

MANAGING PULSES TO MINIMIZE FROST DAMAGE

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Keys to success for minimizing frost damage in pulses

Although it is difficult to totally manage frost risk in pulses, it is important to:

- Know the period of highest probability of frost incidence
- Map the topography to show areas of greatest risk, and specifically manage these areas to minimize frost damage
- Aim to help reduce exposure to frost or impact at vulnerable growth stages of the pulse
- Choose the appropriate crop type, variety and sowing time
- Small changes in temperature around the critical trigger point can help avoid frost damage, so manage the pulse canopy, row spacing and any cereal stubble retained
- Understand the impact of soil type, condition and moisture status
- Manage crop nutrition and minimize crop stress level to lessen frost damage

Frost occurrence

Frost damage occurs if a pulse crop is at a vulnerable growth stage at the time of the frost. Timing is everything, and the relativity of damage depends on severity of the frost, crop sensitivity, variety maturity and sowing time. Any subsequent frosts can lead to further damage. Frost frequency and intensity is unpredictable. We can only work on probabilities when managing frost risk.

Yield and financial losses from frost damage can be severe, especially with high value crops like chickpeas and lentils, or high yielding crops like peas and beans. While pulses can be foraged for hay, silage, grazed or “brown” manured after frost (Hawthorne 2006), the potential for per-hectare dollar losses are still great. A recent decade of dry seasons appears to have increased incidence of frost, particularly in 2006, and reinforces the need for flexibility and change in pulse crop production management.

Know the problem areas and times

Know when the period of greatest probability of frost risk occurs is important for crop management. Little can be done to ameliorate severe, widespread frost events like those “one in a lifetime” events that occurred in many southern areas in 2006. However, for year-to-year management of frost risk, the initial key is to identify frost-prone paddocks or areas on the farm. Frost damage is most frequent, and most severe, in “frost pockets”, which can vary greatly in size, depending on topography and related factors.

A topographic map of paddocks will assist in identifying frost prone areas and planning the direction in which wide rows should be sown to channel cold air. GPS and harvest monitors are also of assistance in mapping frost prone areas. Installing a data logger for recording temperatures at low and high points will provide records to indicate the magnitude, timing and area of frost events as they occur. Temperatures in the paddock are unlikely to be the same as those of the closest weather recording station, so an on farm minimum-maximum thermometer can help.

Mapping or marking areas identified as frost-prone will enable growers to target management strategies to these high-risk areas. Suggestions for managing frost risk in pulses represent the best available experiences and science-based options to reduce the risk of losses from frost in pulses.

Least risk strategy options – principles

Pulses can be sensitive to frost, and in some situations damage is unavoidable. There are however several agronomic strategies learnt from cereals (Knell et al 2006) and experience that might be of benefit.

The soil forms a heat bank, and we want warm soil for warm air rise at night to minimize frost risk. The crop canopy will trap cold air on top, so a dense canopy is not necessarily desirable. Strategies for pulses evolve around these principles, and crop choice.

Strategies to minimize frost damage in pulses work in combinations of: selecting a more tolerant species; selection of variety that avoids peak flowering and early podding during the period of most risk or has extended flowering to compensate for losses to frost; or ensuring that most grain is sufficiently filled to avoid damage when frost occurs. Targeting flowering and early podding to periods of least frost risk is achieved through combinations of sowing date and variety choice for flowering time and flowering duration. Local experience will indicate the best choices.

Crop, variety and sowing time principles

Flowering time: Long-season pulse varieties or species may escape frost because they flower later in the growing season, when frost incidence can be lower (eg chickpeas). Delayed sowing of later flowering varieties or species, rather than sowing them first, further reduces frost risk or exposure. Crop and variety choice will need to vary from location to location. A disadvantage of this strategy may be a reduction in yield potential in the absence of frost, due to the late flowering crop running out of moisture before it can fill its grain. Soils in low-lying, frost-prone areas often can better store subsoil moisture, so the yield penalty from delayed seeding may not be as severe as it would be in drier soil, higher in the landscape.

