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FIELD PEA SECTION 13 ENVIRONMENTAL ISSUES

KEY POINTS | FROST ISSUES FOR PULSES | WATERLOGGING | MOISTURE AND HEAT STRESS | OTHER ENVIRONMENTAL ISSUES



Environmental issues

Key points

- Field pea crops are most vulnerable to frost during reproductive phases of flowering, pod-set and grain-fill. Field pea varieties range in flowering time and duration, so select varieties to best suit your conditions.
- Avoid growing field pea on poorly drained soils and areas prone to waterlogging.
- Field pea respond well to minimum temperatures not less than 7°C during establishment and canopy expansion and 25°C and less during critical reproductive phases.







WatchGCTV20: Extreme Temperature Analysis to Better Understand Frost Events, https://youtu.be/Zw637FiX5PU

CROUNDER ENTREME



Watch GCTV3: Frost R&D https://youtu.be/og9wPzjchjA





Watch GCTV20: Frost's emotional impact, is it greater than its economic impact? https://youtu.be/GC2P2Tha5Es



13.1 Frost issues for pulses

Radiant frost can be a major stress to crops, and one of the principal limiting factors for agricultural production worldwide, including Australia. Radiant frosts occur when plants and soil absorb sunlight during the day and radiate heat during the night when the sky is clear and the air is still. Dense, chilled air settles into the lowest areas of the canopy, where the most serious frost damage occurs. The cold air causes nucleation of the intracellular fluid in plant tissues, and this causes the plasma membrane to rupture.¹ Legumes, including chickpea, field pea, faba bean and lentil, are very sensitive to chilling and freezing temperatures, particularly at the stages of flowering, early pod formation and seed filling, although damage may occur at any stage of development.

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Frosts (or isolated freezing events) are a problem for chickpea (Figure 1) in southern Australia, especially when they occur in the late vegetative and reproductive phenological (climate-induced developmental) stages, and the air temperature drops to 2°C or less on clear nights in early spring. They occur most frequently after the passing of a cold front, when the moisture and wind dissipates, leaving cold and still conditions with clear skies.

Areas of high frost risk in southern Australia include the Eyre Peninsula, Murray Mallee and Mid North of South Australia, and the Wimmera–Mallee region of Victoria. Over the past few years, the worst-affected areas have had crop production losses close to 100%.²

The occurrence and extent of frost damage tends to be affected by the microclimate, with great variability occurring within paddocks and even on the same plant. Therefore, soil type, soil moisture, position in the landscape, and crop density can have a bearing on the damage caused by a frost. In some species, crop nutrition has been shown to mitigate the effect of freezing-range temperatures on the plant. It is thought that fertilisation of the plant, and consequent fast growth rates, can exacerbate the effect of freezing, particularly on the part of the plant undergoing elongation.

13.1.1 Industry costs

Crop losses due to frost are estimated to average more than \$33 million a year in SA and Victoria, and over the whole of Australia may cost the grains industry, on average, more than \$100 million a year.³ The real cost of frost is a combination of the monetary cost due to both reduced yield and quality, and the hidden cost of management tactics used to minimise frost risk. These include:

- delaying sowing and its associated yield reduction;
- sowing less-profitable crops such as barley and oats; and
- avoiding cropping on valley floors, which are among the most productive parts of the landscape.

13.1.2 Impacts on field pea

Field pea is considered to be one of the more sensitive pulses to frost damage during reproduction.

Pod-set and grain-fill are 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 a total loss to frost with their extended flowering (e.g. Parafield). Other late flowering varieties may escape early frost periods (e.g. Morgan⁰, Mukta). Some varieties can occasionally be extremely vulnerable if they flower over a very short period (e.g. Kaspa⁰ as a late flowering pea, Excel as an early flowering type).



¹ A Maqbool, S Shafiq, L Lake (2010) Radiant frost tolerance in pulse crops: a review. Euphytica 172 (1), 1–12

² M Rebbeck, G Kneil (2007) Managing frost risk: a guide for southern Australian growers. SARDI, GRDC.

