Grape Powdery Mildew Eradication Trial January 2016

Omarunui Rd, Waiohiki, Hawke's Bay

Final

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Chris Henry

Landline 06 874 2921
Mobile 027 294 1490
Email chrishenry@actrix.co.nz

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Executive Summary

Eradication of powdery mildew is not an easy matter to research in the field as naturally occurring infection is required first and with that comes all the variability that occurs in nature. The site that was used for this study was excellent for its consistently high levels of infection in a susceptible variety (Gewurztraminer), brought about by poor spray deposition from a minimum of sulphur applications and a lack of bunch exposure to light.

The aftermath of a significant powdery mildew infection can be catastrophic and is generally seen as splitting of berries, desiccation, and the accelerated advance of secondary rots such as botrytis and sour rots closer to harvest.

The trial site was also excellent from the point of view that the crop outcomes were able to be properly assessed close to when it would have been harvested, rather than just depending on level of disease control determined by field and laboratory assessments close to the time of application.

Harvest outcomes, that is, the condition of the crop after the disease has been eradicated or not and the harvestable nature of it, are perhaps more important from a grower's perspective.

This main purpose of this trial was to validate and improve on 2014 trial work on powdery mildew eradication. The best treatment arising out of the 2014 trial was HML32 - 1.25l/100L + metallic copper - 45g/100L + potassium bicarbonate - 300g/100L.

In this trial, the base product HML32 and its use rate were constant but the rates of the additives (copper, potassium bicarbonate and sulphur) were altered. There was also the addition of potassium silicate (HML Silco), a material which had shown promise in the powdery mildew prevention trial undertaken at the same time in another location.

Overall the findings of the trial are:

- Eradication of epidemic powdery mildew infection using the base formula of HML32 - 1.25l/100L + metallic copper - 45g/100L + potassium bicarbonate - 300g/100L. is completely achievable, the crop does not necessarily split following the infection and can go on to deliver excellent harvestable outcomes.
- Once eradicated the disease did not return, indicating considerable forward protection.
- Two applications of any treatment was clearly are better than one application.
- The copper rate had no effect if two applications were made, but if one application was made, there was clearly a copper rate effect and therefore it would be better to lift the copper rate (from metallic copper 45g to 67.5g - 90g/100l) if only one application is possible.
- The inclusion of sulphur had a negative effect on harvestable outcomes, including when it was applied once within the second application.
- The inclusion of HML Silco (potassium silicate) without copper but with a boost of potassium bicarbonate produced nearly the best efficacy within the 'sprayed once' group and the best efficacy in the 'sprayed twice' group.

The recommendation for eradication of powdery mildew infection is to spray HML32 - 1.25l/100L + metallic copper - 45g/100L + potassium bicarbonate - 300g/100L twice 7 days apart, confirming the 2014 trial result.

On the basis of this report, it is not recommended to include any sulphur in treatments targeted specifically at eradication of infection.

On the basis of this report and what has been observed elsewhere, preventative applications may be made separately, but there appears to be significant forward protection following successful eradication, at least to the point where preventative applications can be made as planned, rather than bringing them on earlier assuming no forward cover.

1.0 Introduction and Trial Background

The purpose of this trial was to explore again the efficacy of different rates of both potassium bicarbonate and copper when used with HML32 for eradication of powdery mildew infections and in addition explore the efficacy/effects of including sulphur as part of the eradication recipe.

This trial extends knowledge gained from 2014 Powdery Mildew Eradication Trial undertaken on Montepulciano (http://www.henrymanufacturing.co.nz/products/hml-32/research-and-trials/final-report-of-eradication-of-powdery-mildew-infection.pdf). That trial demonstrated that a mixture of HML32, copper and potassium bicarbonate was an effective eradicant of powdery mildew, particularly when sprayed twice, 7 days apart.

