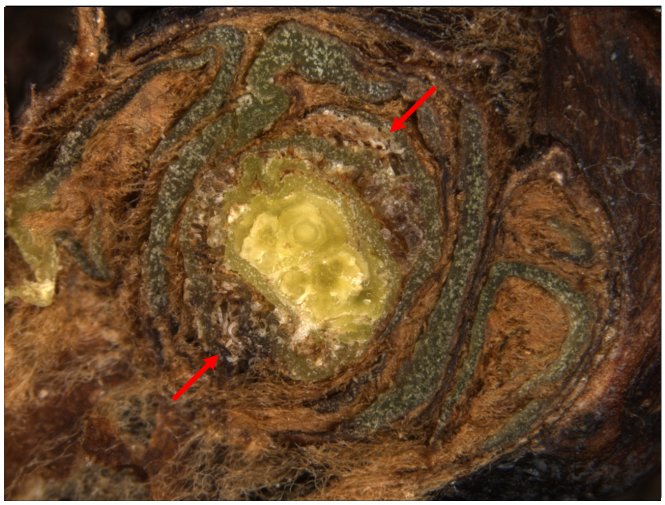
The Role of Eriophyid Mites in Yield Decline in Cabernet Sauvignon in Western Australia



Cross-section of a bud infested with grapevine bud mite (clusters of mites at arrows) in a block of Cabernet Sauvignon, winter 2010

FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **RD 08/02-1**

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Research Organisation:
Department of Agriculture and Food, Western Australia

Date Report Completed**: 11 April 2011**

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1. Abstract
This project sought to determine whether yield decline in Cabernet Sauvignon grapes in the Margaret River region of Western Australia was caused by bud infesting mites. This variety was the most heavily infested according to bud dissection data available. In two vineyards chosen for this study, the species involved was identified as grapevine bud mite where the infestation levels were 40% and 70%.

A range of chemical products was applied to grapevines in the two vineyards during spring to attempt to exclude the mite to compare yield levels in the subsequent season to untreated vines.

Although paraffin oil, the insecticide carbaryl and the miticide tebufenpyrad resulted in some reduction in mite abundance, the effect was not as great as expected. This reduction did not result in significant increases in bud health or vine growth measured as shoot number and health, bunch number or yield.

Assessment of these parameters of mite presence or vine characteristics was also made in adjacent vines that had been either spur- or cane- pruned the previous season. No significant effects of pruning method were found.

Two species of predatory mites were recorded associated with the grapevine bud mite infestations. Their effect on a mite that occurs outside buds for such a limited portion of its life cycle was thought to be minor, but could form part of an integrated approach to management.

Further work is required to identify chemicals or methods that can successfully control grapevine bud mite to fully assess its pest status in Cabernet Sauvignon.

2. Executive summary

This project had the objective of comparing untreated vines infested with grapevine bud mite to treated vines to determine whether the mite was causing yield decline in Cabernet Sauvignon grapes in the Margaret River region of Western Australia. One of the vineyards studied had recently converted a portion of vines to cane pruning from spur pruning. Measuring the effect of this on mite abundance and consequent effect of yield was included.

The miticide treatments did not result in significant reduction in mite presence and no difference in vine growth characteristics or yield among the treatments for mite control was found. There were no significant difference between cane and spur pruning on mite abundance, vine growth characteristics or yield.

Further work is required to identify successful mite suppression methods in order to clarify the pest status of grapevine bud mite on yield in Cabernet Sauvignon.

Two species of predatory mite were identified in the study vineyards, but their role in mite management would only at best be seen to supplement other tactics in mite management.

This project received financial support from the Grape and Wine Research and Development Corporation, and Pialligo and Voyager Vineyards of Western Australia.

3. Background

Over the past five years, a number of vignerons in the Margaret River region of Western Australia have noticed a decline in the yield of up to 50% in the variety Cabernet Sauvignon. Because of their concern over this issue vignerons have considered reworking or replacing the vines. At present, they prefer to seek solutions to the problem for what they consider to be a valuable variety.

Some vignerons involved have regularly submitted cane samples for bud dissection. As part of the dissection service, information on the presence of mites in buds has been provided. Infestation levels of around 30% have been found consistently in the Cabernet Sauvignon blocks suffering yield decline (Jim Campbell-Claus, AHA Viticulture Per comm and see Appendix 5a for detailed results of bud dissections). Such levels of bud infestation contrasted with the virtual absence of mites in other varieties on the same vineyards in which no yield decline was observed.

Because Cabernet Sauvignon is one of the last varieties to shoot in spring and affected blocks have a known high infestation level of a bud-infesting mite, this provided reasonable justification for clarifying whether mites were the primary cause of yield decline in this particular variety.

The mite found in buds was identified as grapevine bud mite, *Colomerus vitis* (Pagenstecher). This is unlike the other common eriophyid mite found in Western Australian vineyards, the grapeleaf rust mite (*Calepitrimerus vitis* (Nalepa)), because bud mite spends most of its life cycle within buds. It moves out only in spring as buds shoot. The bud mites spend a short time exposed on the young shoots before moving into next season's buds.

This mite has been implicated in yield decline in grapevines through damage to emerging shoots in spring which affects bunch health and later yield. Many workers have described the damage (for example in Australia by Buchanan and Amos 1992 and Bernard et al. 2005; in South Africa by Whitehead et al. 1978 and Dennill 1986; in USA by Smith and Schuster 1963 and reviewed in Lindquist et al. 1996).

Much detailed research has been conducted on grapevine bud mite biology overseas (for example Dennill 1986, 1991), with less in Australia. This is in comparison to the very detailed studies conducted on rust mite by Bernard et al. (2000, 2005) and more recently in USA by Walton (2010). There has been little recent research reported on the management of bud mite, either in Australia or overseas.

