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

Vista Wines. Photo by Chocolate Dog Studio

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 & Food Research and Lincoln University (Various) jointly funded by New Zealand Winegrowers 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)

The importance of green: understanding 'green' and 'herbaceous' characters in Pinot noir wine and their role in driving judgements of perceived quality.
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)

Potential applications of nanotechnology for wine growing in New Zealand
University of Auckland (M Kah)

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), South Australian Research & Development Institute (M Sosnowski)

Weevils in New Zealand vineyards
Bragato Research Institute (P Epee)

Cost Reduction/Increased Profitability

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

The Vineyard Environment

Microbial Responses to Under Vine Treatment
Bragato Research Institute (M Barry)

Shared Vision for Land Use in Marlborough
Bragato Research Institute (M Barry)

Regenerating Vineyard Soils - Phase One
Bragato Research Institute (M Barry)

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

Evaluating ecologically sustainable ways to disrupt the wine weta-vine association
Plant and Food Research (J Vereijssen)

Weather and Climate

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

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

Evaluating water use efficiency and drought tolerance of various rootstocks grafted to Sauvignon blanc
Bragato Research Institute (C Vasconcelos)

Tuned Vines
Bragato Research Institute (D Lizamore)

NEW PROJECT

Introducing the new BRI rootstock trial

Dr M Carmo Vasconcelos (Bragato Research Institute)

As vineyards age and succumb to trunk disease, there is an urgent need for information to support replanting decision-making. The selection of rootstock is one of the most important decisions in the development of a vineyard. To address this issue, Bragato Research Institute (BRI) recently started a rootstock research programme. A new research trial was planted in October 2022 in the Wairau Valley of Marlborough. It includes 14 rootstocks combined with three levels of irrigation, with the goal of identifying rootstocks which will prepare us for a warmer and drier future.

New adaptation strategies are required to deal with climate change, and using more efficient rootstocks is a sustainable solution.

The domesticated grapevine is a composite of two genomes. The root system of the vine, or the connection between the soil environment and the plant, is represented by the rootstock genotype. Rootstocks are crucial for storing nutrients and carbon assimilates and absorbing water and minerals. The grafting point designates the junction between the root (below-ground organs, i.e. rootstocks) and the shoot (above-ground organs, such as those of V. vinifera).

Rootstocks were originally selected for pest resistance, ease of rooting, grafting, propagation, and limestone tolerance. By providing the interface between the soil and the scion, rootstocks also impact nutrient and water uptake and many aspects of scion physiology via hydraulic and chemical signalling.

Anthropogenic climate change has impacted viticulture in almost all wine regions in recent decades, primarily due to rising temperatures, changing precipitation patterns, and an increase in the frequency of extreme events (Pörtner et al., 2022), affecting grape yield and quality. Drought, flooding, and soil erosion are only a few indirect effects of climate change that limit productivity and alter grape composition. Adaptation and mitigation are two strategies for reducing and controlling the impact of climate change.

New adaptation strategies are required to deal with climate change, and using more efficient rootstocks is a sustainable solution.

Higher global air temperature and intensity of climatic anomalies are projected to increase evaporative demand (Pörtner et al., 2022). These effects could be mitigated by increasing transpiration rates and lowering leaf temperature.

The water footprint of agriculture is under increased scrutiny, and industries need to be prepared for future restrictions on water available for irrigation. Optimising water use for vineyards by increasing water use efficiency (WUE) is critical to ensure viticulture's long-term viability.

Rootstocks have been reported to alter the gas-exchange performance of the scion and regulate water use efficiency (Barrios-Masias et al., 2015; Bartlett et al., 2022; Berdeja et al., 2014; Candolfi-Vasconcelos et al., 1994; Carbonneau, 1985; Cuneo et al., 2021; Dargie et al., 2014; de Souza et al., 2022; Lucini et al., 2020; Marguerit et al., 2012; Reingwirtz et al., 2021; Sampaio, 2007; Tsegay et al., 2014; Yildirim et al., 2018; Zhang et al., 2016; Zombardo et al., 2020).

UNDERSTANDING GEOGRAPHIC ORIGINS AND CHARACTERISTICS OF ROOTSTOCKS

Interspecific hybrids of the American species Vitis riparia, Vitis rupestris, and Vitis berlandieri make up the majority of rootstock types. Knowledge of the geographic origins and characteristics of the parent species helps in understanding the potential attributes of their crosses.

