			DCT Plus 97 (1%)	781
			Citrole oil (1%)	677
23/1/98	16	33	Topas (75 & 150ml/ha)	781
			Topas (125 & 150 ml/ha	781
			Bayfidan (100ml/ha)	781
			Rubigan (20ml/ha)	781
			DCT Plus 97 (1%)	781
			Citrole oil (1%)	781

APPENDIX 14 – Verdelho spray records, Nuriootpa 1997/98.

Date	Days between spraying	Growth Stage	L/ha
7/11/97	-	15	All treatments 500 l/ha
13/11/97	6	19	All treatments 500 L/ha Topas 500 L/ha
27/11/97	14	24	All treatments 1000 L/ha Topas 1000 L/ha
10/12/97	13	27	All treatments 1000 L/ha Topas 2000 L/ha
19/12/97	9	31	All treatments 1000 L/ha
29/12/97	10	32	All treatments 1000 L/ha
9/1/98	11	33	All treatments 1000 L/ha

APPENDIX 15 - Verdelho spray records, Nuriootpa 1996/97.

Date	Days between spraying	Growth Stage	Treatment	Average L/ha #
15/11/96	-	16	½ RR Bayfidan ¼ RR Bayfidan ¼ RR Bayfidan + DCT Plus (1%) DCT Plus (1%)	330
28/11/96	13	23	½ RR Bayfidan ¼ RR Bayfidan ¼ RR Bayfidan + DCT Plus (1%) DCT Plus (1%)	410
11/12/96	13	27	½ RR Bayfidan ¼ RR Bayfidan ¼ RR Bayfidan + DCT Plus (1%) DCT Plus (1%)	670
23/12/96	12	31	½ RR Bayfidan ¼ RR Bayfidan ¼ RR Bayfidan + DCT Plus (1%) DCT Plus (1%)	750
8/1/97	16	32	½ RR Bayfidan ¼ RR Bayfidan ¼ RR Bayfidan + DCT Plus (1%) DCT Plus (1%)	670
16/1/97	8	33	½ RR Bayfidan ¼ RR Bayfidan ¼ RR Bayfidan + DCT Plus (1%) DCT Plus (1%)	915

= Average of all treatments applied on that day.

APPENDIX 16 - Columbard spray records, Loxton 1996/97.

Date	Days between sprays	Growth Stage	Treatment	L/ha
21/10/96	-	16	½RR Bayfidan	1320
			¼RR Bayfidan	1280
			¼RR Bayfidan + DCT Plus (1%)	1320
			DCT Plus (1%)	1000
12/11/96	22	24	½RR Bayfidan	320
			¼RR Bayfidan	350
			¼RR Bayfidan + DCT Plus (1%)	300
			DCT Plus (1%)	320
26/11/96	14	27	½RR Bayfidan	530
			¼RR Bayfidan	600
			¼RR Bayfidan + DCT Plus (1%)	530
			DCT Plus (1%)	530
10/12/96	14	29	½RR Bayfidan	530
			¼RR Bayfidan	500
			¼RR Bayfidan + DCT Plus (1%)	500
			DCT Plus (1%)	570
2/1/97	23	31	½RR Bayfidan	780
			¼RR Bayfidan	710
			¼RR Bayfidan + DCT Plus (1%)	710
			DCT Plus (1%)	780

APPENDIX 17 - Gamay and Red Globe spray records, Nuriootpa 1997/98.

Date	Days between spraying	Growth Stage	Treatment	L/ha
17/11/97	-	23	Mineral oil (1%) Mineral oil (1%)	500 1000
27/11/97	10	25	Mineral oil (1%) Mineral oil (1%)	500 1000
10/12/97	12	27	Mineral oil (1%) Mineral oil (1%)	500 1000
19/12/97	9	29	Bayfidan Bayfidan	500 1000
29/12/97	10	31	Bayfidan Bayfidan	500 1000
9/1/98	11	33	Bayfidan Bayfidan	500 1000
19/1/98	10	35	Bayfidan Bayfidan	500 1000

APPENDIX 18 - Gamay spray records, Nuriootpa 1996/97.

Date	Days between spraying	Growth Stage	Treatment	L/ha
15/11/96	-	16	DCT plus (1%)	420
28/11/96	13	25	DCT Plus (1%)	470
11/12/96	13	27-29	DCT Plus (1%)	520
23/12/96	12	31	DCT Plus (1%)	535
8/1/97	16	32	DCT Plus (1%)	520
9/1/97	1	32	Sulphur (300g/100L)	500
15/1/97	6	33	DCT Plus (1%)	520
16/1/97	1	33	Sulphur (300g/100L)	500

APPENDIX 19 - Red Globe spray records, Nuriootpa 1996/97.

Date	Days between spraying	Growth Stage	Treatment	L/ha
15/11/96	-	15-17	DCT Plus (1%)	400
28/11/96	13	23-27	DCT Plus (1%)	400
11/12/96	13	27-29	DCT Plus (1%)	500
23/12/96	12	31	DCT Plus (1%) Bayfidan (10ml/100L)	500 535
8/1/97	16	32	DCT Plus (1%) Bayfidan (10ml/100L)	600 535
16/1/97	7	33	DCT Plus (1%) Bayfidan (10ml/100L)	600 535