Applying treatments against bud- and vine-infesting eriophyid mites to Cabernet Sauvignon in vineyards during spring according to recommendations by Bernard et al. (2000), has not reversed the trend of declining yield. This may be the result of assumptions made regarding mite identification - rust mite or bud mite. While both species can cause similar symptoms of damage to vines in spring (Bernard et al. 2005), their biology differs to such an extent that appropriate management for each species differs (Dennill 1986, 1991; Lindquist et al. 1996; Bernard et al. 2005). In one study in South Africa a total of three sprays 14 days apart and commencing from 'budding' swell resulted in a greater reduction in mite numbers compared to a program that commenced at shoots 100 mm (De Klerk 1985).

These factors suggest the need for detailed information on mites inhabiting the buds of Cabernet Sauvignon in order to clarify their possible role in the yield decline reported in this variety.

4. Project aims and performance targets

The aim of the project was to determine whether eriophyid mites in buds of Cabernet Sauvignon result in yield decline. Progressive objectives included demonstration that chemical treatments successfully controlled eriophyid mites in Cabernet Sauvignon vines - efficacy of four types of miticide on eriophyid mites - and then whether vines free of eriophyid mites sustain less bud damage in spring and subsequently result in higher yield.

The opportunity arose to compare spur and cane pruning on mite abundance in adjacent rows of Cabernet Sauvignon in one of the study vineyards.

The project also sought to clarify the identity of mites, both pest and beneficial, inhabiting buds of Cabernet Sauvignon vines.

The Outputs and Performance Targets over the two seasons of the project were:

Outputs	Performance Targets	Target Date
	2008/09	
1.	Report to GWRDC on progress assessing the efficacy of miticides in reducing the abundance of mites inhabiting buds of Cabernet Sauvignon and more detail on the species of eriophyid mites and their natural enemies in Cabernet Sauvignon in season one.	July 2009
	2009/10	
1.	Present one article for publication in a national industry magazine on progress in the project.	October 2009
2.	Report to GWRDC on progress assessing the efficacy of miticides in reducing damage to buds and shoots of Cabernet Sauvignon in spring in season two.	January 2010
3.	Final report to GWRDC on the project.	June 2010
4.	Present one article for publication in a national industry magazine on results in the project.	October 2010

5. Method

The mites infesting the buds of two vineyards in this study were identified to be grapevine bud mite (Knihinicki, New South Wales Department of Industries and Investment, Primary Industries mite taxonomic service, pers comm). The treatments applied to attempt to reduce the abundance of this mite were based on products registered for use in Australian vineyards (Fisher and Learmonth 2009). These included sulphur and carbaryl. Although dicofol is registered for use against mites, this product was regarded as unsuitable because it had no reputation locally as being successful in controlling this group of mites, and in any case is unlikely to be available for use in the near future. Carbaryl has been used successfully in Western Australia against the other common grapevine eriophyid mite, grapevine rust mite. Likewise, sulphur and oil have been used successfully to control grapeleaf rust mite (Bernard et al. 2005). In the selection of a conventional miticide for activity against eriophyid mites, one study showed the ficus mottle mite, *Aceria ficus,* was controlled by the miticide tebufenpyrad (Ahihara et al. 2004). This miticide is registered for use in Australian deciduous fruit tree orchards and although it has some activity against predatory mites, has a short residual activity time (www.goodbugs.org.au/chemicals.html, 2011). This miticide was also included.

From the literature review described above, the spray program was devised to disinfest vines of bud mite. Chemicals listed in Table 1 were applied at approximately weekly intervals to plots in a randomised complete block design trial within two commercial vineyard blocks of Cabernet Sauvignon that had a history of infestation with bud-inhabiting mites.

Table 1. Miticides applied to vines to control grapevine bud mite.

Treatment (active ingredient, concentration)	Rate applied
Untreated	Untreated control
Water only	Water check
Sacoa Biopest Oil (paraffinic oil 815 g/L)	2 L/100 L
Wettable sulphur WP (800 g/kg)	500 g/100 L
Pyranica (tebufenpyrad 200 g/kg)	50 g/100 L
Carbaryl Flowable (500 mL/L)	200 mL/100 L

The size of plots for treatment consisted of one complete panel of four vines for all measurements and two half panels (two vines) at each end of the complete panel acting as buffers. Vines in both vineyards were spur-pruned. Miticides were applied to run-off using a backpack Hardi sprayer commencing at bud swell and continuing to early shoot development in spring 2008. Over this time, miticides were applied on five occasions at approximately weekly intervals: 24 September, and 1, 7, 15 and 22 October. The vine growth stage according to the definitions of Coombe (1995) was recorded at each time of application.

While no effect of control of bud mite on fruit load in vines was expected at the end of the first season after application of miticides (Bernard et al. 2005), a bunch count was undertaken in both vineyards near vintage in autumn 2009.

The main assessment of the effect of these applications was based on:

- mite abundance in buds and bud damage by dissection of buds after vintage in 2009
- shoot health and number in spring 2009
- bunch numbers in early summer 2009/10
- yield in 2010
- mite abundance in buds and bud damage by dissection of buds after vintage in 2010.

The vines in the block where trial area at Vineyard 1 was located, were removed in the 2009/10 summer, so no further measurements could be made at that site.

In Vineyard 2, four adjacent rows near the spray trial site had been cane-pruned in winter 2009. A comparison of vine health and yield, and bud mite abundance between the edge row of the cane-pruned area and the adjacent spur-pruned row was made. For this, 10 panels selected as every second panel down each row were assessed for:

- shoot health and number and bunch numbers in November 2009
- yield in 2010
- mite abundance in buds and bud damage by dissection of buds after vintage in 2010.