A Best Practice Note for eradication was developed to give guidance to growers as to how best to achieve the eradicant effect. It included machine spraying the combination of HML32, copper and potassium bicarbonate twice 7 days apart, and spraying in both directions in order to achieve adequate coverage, with notes on sprayer speed, water rates and spray deposition (http://www.henrymanufacturing.co.nz/products/hml-32/research-and-trials/best-practice-powdery-mildew-infection-eradication-2015.pdf).

There have been excellent results reported from growers. Where the outcome has been less than expected, issues around application appear to be the key factors.

Henry Manufacturing Limited also developed a preventative fungal spray programme involving combinations of Protector and HML32 with sulphur and copper.

Growers have asked whether sulphur could be added to the mix to provide some additional forward protection against reinfection, and part of that same issue is whether the eradication treatments provided forward protection themselves.

There is also a question as to whether the copper could be further reduced or a replacement found, the reasons being that copper use precluded sheep leaf plucking and the perception amongst some winemakers that copper suppresses phenolics. These were also considered as part of this trial.

2.0 Trial Objectives

The objective of the trial is to address the following questions:

- does sulphur assist with eradication efficacy of HML32, Copper and Potassium Bicarbonate
- does a lower/higher copper rate alter any eradicative effect
- can a lower copper rate be mitigated/improved by a higher potassium bicarbonate rate
- does the addition of potassium silicate (HML Silco) improve eradicative ability

3.0 Trial Site

The trial site is located on a mothballed block of Gewurztraminer on Omarunui Rd, Waiohiki, Hawke's Bay (see Figure 1). It had received minimal viticultural attention during the growing season but had received some applications of sulphur. Four rows were used (see Figure 2)

All vines were mature (perhaps 15 years old). They were 2 & 3 cane-pruned, VSP trellised and planted in an approximate north-south orientation.

The block has a history of poor crop outcomes, mainly due to high powdery mildew infection.
When this trial began all bunches were severely infected with powdery mildew. Bunches were almost completely shaded by canopy and adjacent leaves.

All trial plots (including untreated) were heavily leaf plucked bringing a high level of bunch exposure before application/s of treatments.

Figure 1: Location of Eradication Trial Site, Omarunui Rd, Hawke's Bay


Figure 2: Trial site - 4 rows

Figure 3: Leaf Plucked Vines

3.1. Trial Design

There are 15 treatments, described in Table 1. The replication was four, with plots randomised within each replicate (individual row). Each plot contained two plants except for Treatment 15 (with HML Silco). This arose as a result of a late decision to also have a single spray treatment for Treatment 15, it was split into Treatment 15a (single spray) and Treatment 15b (2 sprays) resulting in one plant per replicate.

End bays and non-representative vines (low cropping etc.) were not used.

Some treatments were sprayed once, and some twice 8 days apart. The spray dates are shown in Table 1.

3.2. Application Method

All vines including the untreated were leaf plucked to allow a high level of exposure both to light and spray deposition.

All treatments were applied at high volume, to the bunch line only, to the point of run off in one pass by electric pump assisted hand gun on each side of the row. Spray applications were undertaken by Chris Henry. No attempt is made to convert this to litres/ha.

