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GRDC

# GROWNOTES™

# FIELD PEAS




GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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# Start here for answers to your immediate field peaS crop management issues

**What are the best field pea varieties to grow in WA?**

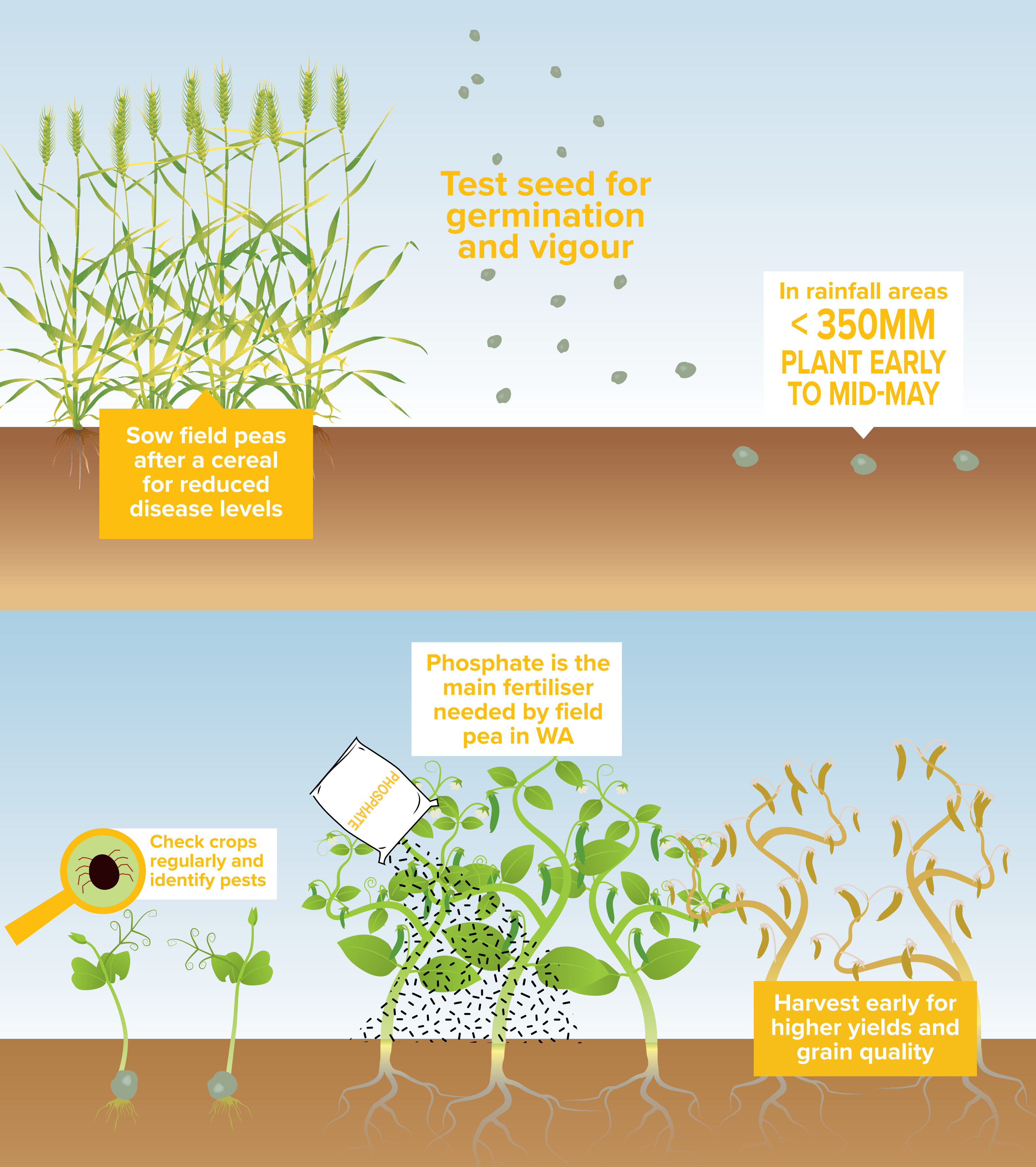
**What type of inoculant should I use?**

**Do I need to modify equipment for seeding?**

**What are the key nutrients required by field peas?**

**How do I manage native budworm and other pests in field peas?**

**How do I manage blackspot infection in field peas?**


Test seed for germination and vigour
In rainfall areas < 350MM PLANT EARLY TO MID-MAY
Sow field peas after a cereal for reduced disease levels
Phosphate is the main fertiliser needed by field pea in WA
PHOSPHATE
Check crops regularly and identify pests
Harvest early for higher yields and grain quality

# Contents

# Introduction

## A.1 Crop overview

**Photo 1:** *Field pea flowers.*

Photo: AM Photography

## A.2 Field pea types

There are several types of field pea grown in Australia. Dun types are the most common; they usually have purple or faintly pink flowers and seeds that have yellow cotyledons, and a mixture of either green or brown seed coats. Some dun varieties, though, have almost uniformly green (Helena) or light brown to cream (Kaspa⑽) seed coats. [1]

Up until the early 2000s the field pea industry in Australia was based almost entirely on tall trailing, indeterminate flowering and late-maturing cultivars. More recently a major shift has occurred across southern Australia towards a uniquely Australian bred field pea plant ideotype (cv. Kaspa⑽) that is broadly adapted. This cultivar is semi-dwarf, semi-leafless, determinate, late in flowering although early maturing, semi-erect at maturity and highly resistant to seed shattering. [2]

Round-white peas (called yellow peas in North America and Europe) are also grown in significant quantities, particularly in eastern Australia. These types generally have white flowers, yellow cotyledons, and a white-creamy seed coat. [3]

## A.3 Growing field peas

Field pea is the most widely adapted pulse crop in Western Australia. Field pea has a farming system advantage because it can be sown later than most other annual crops. This allows weeds to germinate with adequate time left for control by either mechanical means, or with non-selective herbicides, before sowing.

1 DAFWA (2015) Growing field pea. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/1755

2 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 2–Plant physiology.

3 DAFWA (2015) Growing field pea. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/1755

The early maturity of field pea also makes it ideally suited to crop topping to prevent seed set of surviving in-crop weeds. The reduced reliance on selective herbicides provides a very useful tool in the battle against herbicide resistant weeds.

The late sowing and early harvest means the planting and harvest windows of the cropping program as a whole can be widened, allowing more efficient labour and machinery use.

Field pea provides substantial rotational benefits to subsequent cereal and oilseed crops. The three main areas of benefit are weed management, disease-break root and foliar diseases, and through N fixation to the soil. [4]

They will grow successfully on a wide range of soil types from sands to clay loam, but best results can be expected from those with a heavier texture. They are also suited to both medium and low rainfall environments. Crops can be grown successfully on sandy soil, but there is a considerable soil erosion risk, particularly after harvest as the remaining field pea vine can break down very rapidly leaving the soil exposed. Management techniques including stubble retention and avoiding grazing are critical where erosion is likely.

The addition of N fertiliser can help with crop establishment where field peas are grown, e.g. on deep siliceous sands. Field peas have a poor tolerance to saline soils and those prone to surface sealing or waterlogging. Crop tolerance to waterlogging is fair. The fungal disease complex Ascochyta is more severe on poorly drained soils.

Stony soils are generally unsuitable for field pea production because of harvesting difficulties, although rolling when the crops are up to 10 cm high may push the surface stones down to soil level. Field peas are more sensitive than other pulses to frost during the flowering and pod filling stages of growth. Low lying, frost prone areas should be avoided. Choosing when to sow field peas requires a compromise between sowing early enough to avoid end of season drought and late enough to avoid Ascochyta infection. [5]

## A.4 Products and uses

Pulses are an excellent source of vegetable protein. They are high in minerals such as iron, calcium, magnesium and potassium, and the essential trace minerals copper, manganese, molybdenum, selenium and zinc. They also contain essential vitamins such as the B vitamins thiamine, niacin and folate. [6]

## A.5 Market

Canada and France dominate world export markets and produce mainly white peas. Australia is the major exporter of dun type peas. Victoria and South Australia have historically been the largest Australian field pea producers, but production has recently expanded considerably in Western Australia as a result of better varieties and improved production technology. More than 90% of the field pea grown in Western Australia is the Kaspa⦇ dun type, with the majority of the grain exported to the Indian sub-continent for food. [7]

Field pea market issues must take chickpea supplies into account, although Australian kaspa peas are now finding their own unique market in India apart from as a substitute for chickpeas.

4 DAFWA (2015) Growing field pea. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/1755

5 GRDC (2008) Grain Legume Handbook. Update 7 February 2008. Grains Research & Development Corporation, https://grdc.com.au/Resources/Publications/2008/03/2008-Grains-Legume-Handbook

6 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course,

7 DAFWA (2015) Growing field pea. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/1755

# Planning/Paddock preparation

### Key messages

- Field peas provides diversity and help reduce disease, weed and pest levels in a paddock
- Field peas prefer rainfall of more than 300 mm per year but do not tolerate extended periods of waterlogging.
- Avoid chickpea stubble to reduce Ascochyta blight risk.
- Herbicide residues can affect crop damage in field peas.

## 1.1 Paddock selection

Field peas have the widest adaptation to soil types of all pulse crops, from sandy loams through to heavy clays and will grow on slightly acid to alkaline soils (pH $CaCl_2$ 5–9.0). Field peas are less productive on soils with a hard-setting surface or with heavy clay subsoils that drain poorly, but are the best suited of all the pulses to grow on these soils.

Danger levels for crops are when soil pH is <5 (in $CaCl_2$). On light textured soils make sure top soil and subsoil pH is tested. Low soil pH often leads to poor or ineffective nodulation in field peas because acid soil conditions affect rhizobial numbers and multiplication.

Field peas do not tolerate extended periods of waterlogging, particularly when just sown, or at the seedling stage. Well-drained soils are therefore important for successful crop establishment and growth.

Field peas have lower tolerance than cereal grains to salinity and water logging. These conditions cause the plants to be stunted with yellowish discoloration followed by bright red pigmentation.

**Photo 1:** *Marginal necrosis of older leaves that progresses up the plant.*

Photo: DAFWA

Salinity damage varies from season to season due to variations in the soil salt concentration. Waterlogging increases salinity damage (Photo 2). [1]

*Salinity and boron*

A glasshouse study in Western Australia was conducted to determine the influence of salinity and boron and the combined effects of both on the early growth of two field pea varieties, Kaspa⦸ and Parafield. The study revealed that salinity was the main inhibitor to plant growth in both varieties, reducing plant height, root length, and the number of nodes on the main stem.

No interaction was observed between the combined effects of salinity and boron toxic soils. Kaspa⦸ was more tolerant of boron toxic soils than Parafield with no significant difference between low and high boron soils. In Parafield, boron significantly reduced plant growth under low saline conditions. [2]

**Photo 2:** *The combined effects of salinity and waterlogging.*

Photo: DAFWA

Level paddocks are preferred; paddocks with crabholes, rocks or sticks, and hardpans should be avoided as they can create issues at harvest time with contamination of the sample, damage to machinery or an inability to pick up all the crop. [3]

Field peas are the best adapted pulse to lower rainfall situations, but are prone to frost and heat stress during flowering and podding.

A check list for field pea paddock selection includes:

- research variety choice and specific variety management packages
- rainfall >300 mm/year
- soil is friable, free draining, not prone to waterlogging, surface not hard setting
- soil surface flat and free of undulations. Rolling will flatten clods, rocks and stones
- field peas not sown in the previous 4 years and paddock not downwind of last year's pea stubble to avoid Ascochyta

1 DAFWA (2015) Diagnosing salinity damage in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4484

2 S Bennett (2012) Early growth of field peas under saline and boron toxic soils. Department of Environment and Agriculture, Curtin University, http://www.regional.org.au/au/asa/2012/nutrition/7946_bennettsl.htm

3 Pulse Australia (2010) Northern Region Field Pea Management Guide, http://sydney.edu.au/agriculture/documents/pbi/pbi_region_north_field_pea_management_guide.pdf

- Low wild radish burden
- maximum herbicide plant-back periods satisfied (e.g. Group Bs, clorpyralid, triazines) [4]

Field peas can be sensitive to high levels of exchangeable aluminium (Al) in acid soils. They will tolerate levels of 5–10% exchangeable Al%. Acid soils can significantly reduce production and profitability before paddock symptoms are noticed.

## 1.2 Paddock rotation and history

Avoid sowing a pulse after another broadleaf crop, (eg. pulse after canola), even following a drought due to the difficulties of controlling broadleaf weeds in a broadleaf crop. There is also the potential disease carry-over such as Sclerotinia (*Sclerotinia sclerotiorum*) and other diseases.

Field peas are well-suited to no-till systems. It is preferable for the previous crop to have been a cereal, resulting in low soil nitrogen (N) and disease levels for pulses. This maximises N fixation and helps minimise disease. Standing cereal stubble also deters aphid transmit viruses. The stubble also provides architectural support for the growing field pea crop.

Broadleaf weed pressure should be low together with a low weed seed bank. Avoid problem weed paddocks, considering both weeds which are difficult to control, and weeds which may contaminate the grain sample.

Herbicide residues and herbicide history must also be considered. Herbicide residues, for example the Group B sulfonylurea herbicides such as chlorsulfuron and metsulfuron methyl, can be very damaging, particularly in alkaline soils after extended dry periods. [5]

**MORE INFORMATION**

GRDC (2014) Nitrogen fixation of crop legumes: basic principles and practical management. Fact Sheet.

GRDC (2009) Field peas: The Ute guide.

## 1.3 Advantages of field pea as a rotation crop

Pulse and cereal crops are complementary in a cropping rotation. The way a crop affects following crops include well recognised processes related to disease, weeds, rhizosphere microorganisms, herbicide soil water and mineral N.

Pulses fix their own N, leaving available N in the soil for the following cereal crop. The amount of N fixed is linked to biomass production with around 20–25 kg of shoot N being fixed for every tonne of legume shoot dry matter accumulated. [6]

Pulses also play a vital role in controlling major cereal root diseases, particularly cereal cyst nematode and take-all. [7]

The impacts of a pulse crop on farm profits is a real one with results across 900 experimental comparisons in Australia showing that, on average, wheat yields increased by 0.5 t/ha following oats, 0.8 t/ha following canola and 1.0 t/ha following grain legumes (0.7 to 1.6 t/ha) compared with wheat on wheat. This 'break-crop effect' often extended to a second wheat crop in the sequence, especially following legumes (benefit of 0.2 to 0.3 t/ha), but rarely to a third except under dry conditions. [8]

4 GRDC (2009) Field Peas: The Ute Guide. Grains Research and Development Corporation, http://www.grdc.com.au/Resources/Bookshop/2009/12/Field-Peas-The-Ute-Guide

5 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

6 M Peoples, et al. (2001) Contributions of Fixed Nitrogen by Crop Legumes to Farming Systems of Eastern Australia. Australian Agronomy Conference 2001, http://www.regional.org.au/au/asa/2001/1/c/peoples.htm

7 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 1–Rotational Benefits.

8 J Kirkegaard (2015) Grain legumes can deliver an extra 1t/ha yield to wheat crops. Grains Research and Development Corporation, http://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-115-Profitable-pulses-and-pastures/Grain-legumes-can-delivery-an-extra-1tha-yield-to-wheat-crops

## 1.4 Disadvantages of field pea as a rotation crop

Compared to cereals, field peas provide little ground cover over the summer period but will leave more residues than chickpea or lentil. Being weak-stemmed with fragile surface roots, they leave little stubble after harvest to hold the soil. If grown on erosion susceptible soils, field pea stubble should either not be grazed or carefully grazed to ensure adequate stubble cover is maintained. [9]

Factors to consider:

- Field peas can be a riskier crop to grow than cereals especially in dry or frosty conditions.
- Field peas are less productive on soils with a hard setting surface, or heavy clay sub-soils.
- They will not tolerate waterlogging at sowing or at the seedling phase.
- They are susceptible to insect attack, especially Native budworm and pea weevil.
- Sand blasting by wind can severely damage seedling crops.
- Crops can lodge prior to harvest.
- Weed control, particularly broadleaf weeds, can be an issue, especially for weeds such as medic and clover.
- Harvest is slow and expensive and can be tough on machines.

## 1.5 Fallow management

### Fallow weed management

Field peas are poor competitors with weeds when they are in the early stages of their growth. The best form of weed control is rotation. Having a well thought-out rotational plan for three to five years helps determine which paddocks will be sown to pulses so broadleaf weed control in preceding cereals can be thorough.

Benefits of summer weed control are significant. It is important to conserve soil moisture especially in dry environments. GRDC-funded research shows stopping weed growth in the fallow can lead to yield increases in the following crop due to moisture conservation and other factors including a wider and more reliable sowing window, higher levels of plant available N, reduced levels of weed vectored diseases and nematodes, reduced levels of rust inoculum via interruption of the green bridge, reduced levels of diseases vectored by aphids that build in numbers onsummer weeds, and reduced weed physical impacts on crop establishment.

### Fallow chemical plant-back effects

Residues of sulfonylurea Group B herbicides can persist in some soils. These residues can last for several years, especially in more alkaline soils and where there is little summer rainfall. The pulses emerge and grow normally for a few weeks, and then start to show signs of stress when they hit the band of residual chemical at depth. Leaves become off-colour (often yellow), roots may be clubbed, and plants stop growing and eventually die.

9 I Pritchard (2014) Field pea stubble: wind erosion control and grazing management. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/field-peas/field-pea-stubble-wind-erosion-control-and-grazing-management?page=0%2C0

**Photo 3:** *Peas on leaf showing the SU (Chlosulfuron) damage versus a healthy plant on the right*

Source: DAFWA

Be especially wary under conditions of limited rainfall since herbicide application. Usually Glean® or Logran® damage is not serious when these products are used as directed and plant-backs adhered to, although there is an increased risk of damage given:

- very dry or drought conditions
- highly alkaline (pH >8.5) soils
- excessive overlapping during application

Sulfonylurea breakdown occurs by hydrolysis, and is favoured by warm, moist conditions in neutral to acid soils (Photo 3). Residues will tend to persist for longer periods under alkaline and/or dry conditions. Persistence of residues is greater for Glean® and Logran® than for Ally® or Harmony®M. Residues are root-absorbed and translocated to the growing points; therefore, both roots and shoots are affected. [10]

In wheat–field pea rotations the use of fallow and in-crop residual herbicides such as Broadstrike®, Eclipse®, Flame® Grazon®DS, Lontrel® and metsulfuron (Ally®, Associate®, Lynx®) and Harmony®M should be avoided, particularly during the summer fallow or weed-control period.

The use of long-term residual sulfonylurea herbicides such as Monza®, chlorsulfuron (Glean®, Lusta®), and Logran® in wheat should be avoided when re-cropping to field peas (Table 1) [11].

10 GRDC (2008) Grain Legume Handbook update 7 Feb 2008. Grain Legume Handbook Committee, supported by GRDC, https://grdc.com.au/Resources/Publications/2008/03/2008-Grains-Legume-Handbook

11 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

**Table 1:** *Residual persistence of common pre-emergent herbicides, and noted residual persistence in broadacre trials and paddock experience* [12]

| Herbicide | Half-life (days) | Residual persistence and prolonged weed control |
|---|---|---|
| Logran® (triasulfuron) | 19 | High. Persists longer in high pH soils. Weed control commonly drops off within 6 weeks |
| Glean® (chlorsulfuron) | 28–42 | High. Persists longer in high pH soils. Weed control longer than Logran |
| Diuron | 90 (range 1 month to 1 year, depending on rate) | High. Weed control will drop off within 6 weeks, depending on rate. Has had observed long lasting activity on grass weeds. |
| Atrazine | 60–100, up to 1 year if dry) | High. Has had observed long lasting (> 3 months) activity on broadleaf weeds such as fleabane |
| Simazine | 60 (range 28–149) | Med/High. 1 year residual in high pH soils. Has had observed long lasting<br>(> 3 months) activity on broadleaf weeds such as fleabane |
| Terbyne® (terbulthylazine) | 6.5–139 | High. Has had observed long lasting (> 6 months) activity on broadleaf weeds such as fleabane and sow thistle |

MORE INFORMATION

Pulse Australia Bulletin: Residual Herbicides and Weed Control

## 1.6 Seedbed requirements

### Inoculate seed with correct rhizobium (Group E)

Because rhizobia are legume-specific and their persistence is affected by soil characteristics and cultural practices, their diversity, number and $N_2$-fixation capacity can vary greatly.

For efficient nodulation and N fixation field peas should be inoculated every year with Group E inoculant. [13]

MORE INFORMATION

GRDC (2016) Rhizobial inoculants. Fact sheet.

This comes in various forms including freeze-dried vials, liquid vials and peat-based products. The vial products can be easily pumped and sprayed onto the seed or injected into the soil with water in a liquid system. The peat products are usually mixed into a slurry with water and poured onto the stream of grain as it goes up the auger. [14]

Nitrogen fixation is the cheapest and most effective N supplied into the farming system.

12 B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf

13 E Drew et al. (2012) GRDC Inoculating legumes: a practical guide. Grains Research and Development Corporation, http://www.grdc.com.au/GRDC-Booklet-InoculatingLegumes

14 G Onus. Fababean Growing Program. Landmark Moree.

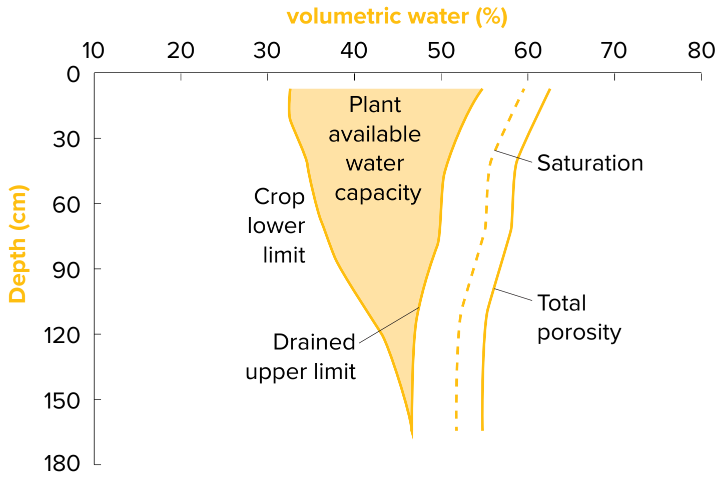



**Figure 1:** *A typical storage profile for a heavy-textured clay soil showing the potential water storage of the soil, PAWC, as defined by the drained upper limit (DUL-blue shading), crop lower limit (CLL), saturation (SAT), and total porosity (PO).* [15]

Fallowing captures out-of-season rainfall and can increase the amount of water available for crop growth, however the proportion of rainfall retained by fallowing (also referred to as fallow efficiency) can be small, typically of the order of 20%.

On sandy soils, there may be little benefit from stubble retention on water capture over summer and in some cases standing stubble may enhance evaporative losses. In contrast, on clay soils in southern Australia, fallow efficiencies up to 40% have been measured with retained stubbles.

The ability to store summer rainfall may also depend on the amount of rainfall, with the potential benefit of stubble retention being greatest where moderate rainfall is received during the fallow period. Small amounts of rain may evaporate quickly irrespective of the presence of stubble, whereas high rainfall may allow soil moisture to accumulate irrespective of the presence or absence of stubble. [16]

## 1.7 Yield and targets

Under ideal conditions pulse crops should be able to produce 15 kg/ha of grain for every mm of growing season rainfall above 130 mm. By comparison wheat can produce 20 kg/ha for every mm of rainfall above 110 mm (Figure 2).

The different pulses do have varying yield potentials under differing yielding situations, based on yield potential under adequate moisture or drought tolerance (Figure 3).

In WA, frost or a dry finish to the season and inability to harvest low crops are the biggest impediment to reliable field pea yields.

15 N Dalgliesh (2014) Practical processes for better soil water management. Grains Research and Development Corporation, Update Papers, 28 Feb 2014, https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Practical-processes-for-better-soil-water-management

16 V Sadras, G McDonald (2012) Water Use Efficiency of grain crops in Australia: principles, benchmarks and management. Grains Research and Development Corporation, https://grdc.com.au/Resources/Publications/2012/07/Water-use-efficiency-of-grain-crops-in-Australia

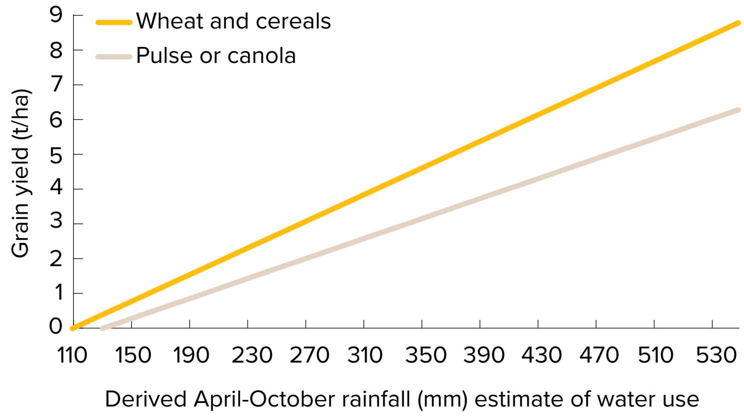



**Figure 2:** *Relationship of grain yield (t/ha) to estimated water use April to October. Pulses are 15 kg/ha/mm water available above 130 mm, Cereals are 20 kg/ha/mm available above 110 mm.*

Source: Grain Legume Handbook from French and Schultz model

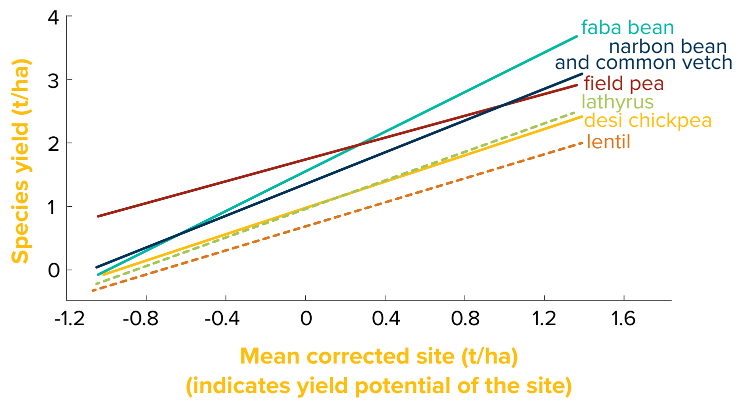



**Figure 3:** *How grain yield of different grain legume species varies across sites with different yield potential in Western Australia.*

Source: adapted from K. Siddique et al. (1999)

### *Ratio of water use/evaporation*

- The average pulse crop is subjected to an evaporation stress of between 600 mm and 650 mm from sowing to harvest.
- The best yields occur when water use by the crop is 0.7 times the evaporation level.

### *Temperature*

One of the most critical factors affecting field pea yield is temperature. High temperatures on flowering to grain fill can have a negative impact on final yield.

Field peas ideally require temperatures of at least 10°C (mean daily temperature) at flowering, but do grow and flower at lower temperatures. This is similar to lupins but lower than the 15°C required by chickpea. Field peas are very sensitive to frost damage during grain fill.

High temperatures (greater than 30°C) can cause flower abortion and cause flowering to cease, even with adequate soil moisture.

For maximum yield, field pea flowering should be completed by the week in which the average maximum daily temperature reaches 20°C. By comparison the critical maximum temperature for wheat is the week of 23°C.

Pulse crops will produce higher yields if they are sown early enough to allow them to finish flowering before the week of critical average daily maximum temperature. [17]

## 1.8 Weeds status of paddock

Selecting the most appropriate paddock to grow field peas includes consideration of weeds or issues that are difficult to control. Delayed sowing enhances the opportunity for knockdown weed control before planting

There are pre-sowing herbicide options (metribuzin, cyanazine and terbuthylazine), post-sowing, pre-emergent options (diuron, metribuzin) and two post-emergent options (diflufenican, flumetsulam) available for conventional field pea varieties. Under adverse conditions, most post sowing, pre-emergent herbicides are capable of causing damage to field peas. Practical scenarios of varying soil types, unevenness in a paddock and instances of heavy rainfall after sowing can pose difficulties to manage the balance of herbicide rates for adequate weed control and minimise crop damage across the whole paddock. Not all herbicide products registered and commonly used in other pulses are registered for use in field peas. [18]

For more information, see Section 6, Weed control.

## 1.9 Disease status of paddock

Disease management in field peas is critical, and relies on delayed sowing to ensure the field peas emerge after the main blackspot spores have been released. It is critical to have a minimum 3-year break between pea crops in order to reduce disease pressure.

The impact of disease on grain quality in pulses can be far greater than yield loss. This must be accounted for in thresholds because in pulses, visual quality has a significant impact on price for food products. Examples are blackspot in most pulses, and Pea seed-borne mosaic virus (PSbMV) in field peas.

A plant disease may be devastating at certain times and yet, under other conditions, it may have little impact. The interaction of host, pathogen and environment are all critical points in disease development, Diseases such as blackspot and phytophthora root rot can cause total crop failures very quickly, whereas botrytis grey mould and root lesion nematodes may 'tick' away over the season and mask their true effects on crop performance and yield. [19]

Selecting the paddock with the lowest disease risk and sowing at the correct time for field peas is the first step to maximising yield and profit.

If possible, avoid sowing this year's crop in a paddock adjacent to last year's field pea crop. Fungal spores can move into adjacent paddocks on infected trash and dust, even if the paddock has never grown a pulse before. Disease pressure can be increased two or three fold simply by poor paddock position. Take note of the wind direction when harvesting adjacent paddocks of field peas the previous year as spores will travel on the prevailing winds.

17 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 1–Rotational Benefits.

18 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

19 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

Look at the condition of the soil. Most pulses do not tolerate waterlogging or hard setting crusting soils, which can result in poor crop growth and promote infection from pathogens. [20]

## 1.10 Nematode status of paddock

Root lesion nematode (RLN) is a microscopic worm-like organism <1 mm in length that feeds in root tissues.

They are found over 5.74 million ha or approximately 65% of the cropping area of WA. RLN populations potentially limit yield in at least 40% of these infested paddocks.

RLN are migratory endoparasites, meaning they enter roots to feed and lay eggs, but may live for some time in soil, feeding on the exterior of the roots or travelling between roots and plants.

In WA, *P. neglectus* is the main species of RLN, with *P. quasitereoides* (originally described as *P.teres*) the next prevalent and *P. thornei* rarely occuring. [21]

Field peas are an attractive option for grain growers wanting to target RLN. Field peas are a profitable crop and will assist in lowering RLN populations where *P. neglectus* or *P. quasitereoides* are present. [22]

Symptoms of infection on root systems include:

- disintegration of outer layers of root tissue
- reduction in root hairs and/or nodules
- a lack of, or stunting of side (lateral) roots
- brown lesions and discoloration of roots.

Root symptoms are often difficult to diagnose in the field and are usually not seen until plants are older than 8 weeks. Root symptoms are generally more obvious in plants grown in sandier soils.

Severely affected plants are stunted and may have some yellowing of their foliage, but often have no obvious foliar symptoms of disease. Diseased plants usually have shorter lateral roots and fewer root hairs.

For more information, see Section 8, Nematode management.

**Photo 4:** *Microscopic examination of the root system is required to confirm the presence of the nematode.*

20 K Lindbeck (1999) Pulse Point 7: Reducing disease risk. NSW Agriculture, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/157144/pulse-point-07.pdf

21 GRDC (2015) Tips and Tactics: root-lesion nematodes, Western region, Grains Research and Development Corporation, www.grdc.com.au/TT-RootLesionNematodes

22 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 1–Rotational Benefits.

## MORE INFORMATION

GRDC (2015) Tips and Tactics: Root-lesion Nematodes, Western Region. Fact Sheet.

Crown Analytical

Paddocks should be diagnosed for plant parasitic nematodes so that optimal management strategies can be implemented (Photo 4). Testing your farm will tell you:

- whether nematodes are present in your paddocks and at what density; and
- which species are present.

It is important to know which species are present because some crop-management options are species-specific. If a particular species is present in high numbers, immediate decisions must be made to avoid losses in the next crop to be grown. With low numbers, plans can be made to safeguard future crops. Learning that a paddock is free of these nematodes is valuable information because steps may be taken to avoid contamination. [23]

For more information, see Section 8, Nematode management.

## 1.11 Insect status of paddock

The two main insects that pose a threat to field pea production and grain quality are pea weevil and native budworm. There is no varietal resistance to either pest.

Severe damage to field pea crops can occur directly because of pest numbers, or from a lack of more palatable alternatives. Crops should be checked from the beginning of flowering for pea weevil and during grain fill for Native budworm.

For more information, see Section 7, Insect control.

23 DEEDI (2009) Root lesion nematodes—management of root-lesion nematodes in the northern grain region. Department of Employment Economic Development and Innovation, Queensland, http://www.daff.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

# Pre-planting

## Key messages

- Australia is the major exporter of dun type field peas.
- More than 90% of field peas grown in Western Australia are the Kaspaⓓ dun type.
- Field pea production has expanded considerably in Western Australia as a result of better varieties and improved production technology.
- When choosing varieties, it is essential to consider their susceptibility to bacterial blight and Ascochyta blight.

## 2.1 Field pea types

Field pea varieties grown in Australia can be divided into five groups, with the most common of these being dun followed by white and blue/green pea. Dun is mostly commonly grown in WA.

### Dun field pea

Dun has greenish-brown (dun) coloured seed with yellow cotyledons. Traditionally dimpled, rounded 'kaspa' types also exist now. Increased seed hardness can occur in dun types under certain climatic conditions, which can result in a lower germination. Used for human consumption and stockfeed. [1]

Dun field peas constitute the greatest portion of varieties grown, with Australia being the major exporter of dun-type field peas. A dun field pea has a yellow cotyledon with a greenish-brown or dun-coloured seed coat. Older dun varieties, such as Morgan and Yarrum, have a 'dimpled' seed coat that is undesirable in the human consumption market, as it makes for an unaesthetically pleasing split product for this market. Some newer dun types (e.g. PBA Twilightⓓ and Kaspaⓓ) have a more spherical seed. They are used for human consumption, with lower grade field pea making a high quality stock feed.

### Dun 'Kaspaⓓ' type

Dun 'Kaspaⓓ' type field peas are a round-type seed. The cotyledon (kernel) colour required for international trade is yellow, but seed coat colour can vary between varieties. The predominant seed coat colour being targeted in Australia is a pale brown, and this to a large extent is genetically determined and highly heritable. [2]

Over 95% of Australian production is from dun types, of which more than 90% is now 'Kaspaⓓ' type (e.g. Kaspaⓓ, PBA Gunyahⓓ, PBA Twilightⓓ). Kaspaⓓ-type grain is preferred for snack food in India and Sri Lanka due to its distinct 'nutty' taste over other pea grain types, and it attracts a price premium. The grain is preferred in these markets due to its round shape and lack of dimples allowing easier seed coat removal and greater split returns. [3]

To avoid limiting the marketing of Kaspaⓓ-type grain for export, growers should avoid sowing seed contaminated with Parafield or other dun types. [4]

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1 Field Peas: The Ute Guide (2009) Grains Research & Development Corporation. http://www.grdc.com.au/Resources/Bookshop/2009/12/Field-Peas-The-Ute-Guide

2 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

3 SARDI (2015) Pea variety sowing guide. South Australian Research and Development Institute, http://www.pir.sa.gov.au/__data/assets/pdf_file/0010/237907/peas.pdf

4 P Kennedy, J Brand, F Henry, M Raynes (2014) Field Pea. Department of Environment and Primary Industries, Victoria, http://agriculture.vic.gov.au/__data/assets/word_doc/0007/294721/Field-Pea-WCS-2015.docx

### 2.1.1 Varieties

#### Habit

Field pea varieties range in growth habit from trailing to erect at maturity. The trailing growth type can be difficult to harvest, but the semi-leafless/semi-dwarf forms of field pea—where leaves have been modified into tendrils—can have a better standability, aiding harvest. Plant height at flowering is affected by temperature and light, as well as variety.

The individual varieties have different coloured flowers from all white to pink, and white to purple and pink (Photo 1).

#### Disease resistance

Varietal resistance to bacterial blight and Ascochyta is extremely important. This is difficult to achieve, however, as these diseases are a potential problem with field peas in tight rotation, in higher rainfall areas, or wetter years.

Ascochyta blight of field pea has been a production and marketing problem in Western Australia. Foliar fungicides are used, but now resistant varieties help overcome the risk to growing this crop. Ascochyta blight can be managed through an integrated approach using stubble management, rate and time of sowing, and chemical seed dressing.

When comparing yields between varieties, growers need to be aware that under bacterial blight pressure or high moisture stress, varieties with greater susceptibility are more likely to suffer greater yield loss.

Improved tolerance to salt and/or boron has also been important in variety selection for some areas. [5]

**Photo 1:** *The white and pink flower of the Kaspa⟬ field pea.*

Source: DAFWA

MORE INFORMATION

Pulse Breeding Australia PBA varieties and brochures

S Clarry (2016) Breeders aiming for 'bulletproof' peas. GRDC Ground Cover Issue 125.

National Variety Trials

FAQ

## 2.2 Choosing a variety

When choosing varieties to grow, it is essential to consider their susceptibility to bacterial blight and Ascochyta blight, along with yield potential, price potential, marketing opportunities, seed availability and markets, maturity timing, lodging resistance and other agronomic features relevant to the growing region.

The national pulse production area has been categorised by Pulse Breeding Australia (PBA) into five regions based on rainfall and geographic location (Figure 1).

- Region 1: low rainfall, tropical
- Region 2: medium rainfall, sub-tropical
- Region 3: low rainfall, sub-tropical

5 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

- Region 4: medium/high rainfall, Mediterranean/temperate
- Region 5: low/medium rainfall, Mediterranean/temperate

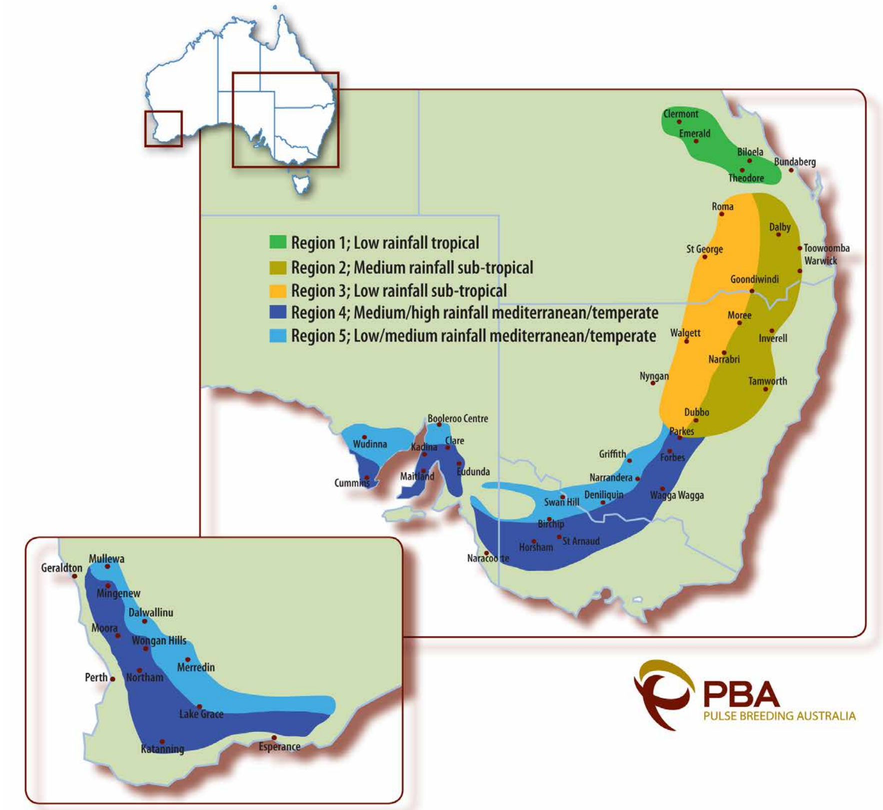


**Figure 1:** *PBA regions used to describe area of adaptation*

Most field pea variety releases have targeted Region 4 and/or Region 5. Some varieties have been found to be better adapted to specific parts of regions. The area of adaption is specified for each variety, so potential users can be aware of their best fit. [6]

## 2.2.1 Dun (Kaspa-type) round field pea varieties

### Kaspa

- commercialised by Seednet
- released in 2002
- area of adaption: Regions 4 and 5

Kaspa is semi-leafless, late-flowering, and resistant to shattering, with good early-season vigour and moderate resistance to lodging. Kaspa is susceptible to powdery mildew, Ascochyta and the 'Kaspa strain' of downy mildew.

Kaspa seed should be treated with metalaxyl seed dressing, particularly in cropping regions prone to downy mildew. The seed of Kaspa is distinct from traditional dun types (e.g. Parafield), being red brown in colour and almost spherical in shape.

Kaspa is high yielding in many areas of southern Australia. It should, however, be considered carefully before use as an option in low rainfall areas, or areas prone to early periods of high temperature and drought stress, due to its late and condensed flowering period. Kaspa should also be considered carefully in areas prone to frequent severe vegetative frosts, due to potential for yield loss to bacterial blight.

For more detailed information: Kaspa variety management package

6 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

### PBA Gunyah⦸

- commercialised by SeedNet
- released in 2010
- area of adaption: Regions 4 and 5

PBA Gunyah⦸ is a Kaspa⦸-type field pea, with earlier and longer flowering than Kaspa⦸, and higher yield in shorter season environments and drier seasons than Kaspa⦸. It is early to mid-flowering and early maturing, making it more suitable to the practice of crop-topping than Kaspa⦸.

It is well suited to delayed sowing for disease management. PBA Gunyah⦸'s disease resistance profile is similar to Kaspa⦸, and therefore not well suited to bacterial blight prone environments. Despite being susceptible to powdery mildew, it is likely that PBA Gunyah⦸ will incur less yield loss from this disease than Kaspa⦸, due to its earlier maturity.

Widespread evaluation over a number of years shows PBA Gunyah⦸ is higher yielding than Kaspa⦸ when yield potential is below 2.25 t/ha.

For more detailed information: PBA Gunyah⦸ variety management package

### PBA Twilight⦸

- commercialised by SeedNet
- released in 2010
- area of adaption: Regions 4 and 5

PBA Twilight⦸ is a Kaspa⦸-type seed with similar attributes to PBA Gunyah⦸. It has a shorter flowering period and is earlier in maturity than PBA Gunyah⦸, making it well suited to the low rainfall and very short season field pea growing environments. It is better adapted to low and medium rainfall climates than Kaspa⦸.

Widespread evaluation over a number of years shows it is higher yielding than PBA Gunyah⦸ and Kaspa⦸ in shorter season climates, but PBA Gunyah⦸ is considered to be more broadly adapted.

With a disease resistance profile similar to Kaspa⦸, PBA Twilight⦸ is therefore not well suited to bacterial blight-prone environments. Despite being susceptible to powdery mildew, PBA Twilight⦸ is likely to incur less yield loss from this disease than Kaspa⦸ due to its earlier maturity.

Growers in low rainfall regions have the option of growing both PBA Twilight⦸ and PBA Gunyah⦸ to manage the risk of low seasonal rainfall or paddock variability and still market grain from either variety as 'Kaspa⦸-type'.

Both varieties are better suited than Kaspa⦸ to the practices of delayed sowing for disease management and crop-topping to control annual ryegrass.

For more detailed information: PBA Twilight⦸ variety management package

### PBA Wharton⦸

- commercialised by SeedNet
- released in 2013
- area of adaption: Regions 2, 3, 4 and 5 [7]

PBA Wharton⦸ can be marketed as Kaspa⦸-type dun field pea grain, offering improved powdery mildew and virus resistances (Bean leaf roll and Pea seed-borne mosaic viruses) and significantly improved tolerance to subsoil boron, relative to other Kaspa⦸-types. It provides the same agronomic benefits as Kaspa⦸ (e.g. lodging and shattering resistance), and will provide a reliable alternative in those areas where powdery mildew and viruses are regular problems. PBA Wharton⦸ is early to mid-flowering and early maturing, making it more suitable to the practices of crop-topping and delayed sowing for Ascochyta management.

7 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

PBA Wharton⚐ has a semi-leafless erect growth habit, pink flowers and shatter resistant pods like Kaspa⚐. Its grain colour and size is similar to Kaspa⚐ but more spherical and smoother. [8]

For more detailed information: PBA Wharton⚐ variety management package

### 2.2.2 Dun field pea varieties

#### PBA Coogee⚐

- commercialised by Seednet
- released in 2013
- area of adaption: Regions 4 and 5

PBA Coogee⚐ is a conventional (trailing) type dun pea that provides the flexibility of a forage option if frost or drought limit grain yield. It has a conventional plant type similar to the variety Parafield but with increased early season growth, more basal branching and longer vines. PBA Coogee⚐ is a long-season variety that flowers mid- to late-season, but pods rapidly and combines resistance to powdery mildew with high tolerance to soil boron and salinity. This variety has moderate resistance to bacterial blight. PBA Coogee⚐ produces grain that can be marketed as 'Australian dun type', suitable for human consumption or stockfeed.

PBA Coogee⚐ is more sensitive to metribuzin than most other varieties and caution is required to avoid application when conditions are conducive to damage.

For more detailed information: PBA Coogee⚐ variety management package

#### PBA Oura⚐

- commercialised by SeedNet
- released in 2011
- area of adaption: Regions 4 and 5

PBA Oura⚐ was released concurrently with PBA Percy⚐ to provide growers with superior field pea options in bacterial blight prone regions. PBA Oura⚐ has a high yield potential, is broadly adapted, and performs relatively well in short growing seasons and low rainfall climates.

PBA Oura⚐ has good levels of resistance to bacterial blight, showing minimal yield loss in trials subjected to high levels of bacterial blight pressure. It is an erect semi-dwarf type with early flowering and maturing, and is better suited for crop topping than Kaspa⚐. PBA Oura⚐ produce Australian dun-type grains suitable for human consumption export or stockfeed markets.

Coated seeds are classified at receival point as seeds of contrasting colour with a limit of 1% allowed.

For more detailed information: PBA Oura⚐ variety management package

#### PBA Percy⚐

- commercialised by SeedNet
- released in 2011
- area of adaption: Regions 4 and 5

PBA Percy⚐ was released to provide growers with superior field pea options in bacterial blight prone regions. PBA Percy⚐ has high yield potential, is broadly adapted, and performs relatively well in short growing seasons and low rainfall climates.

PBA Percy⚐ has good levels of resistance to bacterial blight, showing minimal yield loss in trials subjected to high levels of bacterial blight pressure.

8 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

It has very similar characteristics to PBA Oura however, it provides growers with the option of growing a conventional type (PBA Percy⦸) as opposed to an erect semi-dwarf type (PBA Oura⦸).

PBA Percy⦸ is an early flowering and maturing type, and is better suited for crop-topping than Kaspa⦸. PBA Percy⦸ is an Australian dun-type grain suitable for human consumption export or stockfeed markets. [9]

For more detailed information: PBA Percy⦸ variety management package

### Parafield⦸

- commercialised by Paramount Seeds
- released in 2000

Parafield⦸ is a mid-season maturing field pea that replaced Alma, Dundale and Early due to its earlier flowering and better yields.

