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AUSTRALIAN WINE RESEARCH INSTITUTE

Final Report - Murray Valley Winegrowers Inc. cover crop demonstration

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Introduction

In July 2020 a multi-year cover crop demonstration trial for Murray Valley Winegrowers Inc. commenced. This activity, designed and delivered by the Australian Wine Research Institute (AWRI) with funding support from Wine Australia's Regional Program, had a focus on improving soil health and vineyard sustainability through the use of mid-row and under-vine cover crops.

The aim of the demonstration was to show growers how sown cover crops can be used effectively in Murray Valley vineyards to improve soil health and suppress weeds. The impacts of the cover crop treatments on vine yield, soil and vine water status, weed suppression and soil properties were measured. The first two years of the project (2020/21 and 2021/22) involved establishing two demonstration sites – one in Swan Hill (Gorton Drive Estates) and one in Irymple (SuniTafe), with the subsequent two years devoted to data collection.

Materials and methods

1. Site description

The Swan Hill demonstration site was a Pinot Noir vineyard planted on clay-loam (with gravelly limestone) while the Irymple site was a Shiraz vineyard planted on sandy loam. The Irymple site has lower average annual rainfall (251 mm) and lower average growing season rainfall (177 mm) than the Swan Hill site (357 mm average annual rainfall and 236 mm average growing season rainfall). Both blocks were drip irrigated.

2. Demonstration design

Cover crop treatments were carefully selected for the demonstration sites based on their periods of activity, weed suppression abilities and capacity to improve soil quality. Other factors such as soil type, climate, water availability, vineyard floor management practices, vineyard layout and where the cover crop was to be established (under-vine or mid-row were) were also considered. The treatments are presented in Tables 1 and 2. Spring suppression of cover crops and its effects on yield were also explored at Irymple in 2023/24.

Table 1. Cover crop treatments at Irymple

Treatment	Mid-row
T1	Medic
T2	Cocksfoot
T3	Creeping saltbush
T4 (Control)	Volunteer sward

Treatment	Under-vine
T5	Medic*
T6	Cocksfoot*
T7	Lucerne*
T8 (Control)	Herbicide

*In 2023/24 only, cover crops treatments were further separated into herbicide and non-herbicide treatment variations. For the herbicide variations paraquat was applied at a rate of 9.6 L/ha on 13 November 2023, in spring to see whether this management intervention could improve yields. Non-herbicide variations were not intervened upon in anyway.

Table 2. Cover crop treatments at Swan Hill

Treatment	Under-vine
T1 (Control)	Grower practice*
T2	Summadorm Cocksfoot
T3	Sultan and Scimitar medic
T4	Silver Snail and Seraph medic
T5	Lucerne
T6	Medic/Cocksfoot blend

Treatment	Mid-row
T7 (Control)	Volunteer sward
T8	Medic
T9	Medic/Cocksfoot blend
T10	Saltbush

*Prior to the 2023/24 season, the grower's usual practice was herbicide control (typically sprayed out in mid-November). In 2023/24 a volunteer sward was allowed to grow instead. Therefore, this control treatment varied depending on the year

3. Site preparation

To ensure good site preparation for effective cover crop establishment, targeted herbicide applications were used to ensure the seed bed was weed-free prior to sowing.

Figure 1. Seeding mid-row cover crop with Taege seeder.

4. Seeding

The cover crops were sown in Swan Hill in May 2021 and in Irymple in May 2022 at the rates shown in Table 3. The medic treatment consisted of four medic species (*Medicago truncatulata, Medicago scutellate, Medicago polymorpha, Medicago littoralis*) combined to give a total seeding rate of 25 kg/ha. All the medic seed was pre-treated with rhizobium bacteria to help ensure nodulation and nitrogen fixation.

Figure 2. Seeding under-vine cover crop with Taege seeder

All treatments were sown using a quad bike towing a 1.6 m wide, 6-row (25 cm space between seeded rows) Taege direct drill seeder. The mid-row treatments were sown with one 1.6 m pass down the centre of the vine row (Figure 1), apart from the saltbush, which was sown using a single row of seed down the centre of the mid-row (recognising that individual plants will spread to about 1.5 m). The under-vine cover crops were sown with one run each side of the vine row, with the other runs blocked off (Figure 2). No fertiliser was applied during sowing and no cover crops were resown after initial seeding.