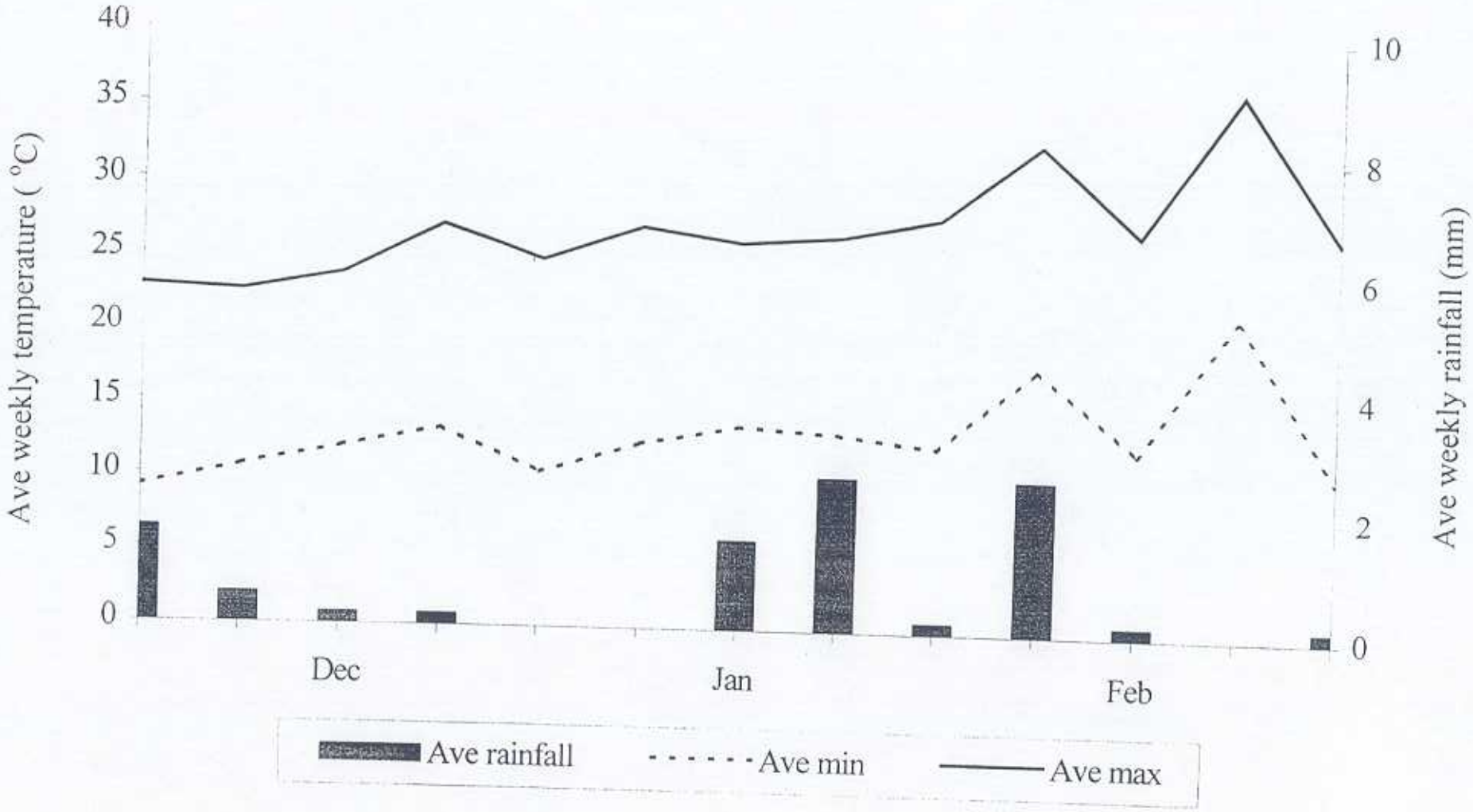
Appendix 20 - Sultana spray records, Loxton 1996/97.

Date	Days between spraying	Growth Stage	Treatment	L/ha
21/10/96	-	15-17	DCT Plus (1%) DCT Plus (2%) Bayfidan	1875 2000 2230
12/11/96	22	23-25	DCT Plus (1%) DCT Plus (2%) Bayfidan	420 450 560
26/11/96	14	25-27	DCT Plus (1%) DCT Plus (2%) Bayfidan	470 450 445
10/12/96	14	27-31	DCT Plus (1%) DCT Plus (2%) Bayfidan	520 610 610
2/1/97	23	31	DCT Plus(1%) DCT Plus (2%) Bayfidan	1090 1225 1110

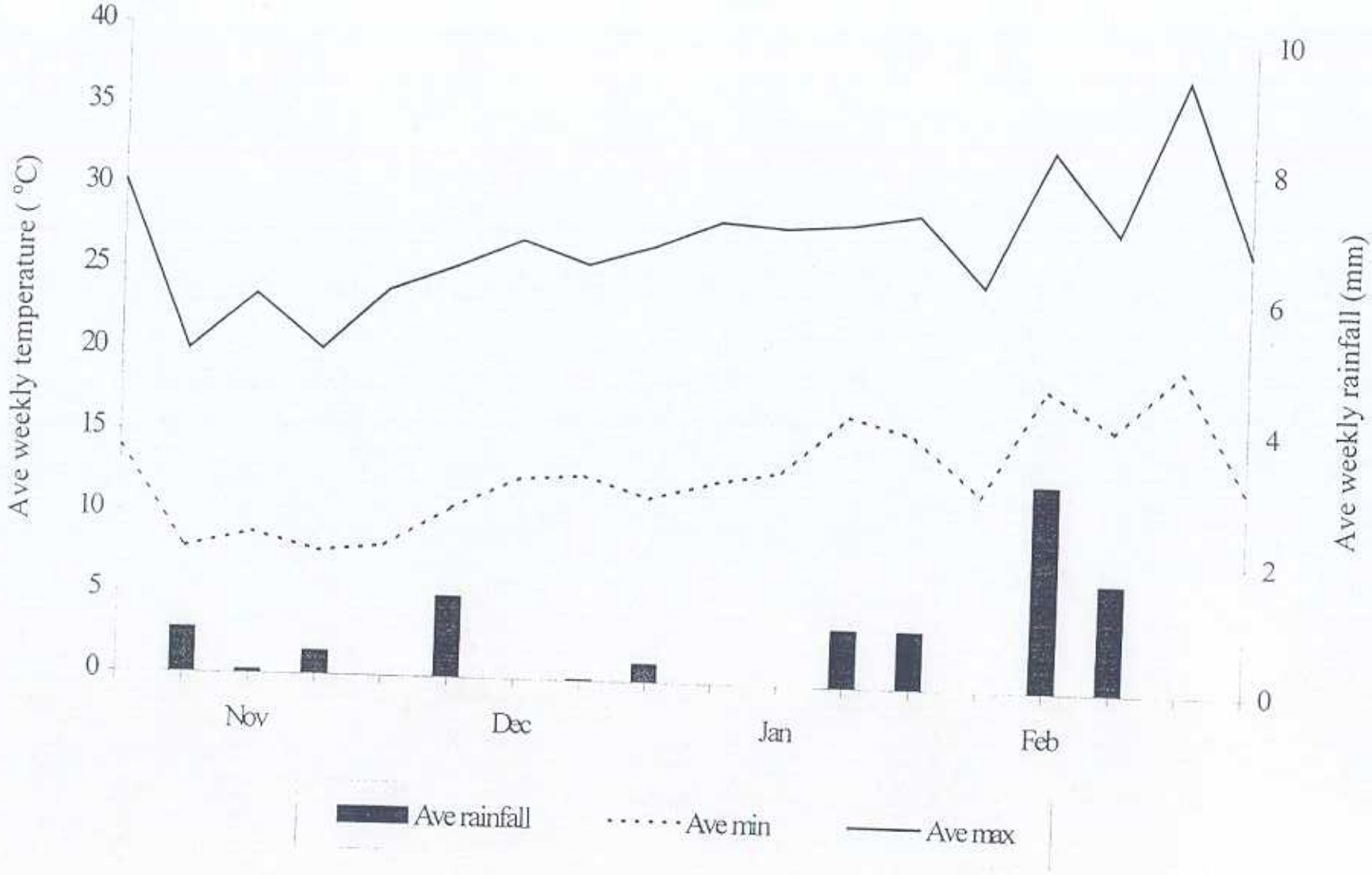
APPENDIX 21 - Rootstock variety trial spray records, Loxton 1996/97.