Wild Vitis riparia spreads over the largest geographic area, from the centre of Canada to Texas and

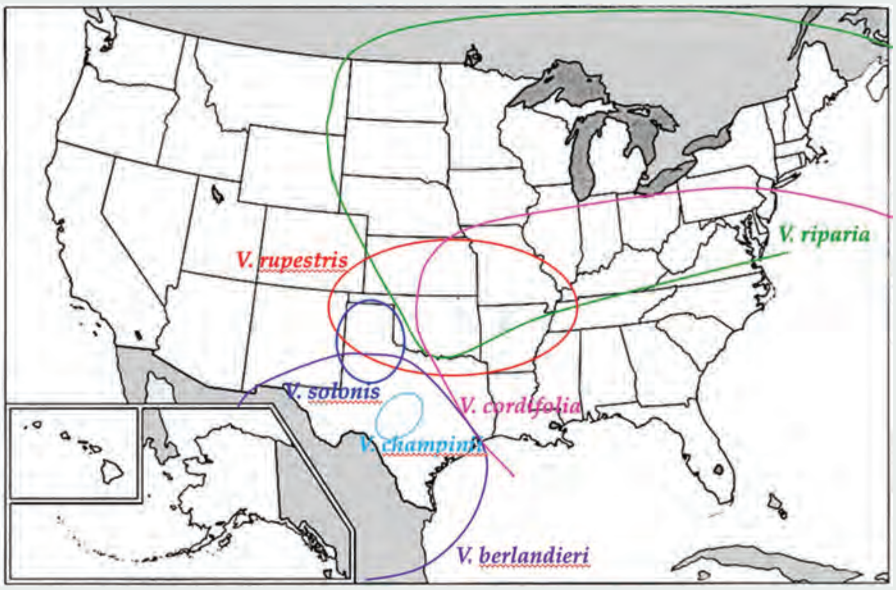

Figure 1. Geographical origin of the main American Vitis species used as rootstocks

Louisiana in the south and extends to eastern Canada and the American states bordering the Atlantic (Figure 1). It grows on riverbanks in moist, fertile soils. The root system is shallow growing. It has high resistance to phylloxera, resistance to humidity, has a short vegetative cycle and is adapted to cold climates. It has low to moderate vigour and low tolerance to limestone. It grafts well (Galet, 1988; Pongrácz, 1983). Vitis riparia Gloire de Montpellier is a widespread selection used as a devigourating rootstock in fertile soils.

Vitis rupestris is native to the South of the United States. It is a shrub rather than a vine. It is found in the wild on gravelly banks of mountain streams. It has high resistance to phylloxera, is resistant to drought in deep soils with penetrable subsoils, has a very long vegetative cycle, and is very vigorous. The root system is very deep growing. It roots easily and grafts well. It is sensitive to lime-induced chlorosis and does not tolerate wet feet (Galet, 1988; Pongrácz, 1983). Rupestris du Lot is a variety used in warm climates with long growing seasons.

Vitis berlandieri is native to the limestone hills of southwest Texas and grows in northern Mexico. It has an excellent grafting affinity with V. vinifera. This species is not used as a rootstock because its cuttings are very difficult to root. That is why it has been crossed with easy-rooting species such as V. riparia and V. rupestris. V. berlandieri was originally selected for its resistance to lime-induced chlorosis. It is a species best suited to hot climates and has a long vegetative cycle. It is very vigorous and very drought tolerant (Galet, 1988; Pongrácz, 1983).

There have been several long-term rootstock trials conducted by Plant & Food Research comparing the performance of Sauvignon blanc grafted to five rootstocks (3309 C, 101-14 Mgt, Schwarzmann, Teleki 5C, Kobber 125 AA) (Neal et al., 2014). Commercial rootstock trials have also generated valuable information on yield performance and fruit composition. The objectives of those studies did not include rootstock's impact on the water relations of the scion. We propose focusing this