Mite abundance in buds and health of buds were assessed in the four basal buds of five canes. The canes were selected near the crown of four vines in each main panel, with two canes selected from one of the two central vines of each panel. Buds were examined under a dissecting microscope in the laboratory to determine whether mites were present and whether they had adversely affected buds. For this, buds were sectioned in sequential thin layers using a one-sided razor blade.

In winter 2009, for each main bud, bud health and mite presence were assessed for the primary, secondary and tertiary buds individually. In winter 2010, for each main bud the abundance of pest and predatory mites was grouped for primary, secondary and tertiary buds.

During the dissection of buds, they were defined as healthy, questionable (where buds looked affected by mites such as with brownish/discoloured bud scales) or necrotic (severely discoloured to dead). The abundance of bud mites was recorded as absent or present at densities rated as low (1-5 mites per bud), medium (6-20 mites per bud) or high (more than 20 mites per bud).

Identification of beneficial mites from each vineyard was provided also by Danuta Knihinicki of New South Wales Department of Industries and Investment, Primary Industries mite taxonomic service.

6. Results

The growth stages of the vines in the two vineyards where chemicals were applied to control bud mites are listed in Table 2.

Table 2. The dates and growth stages of Cabernet Sauvignon grapevines in two commercial vineyards during the application of chemicals to control grapevine bud mite in Margaret River, Western Australia.

Date	Vineyard 1		Vineyard 2	
	E-L Growth stage	Comment	E-L Growth stage	Comment
10-Sep-08	2	budswell		dormant
17-Sep-08	3	dormant to 1st leaf	4	budswell to 2 leaf
23-Sep-08	3 to 9		3 to 7	50% at rosette
1-Oct-08	5 to 9	10% at 9	4 to 11	10% to 90%
7-Oct-08	5 to 12	50% to 50%	12 to 15	10% to 90%
15-Oct-08	12	100%	12	80% at 12
22-Oct-08	15	90% at 30 to 40 cm	12 to 14	30cm

Rainfall occurred frequently during the period of miticide application. Rainfall for September and October 2008 which covers this duration is shown in Figure 1.

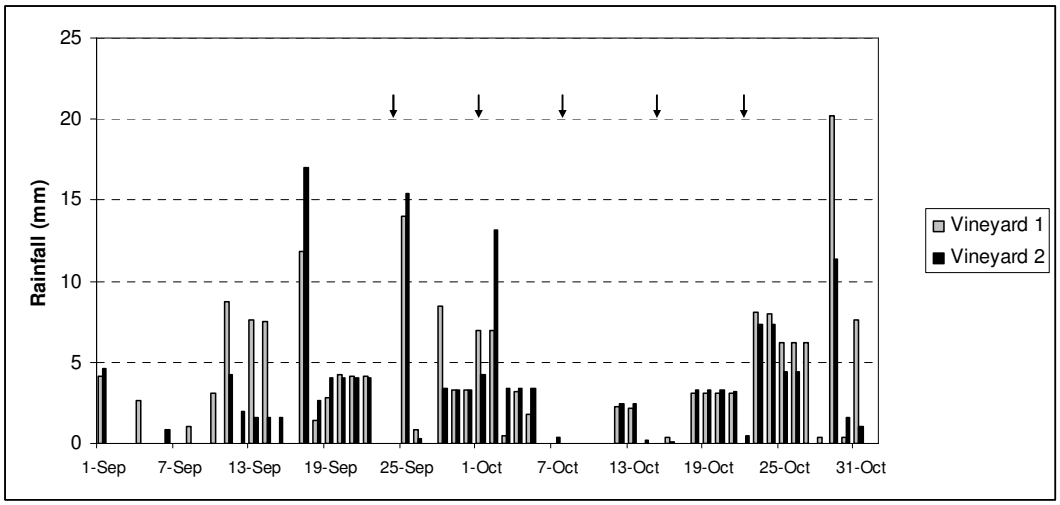


Figure 1. Daily rainfall at weather stations near two vineyards when miticide sprays were applied in an attempt to control eriophyid mites. Arrows indicate dates of application of miticide.

Chemical treatments

Bunch counts in autumn 2009

The average number of bunches on vines in both vineyards for each of the spraying treatments is shown in Table 3.

As expected, there was no significant difference among treatments so soon after the application of miticides. Any reduction in damage to the vines from bud mite as a result of the treatments would not appear until the following season because damage from bud mite occurs during the growing season to be expressed in new vine growth in the following spring.

Table 3. Average number of grape bunches per panel in two vineyards at the end of the first season after a range of miticides was applied in the previous spring to control bud mite.

Treatment	Vineyard1	Vineyard2
Untreated	64.0	71.8
Water only	75.2	69.6
Biopest Oil	73.2	67.2
Wettable sulphur	77.8	68.0
Pyranica	61.4	80.6
Carbaryl	76.4	68.4
LSD $_{0.05}$	22.4 (ns)	15.7 (ns)

Mite abundance in buds and bud damage in winter 2009

For Vineyard 1, the average across the five replications of the proportion of the combined primary, secondary and tertiary buds for the total of 20 buds examined per treatment plot that were healthy or necrotic for each of the six treatments is given in Table 4a.

There was no significant difference in bud health among the treatments.

For Vineyard 2, the average across the five replications of the proportion of the combined primary, secondary and tertiary buds for the total of 20 buds examined per treatment plot that were healthy or necrotic for each of the six treatments is given in Table 4b.

There was no significant difference in bud health among the treatments.

Table 4a. Average percentage of healthy and necrotic buds (primary, secondary and tertiary combined) in Vineyard 1 at the end of the first season (June 2009) after a range of miticides was applied in the previous spring to control bud mite. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant).

Treatment	Healthy	Necrotic
Untreated	84	8
Water only	85	9
Biopest Oil	91	5
Wettable sulphur	86	7
Pyranica	86	10
Carbaryl	93	3
LSD $_{0.05}$	8 (ns)	5 (ns)

Table 4b. Average percentage of healthy and necrotic buds (primary, secondary and tertiary combined) in Vineyard 2 at the end of the first season (June 2009) after a range of miticides was applied in the previous spring to control bud mite. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant).