Date	Days between spraying	Growth Stage	Treatment	L/ha
12/11/96	-	17	DCT Plus (1%)	270
26/11/96	14	17-23	DCT Plus (1%)	350
10/12/96	14	23-31	DCT Plus (1%)	470
2/1/97	23	31	DCT Plus (1%)	600

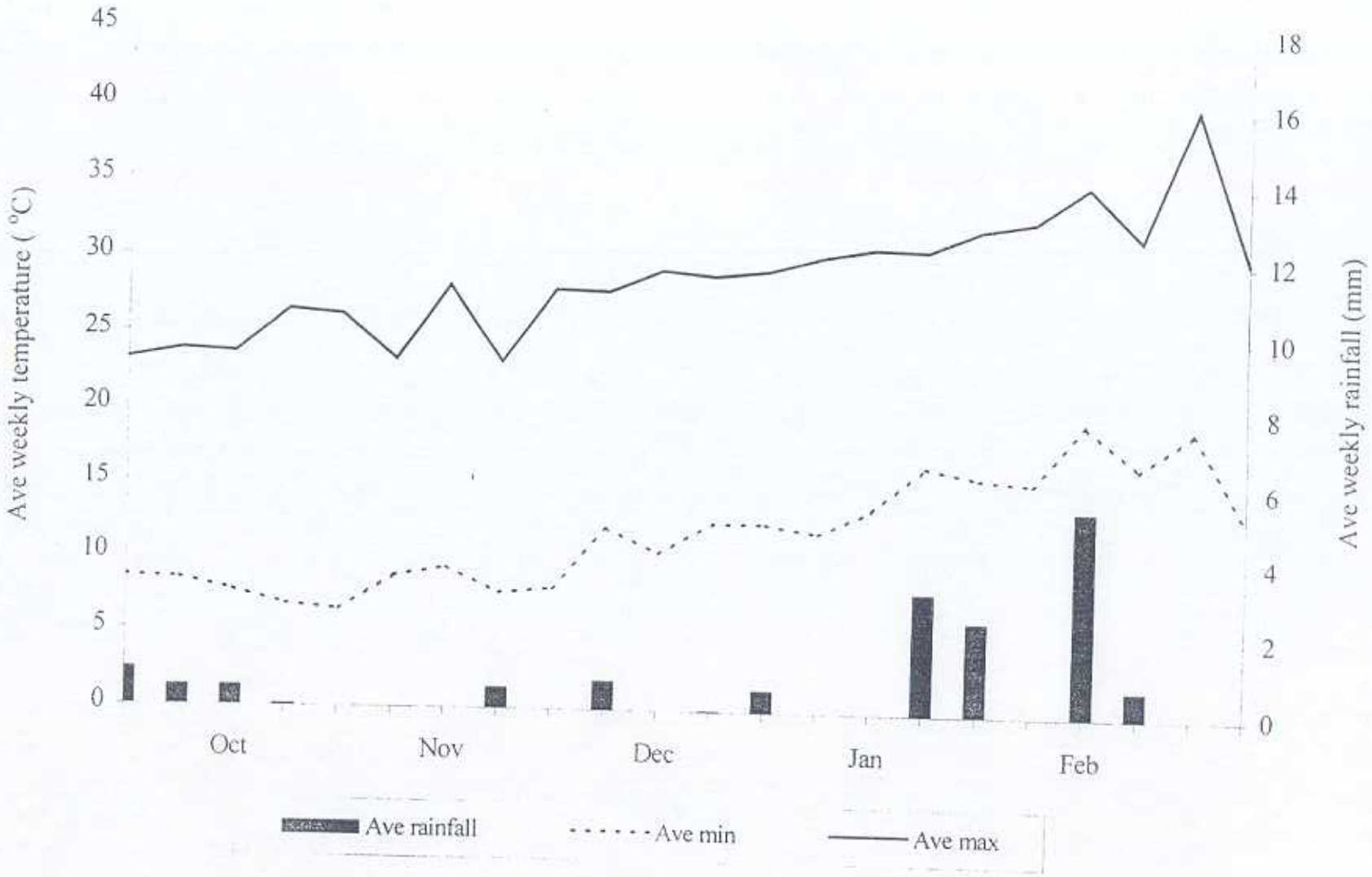
APPENDIX 22 – Rainfall and temperature for the Lenswood Research Centre, December 1996 to February 1997.



