A regular feature to inform industry about research projects being undertaken for their benefit. Newly approved projects (when available) are briefly summarised and longer reports will describe what has been achieved so far. When completed, each project will be reported in full detail with references, on nzwine.com

NZW Inc, Maori Point Vineyard

Research Supplement

Information and updates on Bragato Research Institute research programmes.

CONTRACTED RESEARCH PROJECTS

Quality Wine Styles for Existing and Developing Markets

Breaking the quality-productivity seesaw in wine grape production (Pinot Noir Programme)
University of Auckland, Plant and Food Research and Lincoln University (Various) jointly funded by NZW and MBIE

Prevention of quercetin instability in bottled wine
Villa Maria Wines Limited (O Powrie)

The effect of winemaking decisions on polysaccharide content in wine
University of Auckland (B Fedrizzi)

Understanding green character in Pinot noir wine
Lincoln University (D Torrico)

Exploring reductive aromas in Pinot noir
University of Auckland (B Fedrizzi)

Precipitation of calcium tartrate and other compounds in wine
University of Canterbury (K Morison)

Effect of bentonite addition prior to cold soaking on Pinot noir wine colour, tannin and aroma profile
Lincoln University (B Tian)

National Vine Collection Virus Eradication
Bragato Research Institute (D Lizamore)

Pests and Disease

Improving remedial surgery practices for control of grapevine trunk disease to increase vineyard longevity
Linnaeus (E van Zijll de Jong)

Improving the outcomes of mealybug insecticide use in vineyards
Plant and Food Research (V Bell)

Central Otago mealybug and grapevine leafroll virus management
Bragato Research Institute (L Ibbotson)

Weevils in New Zealand vineyards
Bragato Research Institute (L Ibbotson)

Cost Reduction/Increased Profitability

Long spur pruning as an alternative to cane pruning for Sauvignon blanc in Marlborough
Bragato Research Institute (L Ibbotson)

The Vineyard Environment

Vineyard Ecosystems Programme
University of Auckland and Plant and Food Research (Various) Jointly funded by NZW and MBIE

The effect of herbicide, buffered herbicide and under-vine weeding on soil biological communities and other measures of soil health.
Bragato Research Institute (M Barry)

Development of an anaerobic chain-elongation bioprocess for grape marc valorisation
University of Auckland (S Yi)

Weather and Climate

Sauvignon Blanc Grapevine Improvement Programme
Bragato Research Institute (D Lizamore)

Climate case study – Managing hail damaged vineyards
Bragato Research Institute (L Ibbotson)

Microbial community and vine responses to increasing temperatures in the New Zealand context
University of Auckland (S Knight)

Assessing foliar fertiliser for grapevine frost recovery
Bragato Research Institute (L Ibbotson)

Long spur pruning as an alternative to cane pruning for Sauvignon blanc in Marlborough

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ABSTRACT

The combination of increasing production costs, a constrained labour supply and increasing vineyard area all signal a need to explore alternative production systems for producing Sauvignon blanc. Long spur pruning has shown promise as an alternative to cane pruning for Sauvignon blanc in Marlborough, with the potential for reduced labour inputs at a similar yield and quality. Spur pruning has a greater potential for full automation than cane pruning.

A comparison of cane and long spur pruning was initiated at four Wairau Valley vineyards. The typical Marlborough pruning system of four canes per vine (4C) is compared to vines with the same number of buds but pruned to four bud spurs (4BS). It is known that bud fertility increases from the base towards the middle of the vine cane in most varieties. It follows that to achieve similar yields, more buds need to be left on spur pruned vines than cane pruned vines. For this reason, an additional treatment of five-bud spurs (5BS) with 23% more buds than the four-cane or four-bud spurs was also introduced.

We are reporting on the data collected during the first season following conversion from cane to long spur. Cane pruned vines had fewer leaf layers than 4BS in two of the four vineyards in December and in one of the vineyards in February. As expected, bud fruitfulness (bunches/bud left at pruning) was 19% lower in the spur pruned vines than cane pruned vines. The number of berries per bunch was also lower in spur-pruned vines. Compared to cane pruned vines, yields were lower in the 4BS treatment in two of the four vineyards and lower in the 5BS treatment in one of the four vineyards. Juice soluble sugars were higher in spur pruned vines in two of the vineyards, probably due to the lower yields. There were no differences in incidence and severity of powdery mildew or botrytis. There were also no pruning system differences in wine thiols and methoxypyrazines.

INTRODUCTION

To ensure its financial sustainability, the wine industry places a high priority on increasing profitability. There are no expedient ways of lowering the manual labour inputs needed for high-quality wine grape cultivation in New Zealand, and labour prices are quickly rising. This is especially true when it comes to winter pruning.

Although anecdotal data suggests that this variety can be successfully spur pruned, Marlborough Sauvignon blanc growers still favour labour-intensive cane pruning. The combination of rising production costs, a limited labour pool, and expanding vineyard area in Marlborough exacerbates the need to investigate alternate production methods for Sauvignon blanc. Delivering unbiased, scientific data on the effect of pruning systems on the performance of Sauvignon blanc will provide the basis for decision making.

The production of quality grapes generally goes hand in hand with controlling yields. Unlike other crops, winegrowers do not seek maximum yield but optimal yield according to the level of quality desired and the economic profitability of their vineyard (Ollat, 2002). Consequently, the study of the effects of cultural practices on grape production is rarely disconnected from the qualitative aspect. Yield components are number of vines/ha, number of buds/vine, bud fruitfulness (number of bunches/bud), number of berries/bunch (determined by fruit set) and berry size. The yield/ha largely depends on the number of buds/ha left at the pruning, i.e. the load of buds/ha. Cultural practices significantly affect bud fertility, fruit set rate, and berry weight. Finally, controlling yield is based on the idea of a negative relationship between the level and quality of production, the foundations of which need to be clarified.

The pruning method depends above all on the fertility of the grape variety. Spur pruning is used for grape varieties fertile on the basal buds (e.g. Merlot) and cane pruning for those of low fertility on the basal buds. It has indeed been shown that fertility increases from the base towards the middle of the vine cane (Meneguzzi et al., 2020).
The pruning method is a means of controlling yield since, at the same level of bud load, the average fertility will be different for spur pruned or cane pruned vines. As an example, Argillier (1989) (cited in Ollat 2002)) reported that spur-pruned Cabernet Sauvignon has a fertility index (average number of bunches per bud left at pruning) of 1.22 and an average bunch weight of 162g. The same variety cane-pruned has a fertility index of 1.92 and an average bunch weight of 204 g. Murisier and Spring (1986) also recorded

Figure 1. Pruning treatments

lower yields for Chasselas spur pruned than cane pruning. In New Zealand, Bennett and Trought (2009) measured a decrease of more than 40% in yield during the conversion year and around 25% in the following year when 4-cane pruned Sauvignon blanc vines were converted to spur pruning (2-bud spurs). However, one of the reasons for this decrease was the different number of buds left at pruning.