Treatment	Healthy (%)	Necrotic (%)
Untreated	94.3	0.3
Water only	87.0	4.3
Biopest Oil	98.0	1.3
Wettable sulphur	91.3	4.7
Pyranica	91.7	3.7
Carbaryl	94.3	3.3
LSD $_{0.05}$	10.9 (ns)	4.6 (ns)

The data on mite abundance in buds were assessed for each of the four buds per cane based on a score for the combined presence of mites in the primary, secondary and tertiary buds. Combining the mite presence was the method adopted because of their proximity to each other within each main bud and the time taken in assigning mites to these individual buds within the main bud. The abundance of mites was scored as absent, low = 1 to 5 mites; medium = 6 to 20 mites and high = more than 20 mites. This scoring system was adopted to enable processing of the large number of canes and buds examined and the occasional presence of hundreds of bud mites which would only have been reasonably accurately counted after much time was devoted to such a task. For the purpose of statistical analysis, these scores of abundance were converted to a mite number per bud using the factors 1 for low, 2.5 for medium and 25 for high.

For Vineyard 1, the average across the five replications of the proportion of the combined primary, secondary and tertiary buds for the total of 20 buds examined per treatment plot that were uninfested, infested at high density and mite number for each of the six treatments is given in Table 5a.

The only significant effects of the chemicals in Vineyard 1 was a greater proportion of uninfested buds in the oil and carbaryl treated vines, a reduced level of buds infested at the "high" category in carbaryl treated vines and reductions in mite number for oil and carbaryl treated vines compared with untreated and water treated vines.

Table 5a. Average percentage of uninfested buds, buds infested with bud mite at "high" density and bud mite number (see text for explanation) for primary, secondary and tertiary buds combined in Vineyard 1 at the end of the first season (June 2009) after a range of miticides was applied in the previous spring to control bud mite. Also included are the $LSD_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Treatment	Uninfested (%)	Infested at "High" (%)	Mite number
Untreated	36	44	252
Water only	26	54	278
Biopest Oil	55	31	161
Wettable sulphur	41	48	244
Pyranica	46	39	202
Carbaryl	61	28	144
$LSD_{0.05}$	18 (**)	15 (*)	78 (**)

For Vineyard 2, the average across the five replications of the proportion of the combined primary, secondary and tertiary buds for the total of 20 buds examined per treatment plot that were uninfested, infested at high density and mite number for each of the six treatments is given in Table 5b. The number of mites in each bud and mite number were scored and calculated as described above for Vineyard 1.

The only significant effect of the chemicals in Vineyard 2 was a greater proportion of uninfested buds in the Pyranica treated vines.

Table 5b. Average percentage of uninfested buds, buds infested with bud mite at "high" density and bud mite number (see text for explanation) for primary, secondary and tertiary buds combined in Vineyard 2 at the end of the first season (June 2009) after a range of miticides was applied in the previous spring to control bud mite. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Treatment	Uninfested (%)	Infested at "High" (%)	Mite number
Untreated	40.0	25.0	137.7
Water only	30.0	25.0	142.1
Biopest Oil	60.0	17.0	94.7
Wettable sulphur	41.0	36.0	189.4
Pyranica	62.0	24.0	125.8
Carbaryl	55.0	24.0	127.8
LSD $_{0.05}$	21.3 (*)	20.4 (ns)	101.6 (ns)

Shoot damage: spring, early summer 2009
For Vineyard 1, the averages for number of shoots and the percentage of shoots not malformed in spring 2009, and the number of bunches in early summer 2009/10 are given in Table 6a.

The only significant effect was for fewer shoots and bunches in the vines treated with Pyranica compared to other chemical treatments.

Table 6a. For Vineyard 1, the averages for total number of shoots and the percentage of shoots not malformed in spring 2009, and the number of bunches in early summer 2009/10. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Treatment	Total shoots November 2009	Percent shoots OK November 2009	Bunches December 2009
Untreated	105.8	37.7	52.6
Water only	105.8	40.5	59.6
Biopest Oil	118.4	44.0	69.6
Wettable sulphur	108.4	38.3	60.0
Pyranica	97.0	37.6	46.4
Carbaryl	110.0	42.0	70.6
LSD $_{0.05}$	9.5 (**)	8.2 (ns)	15.8 (*)

For Vineyard 2 the averages for number of shoots, the percentage of shoots not malformed in spring 2009, and the number of bunches in early summer 2009/10 are given in Table 6b.

There were no significant treatment effects on shoots or bunches at this time.

Table 6b. For Vineyard 2, the averages for number of shoots and the percentage of shoots not malformed in spring 2009, and the number of bunches in early summer 2009/10. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Treatment	Total shoots November 2009	Percent shoots OK November 2009	Bunches November 2009
Untreated	26.4	51.4	53.4
Water only	28.8	48.5	61.2
Biopest Oil	27.4	54.4	68.6
Wettable sulphur	30.6	53.0	58.6
Pyranica	27.6	57.3	46.0
Carbaryl	22.4	58.7	67.8
LSD $_{0.05}$	8.3 (ns)	8.9 (ns)	16.1 (ns)

For Vineyard 2 the averages for number of shoots, the percentage of shoots not malformed in early summer 2009/10 are given in Table 6c.

There were significantly fewer bunches in panels treated with oil compared to other chemical treatments.