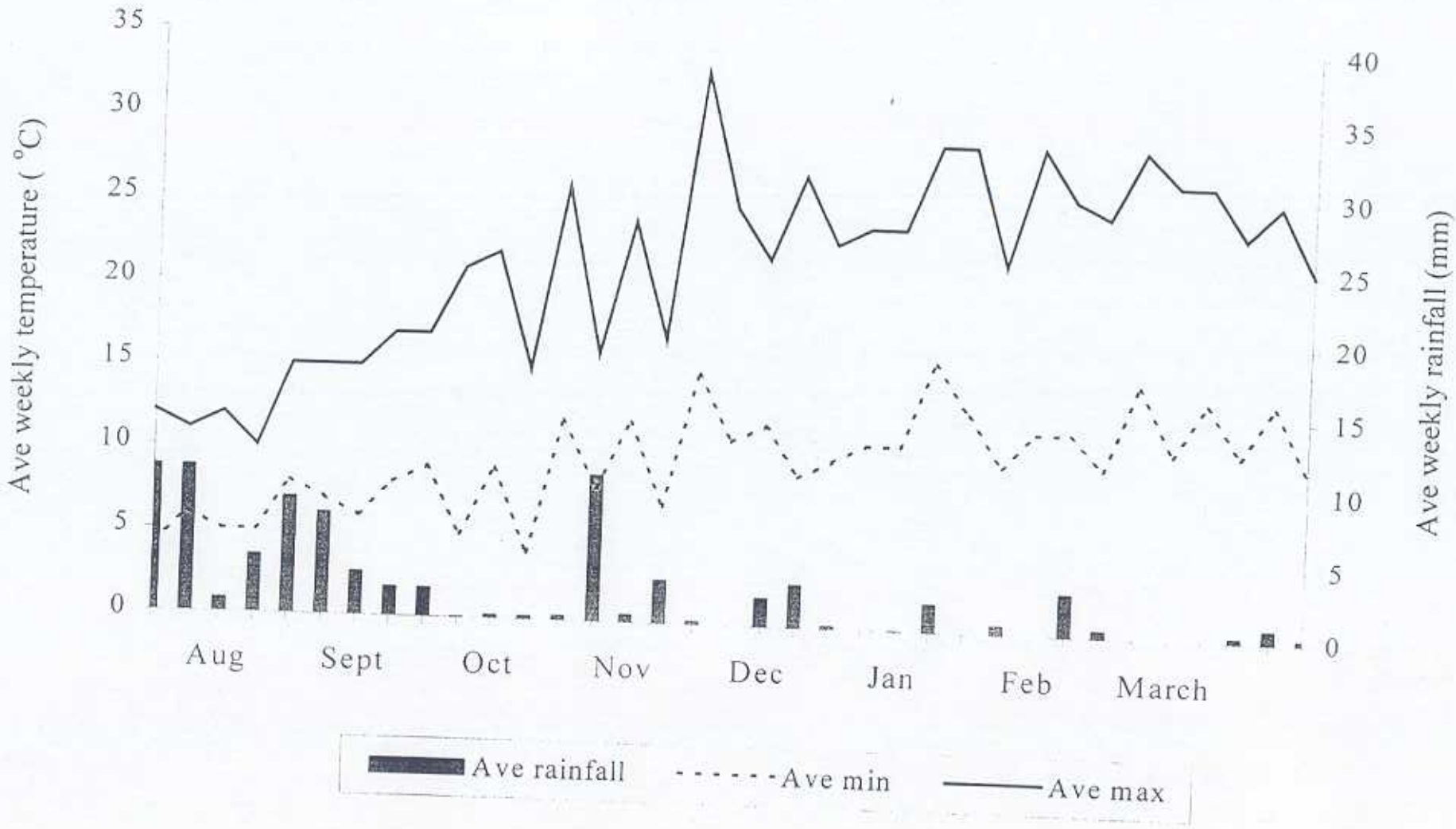
APPENDIX 23 – Rainfall and temperature data for the Nuriootpa Research Centre, November 1996 to February 1997.