Table 3. Cost and seeding rates of cover crops planted

Treatment	Species	Common name	Rainfall range (mm)	Seeding rate (kg/ sown ha)	Seed cost ($/kg)	Total cost ($/sown ha)
Medic	*Medicago truncatulata*	Jester	250 - 400	6	$11.00	$264.50
	Medicago scutellata	Silver snail	300 - 700	7	$9.50	
	Medicago polymorpha	Scimitar	250 - 650	6	$11.00	
	Medicago littoralis	Seraph	250 - 650	6	$11.00	
Cocksfoot	*Dactylis glomerata*	Summadorm	400 – 550	7	$22.00	$154.00
Saltbush	*Atriplex semibaccata*	Creeping saltbush	250 - 900	6	$140.00	$840.00
Lucerne	*Medicago sativa*	Lucerne	250 - 800	5	$16.50	$82.50

5. Cover crop maintenance

After establishment, periodic visits were made to each site to check progress and provide weed management using a wick wiper and line trimmer as required. The under-vine areas of the mid-row treatments were kept weed-free using herbicide applications. The mid-row treatments were mown as required.

6. Irrigation management

Phytech dendrometers, alongside soil moisture sensors measuring volumetric water content were used to provide information about the water status of each treatment. Dendrometers are plant sensors that continuously monitor microvariations (shrinkage and swelling) in trunk diameter and can be used alongside soil moisture sensors to provide a more complete picture of vine water requirements. At each demonstration site, the treatments were all on the same irrigation valve, receiving the same volumes of irrigation. Irrigation was applied across each of the demonstration sites to meet the needs of the vines with the highest irrigation needs (as indicated by the Phytech platform).

7. Harvest

Each treatment was harvested separately to measure the interaction between cover crop treatment and vine yield. With the lack of treatment replication at each site, no statistical analysis was performed on results. Vine yield was not measured at the Swan Hill site in 2023 due to severe disease pressure.

8. Soil analysis

A variety of soil analyses were undertaken to assess parameters such as microbial biomass, soil carbon, soil compaction and soil chemistry. Soil sampling was undertaken on 6 November 2023,. Analysis was performed by Analytical Laboratories & Technical Services Australia in Merbein.

Results and discussion

1. Mid-row cover crops

1.1. Establishment success and weed suppression

Only mid-row cover crop results from Irymple are reported here.

At Swan Hill, cover crop establishment in the mid-row was compromised and accordingly no results are reported. The hard setting nature of the soil prevented the seeder from obtaining the correct seeding depth required for germination. The mid-row area was also very uneven due to removal of soil from the mid-row to mound the under-vine strip, and this prevented the seeder from making effective contact with the ground.

Medic

At Irymple the four medic species established and grew well, enjoying the benefits of above-average rainfall (Figure 3) in 2022. Following seed set and then senescence, the medics were mown to control the summer weeds that had emerged. Unfortunately, the medics were mown lower than desired, and the mulching value of the crop was diminished; however, a very good seed bank remained on the soil surface (Figure 4). In 2023 the medics regenerated from their own seed bank established in the previous year. They again grew well, despite the dry early spring period and by early November they had senesced in the mid-row (Figure 5). They showed they were well

adapted to the growing environment. It is generally preferable to mix medics with annual ryegrass as they are complimentary in growth and the ryegrass provides benefits to soil quality not realised by medics alone. However, the site manager's allergy to ryegrass prevented this as part of the demonstration trial.

Cocksfoot

At Irymple the mid-row cocksfoot treatment established very well, growing to a maximum height of 30 cm during the winter/spring periods of each season (Figure 6), before entering dormancy in late spring (approximately mid-late November). The cocksfoot provided a good mulch layer on the soil surface (Figure 7), which in the second year suppressed summer weeds such as caltrop, prickly lettuce, fleabane and milk thistle.