The effect of the pruning system on the quality of grapes with equal yield has not yet been clearly demonstrated. The pruning method is still closely linked to regional practices and the level of production desired for a given type of wine. For Sauvignon blanc in Marlborough, long spur pruning has shown promise as an alternative to cane pruning, with the potential for reducing labour inputs at a similar yield and quality. Moreover, a spur-pruned system has a higher potential for complete automation than a cane-pruned system.

A modified spur pruning strategy might provide a quick and easy fix for these issues without completely retrofitting the system. The project aims to examine the effectiveness of long spur pruning in multiple Marlborough vineyards and give growers the knowledge they need to decide whether this alternative pruning technique is appropriate for their circumstances.

MATERIALS AND METHODS

Vineyard sites

Four Sauvignon blanc vineyards in the Wairau Valley of Marlborough were used in the experiment. Vineyard location, soil characteristics, scion, rootstock, plant density, planting year, previous pruning system, and bud load are summarised in Table 1.

Pruning treatments

A comparison of cane and long spur pruning was investigated (Figure 1). The typical Marlborough pruning system of four canes per vine (4C) was compared to vines with the same number of buds but pruned to 4BS. Because we expected lower bud fruitfulness on the long spur treatment and therefore lower yield with the same bud load, an additional treatment of 5BS with 23% more buds than the four-cane or four-bud spurs was also introduced (Table 1). Treatments were applied to four adjacent vines in a randomised complete block design and were replicated six times. Data were collected in the two middle vines of each plot. Pruning started on 28th June and was completed on 5th July 2021.

Canopy density

Vine canopies were assessed by Point quadrat analysis in December, before leaf plucking (E-L 27/ BBCH 71) and after leaf plucking in February (E-L 35/BBCH 81). Two vines per plot were monitored. Thirty-four insertions per vine, 17 at each of the two fruiting zones totalling 68 per plot, were used (Table 1).

Powdery mildew assessment

Powdery mildew monitoring was carried out on 21 December 2021 (E-L 27 - 29) and 20 January 2022 (E-L 32). All bunches on eight shoots per plot (four shoots per vine) were scored for incidence and severity of powdery mildew using the app PMapp (software developed by the University of Adelaide).

Yield components and fruit composition

The number of bunches and shoots per count node was recorded on one cane per vine on cane-pruned vines or two distal spurs on spur-pruned vines. The fruit was hand-harvested. The incidence and severity of Botrytis bunch rot were assessed by scoring the entire population of bunches and by recording the weights of sound and diseased fruit on each plot. The number of bunches per vine was recorded and used to calculate bunch weights. Berry weight was estimated from a 100 berry sample collected from each plot. Care was taken to sample

	Vineyard 1	Vineyard 2	Vineyard 3	Vineyard 4
GPS coordinates				
latitude	S 41° 29' 30"	S 41° 29' 21"	S 41° 25' 05"	S 41° 27' 39"
longitude	E 173° 55' 52"	E 173° 57' 31"	E 174° 00' 48"	E 173° 53' 41"
Soils				
classification	Orthic Gley Soils	Fluvial Recent Soils	Fluvial Recent Soils	Fluvial Recent Soils
family	Flaxton	Selwyn	Rangitata	Selwyn
origin	alluvium	alluvium	alluvium	alluvium
soil material	hard sandstone rock	hard sandstone rock	hard sandstone rock	hard sandstone rock
soil depth	> 1 m	> 1 m	5 – 25 cm	> 1 m
potential rooting depth	80 – 99 cm	unlimited	5 – 80 cm	unlimited
drainage	poorly drained	well-drained	well-drained	well-drained
water-holding capacity	high	high	low	high
water logging vulnerability	high	very low	very low	very low
topsoil texture	silt	silt	sand	silt
subsoil texture	silt	silt	gravel	silt
gravel content in topsoil	stoneless	stoneless	moderately stony	stoneless
gravel content in subsoil	<3%	<3%	extremely gravelly	<3%
Year planted	2002	2008	2003	200
Vine spacing (row x vine)	3.0 x 2.4	2.8 x 1.8	2.2 x 1.8	3.0 x 1.8
Vines/ha	1389	1984	2525	1852
Bottom fruiting wire height (mm)	850	850	900	1000
Top fruiting wire height (mm)	1050	950	1100	1250
Sauvignon blanc clone	BDX316	UCD 1 (MS)	UCD 1 (MS)	UCD 1 (MS)
Rootstock	S04	Schwarzmann	101-14	3309
Previous pruning system	4 canes	4 canes	3 canes	4 canes
Bud load – 4 cane and 4BS (buds /m^2)	7.8	9.5	11.1	9.6
Bud load – 5BS (buds/m^2)	9.6	11.7	13.6	11.9
Point quadrat insertion height (mm)	900 & 1130	940 & 1110	1000 & 1130	1130 & 13300

Table 1: Vineyard site characteristics

both sides of the canopy and different locations and exposures within the bunches. Samples were kept chilled during transport to the laboratory. The number of berries per bunch was obtained from bunch weight and berry weight. The 100-berry sample was crushed by hand and sieved through a strainer. The juice samples were analysed for juice soluble solids, pH, titratable acidity, malic acid, and yeast assimilable nitrogen using FTIR at the Bragato Research Winery.

Winemaking

The sound fruit from two field replicates (15 kg from each plot) was pooled in the winery to obtain three ferments per pruning treatment (nine wines per site) for sites two, three, and four. Standard small-