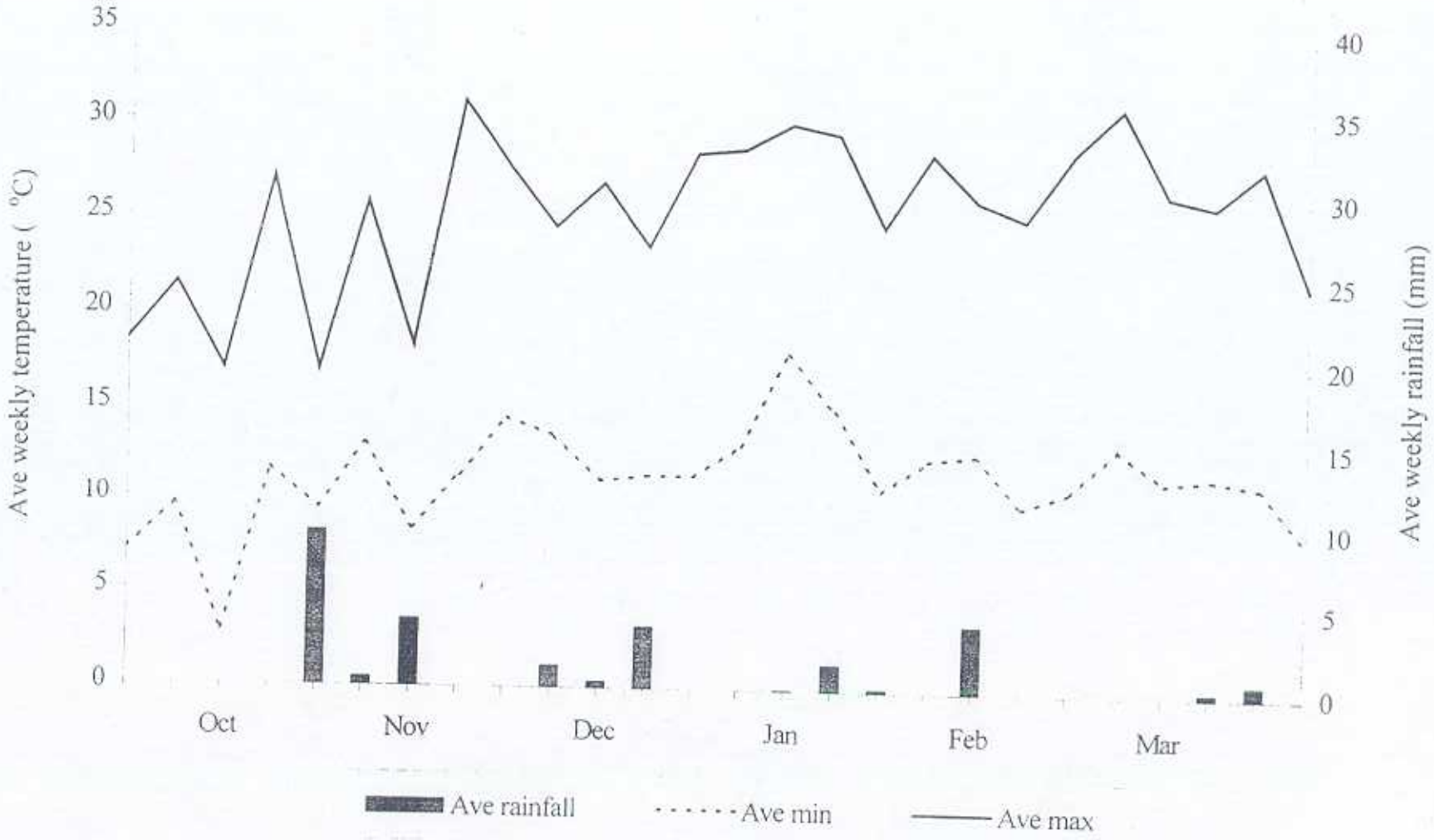
APPENDIX 24– Rainfall and temperature data for the Loxton Research Centre, October 1996 to February 1997.



APPENDIX 25– Rainfall and temperature data for Lenswood Research Centre, August 1997 to March 1998.



APPENDIX 26– Rainfall and temperature data for Nuriootpa Research Centre, October 1997 to March 1998.



DAS - 93/3

Control of grapevine powdery mildew with mineral oil: an assessment of oil concentration and spray volume

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Abstract

DC Tron, a highly refined mineral oil containing patented additives to prevent UV light induced breakdown, was evaluated in vineyards for control of powdery mildew. DC Tron suppressed development of powdery mildew but was not as effective as the conventional fungicide Topas. Of the oil treatments the 1% rate applied in spray volumes of 1000 L/ha was the most efficient. Poor control was achieved with oil rates less than 1% as well as spray volumes less than 1000 L/ha whereas phytotoxicity developed in many cases at concentrations greater than 1% or spray volumes higher than 1000 L/ha. In all oil treatments, powdery mildew developed less in leaves than on bunches. This difference was attributed to poor spray coverage on bunches compared to leaves.

Keywords: powdery mildew, mineral oils, spray volume, oil concentration

Abbreviations

C_{24} mineral oil average carbon number of a light, paraffinic solvent refined, hydrotreated oil; **DC Tron** registered trade name of a paraffinic spray oil; **DC Tron Plus** registered trade name of a C_{24} paraffinic spray oil with additives that provide protection against UV radiation; **DMI** dimethylation inhibiting fungicide; **Fenarimol** active ingredient of the registered fungicide Rubigan; **Penconazole** active ingredient of the registered fungicide Topas; **Topas** registered trade name of the fungicide based on penconazole; **Triadimenol** active ingredient of the registered fungicide Bayfidan.

Introduction

Powdery mildew caused by *Uncinula necator* is the most widespread and economically important fungal disease of grapes in Australia. The disease is found in all grape-growing districts of Australia and costs the industry over $30 million annually (Wicks et al. 1997). Although fungicides such as elemental sulfur and the demethylation inhibiting (DMI) materials triadimenol, fenarimol and penconazole control the disease, alternatives to these materials are needed. This is due to the problem of sulfur phytotoxicity in some seasons (Pearson and Gadoury 1992), sulfur residues if sprays are applied near harvest (Bulit and Lafon 1978) and the recent development of resistance to DMI-based fungicides (Gubler et al. 1996, Erickson and Wilcox 1997).

Non-conventional chemicals such as bicarbonates have controlled powdery mildew on other crops (Ziv and Zitter 1992) and preliminary experiments (Wicks and Magarey unpublished data) showed that a range of materials have potential for use on grapes. Oils were found to be effective on grape powdery mildew in laboratory and glasshouse tests and they have been used commercially for many years to control pests and

controlled powdery mildew on grapes in glasshouse experiments (Azam et al. 1995, Wicks et al. 1995) where oils were applied using hand-held sprayers.

Preliminary experiments also showed that the efficacy of oil sprays was dependent on adequate spray coverage. Moreover, we considered that spray coverage from hand-held application may differ from that achieved from commercial spray machines. Given these issues, we decided to undertake further field evaluation of a mineral oil applied with a spray machine.

We describe the comparative efficacy of different oil concentrations, spray volumes, and spray regimes that include various combinations of oil in the spray program.

General methods

Products and formulations

In most experiments, we used a C_{24} mineral oil DC Tron Plus, developed by Ampol Rural (Caltex Australia Petroleum Pty Ltd, Martin Place, Sydney). DC Tron Plus is a highly refined, emulsified mineral spray oil that has been photoprotected with an additive package (patented) that prevents UV light-induced breakdown of the oil, and

Australian Journal of Grape and Wine Research 5, 61–65, 1999

lation incorporated a separate base oil and spreader additive. When present in tank mixes at 0.08%, this additional formulation alleviated blending difficulties. The new formulation was slightly lighter and used a different emulsifier compared to DC Tron Plus (see Caltex Australia Petroleum Pty Ltd for complete details).

