The art and science of cover cropping

Post-vintage is the time to consider sowing winter cover crops. Organic farm researcher Dr Charles Merfield sets out the key issues for growers to consider.

Cover crops have a multitude of different uses and objectives.

Some of the key ones are:

- Increasing soil organic matter/soil carbon;
- Protecting the soil surface, particularly from erosion;
- Improving soil 'fertility', e.g. by fixing nitrogen, increasing available phosphorus, increasing cation exchange capacity via increased soil organic matter, reducing nutrient leaching, etc.;
- Improving soil health/quality, such as soil structure, principally as a result of increased soil organic matter;
- Improving drainage and water-holding capacity, as a function of organic matter, and macropores resulting from dead root holes and earthworm burrows;
- Suppressing weeds;
- Managing pests and diseases;
- Increasing biodiversity and assisting wildlife.

The key thing is that although they are non-cash-generating crops, most cover crops aim to improve the overall profitability of production systems in the long term. They therefore represent an investment in the vineyard with an expectation of a good return in future years, and should be considered the same as any other form of investment. Cover crops are definitely not 'luxury' items.

The diversity of cover crops and vineyard systems also means that it is impossible to provide more than an introduction and highlight the key issues here.

This article first gives a general introduction to cover crops and discusses their use in the undervine area. The final section deals with the use of cover crops specific to the midrow area of the vineyard floor.

Using cover crops in the undervine area is the most technically challenging option, due to the interaction between the vines and cover crops, but when it works, it can be highly effective and one of the cheapest management options, compared with mechanical weeding. Therefore, if using undervine cover crops has the potential to work for a given vineyard, it is worth expending significant management time trying to get it to work, as the long-term payoffs can be considerable.

Undervine cover crops: Competitive interaction

Fundamentally, using cover crops undervine is about managing the ecological/competitive interaction between the cover crop and the vine plant. It is important to consider whether vine and cover crop roots are likely to share the same soil area, and if so, which root system is going to dominate the below-ground battle for soil and nutrient resources.

Having a cover crop compete with the vines is not always a bad thing. In highly productive terroirs (fertile soils, lots of soil moisture), vines may be over-vigorous. In such situations, having a cover crop that competes with the vines and reduces vigour has the potential to reduce costs associated with vigour control through foliar management, e.g. trimming.

Timing: Vine dormancy and growth

Cover crops do not have to be grown all year round, nor do the same crops have to be grown all year. When vines are dormant over winter, there is effectively zero immediate competitive effect, as the vines are inactive. Therefore, cover crops that could have large competitive impacts

on the vine during spring and summer (e.g. cereals) could be grown over winter. Cover crops for use over summer typically need to be less competitive species to avoid restricting vine growth, even on overly vigorous vines.

Residual competitive effects: Nitrogen robbery and soil moisture

Although vines are not susceptible to competition while they are dormant, growing an undervine green manure over winter does not completely eliminate the effects of the cover crop on the vine. The cover crop can still have a large impact on soil conditions, especially around soil water, and most critically, soil nitrogen.

Overwintered cereals and other species, e.g. mustard, can take up considerable amounts of soil nitrogen over winter; figures of 50 to 100 kg N/ha are not uncommon, though this amount is very variable and depends on the amount of available soil nitrogen, the cover crop species, soil type, water status, etc. This nitrogren is then 'locked up' in the roots and foliage of the cover crop, and it cannot be released until the cover crop is killed and then decays. Decomposition can take quite some time, especially in cold spring soils, and it almost stops if soils are dry, so it can take weeks or even months for the nitrogen to be released back. This is referred to as 'nitrogen robbery'. The amount of nitrogen locked up in such situations can be almost 100%, with examples from vegetable production where healthy, robust cabbage transplants have died of nitrogen deficiency, having been planted into a mulched over-wintered ryecorn cover crop.

In overseas arable cropping systems using overwintered cover crops, research indicates that for non-legume cash crops, it is vital to have 50% or more of the cover crop as legumes. It is clear from this that growing undervine, overwintered cover crops is complex, so initial small trial areas are highly advisable.