Table 1: Trial Treatments and Application Dates

Treatment Number	Appl. Date	Appl. Date	no. apps	Treatment Description and Rates (per 100L water)	Colour code (first application)	Colour Code (second application)
1			0	Untreated	Green	Green
2		15-Jan	1	HML32 1.25l + Nordox 60g + PB 300g		Red/White
3		15-Jan	1	HML32 1.25l + Nordox 90g + PB 300g		Red/Red/White
4		15-Jan	1	HML32 1.25l + Nordox 30g + PB 300g		Red-White/White
5		15-Jan	1	HML32 1.25l + Nordox 30g + PB 600g		Red-White /White/White
6		15-Jan	1	HML32 1.25l + Nordox 60g + PB 300g + Sulphur 300g		Red/white/ Yellow
7		15-Jan	1	HML32 1.25l + Sulphur 300g + PB 300g		Yellow/White
8	7-Jan	15-Jan	2	HML32 1.25l + Nordox 60g + PB 300g then HML32 1.25l + Nordox 60g + PB 300g + Sulphur 300g	(B/P) Red/White	(B/P) Red /White/ Black-Yellow
9	7-Jan	15-Jan	2	HML32 1.25l + Nordox 60g + PB 300g	(B/P) Red/white	(B/P) Red/white
10	7-Jan	15-Jan	2	HML32 1.25l + Nordox 90g + PB 300g	(B/P) Red/Red /White	(B/P) Red/Red/White
11	7-Jan	15-Jan	2	HML32 1.25l + Nordox 30g + PB 300g	(B/P) Red-White /White	(B/P) Red-White /White
12	7-Jan	15-Jan	2	HML32 1.25l + Nordox 30g + PB 600g	(B/P) Red-White /White/ White	(B/P) Red-White/White/ White
13	7-Jan	15-Jan	2	HML32 1.25l + Nordox 60g + PB 300g + Sulphur 300g	(B/P) Red/White /Yellow	(B/P) Red/White /Yellow
14	7-Jan	15-Jan	2	HML32 1.25l + Sulphur 300g + PB 300g	(B/P) Yellow/White	(B/P) Yellow/White
15a	7-Jan		1	HML32 1.25l + Silco 425g + PB 300g	(B/P) Orange-White /White (tagged plant sprayed once)	
15b	7-Jan	15-Jan	2	HML32 1.25l + Silco 425g + PB 300g	(B/P) Orange-White /White (untagged plant sprayed twice)	Orange-White/White

4.0 Assessments and Results

The trial was assessed in three ways - field assessment of active powdery mildew infection, laboratory assessment of powdery mildew incidence and severity, and assessment of harvestable crop. These are shown on the timeline shown in Figure 4.

Figure 4: Timeline showing application and assessment dates

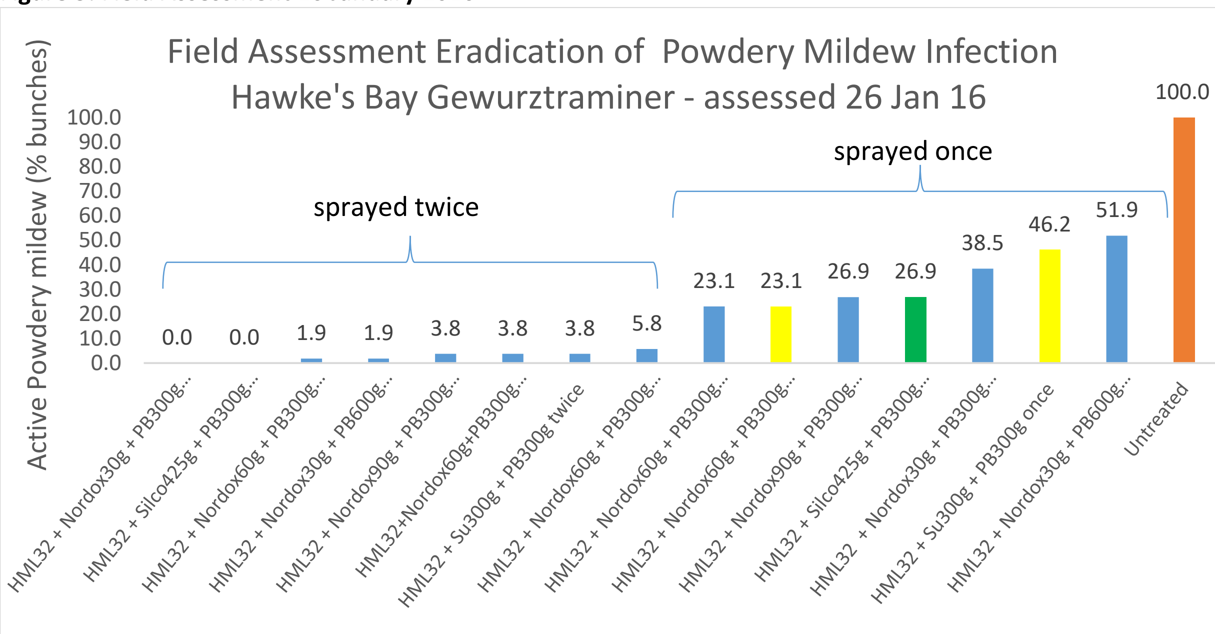
Timeline	**7 January 2016**	**15 January 2016**		**26 January 2016**	**31 January 2016**		**27 February 2016**
Activity	Ist application of Treatments sprayed twice	2nd application of Treatments sprayed twice Only application of Treatments sprayed once		Field Assessment of Powdery Mildew	Laboratory Assessment of Powdery Mildew		Harvestable Crop Assessment
Time intervals	8 days between application		11 - 16 days since last application				
				43 days (6 weeks) since last application			