Sites

Experiments were carried out at either Lenswood or Nuriootpa Research Centres situated approximately 30 km east and 100 km north east of Adelaide, respectively.

At Lenswood the sprays were applied to 5-year-old Chardonnay vines planted 1.5 m apart at 3 m row spacings. Each row contained 40 vines trained to a single cordon vertical foliage system. Plots consisted of 8 vines each replicated 4 times and arranged in a randomised block with unsprayed buffer rows separating treatment rows.

Nuriootpa experiments were conducted on 9-year-old Chardonnay vines and 10-year-old Verdelho vines each planted 3.5 m apart at 2 m row spacings and trained to a single cordon wire. Chardonnay plots consisted of 9 vines with at least 5 replicates per treatment; Verdelho plots consisted of 6 vines plots with 4 replicates per treatment.

Plots in both Chardonnay and Verdelho plantings were arranged in randomised blocks where treated rows were separated by an untreated barrier row of vines to reduce spray drift between treatments.

Hydra spray unit

Sprays were applied with a 'Hydra' machine (Furness 1996) which featured two 500 mm diameter axial fans with 6 broad chord blades rotating at 1,600 to 3,000 rpm, a plastic fan shroud, 8 hollow cone swing nozzles, and a 415 volt 3 phase AC electric drive. Turbulence created by the axial fans, combined with converging air streams from the 2 fans, carried spray into the inner canopy of the vines. Small droplets were created by the spray cloud passing through the fan and being subjected to high air shear forces. Preliminary experiments (Wicks and Furness unpublished data) showed that the Hydra sprayer provided superior coverage to that achieved with a commercial 'Hardi' sprayer, particularly on bunches in the centre of the canopy.

Bunch and leaf sampling and assessment methods

Bunches and leaves were field-assessed for incidence and severity of powdery mildew. Twenty to fifty leaves or bunches were randomly selected from the middle vines of each plot. They were assessed *in situ* using a modified 0 – 10 rating scale where 1 = 1%, 2 = 2%, 3 = 5%, 4 = 10%, 5 = 20%, 6= 40%, 7 = 60%, 8 = 80%, 9 = 90% and 10 = 100% of bunches or leaves infected with mildew (method developed by Dr R.W. Emmett of Sunraysia Horticultural Centre, Mildura Victoria; pers. comm.).

Bunches and leaves were rated on at least 4 occasions starting after flowering in most experiments. Data from the final assessment was analysed with the Analytical Software package Statistix V4.1, using a general analysis of variance to generate values for least significant differences (LSD, P = 0.05).

Lenswood experiments

Experiment 1 – 1996/97

DC Tron Plus was applied at either 0.25, 0.5, 1 or 2.5% (v/v) on 5 occasions. Dates of application were 4, 19 and 27 December, and 9 and 23 January, which corresponded to growth stages 25, 29, 32, 33 and 35 respectively (Coombe 1995). Spray volume ranged from 800 to 900 L/ha for the first 3 applications to 1400 L/ha for the final 2 applications.

Experiment 2 – 1997/98

DC Tron Plus at 1% (v/v) was applied in spray volumes of either 500, 1000, 1500, or 2000 L/ha on each of 10 occasions. Application dates were 6, 12 and 20 November, 2, 12 and 23 December, 6, 15 and 23 January and 4 February, corresponding to growth stages 14, 15, 16, 19, 23, 27, 31, 32, 33 and 35 respectively.

Nuriootpa experiments

Experiment 3 – 1997/98

DC Tron Plus at either 0.5% or 1% (v/v) was applied on 9 occasions in spray volumes of 500 L/ha for the first 3 applications and thereafter at either 500, 1000 or 2000 L/ha. Application times were 29 October, 5, 17 and 27 November, 10, 19 and 29 December, 19 January and 4 February corresponding to growth stages 13, 15, 17, 19, 23, 27, 31, 33 and 35 respectively.

Experiment 4 – 1997/98

DC Tron Plus was applied at 1% (v/v) in spray volumes of 100, 200, 500, 1000 and 1500 L/ha on 15 and 28 November and 17 and 23 December, which corresponded to growth stages 17, 23, 29 and 31 respectively.

Table 1. Spray regimes for Verdelho vines, Nuriootpa 1997/98 growing season. Treatment 6 = unsprayed control.

Treatment	7/11/97	17/11/97	27/11/97	10/12/97	19/12/97	29/12/97	9/1/98
1	Topas	Oil	Topas	Oil	Topas	Oil	Bayfidan
2	Oil	Oil	Topas	Topas	Topas	Oil	Bayfidan
3	Oil	Oil	Oil	Oil	Oil	Oil	Oil
4	Oil	Topas	Topas	Topas	Oil	Oil	Bayfidan
5	Oil	Topas	Topas	Topas	Oil	Oil	Bayfidan
6	–	–	–	–	–	–	–

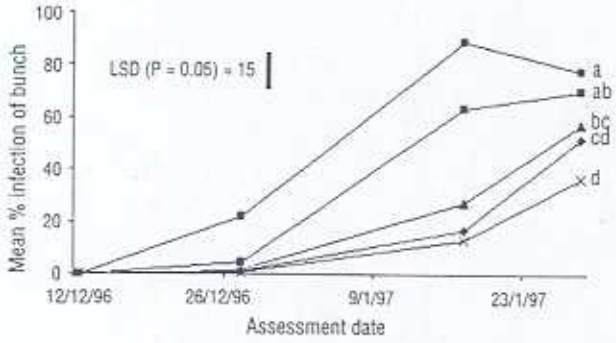


Figure 1a. Severity of powdery mildew on Chardonnay bunches unsprayed (●) and sprayed with DC Tron Plus oil at 0.25% (■), 0.5% (▲), 1% (◆) or 2.5%(×) Lenswood 1996/97.
Means with no letter in common are significantly different (P = 0.05).