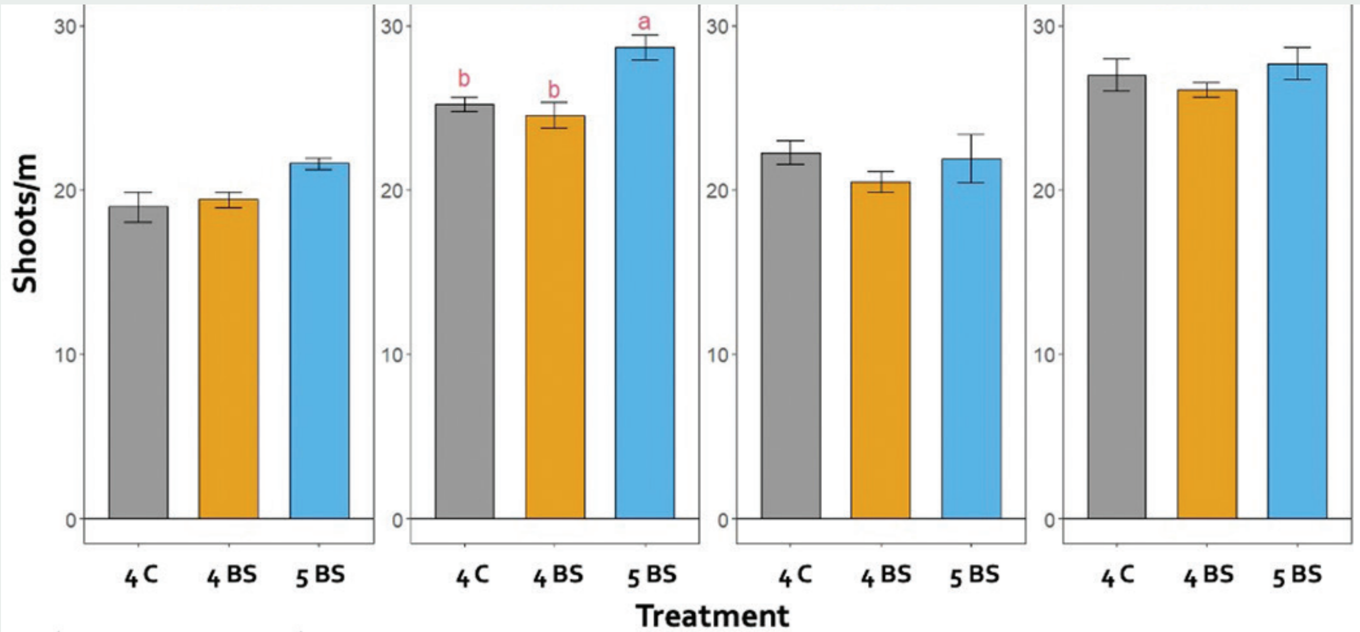

Figure 2. Shoot density in response to pruning treatments

lot Sauvignon Blanc winemaking procedures were followed.

Wine aroma compounds
Wine volatile thiols and methoxypyrazines were analysed by Hill Laboratories Limited.

Statistical analysis
Statistical analysis of data was conducted using analysis of variance (ANOVA) for parametric data and the Friedman test for non-parametric data, as appropriate, using the R programming language (R-Core-Team, 2019). The Tukey's Honest Significant Difference test was used to compare means of parametric data and the Pairwise Wilcoxon Rank Sum Test for non-parametric data.

RESULTS AND DISCUSSION CANOPY ARCHITECTURE

Shoot density
The number of shoots per linear metre was higher for the 5BS treatment in one of the four vineyards (Figure 2). This is maybe a reflection of the higher bud number in this treatment

Canopy density
Canopies were denser prior to leaf plucking in December, with more than three leaf layers. Cane pruned vines had fewer leaf layers than 4BS in two of the four vineyards in December and in one of the vineyards in February (Table 2). A higher percentage of interior leaves was also recorded in December on treatment 4BS but in only one of the four vineyards. There were no differences in the percentage of canopy gaps and interior bunches (Table 2). Treatment BS canopies did not differ from the other two treatments except for the number of leaf layers post leaf plucking in vineyard 4 when it was denser than the 4C vines (Table 2).

	Vineyard	4 C		4 BS		5 BS	
	E-L 27, 07/12/2021, before leaf plucking						
leaf layer number	1	3.49	b*	3.83	a	3.79	ab
	2	3.80		3.79		3.95	
	3	2.98		3.07		3.40	
	4	3.25	b	3.77	a	3.73	ab
% interior leaves	1	45%		48%		48%	
	2	48%		48%		50%	
	3	39%		38%		43%	
	4	41%	b	48%	a	47%	ab
% interior bunches	1	84%		95%		89%	
	2	93%		88%		89%	
	3	81%		87%		85%	
	4	89%	9	0%		91%	
% gaps	1	0%		0%		0%	
	2	0%		0%		0%	
	3	2%		0%		1%	
	4	1%		0%		0%	
	E-L 35, 16/02/2022, after leaf plucking						
leaf layer number	1	2.78		2.92		3.01	
	2	3.00		2.97		2.90	
	3	2.11		2.30		2.10	
	4	2.73	b	3.09	a	3.08	a
% interior leaves	1	37%		38%		41%	
	2	39%		39%		37%	
	3	26%		29%		26%	
	4	36%		39%		40%	
% interior bunches	1	66%		64%		63%	
	2	66%		66%		61%	
	3	39%		37%		35%	
	4	67%		75%		68%	
% gaps	1	1%		1%		1%	
	2	0%		0%		0%	
	3	3%		2%		3%	
	4	1%		0%		0%	

* Differences in the letters within rows indicate significant differences

Table 2. Point quadrat analysis of vine canopies in response to pruning treatment conducted pre-leaf plucking in December and post leaf plucking in February. N= 408: 2 vines x 34 insertions/vine x 6 replicates

YIELD COMPONENTS AND FRUIT COMPOSITION

The number of buds left at pruning varied from site to site, reflecting the different plant spacings and site vigour. Cane-pruned and 4BS vines had the same bud density, while 5BS vines had the same number of spurs as the 4BS treatment, but each spur had five buds (Table 3).

FRUITFULNESS

Treatment 4BS reached 50% bud burst two days ahead of the other treatments in vineyard 4 (data not shown). Per cent bud burst was lower for treatment 5BS in two sites (Table 3). This may be the reflection of the higher bud number in this treatment.

There are several indices to express fruitfulness. When deciding on bud loads at pruning, viticulturists use their knowledge on bud fruitfulness (number of bunches per bud left at pruning) which encompasses per cent bud burst and bunches per shoot. Bud fruitfulness was lower for the five-bud spur treatment in three sites (Table 3). Again, this may result from the higher bud number on this treatment. It was also lower for the four-bud spur treatment in one of the sites. Spur pruned vines have a higher proportion of basal buds, known to have lower fertility. Another fertility index is fruitfulness or the number of bunches per shoot. This index is used during the season to forecast yields. The indices differ, and fruitfulness is typically higher than bud fruitfulness because not all count buds produce shoots. Fruitfulness was lower for the spur-pruned vines but only on one of the sites (Table 3).

BUNCH ARCHITECTURE

The number of berries per bunch was lower in spur-pruned vines in two vineyards (table 3). Berry weights varied little across the vineyards and pruning treatments. They were lower for cane pruned vines in one of the vineyards (Table 3). The resulting bunch weights did not vary much across treatments, with 4BS vines having smaller bunches in one of the sites (Table 3).

FRUIT YIELD

Fruit yield exceeded the target of 15 onne/ha, set at the beginning of the experiment for all but one treatment in one site (Table 3).

Treatment 4BS tended to have lower yields than the other treatments, but the differences were only significant in two sites. At site 4, the cane pruned vines had much higher fruit yields than other treatments and other sites. We do not have an explanation for this inconsistency.

FRUIT COMPOSITION

From all the measured parameters, only juice soluble solids showed some response to pruning treatments. Juice soluble sugars were higher in spur pruned vines in two of the vineyards, probably due to the lower yields (Figure 3).

