



Reducing Frost Damage in Vineyards

Frost protection in vineyards is important and if not addressed correctly can lead to serious losses. The Weekly Times (1.11.06) stated "expected crop (grape) losses were;

- Henty (Western Vic) 96% per cent of the crop
- Goulburn Valley, 79%
- Upper Goulburn, 69%
- Heathcote, 63%
- Pyrenees, 46%
- King Valley, 68%
- Rutherglen, 52%."

Most of these losses were due to a single frost although they occurred on different days in each region. No method or combination of methods are 100% effective in preventing frost damage but it is important to realise that the difference between minimal damage and a virtual wipe out may be due to a difference of a few tenths of a degree for an hour (or even a few hundredths of a degree for two to three hours).

Frost protection is more than just spraying a formulation and hoping for the best. While very hard frosts late in the season are the hardest to address, there are strategies which can impart a few extra degrees of frost tolerance. It requires a strategy using a combination of physical methods and carefully timed product application.

Physical methods

Location

When setting up a new venture it is important to:

- Choose a location which is not susceptible to hard frosts. Frosts are reduced if there is protection from southerly and westerly winds.
- Choose a site within the location without gullies and hollows. A two per cent fall along the vines with no barrier to airflow is ideal
- Avoid windbreaks that hinder airflow including windbreaks across the bottom of the vineyard which traps cold air causing it to bank up. Windbreaks even across the top of the vineyard can severely restrict air movement within the vineyard.

Soil type and moisture

Dark soil absorbs more heat than light soils and gravel soils absorb more heat than clay soils. Soils that absorb more heat are less likely to be frost prone. In some circumstances it may be worthwhile considering applying organic humate (which is very dark) to the soil. Although this has a cost of, \$500- \$1500 per hectare, there are added long term advantages such as increased organic matter, better water and nutrient holding capacity and release of locked up nutrients.



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Soil with significant moisture will tend to be warmer than the surrounding air so trees or vines with moist bare soil around the trunks will suffer less freezing than dry soil or soil covered with mulch. Dry mulch will attract ground frosts - avoid it at all costs until the frost danger period is over. Compacted soils are less frost prone than cultivated soils.

Variety selection

Spring frost damage is not the only consideration and variety selection is important. Earlier bursting varieties are more likely to be affected by frosts than later bursting varieties. The temperature at which damage occurs increases as the vine grows. Typically temperatures of less than -3.5°C are needed to damage vine tissue at the woolly bud stage whereas temperatures of less than -0.6°C will damage shoots of 15 cm or so. Therefore if there is a very late frost, early bursting varieties will be damaged more than later bursting varieties.

Dormant vines and trees can often tolerate temperatures as low as -10°C without any damage. The problem arises when dormancy breaks and buds appear. The table below gives values of the air temperature when damage to vine tissue may occur (based on data given by Hedberg, 2000, Australian Viticulture Vol 4. No 4, p18-22).

- 3.5°C or less	woolly bud stage (continued periods can kill the primary bud*)
- 2.0°C or less	early budburst
- 0.6°C or less	shoots up to 15 cm long
- 0°C or less	shoots 15 cm and longer

* A grapevine compound bud (winter bud) contains three dormant buds: the primary, secondary and tertiary bud. The primary bud is the one that normally grows. If that shoot is killed the secondary or tertiary bud will usually develop. However, these other buds tend not to be as fruitful as the primary bud.

Trellis Height

Radiation frosts, those that form on clear still nights, have an inversion layer several metres above the ground that contains warmer air than that found at the soil surface. These are the most typical frost experienced by vineyards in Australia. The temperature is lower at ground level than 4 metres above the ground. The difference can be 3 or 4°C . The air temperature difference between buds separated by a height difference of 1 metre could well be 1°C . Consequently there is a greater risk of frost damage the closer the buds or shoots are to the ground.

Timing of Pruning

Bud burst can be delayed by late pruning and this can reduce the risk of frost damage.