Sowing time: Pulses that are sown very early may escape frost damage because they flower and develop grain well before the frosts. There is also a greater disease risk. Late sown pulses may escape early frosts because they flower later in the growing season, when frost incidence is perhaps less, but there may be a yield potential penalty. Combinations of sowing date and variety maturity provide options to target the ideal flowering time when frost risk is considered least yet allowing sufficient season for grain fill. Local experience will indicate the best choices. Choose a soil type with stored subsoil moisture, to minimise yield penalty from delayed seeding.

Crop choice

Chickpeas flower later than the other pulses, and so can escape early frosts. They are however quite sensitive to poor pod set or grain fill when late frosts do occur. They are deep rooted and tolerate heat better than other temperate pulses.

Lentils flower later than some other pulses, and can escape some early frosts. They are a short crop and can be sensitive to poor pod set or grain fill when frosts do occur. Sowing too late can lead to short crops, harvest difficulties and poor quality, if the season finishes quickly.

Faba beans flower very early compared with most other pulses, and do not avoid early frosts. They are the most tolerant pulse to frost effects on grain fill, but are not immune to other frost damage. Thick pods assist in protecting the seed during filling unless the frost is severe. Beans flower and pod early, so the grain is often well filled and able to tolerate late frosts because most of the yield has been set at the time. Frost can damage grain appearance though, with “frost burn” staining the seed coat and affecting marketability into food markets.

Lupins varieties generally flower relatively early compared with other pulses, but flower over an extended period. Pod set is affected by frost, but compensation occurs with later pods provided conditions are suitable. Continued frosts or heat can lead to overall poor pod set in extreme exposures. Grain that is filling can also be damaged by severe frosts. Experience from 2006 is that Albus lupins are possibly more frost sensitive than narrow leafed lupins.

Field peas are considered to be one of the more sensitive pulses to frost damage. Pod set and grain fill is affected by even mild frosts, so that overall frost damage can be great. Pea varieties differ in flowering time (early to late) and duration (short to an extended flowering). Some pea varieties may escape total loss to frost with their extended flowering (eg Parafield). Other late flowering varieties may escape early frost periods (eg Morgan, Mukta). Some varieties can occasionally be extremely vulnerable if they flower over a very short period (eg Kaspera as a late flowering pea, Excel as an early flowering type).

Conventional, trailing type peas in the field appear less frost sensitive than many of the shorter, erect semi-leafless types. Physical damage from traffic or herbicides on frosted peas during the pre-flowering stages can leave the peas more vulnerable to the spread of the disease bacterial blight, an additional complication with frost damage in peas.

Vetch for grain or forage is also very sensitive to frost damage for similar reasons to field peas. Growers who sow vetch are doing so mainly as a multi-purpose crop that is flexible in use, so grain yield is only one consideration. Seed harvest can be greatly affected by frost, so reserves need to be kept.

Least risk strategy alternative options

Have forage as an optional use. Designating hay or forage as a possible optional use for pulses sown in high frost-risk paddocks provides flexibility and may help reduce economic loss. It is widely practiced with vetch. Pea, bean or lupin hay is also of excellent quality. Forage options are less suited to lentils and chickpeas. Pulses do not lose their hay quality as quickly after frost as cereals do, so there is more flexibility in cutting time - allowing more accurate assessment of grain versus hay yield potential.

Mixing two varieties (long and short season, short and tall) balances frost risk against the risk of end of season drought, and reduces the risk of losses from any one frost event. Multiple frost events can however damage both varieties. When choosing varieties for a mixture, suitability for delivery of the grain from both into the same grade must be considered, otherwise the lowest grade is achieved. Mixtures are only a practical option in peas, narrow leafed lupins, kabuli chickpeas, and perhaps desi chickpeas if the less favourable, old ascochyta susceptible varieties are used in the mix. Flowering time differences between varieties are minimal in lentils and beans.