³ M Rebbeck, G Kneil (2007) Managing frost risk: a guide for southern Australian growers. SARDI, GRDC



FEEDBACK

(i) MORE INFORMATION

GRDC Tips and Tactics Managing frost risk (all regions), https://grdc.com.au/__data/assets/ pdf_file/0027/208674/grdcmanaging-frost-risk-tips-and-tacticsfrost-050216-northen-southern-andwestern-region.pdf.pdf

Pulse Australia (2015) Minimising frost damage in pulses. Australian Pulse Bulletin, Updated 20 November, <u>http://pulseaus.com.au/growingpulses/publications/minimise-frostdamage</u>

W Hawthorne (2007) Managing Pulses to Minimise Frost Damage. Australian Pulse Bulletin PA 2007 #01, <u>http://www.pulseaus.com.au/storage/</u> <u>app/media/crops/2007_APB-Pulses-</u> <u>frost.pdf</u>



Conventional, trailing type peas in the field appear less frost sensitive than many of the shorter, erect semi-leafless types (e.g. Sturt, Parafield by comparison with Kaspa⁶).

Physical damage from traffic or herbicides on frosted peas during the pre-flowering stages can leave the peas far more vulnerable to the spread of the disease bacterial blight, an additional complication with frost damage in peas.⁴

Symptoms of frost damage in field pea (Photo 1):

- Flowers are killed by frost.
- Developing seeds in the pod are shrivelled or absent.
- White/green mottling and blistering of pods.
- Affected pods feel 'spongy' and the seeds inside turn brown/black.⁵



Photo 1: Frost-damaged seeds are shrivelled and the seeds inside pods turn brown/black.

Photo: DPIRD (2014), B Biddulph (2015) Diagnosing frost in field peas, https://www.agric.wa.gov.au/mycrop/diagnosing-frost-field-peas

13.1.3 Managing to lower frost risk

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

- Know the period of highest probability of frost incidence.
- 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 minimise crop stress level to lessen frost damage.
- Map the topography to show areas of greatest risk, and specifically manage these areas to minimise frost damage.⁶

Problem areas and timing

Mapping or marking areas identified as frost-prone will enable growers to target frost and crop management strategies to these high-risk areas.

Knowing when the period of greatest probability of frost occurs is also important for crop management.



⁴ W Hawthorne (2007) Managing Pulses to Minimise Frost Damage, Australian Pulse Bulletin PA 2007 #01

⁵ B Biddulph (2015) Diagnosing frost in field peas. Department of Agriculture and Food, Western Australia, <u>https://www.agric.wa.gov.au/mycrop/diagnosing-frost-field-peas</u>

⁶ W Hawthorne (2007) Managing Pulses to Minimise Frost Damage, Australian Pulse Bulletin PA 2007 #01, <u>http://www.pulseaus.com.au/</u> storage/app/media/crops/2007_APB-Pulses-frost.pdf





Crop and sowing time

The main strategy used to minimise frost risk in broadacre cropping has been to sow crops later. Risks exist with delayed sowing, even though this practice can reduce the probability of crops flowering in a frost-risk period. Crops sown later can still be affected by frost. Strategies to minimise frost damage in pulses work in combinations of:

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- growing a more tolerant species;
- trying to avoid having peak flowering and early podding during the period of most risk;
- extended flowering to compensate for losses to frost; and
- ensuring that most grain is sufficiently filled to avoid damage when frost occurs.

Targeting flowering and early podding to periods of the lowest probability of frost is achieved through combinations of sowing date and variety choice based on flowering time and flowering duration. Local experience will indicate the best choices. By planting for late flowering, farmers target the avoidance of early frosts, but in the absence of frost, late flowering may reduce yields if moisture is deficient or there are high temperatures. Very early flowering can allow pods to be sufficiently developed to escape frost damage, and ensure some grain yield at least before a frost occurs. Increased disease risk needs to be considered with early sowing.

Spread the risk

Match different pulses to risk areas by sowing a different variety or species into targeted areas within the same paddock. Matching the crop, variety, sowing date and subsequent inputs to the frost-risk location spreads the risk.

Have forage as an optional use. Designating hay or forage as a possible use for the pulse in paddocks with a high frost risk provides flexibility.

Mixing two pulse varieties (e.g. long and short season, tall and short) balances the risks of frost and of end-of-season (terminal) drought, and reduces the risk of losses from any one frost event. Multiple frost events can damage both varieties. If grain from both varieties is not of the same delivery grade, then only the lowest grade is achieved. The only realistic, practical options are in pea, narrow-leaf lupin, kabuli chickpea; perhaps desi chickpea are an option. Differences in flowering times are minimal in lentil and bean.

Sowing a mixture of pulse species is feasible, but not common. Complications in crop choice include achieving contrasting grain sizes, herbicide requirements, harvest timing and grain cleaning. Multiple frosts may damage both crops. Pulses grown in a mix will be suitable for feed markets only if 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 pulses.