Parafield has a conventional plant morphology. It is a tall variety with similar standing ability to Alma,

Early Dun and Dundale, and may lodge as the plant approaches maturity. Parafield has mid season maturity (similar to Dundale) and generally flowers 10-12 days earlier than Alma and Early Dun.

Parafield has similar ability to withstand pod shatter at maturity as Alma, Dundale and Early Dun.

Parafield is rated as susceptible to black spot and powdery mildew and downy mildew.

## 2.2.3 White field pea varieties

### PBA Pearl⦸

- commercialised by SeedNet
- released in 2012
- area of adaption: Regions 4 and 5

PBA Pearl⦸ has superior grain yield potential, and is the first broadly adapted white-seeded field pea variety released for Australia. It is semi-leafless, and has had high yields in evaluation trials in all districts.

PBA Pearl⦸ has good early season plant vigour and flowers early to mid-season. It produces a high number of non-sugar-type pods per plant, but is not prone to shattering (similar to PBA Oura⦸ and Parafield).

With a favourable disease resistance profile, PBA Pearl⦸ has good resistance to downy mildew (Parafield strain) and Bean leaf roll virus, and reasonable tolerance to bacterial blight. Disease management for PBA Pearl⦸ is similar to other field pea varieties; specifically, it is a low risk option for regions prone to bacterial blight compared to Kaspa⦸, but is not as tolerant as PBA Percy⦸.

It has an erect growth habit with excellent standability at maturity, as crop maturity is uniform and therefore suitable for crop-topping. At maturity, PBA Pearl⦸ has superior lodging resistance compared to other semi-dwarf varieties.

PBA Pearl⦸ produces medium to large spherical white pea seed suitable to market for human consumption, or for stockfeed. PBA Pearl⦸ is initially recommended for regions where growers can deliver white pea seed for export or for domestic sale.

For more detailed information: PBA Pearl⦸ variety management package

### PBA Hayman⦸

- commercialised by SeedNet
- released in 2013

9 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

- area of adaption: Regions 4 and 5

PBA Hayman⅁ is a late flowering and late maturing conventional pea, suitable for forage production as a potential alternative to vetch. It is considered a forage-only pea, producing small white seed. PBA Hayman⅁ has lower seed yield than Morgan (which is generally considered a dual purpose variety) but also has higher biomass production, predominantly accumulated in spring. PBA Hayman⅁ also has improved resistance to powdery mildew over Morgan and is rated moderately resistant to bacterial blight.

For more detailed information: PBA Hayman⅁ variety management package

### SW Celine⅁

- commercially available from CropCare
- released in 2008
- area of adaption: Regions 2,3 4 and 5

SW Celine⅁ bred in Sweden is a semi-leafless white pea of medium height with erect growth habit and white flowers. It has good early vigour and is early to commence flowering with a short to medium flowering duration with very early maturity making it suitable for crop topping in most regions. SW Celine⅁ has good lodging resistance at harvest but does not have pod shatter resistance. It produces a medium-to-large, creamy, white grain that will be suitable to both human consumption and stockfeed markets. It has shown yield potential across a range of cropping zones in recent trials, but long term comparisons are limited. [10]

For more detailed information: SW Celine⅁ variety management variety

## 2.2.4 Marrowfat pea varieties

### Jupiter

- market contracts with UniGrain, Victoria
- released in early 1990s
- area of adaption: Regions 4 and 5

Jupiter is a tall, early-flowering, cream- to white-flowered, mid- to late-season maturing field pea. It has large rhomboid (like a cube), blue-grey, smooth-coated seeds (29 g per 100 seeds). The cotyledons are green, and it is considered a marrowfat pea. Jupiter is best suited to areas receiving good late winter rains, but not to the high rainfall areas. It is prone to shattering if harvest is delayed. [11]

10 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

11 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

**Table 1:** *Variety characteristics and reaction to diseases.*

| Variety | PBR | Standing at maturity | Leaf type | Height | Maturity | Shatter resistance | Disease: Bacterial blight# (*Pseudomonas syringae* pv *syringae*) | Disease: Downy mildew (Parafield strain) | Disease: Powdery mildew | Seed size (g/100 seeds) | Yield % Kaspa(b)* South East % | South East No. Trials | Yield % Kaspa(b)* South West % | South West No. Trials | Yield % Yarrum* North West % | North West No. Trials |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Dun Field Peas** | | | | | | | | | | | Kaspa(b) = 2.48 t/ha | | Kaspa(b) = 1.76 t/ha | | Yarrum = 2.14 t/ha | |
| Kaspa(b) | Yes | 4 | SL | M | 8 | R | S | MR | S | 22 | 100 | 16 | 100 | 19 | 80 | 12 |
| Morgan | Yes | 3 | SL | T | 9 | MR | MR | R | S | 18 | 98 | 13 | 102 | 15 | 80 | 9 |
| Parafield | No | 2 | C | T | 7 | MR | MR–MS | S | S | 23 | 93 | 9 | 99 | 13 | 78 | 3 |
| PBA Coogee(b) | Yes | 2 | C | T | 8 | MR | MS–MR | – | R | 20 | 87 | 6 | 101 | 10 | 83 | 7 |
| PBA Gunyah(b) | Yes | 4 | SL | M | 5 | R | S | R | S | 22 | 102 | 16 | 102 | 19 | 89 | 12 |
| PBA Oura(b) | Yes | 4 | SL | M | 5 | MR | MR | MR | S | 22 | 110 | 16 | 112 | 19 | 95 | 12 |
| PBA Percy(b) | Yes | 2 | C | T | 5 | MR | R | S | S | 23 | 107 | 16 | 113 | 19 | 89 | 12 |
| PBA Twilight(b) | Yes | 4 | SL | M | 4 | R | S | R | S | 22 | 100 | 16 | 100 | 19 | 89 | 12 |
| PBA Wharton(b) | Yes | 4 | SL | M | 5 | R | S | R | R | 23 | 104 | 16 | 107 | 19 | 99 | 12 |
| Yarrum | Yes | 4 | SL | M–S | 5 | MR | MR–MS | S | R | 22 | 115 | 11 | 107 | 13 | 100 | 10 |
| **White Field Peas** | | | | | | | | | | | | | | | | |
| CRC Walana | Yes | 4 | SL | M | 3 | MS | – | – | R | 18 | 108 | 3 | 99 | 5 | 103 | 5 |
| PBA Hayman(b) | Yes | 3 | C | T | 9 | MR | MR | MR–R | R | 13 | n.d. | n.d. | n.d. | n.d. | n.d. | n.d. |
| PBA Pearl(b) | Yes | 5 | SL | M | 4 | MR | MS | R | S | 22 | 115 | 16 | 120 | 19 | 95 | 12 |
| Sturt | Yes | 2 | C | T | 5 | MR | MR–MS | MS | S | 19 | 105 | 14 | 119 | 17 | 86 | 7 |
| SW Celine(b) | Yes | 5 | SL | M | 4 | MR–MS | S | MR–MS | S | 22 | 112 | 8 | 107 | 11 | 85 | 5 |

* Yield results are a combined across sites analysis using NSW DPI, PBA and NVT yield trials from 2010-2014.

# Resistance only demonstrated to the bacterial blight pathovar *Pseudomonas syringae* pv *syringae*.

Standing: 1–9 (1=flat on ground, 9=erect) Leaf type: C=Conventional; SL=semi-leafless Height: T=Tall; M=Medium; S=Short. –=unknown or no data available

Shatter resistance and disease resistance ratings: R=Resistant; MR=Moderately resistant; MS=Moderately susceptible; S=Susceptible

Maturity: 1 to 9 (1=early, 9=late) less than 5 best for crop-topping;

Source: NSW DPI

## Varieties suited to green/brown manuring

Two varieties (PBA Hayman(b) and PBA Coogee(b)) have been released for suitability to forage (hay/silage) or green/brown manuring. Results of testing show:

- The ideal timing of hay cutting for both maximum biomass production and ease of drying (i.e. before podset) is likely to be approximately 7–14 days after commencement of flowering (i.e. early pod development).
- Varieties with later flowering and podset (e.g. PBA Hayman(b)) are likely to be better suited to hay production as this allows maximum vegetative growth prior to cutting, and extends hay cut timing into better (warmer and quicker) drying conditions.
- PBA Coogee(b) may not produce more biomass than Kaspa(b) or Morgan at the early pod stage.
- PBA Hayman(b) will generally produce more biomass at flowering than grain or dual purpose varieties (due to its later flowering). This variety shows more rapid growth in early spring than other varieties.

- Kaspa⚐ and PBA Coogee⚐ produce significantly higher grain yield than Morgan or PBA Hayman⚐.
- PBA Hayman⚐ has shown the lowest yield and lowest harvest index, indicating grain retrieval may be difficult in low rainfall areas. However, due to its lower seed weight (averages 14 g/100 compared with 20–25 g/100 seeds in other varieties), seed requirements for sowing will be significantly lower than other varieties. [12]

### 2.2.5 Protein and other quality traits

Australian field peas have a global reputation for their excellent processing quality, which enables processors to maximise the efficiency of their operations. The main differing feature between varieties for quality traits amongst field peas is the seed coat colour. This coat colour determines the market and end point usage for the grain. [13]

Table 2 shows the nutritional value of field peas as a source of stock feed for the seed portion of the crop. [14]

**Table 2:** *Average nutritive value of common feeds.*

| Feed | Dry matter % | Crude protein % | Metabolisable energy (Mj/kg DM) |
|---|---|---|---|
| Field peas | 90 | 23 | 14 |
| Lupins | 90 | 30 | 13 |
| Faba beans | 90 | 25 | 13 |
| Chickpeas | 90 | 19 | 15 |
| Mungbeans | 90 | 24 | 11 |
| Triticale | 90 | 12 | 13 |
| Barley | 90 | 11 | 13 |
| Wheat | 90 | 12 | 13 |
| Oats | 90 | 8 | 11 |
| Soybean meal | 90 | 47 | 12 |

Source: Pulse Australia

## 2.3 Seed quality

High quality seed is essential to ensure the best start for the crop (Photo 2). Grower-retained seed may be of poor quality with reduced germination and vigour, as well as being infected with seed-borne pathogens.

All seed should be tested for quality including germination and vigour:

- If grower-retained seed is of low quality, consider purchasing registered or certified seed from a commercial supplier. Always ask for a copy of the germination report.
- Careful attention should be paid to the harvest, storage, and handling of seed intended for sowing.
- Calculate seeding rates in accordance with seed quality (germination, vigour and seed size).

12 J Brand et al. (2014) Pulse varieties and agronomy update (Ballarat). GRDC Update papers 5 Feb 2014, http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Pulse-varieties-and-agronomy-update-Ballarat

13 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

14 Pulse Australia (2010) Northern Region Field Pea Management Guide, https://sydney.edu.au/agriculture/documents/pbi/pbi_region_north_field_pea_management_guide.pdf

**Photo 2:** *Example of a good plant stand in field peas sown in central-west NSW.*

Photo: Penny Heuston

The minimum germination requirement for certified pulse seed is 70%, which is far less than the 90% or greater often obtained in pulse seed. Many believe this minimum should be raised to 80%, as not all growers or retailers request seed test results of certified pulse seed. Test results must be made available under the Seeds Act and Australian Seeds Federation guidelines.

Often, seed quality problems only emerge if the crop is not harvested under ideal moisture or seasonal finishing conditions. A sharp seasonal finish, a wet harvest, or delayed harvest can have a big impact on seed quality.

Seed with low germination rates and poor seedling vigour can result in sparse establishment and a weak crop, which then becomes more vulnerable to viruses, fungal disease infection and insect attack, and is less competitive with weeds. Inevitably, this will result in significantly lower yields. The crop may also have variable maturity rates, making it difficult to manage.

Poor seed germination or low seed germination of pulse crops predominately occurs when the grain has been desiccated or crop topped before it has achieved full physiological maturity prior to harvesting. [15]

MORE INFORMATION

GRDC (2011) Saving weather damaged grain for seed. Factsheet.

## 2.3.1 Seed size

As for most pulses, seed size varies between varieties and within varieties. Sowing rates for varieties with considerably smaller seed size should be adjusted accordingly. Growers should do a seed count on each batch of seed they wish to sow to determine the weight in grams of 100 seeds, which will help determine an accurate sowing rate.

The larger the seed, the better it will be as a sowing source, as it will have more energy and vigour to push out of the ground at germination time. [16]

Ideally, only pulse seed with >80% germination should be used, and testing for germination and vigour should be conducted by an accredited laboratory.

The best time to sample is at, or just after, seed cleaning. It also provides an ideal way to get a good representative sample, and to see if any weed seeds have made it into the sample after the cleaning process, which may cause a concern at sowing.

15 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

16 L Jenkins et al. (2005) Field Pea: Western NSW Planting Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/157507/field-pea-western-NSW-planting-guide.pdf

However, if a seed lot is likely to have reduced germination as a result of wet harvest or heat stress at crop flowering, testing should be done before seed cleaning. This minimises expenses and provides time to obtain replacement seed. [17]

A laboratory seed test for germination should be carried out before seeding to calculate seeding rates. A simple preliminary test on-farm can be done in soil after harvest or during storage. Results from a laboratory germination and vigour test should be used in seeding rate calculations.

### 2.3.2 Grower-retained planting seed

Grower-retained sowing seed should always be harvested from the best part of the crop where weeds and diseases are absent and the crop has matured evenly. Seed should be harvested first to avoid low-moisture grain, which is more susceptible to cracking. Seed moisture of 11–13% is ideal. Weeds, other grains, or disease contamination from other pulse crops should be avoided when selecting parts of the paddock for seed harvest.

Seeds should be professionally graded to remove unviable seeds and weed seeds.

Seed-borne diseases have the potential to lower germination levels, and testing for presence in seed can be conducted by specialist laboratories for a number of diseases, such as bacterial blight in field peas.

Seed with poor germination potential or high levels of seed-borne disease should not be sown. The lower cost of this seed will be offset by higher sowing rates needed to make up for the lower germination, and there is potential to introduce further disease onto the property.

Do not use grain for seed of field pea crops harvested from a paddock that was desiccated with glyphosate. Germination, normal seedling count, and vigour can be affected by its use.

The only way to accurately know the seed's germination rate, vigour, and disease level is to have it tested. [18]

### 2.3.3 Safe storage of seed

Retained seed needs to be stored safely to ensure its quality is maintained. Safest storing conditions for pulses are at 20°C and at 12.5% moisture content.

Like other grain, field pea seed quality deteriorates in storage. Most rapid deterioration occurs under conditions of high temperature and moisture. Crops grown from seed that has been stored under such conditions may have poor germination and emergence.

Reducing moisture and temperature increases longevity of the seed, although storage at very low moisture content (<10%) may render field pea more vulnerable to mechanical damage during subsequent handling as the seed pulls away from the seed-coat.

Using aerated storage is the best method of cooling the grain and reducing temperature in storage facilities, and is the easiest method of increasing seed longevity. Not only will it increase the viable lifespan of the seed, it will also slow the rate at which insect pests multiply in the grain.

To reduce temperature in grain silos:

- Paint the outside of the silo with white paint. This reduces storage temperature by as much as 4–5°C and can double safe storage life of grain.
- Aerate silos with dry, ambient air. This option is more expensive, but in addition to reducing storage temperatures, it also miminises problems if the seed moisture content is higher than ideal.

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17 P Matthews and D Holding (2005) Pulse Point 20: Germination testing and seed rate calculation. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/157442/pulse-point-20.pdf

18 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

- Heat drying of field pea sowing seed should be limited to temperatures ≤40°C. [19]

For more information, see GRDC GrowNotes (Field peas) Section 13, Storage.

## 2.3.4 Germination testing

Germination tests can be conducted by a simple home test, or ideally by sending a representative sample to seed testing laboratories for germination and vigour tests. For field peas, take 1 kg for each 10 t of seed.

Sampling should be random and consist of numerous sub-samples to give best results. It is easier and more accurate to take numerous samples while seed is being moved either out of the seed cleaner, storage or truck, or sampling from numerous bags if stored this way.

If there is an issue with kept grain, test a sample before grading and seed treatment. This could result in savings if the quality is unsatisfactory, and allows more time to source replacement seed. If the germination and vigour are below optimal or marginal, or the crop was weather damaged at harvest, it may be advisable to have it re-tested closer to harvest after storage, handling and grading have occurred.

## 2.3.5 Seed testing for disease

Seed-borne diseases such as Cucumber mosaic virus and Ascochyta in field peas, pose a serious threat to yields. Seed-borne diseases can strike early in the growth of the crop when seedlings are most vulnerable, resulting in severe plant losses and lower yields.

When infected seed is sown, it gives rise to infected seedlings that act as a source of contamination, often developing into hot spots of disease. Plants affected early often die or produce no seed. When late infection occurs, the seed becomes infected too.

Growers who have retained seed on farm for a number of years should test their seed for common diseases.

Testing seed before sowing will identify the presence of disease and allow steps to be taken to reduce the disease risk. If disease is detected, the seed may be treated with a fungicide before sowing or a clean seed source may be used.

Grading also removes sclerotes (fruiting bodies of the fungus which causes sclerotinia), which would otherwise be sown with the seed. [20]

## 2.3.6 Safe rates of fertiliser sown with the seed

All pulses can be affected by fertiliser toxicity. Practices involving drilling 10 kg/ha of phosphorous with the seed at 18 cm row spacing through 10 cm points rarely caused any problems.

The effects are also increased in highly acidic soils, sandy soils, and where moisture conditions at sowing are marginal. Drilling concentrated fertilisers to reduce the product rate per hectare does not reduce the risk.

The use of starter N, such as DAP, banded with the seed when sowing pulse crops has the potential to reduce establishment and nodulation if higher rates are used. On sands, up to 10 kg/ha of N at 18 cm row spacing can be safely used. On clay soils, do not exceed 20 kg/ha of N at 18 cm row spacing. [21]

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19 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

20 K Lindbeck (1999) Pulse Point 7: Reducing disease risk. NSW Agriculture, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/157144/pulse-point-07.pdf

21 GRDC (2008) Grain Legume Handbook update 7 Feb 2008. Grain Legume Handbook Committee, supported by the Grains Research and Development Corporation

### 2.3.7 Vigour testing

In years of drought or a wet harvest, seed germination can be affected, but more importantly, seedling vigour can also be reduced. Poor seedling vigour can impact heavily on establishment and early seedling growth. This can occur under difficult establishment conditions such as deep sowing, crusting, compaction, and wet soils, or when seed treatments have been applied. Some laboratories also offer a seed vigour test when doing their germination testing. Otherwise, conduct your own test by sowing seeds into a soil tray that is kept cold (<20°C). Observe the germination, speed and uniformity of emergence, and any abnormal shoot and root development.

Vigour represents the rapid, uniform emergence and development of normal seedlings under a wide range of conditions. Several different tests are used by seed laboratories to establish seed and seedling vigour.

Germination and vigour tests can be done on farm but field peas need to be soaked overnight before following the standard germination and vigour test procedure.

## 2.4 Seed testing

Australian Seeds Authority (ASA) is licensed by the Commonwealth Department of Agriculture Fisheries and Forestry (DAFF) to undertake the role of the National Designated Authority for the OECD seed schemes. It operates the Australian Seed Certification Scheme, which is used principally for seed not destined for export. The following Australian seed testing laboratories are accredited by the International Seed Testing Association (ISTA) to issue International Seed Testing Certificates. [22]

*AGWEST Plant Laboratories*

Seed Testing Station
Department of Agriculture and Food
Bentley Delivery Centre
3 Baron-Hay Court
South Perth 6151 WA
Phone: (08) 9368 3844
Fax: (08) 9474 2658
Email: agwestplantlabs@agric.wa.gov.au

22 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 3–Variety Selection.

# Planting

## Key messages

- Field peas have specific requirements for rhizobia and should be inoculated each year with group E inoculant.
- DAFWA research has shown that in Western Australia the ideal time of sowing is 7–28 days after the break of season to ensure blackspot spore levels have declined.

## 3.1 Inoculation

Field peas have the ability to 'fix' their own nitrogen (N) in the soil via nodules on their roots, if $N_2$ fixing bacteria (rhizobia) are available (Figure 1).

For efficient nodulation and N fixation field peas need inoculation each season with Group E rhizobia (SU303). Older naturalised strains will not always provide a fully effective level of nodulation or N fixation.

Unless the right strain is present in the soil or has been supplied by adding a commercial inoculant at seeding time, effective root nodulation will not take place, and little if any N will be fixed. These effects are not always immediately obvious above ground.

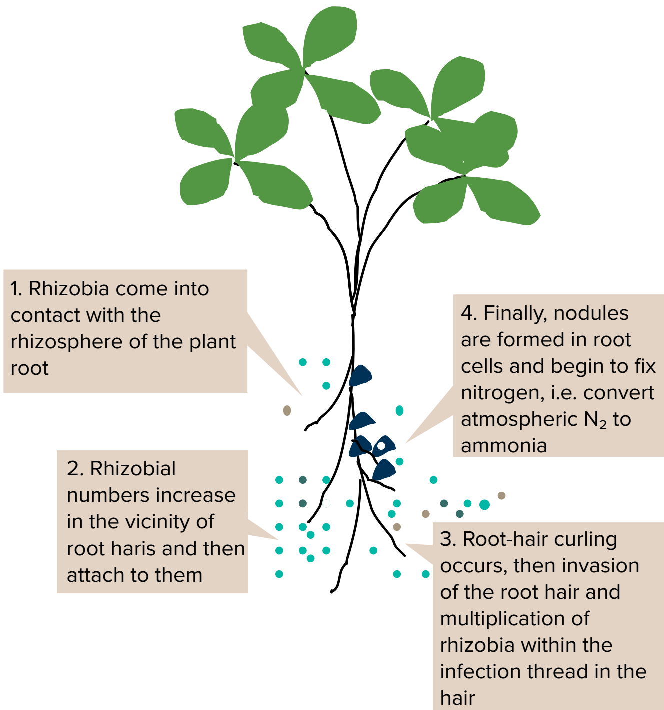



**Figure 1:** *Schematic representation of the process of nodulation.*

Source: D Herridge 2013

A minimum rotation length of 3 years is recommended between successive field pea crops as a disease management strategy (i.e. for Ascochyta blight). [1]

### MORE INFORMATION

GRDC (2015) Inoculating legumes: A practical guide.

GRDC (2013) Rhizobial Inoculants. Fact sheet.

Pulse Australia (2015) Pulse inoculation techniques. Australian Pulse Bulletin.

1 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

FAQ

### 3.1.1 Inoculant types

A diverse range of inoculant products with different methods of application is available (Photo 1):

**Table 1:** *Rhizobial inoculants available for use in Australia*

| Manufacturer | Brand | Formulation | Application |
|---|---|---|---|
| BASF | Nodulaid™ | Peat | Slurry on seed; slurry/ liquid in furrow |
| | Nodulaid™ | Liquid | On seed; in furrow |
| | Nodulaid™ | Clay granule | In furrow |
| | BioStacked® | Peat (rhizobia) plus (*Penicillium bilail)* | Slurry on seed; slurry/ liquid in furrow |
| New-Edge Microbials | EasyRhiz™ | Freeze-dried | Liquid on seed; liquid in furrow |
| | Nodule N™ | Peat | Slurry on seed; slurry/ liquid in furrow |
| Novozymes Biologicals Australia | N-Prove® | Peat | Slurry on seed; slurry/ liquid in furrow |
| | | Peat granule | In furrow |
| | TagTeam® | Peat (rhizobia) plus (*Penicillium bilail)* | Slurry on seed; slurry/ liquid in furrow |
| | TagTeam® | Peat granule (rhizobia) plus (*Penicillium bilail)* | In furrow |
| ALOSCA Technologies | ALOSCA® | Clay granule | In furrow |
| Brushmaster | Inoculeze™ | Peat | ‘Tea extract’ on seed via an applicator |

Source: D Herridge, 2013


**Photo 1:** *Different forms of Rhizobia. Left to right: EasyRhiz® freeze dried, Nodulator® granules, Alosca® granules, N-Prove® granules and Nodulaid® peat inoculant.*

Photo: M Denton, formerly Vic DPI

### 3.1.2 Newer inoculation methods

With new inoculant types and technologies, each type’s strengths and limitations need to be assessed. Rhizobial survival becomes more important under more ‘difficult’ circumstances; for example, placement in dry soil, prolonged dry soil conditions, use of a seed treatment fungicide or trace elements, and acidic soil. Survival is associated with the degree of protection the rhizobia have against drying or adverse conditions. Ease of inoculant application is important and needs to be accounted for in costing. [2]

### In-furrow water injection

Injection of inoculants mixed in water is becoming more common practice. It can be used where machines are set up to apply other liquids at seeding, such as liquid N or phosphorus.

Water injection of inoculant requires at least 40 L/ha water, and is better with more water. The slurry-water suspension is sprayed under low pressure onto the soil in the seed row during seeding. Benefits of the new inoculants over peat are that they mix more readily, and do not need to filter out peat. Compatibility of the inoculant with trace elements is not yet known, but caution is advised because water pH is critical, and trace element types, forms and products behave differently between products and inoculant groups. [3]

**Photo 2:** *A seeding bar setup with Atom Jet narrow points, gang press wheels and liquid injection for either inoculum or trace element application during sowing.*

Photo: W Hawthorne, Pulse Australia

**MORE INFORMATION**

GRDC (2015) Inoculating legumes: A practical guide.

2 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

3 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

**Photo 3:** *Tanks mounted on the seeding bar for liquid injection of rhizobia or trace elements during seeding. Agitation is required. Note the tubes and manifold. Inoculum must be applied under low pressure only. Some machines have their tanks set up as a separate, trailed tanker.*

Photo: W Hawthorne, Pulse Australia

**Photo 4:** *A disc seeder set up with Yetter trash clearing wheels and tubing for liquid injection of inoculum or trace elements during sowing. Note also the closer, covering the seeding slot to act like a press-wheel from the side.*

Photo: W Hawthorne, Pulse Australia

**Photo 5:** *In-furrow liquid injection: Note the droplets from liquid injection, which can be used for inoculating pulses or applying liquid trace elements.*

Photo: W Hawthorne, Pulse Australia

### 3.1.3 Granular inoculants

Granular inoculants are applied like fertiliser as a solid into the seed furrow, near the seed or below. They avoid many of the compatibility problems that rhizobia have with fertilisers and fungicides. They also eliminate the need to inoculate seed before sowing. Granular inoculant may also be better where dry sowing is practiced or when sowing into acidic soils, because the rhizobia survive better than on seed. A third, small seed box is required to apply granular inoculum (Photo 6). This is because rhizobial survival is jeopardised if the granular inoculum is mixed with fertiliser. If it is mixed with the seed, then distribution of both seed and inoculum is affected, causing poor and uneven establishment and/or patchy nodulation.

Granules contain fewer rhizobia per gram than peat-based inoculants, so they must be applied at higher application rates. The size, form, uniformity, moisture and rate of application of granules differ between products. Depending on product or row-spacing, rates can vary from 2 to 10 kg/ha to deliver comparable levels of nodulation. [4]

4 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.


**Photo 6:** *An 'after-market' third box fitted to a Flexicoil box to enable application of granular inoculum. Note that granular inoculum cannot be applied mixed with the seed (uneven distribution of seed and/or inoculums occurs). Rhizobia survival is severely jeopardised if granular inoculum is applied mixed with fertiliser.*

Photo: W Hawthorne, Pulse Australia

### 3.1.4 Inoculant and chemical compatibility

As rhizobia are living organisms, it is very important inoculants are kept away from toxic substances that will reduce their viability such as fertilisers, fungicides, insecticides and herbicides. Inoculated seed should not come in direct contact with fertiliser because it will kill the rhizobia through desiccation and exposure to acidity. Certain pesticides can also have an impact on rhizobial survival and nodulation. [5]

Caution should be used when treating pulse seed with a fungicide. Fungicide seed dressings can reduce the life span of the inoculum. Seed dressings have little value in preventing disease in field peas Western Australia (WA), so their use is not recommended. [6]

### 3.1.5 Compatibility with trace elements and seed treatments

Rhizobia can be compatible with some specific trace element formulations, but many are not compatible for rhizobial survival. Mixing of inoculants with trace elements should only occur if the trace element formulation being used has been laboratory-tested against the rhizobial type (Table 2).

5 GRDC (2012) Inoculating Legumes: A Practical Guide. https://grdc.com.au/resources-and-publications/all-publications/bookshop/2015/07/inoculating-legumes

6 DAFWA (2015) Field pea: crop management and production. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/1785

**Table 2:** *Rhizobial compatibility with different trace element (TE) products after 24 h of tank mixing. Note the differences between inoculant types for a given TE product, as well as differences between TE products with a given inoculant*

| TE formulation | Inoculant strain (by crop) | | | | |
|---|---|---|---|---|---|
| | Field peas | Faba beans | Chickpeas | Lupins | Soybean |
| Manganese 1 | × | × | × | ✓ | ✓ |
| Manganese 2 | ✓ | ✓ | ✓ | ✓ | ✓ |
| Zinc 1 | × | × | × | × | ✓ |
| Zinc 2 | × | × | × | × | ✓ |
| Zinc 3 | × | × | × | × | ✓ |
| Zinc 4 | × | ✓ | × | ✓ | ✓ |
| Zinc 5 | × | ✓ | × | ✓ | ✓ |

Source: BASF

## 3.1.6 Assessing nodulation

When using this rating system to assess nodulation, plants should be gently dug from the soil and the root system rinsed in water before scoring the level of nodulation.

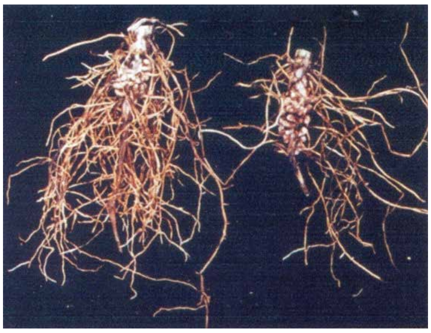
Obvious signs of nodulation should be visible by 6 weeks after sowing (even in high soil nitrate situations).

Nodules on the main taproot clustered near the seed are an indication that nodulation occurred because of the inoculation process. These are referred to as ‘crown nodules’.

If there are no crown nodules but nodules on the lateral roots, it is more likely that they have formed from native soil bacteria, which are usually less effective at fixing $N_2$.

Nodules on both the crown and lateral branches indicate that inoculation was successful and that bacteria have spread in the soil.

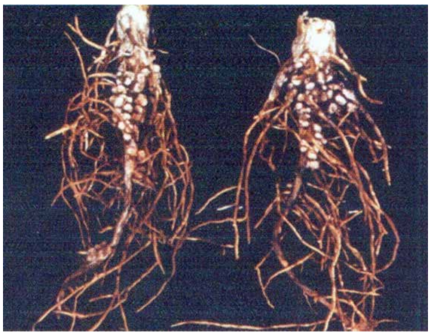
*(a) Score 0: taproot, absent; lateral, absent.*



*(b). Score 1: taproot, few-medium; lateral, absent-few*

*(c) Score 2: taproot, medium; lateral, absent-low.*

(d) Score 3: tap root, medium-high; lateral, low.



(e) Score 4: taproot, high; lateral, medium.

(f) Score 5: taproot, high; lateral, high.

**Photo 7:** *Visual key for nodulation scores.*

Source: TopCrop 'Growers guide to assessing nodulation in pulse crops'

Inspect nodules for N-fixation activity by assessing their internal 'pink' (leghaemoglobin) colour (Photo 8). The best method is to slice a few nodules open with a razor blade or sharp knife and examine their colour.

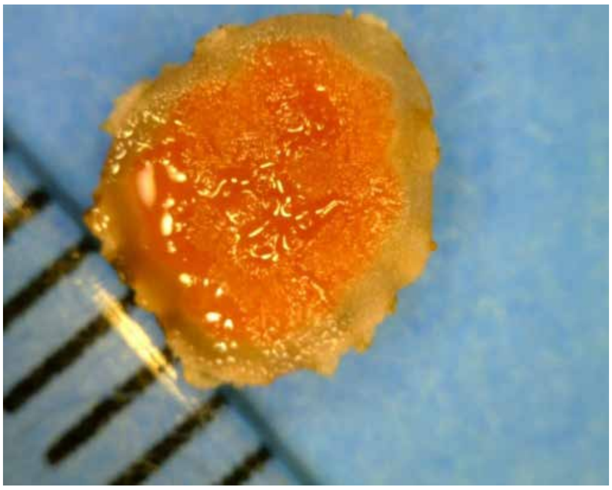


**Photo 8:** *Active nodules have a pink centre.*

Photo: G Cumming, formerly Pulse Australia

## MORE INFORMATION

[GRDC (2008) Grain Legume Handbook.]

[GRDC (2015) Inoculating legumes: A practical guide.]

Young nodules are usually white and still developing. White nodules can also indicate the wrong bacteria in the nodule, and these will not fix $N_2$. Effective nodules are a rusty red or pink inside, and these are usually actively fixing $N_2$. Effective red nodules can sometimes turn green when a plant is under water, disease or other stress, or is suffering from nutrient deficiencies. These do not fix $N_2$, but they can change back to red and begin to fix again if the stress is relieved without too much damage being done. Black nodules are usually dead or dying. These are often seen as the crop matures, or after a crop has suffered severe waterlogging. [7]

### 3.1.7 Storing inoculants

For maximum survival, peat inoculant should be stored in a refrigerator at ~4°C until used. If refrigeration is not possible, store in a cool, dry place away from direct sunlight for a short period of time. Granules and other forms also need to be stored in a cool place out of direct sunlight. Do not store an opened inoculum packet, as it will deteriorate rapidly.

Discard the inoculant after the expiry date shown because the rhizobia population may have dropped to an unacceptable level. [8]

### 3.1.8 Inoculum survival

Rhizobia can dry out and lose viability once applied to seed and not kept in moist soil. Granular inoculant forms may not dry out as quickly.

With non-peat based inoculants, such as freeze-dried rhizobia, it is recommended treated seed should be sown within 5 h of inoculation.

Most commercial inoculants contain an adhesive solution, or ‘sticker’, which delays drying and increases survival of the rhizobia. If inoculated seed is sown into dry soil, the sticker assists in the survival of rhizobia until rain. Inoculum viability rapidly diminishes over time in warm, dry soil temperatures.

Rhizobia will survive for longer in granules than when applied to seed. Hence, when dry-sowing pulses, granular inoculant is preferred over peat and liquid-injection methods.

7 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

8 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

Nodulation failure after dry-sowing of inoculated seed is more likely if the soil has no naturalised rhizobia present. [9]

### 3.1.9 Applying peat-based inoculants

If using a peat-slurry mix, use the mix within 24 hours, and sow seed soon as possible or store for up to three days in a cool place, away from sunlight.

When mixing the slurry, do not use hot or chlorinated water. Add the appropriate amount of the inoculant group to the solution and stir quickly. Mix into a heavy paste with a small amount of water prior to adding to the main solution. Read the inoculant label before adding any approved insecticides, fungicides, herbicides, detergents or fertilisers into the slurry (see Section 3.2 Seed treatments). Add the inoculant suspension (slurry) to the seed and mix thoroughly until all seeds are evenly covered. A small amount of fine lime can be added after mixing is complete to help dry the seed and prevent tackiness. If adding lime use only calcite lime; agricultural lime is too coarse. Do not use builders' lime, hydrated lime or slaked lime—they will kill the rhizobia. [10]

Slurry can be applied to the seed using:

- A cement mixer–this is practical for small lots only.
- Through an auger (see Figure 2). Make sure the auger is turning as slowly as possible. Reduce the height of the auger to minimise the height of seed-fall. Add a slide, e.g. tin, to the outlet end of the auger to stop seed from falling and cracking. Meter the slurry in, according to the flow rate of the auger (about a 250 g packet per 100 kg seed). If the auger outlet is out of reach, e.g. under a field bin, then use some poly water pipe to run the slurry into the auger. A clean drench pack fixed to a dropper makes a good funnel into the poly pipe.
- Through a tubulator–use of a tubulator reduces the risk of damaging the seed, but its mixing ability is not as effective as an auger. Apply the slurry in a similar fashion to an auger.

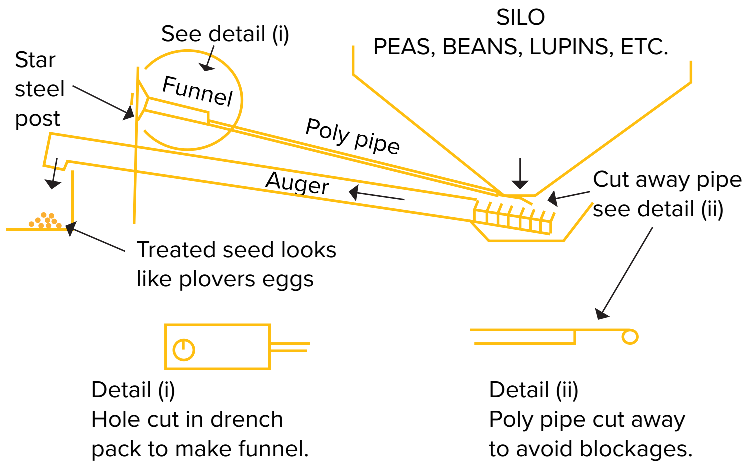



**Figure 2:** *Applying inoculum through an auger.*

Source: Grain Legume Handbook

MORE INFORMATION

GRDC (2008) Grain Legume Handbook.

9 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

10 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

## 3.2 Seed treatments

Inoculant companies conduct compatibility tests with registered seed treatments to ensure the viability of inoculants is not compromised by pesticides and other seed treatments. Each inoculum formulation is tested with various seed treatments using different application methods. The compatabilities and planting windows are specific to the individual product, and should not be used for other purposes.

Read the label of both the specific inoculum and the seed treatment being used. Some fungicide labels specify that their fungicides should not be mixed in a slurry mixture with particular rhizobial inoculants, as they may have adverse effect on rhizobium survival. [11]

## 3.3 Time of sowing

Field peas show a marked response to time of sowing with crops sown 'on time' having an excellent chance of producing very high yields. However, crops sown earlier or later than recommended will often suffer from reduced yields due to disease if sown too early, or drought if sown too late.

Ideal sowing times should ensure that all pulse crops:

- finish flowering before being subjected to periods of heat stress—generally when maximum day temperatures over a week average 25°C or more
- flower over an extended period to encourage a better podset, and produce sufficient growth to set and fill an adequate number of pods

Sowing must not be too early, otherwise:

- crop emergence may coincide with maximum dispersion of Ascochyta spores
- flowering may occur during a frost period
- growth may be excessive, resulting in crop lodging while dramatically increasing the likelihood of fungal disease problems in the medium-to-high rainfall districts
- conditions at seeding time may not be suitable for controlling broadleaved weeds with recommended herbicides, resulting in weedy crops

In low rainfall areas field peas must be sown relatively early. Hot winds in spring cause field peas to stop flowering and instigate premature ripening. [12]

**Table 3:** *Sowing time recommendations for field peas in the northern and southern agricultural regions of Western Australia*

| North | | | South | | |
|---|---|---|---|---|---|
| **Rainfall** | **Date window** | **Target date** | **Rainfall** | **Date window** | **Target date** |
| Low | If <100 mm soil water : 7 May-1 June<br>If >100 mm soil water: 7 May-15 June | 25 May | Low | 7 May-30 June<br>Blackspot risk reduced if delayed to June | 4 June |
| Medium | 15 May - 30 June | 1 June | Medium | 15 May-30 June<br>Blackspot risk reduced if delayed to June | 10 June |
| High | 15 May-30 June | 1 June | High | 30 May-30 June | 10 June |

Source: DAFWA

11 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

12 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

## 3.4 Sowing depth

### 3.4.1 Sowing rate and depth

Sow sufficient seed to establish 45 plants/m for conventional-leaved varieties, and 55 plants/m for semi-leafless varieties. The necessary sowing rate will depend on germination percentage and seed size. It can be calculated from the following formula:

- seed rate kg/ha = thousand seed weight (grams) x by target population
- germination %

This formula assumes all viable seeds sown establish, so it can underestimate the required sowing rate slightly, but with good management it should not be out by more than 10% under most WA conditions.

Yield is usually fairly unresponsive to changes in density. However, dense crops compete better with weeds and feed better when harvesting, so resist the temptation to reduce sowing rates (if in doubt seed at 100-120 kg/ha).

Field peas grow well in conventionally spaced rows (18–25 cm). Wide row spacing makes harvest difficult as the crop usually has poor standability without the neighbouring row.

However, if using wider row spacing, consider it as part of an overall system of production. Reasons for choosing wider rows with pulses vary with location and operator, but key drivers are the combination of:

- yield and yield consistency
- better stubble clearance
- improved Water Use Efficiency (drought tolerance)
- minimise disease risk and easier management
- desire to sow pulses early without having early canopy closure
- weed control through minimal soil disturbance inter-row
- herbicide application options between the rows

If row spacing is doubled, the seeding rate per row must also be doubled if the same plant density is to be maintained. This is significant for seeders with one seed meter per row, but relatively unimportant in air seeders where one meter supplies all or part of the machine. Be aware of changes needed for seeding rate calibrations.

The same considerations apply for fertiliser rates, but the risk of toxicity to seed is increased when fertiliser is more concentrated in the seeding furrow. Sowing pulses into wider rows may require deep placement or side banding of the fertiliser. [13]

#### How deep?

DAFWA research has shown that field peas should be sown at 5 cm deep. For example, field peas are less affected by metribuzin, applied either pre-sowing or post-sowing pre-emergent, if they are sown deeper.

This minimise the effects of soil applied herbicides and reduces the risks of seedling roots drying out during establishment. It also improves rhizobia survival in the cooler moist soil at depth.

### 3.4.2 Rolling

Leaving a flat, firm soil surface free of stumps, stones and clumps is essential when growing most pulse crops. Rolling field peas after sowing to aid harvestability is required where height to bottom pods is often low, particularly in lower rainfall areas or late sown crops.

13 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course, Module 4–General Agronomy.

Another reason for rolling soils is to leave a flat soil surface for post-sowing herbicide application, to prevent herbicides washing and accumulating in furrows. Rolling also improves seed soil contact in sandy non wetting soils, although press wheels normally will have achieved this.

In the past, rolling of paddocks sown to pulses generally occurred before crop emergence. However, field peas can be rolled post-emergent if the plants themselves are not taking the weight of the roller. If rolling post-emergent, aim to do this between 3 and 10 node stage of the plants.

There is a slightly greater risk of foliar disease if field peas are rolled post-emergence. Damaged tissue can become the site for powdery mildew or bacterial blight or other common diseases to develop, particularly if cold and wet conditions follow. Frosty conditions and wet foliage must be avoided when rolling. The main reason to shift to post-emergent rolling include:

- soils prone to hard setting or crusting can lead to emergence problems if rolled pre-emergence
- shoot damage occurring in crops rolled just as the crop is emerging
- greater ability to pick the right soil moisture conditions to:
- achieve maximum burial of stones and clumps
- avoid rolling dry soils that are more prone to wind erosion and sand blasting of seedlings
- greater erosion risk where plants have not yet established, particularly on sloping soils and lighter, sandier soils

Considerations when rolling post-emergent in pulses:

- Ridges left by sowing with a narrow point help to take the weight of the roller off the plant itself.
- Avoid rolling during the period when plants are just starting to emerge.
- Allow 14 days after herbicide application; conversely, only apply sprays 14 days after rolling.
- Do not roll stressed, frosted or diseased plants.
- Rolling the crop when it is limp, i.e. in the mid-afternoon, will cause least damage.
- Avoid rolling straight after rain or dew in heavier soil types.

Both rubber tyre and steel rollers can be used successfully, although a lighter roller is preferred when rolling post-emergent. However, the choice of roller is largely dictated by soil conditions and what is being rolled. Heavier rollers do a better job of levelling heavy soil types and pushing rocks and sticks below the soil surface. Lighter rollers work well on sandier soils. [14]

FAQ

## 3.5 Sowing equipment

Success with pulses may depend on the type of sowing equipment used.

Field peas can be sown with a standard airseeder or conventional combine, but care should be taken as seeds tend to bridge over the outlets, causing very uneven sowing. This difficulty can be eliminated by filling the box to only a third or a half capacity, or by fitting an agitator.

Field peas can also cause problems in some combines, but airseeders with adequate metering rollers can sow them successfully, as long as the airflow is adequate.

The key functional or mechanical issues that arise with establishing all crops include having:

- adequate seeding mechanism to handle the pulse seed without damaging it or bridging or blocking, especially when larger seeded types are being sown

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- adequate sizes of seed and fertiliser tubes and boots to prevent seed blockages and bridging during sowing
- ability to sow into stubbles and residues, without blockages
- sufficient down pressure to penetrate the soil and sow at the desirable depth (5 cm)
- seeds covered so that good seed-to-soil contact or moisture vapour ensures rapid germination
- soil compacted by press-wheels or closers, otherwise a prickle chain or roller is required afterwards for many pulses
- sufficient soil throw to incorporate herbicides. This can be by using either aggressive discs or narrow point set-ups in no till or full disturbance in more conventional or direct-drill systems. [15]

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# Plant growth and physiology

## Key messages

- The Australian-bred field pea plant ideotype is semi-dwarf, determinate and late in flowering
- Dun types are most commonly grown in WA.
- Field peas are classified as hermaphrodites. All the tools that peas need to reproduce are contained in a single blossom.
- Field peas are considered one of the more tolerant of the winter pulses to moisture stress (drought).
- The early maturity of field pea makes it ideally suited to crop topping to prevent seed set of surviving in-crop weeds.

## 4.1 Introduction

Field peas, being legumes, belong to the botanical family of Leguminosae. They are closely related to the garden pea, whose immature pods and seeds are used throughout the world as green vegetables. It is a climbing annual legume with weak, vine-like, and relatively succulent stems. Vines often are 1–2 m long. Leaves have two leaflets and a tendril. Flowers are white, pink, or purple. Pods carry seeds that are large nearly spherical, and are white, grey, green, or brown. They are an annual plant with a shallow root system.

in WA, most field peas grown are the Kaspa dun type field pea which is semi-dwarf, semi-leafless, determinate, late in flowering (although early maturing), semi-erect at maturity, and highly resistant to seed shattering. [1]

## 4.2 Plant growth stages

Growth stages for field peas are shown in Figure 1. The vegetative stage is determined by counting the number of developed nodes on the main stem, above ground level. The last node counted must have its leaves unfolded.

Germination is hypogeal, with the cotyledons remaining below the soil surface. This enables it to emerge from sowings as deep as 20 cm, although recommended sowing depth in good conditions is 5 cm. Field pea is sown deep to avoid herbicide damage; in drier regions, it is sown deep as surface moisture is often inadequate to enable crop germination and establishment.

The node at which the first leaflet arises from the main stem above the soil is counted as node one. A node is counted as developed when leaves are unfolded and flattened out. Scale leaves at the base of the plant and close to the ground are not counted as true nodes.