Sowing a mixture of pulses is feasible, but not common. Complications in crop choice include contrasting grain sizes, differing herbicide requirements, harvest timing and grain cleaning. Multiple frost events may damage both crops. Pulses grown in a mix will only be suitable for feed markets unless they can be cleaned to enable purity in segregation. If these difficulties can be overcome there is an opportunity for alternate row sowing of different pulse species.

Matching different pulses to risk areas by sowing a different variety or pulse species separately into targeted areas within the same paddock is an option. By matching the crop, variety and sowing date to the frost risk location, the risk is spread, the crops are handled separately, and there isn't a grain mixture to deal with. Since it is already common practice to match different soil types within a paddock to different crop species, this can also be done with frost risk areas once they are defined.

Management operations

Minimise input costs where possible to reduce financial risk exposure in frost-prone paddocks. Aim for a consistent long-term average rather than peak yields. High-input into pulse crops on frost-prone areas does not necessarily place them at greater risk of being frost-damaged (as it does in cereals). Reducing fertiliser inputs, seed rates, fungicide applications, insect control and weed control might reduce the financial exposure to crop loss, but can lessen the chance of a successful hay cut or jeopardize the pulse grain crop when no frost occurs.

Manage nodulation to ensure pulse crops are adequately nodulated and well supplied with fixed nitrogen. Pulses deficient or marginal in nitrogen are more likely to be susceptible to frost damage. This was visually apparent in one nodulation experiment with faba beans in 2006. This is unlike as in cereals where crop canopy is involved with high nitrogen status, and cereal crops with access to high nitrogen tend to sustain more frost damage than crops with a lower nitrogen supply.

Manage crop nutrition, as with cereals, to ensure pulses have an adequate supply of trace elements and macro-nutrients – (supplying high levels is unlikely to increase frost tolerance). Crops deficient or marginal in potassium and copper are likely to be more susceptible to frost damage, and this may also be the case for molybdenum. Foliar copper, zinc or manganese will only be effective if the crop is deficient in the element applied.

Canopy management is important. In cereals, frost sits on top of the canopy when the cold air is trapped, and so damages the upper parts of the plant. In pulses, the height of crop and the exposure of the pods seem to influence frost damage. The pulse canopy can be managed. Semi-leafless, erect peas may be more vulnerable than conventional, lodging types because their pods are more exposed. A mix of two varieties of differing height, maturity and erectness might assist in reducing frost damage in pulses.

Sowing in wider rows enables frost to get to ground level, and the inter-row soil is more exposed. The open canopy does not trap cold air. Wide rows require the soil to be moist to trap the heat in the soil during the day. With wide or paired rows and a wide gap, the heat can radiate up. Wide rows can be used to channel cold air by aligning the rows downhill.

Channel air flow away from the susceptible crop by using wide rows aligned up and down the hill or slope. In some areas in WA, apparently a 3m wide “moat” is used to channel the cold air. A sacrifice area may be required where the cold air settles.

Cereal stubble presence provides a cooler soil and root zone, worsening the frost effect compared with bare soil. Standing stubble is considered less harmful than slashed stubble as less light is reflected and the soil is more exposed to the sun. Dark coloured stubble will be more beneficial than light coloured stubble.

Rolling can help keep soils warm by preventing soil moisture loss, but not necessarily on self mulching or cracking soils. Note that press wheels roll only in the seed row, but not the inter-row. With no-till practice, avoid having bare, firm moist soil as it will lose some of its stored heat.

Claying or delving sandy soils increase the ability of the soil to absorb and hold heat by making the soil colour darker, and retaining moisture nearer the surface. Claying can be an expensive practice and requires careful costing before treating large areas.

Increase plant carbohydrate levels because higher levels of carbohydrates in plants during a frost event means less leakage, hence damage during thawing. Biological farmers measure “Brix levels” with a refractometer. Crops with a higher sugar content (high Brix) will also have a lower freezing point, with an associated protection against frost damage. A high Brix reading means higher sugar and mineral content, higher true protein content, a greater specific gravity or density, and a lower nitrate and water content for better storage characteristics. In cereals the key to achieving high carbohydrate levels are canopy management and avoiding a high nitrogen status. In pulses, methods are yet to be determined. Various soil and foliar applications are available.