Reduce frost damage

Managing inputs. To minimise financial risk in frost-prone paddocks when growing susceptible crops, growers can:

- Apply conservative rates of fertilisers to frost-prone parts of the landscape.
- Avoid using high sowing rates.

Advantages of avoiding high inputs are:

- Less financial loss if the crop is badly frosted.
- Lower-input crops, though potentially lower yielding during favourable seasons, are less like to suffer severe frost damage than higher-input crops with a denser canopy.
- Input costs saved on the higher frost-risk paddocks may be invested in other areas where frost risk is lower.

Lower sowing rates may result in a less dense canopy that increases crop tillering and may allow more heating of the ground during the day, and transfer of this heat to the canopy at night. However, there is no hard evidence that lower sowing rates will







reduce frost damage. The main disadvantage of this practice is that in the absence of frost, lower grain yield and/or protein may be the result during favourable seasons, contributing to the hidden cost of frost. (This is a particular disadvantage in barley and wheat delivery grades.) Less-vigorous crops can also result in the crop being less competitive with weeds.

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Managing nodulation and nutrition. Ensure pulse crops are adequately nodulated and fixing nitrogen. Ensure pulses have an adequate supply of trace elements and macronutrients, although 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 application of copper, zinc or manganese may assist, but only if the crop is deficient in the element applied.

Managing the canopy. A bulky crop canopy and exposure of the upper pods may increase frost damage to pulses. 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 may also assist in reducing frost damage.

Sow in wider rows, so that frost is allowed to get to ground level and the inter-row soil is more exposed. An 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, however this may not always be effective.

Channel cold air flow away from the susceptible crop by using wide rows aligned up and down the hill or slope. Where cold air settles, a sacrifice area may be required.

The presence of cereal stubble makes the soil cooler in the 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 types.

Rolling can help keep soils warm by slowing soil-moisture loss, but not necessarily on self-mulching or cracking soils. Note that press-wheels roll only in the seed row, and 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 increases the ability of the soil to absorb and hold heat by making the soil colour darker, and retaining moisture nearer the surface.

Higher carbohydrate levels in plants during frost leads to less leakage during thawing. A higher sugar content (high Brix) will also have a lower freezing point, and associated protection against frost damage. The effectiveness of various products applied to soil and plants to increase plant carbohydrates is unknown.

Better varieties coming. Through Pulse Breeding Australia, the GRDC is investing in germplasm enhancement and variety breeding to increase frost tolerance in pulses. The focus is on altered flowering time and duration to avoid frost, and screening of pulse varieties for relative levels of frost tolerance in the field. New varieties will be released when available.⁷

A 5-year research project funded by the GRDC examined the effects of agronomic practices on frost risk in broadacre agriculture in southern Australia. The researchers manipulated the soil heat bank to store heat during the day and release heat into the canopy of the crop at night. The research examined how the crop canopy could be manipulated to allow for warm air from the soil to rise and increase the temperature at crop head height (Figure 1). They have identified strategies that could be used to significantly reduce the impact of frost.



⁷ Pulse Australia (2015) Minimising frost damage in pulses. Australian Pulse Bulletin, Updated 20 November, <u>http://pulseaus.com.au/</u> growing-pulses/publications/minimise-frost-damage







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Figure 1: *Temperature dynamics in a crop canopy and canopy interactions.* Source: Rebbeck and Knell (2007)

Importance of soil moisture

Soil moisture is the most important factor for storing soil heat that will be released to and through the crop canopy at night. Because water has a high specific heat, radiation cooling overnight will be reduced when moisture is present in the soil. On a daily basis, heat is transferred into and out of approximately the top 300 mm of soil. When the soil is wet, heat transfer and storage in the upper soil layer is higher, so more heat is stored during daytime for release during the night.

There is also some evidence that moist soils can retain their warming properties for more than 24 hours, allowing some scope for an accumulation of heat from sunlight for more than one day. Heavier-textured soils hold more moisture (and therefore heat) than lighter-textured soils. A more dense soil can hold more moisture within the soil surface for heat absorption and subsequent release. Darker soils also absorb more light energy than lighter soils. Water-repellent sandy soils are usually drier at the surface than normal soils, and are therefore more frost-prone. Frost studies in SA have found that crops were likely to be more damaged on lighter soil types because the soil temperature is lower as a result of lower soil moisture and the more reflective nature of these soils. On such soils, clay spreading or delving may be an option for reducing frost risk.