Field pea varieties exhibit either indeterminate, semi-determinate or determinate growth habits, depending on the variety. The terminal bud of an indeterminate plant is always vegetative and keeps growing while conditions allow it. Vegetative growth continues even as the plant switches to reproductive mode and flowering begins.

Flower terminals develop from the axillary bud at the base of each node, with flowering commencing at approximately the 6th–10th node, depending on the variety, location and time of sowing. Field pea flowers vary in colour from shades of purple, pink to white. Flowers are borne on a peduncle that arises from nodes. Flowers are self-pollinated.

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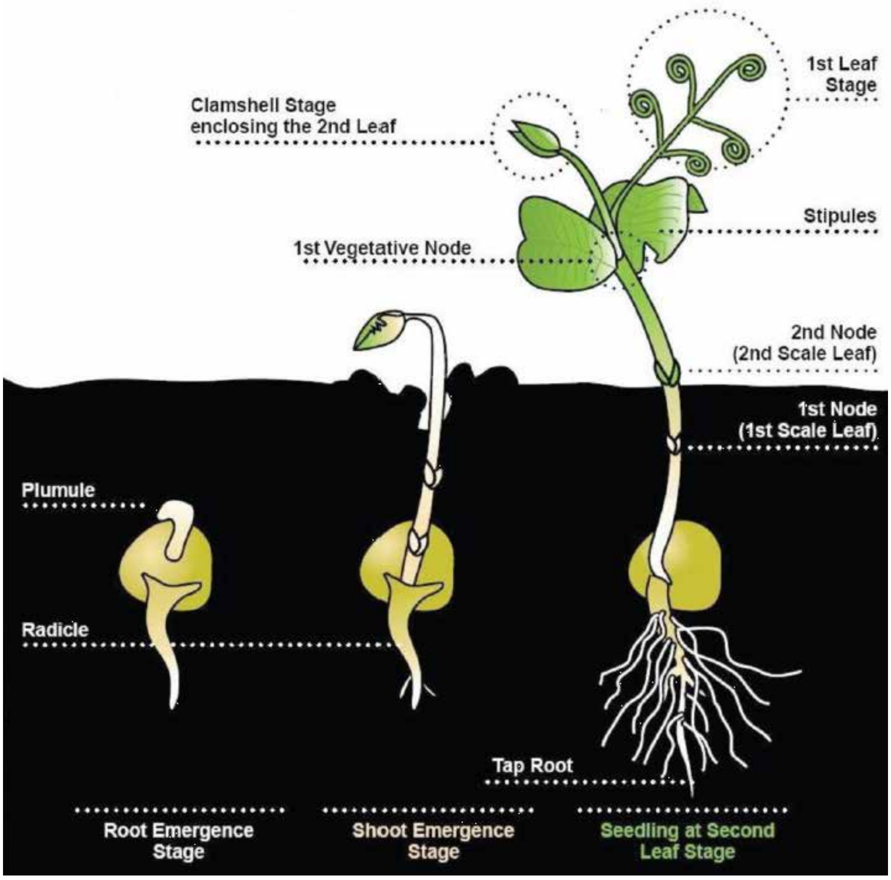


**Figure 1:** *Stages in the development of the field pea (Pisum sativum).*

Source: Saskatchewan Pulse Growers, Field Pea Production Manual

There is a uniform system for the description of the developmental stages of field pea (*Pisum sativum*) that is universally applicable to all growing environments and divergent cultivars (Table 1):

- Vegetative (V) growth stages: Count nodes on the main stem and continue up the basal primary branch to include the highest fully developed leaf. Count the number of visible nodes on the main stem up to the node subtending the basal primary branch, and then continue the node count up the basal primary branch to include the highest fully developed leaf. The basal primary branch usually develops between nodes 1 to 5.
- Reproductive (R) growth stages: Flowering of field pea is indeterminate, occurring from axillary buds on the main stem and branches. It proceeds acropetally from lower to higher nodes. Reproductive stages R1 and R2 are based on flowering, R3 to R5 on pod and seed development, and R6 and R7 on maturation. Kaspa field pea is more determinate than other varieties.
- Physiological maturity is when the seed can develop no further dry matter. [2]

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**Table 1:** *Growth stages of a field pea plant.*

| Development Phase | Growth stage (GS) | Description |
|---|---|---|
| Germination and emergence | VE | Epicotyl emerges from the soil (seedling emergence); cotyledonary node visible |
| | VS | Two small scale leaves (cataphylls appear on the stem); do not count this node |
| Vegetative growth stages | V1 | The true leaf (pair of leaflets) has unfolded at the first node above VS, no tendril |
| Count the number of visible nodes above the cotyledonary node (VS) on the main stem, continuing the node count up the basal primary branch to include the highest fully developed pinnately compound leaf. | V2 | Second true (one or more pairs of leaflets) has unfolded at the second node |
| | V3 | Third true leaf (one or more pairs of leaflets) has unfolded at the third node |
| | Vn | The nth true leaf (one or more pairs of leaflets) has unfolded at the nth node |
| Reproductive growth stages | R1 | Flower bud present at one or more nodes |
| | R2 | First open flower at one or more nodes |
| Field pea is indeterminate, and flower buds are initiated in leaf axils at the apical meristem approximately 20 days after they become visible. | R3 | First flat pod present at one or more nodes |
| | R4 | Green seeds fill the pod cavity at one or more nodes |
| | R5 | The leaves start yellowing and low pods have turned yellow to golden-brown |
| | R6 | Yellow or dry seeds fill the pod cavity at one or more nodes |
| Kaspa is more determinant than other varieties. | R7 | Most pods on the plant are yellow to golden-brown |
| Physiological maturity | R7 | leaves start yellowing, and 50% of the pods have turned yellow |
| | R8 | 90% of pods on the plant are golden-brown. |

Source: W. Erskine, F. J. Muehlbauer and R. W. Short, 1990

## 4.3 Factors that impact plant growth

Tolerance to high temperatures and moisture stress in the reproductive stages and improved podset under conditions of either high or low temperatures are breeding priorities for field pea breeding.

Crop duration is highly correlated with temperature. Crops will take different times from sowing to maturity under different temperature regimes. The concept of thermal time is the mechanism used to represent a crop's requirement to accumulate a minimum time for development through each essential growth stage (e.g. vegetative or reproductive growth). Consequently, crops growing under low air temperatures generally require more time to develop than crops growing at warmer temperatures.

Progress to flowering in field pea is similar to other pulse crops, in that it is significantly influenced by temperature. Progress to flowering can be described by the accumulation of thermal time {(max T°- min T°)}/2 assuming a base temperature of 0°C.

Thermal time is also referred to as heat units, degree-days or growing degree-days. The base temperature for calculating thermal time for field pea is 0°C. Once a certain number of degree-days are reached (accumulated), flowering commences, but the actual number of thermal units required varies with the location, photoperiod and variety. Similarly, the end of flowering is controlled by thermal unit accumulation.

Field pea are a medium duration crop, usually beginning flowering within 80–125 days of sowing, depending on sowing date, photoperiod and temperature. Field pea is either day-neutral or long-day requiring, depending on variety. [3]

Field peas are like other cool season pulses in their susceptibility to extreme hot or cold conditions, especially at flowering. In other pulses it is the average day/night temperature that is critical for flowering and podset, rather than any specific effects of maximum or minimum temperatures (Singh, 1996). This is not necessarily so with field peas. If there is a critical mean, or average daily temperature for field pea to flower, in most current varieties it would be below 10°C.

In Mediterranean environments, radiant frost commonly occurs during clear nights in spring. At that time of year, field pea plants are likely to be at flowering and podding stages. Exposure to frost at reproductive stages can damage or kill buds, flowers and pods, and can reduce seed weight. Current cultivars of field pea have inadequate tolerance to radiant frost at reproductive stages.

The extent of frost damage depends on the developmental stage of the plant and tolerance to frost has an inverse relationship to plant age.

During the reproductive phase field pea plants are more sensitive to frost than the vegetative stage. Frosts can impact field pea flowers, but low temperatures (greater than 2°C) are not known to cause pollen sterility in field pea.

If moisture and temperature conditions are favourable, additional crop growth, node production, and flowering crop height occurs. Hot conditions (maximum temperatures greater than 30°C) or lack of moisture causes flowering and additional crop growth to cease. If the crop is able to continue to grow taller as it flowers, it will use more soil water. Water use efficiencies will decline under such circumstances. Field pea is considered one of the more tolerant of the winter pulses to moisture stress (drought).

Note that the impacts of low air temperatures will be moderated by topography and altitude; i.e. there will be warmer and cooler areas in undulating country.

### 4.3.1 Flower and fruit development

Field pea plants generally produce many flowers; however, a major proportion do not develop into pods, depending upon the variety, sowing date and other environmental conditions. Some pods that set do not progress to fill seeds either.

It is not unusual for fewer than 20% of the flowers set by field pea to develop into pods. Field peas are classified as a hermaphrodite plant because their flowers have both male and female parts. All the tools that field peas need to reproduce are contained in a single blossom.

Flowers are large, borne on short pedicels in clusters of 1–3 on each axillary raceme usually from the node where flowering commences. There can be many flowering nodes in well-grown field peas. One to four pods develop from each flower cluster. Growth is largely indeterminate. Flowers are 1.0–1.5 cm long, with five petals; the standard petal, white.

Progress toward flowering follows a conventional thermal-time model. For commercial field pea varieties, approximately 750–850°C days (above 0°C) are required for the onset of flowering; but this varies with variety, location and time of sowing. Optimum temperature of flowering is 22–23°C.

Flowers may abscise from the crop because:

- proximal flowers on the same raceme are fertilised

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3 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 2–Plant Physiology.

- vegetative-reproductive competition for assimilate
- stresses such as drought, or excessively high or low temperatures (frost)

### Phenological stages

The phenology of most crops can be described using nine phases:

1. sowing to germination
2. germination to emergence
3. period of vegetative growth after emergence, called the basic vegetative phase (BVP), during which the plant is unresponsive to photoperiod
4. photoperiod-induced phase (PIP), which ends at floral initiation
5. flower development phase (FDP), which ends at 50% flowering
6. lag phase prior to commencement of grainfilling
7. linear phase of grainfilling
8. period between the end of grainfilling and physiological maturity
9. harvest-ripe period, prior to grain harvest.

These stages of development are generally modelled as functions of temperature (Phases 1–8) and photoperiod (Phase 4).

Under favourable temperature and soil moisture conditions, the time taken from fertilisation of the ovule (egg) to the first appearance of a pod (podset) is about 6 days. The seed then fills over the next 3–4 weeks. The developing pod stands above its subtending leaf. It may become too heavy and then hang below the flowering node for harvest.

After podset, the pod itself grows rapidly for the first 10–15 days while seed growth (fill) mainly occurs later.

At any location, seasonal variations in temperature can bring about a significant shift in flowering times for the same sowing time (i.e. ± 10 days is possible). Warmer temperatures hasten development, as reflected in the thermal time formula and calculations.

Once flowers begin to develop and fertilisation has occurred, the pods drop beneath the leaf canopy. Pods bend further downward when seeds are nearer to maturity. The pod can contain between one and two ovules which usually develop into seeds. The bulk of the yield is found on the earlier flowering nodes of the main stem and basal branches. [4]

Full physiological plant maturity can vary among variety and within seasons. Crop desiccation can aid harvest management.

Field pea crops can reach maturity 180–220 days after sowing, depending on the sowing date, variety, and a range of environmental factors including rainfall and temperature.

If desiccated occurs when there are a considerable percentage of green pods/ green seeds, significant grade discounts will most likely occur because of wrinkling, discolouration or even poor kernel colour.

## 4.3.2 Germination

When placed in a moist environment, seed goes through three stages of water uptake during germination as it imbibes water.

**Phase 1:** is water movement into the grain, imbibition, which occurs because the moisture content in the soil is greater than that in the seed. The seed swells. Water enters primarily at the hilum end of the grain where it was originally attached to the funiculus and nutrient conducting tissues of the plant. There is also some minor movement of water through the seed coat. Water uptake into the embryo (germ)

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proceeds very rapidly, depending on the soil moisture content, to the point that normal cellular processes (metabolism, cell division etc.) can occur. Too much water can impede germination by restricting diffusion of oxygen to the seed. All seeds whether viable or non-viable, dormant or non-dormant, go through this phase 1 process.

**Phase 2:** is when there is minimal uptake of water, and it extends through to the first visible signs of germination. The major metabolic events required to prepare the seed for germination occur during phase 2 only in viable and non-dormant seeds. These changes are conserved if the seed is dried, and the seed can remain dry for considerable period without significant reduction in viability or germination potential. When these seeds are re-wetted, they again rapidly imbibe and show accelerated germination as the phase 2 duration is markedly shortened.

**Phase 3:** is associated with visible germination and subsequent growth. As part of this growth there is rapid uptake of water again and new metabolic activity, including the start of mobilisation of stored food reserves in the endosperm. Visible germination starts with rupture of the seed coat over the germ and the protrusion of the shoot and radicle. As this process advances, the seedling becomes increasingly vulnerable to damage through drying, and there is a reducing capacity to regenerate following re-wetting.

Up until the establishment of green leaves, the seedling is totally dependent on the stored food reserves in the endosperm. During the early stages of germination, the embryo produces gibberellic acid that triggers the synthesis of enzymes that ultimately lead to the production of sugars and amino acids required by the growing seedling.

Implications of this information are that:

- Seeds sown into marginal moisture may have either dried down or not taken in sufficient moisture to germinate. These 'primed' seeds will germinate quickly when the soil is again wetted up, as part of the germination process has commenced.
- Seed with a cracked seed coat can allow direct access of water and micro-organisms into the stored starch and protein reserves in the endosperm.
- Seed with a cracked seed coat may imbibe moisture too quickly and impede oxygen diffusion into the seed.
- If there has been pre-harvest sprouting, it may have limited effects on germination percentage when tested at harvest, but will cause a decline in germination percentage, germination vigour and seed viability during storage. [5]

## 4.3.3 Emergence

Field pea germination requires a minimum soil temperature of 5°C.

Soil temperature and days to emergence:

- 5°C–7.2°C: 17 to 21 days to emerge
- 7.2°C–10°C: 14 to 17 days to emerge
- 10°C–12.8°C+: 10 to 14 days to emerge

Approximate times to reach growth stages:

- 1st node/leaf stage: depending on soil temperatures, usually 14 days
- 2nd node/leaf stage and after: every 4 to 5 days

## 4.3.4 Nodes and leaves

Field pea is a glabrous annual, with angular or roundish hollow stems covered with a waxy bloom. In leafy types, leaves consist of one or more pairs of opposite leaflets borne on petioles together with several pairs of tendrils (which are essentially modified leaves) and a single or compound terminal tendril (Figure 2). Leaflets are

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broad and ovate with distinct ribs, and slightly toothed or entire. The two (pseudo) stipules at the base of the leaf are also ovate but much larger than the leaflets.

In semi-leafless types, the leaflets are replaced by tendrils but the stipules are still present. In leafless types the leaflets are also replaced by tendrils but the stipules are stunted (Figure 3). Leafless types have better standing ability than the leafy types.

Plants normally range from 30 to 50 cm tall—the taller plants result from cool growing season temperatures, good moisture and good fertility. Plants can have single stems or many branches depending upon plant density. [6]

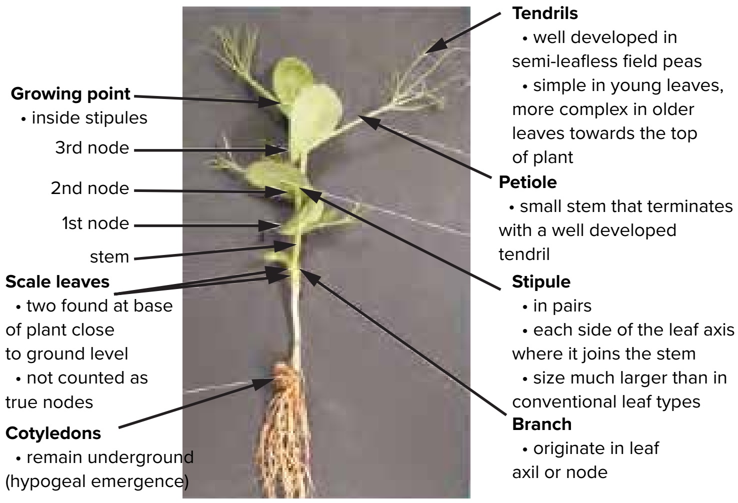


**Figure 2:** *Field pea—semi-leafless type, e.g. PBA Wharton⦶, PBA Twilight⦶, PBA Gunyah⦶, PBA Pearl⦶, PBA Oura⦶ and Kaspa⦶.*

Photo: NSW DPI) 7

6 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 2–Plant Physiology.

7 G Brooke, C McMaster (2015) Weed control in winter crops 2015: NSW DPI Management Guide. NSW Government Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/weed-control-winter-crops

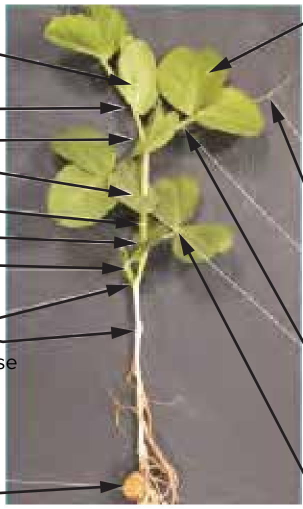


**Figure 3:** *Field pea—conventional type (Pisum sativum), e.g. PBA Percy(ꝺ), Parafield, Alma.* [8]

Source: NSW DPI

## Erectness

Erectness of field pea plants is related to plant type, as there are conventional-leaved or semi-leafless plant types in which the leaflets on the conventional type are replaced by tendrils. Conventional-leaved plants are almost always prostrate at maturity, which means they have to be picked up from close to the soil surface when harvesting. Semi-leafless field peas are also often prostrate at maturity, but there are semi-erect types that, under the right conditions, maintain their erectness to maturity with the lowest pods no closer than 30 cm to the soil surface. However, under other conditions semi-erect types can lodge at maturity in a similar fashion to normal prostrate types. [9]

## Crop lodging

Lodging leads to shading of other plants, loss of flowers and pods, and increased incidence and severity of leaf disease. It is more likely in higher rainfall areas.

Tall trailing field pea types with poor resistance to lodging (e.g. PBA Hayman(ꝺ), PBA Percy(ꝺ)) are more likely to fall over in spring. Areas of ground exposed by lodging enable late spring weeds spring weeds such as ryegrass to grow and set seed.

It is recommended to grow varieties with greater resistance to lodging. Planting field peas into standing cereal stubble will help anchor the plant and provide a natural trellis for the crop to grow on. Narrower row spacing and higher sowing rates can also aid in standability. [10]

8 G Brooke, C McMaster (2015) Weed control in winter crops 2015: NSW DPI Management Guide. NSW Government Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/weed-control-winter-crops

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WA growers are trialling intercropping field peas with canola, which can help address harvesting difficulties due to lodging at maturity and diease issues by allowing for better aeration.

### 4.3.5 Roots

Field peas have a slender tap root with a mass of lateral fibrous roots. Large genotypic variation has been reported in root growth in terms of tap root growth, number of lateral roots, total root length, root weight and number of root hairs per unit of root length.

The field pea varieties grown in Australia have profusely branched secondary roots that increase in size near the soil surface as the season develops. Their root systems are relatively strong, but do not penetrate to the same depths as cereal roots, especially when there are subsoil constraints. Field pea roots are highly sensitive to saline, boron and sodic soils. Implications of this include:

- limited root growth
- root depth and moisture extraction capabilities

Root growth of field pea is often most rapid until pod development and seeds begin to fill. After that roots continue to grow at a much slower rate until close to crop maturity. The total root length beneath legume crops is about 10 times smaller than in cereal crops and root length density seldom exceeds 1 cm root/cubic cm of soil, even in the surface layers. This restricted rooting density has consequences for the uptake of water by pulse crops.

Yield can be severely reduced on wet, poorly drained soils, with an increase in root diseases.

Field peas are most sensitive to water logging at flowering, with a similar response to low light or low temperatures with flower and pod abortion and leaf senescence. Sowing date and canopy closure are other factors that can impact on podset and yield.

Field pea roots can leave moisture at depth late in the season. This can contribute to their inability to withstand dry conditions. Root growth is most rapid before flowering but will continue until maturity under favourable conditions. Field pea are susceptible to hard pans, and prefer deep well-structured soils so that roots can penetrate deeply. Subsoil constraints, such as soil chloride in excess of about 800 mg/kg soil in the top 60 cm, will likely restrict root growth and water availability.

#### Nodulation

The tap root and lateral roots near the soil surface carry small round or rectangle shaped nodules if the correct strain of rhizobia is present (group E). Nodules might start appearing as early as 15 days after emergence. Peak nodule growth and development occurs at peak vegetative production and starts to decline at the commencement of flowering, or later if adequate soil moisture is available. Healthy nodules have a pinkish-white appearance, and when cut show a pink discolouration of leghaemoglobin.

Nitrate in the soil can delay nodulation, and decrease nodule number and activity in field pea.

#### Amounts of nitrogen fixed

The amount of shoot nitrogen (N) fixed is closely related to the amount of biomass production, with about 20–25 kg of shoot N often being fixed for every additional tonne of shoot dry matter produced. Although the levels of %N-fixed are important, provided there are adequate numbers of effective rhizobia in the soil and concentrations of soil mineral N are not too high, the amounts of N fixed will be determined by legume growth. [11]

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## 4.3.6 Moisture

Moisture stress in field pea influences plant height and it can affect yield and ease of harvest if the crop is too short. Timing of moisture stress relative to growth stage is important. Variety responses to moisture stress can differ depending on their tolerance and flowering/maturity time.

Field pea crops are largely autogamous, or self-pollinating. Introducing commercial pollinating bees through the field pea crop is not generally required. [12]

## 4.3.7 Frost tolerance

*Radiant frost*

Abiotic stresses are a major source of yield loss in field peas, with radiant frost being one of the principal limiting abiotic factors of grain production. In grain legumes, frost not only affects the N-fixing bacteria and their symbiotic maintenance (Stoddard *et al*. 2006) but also has a particularly damaging effect on the plant itself when it occurs during the reproductive phase of the plant's lifecycle. In pulses, the most susceptible stages are the flowering, early pod formation and seedfilling stages (Siddique *et al*. 1999).

During radiant frost events, the temperature decreases to levels cold enough to cause nucleation of the intracellular fluid and the subsequent rupturing of the plasma membrane. Damage can also be caused via dehydration of cells as a result of the freezing of the extracellular spaces. Radiant frost damage can also lead to other problems, including an increased vulnerability to pathogen entry (e.g. bacterial blight in field pea).

Timing of the exposure to low temperature or frost is a key factor that determines the disruption of fertilisation of flowers in legumes (Stoddard *et al*. 2006). Frozen upper stems in field peas become discoloured (dark green directly after thawing) and associated foliage shrivels and dies. Unaffected parts of the plant can grow, flower and set seed if there is sufficient time and soil moisture.

In severe frost damage cases, leaves are killed and the stem is wilted. If they are at the 1 to 5 node stage, there can be fast recovery from underground axillary buds. If the field peas are at the 7th node stage or beyond, plants will most likely die, because axillary bud initiation is unlikely to occur as the plant is moving into reproductive stages.

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# Nutrition and fertiliser

## Key messages

- DAFWA recommends a maintenance application of 50-100kg/ha superphosphate. It is useful to apply nitrogen (N) at 10-15kg N/ha in soils with marginal pH (<5.0) and clay content.
- Field peas have a reasonably high P requirement as field peas remove about 4 kg of P/t grain, so applying 8 kg of P to a paddock with a 2 t/ha yield potential will maintain soil P levels.
- Soil P levels influence the rate of nodule growth. The higher the P level the greater the nodule growth.
- MAP or DAP fertilisers used in small amounts (5–15 kg/ha N) are not harmful to nodulation and can be beneficial by pushing out the early root growth to establish a stronger plant.
- Western Australia covers a vast area with a wide range of soil types. Many areas of the south-west of the state are characterised by soils with sandy surfaces ranging from deeps sands to sands over clays, and soils dominated by ironstone gravels.
- Soils in the northern parts of the state, although variable, are often characterised by oxides of iron giving them a characteristic red colour.
- Soil type influences the capacity of the land to support agricultural production, and an understanding of their characteristics and distribution is very important for sustainable land management. [1]

## 5.1 Crop removal rates

A balance of soil nutrients is essential for profitable yields. Fertiliser is commonly needed to add the essential nutrients phosphorus (P), potassium (K), sulfur (S) and zinc (Zn). Lack of other micronutrients may also limit production in some situations. [2]

*DAFWA research has found that Phosphate is the main fertiliser required by field peas in WA. Response rate research is inconsistent with some sites being more responsive to P than wheat, and others less responsive. There are no clear patterns according to soil type or other conditions.*

*To be safe it is recommended to apply as much P as you would to a wheat crop grown on the same paddock.*

Agronomist's view

### Balancing inputs

The nutrients removed by 1 t of grain by various pulses are shown in Table 1. Actual values may vary by 30% or sometimes more, due to the differences in soil fertility, varieties and seasons.

1 DAFWA (2017) Soil identification https://www.agric.wa.gov.au/climate-land-water/soils/soil-identification

2 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. New South Wales Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2016.pdf

**Table 1:** *Nutrient removed by 1 t of grain*

| Grain | N | P | K | S | Ca | Mg | Cu | Zn | Mn |
|---|---|---|---|---|---|---|---|---|---|
| | (kg) | | | | | (g) | | | |
| **Pulses** | | | | | | | | | |
| Chickpea (Desi) | 33 | 3.2 | 9 | 2.0 | 1.6 | 1.4 | 7 | 34 | 34 |
| Chickpea (Kabuli) | 36 | 3.4 | 9 | 2.0 | 1.0 | 1.2 | 8 | 33 | 22 |
| Faba bean | 41 | 4.0 | 10 | 1.5 | 1.3 | 1.2 | 10 | 28 | 30 |
| Lupin | 53 | 3.0 | 8 | 2.3 | 2.2 | 1.6 | 5 | 35 | 18 |
| Field pea | 38 | 3.4 | 9 | 1.8 | 0.9 | 1.3 | 5 | 35 | 14 |
| **Cereals** | | | | | | | | | |
| Wheat | 23 | 3.0 | 4 | 1.5 | 0.4 | 1.2 | 5 | 20 | 40 |
| Barley | 20 | 2.7 | 5 | 1.5 | 0.3 | 1.1 | 3 | 14 | 11 |
| Oats | 17 | 3.0 | 5 | 1.6 | 0.5 | 1.1 | 3 | 17 | 40 |

Source: Grain Legume Handbook.

## 5.1.1 Detecting nutrient deficiencies

Soil tests are specific for both the soil type and the plant being grown. The most useful soil tests are for P, K, organic matter, soil pH and salt levels. A test for S has now been developed. Pulse crops can have different requirements for K, hence they have different soil test K critical levels.

Plant tissue testing can also be used to diagnose a deficiency or monitor the general health of the pulse crop. Plant tissue testing is most useful for early monitoring, as yield potential can be markedly reduced by the time noticeable symptoms appear in a crop.

Tissue tests also help to identify the cause of plant symptoms that are expressed by plants but not readily attributable. Technology is enabling faster analysis and reporting of results, so that foliar- or soil-applied remedies can be used in a timely manner for a quick crop response.

Several companies perform plant tissue analysis and derive accurate analytical concentrations; however, it can be difficult to interpret the results and determine a course of action. As with soil tests, different plants have different critical concentrations for a nutrient, and in some cases, varieties can vary in their critical concentrations. [3]

### Nutrition

Too little or too much of a nutrient, or incorrect proportions of nutrients, can cause problems. If the condition is extreme, plants will show visible symptoms, but these may not be apparent until a major effect on yield, growth or development has occurred. Damage can be done before there is visual evidence.

Healthy plants are better able to ward off disease, pests and environmental stresses, leading to higher yields and better grain quality. A plant tissue analysis can be important in detecting non-visible or subclinical symptoms, and in fine-tuning nutrient requirements. This is particularly helpful where growers are aiming to capitalise on available moisture.

MORE INFORMATION

GRDC (2009) Field Peas: The Ute Guide.

GRDC (2013) Better fertiliser decisions for crop nutrition Fact Sheet.

3 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

**Table 2:** *Recommended minimum plant nutrient levels for a range of pulse crops and canola during vegetative stages (seedling to budding).*

| Plant nutrient (%) | Faba beans | Lupins | Field peas | Canola |
|---|---|---|---|---|
| Phosphorus | 0.35-0.45 | 0.2-0.3 | 0.25-0.4 | 0.25-0.3 |
| Nitrogen | 4.0 | 4 | - | 2.7-3.2 |
| Potassium | 2.0-2.5 | 1.2-1.5 | 1.5-2.0 | 1.3-2.8 |
| Sulphur | - | 0.2-0.25 | - | 0.25-0.33 |
| Magnesium | 0.2 | - | 0.2 | 0.14-0.12 |
| Calcium | 0.6 | - | 0.6 | 1.0-1.4 |

Source: DAFWA

**Table 3:** *Recommended minimum micronutrient levels for a range of pulse crops and canola during vegetative stages (seedling to budding).*

| Micronutrient (or trace elements) | Faba beans | Lupins | Field peas | Canola |
|---|---|---|---|---|
| Manganese (Mn) (mg/kg) | 20-25 | 17-20 | 20-30 | 15-20 |
| Iron (Fe) (ppm) | - | - | - | - |
| Copper (Cu) (mg/kg) | >3.0 | >1.2 | >3.0 | Whole shoots of young plants (seedling) below about 4mg/kg to 2.2mg/kg (rosette) and YEB levels below about 3mg/kg indicate copper deficiency |
| Zinc (ppm) | >20-25 | >12-14 | 20-30 | Whole shoots of young plants (40 days) below about 23mg/kg and YEB levels below about 15mg/kg indicate zinc deficiency |
| Boron (mg/kg) (ppm) | 10 | 15 | 10 | 15-22 |

Footnote: young leaves are recommended for micronutrient testing if suspected.
Source: DAFWA

Many nutrient deficiencies may look similar. Knowing what a healthy plant looks is helpful in recognising symptoms of distress, such as:

- determining what the affected areas of the crop look like. For example, are they discoloured (yellow, red, brown etc.), dead (necrotic), wilted or stunted?
- identifying the pattern of symptoms in the field (patches, scattered plants, crop perimeters)
- assessing affected areas in relation to soil type (pH, colour, texture) or elevation
- looking at individual plants for more detailed symptoms, such as stunting or wilting, and where the symptoms are appearing (whole plant, new leaves, old leaves, edge of leaf, veins)

If more than one problem is present, typical visual symptoms may not occur. For example, water stress, disease or insect damage can mask a nutrient deficiency. If two nutrients are simultaneously deficient, symptoms may differ from those when one nutrient alone is deficient. Micronutrients are often used by plants to process other nutrients, or work together with other nutrients, so a deficiency of one may look like a deficiency of another. For instance, molybdenum (Mo) is required by pulses to complete the $N_2$-fixation process. [4] More detail on specific nutrients is contained later in this section.

4 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

FAQ

## 5.2 Fertiliser

Field peas have a reasonably high P requirement as field peas remove about 4 kg of P/t grain, so applying 8 kg of P to a paddock with a 2 t/ha yield potential will maintain soil P levels.

Soil P levels influence the rate of nodule growth. The higher the P level the greater the nodule growth.

MAP or DAP fertilisers used in small amounts (5–15 kg/ha N) are not harmful to nodulation and can be beneficial by pushing out the early root growth to establish a stronger plant.

Excessive amounts of applied N will restrict nodulation and reduce N fixation. High background soil N levels can delay nodulation until N levels are depleted.

Inoculated seed and acidic fertilisers should not be sown down the same tube. The acidity of some fertilisers will kill large numbers of rhizobia. Neutralised and alkaline fertilisers can be used.

Acid fertilisers include:

- super phosphates (single, double, triple)
- Fertilisers with Cu and/or Zn including MAP

Neutral fertilisers include:

- super lime

Alkaline fertilisers include:

- DAP, also known as 18:20:0
- Starter NP
- lime

### 5.2.1 Pulses and fertiliser toxicity

All pulses can be affected by fertiliser toxicity.

Changes in sowing techniques to narrow sowing points or disc seeders with minimal soil disturbance, and wider row spacing, has increased the concentration of fertiliser near the seed. This increases the risk of toxicity.

The effects are also increased in highly acidic soils, sandy soils and where moisture conditions at sowing are marginal. Drilling concentrated fertilisers to reduce the product rate per hectare does not reduce the risk. [5]

### 5.2.2 Nitrogen

Nitrogen deficiency from nodule dysfunction can be caused by lack of Rhizobia, soil conditions, herbicide toxicity, or molybdenum or sulphur deficiency. [6]

Seed should be inoculated with group E strain of rhizobia every year.

Field peas do take up residual soil nitrates (nitrates not used by the preceding crops) and therefore reduce the potential for N loss by leaching.

#### Deficiency symptoms

The first sign of N deficiency in field peas is a general paleness of the whole plant, even before a general reduction in plant growth. There may be a cupping of the middle to new leaves. With time, a mottled chlorosis of old leaves slowly develops with little sign of necrosis. [7]

5 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

6 DAFWA (2015) Diagnosing nodule dysfunction in field peas. Department of Agriculture and Foo, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-nodule-dysfunction-field-peas

7 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

Older growth is first and worst affected old leaves becoming yellow-mottled to marginally chlorotic. As deficiency worsens plants becomes stunted and pale; older leaves become progressively pinkish pale and die, leaving green new growth.

Symptoms may appear within a month of seeding and symptom severity can vary according to available soil nitrogen.

If nodules are present they are small, and when split have pale or white, rather than pink interiors. [8]

Growers should check for nodulation, and whether nodules are fixing N.

Some situations where N fertiliser may warrant consideration include:

- not adopting recommended inoculation procedures
- late sowing or low fertility situations, where rapid early growth is critical in achieving adequate height and sufficient biomass to support a reasonable grain yield

### 5.2.3 Phosphorus

Nearly all soils in WA were P deficient when cleared for agriculture, but continual use of P fertiliser means acute deficiency in broadacre crops is rare, with the exception of very acidic and high PBI (phosphorus buffering index) soils. Phosphorus deficiency is often transitory and compounded by dry soil, with symptoms disappearing when topsoil is re-wet following rainfall. [9]

Phosphorus is essential for many growth processes, and in many biochemical reactions involved in the metabolism of carbohydrates, fats, proteins and in energy transfer in the plant. Adequate P is essential for seed germination, root development, and in the ripening process of fruits and seeds. Phosphorus deficiency is usually denoted by small leaf size, and leaf colour.

#### Deficiency symptoms

Symptoms of P deficiency may take time to develop because of initial seed reserves of P. When symptoms start to appear, there are growth differences, and leaves are smaller compared with P adequate plants. Visual symptoms appear first on the oldest leaves as a mildly mottled chlorosis over much of the leaf. These symptoms could be confused with either N or S deficiency, but the middle and new leaves remain a healthy green so that the whole plant does not appear pale.

As symptoms on old leaves develop, round purple spots may appear within areas of dark green in an otherwise mildly chlorotic leaf.

Phosphorus is not very mobile in the soil, so placing it at or near the seed at sowing is the most efficient way to ensure it is readily available to the growing plant.

On soils that have the capacity to retain P, such as the ironstone gravel soils east of the Darling Range, it is best to drill fertiliser with the seed. [10]

Germinating field peas are extremely sensitive to salts contained in fertiliser N, K and S. If heavy P applications are required to correct nutrient deficiencies, apply fertiliser before or during seedbed preparation. [11]

**MORE INFORMATION**

DAFWA (2015) MyCrop: Diagnosing phosphorus deficiency in field peas.

GRDC (2012) Western Region Phosphorus Management. Fact sheet.

8 DAFWA (2015) Diagnosing nodule dysfunction in field peas. Department of Agriculture and Foo, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-nodule-dysfunction-field-peas

9 DAFWA (2015) Diagnosing phosphorus deficiency in field peas. Department of Agriculture and Foo, Western Australia, https://agric.wa.gov.au/n/4478

10 GRDC (2012) Western Region Phosphorus Management. Fact sheet, https://grdc.com.au/Resources/Factsheets/2012/11/Crop-Nutrition-Phosphorus-Management-Fact-Sheet

11 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

### 5.2.4 Potassium

Field peas have a high K requirement, but deficiency has been rare because they are mainly grown on heavy textured soils. [12]

#### Deficiency symptoms

Older leaflets show symptoms first, and initially growth is stunted compared with other parts of the paddock, for example in old stubble rows. Margins and tips of leaflets lose their green colour and become yellow-green. Reddish pigmentation is also seen on some leaflets. These leaflets often drop from the plant. Symptoms progress up the plant when deficiency persists. Necrotic patches develop on leaflets. Stems of some plants may also develop reddish-brown anthocyanin pigmentation. Older leaves may show a slight curling and then a distinct browning of leaf margins, eventually dying.

Applying 20–40 kg/ha K banded 5 cm to the side of, and below the seed line is recommended in situations where soil test levels are critically low.

MORE INFORMATION

DAFWA (2015) MyCrop: Diagnosing potassium deficiency in field peas.

### 5.2.5 Sulfur

Like potassium, sulfur deficiency is rare in WA as field peas are generally grown on heavy-textured soils. [13]

Sulfur is present in proteins, in some oils, and as sulphates. Avoid using granular elemental S on field peas because this form of S becomes available only slowly. Elemental S also greatly reduces soil pH.

#### Deficiency symptoms

Symptoms on S-deficient plants can resemble those of N deficiency. Chlorosis (yellowing) on S-deficient plants firstly affects the leaves near the top of the plant, while leaves near the base remain green. With increasing severity of S deficiency, the chlorosis extends over the whole plant. The pattern of chlorosis development helps to differentiate the symptoms of S deficiency from those of N deficiency. Some leaflets become completely yellow, wither and drop from the plant. Reddish-brown pigmentation appears on the stems and leaves of S-deficient plants. Deficient plants are slender and small.

Applying 5–10 kg/ha S will normally correct a S deficiency.

Where soil phosphate levels are adequate, a low rate of gypsum is the most cost effective long-term method of correcting S deficiency.

Granulated sulphate of ammonia is another effective option in situations where low rates of N are also required. [14]

MORE INFORMATION

DAFWA (2015) MyCrop: Diagnosing sulfur deficiency in field peas.

### 5.2.6 Lime

If field peas are grown on acidic soils, lime applications (2.5 t/ha) may be necessary on paddocks with a pH of 5.0 ($CaCl_2$) and below. Reduced field pea yields may occur at soil pH of 5.4 or lower. It may well be poor nodulation that limits field pea production on low pH soils.

### 5.2.7 Zinc

Field peas are susceptible to Zn deficiency, but it is rarely seen in WA. [15]

12 DAFWA (2015) Diagnosing potassium deficiency in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4480

13 DAFWA (2015) Diagnosing sulfur deficiency in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4488

14 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

15 DAFWA (2015) Diagnosing zinc deficiency in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4490

Both Zn and Cu deficiencies have a major effect on flowering and seed production, and when very deficient, on plant growth. Both play an important role in legume nodulation and N fixation.

Field peas can be responsive to Zn fertiliser, but P status must be adequate to achieve a Zn response.

### Deficiency symptoms

Zinc deficiency appears as a reduction in inter-nodal growth; it results in a rosette growth habit. The younger leaves of Zn-deficient plants initially become pale green in colour. Pigmentation (reddish-brown) takes place on the margins of upper surfaces of leaflets and on the lower portions of the stems. Plants are small, and the areas between veins turn yellow, becoming yellower on the lowest leaves. Maturity can be delayed.

Field peas are considered to have a relatively medium demand for Zn, and have efficient mechanisms for extracting Zn from the soil.

Foliar application of Zn is relatively common, often fitting in with herbicide or early fungicide applications.

### Seed treatments

Zinc seed treatments may be a cost-effective option in situations where soil P levels are adequate but Zn levels are likely to be deficient.

### Fertilisers

A range of phosphate-based fertilisers either contain, or can be blended with a Zn additive.

Foliar spray (effective only in current season) or soil fertiliser can be drilled with the following crop. Zinc foliar sprays need to be applied as soon as deficiency is detected to avoid irreversible damage.

As zinc is immobile in the soil, topdressing is ineffective, as it would only be available to the plant when the topsoil is wet. Zinc drilled deep increases the chances of roots being able to obtain enough in dry seasons.

Zinc has a 15 to 20 year residual life in soil. Zinc present in compound fertilisers often meets the current requirements of the crop. [16]

## 5.2.8 Iron

Iron is very important in many plant enzyme systems, including the formation of chlorophyll. Iron deficiency can be confused with Mn and Mg deficiency. Iron is strongly immobile in plants.

### Deficiency symptoms

Iron deficiency is often seen on highly calcareous soils in the Esperance mallee, particularly in late July when soil temperatures are low and there is excess water in the soil. [17]

With Fe deficiency, the youngest leaves and new growth become chlorotic (even bright yellow) over the entire leaf. The deficiency can spread to older leaves and new growth can cease. Stems become slender and shortened.

Iron deficiency appears as an interveinal chlorosis in younger leaves, because Fe cannot be readily mobilised from older leaves. Leaflets on deficient plants turn a yellow-green colour. White or light-coloured necrotic patches develop on the leaflets of young leaves if the deficiency becomes more severe. Acute Fe deficiency

16 DAFWA (2015) Diagnosing zinc deficiency in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4490

17 DAFWA (2015) Diagnosing iron deficiency in field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-iron-deficiency-field-peas

MORE INFORMATION

DAFWA (2015) MyCrop: Diagnosing iron deficiency in field peas.

GRDC (2009) Field Peas: The Ute Guide.

causes leaflets to wither and die. The young shoots also wither from the tip back towards the base.

Yellowing between leaf veins can progress to completely yellow plants. Colour contrast between old and new leaves is much stronger with Fe deficiency compared with that of Mn deficiency.

Iron chlorosis can be transient, with deficiency symptoms largely disappearing at a time coinciding with increases in soil temperature and day length during reproductive growth.

Iron deficiency symptoms tend to be very transient, with the crop making a rapid recovery once the soil begins to dry out. [18]

No yield responses to iron have been measured in the field to justify soil application.

Where symptoms occur, particularly in cold and wet conditions, they are frequently eliminated by increased soil and air temperatures.

Foliar sprays will remove the symptoms where they occur in highly calcareous or limed soils, but there is no yield benefit. [19]

MORE INFORMATION

DAFWA (2015) MyCrop: Diagnosing manganese deficiency in field peas.

## 5.2.9 Manganese

### Deficiency symptoms

Manganese deficiency is observed occasionally on alkaline, high pH soils such as the Esperance mallee. It is usually associated with a drier, fluffy soil conditions; for example, rolled areas or wheel tracks in a paddock may appear healthy while the remainder shows Mn deficiency.

Apply Mn fertiliser at seeding, on the seed, or as a foliar application.

Plants deficient in Mn are a lighter green colour on younger expanded leaves. In dun type varieties, new leaves become puckered and narrowly cupped with necrotic tipping on leaves and tendrils. [20]

In white seed varieties, affected leaves curl downwards along the length of the leaf. Interveinal leaf chlorosis turns into necrotic light brown spotting. Tendrils on new leaves have pale and excessively curled ends.

Prevalence of Mn deficiency results in symptoms similar to those of Ca deficiency. There is enhanced axillary bud development on Mn-deficient plants as a result of death of young shoots

Deficiency late season may lead to seeds being discoloured, splitting, deformity or having a brown spot or cavity in the centre.

A foliar spray will correct the deficiency and Mn fertiliser is effective but expensive as high rates and several applications are required to generate residual value.

Seed Mn coating treatments have little effect in correcting deficiency. [21]

## 5.2.10 Copper

### Deficiency symptoms

Copper deficiency symptoms appear on the younger leaves, while the plant remains a normal green colour. The leaflets on the top leaves of each stem are smaller than on normal plants. Copper deficient plants produce small leaves with fewer leaflets on the young shoots. In such cases these leaves usually wither and appear rust-brown

18 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

19 DAFWA (2015) Diagnosing iron deficiency in field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-iron-deficiency-field-peas

20 DAFWA (2015) Diagnosing manganese deficiency in field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-manganese-deficiency-field-peas

21 DAFWA (2015) Diagnosing manganese deficiency in field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-manganese-deficiency-field-peas

in colour. Shoot elongation is also reduced due to insufficient development of the terminal growing point.

Symptoms of Cu deficiency may not appear until flowering, hence there may be little effect on vegetative growth. The first symptom of Cu deficiency is an apparent wilting and rolling of the leaflet ends of fully opened leaves. Such a symptom of wilting is also seen in other crop plants with Cu deficiency. [22] Both Cu and Zn deficiencies have a major effect on flowering and seed production, and when very deficient, on plant growth. Both play an important role in legume nodulation and N fixation. Copper has a role in cell wall constituents of plants.

### 5.2.11 Molybdenum

Molybdenum is required for growth of legumes and by rhizobia in root nodules. It is often deficient in acid soils. Field peas grown in acid soils can respond to Mo as it is present in soil in only small amounts. Soil Mo analysis is not commercially available. Growers should base Mo fertiliser applications on cropping history and soil pH.

Molybdenum can be applied as a liquid (to soil or foliage), granular fertiliser inclusion or as a seed treatment on field peas at the rate of 9–35 g/ha when:

- the soil pH is less than 5.7, or
- every third time field peas are grown in a field

Do not exceed 35 g/ha Mo as a seed dressing—at higher rates, the N-fixing bacteria may die.

Symptoms start with chlorotic interveinal mottling of older leaves. In severe deficiency conditions, Mo causes leaf wilting and disorders. In addition to growth depression, there are fewer and smaller flowers, and many fail to open or mature, leading to lower seed yield. Molybdenum stress reduces leaves, flowers, pods, and finally, decreased biomass and yield. Molybdenum deficiency causes symptoms of N deficiency due to the role of Mo in N fixation. Leaves of N-deficient plants are lighter yellow than those of Mo-deficient plants. In many plants, there is an upward cupping of the leaves, and mottled spots developing into large, interveinal chlorotic areas under severe deficiency.

Molybdenum deficient plants may contain high nitrate N levels resulting from the inhibition of nitrate reduction to ammonia. The presence of high nitrate levels in a chlorotic, apparently N deficient plant, is thus evidence for Mo deficiency.

### 5.2.12 Cobalt

Cobalt is essential for growth of the rhizobium, hence legume nodulation and fixation of atmospheric N into amino acids. Vitamin B12, which contains Co, is synthesised by the rhizobium and circulated in haemoglobin. The haemoglobin content in the nodules is directly related to N fixation. Thus a deficiency in Co is shown in reduced Vitamin B12 production and lower N fixation.

As Co is present in soil in only small amounts, soil Co analysis is not commercially available, so base Co fertiliser applications on cropping history and soil pH. Cobalt needs to be applied before or at seeding. It can be applied as a liquid (to soil or foliage) or as a granular fertiliser inclusion.