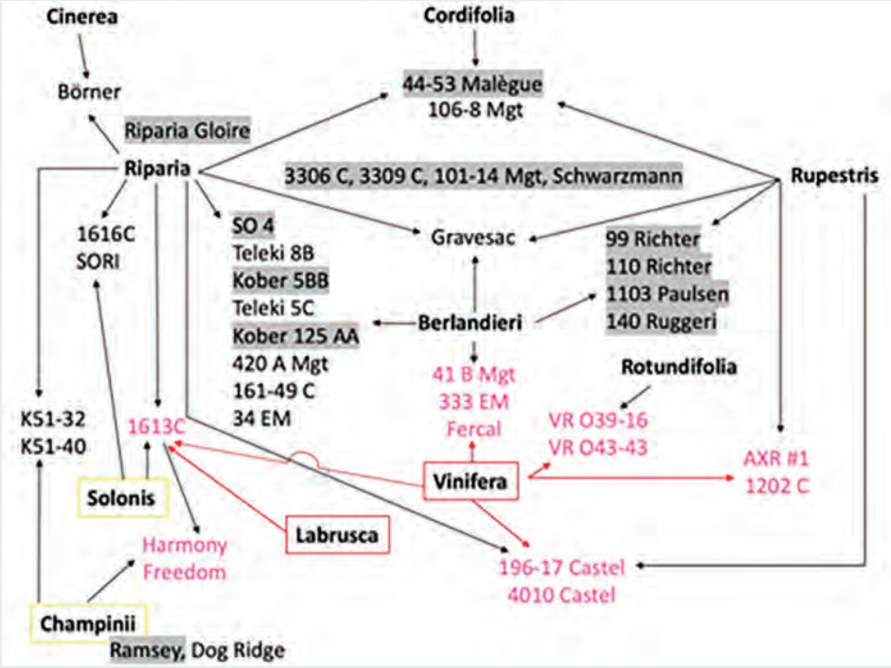

Figure 2. Parentage of internationally available rootstocks according to their breeders. Recent research confirmed the genetic background of most but not all of these hybrids (Riaz et al., 2019). One of the unknowns is the widely used 3309 Couderc. The rootstocks used in the BRI trial are highlighted in grey.

study on rootstocks' performance under limited water availability. Rootstocks that can confer improved water efficiency will contribute to the industry's resilience.

The main rootstocks used in New Zealand vineyards are interspecific hybrids of V. riparia and V. rupestris. As a group, they have low to moderate drought tolerance and confer low to moderate vigour to the scion (Shaffer et al., 2004). Figure 2 shows the parentage of the most common rootstocks.

Crosses of berlandieri X riparia and berlandieri X rupestris have been shown to have a higher tolerance to drought than the riparia X rupestris crosses. They also confer moderate to high vigour to the scion and are potentially better suited to a warmer and drier climate resulting from global warming (Sampaio, 2007).

One of the main issues limiting plant productivity is the availability of water; hence one important strategy for improving agrosystems is the development of crop types that use water more efficiently (Condon et al., 2004). To maximise yield, organic and inorganic assimilates must be preferentially allocated to the harvested organ, the grapes in viticulture. Ravaz (1906) proposed the use of pruning weight as a proxy for canopy size and vegetative growth and popularised the use of the ratio of yield to pruning weight as an estimate of the balance between reproductive and vegetative growth of grapevines. Based on his observations, the ideal values for what is now called Ravaz Index (RI) range between five and seven. Sauvignon blanc grown in Marlborough produce yearly an enormous quantity of wood, 90% of which is removed with winter pruning and displays a RI between one and four. This low ratio may be related to the need to reinforce shoot tissues with thick cell walls to enable the vine to withstand high winds. However, improving this ratio should be one of the criteria for rootstock selection.

Besides tolerance to phylloxera, rootstocks also provide some protection against other pathogens such as nematodes (Edwards, 1989; Ferris et al., 2012; McKenry & Anwar, 2006; Pinkerton et al., 2005; Smith et al., 2018; Téliz et al., 2007; Wallis, 2020), mealybugs (Naegele et al., 2020) and may be more or less tolerant of trunk disease pathogens (Gramaje et al., 2014).

For the literature cited, please visit bri.co.nz/2023/02/07/introducing-bri-rootstock-trial

PINOT NOIR PROGRAMME

Potted Vines: Exploring the management effect of leaf area to fruit weight ratios on yield and quality

Dr Romy Moukarzel, Dr Amber Parker, Dr Olaf Schelezki, Professor Brian Jordan and Professor Mike Trought (Lincoln University)

The concept of vine balance is attaining a functional equilibrium between the three essential grapevine sinks — fruit, shoots, and roots. This means that any manipulation of source-sink balance that alters competing sinks will influence the equilibrium of the plant. The leaf area to fruit weight ratio (LA:FW) is a key metric used for assessing balance between the vegetative and reproductive growth of the vine. This ratio indicates that the main source of carbohydrates supplied to the fruit derives from leaf photosynthesis. A leaf area of 0.8-1.5m2 of leaf/kg of fruit is reported to be optimal in the field. An alternative measure is that to ripen a bunch a shoot requires 14 leaves. Thus, vines that are source limited (inadequate leaf area) or have a high yield and excessive sink demand, will potentially have inadequate carbohydrates to enable fruit to reach an optimum ripening. The outcome of this imbalance is grapes can be low in soluble solids concentration, lighter colour, and undeveloped flavours and aroma at harvest. Therefore, it is essential to define the right balance between the vegetative and productive relationship to increase yield as well as improving the biochemical composition of the grape, ultimately affecting the yield-quality seesaw.