Overhead Sprinklers

Overhead irrigation is the most commonly used method of frost protection in vineyards.

There are many system designs, but all depend on two factors:

- When water freezes, the formation of ice releases energy and
- Irrigation water is usually significantly warmer than the surrounding air.

This method has three disadvantages:

- If significant amounts of ice form on the vines there may be damage caused by the inability of the vine to support the additional weight leading to major vine damage



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- The method can waste considerable amounts of water and
- Systems relying on sensors activating an alarm and subsequent manual start up require 24 hr attention.

Air Mixing

Mixing the layer of air near the soil surface with the layers a few metres above the soil can reduce the risk of frost. There are two man made methods to mix the layers. The first is to use wind machines. Wind machines can generally create an increase in air temperature of 1 to 1.5°C.

Another way in which inversion layers can be mixed is by the use of helicopters. This method is expensive and subject to considerable regulation. It is more common in New Zealand than in Australia.

Chemical methods

Fertilizers

Excess nitrogen induces susceptible new growth and should be avoided until the likelihood of frost is virtually non-existent. Nitrogen can also inhibit the uptake of potassium and should also be avoided early in the season for this reason.

High levels of potassium in a plant have been shown to increase frost tolerance in many crops. Any solution containing large amounts of potassium (or sodium or calcium) salts freezes at temperatures considerably lower than pure water.

Copper sprays

Frost damage to plants occurs when ice crystals form around "ice nucleators" and spread to sensitive areas of the plant, such as buds and foliage. The most important ice nucleators are believed to be bacteria and the most important of these are believed to be *Pseudomonas syringa*.

Copper sprays have the ability to reduce the numbers of *Pseudomonas* bacteria reducing the number of ice nucleation points and hence giving some frost protection. There is no doubt that some benefit is obtained but it is difficult to quantify.

Oil Sprays

Vegetable oil such as canola oil can be used to reduce frost damage. Oil sprays can be applied literally within a few hours of the expected frost and appear to give about 1°C of additional frost tolerance. The effect is rather short lived as shoots tend to outgrow the protection supplied.

Sugars

Sugars such as sorbitol and glycol derivatives have been used to achieve a reduction in the freezing temperature of the plant cell contents. In general, these approaches have been unsuccessful because there are toxic effects, or the treatment is not economically viable at the application rates needed to give a few degrees of frost tolerance.

Anti – transpirants

These cut down the leaf transpiration rate by covering them with a semi-permeable membrane. This membrane forms a polymer coating on the leaf, but still allows them to transpire. The reduction in moisture loss by the leaves maintains turgidity in the plant, which has been shown to aid plant survival under frosty conditions.



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Because frost protection is reliant on a polymer coat these products are not suitable if there is rapid growth, such as occurs when the shoots are 10 cm + long.

Hydrophobic dusts

Overseas studies have indicated that hydrophobic (water hating) dusts can reduce frost damage. These appear to work by repelling water condensation on leaves, which is a normal precursor to frost damage. They do not appear to be commercially available in Australia.

Seaweed digests (liquid seaweed fertilizers)

These are the most important products currently available in Australia to minimise frost damage. Scientific studies both in Australia and overseas have shown that regular application of liquid seaweed (kelp) can increase frost resistance.

Low concentration liquid seaweed applications every 10-12 day periods throughout the frost danger period can give 2 to 3°C degrees of extra frost tolerance. A suitably chosen liquid seaweed can be the grower's best defence against late frost at blossom time.

There is also anecdotal evidence that use of granular dried seaweed applied to the soil in mid to late autumn gives a more persistent frost tolerance from just one application of liquid seaweed. However, it does not seem to have been studied with the same scientific rigour as that for the application of seaweed digest.