Table 6c. For Vineyard 2, the averages for number of shoots and the percentage of shoots not malformed in spring 2009, and the number of bunches in early summer 2009/10. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Treatment	Bunches OK December 2009	Small bunches December 2009
Untreated	45.4	21.0
Water only	45.8	16.2
Biopest Oil	35.0	19.0
Wettable sulphur	50.8	16.6
Pyranica	50.2	18.6
Carbaryl	54.2	19.0
LSD $_{0.05}$	11.6 (*)	5.5 (ns)

Yield in Autumn 2010

For Vineyard 2, the average yield of grapes for each treatment is given in Table 7. There was no significant effect of chemical treatment on yield.

Table 7. Average yield for each miticide treatment in Vineyard 2.

Treatment	Yield (g/panel) March 2010
Untreated	7450.0
Water only	8619.6
Biopest Oil	6682.2
Wettable sulphur	10750.0
Pyranica	9015.2
Carbaryl	10502.6
LSD $_{0.05}$	3488.5 (ns)

Mite abundance in buds and bud damage in Winter 2010
For Vineyard 2, the average across the five replications of the proportion of the combined primary, secondary and tertiary buds for the total of 20 buds examined per treatment plot that were healthy or necrotic for each of the six treatments is given in Table 8.

There was no significant difference in bud health among the treatments.

Table 8. Average percentage of healthy and necrotic buds (primary, secondary and tertiary combined) in Vineyard 2 at the end of the second season (May 2010) after a range of miticides was applied in the spring of 2008 to control bud mite. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Treatment	Healthy (%)	Necrotic (%)
Untreated	90.3	1.0
Water only	91.0	1.0
Biopest Oil	90.7	0.3
Wettable sulphur	88.7	2.3
Pyranica	84.7	2.0
Carbaryl	84.3	3.0
LSD $_{0.05}$	8.6 (ns)	3.1 (ns)

The average percentage buds that were uninfested or infested at high density and mite number for each of the six treatments is given in Table 9. The number of mites in each bud and mite number were scored and calculated as described above for Vineyard 1.

There was no significant effect of any of the chemicals on mite presence.

Table 9. Average percentage of uninfested buds, buds infested with bud mite at "high" density and bud mite number (see text for explanation) for primary, secondary and tertiary buds combined in Vineyard 2 at the end of the second season (May 2010) after a range of miticides was applied in the previous spring to control bud mite. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Treatment	Uninfested (%)	Infested at "High" (%)	Mite number
Untreated	47.0	23.0	126.4
Water only	58.0	18.0	98.1
Biopest Oil	61.0	18.0	96.9
Wettable sulphur	49.0	31.0	162.3
Pyranica	46.0	26.0	141.6
Carbaryl	49.0	28.0	148.5
LSD $_{0.05}$	21.1 (ns)	20.6 (ns)	101.2 (ns)

Spur- versus cane- pruning
Shoot damage in spring, early summer 2009
The averages for number of shoots and the percentage of shoots not malformed in spring 2009, and the number of bunches in early summer 2009/10 are given in Table 10.

There were no significant differences in total or healthy shoots in late spring 2009. There were significantly more bunches in the cane pruned vines in the December count.

Table 10. Average number of shoots and the percentage of shoots not malformed in spring 2009 and the number of bunches in early summer 2009/10 in spur- and cane- pruned vines. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Pruning method	Total shoots November 2009	Percent shoots OK November 2009	Bunches December 2009
Spur	90.2	59.6	71.2
Cane	96.0	56.9	91.2
LSD $_{0.05}$	8.1 (ns)	7.1 (ns)	10.2 (*)

The average number of healthy and small bunches in spur- and cane- pruned vines in March 2010 are given Table 11.

There were significantly fewer bunches in cane-pruned vines, the reverse of the result in early summer. There was no difference in the number of small bunches.

Table 11. For Vineyard 2, the averages for number of shoots and the percentage of shoots not malformed in spring 2009, and the number of bunches in early summer 2009/10 in spur- and cane- pruned vines. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Pruning method	Bunches OK March 2010	Small bunches March 2010
Spur	66.2	2.2
Cane	50.5	1.5
LSD $_{0.05}$	9 (**)	0.9 (ns)

Yield in autumn 2010
For Vineyard 2, the average yield of grapes for spur- and cane- pruned vines are given in Table 12.

There was no significant effect of pruning method on yield.

Table 12. The average yield for each pruning method in Vineyard 2.

Pruning method	Yield (g/panel) March 2010
Spur	9353.1
Cane	9707.5
LSD $_{0.05}$	2244 (ns)

Mite abundance in buds and bud damage in winter 2010
For Vineyard 2, the average across the ten panels for each pruning method of the proportion of the combined primary, secondary and tertiary buds for the total of 20 buds examined that were healthy or necrotic are given in Table 13.

There was no significant difference in bud health between pruning method.

Table 13. Average percentage of healthy and necrotic buds (primary, secondary and tertiary combined) in Vineyard 2 at the end of the first season (May 2010) after spur or cane pruning in winter 2009 to reduce bud mite abundance. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Pruning method	Healthy (%)	Necrotic (%)
Spur	63.2	1.0
Cane	74.3	0.2
LSD $_{0.05}$	10.5 (*)	0.9 (ns)

For Vineyard 2, the average of the proportion of the combined primary, secondary and tertiary buds for the total of 20 buds examined per treatment plot that were uninfested, infested at high density and mite number for each pruning method is given in Table 14. The number of mites in each bud and mite number were scored and calculated as described above for Vineyard 1.

There was no significant effect of any of the chemicals on mite presence.