4.1. Field Assessment 26 January 2016

The plots were evaluated in the field for the presence of active powdery mildew based on 13 randomly selected bunches per plot (52 bunches per treatment). This was undertaken blind by Bridget Wilton (CV in Appendix 1). Given the amount of powdery mildew infection across the trial site, it was difficult to determine what was active infection and what was dead, complicated also because the residue of some of the treatments was light grey/light blue/white.

The field assessment was undertaken on 26 January 2016, 11 days after the last spray so all treatments were subject to the same period of pressure, except for Treatment 15 containing Silco where the plants receiving one application only would have an additional 8 days of pressure. The results are shown in Figure 5.

Figure 5: Field Assessment 26 January 2016



4.2. Laboratory Assessment 31 January 2016

Twenty five bunches from each plot were randomly selected, plastic bagged, and transported on the 26th January 2016. They were left in a cool shaded situation in the lab. Laboratory assessment of active powdery mildew incidence and severity was undertaken by Peter Wood, Plant and Food Research on the 31st January 2016 (5 days after the samples had been taken). Each bunch was viewed under magnification (see **Error! Reference source not found.**) and where necessary, under a higher power microscope with light assistance.

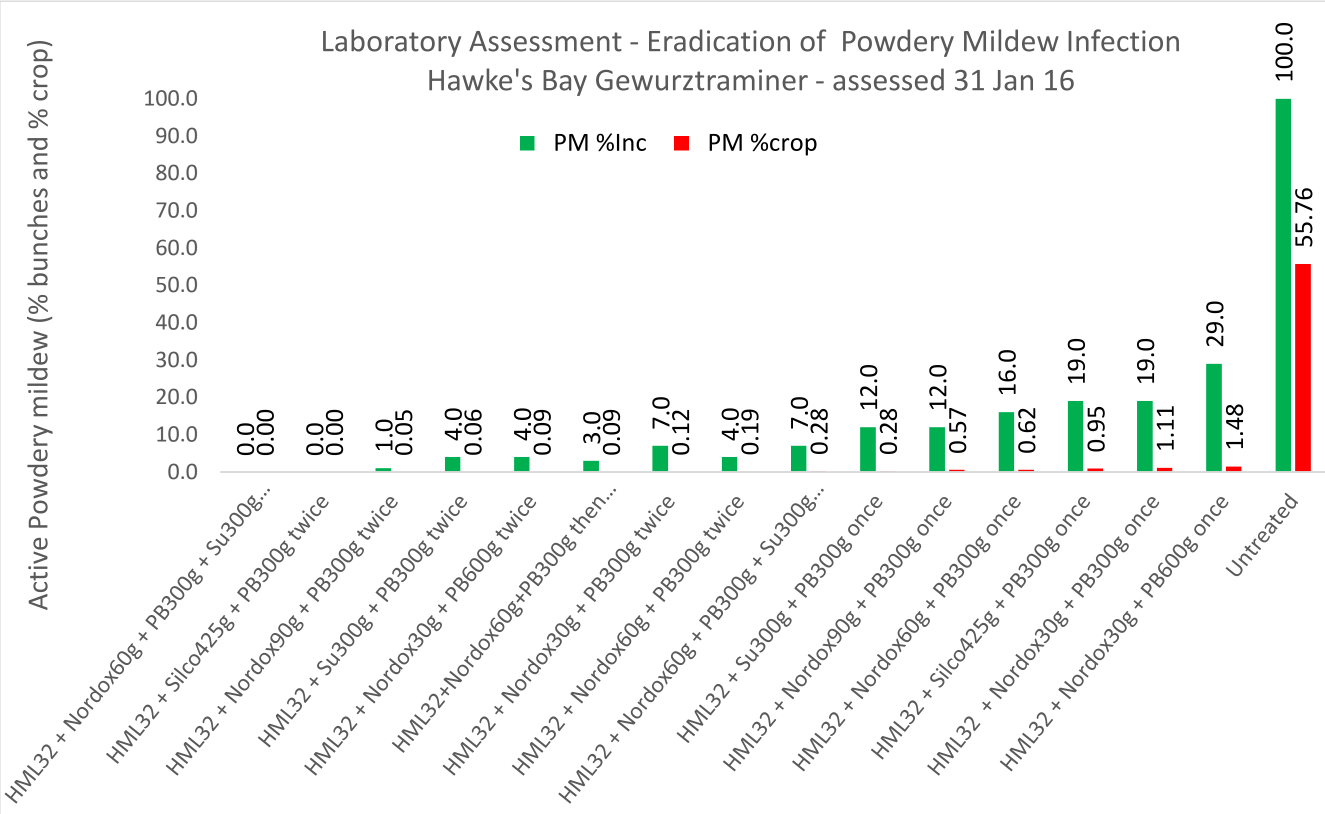
The laboratory assessment was undertaken 16 days after the last spray so all treatments were subject to the same period of pressure, except for Treatment 15 containing Silco where the plants receiving one application only would have an additional 8 days of pressure.