POTTED VINE SYSTEM AND EXPERIMENTAL SET UP

Our work aims to investigate the influence of changing the leaf area to fruit mass ratios on the yield and quality of Pinot noir using a potted vines system. This model system does not limit the theoretical source-sink ratio but alters the overall above-ground source sink size. It also minimises the influence of microclimate and existing source-sink imbalances that happen when working with field vines.

Two treatments were applied to Pinot noir vine clones, 777 and Abel grafted on rootstock 3309 on 2-year-old vines grown in 40 L pots. Vines were either pruned to retain one shoot with one bunch (1 shoot/1 bunch) or two shoots each

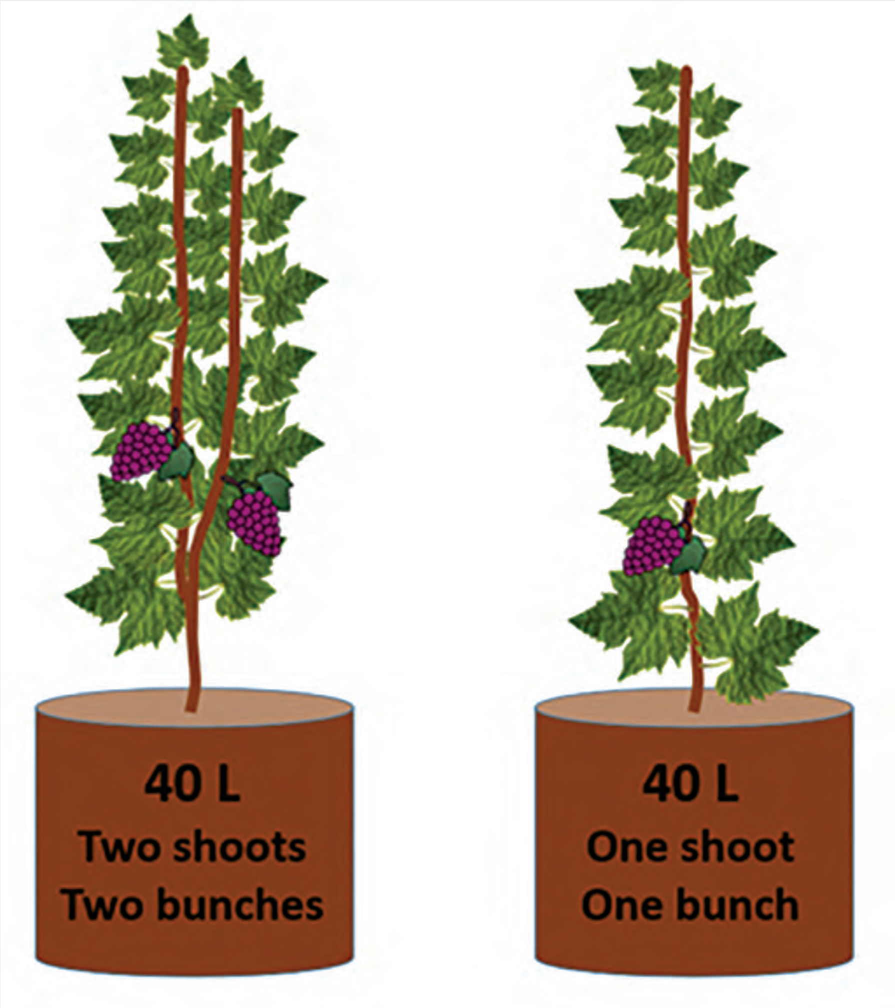

Figure 1 Experiment layout presenting the two applied treatments (one shoot carrying one bunch and two shoots each carrying one bunch). These treatments were tested for two Pinot noir clones, 777 and Abel.

with a bunch (2 shoots/2 bunches), with each shoot limited to 14 leaves per bunch. This is the suggested amount needed to ripen a bunch. Therefore, these treatments had the same LA:FW ratio as calculated by numbers of leaves and bunches despite one treatment having two-fold the total amount of both. This experiment was repeated over two growing seasons and throughout the growing season, the vines were managed, monitored, and sprayed. At harvest, leaf area was measured, and the dry weights of the root, trunk, shoot, and leaves were recorded. Berry weight, total soluble solids (TSS), titratable acidity (TA) and pH as well as phenolics and amino acids were also measured.