DISEASE INCIDENCE

There were no treatment differences in powdery mildew or botrytis incidence and severity (data not shown). Wine aroma compounds There were no significant differences in volatile thiols and methoxypyrazines in response to pruning treatments (Table 4).

CONCLUSIONS

One must exert caution when extracting meaning from the data obtained in the conversion year of a pruning system change. There are many examples of vines suffering a period of instability until a new balance is reached. As we expected, to obtain equivalent yields when spur pruning, a higher bud number is needed than when cane pruning because of the lower bud fruitfulness of basal buds. We did not see an impact on fruit composition, and yield components were not consistently affected by the pruning system. The few results available at the time of this report on wine volatile composition also showed no effect of the pruning system.

	Vineyard	4 C		4 BS		5 BS	
Buds/m²	1	7.8	b	7.8	b	9.6	a
	2	9.5	b	9.5	b	11.7	a
	3	11.1	b	11.1	b	13.6	a
	4	9.6	b	9.6	b	11.9	a
Per cent bud burst (shoots/count bud)	1	0.81	a	0.83	a	0.75	a
	2	0.94	a	0.92	a	0.87	a
	3	0.91	a	0.84	ab	0.73	b
	4	0.93a		0.9	a	0.78	b
Bud fruitfulness (bunches/count bud)	1	1.43	a	1.29	ab	1.28	b
	2	1.44		1.38		1.30	
	3	1.29	a	1.14	ab	1.03	b
	4	1.54	a	1.14	b	1.03	c
Fruitfulness (bunches/ shoot)	1	1.78	a	1.55	a	1.72	a
	2	1.53	a	1.51	a	1.5 a	
	3	1.41	a	1.36	a	1.43	a
	4	1.67	a	1.27	b	1.34	b
Berries/ bunch	1	61.8		60.3		58.5	
	2	57.9		53.6		53.9	
	3	66.1	a	60.0	b	61.6	
ab							
	4	67.7	a	57.6	b	58.5	b
Berry weight (g)	1	2.56		2.59		2.57	
	2	2.20		2.28		2.27	
	3	1.97	b	2.10	a	2.06	a
	4	2.17		2.18		2.19	
Bunch weight (g)	1	157.7		155.7		150.4	
	2	126.9		122.4		122.1	
	3	130.5		126.1		126.9	
	4	146.3	a	125.4	b	127.9	
ab							
Fruit yield (tonne/ha)	1	17.6		15.5		18.5	
	2	17.4	ab	16.1	b	18.7	a
	3	18.6		16.0		17.7	
	4	21.7	a	13.9	b	15.7	b

Means followed by the same letter are not significantly different at the 5% level.

Table 3. Yield and yield components of Sauvignon Blanc in response to pruning treatments

ACKNOWLEDGEMENTS

The authors would like to acknowledge George Jensen and Aalborg Vineyard, Jeremy Walsh and Marlborough Research Centre, Ben Burridge and Wither Hills, Dominic Pecchenino and Matador Estate for hosting the experimental blocks and New Zealand Winegrowers for funding this research.

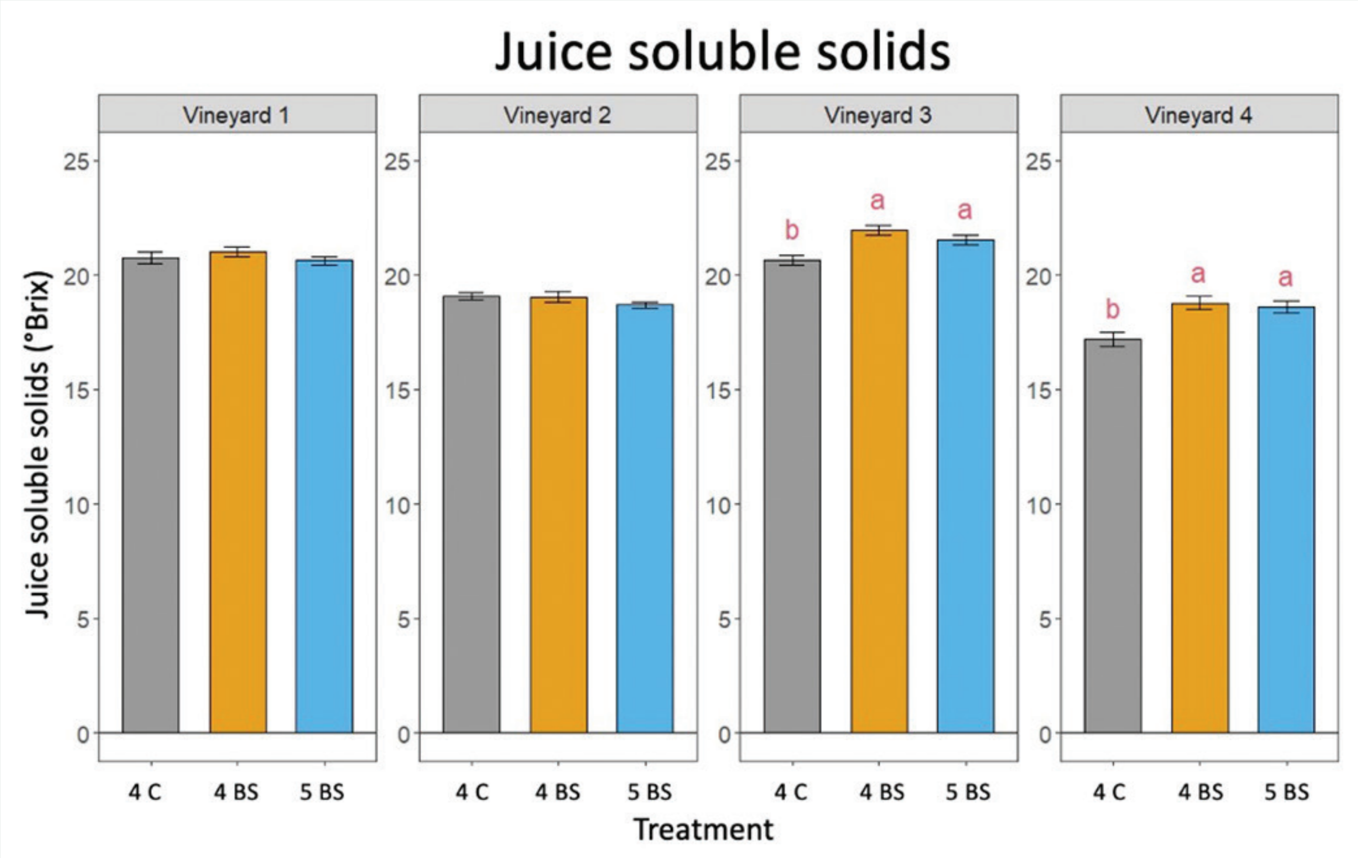

Figure 3. Effect of pruning system on juice soluble solids of Sauvignon blanc vines