The effects on soil moisture of cover crops grown during vine dormancy vary considerably. In some situations, using cover crops can increase residual soil moisture after the cover crop's destruction, as the resulting mulch reduces surface loss. In other situations, the cover crop has used up soil moisture over winter, resulting in less being available in spring. Long term use of cover crops will also improve soil moisture storage capacity through increased soil organic matter, while also improving soil drainage and reducing waterlogging. The impacts of cover crops on soil moisture, both short and long term, are therefore highly specific to individual vineyard situations and can be difficult to predict.

Nitrogen-fixing vs. nitrogen-dependent cover crops

There is a contrast between nitrogen-fixing and nitrogen-dependent cover crops. Within a vineyard, and especially in the undervine, nitrogen-fixing cover crops are mostly limited to the legumes, such as the clovers, lucerne, peas, beans and lupins. Nitrogen-dependent cover crops are therefore everything else.

The fixation of atmospheric nitrogen by legumes in a vineyard can be a positive or a negative. In over-vigorous vines, supplying more nitrogen is likely to make the vines even more vigorous. Conversely, where vines are struggling due to low soil nitrogen, vines are likely to benefit from the extra nitrogen.

Nitrogen cannot be fixed below biologic zero (~8°C), and it is not until soil temperatures are higher that significant amounts