Learn from vineyard experiences: In 2006 the vineyard experiences in the SE of South Australia (“Limestone Coast”) with severe frosts was that the only successful measure was use of frost sprinklers. Air movement through frost fans was inadequate apart from a few metres from the fan. Air did channel down the vine rows into low spots where worst damage occurred. Smoke was useless, and inter-row practices of little benefit in such a severe frost year.

Frost research

The GRDC is investing through Pulse Breeding Australia into pulse variety breeding for frost tolerance by:

- identifying frost resistance and pulse germplasm enhancement
- breeding pulse cultivars with altered flowering time and duration to avoid frost;
- screening of pulse varieties for relative levels of frost tolerance in the field.

Frost Facts

Reducing frost risk requires modification of conditions over very large areas. Minor management changes can have major effects because frost damage occurs at specific ‘trigger’ temperatures, depending on crop and conditions. Keeping the air temperature even 0.1°C above the critical trigger point will avoid frost damage. Modifying air flow through the canopy can also reduce the effects of frost. Once the temperature drops below the ‘trigger temperature’, damage is likely to occur regardless of management action.

Diagnosing frost damage

Frost damage to pulse crops can be easily recognized and quickly identified. Pods take on a different, “mottled” appearance and the grain inside becomes black and shriveled. Frost on well developed grains may be “frost burnt”, leaving a stain on the sides of the grain that were exposed to the pod wall. The GRDC Frost Identification Back Pocket Guide is a valuable source of information, as is the Grain Legume Handbook.

The costs of frost

Pulse crop losses to frost have not been estimated. There is also a hidden cost in the form of reduced yield potential, when growers forgo early seeding opportunities in order to reduce the likelihood of frost damage.

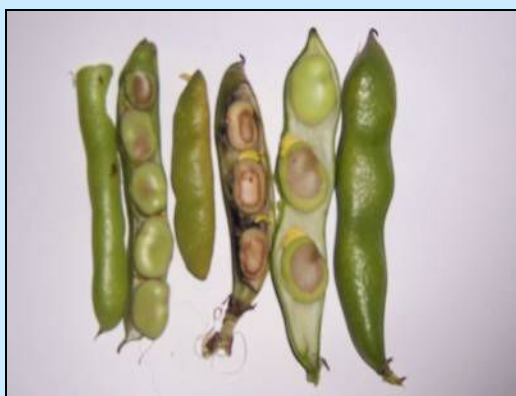
In the northern grains region (northern NSW and Queensland) frost can also cause vegetative damage in pulses, leading to loss of tillers and subsequent grain production losses. This is less of an issue in southern Australian areas.

SUMMARY OF KEY INFLUENCES

Frost risk is influenced by a variety of factors including:

- crop type (sensitivity, flowering date)
- crop variety (flowering date and duration)
- sowing time
- soil type and condition
- canopy management and row spacing
- stubble presence
- atmospheric and soil moisture levels
- crop nutrition and nodulation
- crop stress level
- topography of land
- frost severity, number and timing

Late frosted bean grain



Lupins sown into standing cereal stubble



Frosted field pea pods



Frosted bean pods



Frosted pulses make excellent quality forage



REFERENCES AND ACKNOWLEDGEMENT:

This publication was produced for pulses from information gained on pulses and utilizing the information published for cereals (Knell et al 2006).

- Knell, G; Rebbeck, M; Eglington, J; and Frederiks, T (2006). "Managing frost, minimizing damage". GRDC Advice Sheet, March 2006. <http://www.grdc.com.au/growers/as/frost.htm>
- Hawthorne, W. (2006). "Using Pulses as Forage Crops". Australia Pulse Bulletin PA 2006 #12, Pulse Australia. www.pulseaus.com.au



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