Saltbush

Important in warm, dry environments, creeping saltbush only grows to about 15cm high, but generates a thick mat on the soil surface, suppressing weed growth and keeping soil temperatures cool (not measured as part of the demonstration). Unfortunately, the establishment of this cover crop in this trial was rather sporadic. This was likely caused by the seeder resisting operating at very low output revolutions and therefore switching on and off (it has an electric motor drive for the seed distributor), resulting in irregular seeding.

In the second year the creeping saltbush had spread further, but still had spaces for barley grass to grow amongst it (Figure 8). Saltbush grows mainly over summer, so winter weeds which grow through and between plants may need a high mowing in spring. The summer growth provides lower soil temperatures underneath the plant, which also provides great habitat for beneficial insects. Saltbush can be difficult to establish; however, given its recognised benefits of providing habitat for beneficial insects, there is potential to mix seed in with cocksfoot or medic at low rates, and thereby have some plants but not a solid stand of saltbush in the mid-row.

Volunteer sward (control)

At Irymple the volunteer sward mostly consisted of barley grass, which was mown as per standard practice on the property. A mix of summer weeds including fleabane, prickly lettuce and caltrop were evident, enjoying the lack of soil cover remaining in the mid-row (Figure 9).

Figure 3. Mid-row medic blend, well-established, 19 September 2022, Irymple

Figure 4. Mid-row medic blend following mowing, 28 February 2023, Irymple

Figure 5. By early November the medic and annual grasses in the mid-row had senesced leaving summer weeds (prickly lettuce and milk thistle) to appear, which required the occasional high mow, 11 November 2023, Irymple

Figure 6. Summadorm cocksfoot going dormant in the mid-row at Irymple 11 November 2023. No weeds are visible amongst it.

Figure 7. Mid-row cocksfoot in its dormant state, 28 February 2023, Irymple

Figure 8. Mid-row creeping saltbush, 28 February 2023, Irymple

Figure 9. Mid-row volunteer sward (mown only) with milk thistle and prickly lettuce present, 11 November 2023, Irymple

1.2. Yield

At Irymple, compared to the control volunteer sward, saltbush was associated with a vine yield reduction of 8.7% in 2022/23 and 27% in 2023/24, whereas the medic treatment appeared to have little impact on vine yield in both seasons. On the other hand, vine yield in 2023/24 under the cocksfoot treatment had a reduction of 54% compared to the control (Figure 10).

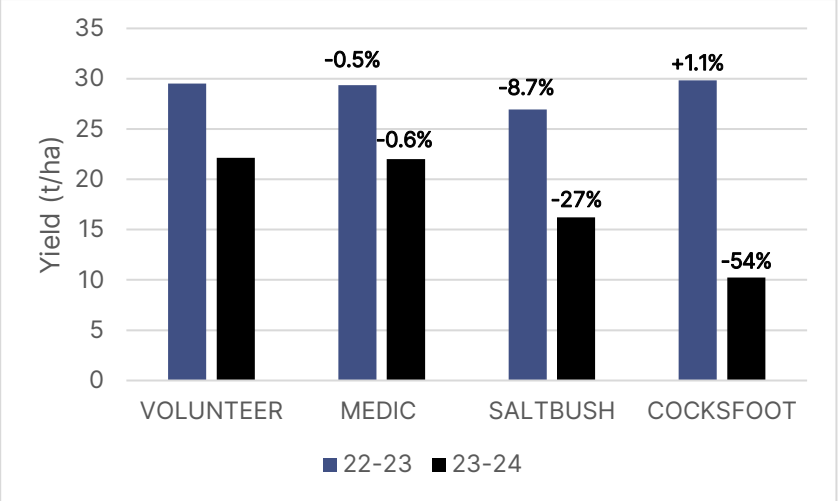

Figure 10. Vine yield in mid-row cover crop treatments at Irymple, in seasons 2022/23 and 2023/24. Values indicate percentage reduction in yield compared to the control in each season

The yield reduction observed with the saltbush treatment in each season was most likely due to the saltbush continuing to actively grow over summer, in comparison to the medic which had senesced in spring. This influence of the saltbush on yield is unexpected as it is generally recognised that drip-irrigated vines in the warm, dry inland regions have little interaction with or dependence on the mid-row. However, for this site at Irymple, an active vine root system must be near or present in the mid-row. In 2023/24 the large reductions in yield in the cocksfoot and saltbush treatments were likely associated with a drier than average August and September, with these species actively consuming soil moisture away from the vines as they entered budburst. It is suspected that competition may have contributed to a poor fruit set and ultimately influenced final yield. Furthermore, despite cocksfoot senescing in late November, as opposed to saltbush growing year-round, the cocksfoot has higher water requirements and therefore had a larger negative impact on vine yield than the saltbush.