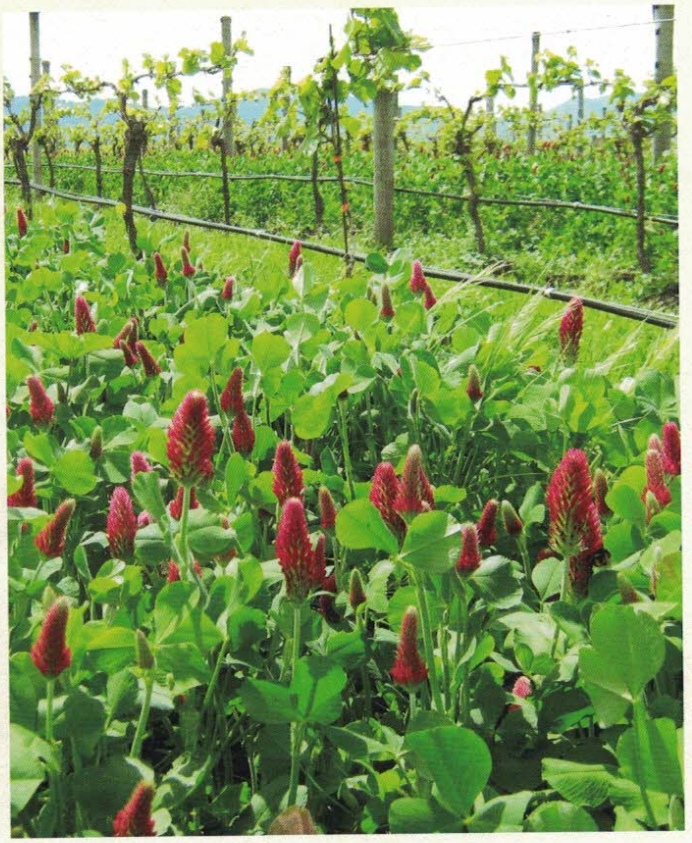

Photo: Kiwiseeds

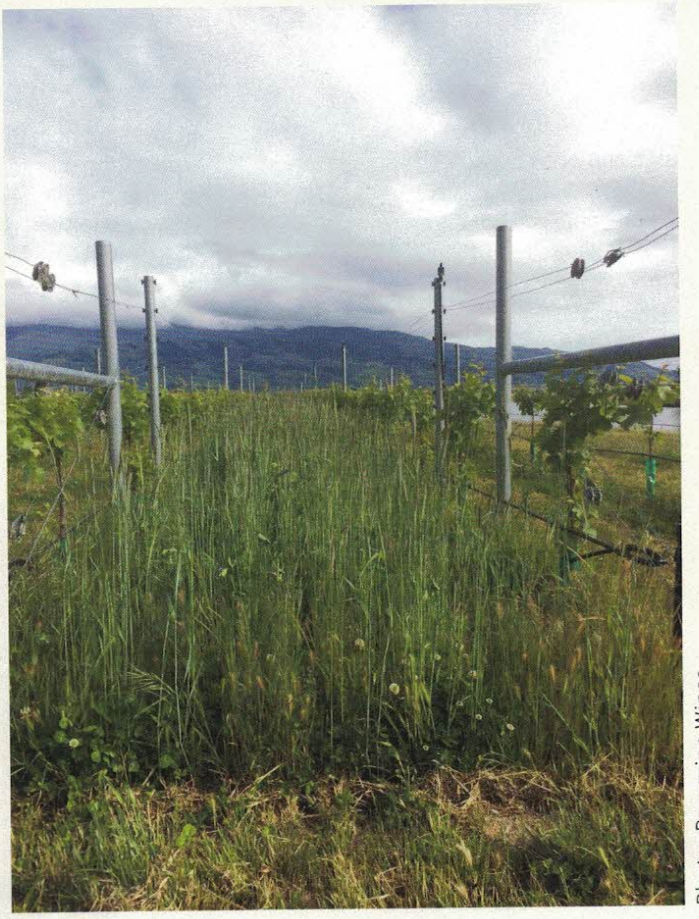

Photo: Peregrine Wines

Top photo: Crimson clover cover crop

Bottom: Mixed cover crop including cereals and clover

are fixed. Therefore little or no nitrogen fixation occurs over winter, and for overwintered green manures, the majority – i.e. 80% of the nitrogen that is fixed – may be fixed in the last two to three weeks of the crop's life in spring. Therefore, leaving such crops as long as possible ensures maximum N-fixation.

Legumes generally have some of the least competitive root systems, as they have the advantage of being able to make their own nitrogen. In relation to vines, most legume cover crops have tap roots that explore the soil bulk, so there is less potential for interaction with vine surface feeder roots.

Cover crops are crops

As the name implies, cover crops are crops. Indeed, most of them are grown as cash crops somewhere in the world, and they have been selectively bred for production. They therefore need to be looked after as well as the cash crop, as sowing and forgetting them is likely to result in them underperforming, potentially significantly, compared to when they are well managed.

Some key components of their management require attention, and these also relate to how the cover crop and vine interact/compete. These include establishment, water, nutrients and pests and diseases.

Establishment

To achieve optimum establishment, most cover crops need to be drilled into the soil (rather than just broadcast on the surface), and they also need existing vegetation controlled, i.e. through cultivation. Requirements will vary, with small-seeded species needing to be sown shallowly, while bigger-seeded types should be sown more deeply.

Competition for water

Cover crops can require considerable amounts of water, because they are quick-growing annuals. Most of that water comes from the top half to one meter of soil, as many are shallow-rooted. The use of cover crops may tip a vineyard that does not require irrigation over to where irrigation is required, both for the cover crop and vines. Where irrigation is already required for the vines, more water may be required due to the combined needs of vines and cover crop.

Competition and requirement for nutrients

Many cover crops are quick-growing annual crops. As such they can have a high demand for soil nutrients, especially nitrogen, phosphorus and potassium (NPK), and they are also often sensitive to pH.

This nutrient demand profile may be quite different to that of the vines, both in the amounts and their distribution across the growing season. It is therefore important to consider and address these different and cumulative nutrient demands. Otherwise the potential for competition between cover crop and vines for nutrients is likely to be exacerbated.

Cover crop species and types

There are a wide range of plant species that can be used as cover crops in vineyards. These include the cereals; pasture species, including both grasses and forbs (herbs) such as chicory and plantain; seed crops such as mustard, buckwheat and phacelia; naturalised vegetation and also native plant species.

Cover crops can be classified by their

attributes, some primary ones being:
- Annuals and biennials, or perennials;
- Whether the active growth stage is in summer or winter, or year-round;
- For annuals/biennials, whether they self-perpetuate, e.g. establish a seed bank, or have to be re-established every time;
- Nitrogen-fixing or nitrogen-dependent;
- Size/competitiveness of above-ground foliage;
- Size/depth/competitiveness of root system.

Due to the large number of cover crop species available, it is not possible to list them all or describe their key attributes here. However, there are a number of good resources that already provide such information. See references at the end of this article for some information sources.

