FROST RISK
FACT SHEET

Grains Research & Development Corporation

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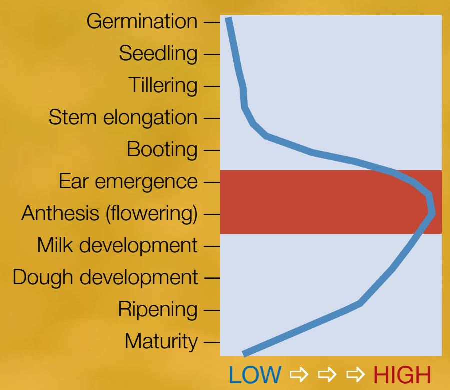
Managing the risk of frost

The risk of frost varies between years as well as across landscapes, so growers need to assess their individual situation throughout each year. The variability in the occurrence and severity of frost means a package of risk management strategies, and not just one, needs to be adopted.

KEY POINTS

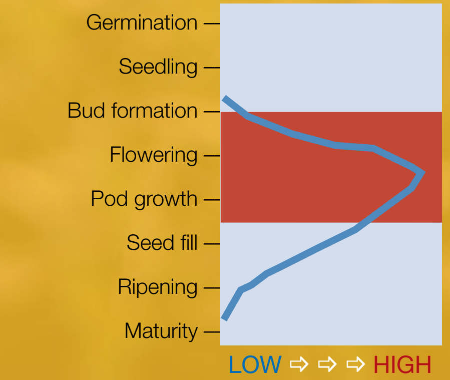
- Frost damage is not always obvious. Inspect for frost damage through the season especially five to seven days after areas are considered to have been frosted.
- Canopy temperature is of importance rather than temperature at the weather station, the difference can be as much as 5°C or greater.
- A package of risk management strategies needs to be applied including choice of crop and variety, manipulating soil and canopy temperature, matching inputs to yield potential in frost risk areas and sowing time.
- Some frost damage can be unavoidable even with best management practice in place.

CEREAL SUSCEPTIBILITY TO FROST DAMAGE



Note: Diagram not to scale

PULSE & CANOLA SUSCEPTIBILITY TO FROST DAMAGE



Note: Diagram not to scale

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PHOTO: SARDI

Frost damage in vegetative growth (wheat). Early frost causing leaf damage may reduce yield potential but other factors later in the season may also come into play. If plants are frosted during booting grain loss can occur.

PHOTO: SARDI

In frost prone areas of a farm, cereal heads and seed pods should be inspected regularly during the later growing stages to ensure yield losses due to frost are identified well before harvest, allowing alternative strategies such as cutting as hay or green manure to be evaluated.

FIGURE 1: CROP SUSCEPTIBILITY TO FROST FROM MOST TO LEAST SUSCEPTIBLE

CEREALS
triticale ⇨ wheat ⇨ barley ⇨ cereal rye ⇨ oats
PULSES
field peas ⇨ faba beans ⇨ lupins

Understanding frost

The occurrence of frost and subsequent frost damage to grain crops is determined by a combination of factors including: temperature, humidity, wind, topography, soil type, crop and variety, and how the crop is managed.

While some crop species are more tolerant of frost (Figure 1) all grain crops are susceptible to damage by chilling or freezing that can result in loss of grain yield. Frost during the flowering period is generally most damaging but cereal crops can be susceptible between booting and grain ripening.

Low temperatures that occur at the grain head are those of concern, however a standard weather station is located 1.5m above the ground. Research has found that a temperature recording of 2.2°C in a weather station can result in frost damage in flowering crops. The difference between canopy temperature and that recorded at the weather station can be as much as 5°C or greater.

At night heat is lost/radiated from the ground into the atmosphere resulting in rapid cooling of the soil surface and the air surrounding the crop canopy. Under calm conditions when the atmosphere is relatively dry (dew point less than 2.2°C) a radiation frost is likely to occur. Radiation frosts are the main cause of crop damage to grain crops. As cool air flows to the lowest point of the landscape it is these areas that are especially prone to frost.

Part of the problem with frost is that it can often go unobserved until grain fill and harvest. For frost damage to occur a white coat of ice crystals are not necessarily seen on the crop. Therefore, in frost prone regions, conditions and crops need to be regularly monitored for signs of frost and detail records of varieties, frost dates and the area of a paddock affected should be maintained for future frost risk management.

When air is moist, conditions are windy, or there is cloud cover the potential for a frost is reduced.

Atmospheric events leading to a frost include:

- A slow moving high pressure system directing an overland air stream from a dry air mass, with light wind speed and no cloud cover overnight.
- A cold outbreak with quite strong winds moves through during the afternoon. A high

Paddock and crop management for frost

pressure system rapidly follows the depression. The very cold air mass 'decouples' the wind in low atmospheric levels and very often the still unstable nature of the air mass allows fairly clear skies. Frost can form in the period just before dawn.

- A cold, cloudy day followed by a calm night where all the cloud cover disappears.
- A rapid drop in air temperature after 3pm (with temperatures starting around 16°C and dropping to 1.5°C within 30 minutes with no air movement).
- A gradual drop in the 'dewpoint'. As the air mass dries during the evening, frost can develop as long as light winds and clear skies prevail.

Delaying sowing

As crops are most vulnerable to frost at flowering much risk management for frost has revolved around managing flowering dates. However, delaying sowing as a method of setting back flowering until after a frost risk, is not without penalties. For cereals the common rule of thumb is for every week sowing is delayed a five per cent yield penalty occurs.

Days from sowing to flowering is determined by accumulated thermal units or a combination of thermal units and day length, therefore flowering date of the same variety at the same location can vary substantially between seasons.

Despite variability in flowering date, research has found that delaying the sowing of long season cereal varieties can help to avoid frost damage at frost prone locations.