It should be noted here, that similar to field assessment where it was difficult to tell which was live powdery mildew and what was dead – in the case of the laboratory assessment there was obviously better equipment to provide definition, however it is the experience of the author that powdery mildew conidia does not transport well, and the live conidia seen in the laboratory lacked normal vigour and length. Hence while the laboratory testing was valid, the robustness of the result was perhaps lowered because of transport/bagging and storage/length of time in storage.

The results are shown in Figure 7.

Figure 6: Peter Wood assessing bunches under magnification

Figure 7: Laboratory Assessment 31 January 2016

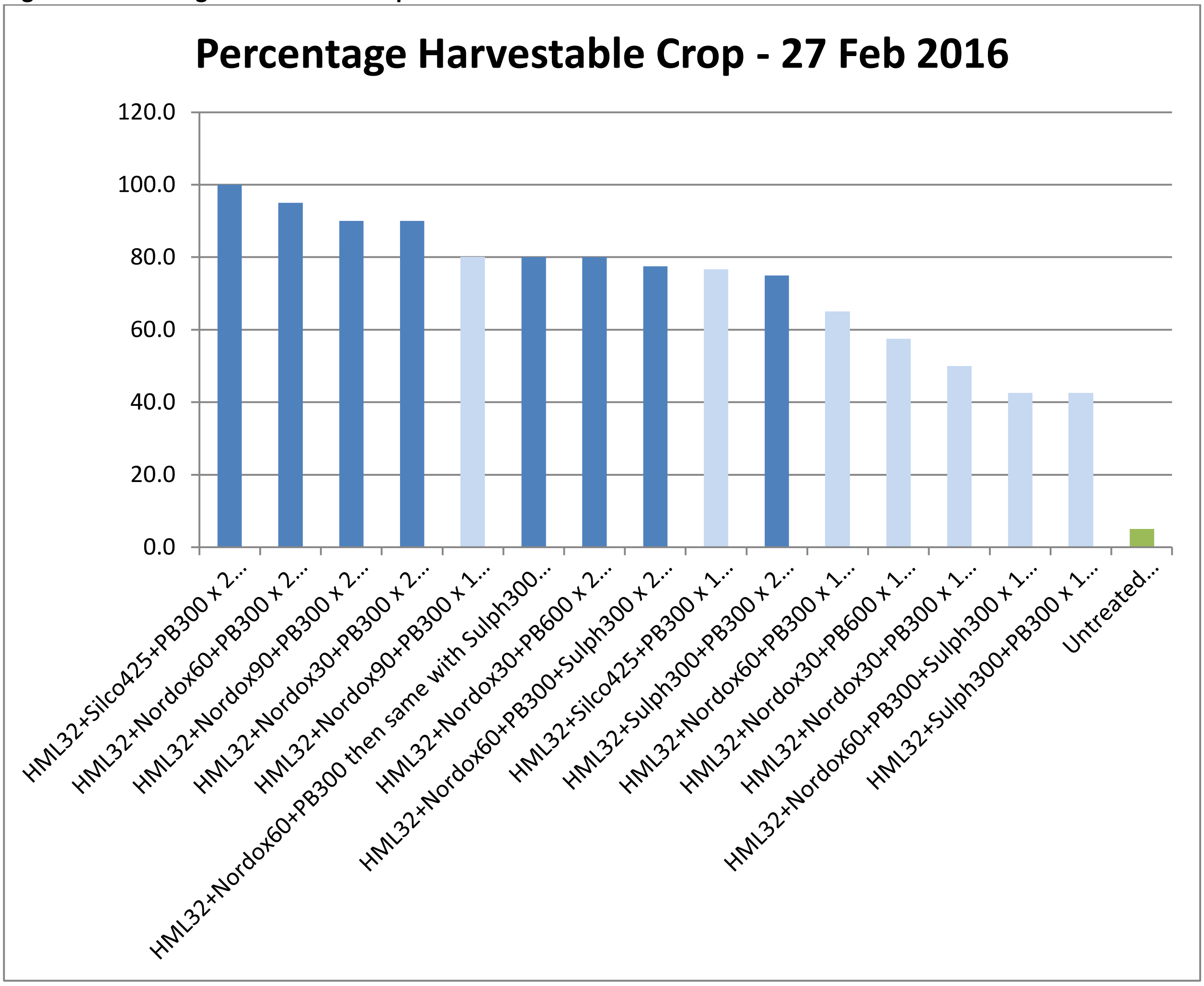


4.3. Field Assessment ‘Harvestable Crop’ 27 February 2016

On the 27th February 2016, all plots were again assessed blind by Bridget Wilton, this time giving a subjective score to each plot as to what percentage of it was of harvestable quality across the whole plot (0 to 10: 0 being completely lost to disease – 10 being completely harvestable). Each plot was 2 vines. The exception was treatment 15 containing Silco, which were single vine plots. The assessment was undertaken approximately 6 weeks after the last spray application. The results are shown in Figure 8. The dark blue are treatments sprayed twice, the light blue are treatments sprayed once.

Of interest is the trial in adjacent rows being undertaken by Farmlands for an adjuvant study. Those rows also had epidemic powdery mildew infection which they eradicated using two applications of the HML32/Copper/potassium bicarbonate recipe applied by mist blower. They achieved excellent control and a harvestable crop could have been made. Farmlands were able to successfully carry out the adjuvant trial.

Figure 8: Percentage Harvestable Crop 27 Feb 2016



Note: Dark Blue- treatments sprayed twice; Light blue - treatments sprayed once

4.4. Statistical Analysis

Statistical analysis was undertaken on the two powdery mildew infection assessments. The results are shown in Table 2. Treatments have been sorted based on the statistical results of the laboratory assessment.

It shows that the two top treatments based on the laboratory assessment were HML32 + Nordox60g + PB300g + Su300g sprayed twice and HML32 + Silco425g + PB300g sprayed twice. The latter treatment was also the top performing treatment in the field assessment but the treatment of HML32, Copper, potassium bicarbonate and sulphur sprayed twice did not score as well. While the harvestable crop was not statistically analysed, these results also confirmed the effectiveness of HML32, Silco and potassium bicarbonate (100% harvestable), and found that the harvestable crop result for the treatments including sulphur dropped to about 80%.