### 5.2.13 Magnesium

Magnesium plays a vital role in the chlorophyll molecules and in many enzyme activities. It is readily transferred from older to younger leaves.

Magnesium, like Ca, is generally deficient in acid and sodic soils. Deficiency occurs in sandy and sandy loam soils if soil contains <1 meq exchangeable mg/100 g soil.

22 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

Magnesium deficiency first appears on young leaves as a chlorosis, which on some leaves later extends down the sides of the leaflets. The symptom on leaflets is yellow to yellow-green with a green area remaining around the midrib. Prevalence of Mg deficiency results in light brown necrotic areas developing on the leaflet tips or margins. The basal leaves usually remain green in severely affected plants. There is no evidence of anthocyanin pigmentation on magnesium-deficient plants.

Magnesium Oxide (MgO) application at a rate of 2 t/ha has been suggested as a way to enhance crop yields in a Mg deficient situation. [23]

### 5.2.14 Boron

Boron is essential in the formation of new tissue—the growing points, and also for effective nodulation and N fixation in legumes, and in satisfying rhizobial requirements.

As with calcium, B deficiency has a dramatic effect on the root systems. Field peas grown in some circumstances can respond to B applications. Bear in mind also that field peas are vulnerable to B toxicity, so the deficiency diagnosis must be accurate before considering B applications.

Boron needs can be determined by a soil test. Boron can be toxic at excessive rates or when concentrated near seedlings. Soil applied B fertiliser should always be broadcast, never banded.

#### Deficiency symptoms

The first symptom on a B-deficient plant is observed on the tip and margins of leaflets of young entire expanded leaves with a yellowing and 'bronzing'. This bronzing effect is partially due to red-brown pigmentation on the upper surfaces of leaflet margins. The tips and margins of affected leaflets start to die. The terminal buds turn rusty brown in colour. The young buds and leaflets die progressively from the tip. As a result of this, axillary bud development is enhanced. Plant roots are also stunted and thick, with dark tips similar to those occurring on Ca-deficient plants. Roots become brown; lateral extremities appear short and thick.

As B becomes deficient, the growing point becomes stunted, deformed or disappears altogether. When this occurs, apical dominance of the growing point ceases to exert control over lateral shoot development. Thus, a proliferation of side shoots can occur resulting in a 'witches broom' condition. Deformed flowers are a common plant symptom of B deficiency. Many plants may respond by reduced flowering and improper pollination, as well as thickened, curled, wilted and chlorotic new growth.

### 5.2.15 Calcium

Calcium occurs mainly in the leaves, and its main occurrence is as part of the cell walls. It is important for root development and in the activities of growing points. Its compounds do not move freely from older to younger tissues, which are always lower in calcium content. Deficiencies are first shown at the tips of young shoots; the result is reduced plant height. In legumes there is a broad inter-veinal chlorosis of central-basal portions of leaflets. Plant roots are less numerous, less branched, and root tips are thickened. [24]

## 5.3 Nutrient toxicity

Soil pH has an effect on the availability of most nutrients. Occasionally some nutrients are so readily available they inhibit plant growth. For example, on acid soils, Al and Mn levels may restrict plant growth, usually by restricting the rhizobia and the plants ability to nodulate.

23 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

24 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

**Table 4:** *Pulse reactions to nutrient toxicities*

| | Boron | Aluminium | Manganese |
|---|---|---|---|
| Chickpeas | sensitive | very sensitive | very sensitive |
| Faba beans | tolerant | sensitive | sensitive |
| Lentils* | very sensitive | very sensitive | very sensitive |
| Lupins* | * | tolerant | tolerant |
| Field peas | sensitive | sensitive | sensitive |

* This crop is not usually grown on alkaline/high boron soils.
Source: Pulse Breeding Australia

## 5.3.1 Boron toxicity

Boron toxicity is usually an inherent feature of a soil and is a particular problem when high boron levels occur in the subsoil. In Western Australia, boron toxicity occurs most commonly in the mallee regions north of Esperance, and on valley soils near lake chains in the south-eastern lakes area and the eastern wheatbelt. [25]

The most characteristic symptom of B toxicity in pulses is chlorosis (yellowing) of the tip and serrated margins of leaflets, and the tip of stipules on lower leaves. Older leaves are usually most affected. Light brown necrotic patches occur, and later develop on yellow areas. The necrotic areas expand to one-third of leaflets, and if severe, some withering, necrosis (death) of leaf tips or margins occurs. Leaflets can abscise. Anthocyanin pigmentation does not appear on plants under excess B conditions.

Field pea varieties, Excell, PBA Pearl⦇, Kaspa⦇, PBA Gunyah⦇, PBA Twilight⦇, Morgan, Parafield and PBA Percy⦇ are rated as susceptible (S) to boron.

MORE INFORMATION

DAFWA (2015) MyCrop: Diagnosing manganese toxicity in field peas.

## 5.3.2 Manganese toxicity

Manganese toxicity has not been diagnosed in field peas in Western Australia (WA). It has recently been diagnosed in canola on an acidic heavy soil with high manganese levels. Field peas are more tolerant than canola or cereals.

## 5.3.3 Aluminium toxicity

Aluminium toxicity can develop in field peas that are well nodulated, but grown on soils with low pH.

There are no visual symptoms of Al toxicity in field peas other than delayed germination and plants appearing miniature and dark green. Roots are extremely stunted, with many laterals appearing dead. Symptoms may be confused with P deficiency.

## 5.3.4 Salinity toxicity

Delays in germination occur with increasing levels of salinity in lentils and chickpeas, and to a lesser extent field peas. After germination, the first signs of salinity damage due to excess ion accumulation in saline conditions are necrosis of the outer margins and yellowing of the older leaves. Leaves die and abscise due to accumulation of ions. Salinity also reduces flower production and podsetting.

Field pea varieties differ in their tolerance to salinity. The best varieties are PBA Wharton⦇ and PBA Percy⦇, rated as Moderately Tolerant (MT). Parafield is rated as Moderately Susceptible (MS) to both salt and B toxicity. [26]

25 DAFWA (2016) Diagnosing boron toxicity. https://www.agric.wa.gov.au/mycrop/diagnosing-boron-toxicity-wheat

26 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

## Benefits of N fixation

Crop legumes are usually grown in rotation with cereals. The benefits to the system are measured in terms of increased soil total and plant-available nitrate N, and grain N and yield of the subsequent cereal crop, all relative to a cereal–cereal sequence.

The N available to the cereal is a combination of the N mineralised as part of the decomposition of legume residues and soil humus, and from applied fertiliser N. A fourth source of N is the mineral N not used by the legume during its growth, but spared. The residue N that is not released as mineral N remains in the soil as organic matter (Figure 1).

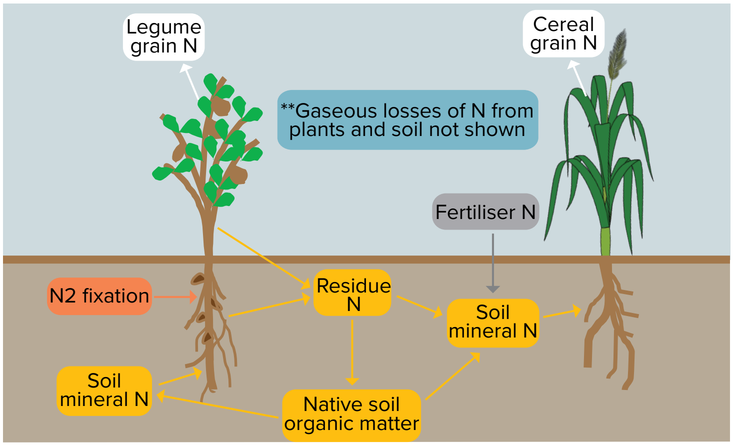


**Figure 1:** *Nitrogen cycling through a grain legume to the following cereal crop. Gaseous losses of N are not shown, nor are potential leaching losses. All of the flows of N are facilitated by the action of the soil biota.*

Source: D Herridge, 2013

Cereals grown after crop legumes commonly yield 0.5–1.5 t/ha grain more than cereals grown after cereals without fertiliser N. To generate equivalent yields in the cereal–cereal sequence, research has also shown that 40–100 kg/ha fertiliser N needs to be applied. [27]

### MORE INFORMATION

GRDC (2014) Nitrogen Fixation. Fact sheet.

GRDC Inoculating Legumes

27 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 4–General Agronomy.

# Weed control

## Key messages

- Field pea is not a strong competitor with weeds, so the best paddocks will have low weed burdens, especially of broadleaf weeds.
- The ability to plant late means that some cultural weed control is usually possible and that there is a greater range of post-emergent herbicides available for use in field pea than in other pulse crops.
- Field pea is sensitive to residues of sulfonylurea herbicides that may have been applied to a preceding cereal crop.
- Residues are likely to be greater on alkaline soils, and after a dry growing season and a dry summer.

Weed control is an essential part of growing a high yielding and effective field pea crop. Weeds not only compete for water and nutrients, but can also hinder the harvest process by blocking up machines. Weed seed in the sample can downgrade the quality of the grain, resulting in a lower price for the pulse at harvest. Grass weeds can harbour diseases such as crown rot and yellow leaf spot, and their presence in a field pea crop will decrease the effectiveness of the rotation crop as a disease break for cereal diseases. [1]

Weed control is important, because weeds can:

- rob the soil of valuable stored moisture
- rob the soil of nutrients
- cause issues at sowing time, restricting access for planting rigs (especially vine-type weeds, such as melons, and wire weed
- cause problems at harvest
- increase moisture levels of the grain sample (green weeds)
- contaminate the sample
- prevent some crops being grown where in-crop herbicide options are limited, i.e. broadleaf crops
- be toxic to stock
- carry disease
- host insects

Download the Integrated Weed Management Manual for more information.

**MORE INFORMATION**

Integrated Weed Management Hub

Integrated Weed Management Manual

GRDC (2013) Harvest weed seed control key to overcoming resistance.

GRDC (2010) Managing weeds—it starts with the seeds. Fact sheet.

GRDC/CropLife Australia (2008) Herbicide resistance mode of action groups

## 6.1 Weed issues for field peas

Problem weeds or issues that require special attention or are difficult to fully control include:

- annual ryegrass that is resistant to group A products ('dims' & 'fops'), particularly where high rates of clethodim (e.g. Select®) are required
- annual ryegrass that is resistant to trifluralin
- crop-topping can usually be conducted at the optimum stage for preventing rye-grass seedset and be safe for field peas
- snail medic (*Medicago scutellata*) and other types of medic
- wild radish–effective control can be difficult to achieve when population numbers are high or the radish are resistant to multiple herbicides.
- Delaying sowing allows effective pre-seeding knockdown.

Growing field peas means delayed sowing is possible in higher rainfall areas or with early maturing varieties, enhancing the opportunity for knockdown weed control

1 DAFWA (2016) Crop weeds: integrated weed management (IWM), https://www.agric.wa.gov.au/grains-research-development/crop-weeds-integrated-weed-management-iwm

before sowing. In addition, field peas can be grown in wider rows in a stubble system that might allow inter-row herbicide application with shielded sprayers.

If sowing into dry soil, a delay of 14–21 days before field peas emerge after germinating rains is not uncommon, depending on soil temperatures and depth of sowing. In the right circumstances, this might allow a non-selective knockdown herbicide application to kill emerged weeds just prior to the field peas emerging.

*Specific herbicides*

There are limitations in current herbicide products in conventional field pea varieties. Not all herbicide products registered and commonly used in other pulses are registered for use in field peas.

There are pre-sowing herbicide options (cyanazine, terbuthylazine, dinethenamid-P), post-sowing pre-emergent options (diuron, metribuzin) and two post-emergent options (diflufenican, flumetsulam) available for conventional field pea varieties. Under adverse conditions, most post sowing, pre-emergent herbicides are capable of causing damage to field peas. Varying soil types, unevenness in a paddock and instances of heavy rainfall after sowing washing herbicide into furrows can pose difficulties. Growers need manage the balance of herbicide rates for adequate weed control and minimise crop damage across the whole paddock. [2]

## 6.2 Integrated weed management

Yield losses caused by weeds can vary enormously from almost negligible to a complete loss. An Integrated Weed Management system (IWM) combining all available methods is the key to successful control of weeds.

### Crop rotation

A well-managed rotation in each paddock, which alternates broadleaf crops with cereal crops, including pastures, is a very useful technique for controlling weeds. For example, grass weeds are easier to control in broadleaf crops, and broadleaf weeds are easier to control in cereal crops. Good crop rotation management can substantially reduce the cost of controlling weeds with chemicals.

Pulses grown in rotation with cereal crops offer opportunities to easily control grass weeds with selective herbicides that cannot be used in the cereal years. An effective kill of grass weeds in pulse crops will reduce root disease carry over and provide a 'break crop' benefit in following cereal crops. Grass-selective herbicides can control most grass weeds in pulses, along with volunteer cereals.

### Good agronomic practice

Use cleaned and graded seed that is weed-free and sow on time with optimal plant populations and adequate nutrition. Some crops and varieties are more competitive against weeds than others. All weeds growing in a paddock should be controlled before the crop emerges. Large advanced weeds not controlled prior or during the sowing operation are often impossible to remedy with in-crop herbicides.

### Timely cultivation

Tillage is a valuable method for killing weeds and preparing seedbeds. There are varying combinations of mechanical and chemical weed control to manage fallows or stubbles. Knockdown herbicides are more commonly used instead of cultivation for fallow commencement, as well as pre-planting weed control in the autumn. These practices are providing clear benefits to soil structure, as well as more timely and effective weed control.

2 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

MORE INFORMATION

Integrated Weed Management Manual

Integrated Weed Management videos

Crop Life

Australian Glyphosate Sustainability Working Group

WeedSmart

### In-crop weed control

A wide range of pre-emergent and early post-emergent herbicides are available for grass weed control in field peas. With broadleaf weeds, post-emergent options are very limited. Weeds should be removed from crops early, and certainly no later than 6 weeks after sowing if yield losses are to be minimised. Yield responses will depend on weed species, weed and crop density and seasonal conditions. The stage of growth of the weed and the crop are vital factors to consider when planning the successful use of post-emergent herbicides.

### Herbicide resistance

Herbicide resistance continues to develop and become more widespread. It is one of the biggest agronomic threats to the sustainability of our cropping systems. The problem can be managed, however, through good crop rotations, rotating herbicide groups, and by combining both chemical and non-chemical methods of weed control (Table 1).

**Table 1:** *Weed control options for Integrated Weed Management (IWM)*

| | Herbicide options | Non-herbicide options |
|---|---|---|
| Crop phase | crop-topping in pulse/legume crops<br>knockdown herbicides, e.g. double-knock strategy before sowing<br>selective herbicides before and/or after sowing, but ensure escapes do not set seed<br>use of moderate Resistance risk herbicides<br>delayed sowing (as late as spring in some cases) with weeds controlled several times before sowing<br>brown manure crops | rotate crops<br>rotate varieties<br>grow a dense and competitive crop<br>cultivation<br>green manure crops<br>delay sowing<br>cut crops for hay/silage<br>burn stubbles/windrows<br>collect weed seeds at harvest and remove/burn<br>destroy weed seeds harvested<br>(use of Harrington Seed Destructor) |
| Pasture phase | spray topping<br>winter cleaning<br>selective herbicides, but ensure escapes do not set seed | good pasture competition<br>hay making or silage<br>cultivated fallow<br>grazing |

Source: GRDC

## 6.3 Knockdown herbicides

The most important part of the weed control strategy is to control the majority of weeds before seeding, either by cultivation or with knockdown herbicides such as glyphosate or Spray Seed®. [3]

3 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

## 6.4 Pre-sowing herbicides (IBS)

Cyanazine may be applied between 14 days before and up to sowing, and is often recommended in combination with trifluralin or pendimethalin. Terbuthylazine must be applied within 7 days of sowing.

Outlook® (dimethenamid) is very soluble, so could damage a crop after a heavy rain. It is likely to also be used with other herbicides.

Practical recommendations for use of Outlook® (dimethenamid) in pulses it is registered for:

- Moderate volatility means it should be incorporated soon after application. Delay in incorporation will result in loss of herbicide.
- As it requires water for activation, any delay in rainfall could result in less effective weed control.
- Outlook® (dimethenamid) will wash off crop residue, but can be lost by volatilisation if it remains on the surface a long time (7–14 days) before rainfall.
- Heavy rainfall can cause leaching below the weed seed zone and into the crop seed zone, which will result in more crop injury and less weed control.

Registered pre-emergent herbicides that are commonly used in Western Australia include:

- Trifluralin 480 1.5-2 L/Ha
- Diuron 900WG 400-500 g/Ha
- Spinnaker – be careful of plant-back and seek local advice for the suitable rate.

## 6.5 Pre-emergent herbicides

Pre-emergent chemicals are the most effective tool in field pea crops to control broadleaf weeds and generally result in less crop damage than the in-crop options. Pre-emergents are becoming increasingly important in grass weed control, as they offer alternative chemical modes of action to help control herbicide resistant weeds; in some areas, herbicide resistance to pre-emergent herbicides is quite low. Examples include Trifluralin (Treflan), Pendimethalin (Stomp), and Triallate (Avadex).

Pre-emergent herbicides:

- offer alternative modes of action to post-emergent and knockdown herbicides
- are very effective on hard-to kill weeds such as annual ryegrass and barley grass
- control weeds early, and they have potential over several germinations, to maximise crop yield potential
- suit a no-till seeding system with knife points and press wheels and/or disc seeders, as well as conventional tillage systems
- can be cost effective

Pre-emergent herbicides are primarily absorbed through the roots, but there may also be some foliar absorption (e.g. Terbyne®). Apply to flat soils that are relatively free of clods and trash. While most pre-emergent herbicides are suitable for use in high stubble load paddocks, modern labels will suggest adequate control with 50% ground cover. Sufficient rainfall (20–30 mm) to wet the soil through the weed root zone is necessary within 2–3 weeks of application.

Pre-emergent herbicides will not adequately control large weed populations by themselves, so they need to be used in conjunction with paddock selection, crop rotation and pre-seeding weed control.

The question of which pre-emergent herbicide to use can only be answered after assessing such factors as weed spectrum, soil type, farming system and local experience.

## 6.6 Post-sowing pre-emergent herbicides

*Terbyne® (750 g/kg terbuthylazine)*

Terbyne® is recommended for pre-emergent use (pre- or post-sowing).

Terbyne® controls a wide range of broadleaf weeds, with some suppression of grasses, particularly if there is good soil moisture. Sufficient rainfall (20–30 mm) to wet the soil through the weed root zone is necessary within 2–3 weeks of application. Best weed control is achieved from post-sowing application because rainfall gives the best incorporation of Terbyne®. Mechanical incorporation pre-sowing is less uniform, and so weed control may be less effective.

While Terbyne® is similar to the old triazine herbicides atrazine and simazine, it controls more weeds, lasts longer and is different in a number of ways, which make it more effective and safer for crops.

Terbyne® has significantly higher soil binding properties than atrazine or simazine leading to greater crop safety and better weed control.

Guidelines for use:

- Terbyne® ideally needs to be applied to moist soil as close to planting as possible. Moist soil helps fix the chemical onto the clay particles, and minimises degradation.
- Weed control will be more reliable if the seedbed is level and free of clods. When clods break down after rainfall, they expose untreated soil and disrupt the herbicide 'blanket'. Heavily ridged seedbeds often exhibit 'striping' and poor weed control on the 'hills'.
- Stubble does not present major problems, other than in heavy header trails or heavily 'bunched' from tillage operations.
- Avoid shallow planting if Terbyne® is to be used, as crop tolerance is based on physical separation of the chemical from the roots. A planting depth of 5 cm is normally adequate on clay soils.
- Crop damage is often evident in compacted wheel tracks due to shallower planting depth and/or the concentration of chemically treated soil in the wheel-track depressions after rain.
- The planting furrow or trench needs to be closed and levelled at planting. This will minimise the risk of herbicide treated soil being washed in and concentrated near the seedling.
- Good subsoil moisture at planting will also help minimise the risk of crop damage as roots develop down into moisture, rather than developing a shallow root system in the topsoil (where product activity is greatest).
- Avoid using Terbyne® on coarse textured, sandy loam soils as even low rates can leach down to the roots and cause significant crop damage.
- Avoid overlapping and double spraying on headlands when applying Terbyne®. [4]

*Sencor® (480 g/L metribuzin and others)*

Depending on soil type, heavy rain (>10–20 mm) after spraying can leach metribuzin into the root zone causing crop damage. Risk of leaching of metribuzin is greatest on sandy soils, followed by friable well-structured soils. Very heavy rain (>80–100 mm) after spraying on deep sandy or friable well-structured soils, may cause crop damage and leach metribuzin beyond the root zone, thus reducing residual effect. The label states metribuzin should not be applied until the soil is wet by the first goos soil-settling rain.

The chemical application rate used must match the soil type (see product label). Apply to crops that were sown at greater than 5 cm deep to minimise damage through root uptake.

4 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

With no-tillage planting systems that use knife points and press wheels, the risk of crop damage is increased, especially on light soil types and if heavy rain falls after spraying. Herbicide wash into the furrows can occur.

General guidelines for use are very similar to those for Terbyne®.

*Spinnaker® (700 g/kg imazethapyr)*

Imazethapyr is a group B herbicide.

Apply to moist, well-prepared, clod and weed-free soil after planting and before crop emergence. Sufficient rainfall is required (after application, and prior to weed emergence) to wet soil to a depth of 5 cm. Under adverse conditions, weeds may not be totally controlled, but populations will be significantly reduced, and surviving plants will generally be severely retarded. Good crop growth will aid weed control.

## 6.7 Contamination of spray equipment

Traces of sulfonylurea herbicides (such as chlorsulfuron, metsulfuron or triasulfuron) and carfentrazone in spray equipment can cause severe damage to field peas. Spray-tank contamination of small quantities of sulfonylurea herbicides such as Glean® and Logran® can be extremely damaging to crops such as pulses, canola and other oilseed crops as well as legume pastures. Grass-control herbicides such as Verdict™, Fusilade® Forte, Correct®, Select®, Targa® and Sertin® can be extremely damaging to winter and summer cereals.

**Photo 1:** *Damage to field peas from failing to decontaminate the spray tank after use of Eclipse®*

Photo: W. Hawthorne, formerly Pulse Australia

Rinse water should be discharged into a designated disposal area; or if this is unavailable, onto unused land away from plants and water sources. [5]

As a guide, use fresh chlorine bleach (household grade containing 4% chlorine) at a rate of 300 mls/100 L water. Allow to stand for 15 minutes with agitation engaged, then drain. [6]

MORE INFORMATION

NSW DPI (2016) Weed control in winter crops 2016.

GRDC (2009) Field Pea: The Ute Guide.

5 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

6 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

## 6.8 Herbicide resistance

Ryegrass surviving selective herbicides used in pulses can be controlled by crop-topping with a desiccant herbicide.

Desiccation and crop-topping are well-established techniques to aid in herbicide resistance management, and to improve the rotational fit, benefits and profitability of the pulse crop. While they are essentially the same physical operation of applying a desiccant herbicide close to final maturity of the pulse, they do achieve different objectives and must be applied with care. Swathing may be considered as an alternative to desiccation. The timing of swathing is similar to desiccation.

When applying pesticides, the aim is to maximise the amount reaching the target for the best pesticide effectiveness and reduced damage and/or contamination of off-target crops and areas.

Pulse crops can be severely damaged by some hormone herbicide sprays, such as 2,4-D ester, drifting into the crop. This can happen when these sprays are applied nearby in very windy or still conditions, especially where there is an inversion layer of air on a cool morning.

When using these herbicides, spray when there is some wind to mix the spray with the crop. Do not use excessively high spray pressure, which will produce very fine droplets that are more likely to drift onto a neighbouring pulse crop. [7]

### Ten ways to weed out herbicide resistance

1. Act now to stop weeds from setting seed.

- Destroy or capture weed seeds.
- Understand the biology of the weeds present.
- Remember that every successful WeedSmart practice can reduce the weed seedbank over time.
- Be strategic and committed—herbicide resistance management is not a one-year decision.
- Research and plan your WeedSmart strategy.
- You may have to sacrifice yield in the short term to manage resistance—be proactive.
- Find out what other growers are doing, and visit www.weedsmart.org.au

2. Capture weed seeds at harvest.

- Options to consider are:
    - towing a chaff cart behind the header
    - checking out the new Harrington Seed Destructor
    - creating and burning narrow windrows (Photo 2)
    - producing hay where suitable
    - funnelling seed onto tramlines in controlled traffic farming (CTF) systems
    - using crop-topping where suitable (field peas offer this option)
    - using a green or brown manure crop to achieve 100% weed control and build soil nitrogen levels. Field peas are perfect for this use

7 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 5–Weed Management.

**Photo 2:** *An example of narrow windrow burning.*

Photo: Penny Heuston

3. Rotate crops and herbicide modes of action.

- Look for opportunities within crop rotations for weed control.
- Understand that repeated application of effective herbicides with the same mode of action (MOA) is the single greatest risk factor for evolution of herbicide resistance.
- Protect the existing herbicide resource.
- Remember that the discovery of new, effective herbicides is rare.
- Acknowledge there is no quick chemical fix on the horizon.
- Use break-crops where suitable.
- Growers in high-rainfall zones should plan carefully to reduce weed populations in the pasture phase prior to returning to cropping.
- Use a green or brown manure crop to achieve 100% weed control and build soil nitrogen levels.

4. Test for resistance to establish a clear picture of paddock-by-paddock weed status.

- Sample weed seeds prior to harvest for resistance testing to determine effective herbicide options.
- Use the 'Quick Test' option to test emerged ryegrass plants after sowing to determine effective herbicide options before applying in-crop selective herbicides.
- Visit WeedSmart or AHRI for more information on herbicide-resistance survey results.

5. Aim for 100% weed control and monitor every spray event.

- Stop resistant weeds from returning into the farming system.
- Where herbicide failures occur, do not let the weeds seed. Consider cutting for hay or silage, fallowing or brown manuring the paddock.
- Patch-spray areas of resistant weeds only if appropriate.

6. Do not automatically reach for glyphosate.

- Use a diversified approach to weed management.
- Consider post-emergent herbicides where suitable.

## MORE INFORMATION

CropLife Australia: Herbicide Resistance Management Strategies

WeedSmart

Australian Herbicide Resistance Initiative (AHRI)

GRDC (2015) Best practice spray application in the western region (includes links to fact sheets)

GRDC/CropLife Australia: Herbicide Resistance Mode of Action Groups

CropLife Australia: Herbicide Mode of Action Table

- Consider strategic tillage.

7. Never cut the on-label herbicide rate and carefully manage spray drift and residues.

- Use best management practice in spray application. GRDC has produced a series of fact sheets, available at www.grdc.com.au
- Consider selective weed sprayers, such as WeedSeeker or WeedIt.

8. Plant clean seed into clean paddocks with clean borders.

- It is easier to control weeds before the crop is planted.
- Plant weed-free crop seed to prevent the introduction of new weeds and the spread of resistant weeds.
- A recent AHRI survey showed that 73% of grower-saved crop seed was contaminated with weed seed.
- The density, diversity and fecundity of weeds are generally greatest along paddock borders and areas such as roadsides channel banks and fence lines.

9. Use the double-knock technique.

- The double-knock technique is the use of any combination of weed control that involves two sequential strategies; the second application is designed to control survivors of the first method of control used.
- See GRDC research results at https://grdc.com.au/ or http://www.nga.org.au/

10. Employ crop competitiveness to combat weeds.

- Consider narrow row spacing and increased seeding rates.
- Consider twin-row seeding points.
- Use barley, canola, and varieties that tiller well.
- Use high-density pastures as a rotation option.
- Consider brown manure crops.
- Rethink bare fallows. [8]

## 6.9 Potential herbicide damage

Herbicide injury may be very obvious (e.g. scorched leaves) or it may undefined (e.g. poor establishment or delayed maturity). Herbicide crop injury symptoms can easily be confused with symptoms produced by other causes, such as frost, disease or nutrition (Photos 3 and 4).

Care should be taken when using crop oils and penetrants with herbicides, as these can increase the uptake of active chemicals and exceed crop tolerance. Always follow the herbicide label.

Pulse crops can be severely damaged by some herbicides. Soil residues from previous applications, contaminants in spray equipment, spray drift onto the crop, or incorrect use of the herbicide can all result in damage to the crop.

Herbicide efficacy and crop safety of the new crop can suffer if the soil is dry at application time.

Taking some general precautions can help to reduce the likelihood of crop damage from residual herbicide use:

- Do not apply if rain is imminent.
- Maintain at least 7.5–10 cm soil coverage.
- Avoid leaving a furrow or depression above the seed that could allow water (and chemical) to concentrate around the seed/seedling.
- Avoid leaving an exposed, open slot over the seed with disc-openers and avoid a cloddy, rough tilth with tined-openers.

8 GRDC (2013) WeedSmart. Grains Research and Development Corporation, http://www.weedsmart.org.au/wp-content/uploads/2013/01/CIC_102505_Weedsmart-brochure_22-FINAL.pdf

*Grass herbicide damage in field pea*

Group A herbicides can occasionally cause leaf spotting in field peas. This is usually associated with either frost or high temperatures occurring soon after spray application.

**Photo 3:** *Spinnaker (imazethapyr) damage in Maki field peas.*

Photo: Penny Heuston

**Photo 4:** *Field peas showing damage from Metribuzin.*

Source: DAFWA

# Insect control

## Key messages:

- The two main insects that pose a threat to field pea production and grain quality are pea weevil and native budworm. There is no varietal resistance to either pest.
- Insects are cold-blooded and their growth depends on temperatures in their environment.
- Long term use of broad-spectrum pesticides for invertebrate pest control is not sustainable.
- Insects can impact on visual and physical quality of field peas as well as yield.

## 7.1 Insect pests

Insect control is essential for field peas, not just to preserve the yield, but to ensure the end product is free from damage. It is particularly important for field peas destined for human consumption where visual appeal is paramount.

It is important to be able to identify the various insects present, whether they are pest or beneficial species, and their growth stages.

Native budworm and pea weevil (*Bruchus pisorum*) are the most damaging pests of field peas. They not only reduce yields but also affect seed and grain quality. [1]

Crops should be checked frequently throughout the growing season. Infestation can occur at any time, but crops are most susceptible to serious damage during emergence–establishment and from flowering and pod formation until harvest. Heavy insect attack during flowering and pod formation can reduce field pea yield and quality significantly (Table 1). [2]

FAQ

## 7.2 Insect control thresholds

Insect control thresholds provide guidelines to allow timely decisions for crop spraying. This can reduce unnecessary spraying and keep populations from reaching a level where damage is high.

The most common threshold used involves control at a density that will prevent the pest numbers from reaching an economically damaging population. Table 1 outlines the crop growth stages at which common field pea insect pests are either present or damaging. [3]

1 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

2 K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops 2013. New South Wales Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

3 K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops 2013. New South Wales Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

*Spray for native budworm if one budworm is found in ten sweeps and do a boarder spray for pea weevil if one weevil is found in 20 sweeps.*

Agronomist's view

**Table 1:** *insect threshold levels*

| Pest | Control thresholds | Sampling recomendation | Additional notes |
|---|---|---|---|
| Caterpillars: brown pasture looper | 10-12 loopers per $m^2$ | Examine plants, old litter and soil surface in 0.5m of row. Repeat at 5-10 sites | Larvae may migrate into crop edges from nearby capeweed |
| Caterpillars: cutworms | 2-3 cutworm per $m^2$ | Examine plants, old litter and soil surface in 0.5m of row. Repeat at 5-10 sites | Apply as soon as pest is noticed at threshold levels |
| Lucerne flea | Consider control measures if holes are increasingly being found on leaves | Inspect 0.5m of crop row. Look for characteristic holes in leaves. Repeat at 5-10 sites | Commonly found on soils with loam or clay texture |
| Mites: Balaustium mites | Look for silvering on extensive areas of cotyledons and leaves and stress caused to plants | Cotyledons and first true leaves appear silvered and leathery, sometimes may shrivel and seedling may die. Damage occurs post emergence | Found on weeds, soil and seedlings |
| Mites: clover mite | Look for silvering on extensive areas of cotyledons and leaves and stress caused to plants | Same damage as redlegged earth mite. White lines often seen on top of cotyledons. Seedling may shrival and die | Found on weeds, soil and seedlings |
| Mites: redlegged earth mite | Look for silvering on extensive areas of cotyledons and leaves and stress caused to plants | Cotyledons appear 'leathery', silver, twisted shrivelled and seedlings may die. Damage may occur before seedling emergence | Found on weeds, soil and seedlings |
| Slugs: black keeled slug, reticulated slug | 10 or more slugs per $m^2$ | They are found on plants at night or hidden under clods, trash or other objects during the day | Chewed leaves or whole plants. They sometimes feed on lupin seeds at seeding.slime trails may sometime be seen |
| Snails: white italian snails, vineyard snail,<br>small pointed snail | 5 or more snails per $m^2$<br>3 or more snails per $m^2$ | Found on leaves, stems or other nearby objects | Look for chewed leaves, slime trails may sometimes be seen |

Source: DAFWA

The following factors should be monitored and considered when using thresholds and making spray decisions:

- Environmental conditions and the health of the crop.
- Extent and severity of the infestation and how quickly the population increases.
- Prevalence of natural control agents such as parasitic wasps, predatory shield bugs, ladybirds and diseases.
- Type and location of pest damage and whether it affects yield indirectly or directly.
- Stage in the life cycle of the pest and the potential for damage.
- Crop stage and ability of the crop to compensate for damage.
- Amount of damage which has already occurred and the additional damage that will occur if the crop is not sprayed.

MORE INFORMATION

DAFWA (2016) Pulse crops–insect threshold levels.

- Value of the crop (high value crops cannot sustain too much damage as a small loss in yield or quality could mean a large financial loss), compared to the cost of the spraying and the likely yield or quality benefit gained from control. [4]

Note that the impact of insects on grain quality in pulses can be far greater than yield damage. This must be accounted for in thresholds because in pulses visual quality has a large impact on price.

## 7.3 Integrated pest management

Integrated pest management (IPM) is primarily based around biological control of pests by either encouraging natural enemies or release of biocontrols. [5]

IPM is an ecological approach and uses a range of complementary methods including mechanical and physical devices, as well as genetic, biological, cultural and chemical management. The main goal is to significantly reduce the use of pesticide. The reduction in cost, contamination, residues and resistance to pesticides are all benefits.

The widespread adoption of low and no-tillage (no-till) farming systems has changed the arthropod pest mix and increased the abundance of some species, such as earth mites, ground beetles and several other pest species. This challenge has mainly been met by growers with use of pesticides, especially the broad-spectrum synthetic pyrethroids (SPs). These have proved highly effective and relatively inexpensive. However, as with use of herbicides, there is an increased risk this approach will accelerate the development of resistance.

Resistant RLEM have already been confirmed in WA and more outbreaks of resistant populations are likely. To achieve long-term sustainability, there is a need to develop IPM strategies that minimise the risks of pesticide dependence and resistance build-up. The incursion of new species, the anticipated loss of cheap generic insecticides, market pressures for insecticide-free grain and community and environmental concerns about spray drift mean 'clean and green' management strategies - such as IPM - are required for broadacre agriculture in Australia. [6]

IPM is performed in three stages: prevention, observation and intervention.

An IPM system is designed around five basic components:

### Acceptable pest levels

Emphasis is on control, not eradication. Wiping out an entire pest population is unlikely and can be economically expensive and environmentally unsafe. IPM programs work to establish acceptable pest levels (action thresholds) and then apply controls if those thresholds are exceeded. Thresholds are pest and site specific. What is acceptable at one site may not be acceptable at another site or crop.

### Preventive cultural practices

Use varieties best suited to local growing conditions, and maintain healthy crops. This is the first line of defence together with plant hygiene and crop sanitation (e.g. removal of diseased plants to prevent spread of infection). Mechanical methods used for snail control such as burning, rolling or cabling can work out of season as pests are unlikely to reach an unacceptable level when there is no crop.

4 K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops 2013. New South Wales Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

5 K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops 2013. New South Wales Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

6 D Hardie and GRDC (2009) Developing and promoting Integrated Pest Management in Australian grains https://grdc.com.au/research/reports/report?id=3822

### Monitoring

Regular observation is the key to IPM: observation is broken into inspection and then identification. Visual inspection, insect traps and other measuring tools are used to monitor insect pest levels. Accurate pest identification is critical to a successful IPM program.

For insects, monitoring for beneficial organisms and predators is important too. These are important to assist in controlling the pest. Record-keeping is essential, as is a thorough knowledge of the behaviour and reproductive cycles of target pests.

Insects are cold-blooded and their physical development is dependent on temperatures in their environment. Many insects have had their development cycles modelled in terms of degree days (e.g. etiella, pea weevil). Monitor the degree days of an environment to determine when is the optimal time for a specific outbreak.

Use synthetic pesticides only as required and at specific times in a pest's life cycle. Many newer pesticide groups are derived from plants or naturally occurring substances. Examples are nicotine, pyrethrum and insect juvenile hormone. The active component may be altered to provide increased biological activity or stability.

Insecticides that are less toxic to beneficial insects should be used where possible. For example, pirimicarb for aphid control may mean less repeat applications compared with the use of synthetic pyrethroids because beneficial insects are preserved. [7]

**MORE INFORMATION**

GRDC (2009) Integrated pest management (national). Fact sheet.

### Resources

PestWeb is a searchable database that contains identification and control information for over 150 insect and allied pests of agricultural and quarantine significance. Entomologists from the Department of Agriculture and Food, Western Australia (DAFWA) add new pest records as required to provide a dynamic guide.

A mobile version of this database is available for iPhone and Android platforms as 'MyPestGuide'.

DAFWA Diagnostic Laboratory Services—an amalgamation of DAFWA plant and animal laboratory and inspection services—have services available for identification of insects. Take a photo of the damage and the pest and send in clear photos with a brief description and your contact details via MyPestGuide (preferred method), email info@agric.wa.gov.au or phone 1800 084 881.

For information on how to send specimens for identification go to: https://www.agric.wa.gov.au/livestock-biosecurity/sending-specimens-identification

GRDC has a range of phone apps available. For more information, go to: https://grdc.com.au/Resources/Apps

Other resources include:

- GRDC Ute Guide—insects
- GRDC Crop Insects: The Ute Guide Western Grain Belt Edition
- Driving Agronomy Podcasts
- The Australian National Insect Collection online tools
- PestFax Map

## 7.4 Sampling methods/protocols

Knowing when field pea crops are susceptible to pest attack is the first step in good pest management. For example, native budworm. do most damage during pod set through to maturity. Seedling insect pests, such as cutworm, can attack field pea early.

7 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

All crops should be scouted for insects at regular intervals, usually once per week during establishment and from flowering onwards.

### Sweep net

The easiest and quickest way to determine the number of grubs in a crop is to 'sweep' the crop with an insect sweep net. It is impossible to accurately determine numbers by simply looking in the crop.

A standard sized net (380 mm in diameter) can be purchased from most chemical suppliers.

Follow these steps:

- Take ten sweeps of the net through the crop canopy while walking slowly through the paddock. A standard sweep of the net needs to be about 2 m in length.
- Empty the contents into a tray or bucket and count the caterpillars of various sizes. It is important to look very carefully for small caterpillars as these have the most potential to cause damage.
- Repeat this process a number of times throughout the paddock to obtain an average insect density.

Sampling with a sweep net provides information including:

- Presence or absence, and levels of, non-flying juvenile stages (eggs, larvae, pupae).
- Presence or absence, and levels of, non-flying adult insects (mites, snails etc.).
- Early stages and extent of pest damage.

### Tiles, hessian bags and slug traps

Use a tile, hessian bag or slug trap left in the paddock over night to count snail or slug numbers. There are many types of slug traps available for home garden use. Use surface traps baited with layer mash and check them early in the morning, as slugs move out of the traps as the day starts to warm up.

### Record results from monitoring

Keeping records should be a routine part of insect checking. Successive records of crop inspections will show whether pest numbers are increasing or decreasing, and help in deciding whether a spray is necessary.

Insect checking records should include as a minimum:

- date and time of day
- crop growth stage and susceptibility
- change in the number of insects present (pest and beneficial) and their stage of development over time
- type of checking method used and number of samples taken per paddock
- control recommendation, if any
- post-spray counts. [8]

## 7.5 Major pests of field peas

The two main insects that pose a threat to field pea production and grain quality are pea weevil and native budworm. There is no varietal resistance to either pest.

Field pea are also prone to insect damage from redlegged earthmite (*Halotydeus destructor*), lucerne flea (*Sminthurus viridis*), cutworm (*Agrotis* spp.), aphids (*Aphis cracciuora*, *Acyrthosiphon kondoi*) and pasture looper (*Chrysodiexis* spp.).

8 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

### 7.5.1 Native budworm (*H. punctigera*)

#### Description

Adult moths of *H. punctigera* are nocturnal, so are rarely seen during the day. They vary in colour from grey-green to pale cream and have a wing span of 3–4.5 cm. The hind wings have a dark, broad band on the outer margin.

The adult moths lay round eggs (0.5 mm in diameter), singly on the host plant. The eggs are white but turn brown just before hatching. The larvae grow to 5 cm long and vary in colour from green, yellow pink and reddish brown to almost black.

Larvae can be easily identified, despite the colour variation, by a broad yellow stripe along the body. The young larvae (less than 10 mm) prefer to feed on foliage. Older larvae prefer to feed on pods.

#### Damage

The larvae bore into the pods and usually destroy the seeds in each pod (Photo 1). One larva may attack four to five pods before reaching maturity. The amount of damage to each seed varies considerably, but the damaged area has jagged edges. This contrasts with damage from pea weevil in field pea which leave a cylindrical, smooth, circular exit-hole.

**Photo 1:** *Damage to pod and seed caused by native budworm.*

Source: Gordon Cumming, Pulse Australia

#### Life cycle

In WA, native budworm produce three generations a year. The spring generation causes the most damage, especially to grain legume crops. During winter, native budworm enters a resting period as a pupa in the soil. Adult moths emerge from these overwintering pupae in August and September and live for about 2–4 weeks. The moths are capable of laying up to 1,000 eggs each.

The eggs hatch 1–2 weeks after laying in spring and the larvae feed in crops for 4–6 weeks. The mature larvae leave the host plant to pupate in the soil. During spring, summer and early autumn the pupae develop quickly and a new generation of moths emerges after about 2 weeks.

#### Monitoring

Native budworm do most damage during pod set through to maturity, and can reduce both grain yield and quality. Regular monitoring is important if targeting small and possibly insecticide resistant larvae.

Check crops regularly for native budworm larvae, usually once per week prior to pod set and two to three times a week from pod set onwards. Activity of adult moths in the crop, and the presence of eggs may be indicative of future larval activity.

The quickest and easiest method to sample most crops is to use a sweep net (380 mm diameter). It works well in short and thin crops such as field peas, lentils and vetch.

Repeat the sweeping process of ten sweeps in at least a dozen places throughout the paddock to obtain an average caterpillar density.

### Control

The decision to spray for field pea needs to be considered from the time of first podding.

If caterpillar numbers are below the threshold levels, the decision to spray should be delayed and periodic sampling continued. One well-timed spray to control native budworm caterpillars should be sufficient in most situations.

Sweep netting of the crop should be carried out after spraying to confirm that the required level of control has been obtained. Effectively applied synthetic pyrethroids will prevent reinfestation for up to six weeks after spraying. Subsequent caterpillar hatchings will usually be too late to cause any damage.

### Economics of spraying

The number of caterpillars present in a crop is the major factor determining whether economic damage will occur.

Crop loss (kilograms per hectare) for each caterpillar netted in 10 sweeps (or found per square metre) is shown in the table. For one caterpillar netted in 10 sweeps is equivalent to about 20 000 caterpillars per hectare for most pulse crops.

The losses given are for the number of caterpillars netted in crops during early pod formation for all crops except lupins and canola. For these canola and lupins numbers are during pod maturation.

To use the table you need to substitute:

- control costs with your own actual costs
- expected grain price per hectare based.

This will calculate the economic threshold or the number of caterpillars that will cause more financial loss than the cost of spraying.

**Table 2:** *Example to calculate the economic threshold or the number of caterpillars that will cause more financial loss than the cost of spraying*

The on-farm value of field peas is $185 per tonne (t)
The cost of control is $12 per hectare (ha)

ET = C ÷ (K x P)
Where:
ET = Economic threshold (numbers of grubs in 10 sweeps)
C = Control cost ( includes price of chemical + application) ($ per ha)
K = Kilogram per hectare (ha) eaten for every one caterpillar netted in 10 sweeps or per square metre (see Table 3)
P = Price of grain per kg (price per tonne ÷ 1000)

Therefore economic threshold for field pea = 12 ÷ (50 x (185 ÷ 1000)) = 1.3 grubs per 10 sweeps

**Table 3:** *Economic thresholds (ET) for native budworm on various crops*

| Crop | P Grain price per tonne | C Control costs including chemical + application | K Loss for each grub in 10 sweeps (kg/ha/grub) | ET Grubs in 10 sweeps | ET Grubs in 5 lots of 10 sweeps | ET Grubs (>15mm) per m2 |
|---|---|---|---|---|---|---|
| Field pea - trailing type (for example, Helena, Dundale) | 200 | 10 | 50 | 1.0 | 5 | - |
| Field pea - semi leaf less (for example, Kaspa) | 200 | 10 | 100 | 0.5 | 2.5 | - |
| Chickpea | 420 | 10 | 30 | 0.8 | 4 | - |
| Faba bean | 280 | 10 | 90 | 0.4 | 2 | - |
| Lentil | 420 | 10 | 60 | 0.4 | 2 | - |
| Canola | 270 | 10 | 6 | 6.2 | 31 | - |
| Lupin | 175 | 10 | 7 | - | - | 8.2 |

Note: Growers using this table to calculate spray thresholds should substitute their own control costs and the current on-farm grain price expected.

Where:

ET = Economic threshold (numbers of grubs in 10 sweeps)
C = Control cost ( includes price of chemical + application) ($ per ha)
K = Kilogram per hectare (ha) eaten for every one caterpillar netted in 10 sweeps or per square metre
P = Price of grain per kg (price per tonne ÷ 1000)

MORE INFORMATION

DAFWA (2016) Management and economic thresholds for native budworm.

*Adjusting thresholds*

Use of the table and calculations will provide a personalised and more precise measure of potential loss from native budworm damage. Sometimes the loss would turn out to be less than predicted, if, for example, the season is shortened by a lack of moisture.

Premiums paid for exceeding quality standards for high value and large-seeded pulses (like Kabuli chickpea) may necessitate even lower thresholds than those provided in the table. The spraying program should aim to control larvae less than 10 mm long because bigger larvae require higher rates of insecticides. The larvae must be sprayed before they burrow into the seed pods or they will be shielded from insecticides and will continue to damage seed. [9]

## 7.5.2 Pea weevil (*Bruchus pisovum*)

The pea weevil (*Bruchus pisorum*) is actually a beetle, however industry refer to *B. pisovum* as 'pea weevil'. The Australian pea weevil is one of the most damaging pests of field pea industry. It not only reduces yield but can also reduce germination rates of seed and grain quality to the point that it is unfit to sell for human consumption.