Soil management

While sowing date remains an important risk management tool for frost, research has established that techniques to manipulate the storage and release of heat from the soil into the crop canopy at night are also important (Tables 1 and 2).

The objective of techniques such as clay spreading and delving, and stubble rolling are to increase water storage and reduce soil water evaporation, as light, dry soils are those most prone to frost.

Delving was found to reduce frost damage by up to 80 per cent over and above any other technique tested (Table 2). This result was on duplex soils with sandy topsoils

TABLE 1 TECHNIQUES TESTED TO MANIPULATE THE SOIL HEAT BANK

Soil heat bank manipulation ranking	Description	Increased temperature at canopy height	Reduction in frost damage*
1. Clay delving	In sandy-surfaced soils, clay delving increases nutrient availability, infiltration rate and heat storage. For more information on delving contact SARDI.	1°C	Up to 80%
2. Rolling	Rolling sandy soil and loamy clay soil after seeding has reduced frost damage, although the results were not statistically significant.	0.5°C	Up to 18%
3. Removing stubble	Removing stubble had a negligible effect on yield and frost risk. The role stubble plays in retaining soil moisture is more important.	0.5°C	Minimal

TABLE 2 TECHNIQUES TESTED TO MANIPULATE TEMPERATURE IN THE CROP CANOPY

Manipulation of the crop canopy ranking	Description	Increased temperature at canopy height	Reduction in frost damage*
1. Blending varieties and variety selection	Blending long and short season wheat varieties of the same quality is a method of hedging against frost or end of season drought within one paddock. However, a similar risk profile occurs when sowing one paddock with a single variety on the same day. Certain varieties such as Yitpi⊕, Stiletto and Camm⊕ flower later. Long season varieties frequently avoid frost by flowering later in the growing season, when frost incidence is less. To further reduce frost risk, these varieties should be sown towards the middle or end of a wheat sowing program rather than first.	0	Yitpi⊕ 12% less damaged than Krichauff
2. Cross sowing	Crops sown twice with half the seed sown in each run to give an even plant density.	0.6	13%
3. Wide row spacing	Wide row sowing (for example, 23 to 46cm spacings) was ineffective for reducing frost damage. Wide row crops consistently yield 10 to 15% less than the standard sowings, with or without frost. In the presence of minor or severe frost, frost damage was similar for normal and wide row spacings.	0.2°C	0
4. Lower sowing rate	A lower sowing rate (35 to 50kg/ha) on frost-prone paddocks has not yet been proven to minimise frost damage. In WA, the plants in thinner crops appear more robust and able to better withstand frost events. The extra tillers formed per plant spread flowering time over a longer window. However, more weeds germinated and competed with the crop.	0	0

* The percent reduction in frost damage will vary from event to event. A light frost may not cause much difference between treatments and nothing will be effective to protect against a very severe frost.

Source: *Managing Frost Risk – A Guide for Southern Grains* over a clay layer located between 20cm and 60cm below the surface.

Crop management

As previously discussed, delaying sowing especially of mid and long season varieties and growing short, mid and late season cereals is an important tool to reduce the risk of crop loss due to frost.

Research has also identified that specific management of frost-prone paddocks or areas within a paddock is important. The aim should be to maximise profit not yield in frost prone areas. Yield potential should be based on records from within these areas and inputs of seed and fertiliser should be conservative to minimise crop bulk and wasted inputs due to poor yields. For example, varieties that produce less bulk have been found to have warmer canopies and reduced frost damage.

Longer season cereal varieties such as Yipti^(ф), that flower later have been recorded to perform better in frost-prone areas. However, if areas are likely to be affected by multiple frosts during late winter and spring, hay or pasture may be a more profitable option for these areas.

Precision tools such as topography, electromagnetic and yield maps can play a part in identifying and spatially locating areas prone to frost. The use of variable rate technology can enable targeted placement of inputs. This can include increasing or decreasing seeding rates and changing fertiliser inputs.

Some frost damage can be unavoidable even with best management practice in place.

If frost damage occurs

Early identification of frost damage is essential if the optimum return is to be achieved from the crop. Detailed frost identification guides for cereals, pulses and canola are available in the GRDC 'Back Pocket' series and in the publication *Managing Frost Risk*.

The first step is to estimate the yield of the frost damaged crop. The next step is to consider the options for achieving a financial return or benefit from the frosted crop.

1. **Harvestable Grain** – use gross margins to establish the grain yield required to recover harvest costs.
2. **Hay** – What is the demand and opportunity for marketing hay from the frosted crop? What are the likely costs and returns from haymaking?
3. **Livestock** – Can the affected crop be grazed by livestock to achieve a return? Do livestock need to be purchased? Is a livestock system in place?
4. **Following crop** – What is planned to be grown on the paddock next year?
5. **Weeds** – What is the density and spectrum of weeds in the frosted crop?
6. **Machinery** – Is machinery or are contractors available for the required tasks?
7. **Soil erosion (water and wind)** – Will the paddock become more susceptible to erosion if some of the above options are adopted?

Useful resources

- **'Managing Frost Risk – a Guide to Southern Australian Grains' and 'Frost identification – Back Pocket Guides' Both available from Ground Cover Direct www.grdc.com.au**
- **Bureau Meteorology – frost forecasts, temperature outlooks**
  www.bom.gov.au
- **Department of Land Information – satellite images of current and historic land surface temperatures**
  www.rss.dola.wa.gov.au
- **Department of Agriculture and Food WA – under climate and follow links to real time and historical weather data**
  www.agric.wa.goc.au
- **FlowerCalc – a program developed in WA and modified for SA that provides a graphic interpretation of a varieties flowering time in relation to the chance of frost or heat stress**
  08 9368 3333 (WA), 08 8303 9718 (SA)

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