OVERALL FINDINGS

Our findings show that whilst the total LA and FW increased (but not doubled) in the 2 shoots/2 bunches compared with the 1 shoot/1 bunch treatment, the LA:FW ratios were the same for both treatments. This means that the treatments were effective in generating the same LA:FW ratio but by carrying different overall (total vine weight) above ground size for the source (LA) and sink (FW) (Table 1). Total berry weight for Pinot noir 777 (both seasons) and Pinot noir Abel (2020/21) as well as total berry number for both clones (both seasons) were twice where vines had 2 shoots/2 bunches compared with those with 1 shoot/1 bunch. Pinot noir Abel had heavier cluster and berry weights than Pinot noir 777 (Figure 2).

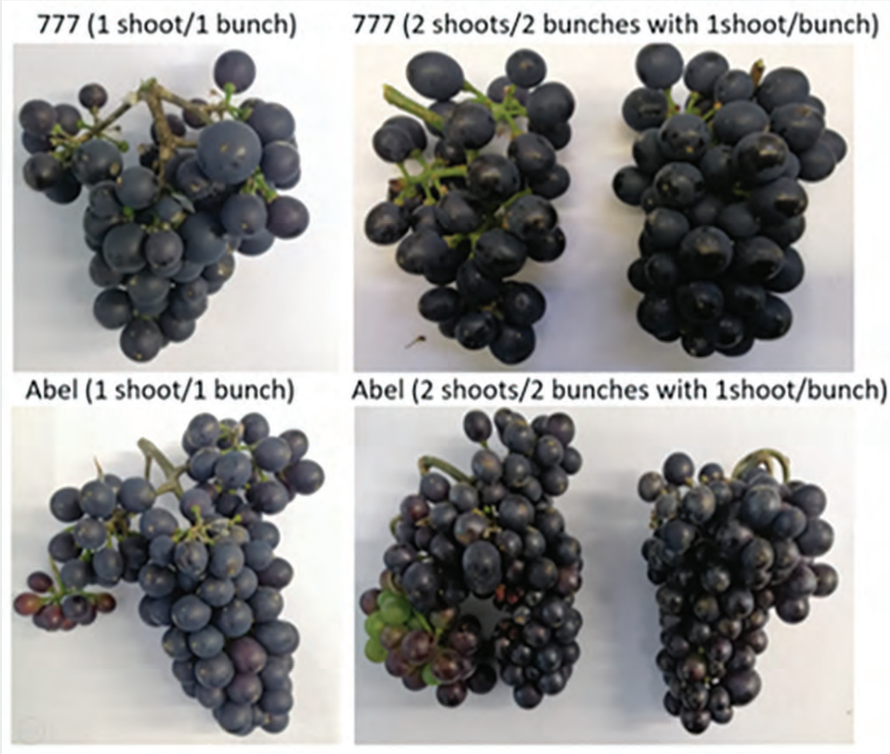

Figure 2. Pinot noir bunches from 1 shoot/1buch and 2 shoots/bunches (1 shoot/bunch) treatments in both clones (777 and Abel).

The one shoot/one bunch vines (season 2020/21) had greater allocation to above ground vegetative growth when there were two shoots, each with one bunch despite both having the same theoretical LA:FW ratio. When there were two shoots/two bunches, root growth was prioritised. There was greater allocation of carbohydrates to fruit compared to leaves in both treatments (Figure 3, A). In the 2021/22 season, both treatments had greater allocation to root growth (below ground) compared to above ground vegetative growth (Figure 3 and 4). It seems

Clone	Shoot and bunch number	Total Leaf Area (m²)	Fruit Fresh Weight (kg)	LA: FW (m²/kg)
	Season 2020/21			
777	1 shoot with 1 bunch	0.15 b ± 0.02	0.10 ± 0.01	1.57 ± 0.13
	2 shoots with 1 bunch per shoot	0.28 a ± 0.03	0.22 ± 0.05	1.47 ± 0.34
Abel	1 shoot with 1 bunch	0.33 b ± 0.03	0.09 b ± 0.03	4.38 ± 1.48
	2 shoots with 1 bunch per shoot	0.59 a ± 0.03	0.25 a ± 0.04	2.64 ± 0.65
	Season 2021/22			
777	1 shoot with 1 bunch	0.31 b ± 0.01	0.05 b ± 0.008	5.83 ± 0.92
	2 shoots with 1 bunch per shoot	0.47 a ± 0.05	0.12 a ± 0.03	4.47 ± 0.84
Abel	1 shoot with 1 bunch	0.35 ± 0.02	0.12 ± 0.02	3.48 ± 0.63
	2 shoots with 1 bunch per shoot	0.52 ± 0.16	0.23 ± 0.14	2.98 ± 1.10

Table 1 Effect of shoot number on average and total leaf area (LA), fruit mass and LA:FW ratio in both PN clones (Abel & 777) for both seasons (2020/21 and 2021/22). 3 indicates Standard Error of the Mean (SEM).

