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Effect of frost on plants

Frosts can be damaging, reducing yield and quality in crops, pasture and forests. Farmers need to understand the circumstances of their location to best protect their plants. NZASE Science Communicator Mike Stone investigates.

Frosts and Aotearoa

At the beginning or end of winter, a frost forms when temperatures in the soil or air around plants drop below freezing point (0°C), causing ice crystals to form on plant surfaces.

When frosts form visible ice crystals, this is called a white or hoar frost. During a rare black frost, few or no ice crystals form because the air in the lower atmosphere is too dry.

In Aotearoa/NZ we tend to get radiation frosts, which form when heat is lost from the ground to the atmosphere on clear, still evenings. This leads to air temperature increasing with altitude. As temperature is usually colder with height, this effect is called an inversion.

This heat loss also significantly drops the temperature at ground level, and on the plant surface. Of the two types of radiation frosts, ground frosts are usually 3-4°C lower than air frosts and occur more frequently.

Research has found a general trend of decreasing frosts across most of Aotearoa, as might be expected with a warming global climate. But with our maritime climate, topography and natural variability, more frosts have been seen in parts of the Wairarapa, and from south Canterbury to south Dunedin. In these areas,



local factors have had a stronger influence than increasing global temperatures.

Frosts in autumn are not such a problem, as the soil is still quite warm, but growers can get hit badly if they haven't harvested fruit by June. Frosts in spring can be more challenging; an October 2022 frost was particularly severe.

Managing the risk of frosts can be expensive, so farmers need to know the frost characteristics of their area and select the most appropriate prevention or protection techniques.

Effects on plants

Light frosts can have a positive effect; they can help control pests and diseases and improve soil structure. And some plants need a frost event to germinate or flower, a process called vernalisation.

Overwhelmingly, though, frosts are harmful. Primarily, the damage is due to the formation of ice crystals in the cell cytoplasm;

because solid crystals take up more space than liquids, they rupture the cell membrane.

When ice forms between cells, its effects may be less serious and last for a shorter time. During the day the ice generally melts, and over a long period, the repeated freezing and thawing of plant tissues can lead to further damage. For example, bark can crack, and branches split.

Spring frosts are particularly damaging to tender new buds, flowers and fruit,

Hoar frost in central Otago. By linzi1nz1.

Solar-powered temperature sensors, Metris.

Frost fans protecting a crop, NZ Frost Fans.

which may be left brown or black, wilted, split or even completely destroyed. Sometimes buds or flowers appear normal but fail to open, leading to stunted growth and a smaller crop. The trees themselves are unlikely to be seriously harmed.

Frost damage reduces the leaf surface area available for photosynthesis, limiting plant growth. Some plants, such as some grasses, abruptly stop growing when damaged by frost.

Tropical crops can be harmed when exposed to temperatures slightly below zero. Some will die (frost tender); others will suffer serious damage but survive (frost tolerant). Crops originating in colder climates often survive with little damage (hardy) if the frost is not too severe. Some plants also have physical protection such as thick bark, furry leaves or a canopy that protects the inner shoots.

Plants hardened to cold temperatures prior to a frost night can become protected against freeze injury, probably due to an increase in solute content (eg, sugars or sugar alcohols) of the plant tissue. During warm periods plants grow, reducing solute concentration, and making the plants less hardy.

Protecting plants from frost

In the garden, protecting perennials, bulbs, woody shrubs, roses, small trees and other woody plants is not necessary or beneficial.

These plants need cold temperatures to help them fully enter dormancy, and will tolerate temperatures at or just below freezing with minimal damage. But other plants need careful tending, especially in spring.

Cold air naturally flows downwards on sloping ground, collecting at the lowest point or against a barrier, known as a frost pocket. Crops can be protected from frost if they are planted in a location that avoids frost pockets, or near gaps in a fence or hedge to improve cold air



drainage. Planting in raised beds keeps the plants above the cold air, reducing their vulnerability to frost damage.

Plants can be heated to prevent frosting. Orchardists used to burn diesel or wood in drums or pots, but this fuels global warming and smoke is also a problem. This method is now rarely used

and is banned in some areas.

It is preferable, but more expensive, to use fans, windmills or helicopters to force the warm air layer above the crop down onto the plants.

When applied to the plant at the correct rate (2.5-3.0 mm/h), overhead sprinklers can actually provide protection from frost damage. This is because as water freezes, it releases the latent heat of fusion, 334 J for every 1g of water that freezes. This heat energy keeps the plant above freezing point. Watering a frost cloth on a really cold night can provide an ice blanket that insulates the plants beneath in the same way.

Annual edible crops can be protected under a cover, which traps heat from the soil to keep the plants warm. Frost cloths, plastic sheets, or other materials can be draped over plants using wooden, plastic or wire frames to keep the covering from touching the foliage.

Research suggests that producing fog may protect plants from frosts by reducing heat radiation, and by heating the crop as the droplets freeze (a similar effect to frost pots). However, a viable practical system is yet to be successfully developed.

In many frost-prone areas, farmers use digital devices to help them: sensors in the canopy detect low temperatures and send an alarm to the farmer's phone. In the field they can then

use probes to check the temperature of leaves and buds on plants in low-lying areas. Protection measures can be started, monitored through the night and turned off when no longer needed.

Frost cloth covers a crop, Empak.



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Prevention

Farmers can reduce losses due to frost if they:

- Select hardy crops to grow in frost-prone paddocks, and select a frost-free site for other crops.
- Manipulate flowering times by staging sowing time, and mixing long and short season varieties.
- Sow plants later in the season.
- Plant frost-tender saplings in late spring so that they can be well settled and hardened off before the cooler temperatures of autumn. Frost-tolerant species can be planted early.
- Grow plants on a north-facing slope, as they are generally warmer.
- Plant in rows orientated parallel to the slope.
- Use permeable shelter belts to ensure wind movement.
- Plant near bodies of water (coastal, lake and river areas are always warmer).
- Select a frost-free site.
- Apply nitrogen-rich fertilisers only after temperatures have risen, the plant is actively growing and the risk of frost has passed.
- Ensure tender garden plants are overwintered safely in greenhouses.
- Delay the pruning of damaged tissue until after the risk of frost has passed, so no new growth is exposed to frost damage.

Ngā Kupu

Ārei – Prevent, shield
Awe kāpara – Planting season
Hauhunga – Frosty; frost
Hukapapa (~tia) – Frost; to have a frost
Hukapuri – Hard or severe frost
Keho – Frost, ice
Kōanga – Spring (season)
Koero – Thawing, melting (of frost/snow)
Pare(-a) – Protection; to protect
Tūrarū – Risk.

From Te Aka Maori Dictionary

Sources

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Susceptibility of fresh fruits and vegetables to injury from frost

Frost tender	Frost tolerant	Hardy
Apricots	Apples	Beetroot
Asparagus	Broccoli	Brussels sprouts
Bananas	Carrots	Cabbages
Berries	Celery	Dates
Capsicum	Grapes	Kale
Cucumbers	Oranges	Kohlrabi
Lettuce	Parsley	Parsnips
Plums	Peas	Turnips
Potatoes	Pears	
Tomatoes	Pumpkin	
Zucchini	Spinach	

Frost tender – Will be damaged or die from frost damage.

Frost tolerant – Appearance will suffer from frost but will survive.

Hardy – Will stop growing over winter but will survive frost with little damage.



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