Table 14. Average percentage of uninfested buds, buds infested with bud mite at "high" density and bud mite number (see text for explanation) for primary, secondary and tertiary buds combined in Vineyard 2 at the end of the first season (May 2010) after being either spur- or cane- pruned in winter 2009 to reduce bud mite abundance. Also included are the LSD $_{0.05}$ for each parameter and whether treatment differences were significant from an analysis of variance (ns = not significant; *, **, * = significant at the 0.1, 1 and 5 % levels respectively).**

Pruning method	Uninfested (%)	Infested at "High" (%)	Mite number
Spur	32.5	40.0	210.9
Cane	25.0	33.5	210.9
LSD $_{0.05}$	13 (ns)	14.1 (ns)	85.7(ns)

Mites in association with the bud mites on dormant canes in May 2010 and thought to be predatory on them were observed in both vineyards. These mites were identified as the phytoseiid predatory mites *Neoseiulus bellinus* (Womersley) in Vineyard 1 and *Typhlodromus dossei* (Schicha) in Vineyard 2. Only one species was recorded in each vineyard.

These predatory mites were observed in low numbers only in winter 2009. The mites were more prevalent in winter 2010 in Vineyard 2 and their abundance was assessed together with that for bud mites. Of the 150 canes examined 20% had at least one predatory mite and the average number of predatory mites per cane was 0.3. For vineyard 1, the predatory mites were collected from vines in a block of Cabernet Sauvignon that was next to the study block. Of 50 canes examined, 18% had at least one predatory mite present and the average number of predatory mites per cane was 0.2.

7. Discussion

Eriophyid mites including grapevine bud mite have been reported as pests of Australian grapevines by Bernard et al. (2005). The objective of this study in clarifying whether bud infesting mites were responsible for yield decline in Cabernet Sauvignon in the Margaret River region of Western Australia has been compromised by an inability to dramatically reduce the infestation level of mites – either through the use of chemicals or pruning method.

While statistically significant differences in mite abundance levels were achieved with the pesticide carbaryl, spray oil and tebufenpyrad, the level of reduction was relatively low. The spray regime for the chemicals chosen was rigorous. Even though the period over which sprays were applied suffered from reasonably consistent rainfall, the period over which the sprays were applied and the frequency of weekly spraying should have been adequate compensation for any spray dilution on some spray dates.

There are few reports in the literature where grapevine bud mite occurred as the sole or major eriophyid mite infesting vines and good control was demonstrated. One such study (De Klerk 1985), reported good control of the mite with chemicals no longer available for use. That study showed it was important to commence spraying at budding and included two subsequent applications. This was to ensure the duration of bud mite movement from overwintering buds to new buds (Dennill 1986) was included. Unfortunately in this study, the demonstration of success for the most effective treatment was limited to a comparison of mite infestation levels and did not include yield. In another study in South Africa, although not significantly different, higher yields were reported where mite abundance had been reduced through use of chemicals (Whitehead et al. 1975).

In terms of possible chemicals for controlling bud mite, at least for the purpose of demonstrating pest status, lime sulphur could have been considered. This chemical has broad spectrum activity including being very toxic to predatory mites. However, it has been found to be ineffective against bud mite (Bernard et al. 2005).

It seems that to identify possible chemicals for control of bud mite, a screening trial involving new chemicals should be undertaken. Miticides available for use against tetranychids in other areas of horticulture would be the source of possible candidates. Some of the new products have low toxicity to predatory mites and are active against mites only. Thus, other potential predators of bud mite such as beetles, bugs, thrips and flies would be safe.

While the comparison of spur and cane pruning in this study failed to show a difference in mite abundance and shoot/bunch health and yield in vines, this was not for the case for Dennill (1991). In that study, it was shown that cane pruning can improve yield in bud mite infested vines. It was shown that the outer buds on canes are less heavily infested with mites. This was also the case in this study where there was a trend to lower infestation with greater distance from the cordon (see Appendix 5 b, c, d). Even though only the four buds closest to the cordon were examined, the trend to lower infestation and bud damage levels was clear. Dennill (1991) advocated a two-season strategy of pruning combined with chemical application to lift yield in bud mite-infested vines.

This study was confined to an examination of the role of bud infesting mites to yield decline in Cabernet Sauvignon. The possibility that other factors may be involved and possibly more important was not investigated as has been undertaken for the variety Shiraz where primary bud necrosis is considered to be caused by other factors (Rawnsley and Collins, 2005). As suggested by bud dissection data for Western Australia (Appendix 5a), primary bud necrosis does not appear to be as important in Cabernet Sauvignon as for Shiraz as an explanation for yield decline. The fact that bud infesting mite numbers were highest for Cabernet Sauvignon may indicate that yield effects could be occurring from damage to shoots and bunches after bud burst rather than damage to the buds themselves. Only by applying a treatment or treatments to successfully reduce mite infestation levels will this hypothesis be tested.

8. Outcome/Conclusion

This project did not achieve the objective as stated.

The requirement to reduce bud-inhabiting mites to low levels through chemical application and through an unexpected opportunity to compare spur- and cane- pruning did not result in sufficiently fewer mites to enable a yield comparison of infested and (relatively) uninfested buds.

While there is considerable information on the biology of grapevine bud mite in the literature for other countries, confirmation that this applies for Australian conditions would provide a better basis on which to assess chemicals for control of bud mite. The objective of determining whether bud mite was the cause of yield decline in Cabernet Sauvignon requires in the first instance the identification of an effective chemical and an appropriate application timing regime. Should this be proven, other management tactics such as pruning method could be examined.

Given the rigorous regime of application of test chemicals and their lack of success in reducing the populations of bud mite to low levels, other chemical control options require examination. These should include comparisons of some of the new chemicals available for use in other horticultural crops. Because predatory mites were recorded in association with bud mites, new chemicals that have no or minor adverse affects on predatory mites would be highly desirable.

Results of this project highlight the need for bud dissection services to confirm the identity of mites because of the differences in control tactics required for bud and rust mite infestation – with rust mite control being more easily achieved with the acceptable products sulphur and horticultural spray oils.

9. Recommendations

Future research should include confirmation of the biology of grapevine bud mite under Australian conditions with a detailed study of the life cycle and seasonality of the mite. Such a study should include identification of beneficial agents that occur in Australian vineyards.