Use of agronomic practices

Table 1 shows the rankings of agronomic practices, adopted in both SA and WA, in order of importance. The table shows the paddock-management strategies that manipulate the soil heat bank or manipulate the canopy air flow within the paddock, followed by paddock management strategies that also may assist crops to better tolerate frost. The final column in the table shows the reduction in frost damage from adopting these various practices in frost prone regions (derived from project trials).

The frost-avoidance strategies described in <u>Table 1</u> are whole-farm approaches to reduce or spread risk of frost injury.⁸



⁸ M Rebbeck, G Knell (2007) Managing frost risk: a guide for southern Australian growers. SARDI, GRDC





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 Table 1: Agronomic practices to reduce frost risk ranked in order of importance.

Soil heat bank manipulation ranking	Description	Increased temp. at canopy height (average) (°C)	Reduction in frost damage
Clay delving or clay spreading	In soils with a sandy surface, clay delving increases heat storage, nutrient availability and infiltration rate.	1.0	Up to 80%
	Reducing frost risk by increasing the clay content of sandy-surfaced soils is the strongest finding in South Australia.		
Rolling	Rolling sandy soil and loamy clay soil after seeding has reduced frost damage, although the results were not statistically significant.	0.5	Up to 18%
Removing stubble	Removing stubble had a negligible effect on yield and frost risk.0.5MinThe role stubble plays in retaining soil moisture could be more important		Minimal
Manipulation of the crop canopy ranking	Description	Increased temp. at canopy height (ave) (°C)	Reduction in frost damage
Blending varieties and variety selection	Blending long and short-season wheat varieties is a way to hedge your bets against frost or end-of-season drought within a paddock. A similar risk profile occurs when sowing one paddock with each variety at the same time.	0.0	Yitpi [⊕] 12% less damaged than Krichauff
	Successful results have been achieved in SA and WA blending Krichauff or Wyalkatchem ^(b) with Yitpi ^(b) . Certain varieties, such as Yitpi ^(b) , Stiletto and Camm ^(b) , 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.		
Cross-sowing	Crops sown twice with half the seed sown in each run gives an even plant density and has been found to more slowly release soil heat so that it can have an impact on air temperature at head height in early morning when frosts are most severe. This practice will incur an increased sowing cost. This result is based on two trials in WA.	0.6	13%
Soil heat bank manipulation ranking	Description	Increased temp. at canopy height (average) (°C)	Reduction in frost damage
Wide row spacing	Wide row sowing (e.g. 230–460 mm spacings) were ineffective in reducing frost damage.	0.2	0
	Wide row crops consistently yield 10–15% 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.		
Lower sowing rate	A lower sowing rate (35–50 kg/ha) on frost-prone paddocks has not yet been proven to minimise frost damage.	0.0	0
	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, the crop is less competitive with weeds.		

Source: Rebbeck and Knell (2007)





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VIDEO

Watch Managing the effects of frost <u>https://youtu.be/z_QN6Mvnlss</u>



(i) MORE INFORMATION

GRDC Tips and Tactics: Managing frost risk (all regions), https://grdc.com.au/__data/assets/ pdf_file/0027/208674/grdcmanaging-frost-risk-tips-and-tacticsfrost-050216-northen-southern-andwestern-region.pdf.pdf

13.1.4 Managing frost-affected crops

There are a number of options available for managing crops that have been frosted (Table 2). The following table highlights these options and the pros and cons of each. The suitability of each option will depend on the severity of the frost and analysis of costs versus returns.⁹

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Table 2: Options for managing frosted crops.

Option	Advantages	Disadvantages
Harvest	No damage estimates required. Salvage remaining grain. Condition stubble for seeding.	Costs may be greater than returns. Need to implement weed control. Threshing problems. Need to remove organic matter.
Hay / silage	Stubble removed. Weed control.	Cost per hectare. Quality may be poor (especially wheat).
Chain / rake	Retains some stubble and reduces erosion risk. Allows better stubble handling.	Cost per hectare. Time taken.
Graze	Feed value. Weed control.	Inadequate stock to utilise feed. Remaining grain may cause acidosis. Stubble may be difficult to sow into.
Spray	Stops weed seedset. Preserves feed quality for grazing. Gives time for decisions. Retains feed. Retains organic matter.	Difficulty getting chemicals onto all of the weeds with a thick crop. May not be as effective as burning. Boom height limitation. Cost per hectare. Some grain still in crop.
Plough	Recycles nutrients and retains organic matter. Stops weed seed set. Green manure effect.	Requires offset discs to cut straw. Soil moisture needed for breakdown and incorporation of stubble.
Swath	Stops weed seedset. Windrow can be baled. Regrowth can be grazed. Weed regrowth can be sprayed.	Relocation of nutrients to windrow. Low market value for straw. Poor weed control under swath. Cost per hectare.
Burn	Recycles some nutrients. Controls surface weed seeds. Permits recropping with disease control. Can be done after rain.	Potential soil and nutrient losses. Fire hazard. Organic matter loss.