### Description

The pea weevil is a small and short in length (5–6 mm long), chunky, brownish beetle flecked with white, grey, and black (Photo 2). The white tip of the abdomen is marked with two black, oval spots. The white larvae have a brown head capsule and mouthparts.

9 DAFWA (2017) Management and economic thresholds for native budworm https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm?page=0%2C4

**Photo 2:** *Pea weevil.*

Source: Grain Legume Handbook

The larva is C-shaped, up to 6 mm long, legless, brown-headed, and cream in color. Adults feed on field pea pollen, and the female lays eggs on developing field pea pods. The larva burrows directly through the pod, where it feeds and develops in the developing pea seed. While one larva develops in a single seed, nearly every field pea may be infested when populations are high.

## Life cycle

The pea weevil has one generation each year. Adults become active when temperatures reach around 20°C and move into field pea crops from their hibernation sites (under tree bark, on posts, along fence lines, around sheds and in bins). Dispersing adults characteristically invade from the edge of the crop and rarely move more than 50 m into the crop. Females must feed on field pea pollen to mature their eggs, which usually takes several weeks. When mature, females lay eggs on the outside of green pea pods.

The eggs (orange in colour) are easily seen by the naked eye and are attached like glue to the pod tissue. The eggs hatch roughly two weeks after laying, the larva channels through the tissue directly below the egg. The number of eggs laid on the surface of a pod usually results in an equivalent number of damaged seeds. The larva enters a seed and feeds for five to seven weeks, in which time it grows to occupy much of the seed. When it is almost fully grown, the larva chews a circular exit hole, 3 mm in diameter, leaving only a translucent skin above the hole (Photo 3).

**Photo 3:** *Example of the holes created in field pea seed by pea weevil as they emerge from the mature field pea seed.*

Source: Department of Agriculture and Fisheries Queensland

**Photo 4:** *Pea weevil damage*

Source: DAFWA

MORE INFORMATION

[DAFWA (2016) Management and economic thresholds for native budworm.]

[DAFWA (2015) Diagnosing aphid damage in field peas.]

[GRDC (2015) Crop Aphids Back Pocket Guide.]

[GRDC (2015) Resistance management strategy for the green peach aphid in Australian grains. Fact sheet.]

The larva pupates in the seed (pupation usually occurs after harvest). The pupa develops into an adult, usually during the time when the grain is put into storage. Adults emerge over several months starting in mid-December. Adult beetles fly to hibernation sites and remain there during summer, autumn and winter. They resume activity when spring temperatures reach about 20°C.

#### Damage

A circular hole of 3 mm diameter in pea seeds. Heavily infested crop may suffer significant weight loss from feeding by pea weevil.

#### Control

A sweep net is the simplest and best tool to use to detect how many adult beetles (pea weevil) occur in the crop. Sample in early spring, but prior to the first pod formation. [10]

Take 25 sweeps within 1-5m of the crop edge. Repeat this at six or more sites.

If weevils are found take more samples from the inside of the crop.

Thresholds:

Peas grown for human consumption: one beetle per 100 sweeps

Peas for stock feed: one beetle per 25 sweeps [11]

### 7.5.3 Aphids

Aphids are small, soft-bodied, winged or wingless insects that damage field peas in WA through transmission of viruses rather than direct feeding damage. The main species are pea aphid (*Acyrthosiphon pisum*), green peach aphid (*Myzus persicae*), bluegreen aphid (*Acyrthosiphon kondoi*) and occasionally cowpea aphid (*Aphis craccivora*). It is unusual for aphids to colonise field peas: winged aphids typically move through the crop and may spread viruses as they move. [12]

#### Description

*Adult insects:*

- The pea aphid is up to 4 mm long, and may be yellow, green or pink in colour. They have black knees and dark joints on their antennal segments. These aphids feed primarily on field pea, faba bean and lucerne.
- The green peach aphid tends to be shiny or waxy, and ranges from yellow, through to green and pink. It can be similar in colour to young unfurled field pea leaves. The green peach aphid has a wide host range including canola, lupins and other pulse crops, and can also be found on weeds including wild radish, doublegee and blackberry nightshade.
- The bluegreen aphid is up to 3 mm long, and matt bluish-green. Large numbers of winged bluegreen aphid fly from pastures to crops later in the growing season (Photos 5 and 6).
- The cowpea aphid has a black body and black and white legs. It is not typically found on field pea, but often colonises lupin and faba bean plants (Photo 7).

Correct identification of the aphids is critical. Green peach aphids are resistant to organophosphorus, carbamate and synthetic pyrethroid insecticides, and can be difficult to control. Green peach aphids are easily identified; they tend to be found on the underside of leaves and vary in colour from bright green to pink. [13]

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10 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

11 DAFWA (2017) Management and economic thresholds for pea weevil https://www.agric.wa.gov.au/pest-insects/management-pea-weevil?page=0%2C2

12 DAFWA (2015) Diagnosing aphid damage in field peas. Department of Agriculture and Food, Western Australia, May 2015, https://www.agric.wa.gov.au/mycrop/diagnosing-aphid-damage-field-peas

13 DAFWA (2015) Diagnosing aphid damage in field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-aphid-damage-field-peas

**Photo 5:** *Bluegreen aphid.*

Source: Grain Legume Handbook

**Photo 6:** *Young and older bluegreen aphids. The brown aphids are dead bluegreen aphids which have been parasitised by wasps.*

Source: Grain Legume Handbook

**Photo 7:** *Cowpea aphids. Note the different aphid ages: the older aphids are shiny black, the younger ones have a white cast as skin that is shed as the aphid grows.*

Source: Grain Legume Handbook

## 7.6 Mites

The two main species that can pose a problem the redlegged earth mites and blue oat mite.

Monitor these pests closely from emergence up to the fournode stage. If crop damage becomes apparent, undertake appropriate control measures. [14]

### 7.6.1 Redlegged earth mite *(Halotydeus destructor)*

#### Description

The redlegged earth mite (RLEM) grows to about 1 mm in length. Adults have a velvety black body and eight red legs (Photo 8 15). Newly hatched mites are pinkish-orange with six legs and are 0.2 mm long. Nymphs develop into mature adults in approximately four to six weeks.

In autumn, over-summering eggs hatch when there is significant rainfall and the mean daily temperatures fall below approximately 21°C. RLEM can have three generations per season.

MORE INFORMATION

GRDC (2016) RLEM resistance management strategies Ground Cover Radio 122.

DAFWA (2015) Diagnosing RLEM.

GRDC (2012) Crop Mites: Back Pocket Guide.

14 P Matthews, D McCaffery, L Jenkins (2016) Winter crop variety sowing guide 2016. New South Wales Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2016.pdf

**Photo 8:** *Redlegged earth mite.*

Source: Grain Legume Handbook

## Life cycle

Earth mites are active in the cool, wet part of the year, usually between April and November. During this winter-spring period, RLEM may pass through three generations, with each generation surviving six to eight weeks. Prolonged plant growth during long, wet springs favours the production of over-summering eggs.

Autumn rains trigger hatching in three to nine days. False breaks in the season can cause large losses in mite numbers. Mites take 20–25 days to mature and start laying eggs (Figure 1).

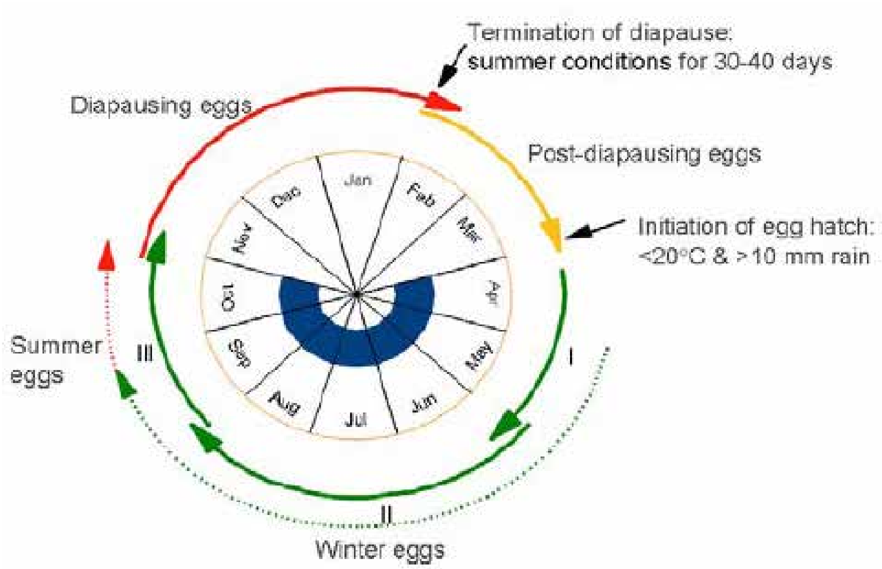


**Figure 1:** *Life cycle of redlegged earth mite.* [15]

Source: Agriculture Victoria

15 P Umina (2007) Redlegged Earth Mite. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/redlegged-earth-mite

### Monitoring

Inspect susceptible crops from autumn to spring for mites and their damage (Photo 9), particularly in the first few weeks after sowing. Mites feed on the leaves in the morning or on overcast days, and in the warmer part of the day RLEM tend to gather at the base of plants, sheltering in leaf sheaths and under debris. They will crawl into cracks in the ground to avoid heat and cold. When disturbed during feeding they will drop to the ground and seek shelter.

**Photo 9:** *Redlegged earth mite feeding causes leaves to first turn silvery, then brown and shrivelled, so that the plants look scorched.*

Source: Grain Legume Handbook

### Control

Control strategies that only target RLEM may not entirely remove pest pressure. Other pests can fill the gap, and this is particularly evident after chemical applications which are generally more effective against RLEM than other mite pests.

Chemicals are the most commonly used control option against earth mites. Chemicals are registered for control of active RLEM, but none currently registered are effective against RLEM eggs.

#### *Autumn sprays*

Control first generation mites before they lay eggs. Pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults begin to lay eggs.

Timing of chemical application:

- Pesticides with persistent residual activity can be used as bare earth treatments to protect seedlings.
- Foliage sprays applied after the crop has emerged are generally an effective control.
- Systemic pesticides applied as seed dressings act by maintaining the pesticide at toxic levels within the seedling. If mite numbers are high, plants may suffer significant damage before the pesticide has much effect.

*Spring sprays*

A correctly timed spring spray can reduce populations of RLEM the following autumn. Use climatic variables and tools such as TIMERITE® to determine the optimum date for spraying. Spring RLEM sprays will generally not be effective against other pest mites.

For more information on TIMERITE® go to http://www.wool.com/woolgrower-tools/timerite/

Avoid successive use the 'spring spray' technique to avoid any pesticide resistance evolving to the strategy. Rotation of products with different modes of action is advised.

Redlegged earth mites (RLEM) that are resistant to commonly applied insecticides including synthetic pyrethroids (Group 2A), the organophosphates (Group 1B) omethoate and chlorpyrifos were first found in WA. Resistant RLEM populations are likely to be present in paddocks that have a history of repeated insecticide applications.

**MORE INFORMATION**

DAFWA Prevent redlegged earth mite resistance

### Biological and cultural control

Choose a chemical spray that has the least environmental impact and try to reduce the number of chemical applications. There are pesticide groups that have low to moderate impacts on many natural enemies such as cyclodienes.

Natural enemies of RLEM residing in windbreaks and roadside vegetation need to be protected also, so avoid pesticides with residual activity applied as border sprays to prevent mites moving into a crop or pasture.

Cultural control measures include:

- Rotating crops or pastures with non-host crops, e.g. cereals.
- Cultivation.
- Clean fallowing and controlling weeds around crop and pasture perimeters.
- Control of weeds, especially thistles and capeweed, to remove breeding sites for RLEM. [16]

## 7.6.2 Blue oat mite (*Penthaleus* spp.)

### Description

Blue oat mites are 1 mm in length and have a blue-black body with a distinctive red mark on their back and eight red-orange legs when adults. Nymphs are pinkish-orange in colour with six legs on hatching, but soon become greenish and then blue-black.

BOM usually have three generations per season, with each generation lasting 8–10 weeks.

Over-summering diapause eggs hatch in autumn, stimulated by cold temperatures and adequate moisture. [17]

16 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

17 GRDC (2012) Crop mites back pocket guide. Grains Research and Development Corporation, http://www.grdc.com.au/BPG-CropMites

**Photo 10:** *Blue oat mites have a purplish-blue rounded body with red legs. The presence of a small red area on the back distinguishes it from redlegged earth mite.*

Source: G. Cumming, Pulse Australia

### Life cycle

BOM are active during cooler, wetter parts of the year (April to late October), and over-summer as eggs. Autumn rains trigger hatching in three to nine days. Mites take 20–25 days from hatching to mature and start laying eggs.

Because BOM reproduce asexually, female 'clones' can respond differently to environmental and chemical conditions. This may influence control strategies and the likelihood of populations developing resistance.

### Monitoring

Monitor germinating pulses. BOM spend most of their time on the soil surface, rather than on the foliage. They are most active during the cooler parts of the day, feeding in the mornings and in cloudy weather. They seek protection during the warmer part of the day on moist soil surfaces or under foliage, and may even dig into the soil under extreme conditions.

### Chemical control

All current pesticides are only effective against the active stages of mites, and do not kill mite eggs.

Different tolerance to chemical levels between species complicates management of BOM. *P. falcatus* has a high natural tolerance to a range of pesticides registered against earth mites in Australia and is responsible for many control failures involving earth mites. The other BOM species, including *P. major*, have a lower level of tolerance to pesticides and are generally easier to control with chemicals in the field.

Control first generation mites before they can lay eggs to avoid a second spray. Pesticides used at or after sowing should be applied within three weeks of first appearance of mites, as adults will then begin laying eggs.

Pesticides with persistent residual effects can be used as bare-earth treatments. If applied by sowing, these treatments can protect the plants throughout their seedling stage.

MORE INFORMATION

DAFWA (2015) Diagnosing blue oat mite.

Systemic pesticides applied as seed dressings maintain the pesticide at toxic levels within the seedlings as they grow. This can help minimise damage to plants during the sensitive establishment phase, however, if mite numbers are high, significant damage may still occur before the pesticide has much effect.

### Biological and cultural control

A number of predator species are known to attack earth mites in Australia. The most important predators of BOM appear to be other mites, although small beetles, spiders and ants may also play a role. [18]

Preserving natural enemies when using chemicals is often difficult because the pesticides generally used are broad spectrum and kill beneficial species as well as the pests.

Cultural controls such as rotating crops or pastures with non-host crops can reduce pest colonisation, reproduction and survival, decreasing the need for chemical control. [19]

## 7.7 Etiella or lucerne seed web moth (*Etiella behrii*)

### Description

The moths are small (12 mm long at rest, with a 20–22 mm wingspan). They are grey-brown with a distinctive stripe along the leading edge of each forewing and an orange band on each forewing (about one quarter of the distance along each forewing from its base).

Hindwings are pale grey. The wings are folded back along the body when resting.

Moths have a prominent "snout' (formed by the labial palps) that is typical of pyralids. The eggs are small (0.6 mm diameter), cream and flattened. Small larvae may be cream or pale green, with no stripes and a dark head. Mid-sized larvae may be pale green or cream, with pale brown or reddish stripes. Larger larvae are characteristically green with pink or reddish stripes and a brown head. Larvae in the pre-pupal stage can be aqua-blue or dark pink with no stripes.

Eggs are laid on pods and flowers or under bracts and are very hard to detect. In most legumes with above-ground pods, newly-hatched etiella larvae bore straight into pods leaving a near-invisible entry hole.

### Damage:

- Pods contain chewed developing seed with jagged edges, silken webbing, droppings, and often a small cream to green caterpillar. During the early stages of an attack, there are few signs of damage. Often the pods must be pulled apart before damage can be seen.
- Larger caterpillars mesh pods together with webbing and chew them.
- Larvae burrow into pods within 24 hours of hatching. They feed on pods and seeds, remaining in pods until entire content has been eaten. Frass is left in the pod, and adjacent pods may be webbed together as larvae move between pods.
- Seeds usually only partially eaten out, often with characteristic pin-hole damage.
- Damage is difficult to grade out and unattractive appearance reduces seed quality.

### Control:

- Chemical control of etiella is only effective on adult moths. Once larvae are in pods they cannot be controlled by insecticides.

18 P Umina (2007) Redlegged Earth Mite. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/redlegged-earth-mite

19 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

- Successful control relies on thorough crop monitoring in order to time insecticide applications to target adult moths prior to egg lay.
- Continue monitoring for 1 week after chemical application. [20]

## 7.7.1 Lucerne flea (*Sminthurus viridis*)

Like field peas, lucerne flea are well adapted to clay soils and this makes them a regular pest on emerging and seedling field pea crops. They require moist conditions to hatch and will produce up to five generations in most years. The final generation of females each season lay eggs that over-summer in the soil and ingest soil particles to help form the protective mass that protects the eggs (Photo 11). [21]

**Photo 11:** *Lucerne flea with eggs.*

Source: Grain Legume Handbook

### Life cycle

Long wet springs favour the build-up of lucerne flea, often causing more serious outbreaks in the following autumn. Over-summering eggs are laid in the soil and hatch soon after opening rains. The eggs take about two weeks to hatch and the immature stages take a further three weeks to grow to sexual maturity.

A second generation may be completed before winter temperatures retard development and reduce the numbers. In spring a second burst of activity occurs when rising temperatures allow fleas to breed faster and increase their numbers. This period of activity stops in late spring when dry conditions lead to the production of over-summering eggs.

### Monitoring

Monitoring from autumn through spring is the key to reducing the impact of lucerne flea. Crops are most susceptible to damage immediately following seedling emergence.

Lucerne fleas are often concentrated in localised patches or 'hot spots' so it is important to have a good spread of monitoring sites within each paddock. Examine foliage for characteristic lucerne flea damage and check the soil surface where insects may be sheltering.

20 QDAF (2016) Etiella. Queensland Department of Agriculture and Fisheries, http://ipmguidelinesforgrains.com.au/pests/etiella/

21 DAFWA (2015) Diagnosing lucerne flea. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2164

### Chemical control

Lucerne flea control is often post-emergence, usually after damage is first detected. Spray only when necessary. Rotate insecticide groups to avoid resistance. Correct identification is critical to ensure insecticide options work.

If warranted, treat the infested area approximately 3 weeks after lucerne fleas have been observed on a newly emerged crop. This will allow for the further hatch of over-summering eggs but will be before the lucerne fleas reach maturity and begin to lay winter eggs.

Lucerne flea control in the paddock in the season prior to the sowing of susceptible crops is recommended.

When both lucerne fleas and RLEM are present, control strategies should consider both pests.

MORE INFORMATION

GRDC (2014) Beating the lucerne flea.

### Biological and cultural control

Several predatory mites (e.g. snout mites), various ground beetles and spiders prey upon lucerne fleas. Clean fallows and control of weeds within crops and around pasture perimeters, especially of capeweed, helps reduce lucerne flea numbers.

Grasses and cereals are less favourable to lucerne flea and as such can be useful for crop borders. [22]

## 7.7.2 Snails and slugs

Snail populations can build up readily under field pea and so can be a major problem if not controlled. They can enter the grain sample at harvest with or without having climbed onto the crop plant.

Snails and slugs live in areas where abundant ground cover and vegetation provides ideal moisture levels and shelter. This is why they can be a problem on the edge of a crop with a weedy fenceline. Good hygiene, weed control and removal of refuges can reduce the problem over time. Be aware, though, that pest problems may increase in the short term after this process, as the pests will no longer have the weeds for food or shelter.

Snail and slug control can include cultural, biological or chemical control.

### Chemical control

Sprays registered for snail and slug control contain methiocarb or silicate salts mixed with copper.

Sprays using methiocarb have a restricted registration and very long withholding periods when used on fruit producing trees and vines.

Sprays containing silicate salts and copper can only be sprayed onto tree trunks and vine canes, not onto foliage.

Sprays containing copper (Bordeaux mixture, copper sulphate or copper oxychloride) are not registered for snail control, but do have some effect, both in killing snails and slugs (usually juveniles) and in protecting plants by making them repellent. Bordeaux mixture contains one part copper sulphate to one part slaked lime to 100 parts of water.

Sprays are most lethal when applied when the snails or slugs are active. This is best achieved very early in the morning when the day is predicted to be fine, so that affected animals dehydrate before they can recover. This can be especially effective when snails or slugs are active on dewy mornings in early summer, when the effect of the sun is much greater.

22 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

Copper sprays can cause burning and fruit drop, especially in hot weather, so follow label directions closely.

For more information on snail control go to the GRDC publication "Bash'Em Burn'Em Bait'Em"

## Slugs

Slug attacks on emerging crops can cause major economic losses, even when slug numbers are relatively low. Slugs will eat all parts of a crop plant, however seedlings are the most vulnerable and this is the time when major economic losses can occur. Slugs are the sixth most damaging invertebrate pest for the Australian grains industry. [23]

### Description

The most common species in WA are the reticulated or field slug, *Deroceras reticulatum*. Usually grey in colour, the adult slugs are 2–4 cm long.

The black keeled slug, *Milax gagates*, has also been found in canola and wheat paddocks. This slug is uniform black to grey and 4–5 cm long (Photo 12).

**Photo 12:** *Field slug (top; Deroceras reticulatum) and black keeled slug (bottom; Milax gagates).*

Source: Peter Mangano, Department of Agriculture and Food Western Australia

### Damage

Plants are eaten to ground level or irregular patches or strips are chewed from the leaves. Leaves can have a shredded appearance. There can be poor legume emergence from slugs feeding in furrows. [24]

### Life cycle

Slugs are hermaphrodites (individuals are both male and female). Each individual can lay about 100 eggs.

Moisture is essential for slug survival and some species may move down the soil to depths of 20 cm or more in dry periods and reappear when conditions improve.

### Control

In pulses, the threshold for control of the black keeled slug is 1-2/$m^2$.

Cultivation and rolling, and burning stubble after weeds are controlled will reduce slug populations. Rolling the soil after seeding can also reduce slug damage.

23 GRDC (2014) Slugging slugs. Grains Research and Development Corporation, https://grdc.com.au/Media-Centre/Hot-Topics/Slugging-slugs

24 DAFWA (2015) Diagnosing slugs in crops. Department of Agriculture and Food, Western Australia, April 2015, https://www.agric.wa.gov.au/mycrop/diagnosing-slugs-crops

MORE INFORMATION

GRDC (2013) Slug identification and management. Fact sheet.

Bait after seeding if crop damage from slugs is expected. Buried bait is less effective than bait on the soil surface. The most effective baits are metaldehyde and iron chelates. Metaldehyde damages the mucus-producing cells and is therefore less affected by cold and wet conditions. Rates of up to 10 kg/ha may be necessary. Baiting will generally only kill 50% of the slug population at any one time. [25]

## 7.8 Beneficial organisms

Beneficial organisms are important in overall pest management. All pest populations are regulated to some degree by the direct effects of other living organisms. Beneficial organisms include a range of wasps, flies, bugs, mites, lacewings, beetles and spiders that can reduce insect pest populations through predation and parasitisation (Photo 13). Virus and fungal diseases also provide control.

A wide range of beneficial organisms can be grouped into three categories:

- *Parasites*: organisms that feed on or in the body of another host. Most eventually kill their host and are free living as an adult (parasitoids) e.g. aphid wasp parasites.
- *Predators*: mainly free living insects that consume a large number of prey during their lifetime e.g. shield bugs, lacewings, hover flies, spiders, predatory mites and predatory beetles.
- *Insect diseases*: includes bacterial, fungal and viral infections of insects.

MORE INFORMATION

GRDC (2012) Beneficial Insects—Southern/Western Regions: The Back Pocket Guide

A key component of any IPM program is to maximise the number of beneficial invertebrates and incorporate management strategies other than pesticides that will help to keep pest insect numbers below an economic threshold.

Correct identification and regular monitoring is the cornerstone of IPM. When monitoring crops for insects, it is important to also check for the presence of, and record the build-up or decline in, the numbers of these beneficials to make the best insect control decisions. [26]

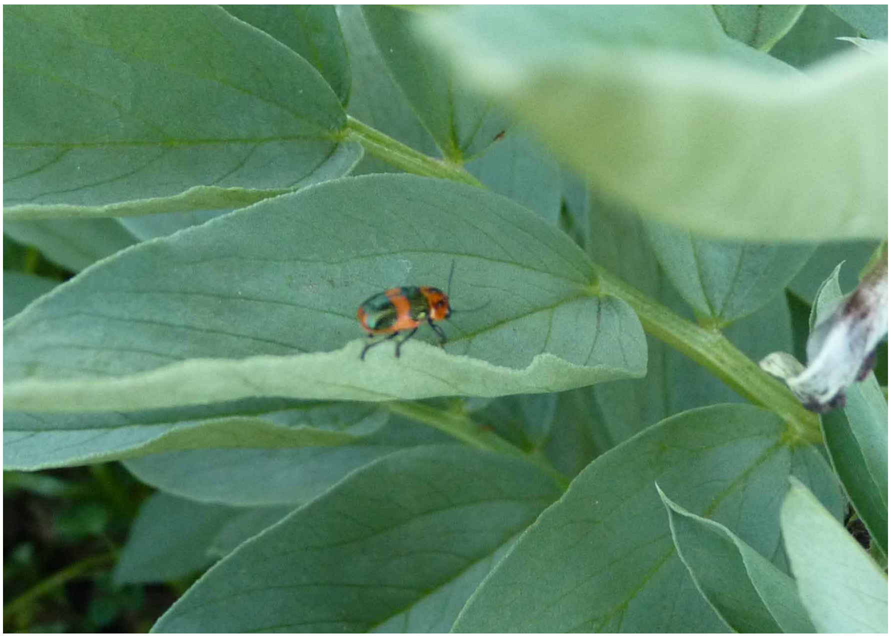

**Photo 13:** *A wide range of beneficial insects exist.*

Source: T. Bray, Pulse Australia

There are a number of beneficials found in southern Australia, these include:

25 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

26 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

*Beetles:*

- carabid beetle (*Notonomous gravis*)
- transverse ladybird
- common ladybird

*Bugs:*

- damsel bug (family *Nabidae)*
- assassin bug
- glossy shield bug
- spined predatory shield bug (*Oechalia schellenbergii*)

*Flies:*

- hoverfly (family *Syrphidae*)
- tachinid fly

*Lacewings:*

- green lacewing (family *Chrysopidae*)
- brown lacewing (family *Hemerobiidae*)

*Mites:*

- pasture snout mite (*Bdellodes lapidaria*)
- French anystis mite

*Caterpillar wasps:*

- orange caterpillar parasite wasp
- two toned caterpillar wasp
- banded caterpillar wasp
- *Telenomus* wasp
- orchid dupe
- *Trichogramma* wasp
- braconid wasp (*Microplitis demolitor*)

*Aphid wasps:*

- *Aphidius ervi*
- *Trioxys complanatus* wasp

*Spiders:*

- wolf spider (family *Lycosidae*)
- jumping spider (family *Salticidae)*

*Insect diseases—viral and fungal:*

- *Bacillus thuringiensis* (BT)
- nuclear polyhedrosis virus (NPV) [27]

27 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 7–Insect Management.

# Nematode management

## Key messages

- Root-lesion nematodes (RLN) are found over 5.74 million ha or 65% of the cropping area of Western Australia.
- RLN are microscopic, worm-like organisms less than 1 mm in length and cannot be seen with the naked eye.
- Rotations of resistant crop species such as field pea can effectively keep RLN to a minimum.
- Test your farm. Different species of RLN can be hosted on different crops.
- Field peas will assist in lowering RLN populations where P. neglectus or P. quasitereoides are present but increase….
- Other things to cover include,
  - » what does nematode damage look like in field peas
  - » is there varietal and or type differences in tolerances etc

## 8.1 Background

Root lesion nematode (RLN) is a microscopic worm-like organism <1 mm in length that feeds in root tissues (Photo 1).

They are migratory endoparasites, meaning they enter roots to feed and lay eggs, but may live for some time in soil, feeding on the exterior of the roots or travelling between roots and plants.

In Western Australia, *P. neglectus* is the main species of RLN, with *P. quasitereoides* (originally described as *P.teres)* [1] the next prevalent and *P. thornei* rarely occurring. [2]

Field peas are an attractive option for grain growers wanting to target RLN. Field peas are a profitable crop and will assist in lowering RLN populations where *P. neglectus* or *P. quasitereoides* are present. As a legume, there is also the nitrogen-fixing benefit that this crop brings to the rotation. [3]

All RLN species cause root damage and yield losses, particularly in cereals. Root lesion nematodes have a wide host range, including cereals and grassy weeds, pulses, pasture and forage legumes and oilseeds. [4]

Intensive cropping of susceptible species, particularly wheat, will lead to an increase in RLN levels. Crop rotation with resistant crop species is the key to reducing RLN and the damage caused by this pest.

1 GRDC (2015) Tips and Tactics: root-lesion nematodes, Western region, www.grdc.com.au/TT-RootLesionNematodes

2 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 6–Disease Management.

3 DAFWA (2014) Field peas a cleaning crop option for 2014. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/news/media-releases/field-peas-cleaning-crop-option-2014

4 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 1–Rotational Benefits & Profitability.

**Photo 1:** *Microscope image of a root-lesion nematode. Notice the syringe-like 'stylet' at the head end, which is used for extracting nutrients from the plant root. This nematode is <1 mm long.*

Photo: Sean Kelly, DAFWA

### 8.1.1 The life cycle of RLN

Root-lesion nematodes are migratory plant parasitic nematodes, and will migrate freely between roots and soil if the soil is moist. In WA, the life cycle of RLN begins after the opening rains in autumn.

Juvenile and adult nematodes rehydrate, become active and invade plant roots, where they feed and multiply as they move through the root (Figure 1). Individual eggs are laid within the root, from which juvenile nematodes hatch and grow, and, in turn, lay more eggs as adults. They develop from egg to adult in 40–45 days (~6 weeks) depending on soil temperature and host (Figure 1). There may be three to five life cycles within the plant host each season.

As plants and soil dry out in late spring, RLN enter a dehydrated state called anhydrobiosis and can survive high soil temperatures and desiccation over summer. As the nematodes feed and multiply, lesions and/or sections of brown discoloration are formed on the plant root. Other symptoms include reduction in the number and size of lateral roots and root hairs. [5]

5 GRDC (2015) Tips and Tactics: root lesion nematodes, Western region. Fact sheet, www.grdc.com.au/TT-RootLesionNematodes

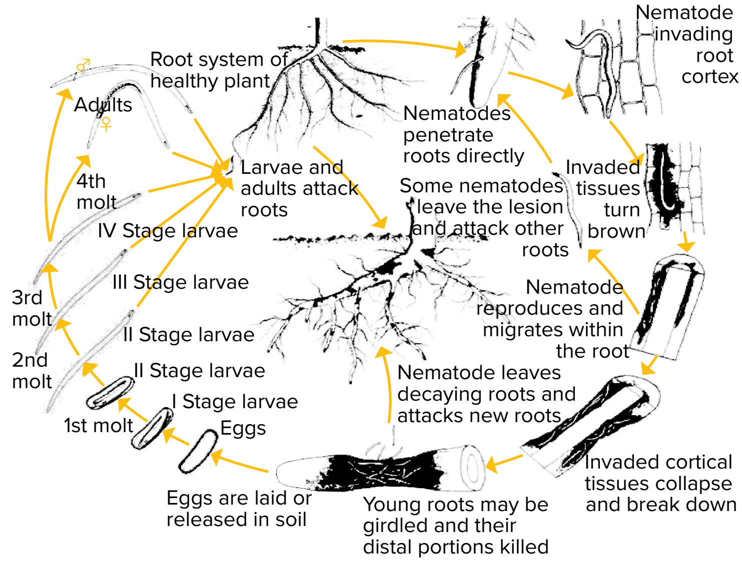


**Figure 1:** *Life cycle of root-lesion nematode.*

Source: GRDC

### 8.1.2 *P. quasitereoides*

*P. quasitereoides* (originally described as *P. teres*) is unique to WA, and can reach high populations and cause more significant and widespread damage within a crop than *P. neglectus*. Growers need to manage *P. quasitereoides* within their cropping rotations through the use of species that are poor- or non-hosts, or use resistant wheat and barley cultivars to limit the multiplication of this pest in the soil. Although *P. quasitereoides* is not as widespread, crops resistant to *P. neglectus* can be highly susceptible to this species, requiring a different suite of rotational crops and cultivars for effective management. It is necessary that in field diagnoses, the species of RLN is correctly identified to enable growers to choose appropriate crop cultivars and species to minimise current and future losses. [6] *P. quasitereoides can now be identified in a predictaB test.*

## 8.2 Symptoms and detection

The four species of root lesion nematodes commonly found in Western Australia are: *P. neglectus*, *P. quasitereoides*, *P. thornei* and *P. penetrans*.

Root-lesion nematodes cannot be seen with the naked eye in the soil or in plants. The most reliable way to confirm the presence of RLN is to soil test. Nematodes are extracted from the soil for identification and determination of their population size.

The aboveground symptoms of disease caused by nematodes can be difficult to detect, and may be often confused with symptoms of nutrient deficiency. Typically, plants do not thrive, are paler than normal, and may wilt in the heat of the day. Affected plants are often dwarfed, with small leaves. Sometimes, when infected plants are growing in moist, fertile soil, or during cool weather, the aboveground parts can still appear healthy.

Symptoms can be confused with nutrient deficiency and may be exacerbated by a lack of nutrients. Infected plants may wilt prematurely in dry periods and at the end of the season.

6 S Collins et al. (2013) *Pratylenchus teres* WA's home grown Root Lesion Nematode. GRDC Update Papers. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/03/Pratylenchus-teres-WAs-home-grown-Root-Lesion-Nematode

MORE INFORMATION

DAFWA (2014) How to diagnose root lesion nematode. Video.

S Collins et al. (2014) Root lesion nematode has a picnic in 2013. GRDC Update Papers.

S Collins et al. (2013) *Pratylenchus teres*: WA's home grown root lesion nematode (RLN) and its unique impacts on broadacre crops. GRDC Update Papers.

GRDC (2010) Plant parasitic nematodes, Southern and Western Region. Fact sheet.

When roots are damaged by RLN, the plants become less efficient at taking up water and nutrients and tolerating stresses, such as drought or nutrient deficiencies. Affected plants may partly recover if the rate of new root growth exceeds the rate at which RLN damage the roots. However, recovery will depend on the extent of root damage and the growing conditions. [7]

Numbers of RLN build up steadily under susceptible crops, causing a decrease in yields over several years. Yield losses >50% can occur in some wheat varieties, and up to 20% in some chickpea varieties. The amount of damage caused will depend on:

- the numbers of nematodes in the soil at sowing
- the tolerance of the variety of the crop being grown
- the environmental conditions [8]

Mixed populations of the RLN species are also regularly identified (Figure 2). *P. penetrans* is rare in broadacre crops, but can cause severe damage to some crops. These estimates represent a compilation of more than 2,300 confirmed RLN reports gathered since 1997 by DAFWA, including research trials, surveys and Agwest Plant Laboratory diagnostic samples. [9]

Identification of nematode species is important to management decisions because varieties and crops species differ in their resistance or susceptibility to different members of the *Pratylenchus* genus (Table 1). For example, field peas, lupins and faba beans are resistant to *P. neglectus* but susceptible to *P. penetrans*; barley may be more susceptible to *P. quasitereoides* than to *P. neglectus*; and canola is more susceptible to *P. neglectus* than to *P. thornei*.

Although there is no truly resistant variety of wheat, barley or oats, sufficient variation exists for susceptibility that variety selection in rotations can be a useful tool in managing the impact of RLN. Refer to the state department of agriculture Crop Variety Guide for information on more resistant varieties. [10]

## 8.3 Varietal resistance or tolerance

### Resistance: nematode multiplication

Resistant crops do not allow RLN to reproduce and increase in number in their roots.

Susceptible crops allow RLN to reproduce so that their numbers increase. Moderately susceptible crops allow increases in nematode populations but at a slower rate.

### Tolerance: crop response

Tolerant varieties or crops yield well when sown in fields containing large populations of nematodes.

Intolerant varieties or crops yield poorly when sown in fields containing large populations of nematodes (Table 1).

A susceptible variety is one that allows the nematodes to build up while it is growing, and so creates a greater nematode population for subsequent crops. Tolerance is different to resistance, and relates to crop yield rather than nematode build-up. A tolerant variety is one that loses little yield to the nematode presence, but nematode populations may increase while that variety is growing.

Field peas generally have adequate levels of resistance to *P. neglectus* and *P. quasitereoides*, and can reduce nematode populations in cropping rotations. [11]

7 GRDC (2009) Root lesion nematode dominates in the north. Northern region. Fact sheet, http://www.grdc.com.au/uploads/documents/GRDC_NematodesFS_North_4pp.pdf

8 R Daniel (2013) Managing root lesion nematodes: how important are crop and variety choice? GRDC Update Papers. https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Managing-root-lesion-nematodes-how-important-are-crop-and-variety-choice

9 GRDC (2015) Tips and Tactics: root lesion nematodes, Western region. Fact sheet, www.grdc.com.au/TT-RootLesionNematodes

10 GRDC (2015) Tips and Tactics: root lesion nematodes, Western region. Fact sheet, www.grdc.com.au/TT-RootLesionNematodes

11 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 1–Rotational Benefits & Profitability.

Field peas are susceptible to *P. penetrans* and are likely to increase numbers, so growers need to be aware which species is present on their land.

**Table 1:** *Resistance and tolerance of pulses to Pratylenchus spp. Chickpea varieties have a range of resistances and tolerances to Pratylenchus species.*

| | ***Pratylenchus neglectus*** | | ***Pratylenchus thornei*** | |
|---|---|---|---|---|
| | **Resistance** | **Tolerance** | **Resistance** | **Tolerance** |
| Chickpeas | S–MR | MI–T | VS–R | MI–T |
| Faba beans | R | - | MR | MI |
| Field peas | R | - | R | T |
| Lentils | R | T | R | MT |
| Vetch: | | | | |
| Blanchefleur | MR | T | S | I–MI |
| Languedoc | MR | T | MS | I–MI |
| Morava | MR | T | MS | I–MI |

Key: S = susceptible; R = resistant; I = intolerant; T = tolerant; M = moderately; V = very. Chickpea varieties have a range of resistances and tolerances to *Pratylenchus* species.

Source: Grain Legume Handbook

## MORE INFORMATION

[GRDC Final Report - Rotations to reduce impact of nematodes in Western cereal cropping systems]

### Paddock hygiene

RLN appears to be spread in soil moved by surface water, vehicles and farm machinery. Good hygiene, by removing adherent soil from farm machinery, should be adopted to avoid infesting clean paddocks.

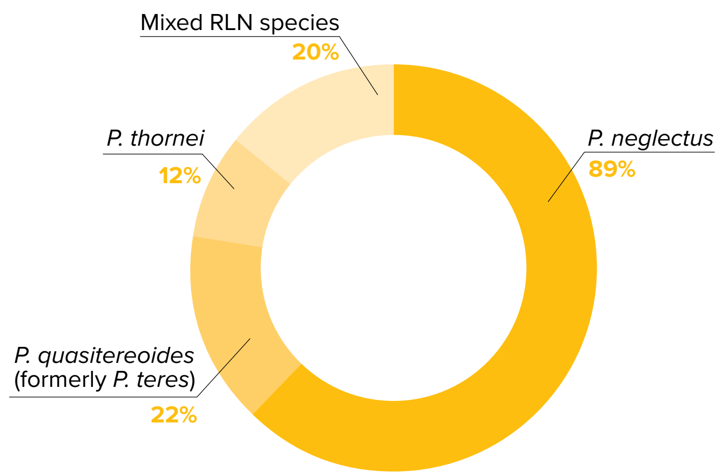


**Figure 2:** *Relative abundance of the main root-lesion nematode species identified in infested broadacre paddocks in Western Australia.*

Source: GRDC

## 8.4 Management of nematodes

Currently, no nematicides are registered for use on broadacre crops in Australia.

Rotations and variety choice are key to the successful reduction of RLN populations in the soil.

Field peas are an excellent break crop for RLN as they are moderately resistant. This means there is a lower multiplication rate of the nematode where field peas are included in the rotation compared to susceptible crops such as wheat. [12] DAFWA reserach shows field pea, significantly reduces the level of P. neglectus.

Weeds can play an important role in the increase or persistence of nematodes in cropping soils. Thus, poor control of susceptible weeds compromises the use of crop rotations for RLN management. [13]

## Testing for RLN

1. *Test your farm*—If RLN infestation is suspected, growers are advised to check the crop roots. Carefully dig up and wash the soil from the roots of an infected plant. This can reveal evidence of infestation in the roots, which warrants laboratory analysis. Testing services are available at Agwest Plant Laboratory at the Department of Agriculture and Food, Western Australia (DAFWA).
2. *PreDicta B*—A DNA-based soil analysis service is available that is delivered by accredited agronomists and can detect *P. neglectus*, *P. thornei* and *P. quasitereoides*. Contact your local agronomist, or email your contact details and location to predictab@saugov.sa.gov.au to locate your nearest supplier.

12 DAFWA (2014) Field peas a cleaning crop option for 2014. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/news/media-releases/field-peas-cleaning-crop-option-2014

13 GRDC (2015) Tips and tactics: root lesion nematodes, Western region. Fact sheet, www.grdc.com.au/TT-RootLesionNematodes

# Diseases

## Key messages

- Blackspot is the most widespread and destructive disease of field peas in Western Australia.
- Use seed with minimal disease transmission. Test seed for disease and virus status.
- *Mycosphaerella pinodes* is the principal pathogen involved in nearly all occurrences of blackspot, and it survives on field pea stubble for more than 3 years.
- Fungicides do not reduce disease nor increase yield sufficiently for them to be recommended for field pea production in WA.
- No variety is resistant to blackspot.

## 9.1 Yield losses

MORE INFORMATION

GRDC (2012): The Current and Potential Costs from Diseases of Pulse Crops in Australia.

Pulse Australia (2012) Field pea Disease Management Strategy Southern & Western Region.

There are six diseases in WA that have the potential to cause yield losses in field pea. They include blackspot complex (also known as Ascochyta blight), sclerotinia, Pea seed-borne mosaic virus, root lesion nematode penetrans (see section 8), downy mildew and Rhizoctonia bare patch.

The current average annual loss from diseases in the Australian field pea industry is $23.7 million or $78.35/ha. These losses are due to diseases caused by fungi, nematodes, bacteria, viruses, and phytoplasmas (Table 1).

Three broad categories of controls are available for pulse diseases:

- breeding (resistant cultivars)
- cultural practices including stubble management, tillage and crop rotations
- pesticides (fungicides applied as seed treatments, in-furrow and foliar sprays, and insecticides/miticides for vector control) [1]

Management of disease in field pea should concentrate on controlling blackspot (Ascochyta blight). [2]

1 G Murray, J Brennan (2012) The Current and Potential Costs from Diseases of Pulse Crops in Australia. Grains Research & Development Corporation, https://grdc.com.au/Resources/Publications/2012/06/The-Current-and-Potential-Costs-from-Diseases-of-Pulse-Crops-in-Australia

2 Pulse Australia (2012) Field pea Disease Management Strategy. Australian Pulse Bulletin, http://www.pulseaus.com.au/storage/app/media/crops/2012_APB-Fieldpea-disease-management-South-West.pdf

**Table 1:** *Occurrence of field pea diseases and pests, including nematodes, by GRDC region.* [3]

| Pathogen | Disease | Northern | Southern | Western | Australia |
|---|---|---|---|---|---|
| **Necrotrophic leaf fungi** | | | | | |
| *Ascochyta pisi* | leaf and pod spot | Y | Y | P | Y |
| *Botrytis cinerea* | grey mould | Y | Y | P | Y |
| *Leptosphaerulina trifolii* | pepper spot | U | Y | U | Y |
| *Phoma medicaginis var. pinodella* | Phoma black spot | Y | Y | P | Y |
| *Phoma koolunga* | Koolunga black spot | U | Y | N | Y |
| *Mycosphaerella pinodes* | Mycosphaerella black spot | Y | Y | P | Y |
| *Septoria pisi* | Septoria blotch | Y | Y | Y | Y |
| *Mp, Ap, Pm* | black spot complex | U | U | Y | Y |
| **Biotrophic leaf fungi** | | | | | |
| *Erysiphe pisi* | powdery mildew | Y | Y | Y | Y |
| *Peronospora viciae* | downy mildew | Y | Y | Y | Y |
| **Root and crown fungi** | | | | | |
| *Aphanomyces euteiches* | Aphanomyces root rot | P | N | N | P |
| *Botrytis cinerea* | Botrytis damping off/root rot | P | Y | N | Y |
| *Fusarium oxysporum* f.sp. *pisi* | Fusarium wilt | U | Y | U | Y |
| *Macrophomina phaseolina* | charcoal rot | U | U | N | N |
| *Mycosphaerella pinodes* | Mycosphaerella foot rot | U | Y | N | Y |
| *Phoma medicaginis var. pinodella* | Phoma foot rot | U | Y | N | Y |
| *Pythium* spp. | Pythium damping off/root rot | U | Y | Y | Y |
| *Rhizoctonia solani* | Rhizoctonia seed and stem rot | Y | Y | U | Y |
| *Rhizoctonia solani* | bare patch | U | U | Y | Y |
| *Rhizoctonia solani AG11* | epicotyl rot | U | U | Y | Y |
| *Sclerotinia sclerotiorum* | Sclerotinia stem rot | Y | Y | Y | Y |
| **Nematodes** | | | | | |
| *Ditylenchus dipsaci* | stem nematode | U | N | N | N |
| *Meloidogyne incognita* | root knot nematode | U | N | U | N |
| *Pratylenchus neglectus* | root lesion nematode neglectus | U | U | U | U |
| *Pratylenchus penetrans* | root lesion nematode penetrans | U | N | Y | Y |
| *Pratylenchus teres* | root lesion nematode teres | U | U | P | P |
| *Pratylenchus thornei* | root lesion nematode thornei | U | N | Y | Y |
| *Radopholus* sp. | burrowing nematode | U | U | P | P |
| **Bacteria** | | | | | |
| *Pseudomonas syringae pv. pisi* | pisi bacterial blight | Y | Y | Y | Y |
| *Ps. syringae pv. syringae* | syringae bacterial blight | Y | Y | U | Y |
| **Viruses** | | | | | |
| Alfalfa mosaic virus | alfalfa mosaic | Y | Y | U | Y |
| Bean common mosaic potyvirus | bean common mosaic | U | U | U | U |
| Bean leaf roll virus | Bean leaf roll | Y | Y | U | Y |

3 G Murray, J Brennan (2012) The Current and Potential Costs from Diseases of Oilseed Crops in Australia. Grains Research & Development Corporation, https://www.grdc.com.au/Resources/Publications/2012/06/The-Current-and-Potential-Costs-from-Diseases-of-Oilseed-Crops-in-Australia

| Pathogen | Disease | Northern | Southern | Western | Australia |
|---|---|---|---|---|---|
| Bean yellow mosaic virus | bean yellow mosaic | Y | Y | P | Y |
| Beet western yellows virus | beet western yellows | Y | Y | P | Y |
| Clover yellow vein virus | clover yellow vein | U | U | U | U |
| Cucumber mosaic virus | cucumber mosaic | Y | Y | U | Y |
| Pea seed-borne mosaic virus | pea seed-borne mosaic | Y | Y | Y | Y |
| Soybean dwarf virus | soybean dwarf | Y | U | U | Y |
| Subterranean clover stunt virus | subterranean clover stunt | Y | P | U | Y |
| Tomato spotted wilt virus | tomato spotted wilt | Y | U | U | Y |

a Y= present in region

P = present in region but no or incomplete data on incidence and severity

N = not recorded in region

U = unknown status

## 9.2 Integrated management

Originally developed for insect pest management, integrated management programs now encompass diseases, weeds, and other pests. It is a multi-layered approach of crop management to reduce chemical inputs and solve ecological problems.