Information on the biology of bud mite would be used to plan both pruning and screening trials to identify chemical miticides and appropriate spraying regimes. The availability of appropriate and effective chemicals would make it possible to be able to both clarify the pest status of bud mite and if necessary provide options for successful intervention should infestations of bud mite be found to reduce yield.

Bud dissecting services should be encouraged to provide customers with not only bud infestation levels but the species of mite involved – bud mite or rust mite, the two eriophyid mites most likely to be found in buds.

10. Appendix 1: Communication

Progress reports on this project were presented to the vignerons of Western Australia via a series of articles in the quarterly *Wine Industry Newsletter*.

11. Appendix 2: Intellectual Property

No intellectual property was produced as a result of this research.

12. Appendix 3: References

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13. Appendix 4: Acknowledgments and Staff

Encouragement to undertake this project and financial support for this project was provided by Pialligo Estate (Graham Lloyd) and Voyager Estate (Alex Wright and Stephen James). Alex Miller and Glen Ryan of Voyager Estate and Verne Tebbutt of Pialligo Estate provided assistance and advice in conducting the field trials.

The following staff members of the Department of Agriculture and Food, Western Australia provided technical support in collection of material from the field, laboratory evaluations and field sampling for vine health and yield assessments and analysis of data:

- Elizabeth Blincow, Casual Wages
- Helen Collie, Casual Wages
- Graziano Giadresco, Farm Operative
- Peter Needs, Farm Operative
- Donna Stanaway, Casual Wages
- Mark Stanaway, Technical Officer
- Andrew Van Burgel, Biometrician.

Danuta Knihinicki of New South Wales Department of Industries and Investment, Primary Industries provided identifications of pest and predatory mites.

Jim Campbell-Claus and Tony Proffitt of AHA Viticulture in Western Australia provided assistance and access in relation to bud dissection data.

14. Appendix 5a Raw data – Bud dissections by AHA Viticulture

Bud dissections to assess the level of necrotic buds and mite infestation are undertaken by vignerons to aid decisions on pruning. The results of bud dissections for the period 2002-2008 in the south west region of Western Australia with most material submitted from the Margaret River region is given in the table.

Variety	% Bud Necrosis ± Std Dev	No. samples	% Mite Incidence ± Std Dev	No. samples
Cabernet Sauvignon	9.0 ± 6.0	120	30.7 ± 22.1	92
Chardonnay	8.5 ± 6.6	79	0.4 ± 1.6	70
Merlot	5.6 ± 3.7	40	1.2 ± 2.7	30
Sauvignon Blanc	6.6 ± 6.6	66	7.5 ± 10.2	61
Semillon	7.0 ± 4.7	50	4.0 ± 5.4	39
Shiraz	30.9 ± 13.4	72	0.3 ± 10.5	55

Cabernet Sauvignon was the variety with the greatest infestation level of bud inhabiting mites. Infestation levels reached as high as 86%. The next most heavily infested variety was Sauvignon Blanc. Chardonnay and Shiraz were the least infested, but Shiraz had the highest level of bud necrosis.

The variety Shiraz has a reputation for being susceptible to bud necrosis as reported by Rawnsley & Collins (2005). These workers ascribe this situation not to the presence of bud inhabiting mites but to excessive vigour and a relationship to the naturally produced growth hormone gibberellic acid. Bud position, pruning levels and irrigation were also considered to be contributory factors, with very heavy pruning and water stress leading to high levels of bud necrosis.

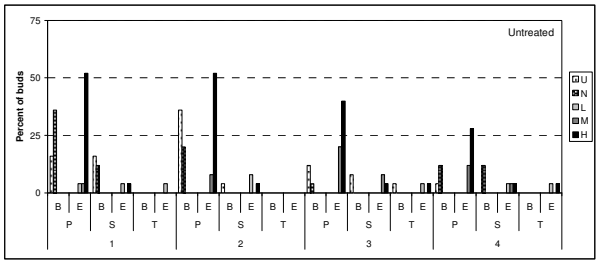
These data on bud dissection in relation to the objective of the current project are discussed further in section 7 above.

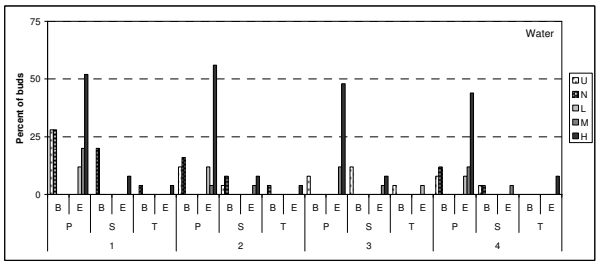
14. Appendix 5b Raw data - Vineyard 1 chemical treatments

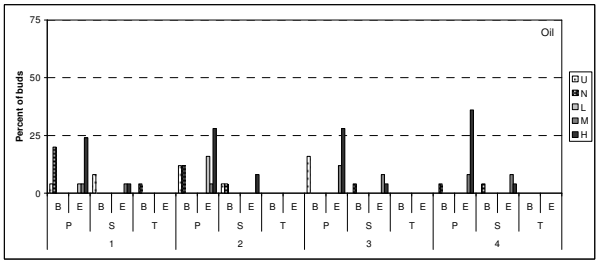
Bud health and mite abundance in primary (P), secondary (S) and tertiary (T) buds up to the fourth bud from the cordon in Cabernet Sauvignon vines in winter on Vineyard 1 after application of different chemical treatments applied the previous spring to control grapevine bud mite.