	Vineyard	4 C		4 BS		5 BS	
Methoxypyrazines							
Isobutylmethoxypyrazine	2	9.33	a	10.20	a	10.20	a
IBMP (ng/L)	3	4.90	a	4.60	a	5.03	a
	4	3.63	a	4.83	a	5.10	a
Isopropylmethoxypyrazine	2	1.23	a	1.20	a	1.13	a
IPMP (ng/L)	3	1.10	a	<1	a	1.07	a
	4	<1	a	<1	a	<1	a
Sec-butylmethoxypyrazine	2	<0.7	a	<0.7	a	<0.7	a
SBMP (ng/L)	3	<0.7	a	<0.7	a	<0.7	a
	4	<0.7	a	<0.7	a	<0.7	a
Volatile thiols							
3-mercaptohexan-1-ol	2	7323	a	6433	a	5860	a
3-MH (ng/L)	3	3831	a	4463	a	4580	a
	4	2177	a	2134	a	2238	a
3-mercaptohexyl acetate	2	2760	a	2727	a	2547	a
3-MHA (ng/L)	3	1482	a	1734	a	1691	a
	4	709	a	818	a	828	a
4-mercapto-4-methylpentan-2-one	2	<11	a	<11	a	<11	a
	3	<11	a	<11	a	<11	a
	4	<11	a	<11	a	<11	a

Means followed by the same letter are not significantly different at the 5% level. Wines were not made from site one

Table 4. Effect of pruning treatment on wine volatile thiols and methoxypyrazines.

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Getting a handle on vineyard soil health

Dr Charles 'Merf' Merfield

Healthy soil is the foundation of the productivity and profitability of your vineyard, as well as being an utterly vital part of the planetary systems that sustain humanity. For example, the sky and the soil are part of the same continuum constantly exchanging carbon, so is a key part of addressing the climate crisis.

Healthy soil is also the biggest and most biodiverse ecosystem on the planet – bigger than tropical rain forests. Maximising soil health is thus a great win-win, but unless you can measure something you can't manage it. Bragato Research Institute (BRI) have been undertaking a range of activities to help winegrowers do exactly that – understand and measure their soil health.

Graham Shepherd at Palliser Estate

BRI hosted Graham Shepherd to do nine visual soil assessment (VSA) workshops in 2021. VSA are the gold standard of vineyard (and farm) soil assessments. The assessment was developed in 1999 by Graham Shepherd to provide farmers and growers with a rigorous way of evaluating their soils and has been validated against laboratory tests by several New Zealand research organisations. See bioagrinomics.com/visual-soil-assessment and fao.org/3/i0007e/i0007e00.htm for more information.

Organic Winegrowers New Zealand then hosted me to present a pair of webinars on soil health. The first presented a range of DIY soil health 'WoF' tests from the 'quick and dirty' to comprehensive. The second outlined the paradigm shift in soil science over how organic matter forms. To watch these webinars, go to organicwinenz.com.

The old paradigm was that residues, such as leaves and compost on the soil surface are broken up by small organisms like earthworms, and then decomposed by microbes, with the simple compounds such as sugars and proteins being completely mineralised in days to months and the tough compounds like straw and wood (lignin) transformed into humus which could last for centuries, even millennia. It has now been shown that this is incorrect, and that this particulate organic matter (POM) only lasts a few years, even the tough stuff. The new part of the paradigm is the vital role of exudates, such as sugars and proteins, from living plant roots. Between 10% to 40% of the photosynthates plants make from sunlight are pushed out of their roots to feed the incredible density and diversity of microbes that live on the root surface. Different plant species have different exudates which feed different kinds of microbes which means plant diversity is vital, rather than monocultures.

The microbes in turn put some of the exudates in the soil minerals, especially clays, to form 'mineral associated organic matter'. This new root exudate pathway for soil organic matter formation and maximising soil microbes is much more important than the POM route. Hence the regenerative agriculture's catch cry "living roots year-round". The reverse, bare soil from herbicides and cultivation, is therefore exceptionally harmful to soil health. Some of this is covered in greater detail in a soil testing booklet I have created in collaboration with BRI.

The booklet of the soil health tests and instructions on how to undertake them, will enable winegrowers to manage their own soils better. This booklet ranges from 'quick and dirty' tests such as spade and probe tests through the infamous 'don't soil your undies' challenge that measures biological activity through cotton decomposition.

The booklet also covers tests used by soil scientists such as penetrometers which measure density, ring infiltrometers which measure infiltration rates, and worm counts that signify overall soil health. This booklet will be available on the New Zealand Winegrowers members' website from mid-July.

Improving the use of mealybug insecticides

Vaughn Bell, Duncan Hedderley, Tara Taylor (The New Zealand Institute for Plant and Food Research Ltd), Andrew Blakeman (AJB Solutions NZ Ltd).

OVERVIEW

The citrophilus and longtailed mealybugs are enduring insect pests in many vineyards. Both species are economically important for two reasons. Firstly, they transmit Grapevine leafroll associated virus 3 (leafroll virus), which can negatively alter vine yield and wine quality. Secondly, feeding mealybugs excrete honeydew, a waste by-product, which, when disposed of by the insect, supports the growth of black sooty mould. Where mealybug numbers in vines are high, there is an increased risk of spreading leafroll virus to infect healthy vines, and of sooty mould, potentially contaminating fruit at harvest.

Because of these risks to the sector, BRI funded this three year project (vintages 2020 to 2022). A primary objective was to improve the industry's understanding and use of insecticides targeting mealybugs on grapevines. This article summarises the main results from the third and final annual report, titled Improving the outcomes of mealybug insecticide use in vineyards. Access to the full report is via the NZW members' only website.

For the latest information on mealybug control always talk to your local crop protection specialist and consult the current version of the NZW Spray Schedule.

ABOUT THE PROJECT

We collaborated with growers from 11 commercial vineyards situated in Gisborne (n=3), Hawke's Bay (2), and Marlborough (6). Hereafter, we refer to these study vineyards as 1C, 3C, 6C, and so on. The growers in each site adopted a mealybug insecticide programme of their choosing. They supplied spray diaries from 2018 to 2022, which we reviewed to evaluate mealybug insecticide use, product choice and product dose rates per unit of area. We linked this information to vine planting density and the approximate canopy size (at the time of use) to determine the point of first runoff (POR) and the likelihood of product under- or over-dosing.

From the outset of this project, we agreed with Bragato Research Institute (BRI) that the term 'insecticide best practice' meant adhering to the manufacturers' label recommendations. We developed a scoresheet that allowed us to measure each vineyard's performance over time objectively. It reflected two essential aspects: (a) the insecticide use patterns by vineyard and (b) whether these use patterns contributed to changed mealybug counts, percentages of mealybug-infested leaves, or percentages of leaves affected by black sooty mould (based on pre-harvest collections of 200 vine leaves per site per vintage).
Each vineyard's scoresheet assessed 10 criteria.