There are three stages: prevention, observation, and intervention, that encompass six basic components.

1. Acceptable disease levels
- Emphasis is on economical control, not eradication.
- Elimination of the disease is often impossible, and can be expensive, environmentally unsafe, and frequently not achievable.
2. Programs work to establish acceptable disease levels (action thresholds) and then apply controls if those thresholds are likely to be exceeded. Thresholds are disease and site specific. What is acceptable at one site may not be acceptable at another site or crop. By allowing some disease to be present at a reasonable threshold means that selection pressure against resistance is reduced.
3. Preventive cultural practices
- Use varieties best suited to local growing conditions and with adequate disease resistance.
4. Maintaining healthy crops is the first line of defence, together with plant hygiene and crop sanitation (e.g. removal of diseased plants to prevent spread of infection). Crop canopy management is also very important in pulses, hence time of sowing, row spacing and plant density and variety attributes become important.
5. Monitoring
- Regular observation is the key to management.
6. Observation is broken into inspection and then identification. Visual inspection, spore traps, and other measuring tools are used to monitor disease levels. Accurate disease identification is critical to a successful IPM program. Record keeping is essential.
7. Diseases are dependent on both specific temperature and moisture regimes to develop (e.g. blackspot often requires colder temperatures). Monitor the climatic conditions and rain likelihood to determine when a specific disease outbreak is likely.
8. Mechanical controls
- Burning or ploughing in pulse stubble, removing hay, cultivating self-sown seedlings.

9. Should a disease reach unacceptable levels, or high inoculums loads anticipated, then mechanical methods may be needed for crop hygiene.
10. Biological controls
- Crop rotation and paddock selection is a form of biological control.
11. Use crops and varieties with resistance to the specific disease. Other biological products are not necessarily available for disease control.
12. Responsible Fungicide Use
- Synthetic pesticides are generally only used as needed and often only at specific times in a disease life cycle.
13. Fungicides that are applied as protection ahead of conditions that are conducive to disease (e.g. sustained rainfall) may reduce total fungicide usage. Timing is critical with foliar fungicides, and may be more important than rate used. Protection is better than cure, because once the disease is established in the canopy there is an internal source of infection that is hard, or even impossible, to control with later fungicide applications. [4]

FAQ

## 9.3 Blackspot or Ascochyta blight

Blackspot is the most widespread and destructive disease of field peas in Western Australia (WA) and has the potential for an average annual yield loss of 100%. It is also known as Ascochyta blight and is caused by a fungal disease complex. Any one or combinations of three fungi may cause blackspot in field peas. All three can occur together, and symptoms caused by each fungi may not be easily distinguished from each other. The organisms involved are: *Mycosphaerella pinodes* (leaf spot, blight); *Phoma medicaginis* var. *pinodella* (foot rot); *Ascochyta pisi* (leaf and pod spot). [5]

Severity of blackspot depends on the level of inoculum (from stubble, soil and seed) and the duration of prolonged wet, cool conditions particularly before flowering. Rainfall or heavy dews on field pea stubble releases spore 'showers' provided the temperature is not too high. These spore 'showers' generally last 3–4 weeks after the opening rains, but in WA may continue well into the growing season and infect emerged plants. This is most likely in seasons or locations where minimal rainfall has fallen prior to seeding. Blackspot is most damaging when it girdles the stem, and in some locations pod and seed infection causes downgrading of pea seed quality. [6]

### Description

The disease initially appears as small, dark, irregular flecks on leaves, stems and pods.

Lesions enlarge in rainy and or humid weather and can show concentric rings in alternating shades of tan and brown. Spots on pods may coalesce to form large, sunken, purplish-black areas (Photo 1).

Stem lesions enlarge to become long, wide streaks that are blue-black or purplish. These often join together to completely girdle stems, leaf stalks or tendrils and kill the plant. The disease damages the base of the stem and blights leaves, stems, pods and flowers (Photo 2).

Infected seeds may be discoloured and appear purplish-brown. Lightly infected seed may appear healthy.

4 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 6–Disease Management.

5 DAFWA (2016) Diagnosing blackspot in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4461

6 Pulse Australia (2012) Field pea Disease Management Strategy. Australian Pulse Bulletin, http://www.pulseaus.com.au/storage/app/media/crops/2012_APB-Fieldpea-disease-management-South-West.pdf

## Disease cycle

The fungi can either be seed-borne, soil-borne, or survive in field pea trash. It can survive in soil for several years, but at insufficient levels to justify a soil test for blackspot fungi in WA. Soil-borne inoculum can cause severe root rot and lesions on the lower stem.

Up to 45% of seeds from areas receiving over 350 mm of rain per year may carry blackspot infection, but seed from lower rainfall areas is almost free from infection. Seedlings grown from infected seed often die, but there is no relationship between level of seed infection and disease development within the crop.

The disease usually becomes established when spores of the fungi produced on old field pea stubble, are carried into the new crop by wind. Infection may occur at any stage of plant growth.

*Mycosphaerella pinodes* is the principal pathogen involved in nearly all occurrences of blackspot, and it survives on field pea stubble for more than 3 years. It produces airborne spores during each growing season, particularly in the first year and after the first rains. Spores released from fruiting bodies on the stubble following rainfall as low as 0.2 mm can infect crops several kilometres away.

During wet weather the disease may spread rapidly. Spores produced on infected plants are transferred onto adjacent healthy plants by wind and rain splash.

## Management strategies

Isolating the new crop from sources of infection and not sowing too early are the best methods of managing blackspot in field peas.

Use the Blackspot Manager to determine optimum sowing time for blackspot control. Blackspot manager is a model that predicts the maturity and release of spores using data weather data from the nearest weather station.

Choose paddocks that have not grown field pea for at least 3 years, and sow no closer than 500 m to paddocks that grew field pea in the previous year. It is preferable to be at least 50 m downwind of 2–3 year old stubble. Separation upwind is not necessary. [7]

Fungicide application for blackspot control has generally proven to be uneconomic for field peas that yield less than 2 t/ha. Some control of blackspot and septoria in field pea is possible with foliar-applied fungicides, but fortnightly applications are required from the early seedling stage until the mid-podfilling stage (approximately 8 sprays) for complete control. [8]

Fungicides do not reduce disease nor increase yield sufficiently for them to be recommended for field pea production in WA.

## How can it be monitored?

In South Australia a soil test has been used to predict disease risk in paddocks. In WA, it does not seem that *Mycosphaerella pinodes* survives in the soil at a sufficient level to justify a soil test for blackspot fungi. [9]

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7 DAFWA (2016) Diagnosing blackspot in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4461

8 Pulse Australia (2012) Field pea Disease Management Strategy. Australian Pulse Bulletin, http://www.pulseaus.com.au/storage/app/media/crops/2012_APB-Fieldpea-disease-management-South-West.pdf

9 DAFWA (2016) Diagnosing blackspot in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4461

**Photo 1:** *Blackspot disease control is central to disease management and maintaining yield potential in field pea.*

Photo: SARDI

**Photo 2:** *Field pea plant with numerous blackspot lesions on leaves, pods and tendrils.*

Photo: Charles Sturt University

## 9.4 Downy mildew

Low levels of downy mildew (*Perenospora viciae)* are sometimes noticed in field pea crops late in winter, but crops usually grow away from it during the longer warmer spring days. It is a minor disease of field pea in WA. [10]

### Description

The disease is most common soon after emergence, but may affect plants at any growth stage during periods of moist, cool weather. Plants are pale yellowish-green and severely stunted and distorted. The undersides of the leaflets are covered with a fluffy mouse-grey spore mass (Photo 3). Infected plants may turn chlorotic while producing an abundant source of spores for secondary infections.

Secondary infection is localised in upper leaves, stems, tendrils and pods and results in the appearance of isolated greenish-yellow to brown blotches on the upper leaf surface. On the lower surface directly below the lesions are masses of mouse-grey fruiting bodies that produce spores under wet and cold conditions. Infected pods are deformed, and are covered with yellow to brownish areas and superficial blistering. The fungus usually affects the lowest leaves and pods. [11]

### Disease cycle

The downy mildew fungus survives in the soil for 10–15 years, and also on plant residues. Infection from these sources can lead to systemic and leaf infections in volunteer pea seedlings. These seedlings act as a source of infection from which the disease spreads by wind to adjacent plants and crops.

### Management strategies

Plants usually recover in spring. Growing a resistant variety is the most effective means of controlling downy mildew in districts prone to this disease. The variety Kaspa⒟ is resistant to the common Parafield strain of the fungus, but susceptible to the new Kaspa⒟ strain. [12]

**Photo 3:** *Thick grey fungal growth on lower leaf surface is typical of downy mildew*

Photo: Pulse Australia.

MORE INFORMATION

Crop Pro (2014) Downy mildew of field peas.

10 DAFWA (2016) Diagnosing downy mildew in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4463

11 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 6–Disease Management.

12 DAFWA (2016) Diagnosing downy mildew in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4463

### 9.4.1 Powdery mildew

Powdery mildew is more likely to occur when the season is protracted, sowing is late, or later maturing field pea varieties are grown. Powdery mildew develops quickly in warm (15–25°C), humid conditions (over 70%) for four to five days, particularly at flowering and after canopy closure. As with downy mildew, rainfall will wash spores off the plants. If infection occurs earlier than four weeks from maturity, yield losses due to powdery mildew arise from the infection covering stems, leaves and pods, which will lead to shrivelled seeds (Photo 4). It is not common in WA. [13]

**Photo 4:** *Powdery mildew infects all of the plant, including pods.*

Photo: Pulse Australia.

## 9.5 Rhizoctonia bare patch

### Description

Rhizoctonia bare patch (*Rhizoctonia solani*) occurs on most soil types throughout the WA wheatbelt and causes similar patches in all crop and pasture species. It causes root disease, resulting in the development of bare patches, and survives as fine fungal threads in organic matter. Following summer/autumn rains, the fungus grows out of this material to infect the roots of young seedlings.

Distinct patches of stunted or dying plants start to show four to six weeks after sowing. Patches are roughly circular, with a diameter varying from 0.5–5 m that may be elongated in the direction of sowing. There is almost no yield within the patches, and weeds within the patch are usually also affected.

Rhizoctonia is likely to be more severe where the fungus has been allowed to infect grass weeds or volunteer cereals prior to seeding.

13 Pulse Australia (2012) Field pea Disease Management Strategy. Australian Pulse Bulletin, http://www.pulseaus.com.au/storage/app/media/crops/2012_APB-Fieldpea-disease-management-South-West.pdf

MORE INFORMATION

[GRDC (2016) Tips and Tactics: Rhizoctonia. Fact sheet.]

[GRDC (2014) New treatment for Rhizoctonia. Podcast.]

[Soil Quality (n_d) Rhizoctonia—Western Australia. Fact sheet.]

### Management strategies

Rhizoctonia bare patch has a wide host range, and cannot be controlled by rotating crops.

Tillage to a depth of 10–15 cm at about the time of sowing reduces the number and severity of patches. Modification of seeding machinery to cultivate 5–10 cm below the sowing depth will provide effective disease control in direct drilled crops. Patches can also be controlled by deep ripping (25–30 cm) immediately before or after seeding. [14]

Summer rainfall events of at least 20 mm in the absence of weeds will reduce the inoculum levels in the soil, and may reduce the disease impact. [15]

## 9.6 Septoria blotch

### Description

Septoria blotch is caused by the fungus *Septoria pisi* and is a minor disease that is widespread in WA. Damage is most severe in short, semi-leafless varieties.

The disease is often seen on old foliage, pods and stems late in the growing season. It is a minor disease of field pea, and appears to have little effect on the yield of most field pea varieties.

The disease is found mainly on the lower, senescing parts of the plant and the pods, and is characterised by yellow blotches on plant tissue, which become necrotic and covered in numerous brown spots. As the blotches dry out, many pinpoint-sized black pycnidia (fungus fruiting bodies) may be seen scattered widely on infected plant parts, including pods. Diseased tissues may dry off prematurely.

### Management strategies

Septoria can be managed by using an integrated approach that encompasses crop rotation, stubble management and fungicides. [16]

## 9.7 Viruses

MORE INFORMATION

[GRDC (2015) Tips and Tactics. Reducing aphid and virus risk. Fact sheet.]

[GRDC (2010) Aphids and viruses in pulse crops. Fact sheet.]

[GRDC (2010) Green bridge. Fact sheet.]

Field pea crops can be affected by a number of viral diseases. Some are seed borne, but all require aphids to move between plants.

In WA's Mediterranean-type climate, the survival of pests and diseases over summer is often critical in determining pest outbreaks and disease epidemics in broadacre crops. While some pests and diseases can persist in seed, stubble or soil, others require green plant material to survive, known as the 'green bridge'. [17]

Summer crops, as well as weeds and volunteers, provide the green bridge for pathogens and pests of winter crops between growing seasons. This is important to viral diseases, as most require living plant tissue to survive and need insect vectors to spread. Surveys in the main field pea growing regions of WA indicated the wide spread occurrence of viruses, even though the Mediterranean climate with dry summers is less favourable for virus survival. Pea seed-borne mosaic virus (PSbMV) was the most widespread, but infections by Bean leafroll virus (BLRV), Beet western yellows virus (BWYV), Bean yellow mosaic virus (BYMV), Cucumber mosaic virus (CMV) and Alfalfa mosaic virus (AMV) are known to infect field peas as well. [18]

14 DAFWA (2015) Diagnosing rhizoctonia bare patch in grain legumes. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/4130

15 DAFWA (2016) Control of green bridge for pest and disease management. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2406

16 CropPro (2014) Septoria blight of field peas, http://www.croppro.com.au/crop_disease_manual/ch07s06.php

17 DAFWA (2016) Control of green bridge for pest and disease management. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/2406

18 JAG van Leur et al. (2013) Virus resistance of Australian pea (*Pisum sativum*) varieties. New Zealand Journal of Crop and Horticultural Science, Vol. 41, No. 2, http://dx.doi.org/10.1080/01140671.2013.781039

### 9.7.1 Pea seed-borne mosaic virus

#### Description

Pea seed-borne mosaic virus (PSbMV) infection is widespread in WA field pea seed stocks, and major seed yield and quality losses are common. [19]

PSbMV can be aphid borne, but the main source of the virus is infected field pea seed. Crops sown with infected seed often reach 100% infection, but as leaf symptoms are difficult to see, the effect on crop growth and yield is often missed (Photo 5).

**Photo 5:** *PSbMV causes downward rolling of the leaf margins in field peas. These symptoms are difficult to recognise under field conditions*

Photo: NSW DPI

Seed-borne PSbMV infection in field pea causes pale, stunted plants. When young field pea plants are infected with PSbMV by aphids, leaf symptoms include faint mottle and downward rolling, and affected plants show mild stunting (Photo 5). These symptoms are not obvious; normally all that can be seen are depressions within the crop canopy that contrast with the flat, even canopy of crops sown with healthy seed. This uneven canopy is an important indicator of widespread crop infection with PSbMV.

Severe defects in seed appearance result when field pea plants are infected with PSbMV before or during seed development. Typical defects include necrotic rings and line patterns on the seed coat (sometimes referred to as 'tennis ball' symptoms), malformation, splitting and reduced seed size (Figure 6). [20]

19 B Congdon et al. (2015) Developing a forecasting model and Decision Support System for Pea seedborne mosaic virus epidemics in field pea crops. GRDC Grains Research Updates, http://www.giwa.org.au/pdfs/CR_2015/Congdon_Benjamin_Developing_a_forecasting_model_and_decision_support_system_FINAL.pdf

20 DAFWA (2016) Pea seed-borne mosaic virus in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/3396

**Photo 6:** *The 'tennis-ball' marking on field pea seed.*

Photo: SARDI

## Disease cycle

PSbMV survives between growing seasons in infected stocks of field pea seed. Seed-borne infection is the main way the disease spreads from paddock to paddock and farm to farm. Sowing infected seed produces infected plants scattered at random within the crop. Aphids then pick up the virus from these infected plants and spread it to healthy plants. The seed transmission rate to seedlings varies with field pea variety. For example, seed transmission rates for Kaspa⦇ can be up to 25%, while for Twilight⦇, rates are less than 5%.

### *Aphid vectors*

PSbMV is spread by many aphid species including the green peach (*Myzus persicae*), cowpea (*Aphis craccivora*) and pea (*Acyrthosiphon pisum*) aphids. An aphid picks up the virus within 1–2 seconds while probing an infected plant, and then transmits the virus within 1–2 seconds to healthy plants.

### *Yield losses*

The yield impact of sowing seed infected with PSbMV varies greatly from year to year and site to site. Yield losses can be substantial in 'green bridge' years, when aphid populations build up early, but are minimal when there is a dry start to the season. PSbMV infection in field pea crops is most widespread and serious when seed with more than 1% infection is sown and aphids arrive early in the life of the crop, resulting in widespread plant infection before or during flowering. Plants infected early become stunted and produce fewer seed pods, resulting in a high potential for yield loss.

## Management strategies

To minimise PSbMV spread in field pea crops, it is necessary to implement an integrated disease management approach.

*Sow healthy seed*

Sow seed from a virus-tested seed stock. Before sowing seed, a representative 400-seed sample should be tested for PSbMV infection. In high rainfall zones with long growing seasons, only sow seed with less than 0.5% infection. In medium-low rainfall zones in years with a substantial 'green bridge', sow seed with less than 1% infection. In medium-low rainfall zones in years with a minimal 'green bridge', seed with less than 2% infection should be sown.

*Target early canopy development*

Early seeding at high rates (more than 120 kg/ha) and narrow row spacing (18 cm) will promote an early, dense plant canopy before aphid arrival. This will help shade out the seed-infected plants that act as a source of PSbMV infection, and also reduce aphid landings. Aim for a plant density of at least 55 plants/m2.

*Retain stubble*

A stubble groundcover helps decrease early virus spread by reducing aphid landing rates.

Avoid spread of infection by isolating pea crops from other pulse or field pea crops sown with untested seed stocks, as these could be a potential source of PSbMV. [21]

*Use resistant varieties*

Currently there are few resistant varieties available. Varieties Wharton⒫, and Yarrum, are resistant to PSbMV. PSbMV-resistant Cv. Wharton⒫ appears to be a reliable option to sow when seed infection levels are >0.5% and the risk of spread is high. [22]

21 DAFWA (2016) Pea seed-borne mosaic virus in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/3396

22 B Congdon et al. (2016) Pea seed-borne mosaic virus: occurrence and management in field pea crops in Western Australia. GRDC Grains Research Updates, http://www.giwa.org.au/2016researchupdates

# Plant growth regulators and canopy management

Not applicable to this crop

# Crop desiccation/spray out

### Key messages

- Field peas are the most vulnerable pulse to frost damage
- Start recording at the end of flowering and desiccate when seed moisture drops to around 30%
- Refer to APVMA for on-label recommendations

## 11.1 Desiccation

Field peas are more vunlerable to frost than other pulses due to thin pod walls and exposure of flowers to frost. Desiccation of field pea crops prior to harvest can improve timeliness of harvest, maintain grain quality and reduce weed seed set of surviving weeds. In addition, crop maturity can be advanced by seven to 14 days. Harvest problems caused by late weed growth or irregular ripening and yield losses from potential shattering, wet weather delays or hail damage can be minimised with desiccation allowing an earlier harvest. High seed quality is also maintained with less damage from late insect attack or disease blemishes.

In seasons with hot dry finishes, the crop naturally matures quickly and evenly, and the benefits of desiccation can be greatly reduced. Producers need to assess their own circumstances to determine if desiccation will provide financial and managerial benefits.

Desiccation acts as the first of the summer fallow sprays and can help ease the workload in an already busy harvest period. The spray can also be used as a tool in herbicide resistance management. Ryegrass plants are often not mature when field peas are ready to desiccate, as such the application can act as a 'spray-topping' tool to reduce seedset of potentially resistant weeds.

Withholding periods must be observed when desiccation sprays are undertaken.

### 11.1.1 Timing of desiccation

A good starting point to estimate the correct timing of desiccation is to record the end of flowering. Wait a further 20 days, then start close crop monitoring as maturity approaches.

1. Visibly assess pod colour and development changes. Desiccate when the lower three quarters of pods along the stem are brown; the seeds are firm, rubbery, and split rather than squash when squeezed; and the shells are thin and leathery. Field pea pods mature from the lowest flowering node upwards. Many plants at this stage may still have green tips.
2. Monitor seed moisture changes. Desiccate when seed moisture drops to around 30%. To collect seed for this, randomly pick 10–20 stems or more across the paddock.

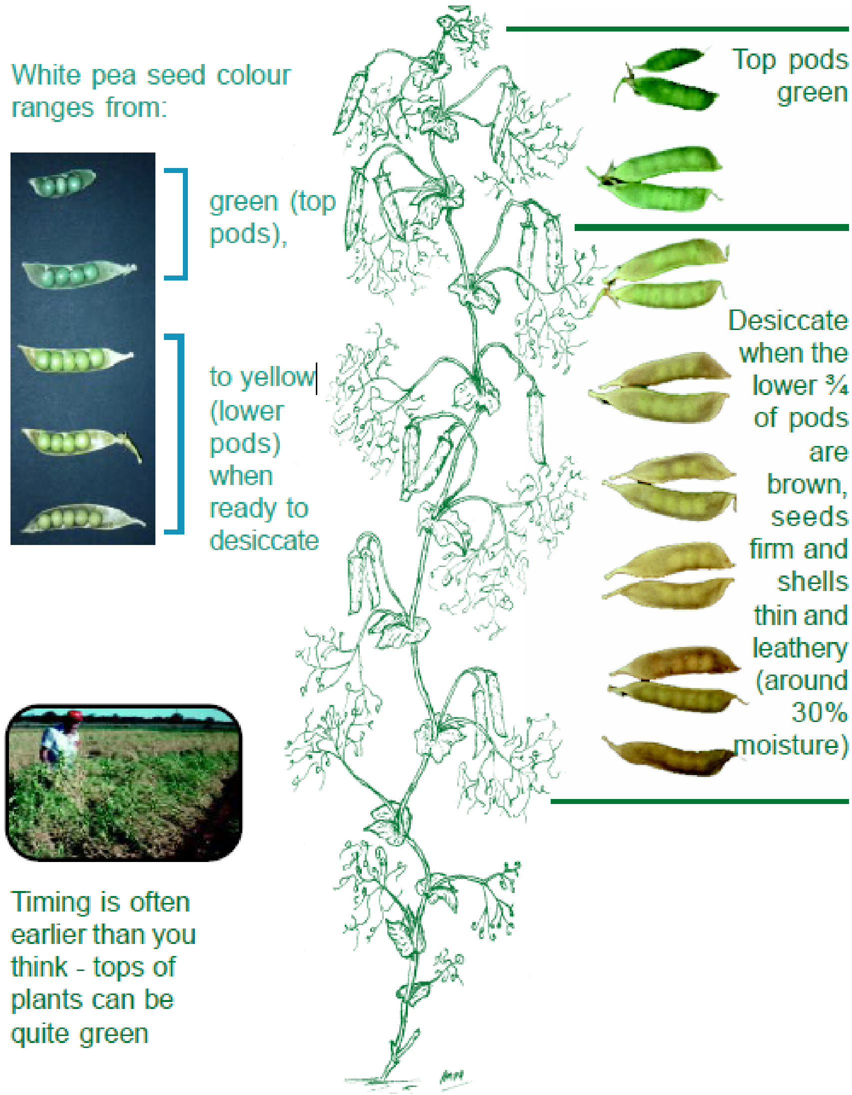


**Figure 1:** *Desiccation and harvest of field peas.*

Source: NSW DPI

Applying desiccants to seed that is still green and actively filling will result in:

- a reduction in grain size (and yield)
- an increase in a greenish discolouration of the seed coat and
- a reduction in seed viability (dead or abnormal seed)

In pulse crops intended for use as seed or for sprouting markets, glyphosate should not be used as it will affect seed germination even when applied after physiological maturity. [1]

1 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

MORE INFORMATION

R Barr (2016) Paraquat preferred for crop-topping pulses. GRDC Ground Cover Issue 124.

*Paraquat can be sprayed later than glyphosate allowing the peas to be more mature and the quicker brown down of paraquat is more effective on ryegrass than glyphosate at the later timing.*

Agronomist's view

### Dun and white field pea

Cotyledon centre of grain (splits) of these types gradually change in colour from green to yellow during maturity phase (ripening). Desiccating dun, dun type and white field pea too early can cause unacceptable proportions of small green seed in the harvest sample. For this reason, it is essential to wait until at least 50% or more of the seeds in the pods have turned yellow before desiccation.

### Products

Glyphosate 540 g/L (e.g. Roundup PowerMAX®), Paraquat and diquat 200 g/L (e.g. Reglone®) are registered for desiccation of field peas. The reason for desiccation will determine product choice (e.g. Paraquat for resistant rye grass, diquat for broad leaf weeds and glyphosate for late germinating weeds). For example, some crops may require the removal of green material to reduce moisture content in the sample (e.g. glyphosate). In other crops a very quick desiccation will speed up maturity as a harvest aid (e.g. diquat). Seed to be used for planting or sprouting should not be desiccated with glyphosate. [2]

## 11.1.2 Windrowing

The biggest challenge for windrowing crops across all regions is losing the swath to wind especially in lower yielding crops. The problem can be further accentuated if the paddock was not sown into a standing cereal stubble, or if the crop was thin and if row spacing is wide.

Growers in the Esperance region of WA have undertaken this practice with the following observations:

- Swathing semi-leafless field peas presents similar problems harvesting with a draper front harvester but it is not quite as bad due to slightly heavier plants at swathing.
- Grower remedies subsequently were also the same—that is, cross-top augers, cross-top augers with paddles and one suggestion yet to be tried: a top belt near the exit hole of the draper.
- All field pea swaths must be rolled with a cotton reel or canola roller. Field pea swaths can be very bulky so adjust swath width and weight of roller to produce a stable swath.
- Semi-leafless field peas make an excellent swath—much better than conventional trailing varieties. There is less risk of blowing. [3]

## 11.2 Crop-topping

Crop-topping is timed to prevent weed seedset, not the crop growth stage. It is however a form of desiccation, so timing is critical from both a weed and crop perspective.

Timing of crop-topping in field peas works very well in early maturing varieties; e.g. PBA Gunyah⫽, PBA Twilight⫽ and PBA Wharton⫽. Timing of crop-topping can, however, be marginal in some years in other field pea varieties that are later maturing.

2 Pulse Australia (2010) Northern Region Field Pea Management Guide. Pulse Australia, https://sydney.edu.au/agriculture/documents/pbi/pbi_region_north_field_pea_management_guide.pdf

3 I Pritchard, M Seymour (2015) Modifying harvesters for semi-leafless field peas crops. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/field-peas/modifying-harvesters-semi-leafless-field-peas-crops

Crop-topping is not always possible in later maturing varieties because they can be too late in maturing relative to the ryegrass in a lengthy growing season.

*Implications of crop-topping too early*

Crop-topping of field peas prematurely can result in discoloured seed coat or cotyledons (kernel), and either rejection at delivery or severe downgrading. There can be grain quality issues, particularly if it occurs just before a significant rainfall event. Also, some of the smaller pods near the top of the plant are more exposed to direct contact by the desiccant spray. Seeds in these less mature pods are not physiologically mature (green kernel) when they dry down.

The rate of desiccant product or the type of product used can also influence speed of dry-down, hence the potential for more grains that are immature. [4]

4 Pulse Breeding Australia (2016) Southern/Western Field Pea–Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

# Harvest

## Key messages

- Yield losses increase significantly the longer harvest is delayed.
- Early-harvested grain means less disease and weathering, and better colour.
- Crop topping or desiccating allows an earlier harvest (7–14 days).
- High moisture harvesting can double the harvest period available.
- Rotary harvesters cause less grain damage than conventional harvesters.

## 12.1 Timing the harvest

Early harvest of field peas is critical and adopting good agronomic practices such as early sowing, timely pest and disease control and swathing or desiccating the crop aids this. Delays can result in significant yield losses and quality downgrading due to lodging, shattering, pod loss and insects. Grain quality can also suffer through mechanical damage or weathering and seed staining. Non-optimum grain moisture levels at harvest can adversely affect the quality of the grain in storage.

If harvesting grain for seed, germination rates can be maintained if the grain is harvested at 12–14% moisture and then stored in aerated silos or immediately graded and bagged. Crop desiccation with herbicides prior to crop maturity may reduce grain quality and seed germination.

There are a number of reasons (or perceptions) that influence a grower's decision to delay field pea harvest:

- Field pea harvest can clash with cereal harvest. Field pea is considered 'secondary' by a minority, with canola, wheat or barley taking precedence at harvest time.
- The possibility of achieving premiums for wheat or malting for barley is also a major incentive for prioritising the cereal harvest, although in reality the premiums for early-harvested field peas may be greater.
- The perception that field peas 'weather' reasonably well and/or do not shatter is a fallacy (this is discussed later in this section).
- Uneven ripening of field pea crops if not desiccated (or windrowed), especially when grown on heavy clay soils or variable soil types.
- Field peas are considered slower or more difficult to harvest than cereals by some, and so less hectares can be harvested in a day. This does not have to be the case if desiccation is used, and the header is modified to suit them. [1]

### 12.1.1 Yield losses

Yield losses increase significantly the longer harvest is delayed. Losses can be reduced by harvesting in high humidity or at night to minimise pod shattering, and also by avoiding harvesting in extreme heat.

Field peas are prone to pod splitting and pod drop if harvest is delayed, especially after weather events once the plant has dried down. Weathering of the grain can also occur in split pods.

It is estimated that grain losses due to a one to three week delay in harvest range from $150–$250/ha, depending on seasonal conditions. Most of the losses are due to pod loss and shattering before harvest, as well as pod loss at the header front. Delays to harvest result in the vines getting lower to the ground making efficient harvest difficult.

1 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

MORE INFORMATION

Australian Pulse Standards 2016/17

### 12.1.2 Deterioration in grain quality

Grain quality deteriorates the longer mature field peas are left exposed to weathering in the field.

The seed coat of field peas is prone to wrinkling following exposure to wetting and drying due to rain or heavy dew during the summer harvest months. Expansion of the seed as it absorbs moisture, and then contraction as it dries, weakens the seed coat. This renders it much more susceptible to mechanical damage during harvest and handling operations.

Levels of cracked and damaged grain can be as high as 50% in extreme cases of field weathering and prolonged rainfall.

Early-harvested field pea seed is much more resilient against breakage during harvesting and subsequent handling, even at low moisture content.

Most field peas are ultimately processed into a protein form, either a dahl or flour, by removing the seed coat (hull) and splitting the cotyledons. However, the visual appearance is still critical for marketing. Older seed, darkened with age, splits better than new season grain. The milling process uses abrasive-type mills to gradually abrade the seed coat from the cotyledons, and is reliant on the seed coat being firmly attached to the cotyledons.

Cracking and weakening of the seed coat prior to processing substantially reduces the recovery percentage of splits, as well as reducing the quality of the final product.

Field weathered field peas after rain are also more difficult to thresh out at harvest, and often contain much higher levels of unthreshed pods and pod material. [2]

Darkening of the seed coat is caused by oxidation of polyphenol compounds (tannins). The following conditions play a major role in accelerating seed coat darkening:

- rainfall
- cool to mild temperatures
- high humidity
- sunlight

While there is usually no direct penalty or discount for a moderate degree of seed coat darkening, it does have a significant impact on the marketability of the product and the reputation of the Australian industry as a supplier of quality product. Quality is becoming increasingly more important as Australian traders attempt to establish market share against field pea exporting competitors such as Canada.

New varieties with quality traits are being developed and the Australian industry is very quality conscious.

### 12.1.3 Missed marketing opportunities

Delayed harvest often means growers miss out on premiums paid for early-harvested crops of good quality. This is the case in most years, with the possible exception where major production problems have been encountered and there is a 'shorts' market place. Weathering and mechanical damage is also more likely in late-harvested crops.

Early harvest gives the grower some degree of control over field pea grain quality, as well as how and when the crop is marketed. Late-harvested field peas can often be price takers in a falling market or encounter delivery delays. [3]

2 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

3 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

### 12.1.4 Implementing early harvest management

A range of management components contribute to an early-matured crop, and these can be important at different times and for different reasons. It is important to understand the potential and limitations of each component. Optimal results in terms of yield, profit and timeliness will come from these components being applied in the most appropriate and balanced way, and as dictated by seasonal conditions.

The following components affect the success of early harvesting.

*Sowing:*

- Sow at the earliest opportunity but within the preferred planting window for your area. This may involve dry sowing by a particular calendar date.
- Moisture seeking equipment and/or press wheels can significantly enhance seeding opportunities under marginal soil moisture conditions.
- Use adapted varieties that meet your target for early harvesting.
- Using precision planters or machines with automatic depth control will often achieve more uniform plant establishment and crop development, and consequently more even crop maturity. This is apparent when sowing into marginal soil moisture and drying conditions.

*In-crop management:*

- Control of Ascochyta if present during flowering.
- Control of native budworm during flowering to maximise early pod set.
- Avoid using herbicides that delay crop maturity, e.g. flumetsulam (i.e. Broadstrike®).

*Harvest management:*

- Consider crop topping or desiccating to dry late plants and any weeds.
- Consider weed wiping (where able) to kill tall, late weeds (in a short crop) that might otherwise delay harvest.
- Windrowing is an option to enable earlier maturity and harvest date.
- If using glyphosate, (or equivalent registered product) to terminate crop growth at the 80–90% black-brown pod stage, be aware of potential impacts on seed quality.
- Set up the header to operate efficiently at 14–15% grain moisture content.

A major advantage of high moisture harvesting is that harvest can commence earlier in the season and earlier each day. Harvesting at 14% moisture content as compared to 12% can effectively double the harvest period available on any one day in hot environments. Blend, aerate and/or dry the sample to the required receival standard of 14% moisture. [4]

## 12.2 Harvesting and header settings

Pulses are easily threshed, so concave clearances should be opened and the drum speed reduced.

When harvesting pulses for seed, take extra care to reduce grain cracking even if this means making a poor sample. Gentle harvesting will give the best seed quality. Rotary harvesters are gentler on the crop and will generally cause less grain damage than conventional harvesters.

Field peas can be harvested with minor adjustments and modifications. Flexi-fronts are best because they can harvest close to the ground and flex with ground contours. Open-front or pick-up fronts are also suitable for the job.

4 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

Field peas, like all pulse crops should be harvested as soon as they mature as pods will fall if harvest is delayed, especially after a rain.

A field pea crop varies in height from 30–110 cm with pods held up in the canopy so direct heading without crop lifters is possible with open front machines. Field peas thresh easily but are prone to cracking, so adjust thresher speed (300–600 rpm) and concave (10–30 mm) to suit (be aware of thresher impact speeds that vary with the drum and adjust drum speed to suit the 12 m/second impact speed required (Table 1).

If there are summer weeds present, the drum speed may need to be increased to ensure that weeds do not block the machine. Alternate wires and blanking off plates may have to be removed. Maximum wind settings and barley sieve settings should ensure a good sample. If there are summer weeds, the rake at the back of the sieves should be blanked-off to stop them entering the returns. Summer weeds may cause walkers and sieves to block completely, causing high grain losses. [5]

**Table 1:** *Harvester settings for pulses.*

| | Chickpea | Faba bean | Green lentil | Red lentil | Lupin | Field pea | Vetch |
|---|---|---|---|---|---|---|---|
| Reel speed | Medium | Slow | Slow | Slow | Slow | Medium | Slow |
| Spiral clearance | High | High | Low | Low | High | Standard | Low |
| Thresher speed (rpm) | 400–600 | 400–600 | 350–450 | 350–450 | 400–600 | 400–600 | 400–600 |
| Concave clearance | 10–30 mm | 15–35 mm | 20–30 mm | 10–20 mm | 10–30 mm | 10–30 mm | 10–30 mm |
| Fan speed | High | High | High | High | High | High | Medium |
| Top sieve | 32 mm | 32–38 mm | 32 mm | 16 mm | 32 mm | 25 mm | 25 mm |
| Bottom sieve | 16 mm | 16–19 mm | 8–16 mm | 3–10 mm | 16 mm | 16 mm | 10–16 mm |
| Rotor speed* (rpm) | 700–900 | 700–900 | 350–450 | 350–450 | 700–900 | 700–900 | Slow |

* Rotary machines only.
Source: Grain legume handbook

## 12.3 Modifications and harvest aids

Early harvesting can solve many problems and losses. The crop is easier to gather because it stands more erect, allowing the harvester front to operate at a greater height, reducing the dirt, rock and sticks entering the harvester. Early harvesting also means there are fewer summer weeds to clog the harvester.

A straw chopper may be of value to chop up the stubble and spread it uniformly. Crop lifters are not always required but can help if the crop is badly lodged.

Finger reels are less aggressive than bat reels and cause fewer pod losses. Double acting cutter bars reduce cutter bar vibration losses. Four finger guards with open second fingers also reduce vibrations (Figure 1).

5 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

**Figure 1:** *Four finger guards with open second fingers.*

Set the finger tine reel to force the field pea material down onto the front. Moving the broad elevator auger forward can improve the feeding of light material.

Vibration due to cutter bar action, plant-on-plant impact, reel-on-crop impact and poor removal of cut material by the auger all cause shattering and grain loss.

A lupin breaker is a cheap and simple device which can increase harvesting capacity to reduce grain loss. It is a small serrated plate which attaches to the front spiral and creates an aggressive, positive feed action to clear cut material from the front of the knife.

**Photo 1:** *Short fingers on a flex-front.*

Source: Grain legume handbook

*Flexible cutter bar fronts (flexi-fronts)*

The cutter bars of these fronts are hinged in short sections, allowing the whole front to flex and closely follow the ground contour (Photo 2). They use skid plates and are particularly good for short crops like lentil and field pea, but can also be used on cereals by locking the hinged sections together.

*Aussie-Air*

An Aussie-Air directs an air blast through reel fingers, and is suitable for both heavy and light crops.

The manufacturer claims an extra 15 horsepower is required to drive an Aussie-Air but there is also less horsepower requirement because of wider concave clearances. The actual horsepower required should be no more than for a heavy cereal crop.

*Harvestaire*

A Harvestaire replaces the reel with a manifold that directs a blast of air into the front. The manifold causes some interference with the incoming crop; correct orientation of air blast is very important. An optional secondary fan to increase the air blast is worthwhile; the device is more effective in light crops (Photo 2).

**Photo 2:** *Harvestaire front combined with extension fingers and a blue vibra-mate.*

Source: G. Cumming, Pulse Australia

*Vibra-Mat*

A Vibra-Mat is a vinyl mat that vibrates with the knife, stops bunching at the knife of open front headers and helps the table auger to clear cut materials. Its chief advantage is that this device is very cheap. It is more effective in light crops.

It is important to match ground speed to table auger capacity and crop density—too slow and the plants will not have enough momentum to carry to the front, too fast and the cut crop will not be cleared from behind the knife.

*Crop lifters*

Crop lifters are attachments to the knife that extend forward and are designed to lift lodged crops above the knife to reduced front losses. Most cereal crop lifters can be used, but since field pea plants have many thin stems, a slim crop lifter should reduce the sideways movement of the plant (Photo 3).

A flexible cutter bar is ideal because it has the best height control. Lifters can dig into wheel ruts left by spraying vehicles so avoid spraying when the soil is very wet or use low pressure tyres.

Soil intake can wear harvester parts and so is best avoided if possible but soil can be removed from the seed by fitting screens to the bottom of the clean grain elevator. Elevator screens can also help remove small, damaged or frosted grain. In general, heavier lifters tend to disturb more soil than lighter lifters, which may contribute to soil in the grain sample.


**Photo 3:** *Light crop lifters that can be used in field pea.*

Source: G. Reithmuller, DAFWA

### *Extension fingers*

Plastic extension fingers, approximately 30 cm long that fit over existing fingers, can save significant losses for little financial outlay. Pods that would have fallen in front of the knife are caught on the fingers and pushed into the comb by the incoming crop.

### *Extended fronts*

Extended fronts are now available for some headers and reduce losses at the knife by increasing the distance between the knife and auger to a maximum of 760 mm. This helps stop losses from bunching in front of the auger, where pods can fall over the knife and be lost.

### *Platform sweeps*

Platform sweeps are used in conjunction with extended fronts and consist of fingers which rake material towards the auger to help eliminate bunching. They can also be used on conventional fronts.

### *Draper fronts*

Draper fronts such as MacDon® and Honeybee® have large clearances behind the knife and carry the crop to the elevator. The front can also be used for cereals without modification (Photo 4).

**Photo 4:** *Plastic extension fingers fitted to a draper front.*

Source: G. Cumming, Pulse Australia

## 12.4 Achieving a clean sample

Harvesting field peas can be costly if stones, sticks or too much dirt are picked up with the plant. Machinery damage can be reduced by a variety of practices.

*Perforated screens*

Perforated screens fitted on the bottom of the broad elevator, cross augers, and grain and seconds elevators all reduce the amount of dirt in the sample. The perforated screen at the broad elevator is large and removes the dirt before it enters the main working mechanism of the harvester.

*Harvester speed*

Excessive harvester speeds will cause large grain losses and force more dirt into the harvester. Generally, speeds greater than 6–8 km/hour are not recommended, irrespective of the type of harvester front used.

*Harvesting in high humidity*

Harvesting in humid conditions, when pods are less prone to shatter can reduce grain losses. However, more unthreshed pods may appear in the grain sample. Care should be exercised when harvesting at night unless using a flex-front or a pick-up front with some positive height control to stop the front from digging into the dirt. Some growers have fitted wheels on the outer end of their fronts, as a depth stop. Others have bought ultra-sonic automatic depth controls to control front height.

*Pick-up fronts*

Pick-up fronts—the same as, or similar to, those used for picking up windrows—can be used to harvest windrowed field peas. The pick-up fronts greatly reduce the amount of dirt entering the harvester and make harvesting easier because harvesting height is not as critical as with a front-fitted with lifters. This allows harvesting at night. The fingers on the pick-ups are closely spaced and will gather the entire crop, so crop losses are reduced.

VIDEOS

WATCH: Agshield (2010) Cross auger kits for fluffy crop harvest.


There are different types of pick-ups. Some have fingers attached to rotating belts (draper pick-ups) and others have fingers attached to rotating drums (peg roller pick-ups). The peg roller types are cheap but tend to shatter pods and cause slightly higher grain losses than the draper type. The draper types are more expensive but will reduce losses if harvesting late.

## 12.5 Wet harvest issues and management

Field peas can handle a wet harvest better than cereals and do not germinate or shoot as easily as cereal or oilseed crops. Growers will often wait for a small shower before commencing harvest if the field peas have dried down too quickly prior to harvest and moisture levels have dropped to a point where split grain would be an issue. The other advantage after rainfall is that field peas can be stripped up to 14% moisture versus their pulse cousins at 12%, so harvest can often start in the field peas while the cereal crops are still drying down.

Problems with a wet harvest include:

- Weathered pods become more difficult to thresh, resulting in grain loss in unthreshed pods discarded out of the back of the header or in the sample, cracked grain and a slower harvest.
- Increased chance for crop to lodge.
- Grain quality can deteriorate. This is an issue if the field peas are destined for the human consumption market.
- If harvest is delayed a long time and weeds emerge, consider desiccation to dry the paddock down, prevent contamination in the sample and commence the fallow for the following year.
- The normal issues of trafficking in a wet harvest obviously apply to field peas with machines getting bogged and access for trucks an issue.

## 12.6 Dry harvest issues and management

Dry harvests can be a real issue with field peas. If the peas are stripped at a low moisture value (i.e. <10%), splits will be greatly increased and the product potentially downgraded, especially if it is destined for the human consumption market.

To avoid this problem:

- Desiccate crops for a more uniform crop.
- Aim to harvest field peas before the cereals, which in dry times, have a greater standability than pulse crops.
- Harvest at night time when conditions are cooler and humidity higher.
- Minimise post header handling to reduce other potential splitting operations. Try to avoid the use of screw augers—belt augers will result in less split grain.

## 12.7 Assessing grain harvest losses

Grain can be lost at a number of places during harvest and each loss needs to be assessed so that corrective action can be taken. Grain can be lost before harvest (due to pod shedding), at the harvester front (due to the front type or setup), and in the thrashing system of the machine (due to drum, concave and sieve settings) (Figure 2).

To determine harvest losses:

- Harvest a typical area without stopping the machine, then stop and allow the machine to clear itself of material.
- Back the harvester about 10 m and shut down the machine.
- Sample grain losses in each of the following three areas:
- pre-harvest (that is, in the standing crop in front of the harvester; 'A' in Figure 2)

- front (in the cut crop in front of the harvester; 'B' in Figure 2)
- machine (in the cut crop behind the harvester including trash; 'C' Figure 2).
- Sampling is best done using a quadrat with an area of 0.1 m$^2$:
- count the number of seeds lying within each of 10 quadrats in each of the three locations
- average the 10 samples in each area.

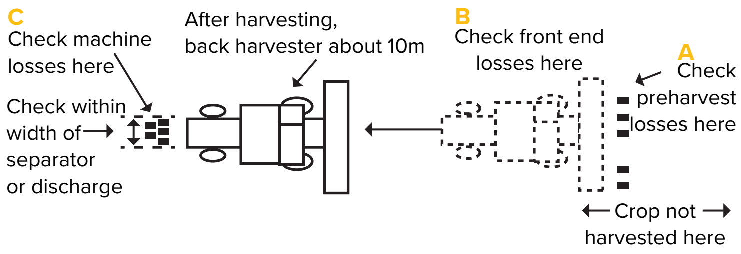


**Figure 2:** *Sampling places for estimating pre-harvest (A), front (B) and machine (C) losses.*

Source: The chickpea book

Grain losses on the ground can then be calculated, using the 100-seed weights.