Table 2: Data and Statistical Analysis

Treatment	% active PM (Farmlands)		PM incidence (% bunches) (lab)		PM Severity (% crop) (lab)	
HML32 + Nordox60g + PB300g + Su300g twice	5.8	abcd	0.0	a	0.00	a
HML32 + Silco425g + PB300g twice	0.0	a	0.0	a	0.00	a
HML32 + Nordox 90g + PB300g twice	3.8	abc	1.0	ab	0.05	a
HML32 + Su300g + PB300g twice	3.8	abc	4.0	abc	0.06	ab
HML32+ Nordox60g+PB300g then HML32+ Nordox60g+PB300g+Su300g	3.8	abcd	3.0	abcd	0.09	abc
HML32 + Nordox30g + PB600g twice	1.9	ab	4.0	abcd	0.09	abc
HML32 + Nordox 30g + PB300g twice	0.0	a	7.0	abcde	0.12	abc
HML32 + Nordox 60g + PB300g twice	1.9	ab	4.0	abcd	0.19	abcd
HML32 + Nordox 60g + PB300g + Su300g once	23.1	cde	7.0	bcde	0.28	abcd
HML32 + Su300g + PB300g once	46.2	e	12.0	cdef	0.28	abcd
HML32 + Nordox 90g + PB300g once	26.9	de	12.0	def	0.57	bcde
HML32 + Nordox 60g + PB300g once	23.1	bcde	16.0	efg	0.62	cde
HML32 + Silco425g + PB300g once	26.9	cde	19.0	fg	0.95	de
HML32 + Nordox 30g + PB300g once	38.5	e	19.0	fg	1.11	e
HML32 + Nordox 30g + PB600g once	51.9	e	29.0	g	1.48	e
Untreated	100.0	f	100.0	h	55.76	f
LSD	*27.7*		*11.6*		*3.35*	
Within each column, means followed by the same letter are not significantly different (LSD, α = 0.05).						
The P value was < 0.001 for both incidence and severity indicating a high level of confidence 99% that treatment effects were real.						

5.0 Discussion and Conclusions

5.1. Trial site conditions

Eradication of powdery mildew is not easy to research in the field as naturally occurring infection is required first and with that comes all the variability that occurs in nature. The site that was used for this study was excellent for its consistently high levels of infection in a susceptible variety (Gewurztraminer), brought about by poor spray deposition from a minimum of sulphur applications and a lack of bunch exposure to light.

5.2. Assessment Opportunities

The aftermath of a significant powdery mildew infection can be catastrophic and is generally seen as splitting of berries, desiccation, and the accelerated advance of secondary rots such as botrytis and sour rots closer to harvest. In this trial, the crop outcomes were able to be assessed close to when it would have been harvested, rather than depending on assessments undertaken closer to the eradicant applications.

Harvest outcomes, that is, the condition of the crop after the disease has been eradicated or not and the harvestable nature of it, are perhaps more important from a grower's perspective that the level of disease control determined by field and laboratory assessments close to the time of application.

All assessments were sound but weak in some areas. They were all undertaken 'blind'. The assessments were in broad agreement that two applications produced far better efficacy than one, the state of the untreated and that most treatments were to a large extent effective. Where there was disparity was in respect of outcomes from sulphur use – the laboratory examination returning a higher level of control than the field examination.

Figure 9 is an example of two bunches that have been assessed under the electronic microscopic as having live infection and no live infection respectively, confirming the challenge for the assessments.

Figure 9: Examples of bunches with and without infection

5.3. Variable rates of Copper

The results show that the copper rate had no effect where two applications had been made.

There was a rate effect where there was only one application, and it indicates that it would be better to lift the copper rate (from metallic Cu 45g to 67.5g - 90g/100l) to achieve adequate efficacy where only one application is intended.