The medic being associated with negligible impacts on vine yield suggested it was the most promising treatment as a mid-row cover crop in these warm, dry, inland conditions. The medic was rated as a good weed suppressor; however, well behind cocksfoot.

2. Under-vine cover crops

2.1. Establishment success and weed suppression

<u>Medic</u>

At both Irymple and Swan Hill, the medic mixes performed very well, producing significant biomass over winter and spring in each season (Figure 11). The medics senesced following seed set to leave a mulch about 5 cm deep under-vine, before regenerating with rains in the following autumn. Unfortunately, the mulch layer was not enough to suppress the germination of all summer weeds at Irymple (rated by visual inspection) (Figure 12), so they received one application of Basta. Similar observations were made at Swan Hill. In a non-chemical situation, the medic could be mown with two passes during the season.

<u>Cocksfoot</u>

The Summadorm variety of cocksfoot is genetically programmed to be summer dormant; however, when supplied with irrigation it continued growing strongly over the summer period at both sites

(Figure 13). Some summer weeds grew at the edges of the planted sward at Irymple in 2022, which competed with the cocksfoot before it was fully established. In the second year after establishment, the cocksfoot growth was very strong, completely preventing weed growth under the vines (Figure 14). Excellent weed suppression was also observed at Swan Hill.

Lucerne

The lucerne stand was slow to establish at both demonstration sites and also suffered from intermittent seed distribution, which generated patchy stands. Where the lucerne was established, it grew well under-vine at Irymple, and was flowering at harvest time, attracting several flying insect species. Where lucerne grew well, it had excellent weed suppression ability (Figure 14).

Figure 11. Medic under-vine at the Swan Hill site, November 2023.

Figure 12. Medic, with some milk thistle and barley grass also growing amongst the biomass at Irymple, November 2023.

Figure 13. Summadorm Cocksfoot under-vine at the Swan Hill site, November 2023.

Figure 14. Cocksfoot (left) and lucerne (right) under-vine, Irymple, 11 November 2023.

Figure 15. Lucerne under-vine at Gorton Drive, Swan Hill. November 2023

2.2. Water requirements for under-vine cover crops

As cover crop treatments at each site were on the same irrigation valve, they were given the same amount of water. Sensor data indicated that cover crops led to reduced water availability for the vine, with impacts varying by season, species and location. At Irymple, cocksfoot had the highest water requirement in 2022/23, whereas lucerne had the highest water requirement in 2023/24 (Figure 16). At Swan Hill, cocksfoot generally had the highest water demand in both seasons.