Field pea: 100 seed weight = 17 grams

Seed on the ground = 32 / quadrat

Seed loss = (No. of seed/m$^2$) X (100 seed weight)
= (32 X 17) /10
= 544 kg/ha [6]

6 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

# Storage

## Key messages

- Good farm hygiene, storage in high quality sealed silos and aeration cooling are important for maintaining grain quality.
- Harvesting grain at a higher moisture content (up to 14%) reduces field mould and mechanical damage, but increases risk of deterioration during storage if not stored under aeration.
- Monitor stored grain monthly for moisture, temperature and pests.

## 13.1 Grain quality

Storing pulses successfully requires a balance between ideal harvest and storage conditions. It is extremely important to monitor the quality of grain before and during harvest. Seed coat and kernel (cotyledon) can be discoloured by crop-topping or premature desiccation. Staining of seed caused by green plants in the crop or a mixture of splits, weeds and stones will reduce the value of the grain and can lead to rejection or dockages.

Visual appearance is vital. Markets demand a quality sample without cracking, staining, de-hulled seeds or insect damage. Pulse samples showing no header damage will always be more acceptable to a buyer. The smaller seed of field pea makes it less prone to mechanical damage than larger seeded crops like faba bean, but it can still be damaged by mishandling. Minimise the number of times augers shift grain around to help reduce mechanical seed damage.

Grain quality is at its highest when first loaded into storage but can steadily deteriorate if the storage environment is not well managed. A combination of good farm hygiene, appropriate storage choice and aeration cooling are important to maintain grain quality and overcome problems associated with storage such as pests.

### 13.1.1 Storage life

Critical points to remember with regard to storing pulses are:

- Pulses stored above 12% moisture content require aeration cooling to maintain quality.
- Meticulous hygiene and aeration cooling are the first lines of defence against pest incursions.
- Fumigation is the only option available to control pests in stored pulses, and requires gas-tight, sealable storage.
- Avoiding mechanical damage to pulse seeds will maintain market quality and seed viability, and make seeds less attractive to insect pests.

Growers contemplating medium to long term storage (6–12 months) need to be aware field peas continue to age and quality will deteriorate over time—especially in sunlight and high temperatures and humidity.

Field peas will darken in storage, although not as dramatically as faba beans or desi chickpeas. Rate of seed coat darkening (deterioration in grain colour) will be accelerated by:

- high seed moisture content
- high temperatures
- high relative humidity
- condition of the seed at harvest
- sunlight [1]

1 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

MORE INFORMATION

GRDC (2014) Storing pulses. Fact sheet.

GRDC (2012) Vigilant monitoring protects grain assets. Fact sheet.

Mature seed subject to field weathering prior to harvest will deteriorate a lot quicker in storage, even if stored under 'acceptable' conditions of temperature and relative humidity. Growers should avoid even short to medium storage of weather damaged grain.

Pulse grain placed in storage with high germination and vigour can remain viable for at least 3 years providing the moisture content of the grain does not exceed 11%.

### Monitor

Check stored grain at least once a month during the cooler months and fortnightly during warmer months. Collect samples from the bottom of the storage and, if safe, at the top. When monitoring stored grain check for insect pests, grain temperature, grain moisture content, grain quality and germination. [2]

### Moisture

Pulses harvested at 14% moisture or higher must be dried before going into storage to preserve seed germination and viability. As a general rule, every 1% rise in moisture content above 11% will reduce the storage life of pulse seed by one third. Any pulse stored above 12% moisture content will require aeration cooling to maintain quality.

### Temperature

High temperatures in storage will cause deterioration in grain viability. Temperatures of stored pulse grain should not exceed an average of 25°C and preferably the average temperature should be below 20°C. In general, each 4°C rise in average stored temperature will halve the storage life of the grain (Table 1). One practical way of reducing temperatures is to paint the silo white as dark coloured silos will absorb more heat.

Grain in large silos (over 75 t) will remain cooler as grain is a poor conductor of heat, and day/night temperature fluctuations rarely reach 15 cm beyond the silo wall. Small silos (less than 20 t) and field bins will have larger temperature fluctuations and can cause deterioration in grain quality. [3]

**Table 1:** *Maximum recommended storage periods by temperature and moisture.*

| | Grain temperature (°C) | |
|---|---|---|
| **Grain moisture (%)** | 20°C | 30°C |
| 14 | 3 months | n/a |
| 13 | 9 months | 3 months |
| 12 | Greater than 9 months | 9 months |

Source: CSIRO

## 13.2 Grain cleaning

Re-cleaning of samples after harvest is sometimes necessary. Cereals can be cleaned from most other pulses, but not field pea because of their similar size. Cleaning cereals out of field pea must occur with herbicides in the paddock well before the cereals produce any grain.

Usually a 4 or 5 mm rotary screen would be used, with the 4.75 mm slotted screen being popular to also help screen out split grain. The paddles or agitators in rotary screens should be either new or sufficiently worn so the grain being harvested cannot jam between the outside of the paddle and the rotary screen.

2 GRDC (2014) Vigilant monitoring protects grain assets, Fact sheet, https://grdc.com.au/Resources/Factsheets/2012/03/Vigilant-monitoring-protects-grain-assets

3 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

Dirt and most small weed seeds can be separated in rotary screens, however the dirt will increase component wear. [4]

**Photo 1:** *A range of on- farm storage silos used to store pulses for either a short term or long term prospect.*

Source: W. Hawthorne, Pulse Australia

## 13.2.1 Cooling grain and aeration cooling

Cooler grain temperatures have several advantages:

- Seed viability (germination and vigour) is maintained longer.
- Moist grain can be safely held for a short time before blending or drying.
- Moisture migration and condensation inside the silo is reduced.
- Insect breeding life cycles are slowed (or cease in some instances) and hot spots are prevented.
- Mould growth is reduced.
- Darkening of the seed coat is slower.

Aeration cooling is a vital tool when storing pulses in a silo. It allows for longer term storage of low moisture grain by creating cool, uniform conditions that maintain seed quality, protect seed viability and reduce mould and insect development. Its use also allows grain to be harvested earlier and at higher moisture levels, capturing grain quality and reducing mechanical seed damage.

Aerated silos are fitted with fans that push air through the grain to cool the grain and equalise the moisture and temperature throughout the silo. With an aeration system, a water-proofed vent on the top of the silo allows escape of air forced from the base of the silo. This vent needs to be replaced with a sealed lid or a capped venting tube during fumigation.

It is important to know the capacity of any existing aeration system. Aeration cooling can be achieved with airflow rates of 2–3 L/sec/t delivered from fans driven by 0.37 kilowatt (0.5 horsepower) electric motor for silos around 100 tonne capacity.

4 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

MORE INFORMATION

GRDC (2016) Using aeration cooling for stored grain in Western Australia.

GRDC (2013) Aerating stored grain, cooling or drying for quality control. Grains industry guide.

GRDC (2012) Performance testing aeration systems. Fact sheet.

Correctly controlled aeration should aim to reduce grain temperature to 20°C or lower. Controlling aeration cooling is a three-stage process – continual, rapid and then maintenance. Cooling achieved during storage depends on the moisture content of the grain and the humidity and temperature of the incoming air. An understanding of the effects of relative humidity and temperature when aerating stored grain is important. Automatic aeration controllers that select optimum fan run times provide the most reliable results and are deemed best for convenience. [5]

## 13.2.2 Preventing moisture migration

Grain stored in sealed silos must be of sufficiently low moisture content to prevent moisture migration. Do not load grain with excess moisture into a sealed store where there is no escape for moisture. An exception is where the silo is aerated and has adequate ventilation fitted.

In a sealed silo, there is no free venting and therefore no escape for moisture in the headspace. Moisture can migrate to condense in upper grain layers. This top area of the grain is at high risk from mould and insect colonisation.

Because field peas are susceptible to splitting at the ideal moisture content of ≤12%, cone-based rather than flat-based silos are recommended for easy out-loading with minimal seed damage. Always fill and empty silos from the centre holes. This is especially important with pulses because most have a high bulk density. Loading or out-loading off-centre will put uneven weight on the structure and could cause it to collapse. [6]

*Moisture sources*

**Grains**: grain and seed are living and release moisture as they respire. This moisture moves upwards by convection currents created by the temperature difference between the grain in the center of the silo and the walls which can be either warmer or cooler.

**Grain insects**: insects or mites in the grain respire and release moisture and heat into air spaces. If grain is stored at less than 14% moisture and is free of insects, moisture content increase in the upper layers of the grain will be minimal. If grain is stored above 14% moisture content, then enough moisture may be carried into upper grain layers to place that grain at risk of mould. There is no moisture migration in an aerated silo as the entire stack is normally cooled to one temperature (20°C or less).

**Condensation impact**: moisture carried into the silo headspace can condense on a cold roof and fall back as free water. This can then cause a circle of mould or germinated grain against the silo wall. Moist grain can also contain greater numbers of insects.

**Leaks**: water entering through structural damage will increase grain moisture content to a level where mould and insect growth can occur.

## 13.2.3 Drying grain and aeration drying

Continuous-flow or batch dryers provide reliable drying, although they can reduce quality if run at too high a temperature. Check the specifications or talk to the manufacturer about safe conditions for drying pulses.

High capacity aeration systems can also be used to dry grain, and are ideally suited for drying grain harvested at 15–16% moisture content. Aeration drying has a lower risk of cracking and damaging pulses, which can occur with hot air dryers. Aeration drying requires a larger capacity fan to move high volumes of air through the grain at a faster rate than that required for cooling only.

5 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

6 GRDC (2014) Storing pulses. Fact sheet, https://grdc.com.au/resources-and-publications/all-publications/factsheets/2014/07/grain-storage-fact-sheet-storing-pulses

MORE INFORMATION

GRDC (2013) Dealing with high-moisture grain. Fact sheet.

Flow rates of at least 15–25 L/sec/t are required for aeration drying. By comparison, air flow rates as little as 2–3 L/sec/t can achieve aeration cooling.

Careful selection of conditions using dry ambient air (using an automated controller) can remove moisture from the stored grain over a period of weeks. [7]

Also for general information on handling, drying and cooling see: Agridry Rimik Pty Ltd

## 13.3 Insect pests in storage

Stored grain insects are not common in field peas. The exception to this is the pea weevil (*Bruchus pisorum*). It not only reduces yields but can also reduce germination rates of seed and grain quality to the point that it is not saleable for human consumption. The pea weevil will not reproduce in stored grain but the larvae can emerge from the seed while in storage leading to both live insects in the sample and pin holes in the grain that will detract from quality.

Many food consumption markets have a nil tolerance for live or dead adult pea weevil contamination or peas damaged by larval feeding. The stock feed market also has tolerance for live pea weevil.

Weevil development ceases at temperatures below 20°C. This is a strong incentive for aeration cooling, especially if gas-tight storage is not available. [8]

Freshly harvested grain usually has a temperature of around 30°C which is an ideal breeding temperature for many storage pests. Aeration fitted to stores will rapidly reduce grain temperatures, reducing insect breeding and aiding grain quality (Table 2).

**Table 2:** *The effect of grain temperature on insects and mould.*

| Temperature (°C) | Insect and mould development |
|---|---|
| 40–55 | Seed damage occurs, reducing viability |
| 30–40 | Mould and insects are prolific |
| 25–30 | Mould and insects active |
| 20–25 | Mould development is limited |
| 18–20 | Young insects stop developing |
| <15 | Most insects stop reproducing, mould stops developing |

Source: Grains Research and Development Corporation

If insects in stored pulses need treatment, the only control options are phosphine fumigation, an alternative fumigant or controlled atmosphere.

To ensure effective fumigation and control of all insect life stages, and reduce the risk of resistance development, fumigation must be carried out in a sealed, gas-tight silo.

Using diatomaceous earth as a structural treatment may be possible. Always check with the grain buyer for delivery standards or allowances before using any product that will come into contact with stored grain.

Not all silos can be sealed adequately to enable fumigation. However, all silos can have aeration added to them. Even if the silo can be sealed gas-tight for fumigation purposes, fitting aeration cooling will help immensely. Aeration coupled with excellent hygiene can overcome many potential problems. [9]

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7 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

8 GRDC (2014) Storing pulses. Fact sheet, https://grdc.com.au/resources-and-publications/all-publications/factsheets/2014/07/grain-storage-fact-sheet-storing-pulses

9 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

## 13.4 Farm and grain hygiene

Maintaining good farm and grain hygiene plays a crucial role in overcoming many problems with storage pests leading to reduced grain quality. Prevention is better than cure.

Basic hygiene practices include:

- Remove all grain residues from empty storage facilities and all grain handling and carriage equipment before new grain is stored and equipment used.
- Clean up spillages around silos and destroy all residues to prevent re-infestation.
- Always spread grain residues to a depth of <50 mm at a dump site to prevent the site from becoming an infested breeding site for storage pests. Most of these insects are strong fliers, moving >1 or 2 km.
- Once storages and equipment have been cleaned, treat them with an inert dust treatment.
- Ensure insect pests and weeds are not transported onto your property on farm equipment (i.e. harvesters). Equipment should be thoroughly cleaned down after use. [10]

MORE INFORMATION

GRDC (2013) Hygiene and structural treatments for grain storages. Fact sheet.

## 13.5 Fumigation

During crop growth, insect control programs aim to control field insects. For insect pests detected in stored grain, fumigation is the primary control measure.

Currently, phosphine is the only fumigant registered for use in pulses and can only be used in sealed storage. It is illegal and dangerous to put phosphine into unsealed storage.

Provided fumigation is carried out correctly, it will destroy all stages of insects: adults, eggs and larvae. This includes insects that may have developed some level of phosphine resistance.

Effective fumigation with phosphine needs a concentration of 300 ppm (a chemical to air ratio) to be maintained for seven days (when grain is stored >25°C) or 200 ppm for 10 days (15–25°C).

An unsealed silo will not hold these concentrations, even using a high dosage rate. Poor fumigations may appear to have been successful when dead adults are observed, but many of the eggs, larvae and pupae survive and will continue to infest the grain. In addition, insects that survive are more likely to carry phosphine-resistance genes. This has serious consequences for future insect control across the entire industry.

Grain stored <15°C should not be fumigated with phosphine because insects are hard to kill at low temperatures.

For large, sealable storages (e.g. >150 t capacity), a fumigation recirculation system should be fitted to the storage to ensure that gas is evenly distributed throughout the grain bulk in a timely manner during the fumigation exposure period.

Phosphine is a highly toxic substance. Always read safety advice on the label and comply with state legislative requirements.

Caution should be used when dealing with phosphine gas; it is not only toxic but also highly explosive. Observe all post-fumigation ventilation and withholding periods.

Always read the product label to confirm recommended application rates.

10 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

**Table 3:** *Recommended rates of phosphine for a sealed silo.*

| Cubic metres | Bushels | Tonnes | Number of tablets |
|---|---|---|---|
| 18 | 500 | 14 | 28 |
| 37 | 1000 | 28 | 56 |
| 56 | 1500 | 42 | 84 |
| 74 | 2000 | 56 | 111 |
| 92 | 2500 | 70 | 138 |

Source: Grain legume handbook

Bag chains may be hung in the head space or rolled out flat in the top of a gas-tight silo so air can pass freely around them. Tablets should be spread out evenly on trays and then hung in the head space or placed level on the grain surface. Some silos may also be fitted with purpose built facilities to apply phosphine from the bottom. These must have a passive or active air circulation system to carry the phosphine gas out of the confined space as it evolves, otherwise explosion can occur.

*Ventilation and withholding period after fumigation*

If there is only natural air flow over the grain there should be a minimum five days ventilation period to allow the phosphine concentrations to drop to safe levels below 0.3 ppm time weighted average.

The concentration of phosphine can be measured with a multigas detector pump fitted with a Draeger testing tube for phosphine. This equipment can detect levels of phosphine as low as 0.01 ppm in the air. See www.draeger.com.au.

*Disposal*

Tablet residues and expended sachets should be buried at least 30 cm below the soil surface. The expended tablets should not be piled in a heap because there is a risk that they will catch fire.

*First aid*

Accidents are always possible so an emergency plan should be prepared in advance. Make sure everyone involved knows the first aid treatment for phosphine poisoning and display diagrams for CPR as well as emergency phone numbers. [11]

## 13.5.1 Sealing silos

The Australian Standard (AS 2628-2010) allows growers to refer to an industry benchmark when purchasing a gas-tight, sealable silo, giving them confidence they are investing in a silo that will perform in the way it is intended.

Growers may choose to retro seal existing farm silos rather than buying new gas-tight silos. It is illegal to put phosphine into unsealed systems, hence the importance of retro sealing. Note however that not all silos can be made gas-tight.

Silos which are inadequately sealed lose gas through small holes, preventing the fumigant reaching and maintaining concentrations necessary for an effective insect kill. [12]

## 13.6 Silo or grain bags

Grain bags (known also as silo bags, sausage bags or harvest bags) are becoming increasingly popular.

11 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

12 GRDC (2008) The grain legume handbook for pulse growers. Grain Legume Handbook Committee and GRDC.

Pulses are riskier than other grains to store in grain bags. Pulse grain has been rejected by markets because of objectionable taints and odours derived during improper storage in a grain bag.

Grain bags are a sealed storage with no aeration. To maintain grain quality in storage it is essential to bag the grain at the correct moisture content and to ensure that the bag remains sealed throughout the entire storage period to prevent moisture ingress.

High moisture grain, condensation, water aggregation under the film or leaks can cause localised mould and widespread spoilage in pulses.

Even with adequate seals, hermetic conditions (low oxygen, high carbon dioxide) to protect against insects and mould are difficult to achieve consistently because of either high grain temperatures or low grain moisture content at the time of storage. [13]

**Photo 2:** *Silo bags (or grain bags, harvest bags) should be considered only as temporary storage for pulse grains because of quality issues that can arise.*

Source: W. Hawthorne, Pulse Australia

There are risks associated with storing pulses in grain bags:

- Pulse grain may not retain its quality, colour or odour, especially if the seal is breached.
- Contamination and moisture can enter bags from vermin and other pests that create holes in the bag.
- Excessive grain moisture can result in condensation within the bag, causing pockets of mouldy grain along with an offensive, distinctive 'mouldy' odour throughout. There is a nil tolerance of this in receival standards.

13 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

MORE INFORMATION

GRDC (2012) Successful storage in grain bags. Fact sheet.

- Marketers have rejected pulse grain because of objectionable moulds, taints and odours acquired through storage in grain bags.
- Removing taints and odours in affected grain is not necessarily possible, even with further aeration.
- Achieving and keeping hermetic conditions under Australian conditions is difficult and it should not be relied upon as the only source of storage insect control.
- Grain moisture content is critical. Pulses, particularly the larger seeded ones such as faba beans, have bigger airspaces between grains than do cereals, so moisture can move more freely in them. [14]

14 Pulse Breeding Australia (2016) Southern/Western Field Pea—Best Management Practices Training Course. Module 8–Desiccation, Harvest & Storage.

# Environmental issues

## Key messages

- Frost damage is not always obvious and crops should be checked 5–7 days after a suspected frost.
- Field peas have a very low tolerance to waterlogging.
- Field peas are one of the better legumes at tolerating drought or water limiting conditions.
- Field peas are more vunlerable to frost than other pulses due to thin pod walls and exposure of flowers to frost.

## 14.1 Frost issues for field pea

Frost is a complex and erratic constraint to Western Australian (WA) cropping systems that can result in dramatic consequences to a grower's business. Research that investigated trends since the 1960s has shown:

- WA's frost window has widened and on average frosts start 3 weeks earlier and finish 2 weeks later in the year.
- Consecutive frost events have increased by an average of up to 3 days at a time and mostly occur in August and September in the frost prone regions.
- The frosts are getting colder minimum temperatures. [1]

The sequence of weather events that typically generate damaging frosts is composed of the passage of a weak cold front, followed by cold southerly winds and the establishment of a ridge of high pressure. This results in cool daytime temperatures, light winds and clear skies overnight. [2]

Field peas are considered to be one of the more sensitive pulses to frost damage. Podset and grainfill are affected by even mild frosts, so overall frost damage can be great (Photo 1).

1 GRDC (2016) Pre-seeding planning to manage frost risk in WA. https://grdc.com.au/Media-Centre/Hot-Topics/Preseeding-planning-to-manage-frost-risk-in-WA

2 DAFWA (2016) The science of frost. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/frost/science-frost

**Photo 1:** *Frost damaged field pea pods.*

Photo: DAFWA

Field pea varieties differ in flowering time (early to late) and duration (short to an extended flowering). Some field pea varieties may escape total loss to frost with their extended flowering. Other late flowering varieties may escape early frost periods. Some varieties can occasionally be extremely vulnerable if they flower over a very short period.

Conventional, trailing type field peas appear less frost sensitive than many of the shorter, erect semi-leafless types. Physical damage from traffic or herbicides on frosted field peas during the pre-flowering stages can leave them more vulnerable to the spread of bacterial blight. [3]

Field peas have low tolerance to frost due to thin pod walls and exposure of pods to the atmosphere. Symptoms of frost damage in field peas include:

- flowers are killed by frost
- developing seeds in the pod are shrivelled or absent
- white/green mottling & blistering of pods
- affected pods feel spongy, and the seeds inside turn brown/black. [4]

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

4 DAFWA (2016) Frost: diagnosing the problem. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/frost/frost-diagnosing-problem?page=0%2C1

*Crop susceptibility to frost from most to least susceptible*

**Cereals**

triticale → wheat → barley → cereal rye → oats

**Pulses**

field peas → faba beans → lupins

Field peas are the most frost-susceptible pulse crop followed by faba beans and lupins. Canola is susceptible to frost, however is least susceptible to frost damage from late flowering (90%) to the clear watery stage (about 60% moisture). [5]

## 14.1.1 Managing frost damage

Although it is difficult to totally manage frost risk in field pea, it is important to know the period of highest probability of frost incidence. Aim to reduce exposure to frost or impact at vulnerable growth stages. Frost zone management tactics include:

*Use of the frost zone*

Map the topography to show areas of greatest risk, and specifically manage these areas. The use of identified frost zones should be carefully considered. Avoid large scale exposure to frost of highly susceptible crops like field peas. It may be prudent to sow annual or perennial pastures on areas that frost regularly to avoid the high costs of crop production.

*Review nutrient management*

On high frost risk sites, plan to use low or nil phosphate (if test levels are good) in order to reduce financial exposure to frost. In WA, field peas are often unresponsive to applied phosphate when soil test levels are strong.

*Modify soil heat bank*

The soil heat bank is important for reducing the risk of frost. Farming practices that manipulate the storage and release of heat from the soil heat bank into the crop canopy at night are important to consider to reduce the impact of a frost event. These include:

- practices that alleviate non-wetting sands, such as clay delving, mouldboard ploughing or spading
- rolling sandy soil and loamy clay soil after seeding
- reducing the amount of stubble
- cross-sowing/seeding–crops sown twice with half the seed sown in each direction have a more even plant density.

*Manipulate flowering times*

Sowing time remains a major driver of yield in all crops. The primary objective is to achieve a balance between crops flowering after the risk of frost has passed, but before the onset of heat stress. The loss of yield from sowing late to avoid frost risk is often outweighed by the gains from sowing on time to reduce heat and moisture stress in spring.

*Data loggers*

A number of tools are available to growers to monitor frost and assess damage. WA growers in frost-prone areas are using temperature data loggers to monitor temperatures. Data loggers allow growers to measure temperature over periods when crops are at their most sensitive. It is important for growers to know their paddocks well, as a frost rarely wipes out an entire crop. Low-lying areas are much

5 DAFWA (2017) Crop susceptibility to frost. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/frost/managing-frost-risk

MORE INFORMATION

GRDC (2016) Pre-seeding planning to manage frost risk in WA.

GRDC (2016) Tips and Tactics. Managing frost risk–Northern Southern and Western Regions. Fact sheet.

GRDC (2016) Frost risk mindset. Video.

GRDC (2014) Stubble removal takes the sting out of spring frosts. Video.

GRDC (2007) Managing Frost Risk - a guide for southern Australian grains.

DAFWA (2017) Managing frost risk

BOM (2016) Annual and monthly potential frost days

more prone to frost damage and the key is to identify just how widespread the damage has been before taking any action.

Over the past 10 years, frost has increased and been more severe. In WA, there are frost-damaged crops in areas not usually frost prone. For growers who are concerned about frost, but not keen on investing in a data logger, go to the Bureau of Meteorology's (BoM) new Frost Potential website. Frost Potential is a web-based frost prediction tool with maps that show forecast low temperature thresholds for various Australian weather station locations. The maps are updated daily and show forecasts for the next 48 hours. [6]

## 14.2 Waterlogging/flooding issues

Field peas have a very low tolerance to waterlogging. Crops sown into hard-setting soils can suffer from water logging as these soils tend to be poor draining. [7]

Waterlogging occurs when there is 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. Waterlogged roots initially have reduced growth then turn brown and die. The plant often compensates with new roots emerging from the hypocotyl.

In the paddock there will be poor germination or yellow plants in areas that collect water, particularly on shallow duplex soils. Saline areas are more affected. There may be bare wet soil and/or water-loving weeds present.

### Plant

Waterlogged seedlings can die before emergence. Plants will be small and pale, with pale to bright orange-yellow leaflets on older leaves. There may be nodulation failure and the plant has small, pale nodules or nodules may die with extended waterlogging.

Plants gradually die if waterlogging persists, or they appear to recover then die prematurely in spring because damaged root systems cannot access subsoil moisture. [8] These shallow roots cannot take up nutrients from drying soil near the surface, nor reach nutrients and water deeper in the profile.

Plants are also more susceptible to root and foliar diseases under these conditions and may be more affected by aphids.

In addition, salinity magnifies waterlogging effects, with more marked stunting and leaflets on oldest leaf tip dying back from the tip.

### Management strategies

Avoid growing field peas on regularly waterlogged soils. Drainage may be appropriate on sandy duplex soils on sloping sites. [9]

In most cases, drainage with or without raised beds is the best way to overcome waterlogging and inundation in most areas. A network of shallow drains in cropped areas pay for themselves within a few years. Where drains can only partially overcome the problem, changes to crop species, varieties and management may be necessary. [10]

6 Farming Ahead (2010) Growers walk the wire as frost bites. http://www.farmingahead.com.au/cropping/cropping-general/growers-walk-the-wire-as-frost-bites/

7 GRDC (2009) Field Peas: The Ute Guide, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/04/field-peas-the-ute-guide

8 DAFWA (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

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

10 DAFWA (2015) Overcoming waterlogging. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/48

### How can it be monitored?

Plants can be waterlogged when there is a water table within 30 cm of the surface and no indication of waterlogging at the surface. Water levels can be monitored with bores or observation pits, but water tables can vary greatly over short distances. Observe plant symptoms and paddock clues and verify by digging a hole. The salinity status of a soil can be assessed from indicator plants, measuring the salt concentration in soil samples or with electromagnetic-induction instruments, or by measuring the depth to a saline water table. [11]

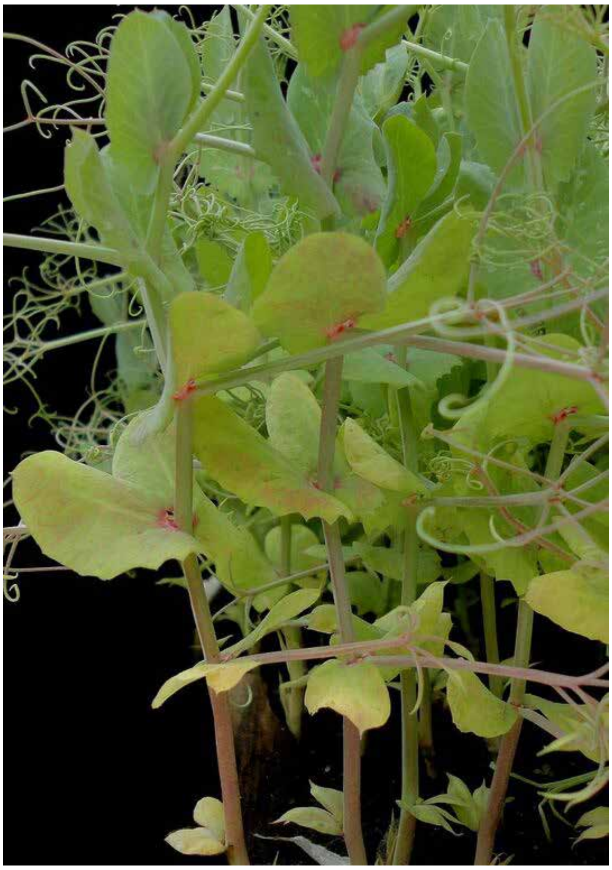


**Photo 2:** *Waterlogged pea plant.*

Photo: DAFWA

## 14.3 Drought tolerance

Field peas are one of the better legumes at tolerating drought or water limiting conditions. However, low soil moisture can lead to poor germination, growth and short crops, which can prove challenging at harvest time. Hot, windy weather at flowering time can result in reduced flower set, poor grainfill, and smaller grain. [12]

Field peas have the highest sensitivity to stress in the period between the beginning of flowering and the beginning of seedfill. [13]

In the paddock there may be patchy germination that may vary according to seeding depth, soil type or other factors that affect soil moisture infiltration and storage.

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

12 GRDC (2009) Field Peas: The Ute Guide, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/04/field-peas-the-ute-guide

13 V Sadras et al. (2012) Water and thermal regimes for field pea in Australia and their implications for breeding. Crop and Pasture Science Jan 2012, http://www.researchgate.net/profile/Victor_Sadras/publication/230626089_Water_and_thermal_regimes_for_field_pea_in_Australia_and_their_implications_for_breeding/links/0c960525f4091c3f83000000.pdf

MORE INFORMATION

Liebe Group: Growing field peas and chickpeas in low rainfall zones

Field pea stubble: Wind erosion control and grazing management,

Plants will be dark and dull coloured. They may have reddened stems, leaves and leaf margins, and plants that have wilted become stunted or die. [14]

Growing field peas and pulses in general requires improved adaptation to low rainfall regions. Research is ongoing to identify and select field pea germplasm that has superior yield and yield stability under water deficit as well as in favourable conditions. [15]

## 14.4 Wind erosion and field pea stubble

The no-grazing option:

- Less potential for wind erosion and soil loss
- May give additional yield and protein improvements in following cereal crops
- Varieties of semi-leafless field pea may have very low harvest losses which do not warrant grazing.

The grazing option:

- Only for a short period, as most available spilt grain is consumed in about four weeks or less if the harvester is well set up or if a semi-leafless sugar pod field pea variety is grown
- Gives good liveweight gain in weaner and adult sheep with low worm burdens, during the short period that seed is available
- Greatly increases the chance of wind erosion in most situations unless carefully managed.
- Not recommended on sandy or fragile surfaced soils
- Breaks down vines which helps seeding.
- Extensive wind erosion of field pea stubble often follows grazing over summer and autumn. Semi-leafless field pea varieties have reduced lodging, improved pod-height and reduced pod-shatter. These traits decrease harvest losses and the relatively small amount of grain left for stock reduces the need to graze field pea stubble paddocks.
- Grazing stubble can loosen 40t/ha or more of surface soil. Light soils such as sandy-surfaced duplex soils may lose much more. Wind tunnel tests show that field pea stubble has few soil erosion problems if left ungrazed and uncultivated.
- Reducing the amount of spilt grain reduces the need to graze field pea stubble. Improving harvest efficiency or decreasing harvest losses will decrease the need or duration of grazing and consequently decrease the risk of wind erosion.
- Retaining as much cereal straw as possible also reduces the risk of wind erosion. The straw helps to anchor the field pea stubble after harvest and increases the amount of surface cover of the soil, whether it is grazed or not.
- Loose field pea stubble can build up against fences, which is unsightly and may damage fences. Using a harvester fitted with choppers and spreaders helps to prevent this build-up. It is best to harvest on days when the residue will chop into small pieces and spread evenly rather than form long vine-like ‘sausages’ or mound to create lumpy paddocks.
- Semi-leafless field pea varieties with the sugar pod trait have a ropey vine which is more likely to form ‘sausages’ than conventional trailing varieties particularly in cool weather. [16]

14 DAFWA (2015) Diagnosing early moisture stress in field peas. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/mycrop/diagnosing-early-moisture-stress-field-peas

15 V Sadras (2013) Improving yield and reliability of field peas under water deficit. GRDC Update papers, 15 Jan 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/01/Improving-yield-and-reliability-of-field-peas-under-water-deficit

16 DAFWA (2017) Field pea stubble: Wind erosion control and grazing management, https://www.agric.wa.gov.au/wind-erosion/field-pea-stubble-wind-erosion-control-and-grazing-management

# Marketing

The final step in generating farm income is converting the tonnes produced into dollars at the farm gate. This section provides best-in-class marketing guidelines for managing price variability to protect income and cash flow.

Figure 1 shows a grain selling flow chart that summarises:

- The decisions to be made.
- The drivers behind the decisions.
- The guiding principles for each decision point.

The reference column refers to the section of the GrowNote where you will find the details to help you in making decisions.

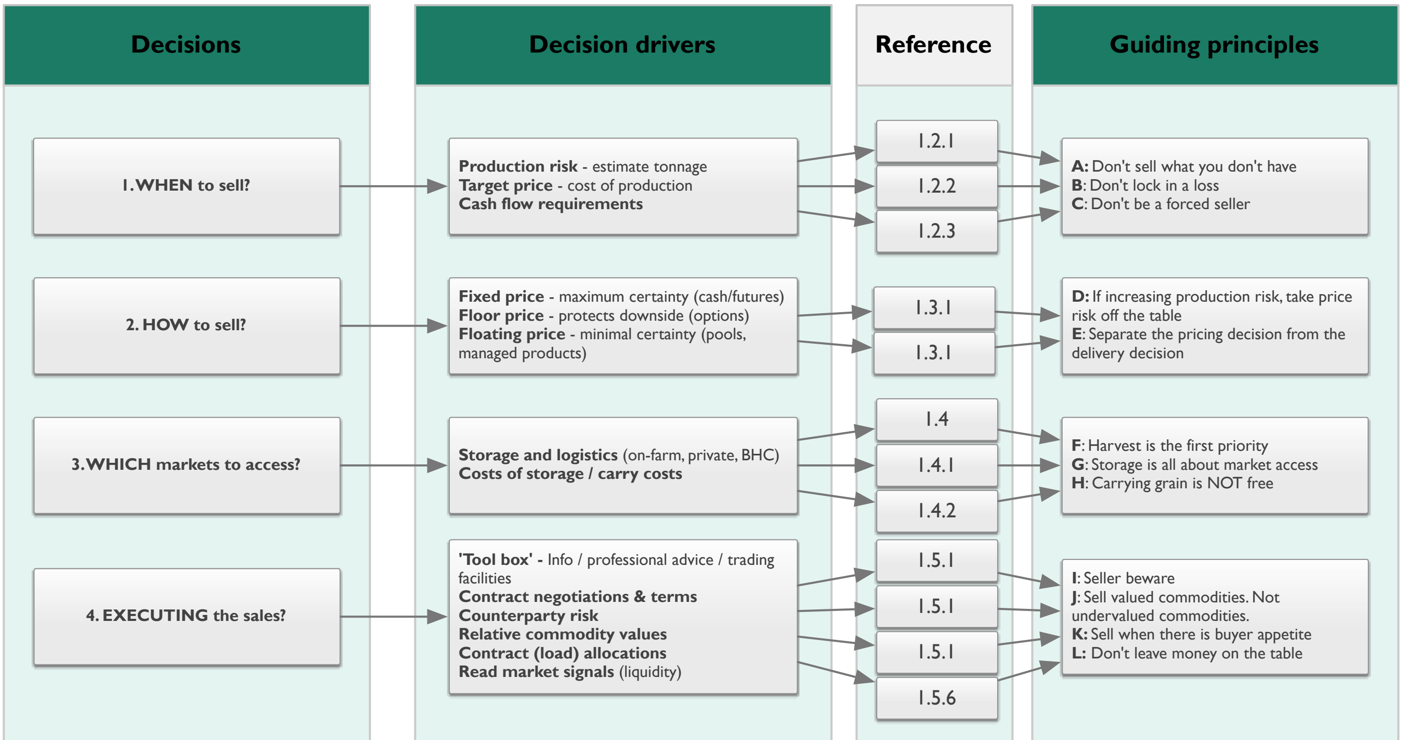



**Figure 1:** *Grain-selling flowchart.*

The grower will run through a decision-making process each season, because growing and harvesting conditions, and prices for grains, change all the time. For example, in the seven years to and including 2015, Port Adelaide field pea values varied A$60–$370/t, a variability of 30–60% (Figure 2). For a property producing 200 tonnes of field peas this means $12,000–$74,000 difference in income, depending on timing of sales.

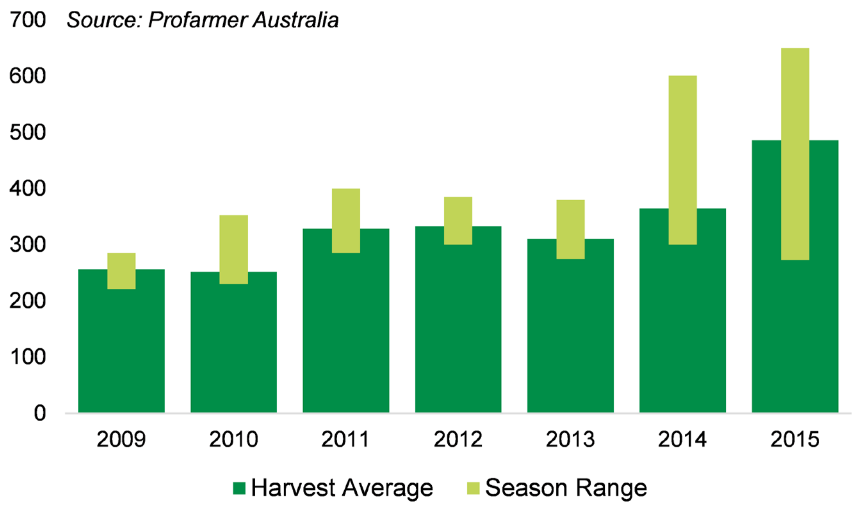



**Figure 2:** *Intraseasonal variance of Port Adelaide field pea values 2009–2015.*

Source: Profarmer Australia

## 15.1 Selling principles

The aim of a selling program is to achieve a profitable average price (the target price) across the entire business. This requires managing several unknowns to establish a target price and then work towards achieving the target price.

Unknowns include the amount of grain available to sell (production variability), the final cost of producing the grain, and the future prices that may result. Australian farm-gate prices are subject to volatility caused by a range of global factors that are beyond our control and are difficult to predict.

The skills growers have developed to manage production unknowns can also be used to manage pricing unknowns. This guide will help growers manage and overcome price uncertainty.

### 15.1.1 Be prepared

Being prepared by having a selling plan is essential for managing uncertainty. The steps involved are forming a selling strategy, and forming a plan for effectively executing sales. The selling strategy consists of when and how to sell.

#### When to sell

Knowing when to sell requires an understanding of the farm's internal business factors, including:

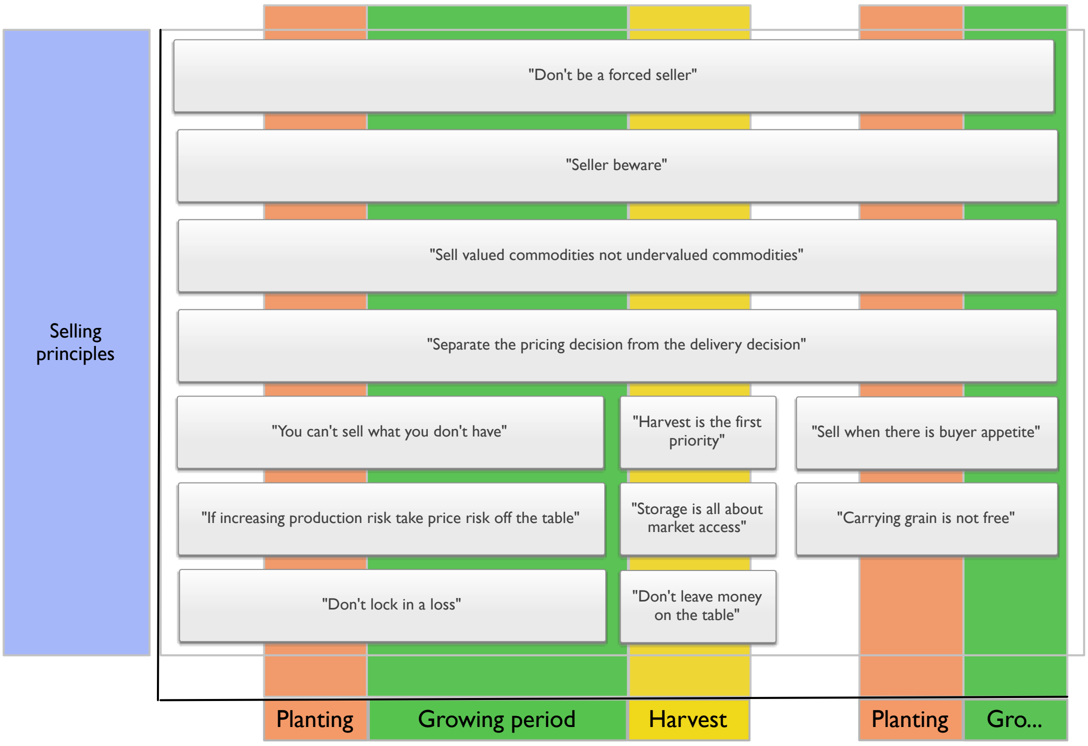
- production risk
- a target price based on the cost of production and the desired profit margin
- business cashflow requirements

#### How to sell

Working out how to sell your grain is more dependent on external market factors, including:

- the time of year, which determines the pricing method
- market access, which determines where to sell
- relative value, which determines what to sell

The following diagram (Figure 3) lists the key principles to employ when considering sales during the growing season. Exactly when each principle comes into play is indicated in the discussion below of the steps involved in marketing and selling.



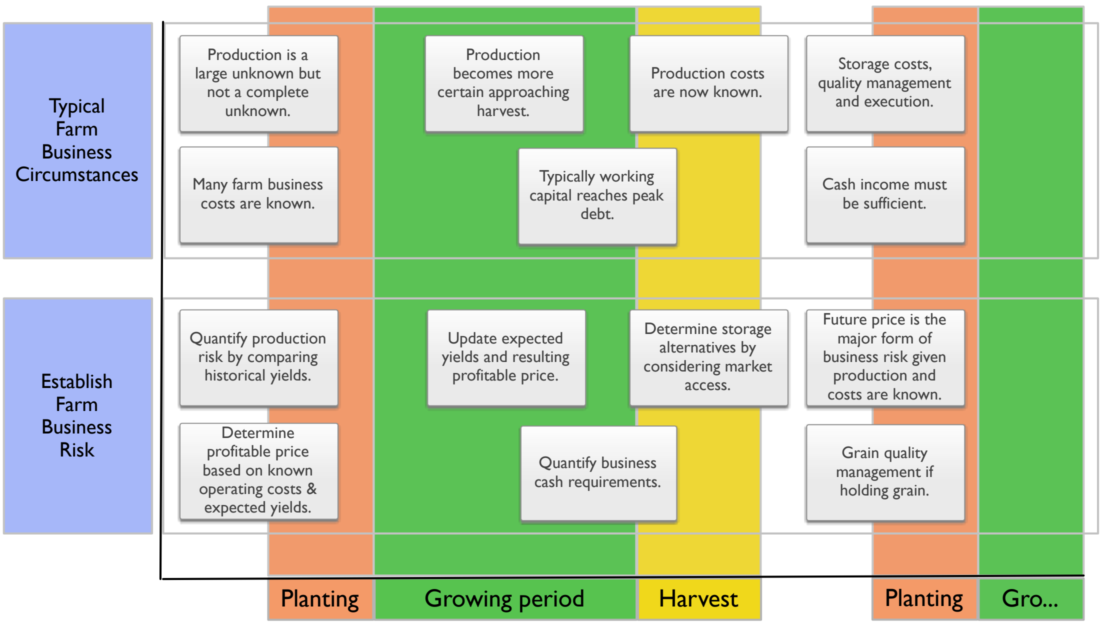

**Note to figure:** The illustration demonstrates the key selling principles throughout the production cycle of a crop.

**Figure 3:** *Timeline of grower commodity selling principles.*

Source: Profarmer Australia

### 15.1.2 Establish the business risk profile

Establishing your business risk profile helps you determine when to sell: it allows you to develop target price ranges for each commodity, and provides confidence to sell when the opportunity arises. Typical business circumstances and how to quantify the risks during the production cycle are described below (Figure 4).




**Note to figure:** When does a grower sell their grain? This decision making is dependent on:
a) Does production risk allow sales? And what portion of production?
b) Is the price profitable?
c) Are business cash requirements being met?

**Figure 4:** *Typical farm business circumstances and risk.*

Source: Profarmer Australia

### Production risk profile of the farm

Production risk is the level of certainty around producing a crop and is influenced by location (climate, season and soil type), crop type, crop management, and the time of the year.

**Principle:** You can't sell what you don't have.

Therefore, don't increase business risk by over committing production. Establish a production risk profile (see Figure 5) by:

1. Collating historical average yields for each crop type and a below-average and above-average range.
2. Assessing the likelihood of achieving the average, based on recent seasonal conditions and the seasonal outlook.
3. Revising production outlooks as the season progresses.

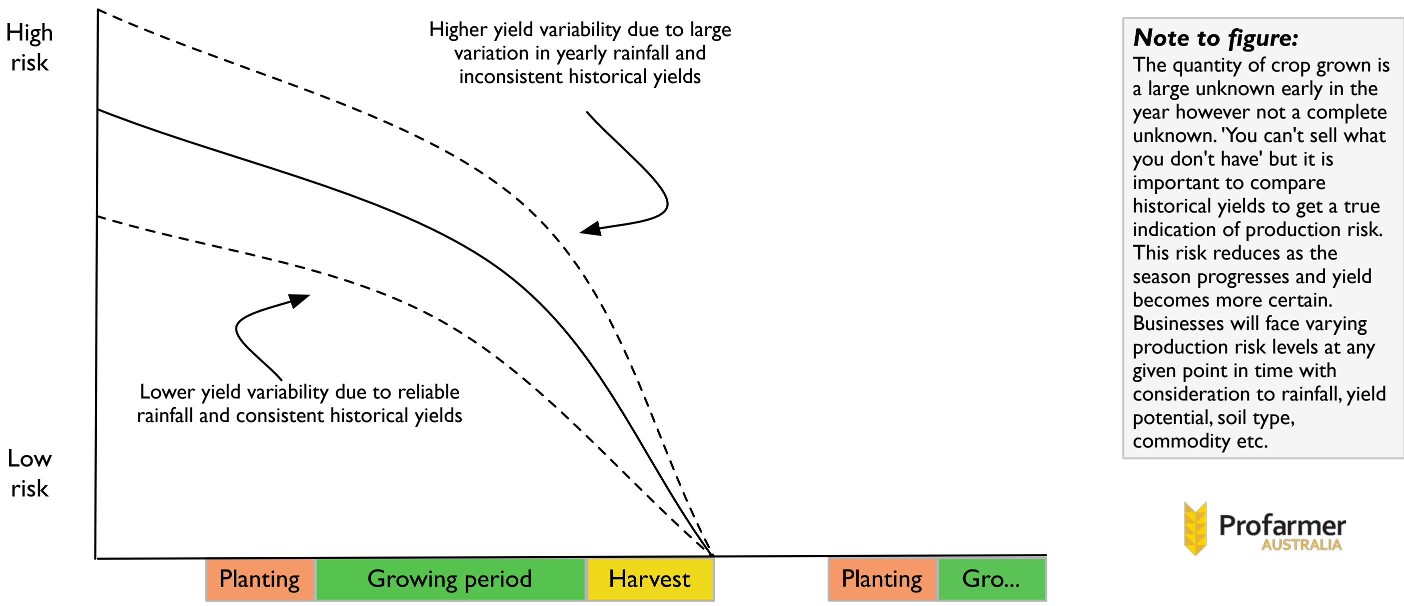



**Figure 5:** *Typical risk profile of a farm operation.*

Source: Profarmer Australia

### Establishing a target price

A profitable commodity target price is the cost of production per tonne plus a desired profit margin. It is essential to know the cost of production per tonne for the farm business, which means knowing all farming costs, both variable and fixed.