For the first six criteria, we allocated one or more points based on our assessment of relevant spray diary data (e.g. product choice, product rate, spray volume, and application timing). We compared these factors with label recommendations and the New Zealand Winegrowers (NZW) Mealybug Seasonal Control factsheet from August 2021. The sum of these criteria provided a sub-total of the 'grower behaviour' score.

For the remaining four criteria, we again allocated one or more points. In the case of vineyards where we detected low mealybug pressure (fewer than 20 per 100 leaves), we deducted points. A vineyard with more than 100 mealybugs per 100 leaves was penalised by the addition of points. The sum of these criteria provided a sub-total of the 'mealybug infestation' score.
We combined both sub-totals to create a total score per site per vintage. Higher scores reflected reduced adherence to 'insecticide best practice' and/or poorer mealybug outcomes (scores 0–5, 6–15, 16+ reflecting 'good', 'moderate', and 'poor' mealybug outcomes, respectively).

Post-harvest, we met every grower to convey results. Based on the spray diary analyses, we offered advice on the insecticide programme, sprayer set-up, and its operation. We also highlighted mealybug results. A measure of success for this project was the extent to which mealybug numbers changed over time relative to changes to the insecticide programme and the quality of its implementation.

Finally, in April 2021, Sustainable Winegrowing New Zealand (SWNZ) confirmed that some mealybug insecticides would no longer be available. Included were the organophosphates Fyfanon® (active ingredient, maldison), Lorsban® 50EC (chlorpyrifos), and Tokuthion® (prothiofos), together with Ambush™ (pirimiphos-methyl), a pyrethroid + organophosphate. The removal of these products from the spray schedule meant the availability of foliar-applied mealybug insecticides was essentially limited to the active ingredients buprofezin (Applaud™, Exault™, Mortar™, Ovation®, Pilan®) and spirotetramat (Groventive®, Movento®, Supremis®). Unlike the organophosphates, these 'softer' products are compatible with biological control. The effect of this change was that no study vineyard applied these 'broad-spectrum' products to grapevines in vintages 2021 and 2022 (further advice on this matter is via SWNZ, +64 3 577 2378).

ABOUT THE FINDINGS

Analysis of the spray diaries of each vineyard revealed varying degrees of non-compliance with 'insecticide best practice'. Commonly observed shortcomings included application timing being too early and application volumes above the point of first runoff. Insecticide timing and/or spray volumes were incompatible with the size of the canopy target. We noted some non-adherence to chemical rates, particularly under-dosing.

A few growers opted for a truncated spray programme when expanding the programme to include additional applications was the better decision. Indeed, we accept that some non-compliance was unavoidable owing to the influence of weather on the time of application and the interval between applications, for example. The annual scoresheets measuring the relationship between 'grower behaviour' and 'mealybug infestations' revealed a steady improvement in the scores allocated to most study vineyards. This resulted from conversations with growers and their generally improved adherence to the principles of 'insecticide best practice', which tended to result in better mealybug management outcomes.

An increase in the number of study vineyards achieving 'good' mealybug control (scores of 0–5) was an important measure of the project's success. In 2020, just three of the 11 study vineyards (27%) achieved this result (Figure 1). By 2021, four vineyards (36%) reached 'good'

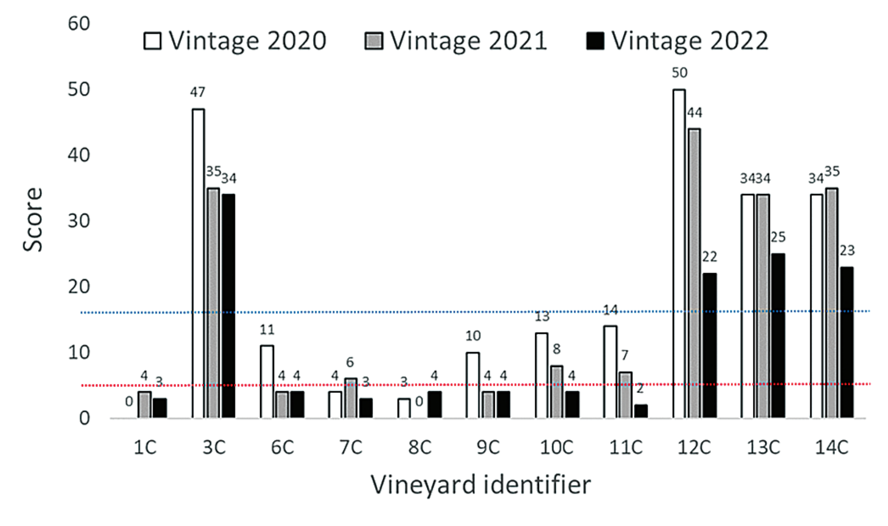


Figure 1. Between vintages 2020 and 2022, we allocated points to every study vineyard according to an analysis of the annual insecticide programme adopted and its adherence to the principles of 'insecticide best practice', which we then linked to the annual mealybug result. The score category 0–5 represents 'good' mealybug management (as indicated by the red line); 6–15 is 'moderate' mealybug management; 16+ is 'poor' mealybug management (as indicated by the blue line).

control, and by 2022, this increased to seven vineyards (64%). Of the seven vineyards, just one site (11C) used one of the abovementioned 'broad-spectrum' products, although the last application was in vintage 2019.
Vineyard 11C demonstrates improved insecticide use positively influencing mealybug management (Table 1).

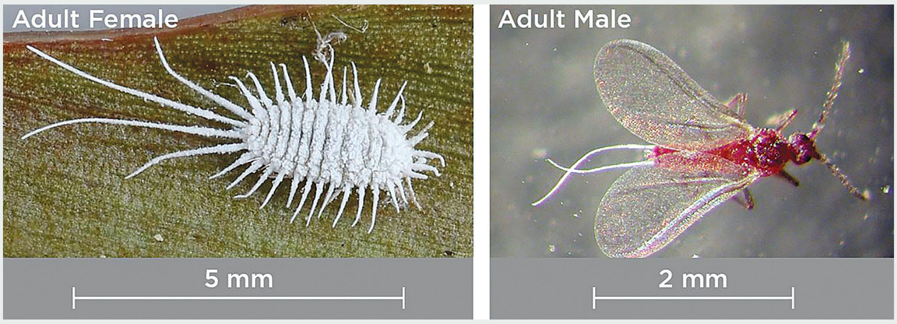
From vintage 2020, the grower applied three insecticides: two pre-flowering buprofezin applications and a spirotetramat (Movento). The buprofezin programme followed 'insecticide best practice' in all years. Spirotetramat was applied marginally earlier (Eichhorn-Lorenz (E-L) stage 20) than it should have been (E-L stages 19–27) in vintage 2020, and 12 months later, we detected lower application volumes and chemical rates relative to label recommendations. The grower corrected these omissions in vintage 2022.