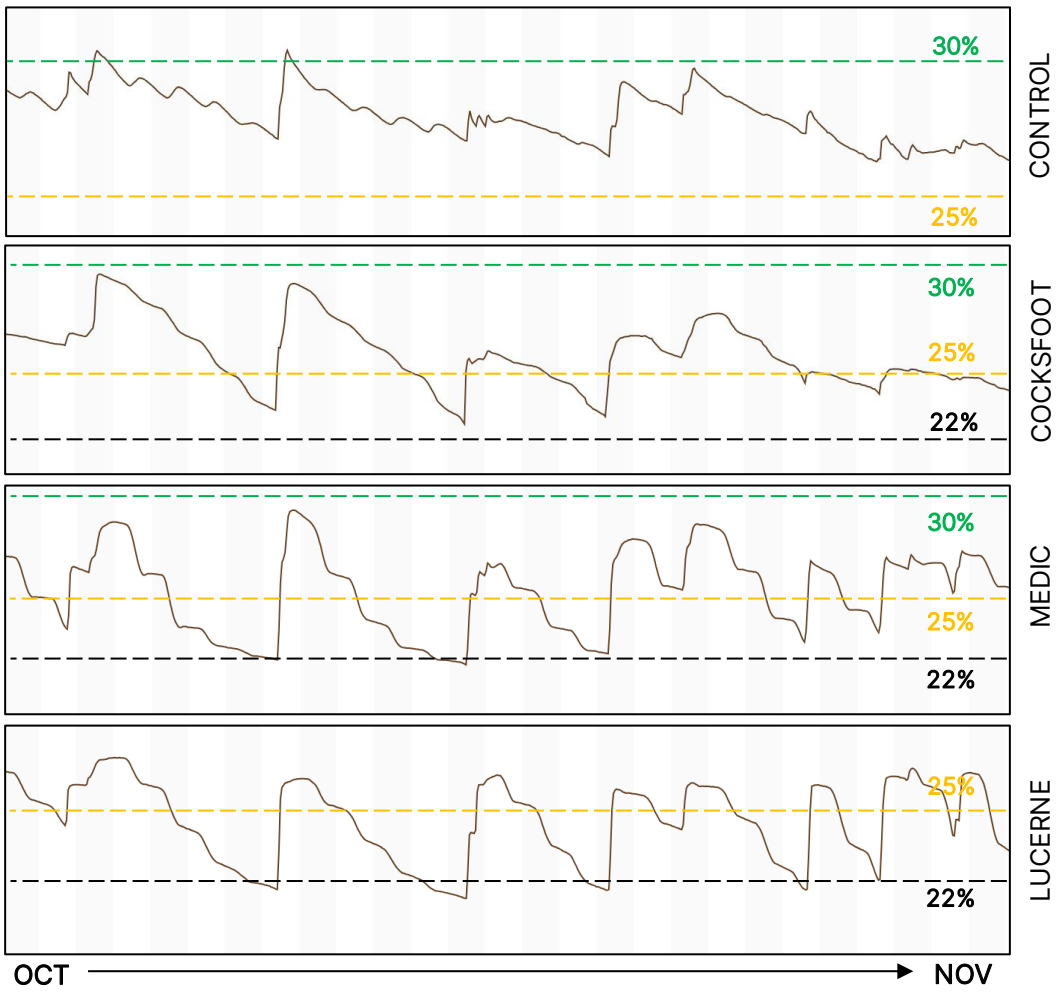

Figure 16. Changes in rootzone soil moisture (up to 30cm) between 16 October 2023 and 12 November 2023 at Irymple, reproduced from the Phytech platform. The green, yellow and black lines indicate 30%, 25% and 22% volumetric water content, respectively.

2.3. Yield

For the under-vine cover crop treatments at Irymple, the cocksfoot and lucerne treatments resulted in larger vine yield reductions compared to the control than the medic treatment in both seasons, (Figure 17). This result was expected, particularly from the lucerne, as it continued to grow and compete for soil moisture throughout the vine's active growth phase. For the cocksfoot, when provided with regular water (as it was at Irymple) it does not enter dormancy. Despite the weed suppression benefits of cocksfoot in both years of the demonstration, this species may be considered an undesirable under-vine cover crop due to its high-water demand.

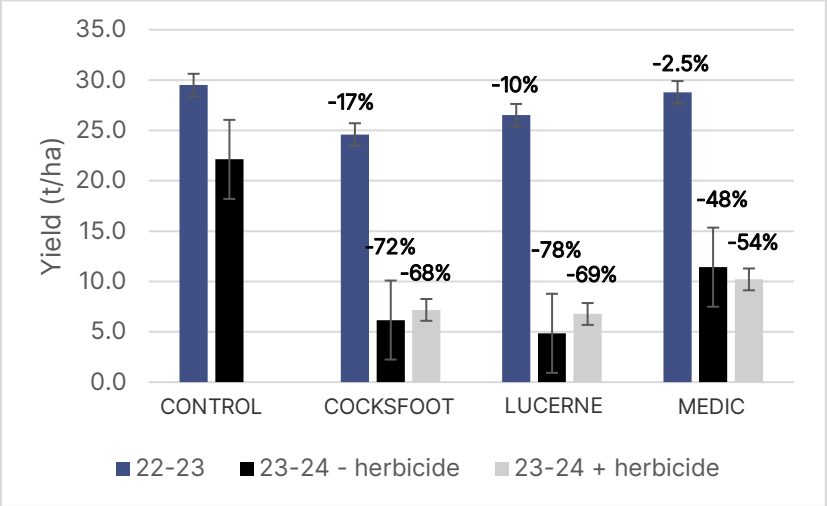

Figure 17. Vine yield in under-vine cover crop treatments at Irymple, in 2022/23 and 2023/24. Values indicate percentage reduction in yield compared to the control in each season.