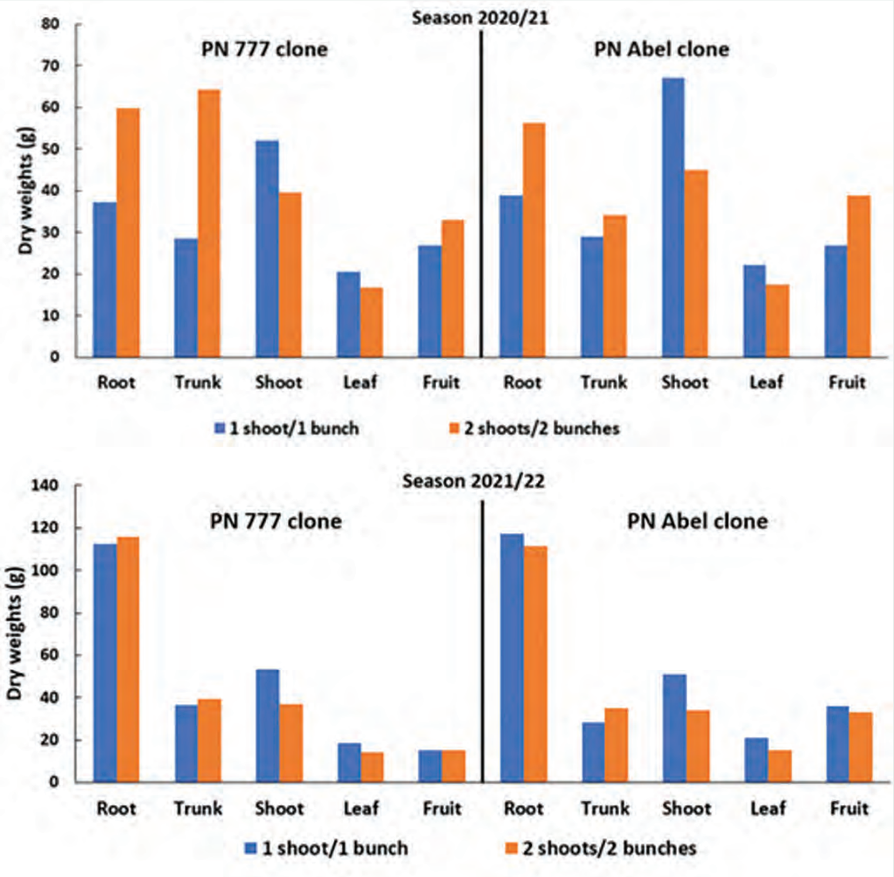

Figure 3. Effect of shoot number on vegetative growth parameters on a per shoot basis: root, trunk, shoot and leaf dry weights (g) in both Pinot noir clones (Abel & 777) for both seasons (2020/21 and 2021/22).

that in this season the carbohydrates were equally allocated between above and below ground vegetative growth (Figure 3, B).

TSS, sugar concentration, TA, and pH, total amino acids and total phenolics did not differ in response to the two treatments. However, anthocyanin concentration as well as the specific anthocyanin malvidin-3-glucoside concentration (known to be important for colour and quality perception in Pinot noir) increased in Pinot noir Abel in vines with one shoot/one bunch compared with two shoots/two bunches (one bunch/shoot). Despite no differences in total phenolics, higher concentrations of caftaric and caffeic acid were found in 2 shoots/2 bunches compared with 1 shoot/1 bunch. This may negatively affect quality as these phenolic acids play a major role in grape reaction product formation, of which high concentrations result in juice and wine oxidation. Individual amino acids (proline, glutamine, alanine, and histidine) had higher concentrations in the 2 shoots/2 bunches vines compared with 1 shoot/1 bunch vines. The increased accumulation of these amino acids (except of proline non-YAN) can have a positive effect on YAN and given amino acids play an important role in aroma and flavour precursor formation, this could have an indirect effect on quality.

TRANSLATING OUR RESULTS TO INDUSTRY

Our findings have emphasised the known importance of thinking beyond simply the yield-quality relationship, and rather focussing on the balance-quality relationship. Yield was less affected by shoot number and may be difficult to change in terms of the yield-quality seesaw in a potted vine model system. However balanced vines (defined by LA:FW ratio metrics) with no source limitation may not change in yield but can still change in berry composition and therefore potential quality. We propose that the vines invest in retention of carbohydrate partitioning at the cost of some secondary metabolism and therefore quality.