Source: DPIRD, https://www.agric.wa.gov.au/frost/managing-frost-risk









13.2 Waterlogging

Field pea is susceptible to waterlogging. Crops sown on hard-settings soils can suffer from waterlogging as they tend to be poor draining. Waterlogging causes insufficient oxygen in the soil pore space for plant roots to adequately respire. Root-harming gases such as carbon dioxide and ethylene also accumulate in the root zone and affect the plants.¹⁰

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Germinating seed is very susceptible to waterlogging. Poor crop establishment is common when waterlogging occurs at seedling emergence. Waterlogging 6 days after germination of field pea can delay the emergence by up to 5 days and reduce the final plant density by 80%. Waterlogging depresses vegetative growth of plants but affects root growth more than shoot growth.11

Plants can show symptoms of iron and or nitrogen deficiency. Plants can appear to survive waterlogging then die prematurely in spring because damaged root systems cannot access subsoil moisture. Nodulation may be affected due to extended waterlogging. Roots have reduced growth then turn brown and die (Photo 2). The plant can compensate with new roots emerging from the hypocotyl.

13.2.1 Minimising waterlogging in field pea

Management strategies may include:

- Avoid growing field pea on poorly drained soils and areas prone to waterlogging.
- Improve drainage and movement of water away from the pea paddock.
- Delay sowing in higher rainfall areas.
- Sow into raised beds.¹²



Photo 2: Brown roots may have poor nodulation and root death.

Photo: DPIRD (2015), D Bakker (2015) Diagnosing waterlogging in narrow-leafed lupins and field peas, Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4140

Plants are more susceptible to root and foliar diseases, and may be more affected by aphids when subjected to waterlogging.

Salinity magnifies the effects of waterlogging, with more marked stunting and leaflets on oldest leaf tip dying back from the tip.13

- 10 D Bakker (2015) Diagnosing waterlogging in narrow-leafed lupins and field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-waterlogging-narrow-leafed-lupins-and-field-peas
- K Siddique. Abiotic stresses of cool season pulses in Australia. University of Western Australia, http://www.farmtrials.com.au/trial/13486
- 12 GRDC (2009) Field Pea: The Ute Guide, Southern region. GRDC Ground Cover Direct
- 13 D Bakker (2015) Diagnosing waterlogging in narrow-leafed lupins and field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-waterlogging-narrow-leafed-lupins-and-field-peas







13.3 Moisture and heat stress

Moisture stress is a major constraint in all pulse-growing regions of Australia, particularly in the low rainfall areas. From a practical point of view, it is difficult to separate moisture stress and heat stress and they generally occur simultaneously. The types of moisture stress that affect pulse production in Australian are: lack of or low opening rainfall at planting, intermittent moisture stress by breaks in winter rainfall and the terminal moisture stress, resulting from receding soil moisture and increasing high temperature in spring.

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Terminal moisture stress is the most common form of moisture stress experienced by cool season pulses in Australia. The severity of terminal moisture stress depends upon the amount and distribution of rainfall, capacity of the soil to store moisture and the evaporative demand of the atmosphere. There are two major effects of moisture stress on pulse productivity: failure to establish the desired plant stand; and reduction in growth and yield due to suboptimal soil moisture availability.

Moisture stress during vegetative stages of growth rarely occurs in winter crops when vegetative growth occurs during cooler periods of the year and when plant moisture demand is low. Flowering is the most sensitive stage to moisture stress.¹⁴

Field pea is one of the better legumes at tolerating drought or moisture limiting conditions. However, a lack of growing-season rainfall can lead to poor establishment, growth (lower biomass) and very short crops, resulting in harvesting difficulties.