At Irymple, in an attempt to suppress the competition of the cover crops for soil moisture, in 2023/24 planted cover crops were treated with herbicide in spring, with sections left untreated for comparison. Given the lack of large differences in yield between herbicide-treated and non-herbicide-treated for each cover crop species (Figure 17), it is clear that the herbicide should have been applied earlier, prior to flowering. Other work in the Riverland, SA (Nelson, Riverland Soil Improvement Trials, 2024) has shown that when under-vine cover crops are sprayed out prior to spring, vine yield losses can be reduced.

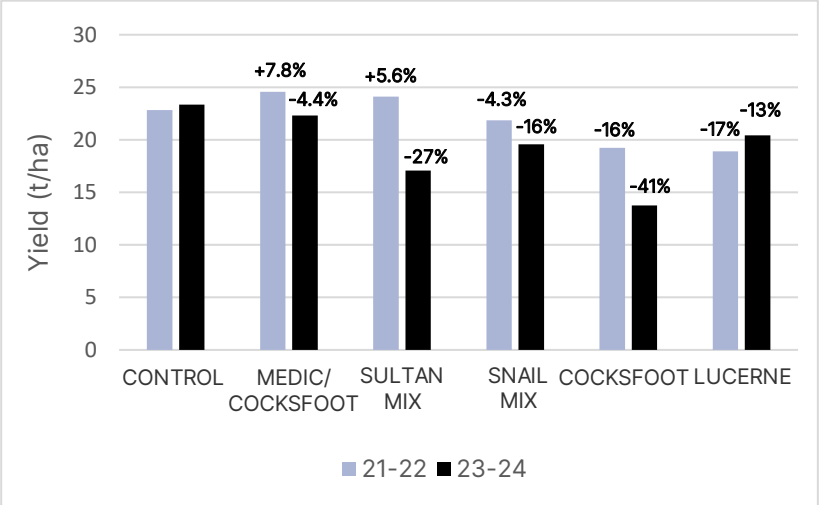

Figure 18. Vine yield in under-vine cover crop treatments at Swan Hill in 2021/2022 and 2023/24. Values indicate percentage reduction in yield compared to the control in each season. In 2021/22 the control was a herbicide treatment and in 2023/24, a volunteer sward.

At Swan Hill, the presence of the under-vine cover crops generally decreased vine yield for all treatments compared to the control in both years, noting that 2021/22 was the first year of establishment and therefore effects on vine yield were expected to vary by species according to the rate of establishment of each cover crop (Figure 18). Yield reductions were lower than at Irymple, likely due to the higher water availability at Swan Hill. Differences in the performance of lucerne are likely attributed to differences in establishment success at the two sites, driven by lucerne's preference for sandier soil at Irymple, where its tap root provides significant soil moisture extraction and therefore competition with the vines (as noted in Figure 16).

In general, vine yield associated with the under-vine cover crops was lower in subsequent years of the demonstration at both sites. This is likely due to both weather conditions, and better establishment of the cover crops and therefore increased competition for soil moisture at critical stages within the vine's growing cycle. Yield reductions may be a function of reduced bunch

number (which is largely determined by conditions around bud initiation in the previous spring), as well as lighter bunches, which could be driven by both bunch size (branching and bunch architecture) and/or flower formation and number of berries (processes which are affected by conditions in the growing spring) (Table 4).