The positive changes to insecticide use and the quality of implementation evident in 11C resulted in the initially high numbers of mealybugs in 2020 (64 per 100 leaves) reducing in 2021 (10) and 2022 (3). Having achieved effective mealybug control, it is now for the grower to decide if they continue with the current programme or to reduce applications (e.g. 2x buprofezin or 1x buprofezin + 1x spirotetramat). Having a good understanding of leafroll virus in the vineyard will help inform this decision.

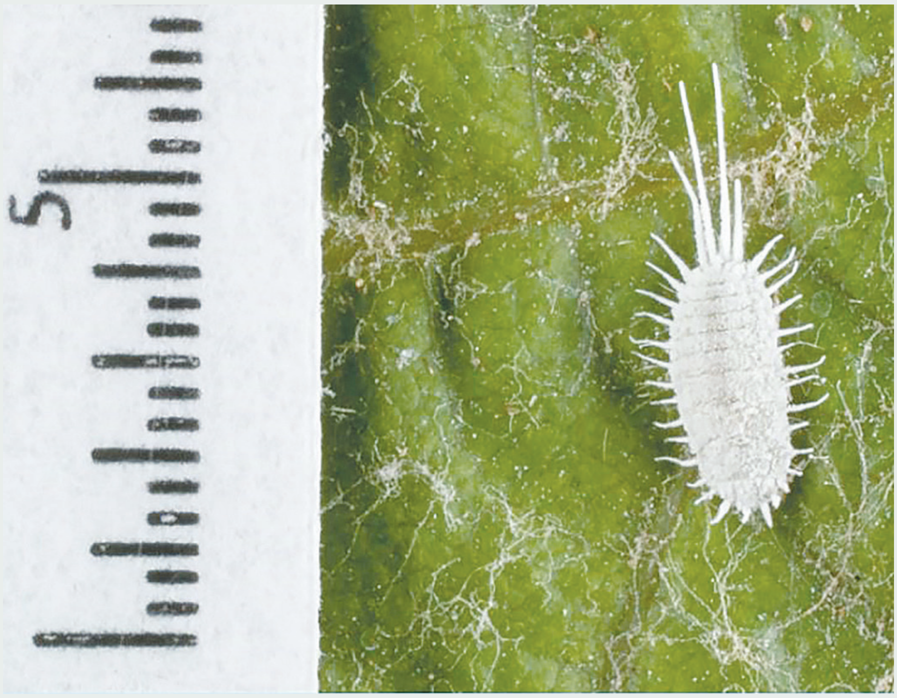
In the remaining four vineyards of the total 11 commercial properties in the trial (3C, 12C, 13C, and 14C), we detected contrasting mealybug management outcomes. The growers in these vineyards applied pre-budburst Tokuthion in almost every vintage from 2017 to 2019 (Table 2). In vintage 2020, growers from three of these four vineyards replaced Tokuthion with Lorsban, which they applied to the vines at véraison. In the fourth vineyard (12C), the grower applied both 'broad-spectrum' products. It was notable that following these decisions about product choice and the spray regime implemented in the four vineyards, we continued to detect hundreds of mealybugs per 100 vine leaves and black sooty mould-affected leaves. It seemed the legacy of broad spectrum insecticides and its influence on biological control persisted well beyond date of last application.
After the removal of the 'broad-

spectrum' products, we suggested to the growers that overcoming the sizeable mealybug populations would benefit from expanding the scope of the insecticide programme. Our suggested revised programme would include two pre-flowering buprofezin applications followed by at least one application of spirotetramat. The growers did not follow this advice in vintages 2021 and 2022.

Despite detecting persistently high numbers of mealybugs (i.e. 100+ per 100 leaves per vintage), we did identify positive links between 'grower behaviour' and 'mealybug infestations' in three of the four vineyards (12C, 13C, and 14C) (Figure 1). In vintage 2020, scores peaked at 34 to 50, but by vintage 2022, these reduced to a range of 22 to 25. Insights from vineyard 12C help to highlight this point.
As noted in Table 2, the severe mealybug infestations found during 2020 (1867 per 100 leaves) improved in 2021 (1154) and further still in 2022 (199). This significant decline in mealybug numbers suggested that the shift to 'softer' products allowed biological control to exert a more powerful influence over residual mealybug populations in a way it could not during annual applications of 'broad-spectrum' products. It is important to note, however, that these results highlight the need for growers to take a longer-term view when seeking to remedy severe mealybug infestations in the vines. The inclusion of an expanded 'softer' insecticide programme would probably have advanced these efforts.



Adult mealybugs



Adult longtailed mealybug

CONCLUSIONS AND RECOMMENDATIONS

With this three year project complete, we outline definitive recommendations to address the title of this project: Improving the outcomes of mealybug insecticide use in vineyards.

Our analysis of spray diaries and assessments of mealybug infestations over successive vintages highlighted several aspects of the insecticide programme requiring improvement. What follows is a list of observations and key findings identified during our data analyses and from conversations with growers. By adopting 'insecticide best practice' and embracing a role for biological control, growers can further consolidate the positive results emerging from this study.

CHEMICAL CHOICE

Removing almost all broad-spectrum insecticides from the NZW Spray Schedule in winter 2021 will have greatly reduced the risk of disruption to biological control. Hence, reliance on mealybug management now shifts to active ingredients like buprofezin and spirotetramat, which are both compatible with biological control.

In vineyards with evidence of relatively good control of mealybugs, adopting a two-insecticide programme successfully maintained the status quo (e.g. 2x buprofezin or 1x buprofezin + 1x spirotetramat).

For some in the industry, adopting the expanded response of a 2+1 programme (e.g. 2x buprofezin + 1x spirotetramat) is common practice, especially in circumstances where mealybugs are putting at risk the recommended control measures for grapevine leafroll virus.

This study highlighted several vineyards with very high numbers of mealybugs infesting grapevines. Evidence from vintage 2020 suggested adopting a 2+1 programme did not consistently reduce mealybug numbers in those vineyards successfully.

Table 1. Summary of mealybugs found on vine leaves and the insecticide spray programmes adopted in the seven study vineyards achieving 'good' mealybug outcomes by at least vintage 2022. Red text denotes non-adoption of 'insecticide best practice' regarding application volume, timing, chemical choice, and/or chemical rate.

	Mealybugs found per 100 leaves† (% infested leaves)			Mealybugs insecticide programme‡			
Vintage/ Identifier	2020	2021	2022	2019	2020	2021	2022
1C	5 (1,5)	8 (4)	4 (1)	BB	B	B	B
6C	123 (21)	79 (21)	13 (6)	B	BBS	BBS	BSSK
7C	50 (11)	55 (140	2 (1)	CBS	BBS	B	BBK
8C	28 (8)	8 (4)	5 (4)	BS	BB	BS	BBK
9C	42 (13)	53 (140	5 (5)	CBBA	BBS	BS	BBK
10C	3 (2)	2 (1)	29 (3)	BBSS	KBBS	BB	BB
11C	64 (17)	10 (6)	3 (3)	TSS	BBS	BBS	BBS

† 200 leaves collected per study vineyard from late February to early March 2020, 2021, and 2022.
‡ Active ingredients, B=buprofezin; S=spirotetramat; and products, A=Attack®; C=Confidor®; K=Karate® Zeon (targeting adult grass grub flying in spring); L=Lorsban®; T=Tokuthion®. Karate use in vintage 2022 was confined to vineyard edges, not entire blocks.

