

Frost Risk monitoring and protection measures available

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There are 2 types of frost. Radiation frost is caused by overnight heat loss from the earth's surface by radiation. It generally lasts a few hours and is thawed by sunshine the next morning. Advection frost results from a blast of sub zero air mass, it may last several days causing devastating crop damage.

Frost Damage

Frost can cause cosmetic damage but it is crop loss that most concerns us.

Critical temperatures for a 10% kill from frost by growth stage are as follows for apples.

Green tip	minus 7.5°C
Tight cluster	minus 3.9°C
First pink	minus 2.8°C
Full pink	minus 2.7°C
First bloom	minus 2.3°C
Full bloom	minus 2.9°C
Post bloom	minus 2.3°C

As the figures above show, buds, which are still at tight cluster at the time of the frost, will tolerate considerably more frost than those, which are much more advanced.

Historical experience indicates that pre-bloom frosts generally have little effect on the crop for pip fruit. The reason for this is that there is a lot of late flower likely to follow up on the main flowering, and with much of the earlier set fruit lost, the inter-fruit competition is reduced, and this late flower will set strongly. Varieties also flower at different times and will therefore obviously have differing sensitivities to the same frost event.

Effect of dew point

Dew point is that temperature when moisture settles out of the air. The more humid the air the higher the dew point. Moisture in the air is very important in preventing heat loss that has accumulated in the ground during the day from disappearing back into the atmosphere at night. The higher the humidity, the less heat is lost to the atmosphere. The lower the dew point or humidity the faster the temperature will fall.

It is advantageous for dew points to be above critical temperatures. When the dew point is reached, water vapour in the air is turned to liquid water. For this to happen the water

molecules have to release a lot of heat, which stalls the rate at which the air temperature is falling.

Understanding this means simple strategies to increase humidity will influence the dew point and heat loss or retention.

Predicting Frost

There are several models, which predict occurrence and severity of a radiation frost. You may get a prediction from a local forecaster but to be of real use you will need a prediction of severity, minimum temperature and duration. All of this is important to apply the right management strategies.

New data has shown applying Newtons Law of Cooling can predict a frost from just a few temperature readings late in the day. Simply under constant conditions the radiation heat loss can be modelled then we can plot a few temperatures readings and then predict the frost; time it starts, minimum temperature and duration.

Frost protection

It is very important to understand the potential frost as it impacts on the control measured used. All resources are limiting so we have to know when and what event to fight. Water for most of you is a very limiting resource but one of the most effective frost control strategies.

Frost protection as with hail protection is not 100% cover, you will not always be able to protect the whole crop.

Under minor events we may only need to protect part of the orchard and maybe with simpler strategies. Under major events, long duration and severity of the frost it would be wise to only protect what you can for the duration of the frost rather than spread your self thin over part of the frost period increasing the risk of damage over the whole orchard

Site selection

Site selection is still the key to lowering frost risk. Yes I know you have planted most of your orchard and the message is the same. If not site selection then at least know your site.

Heat

Heating

One of the oldest methods is to lift fires through out the orchard. From burning prunings in the 1st century to smudge pots and now to gas heaters, all trying to do the same thing warm the air conducting heat to the crop. The amount of energy required can be enormous per ha.

Wind

Redistribution of heat by wind machines and helicopters is an effective means of frost protection when a modest amount of protection is required, wind speed is low and an inversion layer is present. Some of the factors influencing effectiveness are topography of the orchard, inversion layer, wind speed and direction.

There have been examples where running wind machines or the use of helicopters has increased damage where the air being pulled down is cooler and you can blast freeze the crop. In some situations 3 stacked helicopters have been used to bring warm air down from a higher than expected inversion layer

Water

Overhead water provides the highest level of protection, and can protect against -7°C if water application rates are high enough. The heat given off as water freezes protects the crop. The key here is there needs to be water continually freezing to protect the surrounding tissue. Correct water rates, and uniformity of application are both critical to protecting the whole crop, so excellent design is very important. We have seen spectacular failures where sprinklers are blocked or water rates are not adequate. But when it works it is excellent, I have seen the photos of the whole South Tyrol industry under ice for 1 long nights frost fighting and no losses occurred. Modern systems of pulsing the water can maintain protection and reduce water use significantly. Ice is also very heavy so ensure support structures are excellent.

Other

Ground cover: Maintain good weed control (ideally bare earth) and tightly mown grass through the spring frost risk period. It is thought that the mode of action with these strategies is that they help the ground absorb heat during the day prior to the frost. This ground heat is then available to be released slowly throughout the night.

Under tree Sprinklers: Can provide temperature lifts of 1.5°C , by increasing humidity slowing the heat loss to the atmosphere. As the sprinkler water freezes it also releases heat to the atmosphere.

Foliar sprays: There is some anecdotal evidence that applying foliar sprays can reduce the risk of frost injury. For example some growers apply low biuret urea at $500\text{g}/100\text{l}$ at 1000 l of water per hectare immediately prior to frost events.

Summary

Understand:

- **The frost risk and prediction to your situation.**
- **Variety stage of growth and risk across the orchard**
- **Manage resources to best effect for each frost event**

With all systems you may have or want to use it is important to understand your system limitations, it is calibrated and well maintained. If you are going to the expense of a new system seek professional advice on design and installation.

References

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Ireland, W. (2005) Frost and Crops – frost prediction and plant protection

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