Table 4. Key phenological stages and impacts on yield

Stage of the growing cycle	Phenological stage
Preceding spring	Bud initiation (affecting bunch number)
Early spring of growing season (Budburst, or just before)	Inflorescence branching (affecting bunch size)
Late spring of growing season (Flowering to fruit-set)	Flower formation and set (affecting number of berries)
Growing season (fruit-set to harvest)	Berry enlargement and potentially shrivel (affecting berry weight)

Successful management of cover crops in the Murray Valley will need to be driven by species planted and seasonal conditions to minimise competition with vines for soil moisture. Unless growers are willing to spray cocksfoot and lucerne with herbicide by early spring in most seasons, these species are not suitable under-vine cover crops in warm, dry climates. The medics, because they senesce in mid to late spring, are still suitable under-vine cover crops, but in years such as 2023 with a very dry early spring, require early control. This does not affect their capacity to rebound in following years if a good seed bank has been established in the first year's growth.

3. Soil health

Most treatments at both sites had very healthy microbial biomass carbon levels (approximately 400 mg-C/Kg soil and above is recognised as being desirable) and acceptable carbon:nitrogen ratios (important for mobilisation of nitrogen) (Figure 19). At both sites, soil chemical properties under different treatments were quite similar (irrespective of whether under-vine or mid-row), indicating that the different cover crops did not have a significant effect on soil chemistry during the relatively short time periods of measurement. Penetrometer readings showed relatively high soil compaction for both sites, but no treatment differences (data not shown).

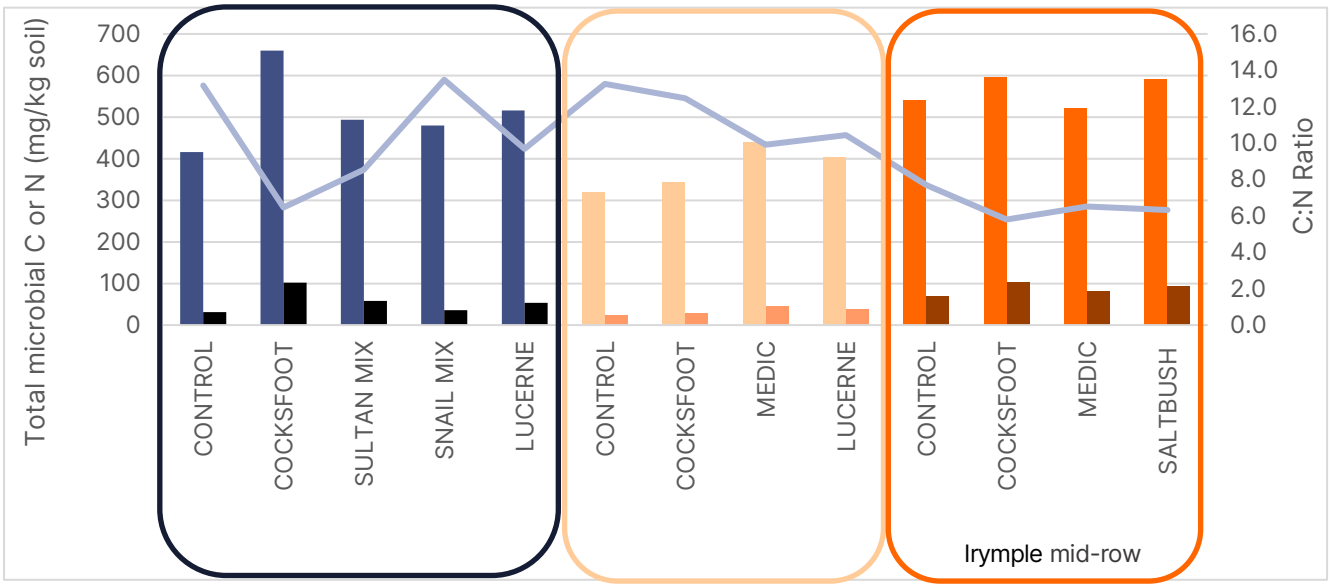

Figure 19. Total microbial biomass carbon (tall bars) and microbial biomass nitrogen (short bars) and associated carbon:nitrogen ratio (blue line).