When interpreting the results in the context of retained node number at pruning, this means the node number could increase without creating a source limitation but still impact quality. Previous research outside of

Figure 4. Root mass differences in relation to shoot number (one shoot vs. two shoot) of the two Pinot noir clones (Abel and 777) at harvest (2020/21).

this programme has demonstrated that high node numbers, which create a source limitation, initially increase yield and delay ripening and TSS accumulation, but vines will compensate and equilibrate yield and maturity over the seasons minimising these observed changes. However, our research suggests it is possible to increase node numbers without creating such a source limitation, but quality may still change. So, the balance for quality may be different to that for carbohydrate partitioning, indicating the potential to define a new 'sweet spot' where we can increase node load, meeting carbohydrate needs without compromising quality.

FUTURE CONSIDERATION

Based on these findings, future research could explore non-source-limiting node loads in field that generate stable increased yields over the years and determine the 'sweet spot' for optimising quality. These will be dependent on-site capacity and climate factors as well so this may need to be tailored at an individual vineyard level. Furthermore, extending shoot length (increasing leaf area by leaving more shoot nodes and trimming higher) could also be considered in combination with optimising non-source-limiting node loads. Based on our findings, an important component of this will be to consider not simply the yield-quality seesaw, but the balance-quality seesaw.

ACKNOWLEDGEMENTS

The Pinot Noir Programme was a multi-year partnership between New Zealand Winegrowers and the Ministry for Business, Innovation and Employment that was managed by the Bragato Research Institute. The research programme ended in September 2022, aiming to grow returns through disassociating quality from yield in New Zealand Pinot noir production. This article concludes the findings of three research aims relating to potted vine studies (2.2, 2.3 and 2.4): manipulating the yield-quality seesaw via competing sink, bunch micro-climate and leaf areas. For more information about the programme and these research aims, please visit the research library in the members' section of nzwine.com.

THE AUTHORS WOULD LIKE TO ACKNOWLEDGE:

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- Damian Martin, Rebecca Deed and Emma Sherman for discussions on quality indicators in the programme.

PINOT NOIR PROGRAMME

Extraction and Reaction

Lokesh Kumar, Bin Tian and Roland Harrison (Lincoln University)

The composition of wine at the pressing stage is a result of the various components from different grape compartments and their reactions. These outcomes depend on the rates that these components transfer from grape to must and/or wine (extraction), and the rates of these important transformations (reaction).

In the Pinot Noir Programme, Research Aim 3.3 addressed this part of the winemaking process. By gaining a better understanding of extraction and reactions, winemakers can make better decisions related to the final phenolic composition of their wines. The programme had two key areas of investigation:

- How sensitive is the composition of wine at pressing to the concentrations of specific metabolites reactants (such as anthocyanins and tannins) in the must/wine at particular times during maceration/fermentation?
- What are the factors that control these concentrations?

Researchers established a maceration fermentation system on a lab scale and used this to investigate the effect of adjusting the relative concentrations of key components, particularly anthocyanins, flavanols and tannins. Because of the complexity and scale of 'real-world' winemaking, these lab scale trials have often been used to study some of the key processes. For example, early studies in a white wine medium demonstrated that anthocyanins combine with tannins during winemaking and that this reaction both increases the amount of soluble tannin in a wine and leads to a more stable red colour. Other later studies have used model systems to study the effect of pH on the formation of coloured compounds in solutions containing anthocyanins, catechin and acetaldehyde; interactions of grape skin, seed and pulp on tannin and anthocyanin extraction; the precipitation of tannin-anthocyanin derivatives in wine; and, the effect of anthocyanin addition on tannin extraction from grape skins. Thus, lab scale model fermentation systems have over the years provided useful insights into processes occurring during winemaking and continue to be used by researchers today.

One of the requirements of this study was sufficient purified anthocyanin material for use in the experiments. Pinot noir grapes have lower anthocyanin concentrations when compared with many other red varieties. Pinot noir also contains no acylated anthocyanins, which are a more stable form of the compound. Therefore, methods for extraction of anthocyanins from Pinot noir grape material were investigated. Some published methods were not suitable because they did not properly separate anthocyanins from other grape components, specifically tannins. This was clearly important because a primary purpose of the experiments was to investigate the reaction between anthocyanins and tannins. However, a suitable method was identified and refined. This allowed anthocyanins of consistent composition to be used in all five experiments conducted in this part of the programme.