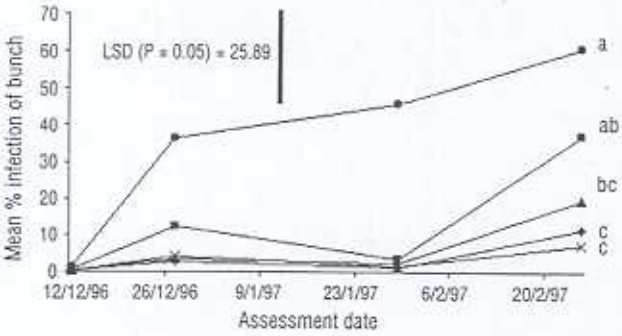


Figure 1b. Severity of powdery mildew on Chardonnay leaves unsprayed (●) and sprayed with DC Tron Plus oil at 0.25% (■), 0.5% (▲), 1% (◆) or 2.5%(×) Lenswood 1996/97.
Means with no letter in common are significantly different (P = 0.05).

Experiment 5 – 1997/98

Various combinations of 1% DC Tron Plus (v/v) and Topas (10% v/v penconazole) at 150 mL/ha were applied either alone or as shown in Table 1 and at a spray volume of 1000 L/ha. Due to the unavailability of Topas, Bayfidan (25% v/v triadimenol) was used as the final spray in some treatments.

Results

Experiment 1

Powdery mildew was detected at low levels on less than 5% of bunches in the unsprayed plots on 12 December. However, by mid January the disease had spread within these vines to infect around 80% of berries. Assessment of disease severity showed that all oil treatments suppressed development of mildew on bunches (Figure 1), with the most inhibitory effect produced at a concentration of 2.5%. Bunch weights were not significantly different (P = 0.05) although bunches treated with 2.5% concentration of oil were 1 to 3 g less than those of other oil treatments.

Mildew development on leaves was suppressed to some extent by all rates of oil application compared with unsprayed control vines (Figure 1b). The disease continued to develop after spraying ceased, and especially

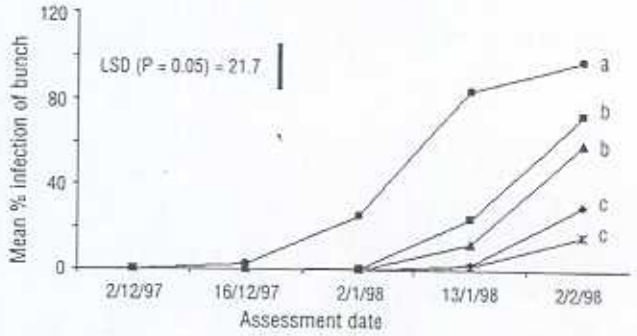


Figure 2. Severity of powdery mildew on Chardonnay bunches unsprayed (●) and sprayed with 1% DC Tron Plus oil at 500 (■), 1000 (▲), 1500 (◆) or 2000 (×) L of water/ha Lenswood 1997/98.
Means with no letter in common are significantly different (P = 0.05).

Experiment 2

Development of powdery mildew in unsprayed bunches was similar to that of the previous season. Most bunches were severely infected by mid January. Severity assessments showed that all oil treatments suppressed development of mildew, and that suppression was more effective with greater spray volume (Figure 2).

Mean bunch weights from oil treatments ranged between 70 and 80 g per bunch and were not significantly different except from that of unsprayed bunches which had a mean weight of 50 g per bunch.

Suppression of mildew on leaves showed the same trend as that on bunches, but the effect was greater with leaves than on bunches. Less than 5% of the leaf area of treated vines was diseased compared with around 30% of leaves on unsprayed control vines. Marginal leaf necrosis developed in all spray treatments, with severity of phytotoxicity lowest in the 500 L/ha treatment and most severe in the 2000 L/ha treatment.

Experiment 3

Although disease severity was low in this experiment, the incidence of disease did show that all oil treatments inhibited development of powdery mildew on bunches compared with that in the unsprayed plots (Figure 3). Least effective oil treatments included those of lowest concentration or of lowest spray volume. Conversely, the

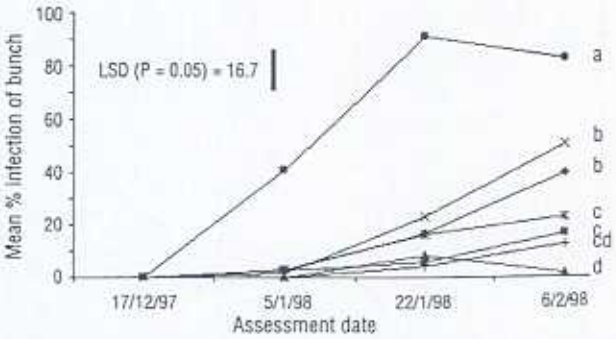


Figure 3. Severity of powdery mildew on Chardonnay bunches unsprayed (●) and sprayed with 0.5% DC Tron Plus oil at 500 (■), 1000 (◆), or 2000 (+) L of water/ha or 1% DC Tron Plus oil at 500 (▲), 1000 (×) or 2000 (✳) L of water/ha Nuriootpa 1997/98.

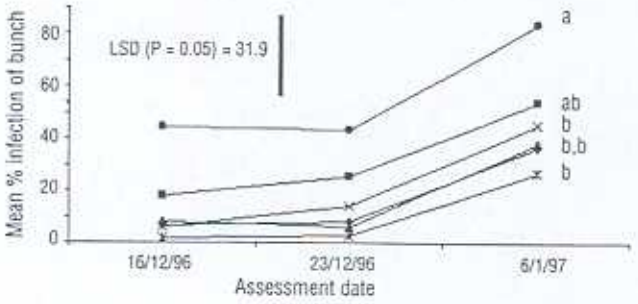


Figure 4. Severity of powdery mildew on Chardonnay bunches unsprayed (●) and sprayed with 1% DC Tron Plus oil at 100 (■), 200 (▲), 500 (×), 1000 (✳) or 1500 (◆) L of water/ha, Nuriootpa 1997/98.
Means with no letter in common are significantly different (P = 0.05).