Along with other parameters such as soil organic carbon (SOC), microbial biomass is typically used as an indicator of soil health. Soil microbes require energy from various carbon sources including root exudates and soil organic matter. Combined with proteins generated from nitrogen providers such as legumes, the mass of microbes will increase as availability of both nitrogen and carbon increase. Therefore, these results (Figure 20) potentially indicate that carbon stores within the soil may be increasing for some treatments. However, it is important to note that due to the numerous influences on microbial biomass, this type of data is generally more of a snapshot in time and may require multiple measurement points. Nevertheless, measuring microbial biomass is a useful indicator of short-term fluxes in soil carbon stores, as other indicators like SOC may take years to show meaningful differences between soil amendments.

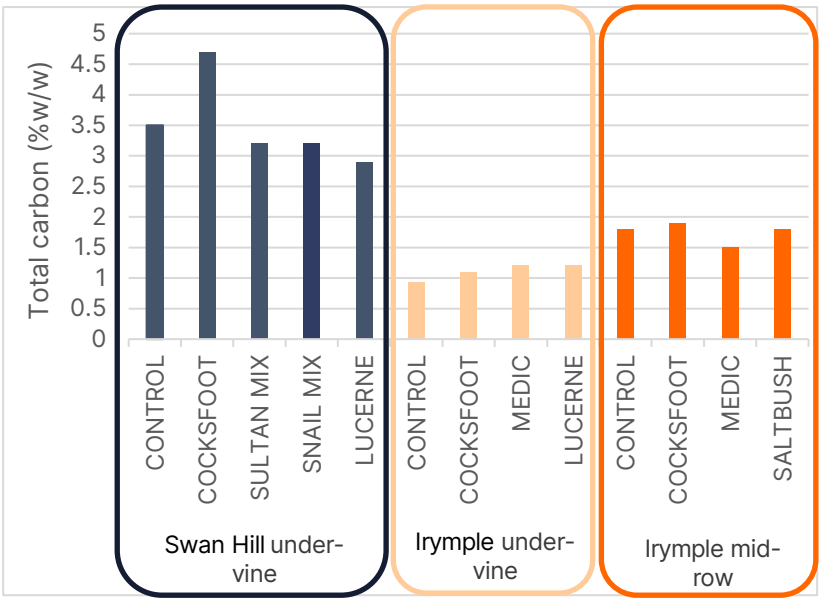

Figure 20. Total soil carbon under each treatment at both demonstration sites (November 2023).

Of note within the SOC data, there were substantial differences in SOC when comparing the under-vine area (1.1%) at Irymple, with the mid-row at Irymple (average of 1.75%), and the under-vine area (3.2%) at Swan Hill. The under-vine soil at Irymple has generally been managed as a clean strip using herbicides, whereas the mid-row has been managed only by mowing the regenerated barley grass and other plants. At Swan Hill, compost is applied under-vine on an annual basis, contributing to an impressive average of 3.2% organic carbon, which then also feeds the microbial biomass. Notwithstanding innate differences between each of these areas, it is likely historical vineyard floor coverage has contributed to improved soil carbon in the mid-row at Irymple and under-vine area at Swan Hill, indicating that maintaining vineyard floor coverage can be a beneficial management practice.

Conclusion

The wetter-than-average conditions experienced at Irymple during the 2021/22 season provided excellent conditions for the cover crops, enhancing their establishment and growth. Rainfall was in line with long-term averages for Swan Hill in 2020/21, which provided enough moisture for cocksfoot and medic species to establish under-vine. Seed set in the annual medics has now provided a seed bank in the soil, which should ensure their long-term recruitment when rainfall is sufficient. Despite inconsistent responses in yield, the mid-row cocksfoot also shows considerable promise as a weed-suppressing cover crop that is cheap, easy to establish and low maintenance. Creeping saltbush could be readily included with the seed mix of the medic or cocksfoot to add some biodiversity and beneficial insect habitat to the mid-row. Cocksfoot, if sown under-vine, will prevent weed growth but suppress yields unless additional water and potential nutrients are applied, but is a very effective weed suppressant. In areas where sub-soil compaction is an issue, the bio-drilling mechanism of lucerne could be used to open up the sub-soil under vine. After having performed this function, it could then be removed using herbicides.

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Wine Australia

Murray Valley Winegrowers