Warm, windy weather with dry conditions in spring can result in reduced flowerset, poor grain-fill, smaller grain and low yield, particularly under low soil moisture conditions.15

Detailed studies of field pea have showed a negative correlation between grain number, the main yield component and the cumulative temperature over 25°C between beginning of flowering and the final stage in seed abortion for the last seed-bearing phytomer.¹⁶



Photo 3: Field pea prematurely wilted by hot winds. Photo: W. Hawthorne, formerly Pulse Australia

- GRDC (2009) Field Pea: The Ute Guide, Southern region. GRDC Ground Cover Direct
- V Sadras, L Lake, K Chenu, L McMurray, A Leonforte (2012) Water and thermal regimes for field pea in Australia and their implications 16 for breeding. Crop and Pasture Science, Jan 2012, https://www.researchgate.net/profile/Victor_Sadras/publication/230626089_Water and_thermal_regimes_for_field_pea_in_Australia_and_their_implications_for_breeding/links/0c960525f4091c3f8300000.pdf



¹⁴ K Siddique (1999) Abiotic stresses of cool season pulses in Australia. University of Western Australia, http://www.farmtrials.com.au/





It should be pointed out that the Kaspa-type field pea varieties are resistant to shattering because of their sugar-pod trait. However, the pod walls do break down over time and expose the seed inside the pod to weather damage. Kaspa⁽⁾ grain has been sun and heat burnt when left unharvested in the pod (Photo 4).

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Photo 4: Kaspa^(b) field pea grain that has been sun and heat burnt through the sugar-pod wall. Normal grain (top) and with different severities of burn (below). Photo: W. Hawthorne, formerly Pulse Australia









Management strategies may include:

- sow early in the sowing period in early-maturing areas; .
- sow early-maturing varieties; and
- retain stubble cover from previous crops (standing or mulch) to minimise moisture loss.17

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Photo 5: Field pea droughted and affected by frost.

Photo: Hawthorne, formerly Pulse Australia



Photo 6: Field pea sown into stubble to minimise soil moisture loss. Photo: W. Hawthorne, formerly Pulse Australia

17 GRDC (2009) Field Pea: The Ute Guide, Southern region. <u>https://grdc.com.au/resources-and-publications/all-publications/</u> publications/2009/04/field-peas-the-ute-guide







13.4 Other environmental issues

13.4.1 Salinity

One of the most significant causes of soil degradation in Australia is salinity, which is the presence of dissolved salts in soil or water. It occurs when the watertable rises, bringing natural salts to the surface. In sufficient quantity, the salts become toxic to most plants. They cause iron toxicity in plants and impede their ability to absorb water. Salinity, a major abiotic stress, is a major environmental production constraint in many parts of the world. In Australia, saline soils have

been caused by extensive land clearing, predominantly for agricultural purposes.

Field pea is sensitive to waterlogging and moderately sensitive to soil salinity. Soil salinity affects plant growth by reducing the roots' ability to extract water from the soil. Soil salinity damage varies from season to season due to variations in soil salt concentration. Waterlogging increases salinity damage. See <u>Section 2.1.4 Salinity</u>.

13.4.2 Soil pH

Soil acidity is measured in pH units. Soil pH is a measure of the concentration of hydrogen ions in the soil solution. The lower the pH of soil, the greater the acidity. pH is measured on a logarithmic scale from 1 to 14, with 7 being neutral. A soil with a pH of 4 has 10 times more acid than a soil with a pH of 5 and 100 times more acid than a soil with a pH of 6.

The ideal pH range for field pea is (water) 6.0-9.0. Field pea can be sensitive to high levels of exchangeable aluminium (AI) in acid soils. They will tolerate levels of 5-10% exchangeable aluminium. Acid soils can significantly reduce production and profitability before paddock symptoms are noticed.

Low soil pH often leads to poor or ineffective nodulation in pulses because acid soil conditions affect rhizobia survival in the soil. Field pea, faba bean, lentil and chickpea are vulnerable, as are vetches.¹⁸

For more information, see Section 4.8 Inoculation.

Acid soils

Acid soils can significantly reduce production and profitability before paddock symptoms are noticed. Danger levels for crops are when soil pH is <5.5 (in $CaCl_2$) or 6.3 (in water). Monitor changes in soil pH by testing the soil regularly. If severe acidity is allowed to develop, irreversible soil damage can occur. Prevention is better than cure, so apply lime regularly in vulnerable soils. The most effective liming sources have a high neutralising value and a high proportion of material with a particle size <0.25 mm. More lime is required to raise pH in clays than in sands. Liming can induce manganese deficiency where soil manganese levels are already marginal. Low soil pH often leads to poor or ineffective nodulation in pulses because acid soil conditions affect initial numbers and multiplication of rhizobia. Field pea, faba bean, lentil and chickpea are vulnerable, as are vetches. Lupin is an exception because its rhizobia (Group G) is acid-tolerant. Granular inoculums seem to provide greater protection to rhizobia in acid soils.