5.4. Inclusion of sulphur

While the laboratory assessment indicated that the inclusion of sulphur improved efficacy, this was not reflected in the field assessment nor the harvestable crop assessment. The reasons for this are not clear but the bunches were picked on a very hot day and it was five days before the laboratory assessment was undertaken. While the bags were stored in a cool situation, it might be possible that the treatments containing sulphur had some residual effect in the bag.

The inclusion of sulphur appeared to have a negative effect on harvestable outcomes, including when it was added to the second application of one treatment.

It is recommended therefore NOT to include any sulphur in treatments targeted specifically at eradication of infection.

5.5. Inclusion of HML Silco (potassium silicate)

The inclusion of HML Silco to HML32 with a boost of potassium bicarbonate but without copper produced close to the best efficacy within the 'sprayed once' group and the best efficacy in the 'sprayed twice' group. This product has significant potential for powdery mildew eradication and reducing copper use.

5.6. Number of applications

The results clearly indicate that two applications of the treatments were more effective than a single application.

5.7. Comparison with 2014 Eradication Trial

This main purpose of this trial was to validate and improve on 2014 trial work on powdery mildew eradication. The best treatment arising out of the 2014 trial was HML32 - 1.25l/100L + metallic copper - 45g/100L + potassium bicarbonate - 300g/100L.

In this trial, the base product HML32 and its use rate were constant but the rates of the additives (copper, potassium bicarbonate and sulphur) were altered. There was also the addition of potassium silicate, a material which had shown promise in the powdery mildew prevention trial undertaken at the same time in another location.

Assessment of 'harvestable' crop was the third assessment and the most relevant from a grower's point of view as the examination was not simply about disease. The assessment was subjective, but valid because it was undertaken blind over the 4 replicates.

This trial confirms the 2014 trial results that eradication of epidemic powdery mildew infection using the base formula of HML32 - 1.25l/100L + metallic copper - 45g/100L + potassium bicarbonate - 300g/100L (sprayed twice 7 days apart) is completely achievable, the crop does not necessarily split following the infection and can go on to deliver excellent harvestable outcomes.

5.8. Overall findings and recommendations

Overall the findings of the trial are:

- Eradication of epidemic powdery mildew infection using the base formula of HML32 - 1.25l/100L + metallic copper - 45g/100L + potassium bicarbonate - 300g/100L. is completely achievable, the crop does not necessarily split following the infection and can go on to deliver excellent harvestable outcomes.
- Two applications of any treatment was clearly are better than one application.
- If only one application is possible, it is better to increase the metallic copper rate to 67 -90g /100L water.
- The addition of sulphur decreases eradicant efficacy as shown by the harvestable outcome result.
- Once eradicated the disease did not return but preventative applications should be made at normal timings.

The recommendation for eradication of powdery mildew infection is to spray HML32 - 1.25l/100L + metallic copper - 45g/100L + potassium bicarbonate - 300g/100L twice 7 days apart, confirming the 2014 trial result. Sulphur should not be included in any eradicant spray.

6.0 Acknowledgements

Chris Henry would like to acknowledge the owner of the vineyard for allowing this trial to be undertaken, Chris Herries of Farmlands for his support and Bridget Wilton of Farmlands for her field assessment of incidence and severity and for selecting the bunches for laboratory assessment, and Peter Wood, Plant and Food Research's scientist for his assessment, analysis and statistical reporting.

Appendix 1: CV for Bridget Wilton

Curriculum Vitae for Bridget Wilton

Farmlands Horticulture Technical Advisor
Bridget.wilton@farmlands.co.nz

Relevant Qualifications

1997 Bachelor of Applied Science (Horticulture)

Relevant Employment History

Farmlands Horticulture - Technical Advisor (Current position)

Eastern Institute of Technology
Pest, Disease and Disorders in Horticulture Tutor

Constellation New Zealand
Technical Viticulturist and Grower Liaison

Montana Wines – Allied Domeq – Pernod Ricard
Assistant Vineyard Manager
Korokipo Estate, Hawke's Bay
Patutahi Estate, Gisborne

Wainawa River Estate - Vineyard Manager