In this experiment, the additions of flavanols (catechin and epicatechin) and tannins were used to establish and test the lab-scale maceration and fermentation system

Despite advances in characterising phenolic compounds in grapes and wines, winemaking products are complex and only their general features are known. A decision was made, therefore, to measure the products from the maceration fermentation system using relatively simple methods which might be relatively easily transferred to the winery situation. These were so-called MCP tannin and SO_2-resistant pigments. MCP tannin is a measure of wine tannin that has shown to be particularly useful for Pinot noir wines. The MCP stands for methylcellulose precipitable, which is essentially the way it is measured. Measuring SO_2-resistant pigments is a long-established method, part of a suite of methods commonly referred to as the Modified Somers Colour Assay. Essentially, this is a measure of the red colour remaining in the wine after excess SO_2 has been added. Because anthocyanins are bleached by SO_2, this method targets modified anthocyanins, mostly after reactions with tannins but also including other red-coloured molecules. Sometimes this measurement is referred to as polymeric pigments because most, but not all, of the pigments determined are polymeric in nature (involving anthocyanins combined with tannins).

RESULTS FROM FIVE EXPERIMENTS RESULTED IN NOTABLE FEATURES:

When anthocyanins were present, wines had higher tannin concentrations than when anthocyanins weren't present. This is a well-known result, but it was good to see it confirmed in the lab scale model maceration fermentation system. In this system, the period of two to four weeks after the end of fermentation was particularly important, indicating that a definite timescale exists for some of these reactions.

Anthocyanins declined exponentially with time, reaching negligible concentrations within 8-12 weeks. The exponential decline was faster in the presence of higher tannin concentration. By contrast, SO_2-resistant pigments increased with time.

Maximum SO_2-resistant pigment values were obtained with lower rather than higher concentrations of tannin. By contrast, maximum MCP tannin was obtained with the higher rather than lower concentration of anthocyanins. This illustrated two points. First, more anthocyanin provided more wine tannin (assuming tannin is in excess, which is reasonable in most cases). Second, the anthocyanin-to-tannin ratio affected the nature of the products of the reaction, specifically that there appeared to be an optimum ratio to generate maximum colour. The other implication of this result was that MCP tannin and SO_2-resistant pigments did not measure exactly the same material, although there was often a strong correlation between the two.

The chemical nature of anthocyanins means that they are highly soluble in water and alcoholic media, but this is less true of tannins and the monomers (predominantly catechin and epicatechin) from which they are derived. This was an important factor in determining the amount of tannin in solution at the end of one experimental period (90 days).

Experiments were also carried out to determine the effects of harvest date (early, mid, late), pre-fermentation maceration (0, 7, 14 days) and timing of tannin release (0, 4, 9 days after inoculation). These experiments generated less clear-cut results. The late harvest date favoured increased MCP tannin and SO_2-resistant pigments, as did the 14 days pre-fermentation maceration. Similarly, later release of tannin also favoured MCP tannin but there was no effect on SO_2-resistant pigments.

Overall, the results reveal that transformations and chemical reactions involving phenolic compounds begin immediately, that anthocyanins decline exponentially, and that modified tannins are the main products. The results presented here suggest a timescale for these processes, although this is likely faster at a commercial scale. The results also indicate that the anthocyanin-to-tannin ratio (something that is assessed in practice by visual observation and tasting but can be objectively measured) influences the nature of products. The results indicate that greater wine tannin and stable colour is favoured by later harvest dates and longer pre-fermentation maceration times (with limits, clearly). Finally, the results suggest that the reaction between anthocyanins and tannins is affected by the inherent solubility of species. Here, tannins and their consistent monomers are strongly influenced by alcohol content, something that increases gradually and then rapidly during fermentation. Also, note that in all experiments, malolactic fermentation was not a factor and that wines were without SO_2 while on skins.

Clearly, every winery and every fermentation are different. So how might these general observations be used in practice? The results suggest that measurement of either MCP tannin or SO_2-resistant pigments are good methods to monitor the progress of the reactions involved. MCP tannin is slightly more complicated to carry out and requires the use of a spectrophotometer (the CloudSpecTM instrument may have a role here). In the laboratory, the measurement of SO_2-resistant pigments also utilises a spectrophotometer, but the procedure could be easily replicated in any winery; all that is required is glassware, a solution of SO_2 of appropriate concentration, and a white background. Using this basic apparatus, it would be relatively straightforward to 'see' the progress of these important processes and thus compare a group of wines from different fruit parcels or resulting from vineyard or winery trials.

Extraction of monomeric anthocyanins from Pinot noir grape skins using solid phase extraction.

The Pinot Noir Programme was a multi-year partnership between New Zealand Winegrowers and the Ministry for Business, Innovation and Employment that was managed by Bragato Research Institute. The science programme ended in September 2022, aiming to grow returns through disassociating quality from yield in New Zealand Pinot noir production. This article summarises and concludes the findings of Research Aim 3.3, relating to extraction and reaction. More information can be found in the research library of the members' section at nzwine.com.