Between pH 5.5 and 8 (CaCl₂)is the ideal pH range for plants. Soil pH targets are 5.5 in the topsoil (0–10 cm) and >4.8 in the subsurface soil (10 cm and below). At pH 4.8 (CaCl₂) or lower, levels of aluminium in the soil become toxic (<u>Figure 2</u>). Free aluminium has a large impact on crop yield. It reduces root growth, which in turn reduces the depth of soil the plant has access to.









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Figure 2: Aluminium (AI) and pH graph with rule of thumb AI toxicity.

Source: Soil quality (2017), P Caszey (2017). Soil Acidity Fact Sheet. Soilquality, http://soilquality.org.au/factsheets/soil-acidity

In terms of lime movement through the soil, a pH of 5.5 is required in the top 0–10 cm of soil before lime can influence any soil deeper than this. Lime applied to the surface will be worked in with the traffic of the seeding implement. This creates a layer where the pH is ameliorated to the depth of the seeding point but no further. Lime must be in contact with the soil of low pH in order to react. This layering effect has an impact on yield potential of rotation crops and pastures. An ameliorated surface, above pH 5.5 (CaCl₂), and subsurface with pH below 4.8 (CaCl₂) reduces the yield potential of rotation crops and the efficacy of N fixation. After lime has been applied, the subsurface pH will remain unchanged until the lime is able to leach through the profile.

It is difficult to make the correct decisions on soil treatment and crop choice if you do not have full knowledge of the soil pH to depth. This is particularly so when the crop is susceptible to low pH or aluminium toxicity, as are break crops such as field pea. Poor yields of these rotation crops may be the result of low pH at depth, in spite of good pH at the surface.¹⁹

Alkaline soils

Soil alkalinity is mainly caused by bicarbonates and carbonates, although phosphates, borates and some organic molecules can also contribute. In a soil with pH 7.0–8.2, bicarbonates and carbonates of calcium and magnesium dominate.

Calcareous soils contain from 1–90% lime material as calcium carbonates, and these sparingly soluble salts cause the soil to have a pH of 8.0–8.2, which is not a severe problem for plant growth or agricultural production.

Problems are encountered in alkaline soils when sodium occurs or accumulates and forms salts such as sodium bicarbonate and sodium carbonate. These are highly soluble and increase the soil pH above 8.

When the pH is more than 9, the soils are considered to be highly alkaline and often have toxic amounts of bicarbonate, carbonate, aluminium and iron. The high amount of exchangeable sodium in these soils reduces soil physical fertility, and nutrient deficiency is also likely to be a major problem.

In alkaline soils, the abundance of carbonates and bicarbonates can reduce crop growth and induce nutrient deficiencies. The presence of free lime has a major impact on lupin growth, inducing iron and manganese deficiency, which cannot be corrected by foliar sprays of those nutrients.²⁰



¹⁹ GRDC (2017) Chickpea GrowNotes™, Southern. https://grdc.com.au/GrowNotes

²⁰ P Rengasamy (n.d.) Soil pH—South Australia. Fact sheet. Soilqualiy, http://www.soilquality.org.au/factsheets/soil-ph-south-australia







Managing soil pH

• Growers are applying more lime per hectare than in the past but, in many cases, much more lime is needed to replenish the soil profile.

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 Liming to remove soil acidity as a production constraint can also bring the benefits of increasing yields, increasing crop and pasture choice, and helping to protect the soil resource.

Soil acidification is an ongoing issue

Soil acidification is an ongoing and unavoidable result of productive agriculture. The main practices that cause soil acidification include the removing of products by harvest (Photo 6) and the leaching of nitrate from soil. Because soil acidification is an ongoing consequence of farming, management also needs to be ongoing.²¹



Photo 7: Hay production, especially legume hay, is one of the most acidifying practices.

Photo: Soil Quality Pty Ltd, http://www.soilquality.org.au/factsheets/managing-soil-acidity-western-australia

Acid soils

Acid soils can be economically managed by the addition of agricultural lime, usually in the form of crushed limestone. Sufficient lime should be added to raise the pH to above 5.5. The amount of lime required to ameliorate acid soils will vary, depending mainly on the quality of the lime, the soil type and how acidic the soil has become.

Soils prone to becoming acidic will need liming every few years. Seek advice on an appropriate liming regime from your local agricultural adviser.

Alkaline soils

Treating alkaline soils by the addition of acidifying agents is not generally a feasible option due to the large buffering capacity of soils and uneconomic amounts of acidifying agent (e.g. sulfuric acid, elemental sulfur or pyrites) required.