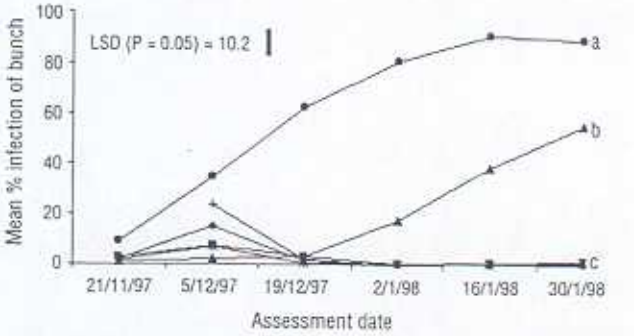


Figure 5. Severity of powdery mildew on bunches od Verdelho grapes unsprayed (●) or sprayed with 1% DC Tron Plus oil alone (▲) alternating Topas and oil (×), Nuriootpa 1997/98.
All treatments described in Table 1 are not shown as disease severity in treatments 1, 2, 4 and 5 are similar.

most effective oil treatments corresponded to higher rates and greater spray volumes. No significant difference in bunch weights was detected between treated and untreated vines.

Marginal leaf burn did develop due to oil treatment, with visible symptoms of phytotoxicity increasing according to spray volume and oil concentration.

Experiment 4

Disease severity assessments showed that powdery mildew was inhibited by all the oil treatments. Although there was no significant differences between different oil treatments, the efficacy of oil treatment did improve as the spray volume increased (Figure 4). Suppression of mildew on leaves showed a trend similar to that on the bunches, with less disease on those treatments sprayed at the highest spray volumes (1000 and 1500 L/ha).

Experiment 5

Powdery mildew was well established at the time of applying the first spray due to the high incidence of 'flag shoots' in this planting. By the third spray in late November, nearly 80% of bunches on untreated vines were infected with powdery mildew, whereas less than 50% of bunches were infected in most of the other treatments. Assessments of disease severity showed that oil sprays alone inhibited development of powdery mildew compared with unsprayed control vines (Figure 5), but oil sprays alone were not as effective as any other treatment that included Topas.

Mean bunch weight of 16 g for unsprayed vines in this experiment was significantly less than that of sprayed vines which ranged between 45 and 70 g. No significant difference was detected between the sprayed treatments.

Discussion

Various rates of mineral oils applied to vines in different spray volumes showed that both oil concentration and spray volume were critical in the use of oils for the control of powdery mildew. In our experiments, an oil concentration of 1% (v/v) in water, and applied at volumes of 1000 L/ha, was the most efficient combination higher rates were phytotoxic. Moreover, when rates were kept constant and spray volume varied, the most efficient water volume was 1000 L/ha. Spray volumes lower than this were less effective and higher volumes phytotoxic to grapevines. However none of the oil treatments reduced yield, even where marginal leaf burning was severe.

Taken overall, present results have shown that mineral oil controlled powdery mildew, but that the efficacy of mineral oil depended on spray coverage. Control of powdery mildew on leaves was relatively easy to achieve whereas powdery mildew was only controlled on bunches that were near the outside of the canopy and well exposed to spray. Powdery mildew was difficult to control on bunches in the centre of the canopy or where parts of bunches were protected by leaves blown over the bunch during spraying. Indeed, the extent of powdery mildew infection in most of the oil treatments would have made the bunches unsuitable for winemaking. As Ough and Berg (1979) have reported, wine made from fruit lots where ≥3% of berries are infected with powdery mildew will develop aromas adverse to overall quality.

Noting a trend for spray volume applications as low as 100 L/ha in Australian vineyards, oils applied at that rate would be insufficient for control of powdery mildew unless new spray technology is developed to improve spray coverage on bunches in dense canopies.

While our results showed that 1% mineral oil applied at 1000 L/ha controlled powdery mildew and reduced the incidence and severity of disease compared with unsprayed vines, the control achieved was inferior to that obtained with a conventional fungicide such as penconazole. Nevertheless, we have observed good control of powdery mildew with oils when they were used on young (less than 4-year-old) vineyards where the canopy was underdeveloped and the level of powdery mildew inoculum low. Oil sprays may be appropriate in those situations.

Since our work was started two papers have reported good control of powdery mildew by mineral oil. Northover and Schneider (1996) reported that 3 petro-

these workers did not assess bunch infection, their results confirm those of our experiments showing that oils applied in high volumes of water are very effective in controlling powdery mildew on leaves. Northover and Schneider (1996) also reported on regrowth and subsequent reappearance of powdery mildew after treatment. This also occurred in our experiments.

In another publication, Dell et al. (1998) reported that up to 6 applications of a highly refined petroleum oil controlled powdery mildew on grapevines and was comparable to the DMI fungicides. The level of control on bunches was much greater than that achieved in our experiments. Greater control in that case can be explained on two grounds, viz. (i) use of a higher (2%) rate of oil that was applied by hand-gun spraying, and (ii) the vines were spur pruned and trained to bilateral cordons on either a 'T' trellis or 3-wire trellis. A combination of hand-spraying, where spray was probably directed onto bunches, and a trellising type which provided a more open canopy, were likely to result in better spray coverage and therefore better control than we achieved with the 'Hydra' sprayer.

Dell et al. (1998) also reported that oil applied in a vineyard had no detrimental effect on subsequent fermentation of harvested grapes, but further work is needed to demonstrate that oil residues do not carry over and impart flavours that may compromise wine quality.

Our results also demonstrate the importance of undertaking field experiments utilising commercial spray machines and not merely extrapolating results from glasshouse experiments to commercial recommendations. For example, in numerous glasshouse experiments where oils were applied with hand-held sprayers to pot-grown grapevines (raised as either seedlings or from cuttings) oils have controlled powdery mildew and were equivalent to conventional fungicides. This impression can be attributed to disease assessment that was limited to leaves plus good spray coverage by high application volumes from a hand sprayer. Such glasshouse tests give no useful indication of spray coverage by oils for control of powdery mildew on bunches in field plantings that are sprayed with an air blast machine.

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