In several of the study vineyards, deviating from 'insecticide best practice' for factors like chemical rates, application volume, and application timing negatively affected mealybug outcomes. The study identified deviation from 'insecticide best practice', some of it occurring over successive vintages. The result often contributed to poor mealybug control.

Under such circumstances, there is merit in reviewing current settings that sees all growers become familiar with the ways in which a mealybug insecticide response can be adapted to facilitate better outcomes. This includes encouraging growers to adopt an expanded spray programme where and when necessary.

If mealybug infestations are persistently very high, like those reported for 3C, 12C, 13C, and 14C, the optimal response may be to substitute a 2+1 programme for a 2+2 (e.g. 2x buprofezin + 2x spirotetramat). To accommodate a 2+1 or 2+2 response whilst mitigating the risk of rapidly advancing vine phenology restricting the number of applications, there must be consideration given to applying product much earlier in the growing season. The severe mealybug infestations described in some of the study vineyards demonstrated circumstances befitting the need to apply product earlier in a growing season rather than miss the opportunity for a third (or possibly even a fourth) application because of PHI restrictions.

Whether a grower adopts a 2+1 or 2+2 programme, we propose the duration of either response should be no longer than three vintages. While the initial severity of infestations will influence the duration of either response, an important determinant is the continued adoption of 'insecticide best practice'. For many vineyards, adopting intensive insecticide programmes for longer than three years will lead to financial and logistical barriers (although it is important to weigh this outcome against the cost of not controlling mealybugs effectively).

Where a 2+1 or 2+2 response is not effectively controlling mealybugs in the vine canopy, it would be sensible to initiate a review of the entire spray programme – from product choice to the application process (e.g. tractor speed and maintenance to nozzle alignment). Where necessary, seek the guidance of outside expertise to help improve management outcomes.

CHEMICAL RATE

This study highlighted the importance of using the correct chemical rate when targeting mealybugs. Indeed, based on the results of this study, adopting the correct chemical rate (to avoid under- or over-dosing) is quite possibly the single most crucial factor determining the outcomes of mealybug management.

There are two risks connected to under-dosing chemicals – a less than fully effective control of the target insect and the potential that surviving individuals become resistant to the mode of action of the active ingredient in question. As the frequency of this error increases, so too do the risks.

Over-dosing increases the risk of tripping higher residues in the crop. For all mealybugs products (except Confidor), the correct dose rate is calculated by multiplying the dilute 'Point of First Runoff' (POR) (L/ha) for the canopy to be sprayed by the label rate g or mL/100 L.

Rate calculators such as SprayMixMate and Grapelink simplify

Table 2. Summary of mealybugs found on vine leaves and the insecticide spray programmes adopted in the four study vineyards achieving 'poor' mealybug management outcomes. Red text denotes non-adoption of 'insecticide best practice' regarding application volume, timing, chemical choice, and/or chemical rate.

	Mealybugs found per 100 leaves† (% infested leaves)			Mealybugs insecticide programme‡			
Vintage/ Identifier	2020	2021	2022	2019	2020	2021	2022
3C	748 (73/14)	359 (48/6)	994 (92/24)	TBB	BBSL	BBS	BB(SS)§
12C	1867 (88/420	1154 (91/35)	199 (57/10)	TBS	TBBSL	BS	BB(S)
13C	427 (67/5)	1226 (82/22)	300 (76/12)	TBS	BBSL	BB	BB(S)
14C	536 (71/7)	1153 (79/25)	360 (74/13)	TBS	BBSL	BB	BB(S)

† 200 leaves collected per study vineyard from late February to early March 2020, 2021, and 2022.
‡ Active ingredients, B=buprofezin; S=spirotetramat; and products, A=Attack®; C=Confidor®; K=Karate® Zeon (targeting adult grass grub flying in spring); L=Lorsban®; T=Tokuthion®.
§ (S) and (SS) denote there were no applications of one or two spirotetramat sprays, respectively, despite our recommendation.

these calculations.
Many labels include a per hectare rate as well as a per 100-L rate, and these aim to identify the correct dose. None of the product labels used by study participants gives a complete description of the canopy per ha rate. It is common practice for growers to apply the per ha rate, owing to a misunderstanding of the correct dose calculation using the per 100-L method.

For a given canopy of the same growth stage or height, on a given row spacing, there can be a 20% increase or decrease in the correct dose rate for dense or open canopies, respectively.

APPLICATION TIMING

Buprofezin: In a one-application programme, apply the product to the vines as close to the start of flowering (E-L 18) as is possible; in the label-recommended two-buprofezin programme, apply the first application 14–21 days prior to that described in the one-application programme.

Spirotetramat: apply this product as close as possible to the start of the PHI (i.e. ten days post-flowering but with a 90-day PHI). Note the different labels for different spirotetramat products.
These insecticide programmes all use these protectant chemicals to keep a cover on the vines for as long as possible and as late into the growing season as the PHI allows.

AT A GLANCE

Growers can no longer use organophosphates to target mealybugs on grapevines.
Follow all label recommendations and the guidance offered by NZW in the Mealybug Seasonal Control fact sheet. Chemical under-dosing risks less than fully effective control of mealybugs, with survivors possibly becoming resistant to the mode of action of the active ingredient applied.

Severe mealybug infestations may result in a two-spray programme expanded to include an additional one or two insecticide applications over the following two or three vintages. An expanded programme may require applying insecticides earlier in a growing season to provide sufficient interval between applications (14–21 days) whilst following PHI guidance

We acknowledge that weather-induced 'spray windows' at or around the time of mealybug insecticide application can disrupt optimal timing and spray interval recommendations. Spray practitioners need to adapt to the circumstances as best they can.

APPLICATION VOLUME (WATER RATE)

Generally, higher application volumes up to the POR increase spray coverage and deposition throughout the vine canopy.

Volumes above POR can lead to lower spray deposition owing to water (and by association, product) runoff onto the ground.Current 'insecticide best practice' is to apply at around half the POR, that is, 2x concentrate for buprofezin and spirotetramat products, which target foliage.

Application volumes for products at less than 2x concentrate or at or above the POR are not considered 'insecticide best practice'. Table 1. Summary of mealybugs found on vine leaves and the insecticide spray programmes adopted in the seven study vineyards achieving 'good' mealybug outcomes by at least vintage 2022.