The midrow/interrow

Traditionally the midrow has been something of a non-area in many vineyards; it is merely the gap between the vines required for machinery and personnel access. Less thought has therefore been given to its use and management, with mown grass swards being a typical approach. However, the interrow has considerable potential to add to overall vineyard management, improve vine production and health, and help meet wider environmental sustainability objectives.

Key management approaches include:
- Growing cover crops and green manures;
- Growing conservation biocontrol plants;
- Increasing biodiversity;
- Extra cash crops.

Vine competition

While the undervine is the area where the largest amount of vine competition occurs, in some vineyards, vine roots, both surface feeder and deeper water-gathering roots, can extend into the midrow. The presence of roots therefore needs to be determined, which is simply done by digging soil pits, at multiple points in the vineyard, to look for vine roots. Soil type and structure are the main determinant of whether vine roots can grow into the midrow, so where vineyards have different soil types, especially if they vary widely, each soil type should be checked. Where vine roots are present, then a precautionary approach is advisable, with a number of small areas trialled first before extending to the whole vineyard.

Photo: Peregrine Wines

Sowing an interrow cover crop, Peregrine Wines, Central Otago

Midrow green manures for N fixation

Despite there generally being far fewer vine feeder roots in the midrow to take up fixed nitrogen, on balance, it may be a better place to fix nitrogen than the undervine, due to the competition with vine roots in the undervine area and the greater difficulty of managing cover crops under the vines.

There is no one 'magic' biodiversity mixture – only horses for courses.

The key to such a system is being able to transfer the nitrogen fixed in the midrow into the undervine area. While there will be some natural transport of nitrogen through the soil system, both by diffusion and active movement by plants and mycorrhizae, this will generally be insufficient. The simple solution is to cut/mow the midrow vegetation and move it to the undervine area. There are a range of flail mowers with optional side discharge systems built for this purpose.

For nitrogen-deficient vineyards, removing the mowings and nitrogen from the midrow means the legumes are forced to fix more nitrogen, which is then transported to the undervine, creating a 'nitrogen factory' within the vineyard.

Cover crop species

The typical green manure for these kinds of systems is a grass and white clover (or other stoloniferous legume) sward. This is because the cover crop needs to be able to survive repeated mowing, which annual legumes wont survive, and non-stoloniferous perennial legumes such as red clover and lucerne will also die out under frequent mowing. Grass is required to fill the empty ecological niches left by the clover, helping to suppress weeds. A wide range of other plant species can also be used in the sward.

All nutrients are transferred, not just N

A key issue with this system is that it is not only nitrogen that is being transferred from midrow to undervine, but the full range of plant nutrients. Where such systems are used over many years, it is essential to measure the soil nutrient status of midrow and undervine separately and to make sure that nutrient levels under the vines don't become excessive.

Side effects: mulching weeds and frost

There are also a range of side effects from undervine mulching. On the positive side, the mulch will have a weed-suppressing effect, and if a continual thick layer (e.g. > 5 cm) is present in late winter before the spring weed flush, it may be able to

provide sufficient weed control by itself. On the downside, a thick layer of mulch under the vines will insulate the ground and may well increase frost risk.

Biodiversity

On the same logic that plants in the midrow have the least direct competition with the vines, the midrow is also a good place to grow plants to improve biodiversity and attract beneficial insects for biocontrol. While planting things such as wildflower mixtures may intuitively feel like it is providing great biodiversity, and they certainly can look spectacular, such approaches may not be the best approach for maximising the total diversity of species. Typically, wildflower mixtures are wholly exotic, and many of the flowers are not good nectar or pollen sources for smaller beneficial insects.

However, there is no one 'magic' biodiversity mixture – only horses for courses. Perhaps the best all-rounder is a diverse mixed-species pasture, with multiple grasses, legumes and herbs/forbs. It is also important to allow the pasture to grow longer between mowings, as this will let some forbs and legumes flower, which will provide more places for insects and increase carbon fixation.

Midrow cash crops?

Globally, some winegrowers, also grow other cash crops in the mid-row, e.g., cereals. While an interesting and attractive idea, there are a considerable number of practical issues that need be resolved. Detailed research and planning are required, and systems should be tested on small areas to start with to test for unexpected results, before rolling out to the whole vineyard.

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