Gypsum will reduce sodicity and this can reduce alkaline pH to some extent. Growing legumes in crop rotations may help in sustaining any reduction in pH.

In high-pH soils, using alkalinity-tolerant species and varieties of crops and pasture can reduce the impact of high $\rm pH^{,22}$



²¹ C Grazey, J Carson (n.d.) Managing soil acidity—Western Australia Fact sheet. Soilquality

²² P Rengasamy (n.d.) Soil pH—South Australia. Fact sheet. Soilqualiy, http://www.soilquality.org.au/factsheets/soil-ph-south-austral





13.4.3 Sodicity

Sodic soils occupy almost one-third of the land area of Australia. Sodicity has serious impacts on farm production, as well as significant off-site consequences such as:

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- surface crusting;
- reduced seedling emergence;
- reduced soil aeration;
- increased risk of run-off and erosion;
- less groundcover and organic matter; and
- less microbial activity.

Sodic soils are known as dispersive clays and reduce seedling emergence (Figure 4). Sodic soils are can lead to tunnel erosion: they turn to slurry when wet, and channels are easily created through them by moving water.²³



Figure 3: The impact of sodic soils on seedling emergence: surface crusting and dispersive clay limit emergence.

Source: Corangamite CMA, http://www.ccmaknowledgebase.vic.gov.au/brown_book/04_Sodic.htm

Soils high in sodium are structurally unstable, with clay particles dispersing when wet. This subsequently blocks soil pores, which reduces water infiltration and aeration, and retards root growth. On drying, a sodic soil becomes dense and forms a hard surface crust up to 10 mm thick. This can restrict seedling emergence. Some indicators of surface sodicity include:

- soils being prone to crusting and sealing up;
- ongoing problems with poor plant establishment; and
- the presence of scalded areas in adjoining pasture.

Exchangeable sodium percentage (ESP) is the measure for sodicity and soils are rated as:

- ESP <3 non-sodic soil
- ESP 3-14 sodic soil

25

ESP >15 – strongly sodic soil.²⁴

Field pea can tolerate subsoil sodicity up to approximately 5 ESP in the surface layer and 8 ESP in the subsoil. $^{\rm 25}$

Sodicity adversely affects cool season pulses by reducing germination and seedling establishment with increasing ESP (15–20). Glasshouse studies and field observations suggest that chickpea and lentil are more sensitive to sodicity than faba bean and field pea.²⁶

- 24 GRDC (2017) Northern Field pea GrowNotes[™]. <u>https://grdc.com.au/GrowNotes</u>
 - C Mullen (2004) The right pulse in the right paddock at the right time. NSW Agriculture, <u>http://www.dpi.nsw.gov.au/agriculture/</u> broadacre-crops/winter-crops/general-information/right-pulse
- 26 K Siddique. Abiotic stresses of cool season pulses in Australia. University of Western Australia, http://www.farmtrials.com.au/trial/13486



²³ Corangamite CMA (2013) How do I manage the impact of sodic soils? Corangamite CMA, <u>http://www.ccmaknowledgebase.vic.gov.au/</u> brown_book/04_Sodic.htm





Soils that are sodic in the topsoil have the greatest impact on crop performance. Sodic layers deeper in the soil profile are not as great a concern, but can still affect yields by restricting root development and water extraction from depth.²⁷

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Managing sodic soils

- Growers need to correctly identify the problem first and ensure that the soils are in fact sodic.
- Sodic soils can be directly treated through the application of gypsum (particularly on the surface), which serves to replace the excess sodium in the soil with calcium.
- In southern Victoria, typical application rates of gypsum are around 2.5 t/ha and applied every 3–5 years.
- The application of lime to sodic soils acts in a similar manner to gypsum, but is much slower acting and less effective.
- Although the application of gypsum can effectively counter sodicity in the short run, longer-term management strategies need to be in place to increase, and then maintain, organic matter in soils. Increased organic matter can improve hard-setting soils, and it can also enhance the effect of gypsum.
- Sodicity can also be reduced by maintaining adequate vegetation cover, leaf litter or stubble on the soil surface.
- Trials in the high-rainfall zone of southern Victoria have shown that the amelioration of dense sodic subsoil using organic amendments can increase wheat yield more than using gypsum.²⁸



²⁷ Pulse Australia (2013) Northern Chickpea–Best Management Practices Training Course Manual, Pulse Australia

²⁸ Pulse Australia (2013) Northern Chickpea—Best Management Practices Training Course Manual. Pulse Australia