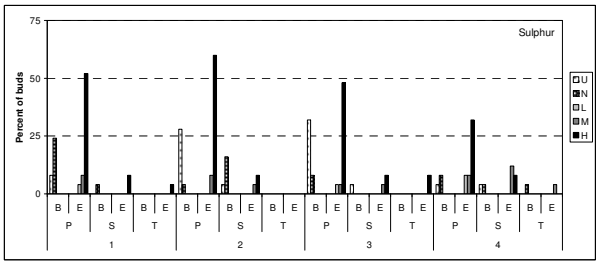
Bud health (B): U = some damage to bud scales; N =necrotic buds.

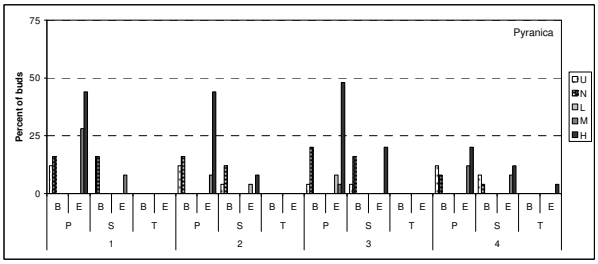
Mite abundance (E): L = low (1-5 mites); M=medium (6-20mites/bud); H=high (>20 mites/bud).

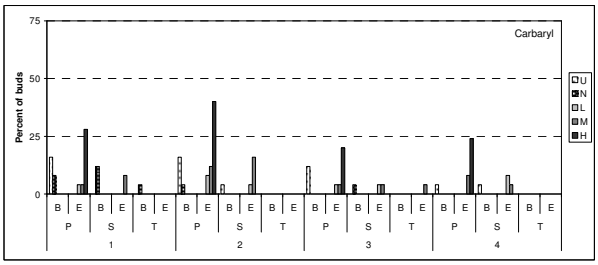










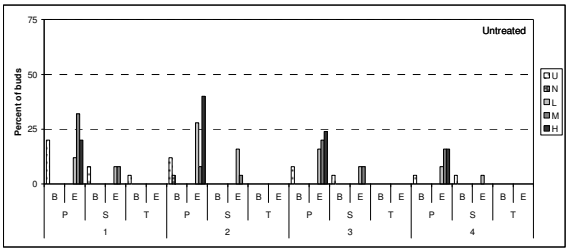


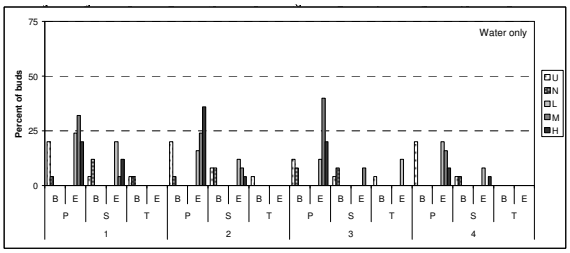
14. Appendix 5c Raw data - Vineyard 2 chemical treatments

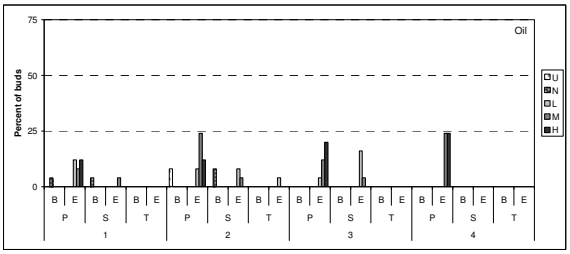
Bud health and mite abundance in primary (P), secondary (S) and tertiary (T) buds up to the fourth bud from the cordon in Cabernet Sauvignon vines in winter on Vineyard 2 after application of different chemical treatments applied the previous spring to control grapevine bud mite.

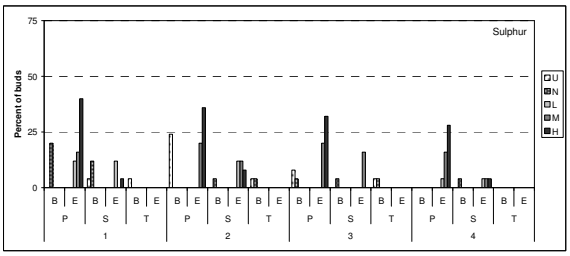
Bud health (B): U = some damage to bud scales; N =necrotic buds.

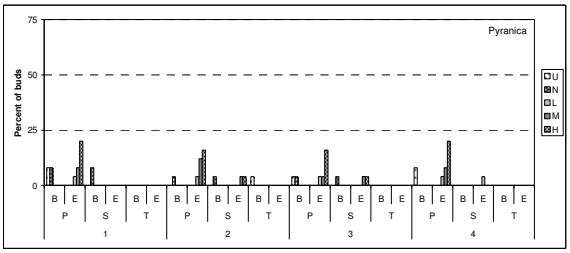
Mite abundance (E): L = low (1-5 mites); M=medium (6-20 mites/bud); H=high (>20 mites/bud).

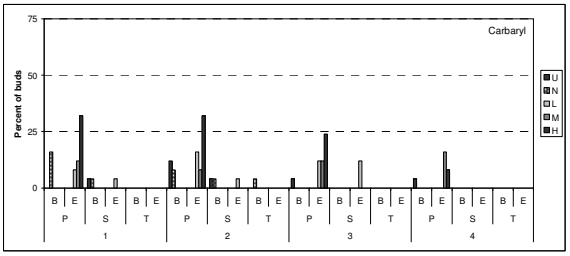












14. Appendix 5d Raw data - Vineyard 2 spur and cane pruning

Mite abundance and bud health in primary (P), secondary (S) and tertiary (T) buds up to the fourth bud from the cordon in Cabernet Sauvignon vines in winter on Vineyard 2 where vines were either spur pruned or cane pruned during the previous winter to control grapevine bud mite.

Mite abundance (E): L = low (1-5 mites/bud); M=medium (6-20mites/bud); H=high (>20 mites/bud).
Bud health (B): U = some damage to bud scales; N =necrotic buds.