Choosing a liquid seaweed fertilizer

Several factors need to be considered:

- Liquid seaweed digests are often tailored for use on a particular crop and are fortified with conventional fertilisers or organic sources of nitrogen. Those that have added nitrogen may well reduce rather than increase frost resistance because of the effect of the nitrogen producing sappy growth. They should be avoided when the aim is to increase frost tolerance. Fish / Kelp mixtures should be avoided for this reason also.
- Most of the scientific work showing increase frost tolerance by liquid seaweed application has been alkaline liquid seaweeds. It is not clear that acidic liquid seaweeds or liquid seaweed produced by fermentation processes work as well. Further, it might be expected fermentation - produced liquid seaweeds may be counterproductive, as the spores present may well be ice nucleators
- Liquid Seaweeds that have a relatively high potassium level are superior to those with low levels because of the effect of increased potassium uptake by the plant through the foliage. Avoid liquid seaweeds which are too low in potassium, (less than 1%), to be classified as a fertilizer as well as plant growth enhancers
- For foliar application of a liquid seaweed, it should be manufactured using a fine filter, to a fine particle size and be applied as a fine spray.
- The manufacturing process needs to be carried out carefully, as it is desirable that once applied, the product should be slightly sticky and form a very thin layer over the leaves.

Liquid seaweed increases frost tolerance in several ways.

- 1 - They contain a number of plant growth regulators, two of them, (cytokinins and betaines) increasing turgidity of the cell wall.



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- 2 - They contain sugars, such as mannitol, and also potassium. Both of these components will lower the freezing point of the cell fluid and explain part of the observed effect.
- 3 - Extensive work by scientists in the UK indicates that there is something in the liquid seaweed that triggers a gene responsible for "hardening off" the plants.

Whatever the mechanism, numerous studies have shown that pure liquid seaweed fertilizers (or liquid seaweed fortified with potash and/or other minerals) which are produced by alkaline hydrolysis and applied regularly every 8-12 days* can give additional frost protection to 2 to 3°C lower temperatures.

*Experience indicates that when the vine enters the rapid growth stage- shoots 10cm + long, frost protection is more difficult to achieve and application frequency of every 6-7 days is recommended by the Fair Dinkum Fertilizers.

Products such as Fair Dinkum **GOLD** and Fair Dinkum **SUPERFINE** Liquid Seaweed are two of the locally produced products shown to give some additional frost protection.

However Fair Dinkum Fertilizers also produce two liquid seaweed fertilizers which, unlike most other liquid seaweed products, have been produced using digestion processes specifically aimed at maximising the amount of plant growth hormones thought to be responsible for frost resistance. These are "Fair Dinkum **COSY WRAP**", which has relatively high potassium and low nitrogen, and "Fair Dinkum **FPC**" which has a higher level of potassium and low nitrogen. **COSY WRAP** is made from the fresh stems of bull kelp whereas **FPC** is made from the ribbons.

The manufacturer's directions need to be followed carefully to avoid excessive fruit set which can be induced by the liquid seaweed, (in varieties which are prone to this problem).

Concluding comments

As pointed out by Margaret Chidgey in "the Olive Press" (www.australianolives.com.au) "Frost (damage) prevention requires a management strategy using a number of physical methods, in conjunction with some products". In 2004 the author added "under most Australian conditions, the amount of frost protection afforded by regular application of suitable kelp digests would be sufficient to deal with about 70% of the frost damage to grapes, apples and stone fruit. Combined with physical methods this percentage could be increased to over 85%".

Research is still in progress on frost damage reduction. Stone fruit orchards in the Murray Goulburn Valley and grapevines in the South Island of New Zealand support the economic feasibility of using Fair Dinkum Fertilizers seaweed based products for minimising frost damage.

If the frost pattern of 2006 is repeated, the time, effort and cost in developing a strategy will pay great dividends. Even if there is no damaging frosts, the other benefits of applying liquid seaweeds, better quality fruit, increased yields and reduced fungal problems will make the application of liquid seaweed fertilizers worthwhile.

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