**Principle:** Don't lock in a loss.

If committing production ahead of harvest, ensure the price will be profitable. The steps needed to calculate an estimated profitable price is based on the total cost of production and a range of yield scenarios, as provided below (Figure 6).

| Estimating cost of production - Wheat | |
|---|---|
| Planted Area | 1,200 ha |
| Estimate Yield | 2.85 t/ha |
| Estimated Production | 3,420 t |
| **Fixed costs** | |
| Insurance and General Expenses | $100,000 |
| Finance | $80,000 |
| Depreciation/Capital Replacement | $70,000 |
| Drawings | $60,000 |
| Other | $30,000 |
| **Variable costs** | |
| Seed and sowing | $48,000 |
| Fertiliser and application | $156,000 |
| Herbicide and application | $78,000 |
| Insect/fungicide and application | $36,000 |
| Harvest costs | $48,000 |
| Crop insurance | $18,000 |
| Total fixed and variable costs | $724,000 |
| Per Tonne Equivalent (Total costs + Estimated production) | $212 /t |
| **Per tonne costs** | |
| Levies | $3 /t |
| Cartage | $12 /t |
| Receival fee | $11 /t |
| Freight to Port | $22 /t |
| Total per tonne costs | $48 /t |
| Cost of production Port track equiv | $259.20 |
| Target profit (ie 20%) | $52.00 |
| **Target price (port equiv)** | **$311.20** |

Step 1: Estimate your production potential. The more uncertain your production is, the more conservative the yield estimate should be. As yield falls, your cost of production per tonne will rise.

Step 2: Attribute your fixed farm business costs. In this instance if 1,200 ha reflects 1/3 of the farm enterprise, we have attributed 1/3 fixed costs. There are a number of methods for doing this (see M Krause "Farming your Business") but the most important thing is that in the end all costs are accounted for.

Step 3: Calculate all the variable costs attributed to producing that crop. This can also be expressed as $ per ha x planted area.

Step 4: Add together fixed and variable costs and divide by estimated production

Step 5: Add on the "per tonne" costs like levies and freight.

Step 6: Add the "per tonne" costs to the fixed and variable per tonne costs calculated at step 4.

Step 7: Add a desired profit margin to arrive at the port equivalent target profitable price.

**Figure 6:** *An example of how to estimate the costs of production.*

Source: Profarmer Australia

## MORE INFORMATION

GRDC's manual Farming the Business also provides a cost-of-production template and tips on grain selling *v.* grain marketing.

## Income requirements

Understanding farm business cash-flow requirements and peak cash debt enables growers to time grain sales so that cash is available when required. This prevents having to sell grain below the target price to satisfy a need for cash.

**Principle:** Don't be a forced seller.

Be ahead of cash requirements to avoid selling in unfavourable markets.

Typical cash-flow to grow a crop are illustrated below (Figures 7 and 8). Costs are incurred up front and during the growing season, with peak working capital debt incurred at or before harvest. Patterns will vary depending on circumstance and enterprise mix. The second figure demonstrates how managing sales can change the farm's cash balance.

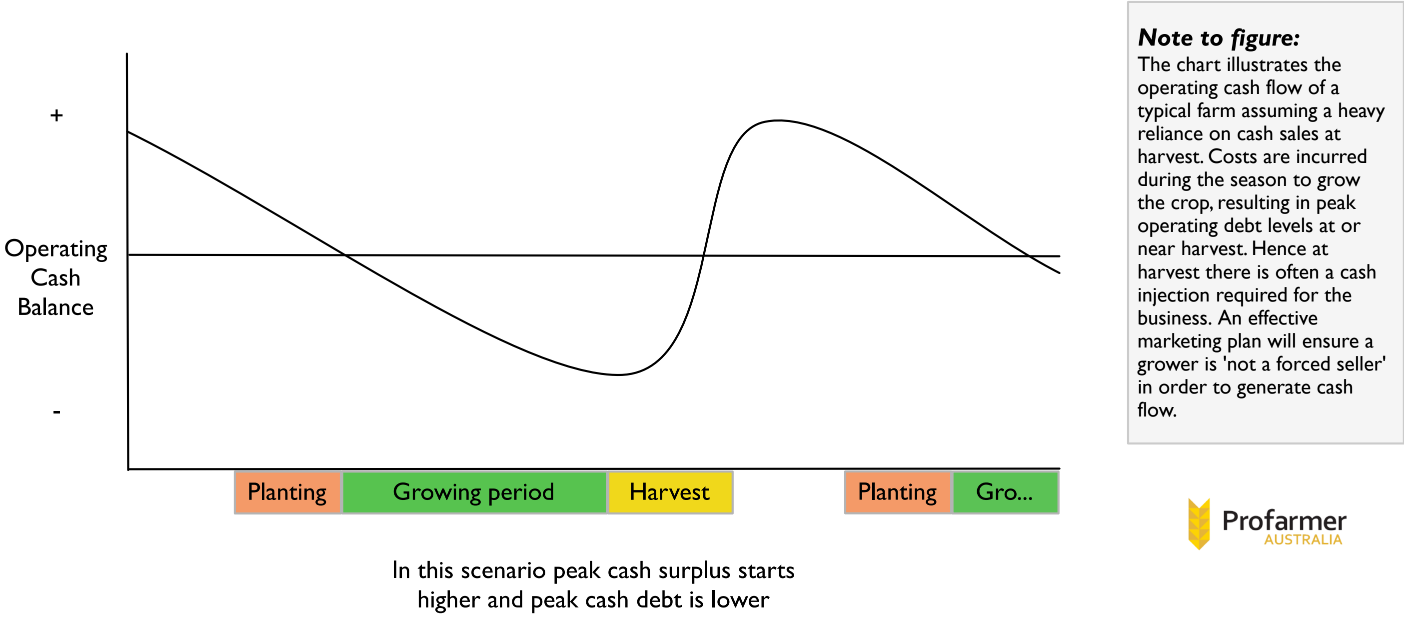



**Figure 7:** *A typical operating cash balance when relying on cash sales at harvest.*

Source: Profarmer Australia

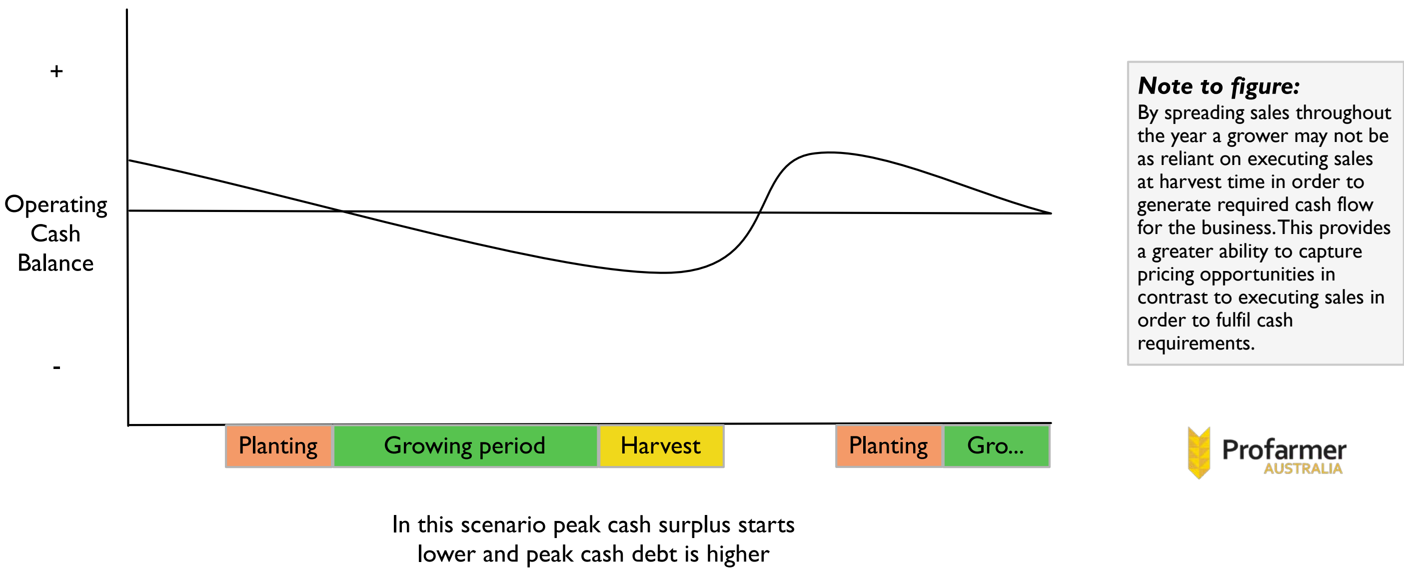



**Figure 8:** *Typical operating cash balance when crop sales are spread over the year.*

Source: Profarmer Australia

The when-to-sell steps above result in an estimated production tonnage and the risk associated with producing that tonnage, a target price range for each commodity, and the time of year when cash is most needed.

### 15.1.3 Managing your price

The first part of the selling strategy answers the question about when to sell and establishes comfort around selling a portion of the harvest.

The second part of the strategy, managing your price, addresses how to sell your crop.

### Methods of price management

Pricing products provide varying levels of price risk coverage, but not all products are available for all crops (Table 1).

**Table 1:** *Pricing methods and how they are used for different crops.*

| | Description | Wheat | Barley | Canola | Oats | Lupins | Field Peas | Chick Peas |
|---|---|---|---|---|---|---|---|---|
| Fixed price products | Provides the most price certainty | Cash, futures, bank swaps | Cash, futures, bank swaps | Cash, futures, bank swaps | Cash | Cash | Cash | Cash |
| Floor price products | Limits price downside but provides exposure to future price upside | Options on futures, floor price pools | Options on futures | Options on futures | none | none | none | none |
| Floating price products | Subject to both price upside and downside | Pools | Pools | Pools | Pools | Pools | Pools | Pools |

Figure 9 summarises how the different methods of price management are suited to the majority of farm businesses.

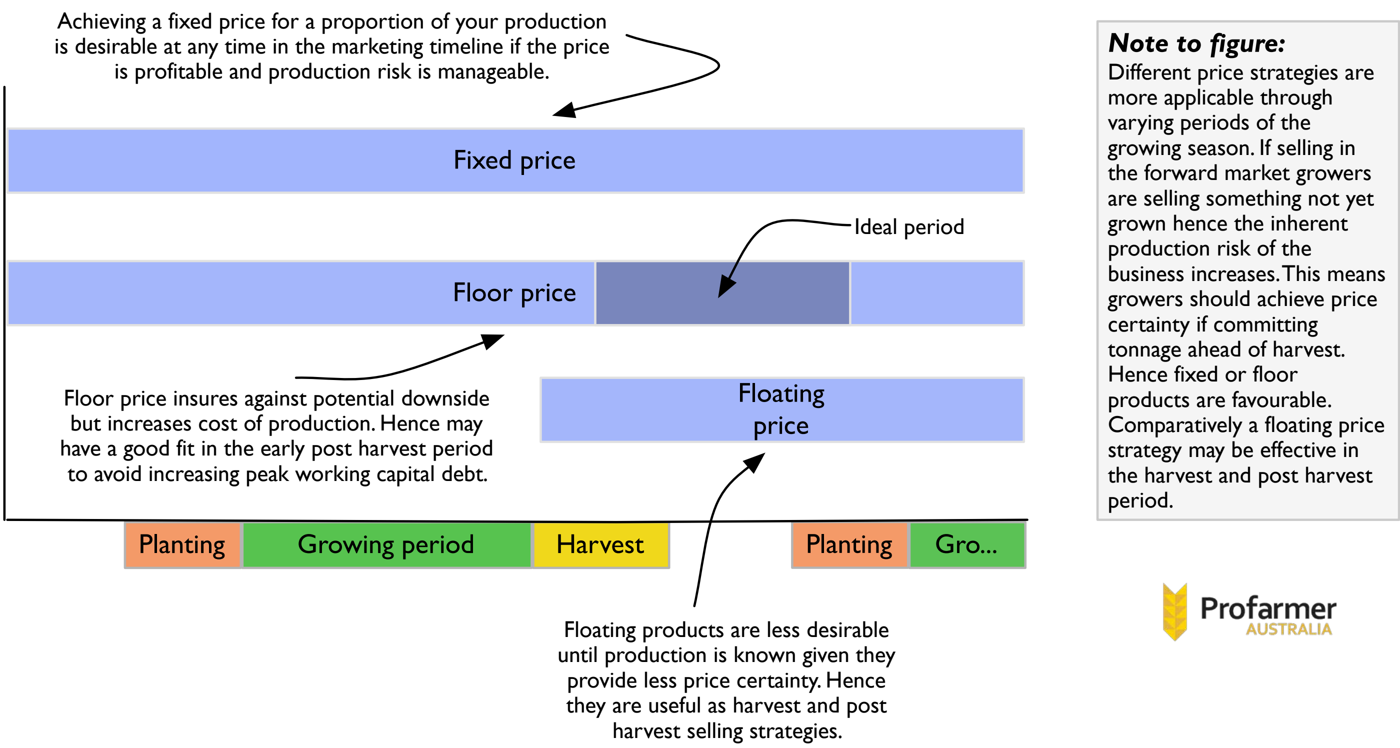



**Figure 9:** *Price strategy timeline, summarising the suitability for most farm businesses of different methods of price management for different phases of production.*

Source: Profarmer Australia

**Principle:** If increasing production risk, take price risk off the table.

When committing to unknown production, price certainty should be achieved to avoid increasing overall business risk.

**Principle:** Separate the pricing decision from the delivery decision.

Most commodities can be sold at any time with delivery timeframes being negotiable, hence price management is not determined by delivery.

*Fixed price*

A fixed price is achieved via cash sales and/or selling a futures position (swaps) (Figure 10). It provides some certainty around expected revenue from a sale as the price is largely a known factor, except when there is a floating component in the price, e.g. a multi-grade cash contract with floating spreads or a floating-basis component on futures positions.

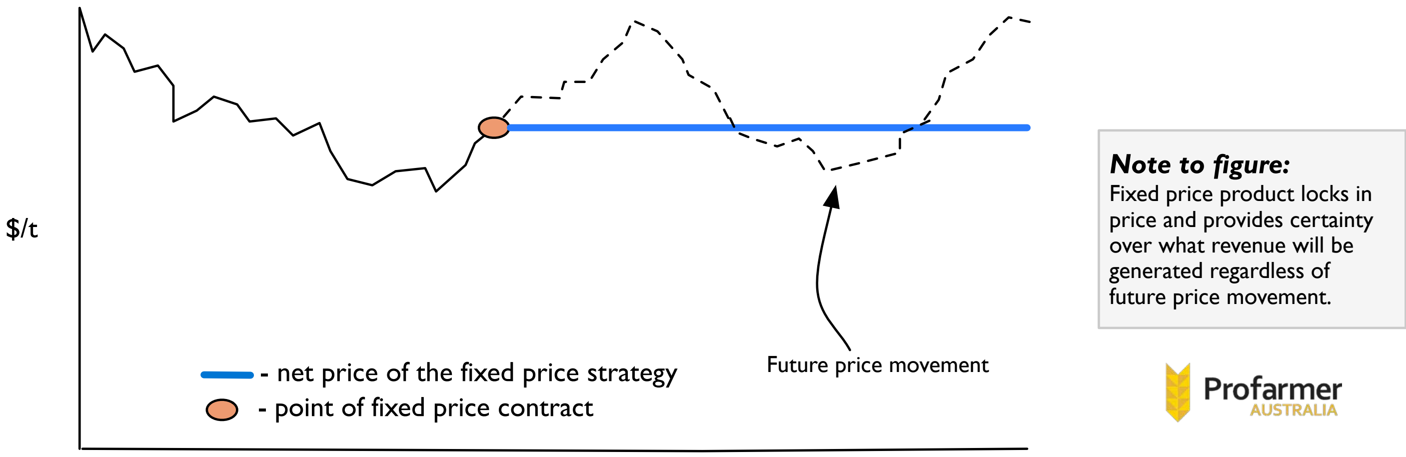



**Figure 10:** *Fixed price strategy.*

Source: Profarmer Australia

*Floor price*

Floor-price strategies (Figure 11) can be achieved by utilising options on a relevant futures exchange (if one exists), or via a managed-sales program (i.e. a pool with a defined floor-price strategy) offered by a third party. This pricing method protects against potential future downside while capturing any upside. The disadvantage is that this kind of price 'insurance' has a cost, which adds to the farm's cost of production.

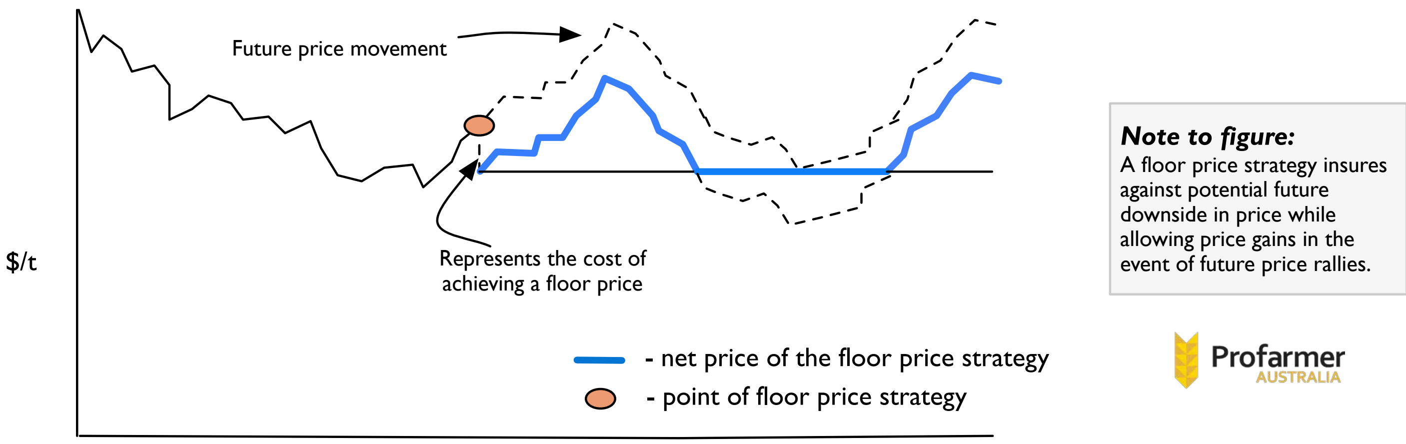
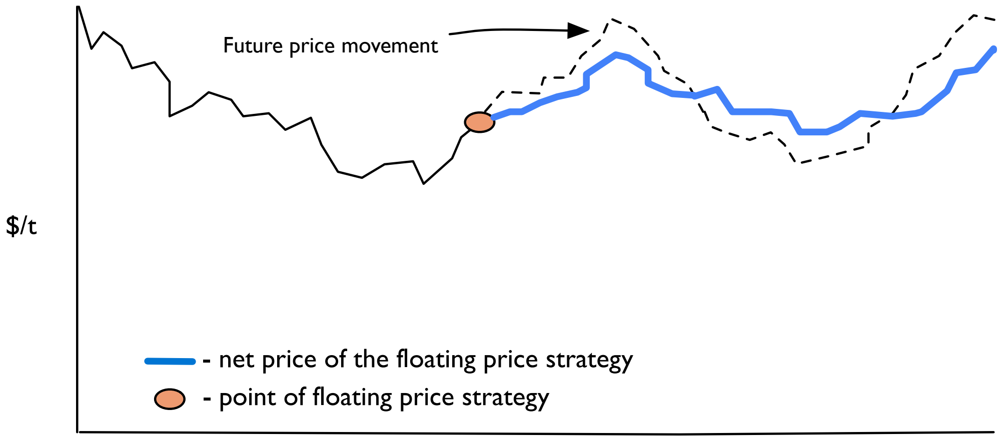



**Figure 11:** *Floor price strategy.*

Source: Profarmer Australia

*3. Floating price*

Many of the pools or managed-sales programs are a floating price, where the net price received will move up and down with the future movement in price (Figure 12). Floating-price products provide the least price certainty and are best suited for use at or after harvest rather than before harvest.




***Note to figure:***
A floating price will move to some extent with future price movements.

Profarmer AUSTRALIA

**Figure 12:** *Floating price strategy.*

Source: Profarmer Australia

Having considered the variables of production for the crop to be sold, and how these fit against the different pricing mechanisms, the farmer may revise their selling strategy, taking the risks associated with each mechanism into account.

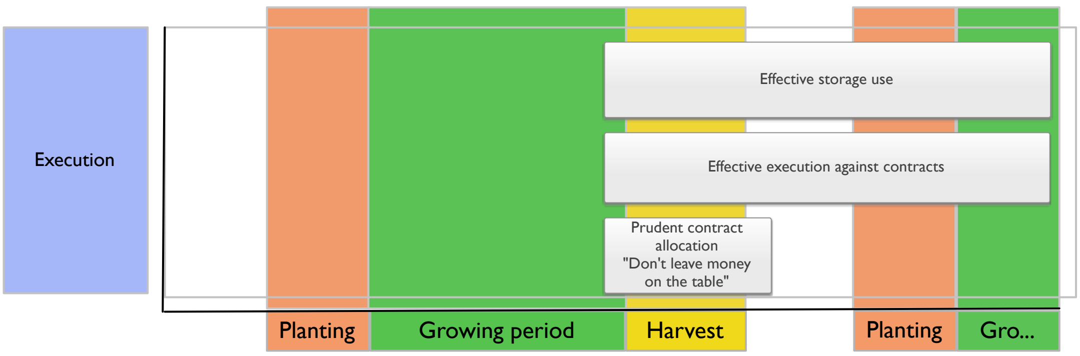
Fixed-price strategies include physical cash sales or futures products, and provide the most price certainty, but production risk must be considered.

Floor-price strategies include options or floor-price pools. They provide a minimum price with upside potential and rely less on production certainty, but cost more.

Floating-price strategies provide minimal price certainty, and so are best used after harvest.

## 15.1.4 Ensuring access to markets

Once the questions of when and how to sell are sorted out, planning moves to the storage and delivery of commodities to ensure timely access to markets and execution of sales. Planning where to store the commodity is an important component of ensuring the type of access to the market that is likely to yield the highest return (Figure 13).




***Note to figure:***
Once a grower has made the decision to sell the question becomes how they achieve this? The decision on how to sell is dependent on:
a) Time of the year determines the pricing method
b) Market Access determines where to sell.
c) Relative value determines what to sell.

Profarmer AUSTRALIA

**Figure 13:** *Storage decisions are influenced by selling decisions and the timing of all farming activities.*

Source: Profarmer Australia

## Storage and logistics

The return on investment from grain handling and storage expenses is optimised when storage is considered in light of market access so as to maximise returns as well as harvest logistics.

Storage alternatives include variations of bulk handling, private off-farm storage, and on-farm storage. Delivery and quality management are key considerations in deciding where to store your commodity (Figure 14).

**Principle:** Harvest is the first priority.

During harvest, getting the crop into the bin is the most critical aspect of business success; hence storage, sale and delivery of grain should be planned well ahead of harvest to allow the grower to focus on the harvest itself.

Bulk export commodities requiring significant quality management are best suited to the bulk-handling system. Commodities destined for the domestic end-user market, (e.g. feedlot, processor, or container packer), may be more suited to on-farm or private storage to increase delivery flexibility.

Storing commodities on the farm requires prudent quality management to ensure that the grain is delivered to the agreed specifications. If not well planned and carried out, it can expose the business to high risk. Penalties for out-of-specification grain arriving at a buyer's weighbridge can be expensive, as the buyer has no obligation to accept it. This means the grower may have to incur the cost of taking the load elsewhere, and may also have to find a new buyer.

On-farm storage also requires that delivery is managed to ensure that the buyer receives the commodities on time and with appropriate weighbridge and sampling tickets.

**Principle:** Storage is all about market access.

Storage decisions depend on quality management and expected markets.

MORE INFORMATION

For more information on on-farm storage alternatives and economics refer to Section 13: Grain Storage.

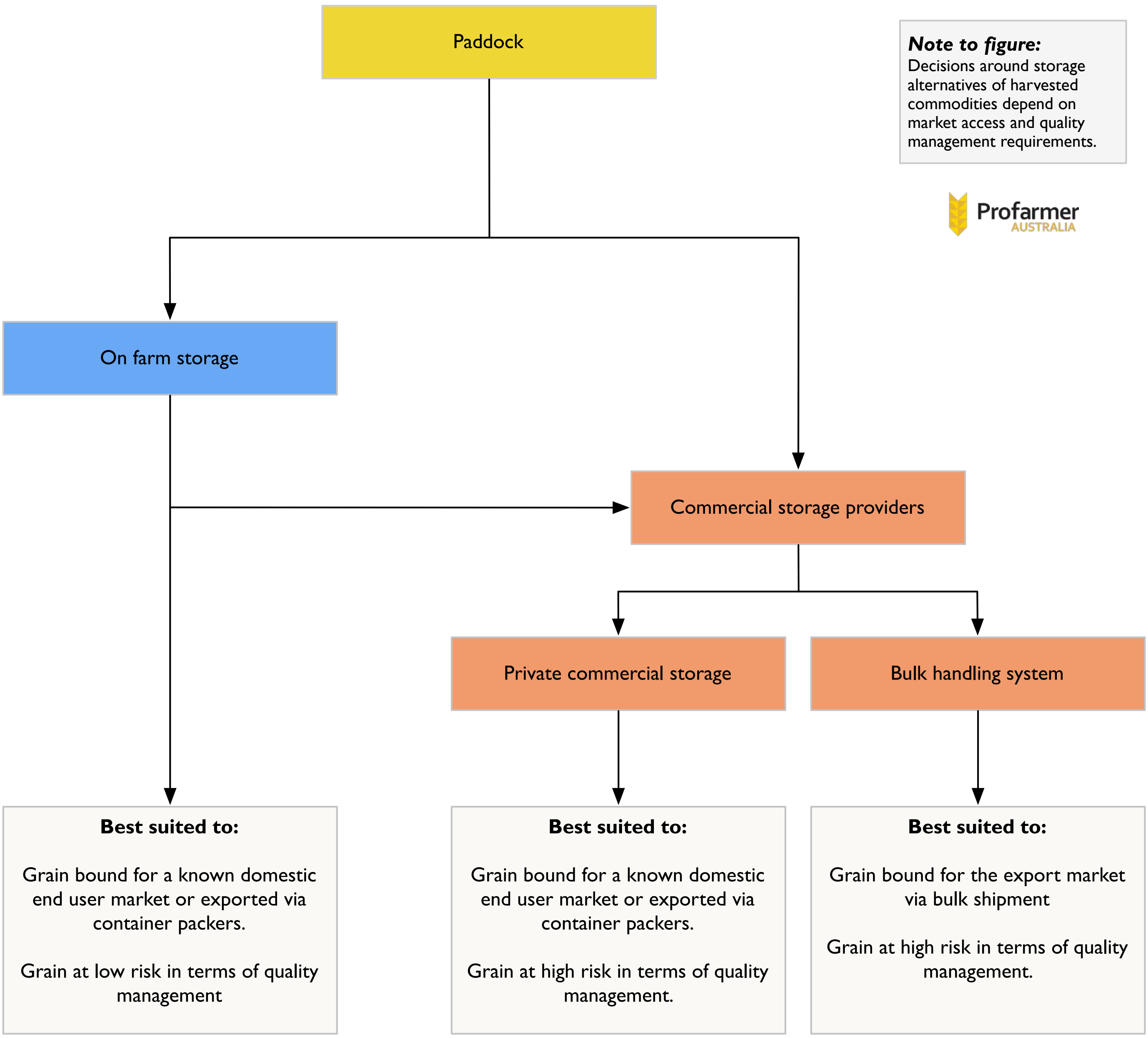



**Figure 14:** *Grain storage decision-making.*

Source: Profarmer Australia

## Cost of carrying grain

Storing grain to access sales opportunities post-harvest invokes a cost to 'carry', or hold, the grain. Price targets for carried grain need to account for the cost of carrying it. Carrying costs are typically \$3–4/t per month and consist of:

- Monthly storage fee charged by a commercial provider (typically ~\$1.50–2.00/t).
- Monthly interest associated with having wealth tied up in grain rather than available as cash or for paying off debt (~\$1.50–\$2.00/t, depending on the price of the commodity and interest rates).

The price of carried grain therefore needs to be \$3–4/t per month higher than the price offered at harvest (see Figure 15).

The cost of carrying also applies to grain stored on the farm, as there is the cost of the capital invested in the farm storage plus the interest component. A reasonable assumption is a cost of $3–4/t per month for on-farm storage.

**Principle:** Carrying grain is not free.

The cost of carrying grain needs to be accounted for if holding it for sale after harvest is part of the selling strategy.

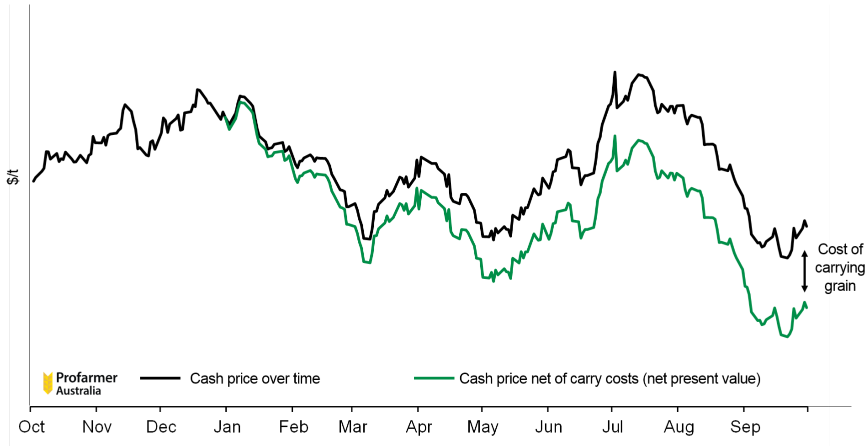



**Figure 15:** *Cash values compared with cash values adjusted for the cost of carrying.*

Source: Profarmer Australia

Optimising farm-gate returns involves planning the appropriate storage strategy for each commodity so as to improve market access and ensure that carrying costs are covered in the price received.

## 15.1.5 Converting tonnes into cash

This section provides guidelines for converting the selling and storage strategy into cash by effective execution of sales.

### Set up the toolbox

Selling opportunities can be captured when they arise by assembling the necessary tools in advance. The toolbox for converting tonnes of grain into cash includes the following.

1. Timely information—this is critical for awareness of selling opportunities and includes:

- Market information provided by independent parties.
- Effective price discovery including indicative bids, firm bids and trade prices.
- Other market information pertinent to the particular commodity.

2. Professional services—grain-selling professional services and cost structures vary considerably. An effective grain-selling professional will put their clients' best interests first by not having conflicts of interest and by investing time in the relationship. A better return on investment for the farm business is achieved through higher farm-gate prices, which are obtained by accessing timely information, and being able to exploit the seller's greater market knowledge and greater market access.
3. Futures account and a bank-swap facility—these accounts provide access to global futures markets. Hedging futures markets is not for everyone; however, strategies which utilise exchanges such as the Chicago Board of Trade (CBOT) can add significant value.

**MORE INFORMATION**

Access to buyers, brokers, agents, products and banks through Grain Trade Australia

Commodity futures brokers

ASX, Find a futures broker

### How to sell for cash

Like any market transaction, a cash–grain transaction occurs when a bid by the buyer is matched by an offer from the seller. Cash contracts are made up of the following components, with each component requiring a level of risk management (Figure 16):

- Price—future price is largely unpredictable, so devising a selling plan to put current prices into the context of the farm business is critical to managing price risk.
- Quantity and quality—when entering a cash contract, you are committing to deliver the nominated amount of grain at the quality specified, so production and quality risks must be managed.
- Delivery terms—the timing of the title transfer from the grower to the buyer is agreed at time of contracting. If this requires delivery direct to end-users, it relies on prudent execution management to ensure delivery within the contracted period.
- Payment terms—in Australia, the traditional method of contracting requires title on the grain to be transferred ahead of payment, so counterparty risk must be managed.

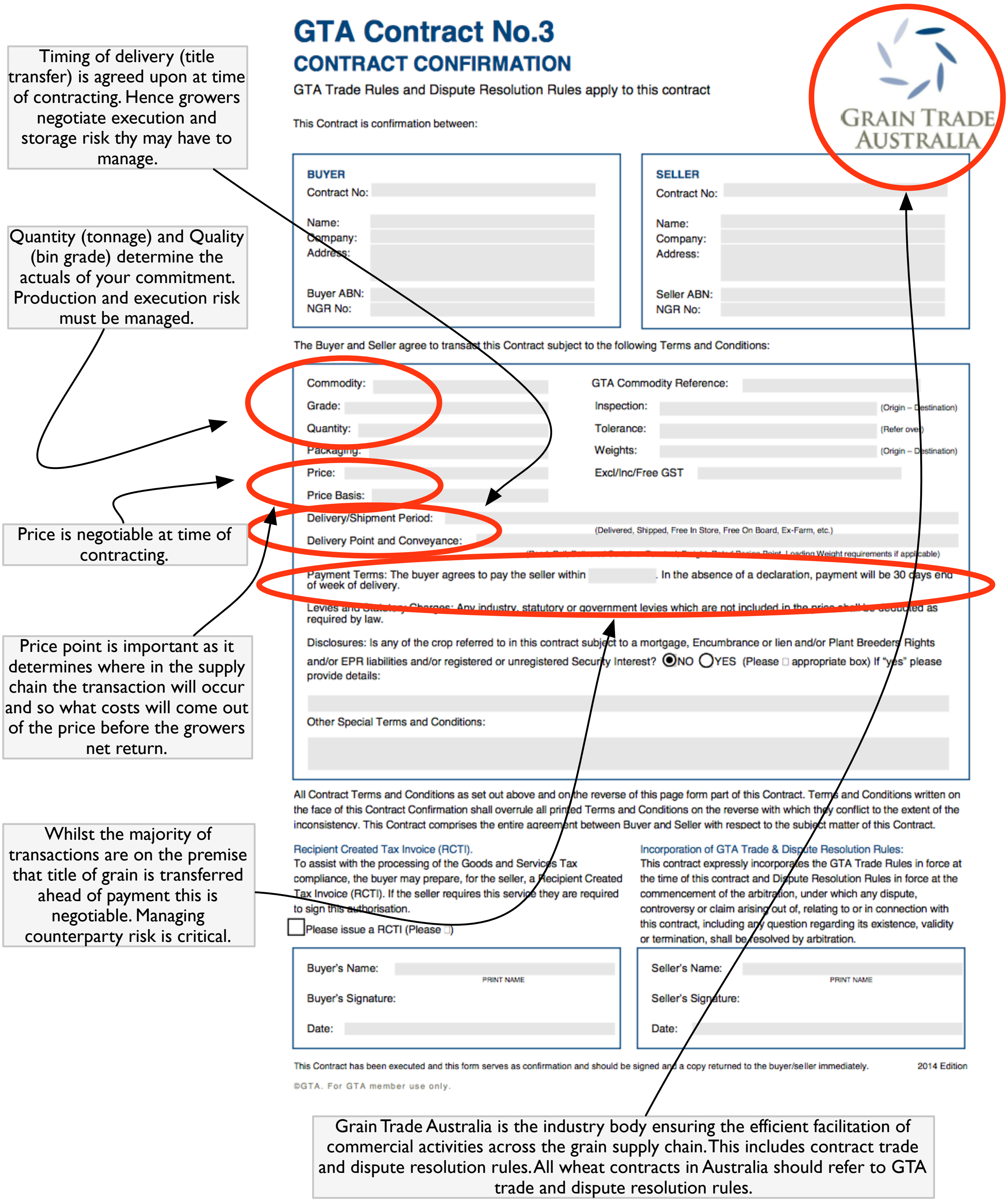



**Figure 16:** *Typical terms of a cash contract.*

Source: Grain Trade Australia

The price point within a cash contract will depend on where the transfer of grain title will occur along the supply chain. Figure 17 depicts the terminology used to describe these points and the associated costs to come out of each price before growers receive their net return.

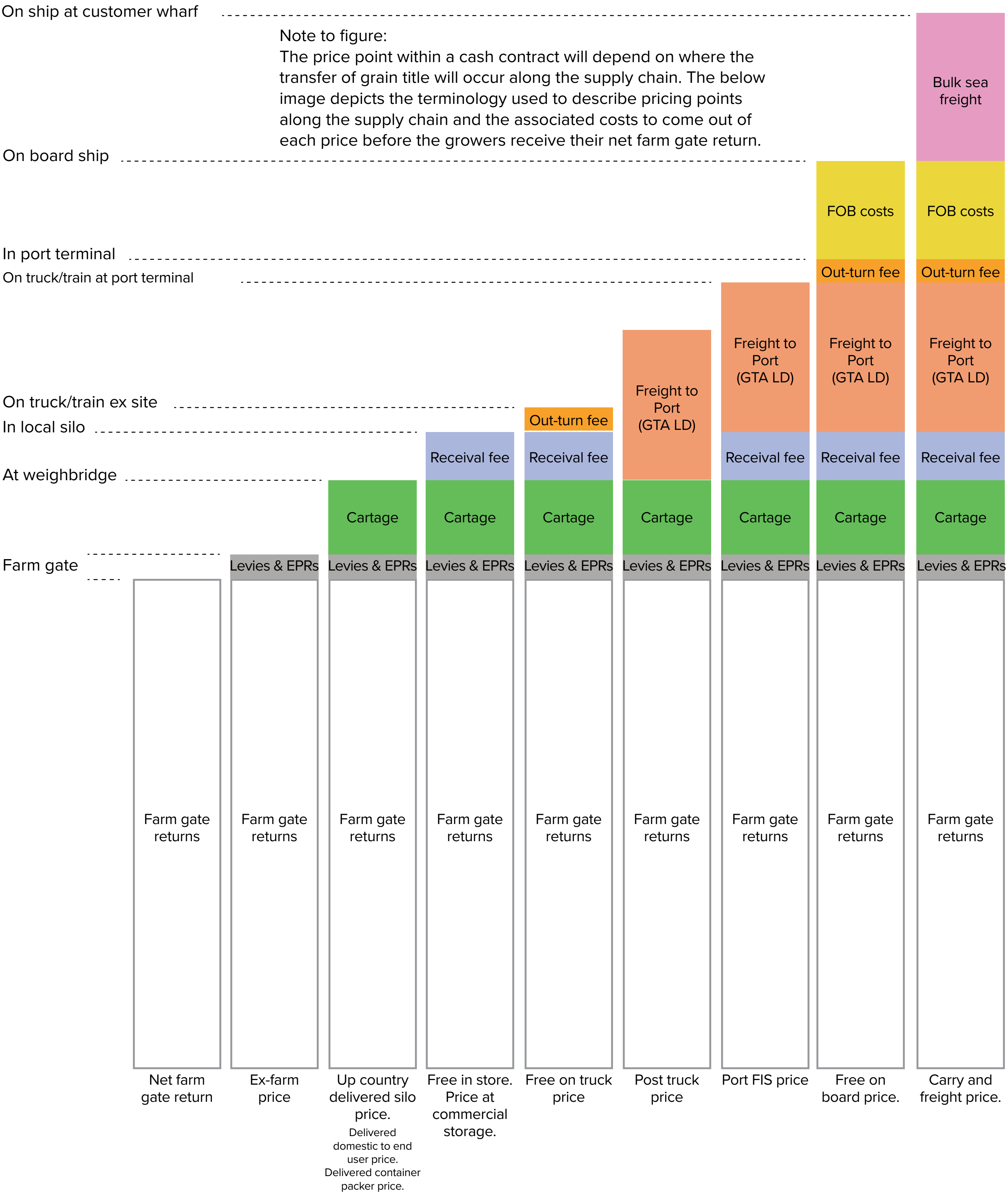



**Figure 17:** *Cost and pricing points throughout the supply chains.*

Source: Profarmer Australia

MORE INFORMATION

Grain Trade Australia, A guide to taking out grain contracts

Grain Trade Australia, Trading standards

GrainTransact Resource Centre

GrainFlow

Emerald Grain

Clear Grain Exchange, Getting started

Clear Grain Exchange, Terms and conditions

GTA, Managing counterparty risk

Clear Grain Exchange's title transfer model

GrainGrowers, Managing risk in grain contracts

Leo Delahunty, Counterparty risk: A producer's perspective

Cash sales generally occur through three methods:

- Negotiation via personal contact—traditionally prices are posted as a public indicative bid. The bid is then accepted or negotiated by a grower with the merchant or via an intermediary. This method is the most common and is available for all commodities.
- Accepting a public firm bid—cash prices in the form of public firm bids are posted during harvest and for warehoused grain by merchants on a site basis. Growers can sell their parcel of grain immediately by accepting the price on offer via an online facility and then transfer the grain online to the buyer. The availability of this option depends on location and commodity.
- Placing an anonymous firm offer—growers can place a firm offer price on a parcel of grain anonymously and expose it to the entire market of buyers, who then bid on it anonymously using the Clear Grain Exchange, which is an independent online exchange. If the offer and bid match, the particulars of the transaction are sent to a secure settlement facility, although the title on the grain does not transfer from the grower until they receive funds from the buyer. The availability of this option depends on location and commodity. Anonymous firm offers can also be placed to buyers by an intermediary acting on behalf of the grower. If the grain sells, the buyer and seller are disclosed to each counterparty.

## Counterparty risk

Most sales involve transferring the title on the grain prior to being paid. The risk of a counterparty defaulting when selling grain is very real and must be managed. Conducting business in a commercial and professional manner minimises this risk.

**Principle:** Seller beware.

There is not much point selling for an extra $5/t if you don't get paid.

Counterparty risk management includes:

- Dealing only with known and trusted counterparties.
- Conducting a credit check (banks will do this) before dealing with a buyer they are unsure of.
- Selling only a small amount of grain to unknown counterparties.
- Considering credit insurance or a letter of credit from the buyer.
- Never delivering a second load of grain if payment has not been received for the first.
- Not parting with the title before payment, or requesting and receiving a cash deposit of part of the value ahead of delivery. Payment terms are negotiated at time of contracting. Alternatively, the Clear Grain Exchange provides secure settlement whereby the grower maintains title on the grain until they receive payment, and then title and payment are settled simultaneously.

Above all, act commercially to ensure the time invested in implementing a selling strategy is not wasted by poor management of counterparty risk. Achieving $5/t more on paper and not getting paid is a disastrous outcome.

## Relative values

Grain-sales revenue is optimised when selling decisions are made in the context of the whole farming business. The aim is to sell each commodity when it is priced well, and to hold commodities that are not well priced at any given time. That is, give preference to the commodities with the highest relative value. This achieves price protection for the overall revenue of the farm business and enables more flexibility to a grower's selling program while achieving the business goal of reducing overall risk.

**Principle:** Sell valued commodities, not undervalued commodities.

If one commodity is priced strongly relative to another, focus sales there. Don't sell the cheaper commodity for a discount. For example, a farmer with wheat and barley to sell would sell the one that is getting good prices relative to the other, and hold the other for the meantime (see Figure 18).

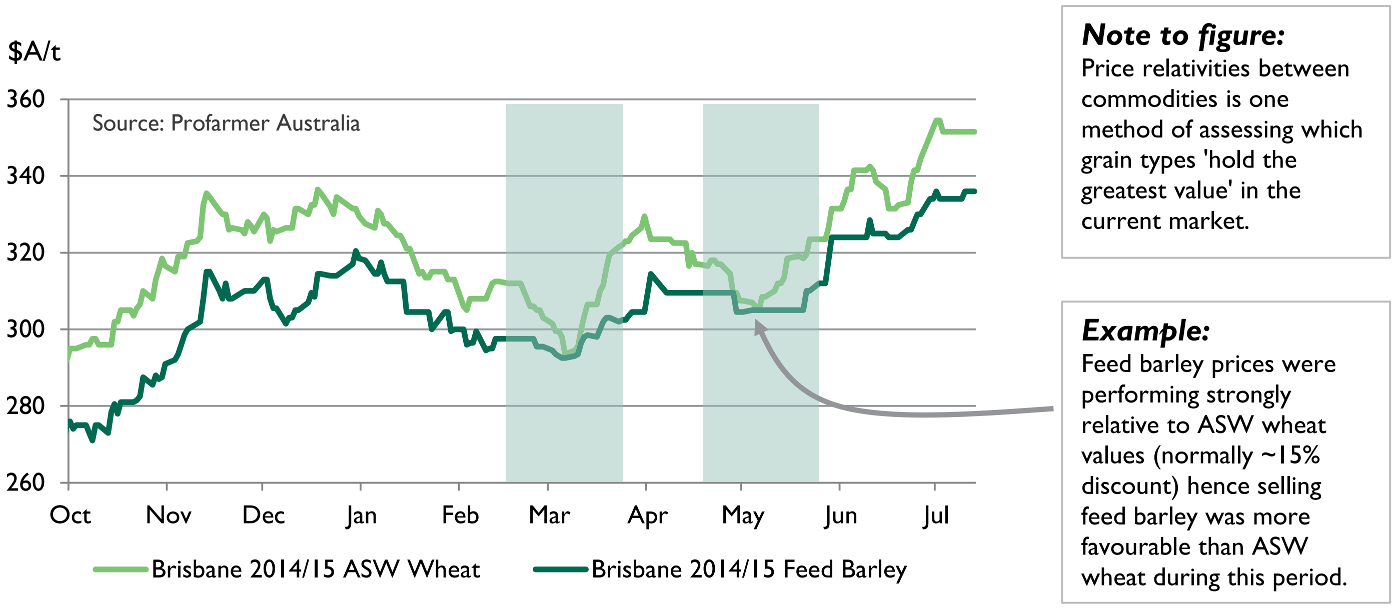



**Figure 18:** *Brisbane ASW wheat v. feed barley are compared, and the barley held until it is favourable to sell it.*

Source: Profarmer Australia

If the decision has been made to sell wheat, CBOT wheat may be the better choice if the futures market is showing better value than the cash market (Figure 19).

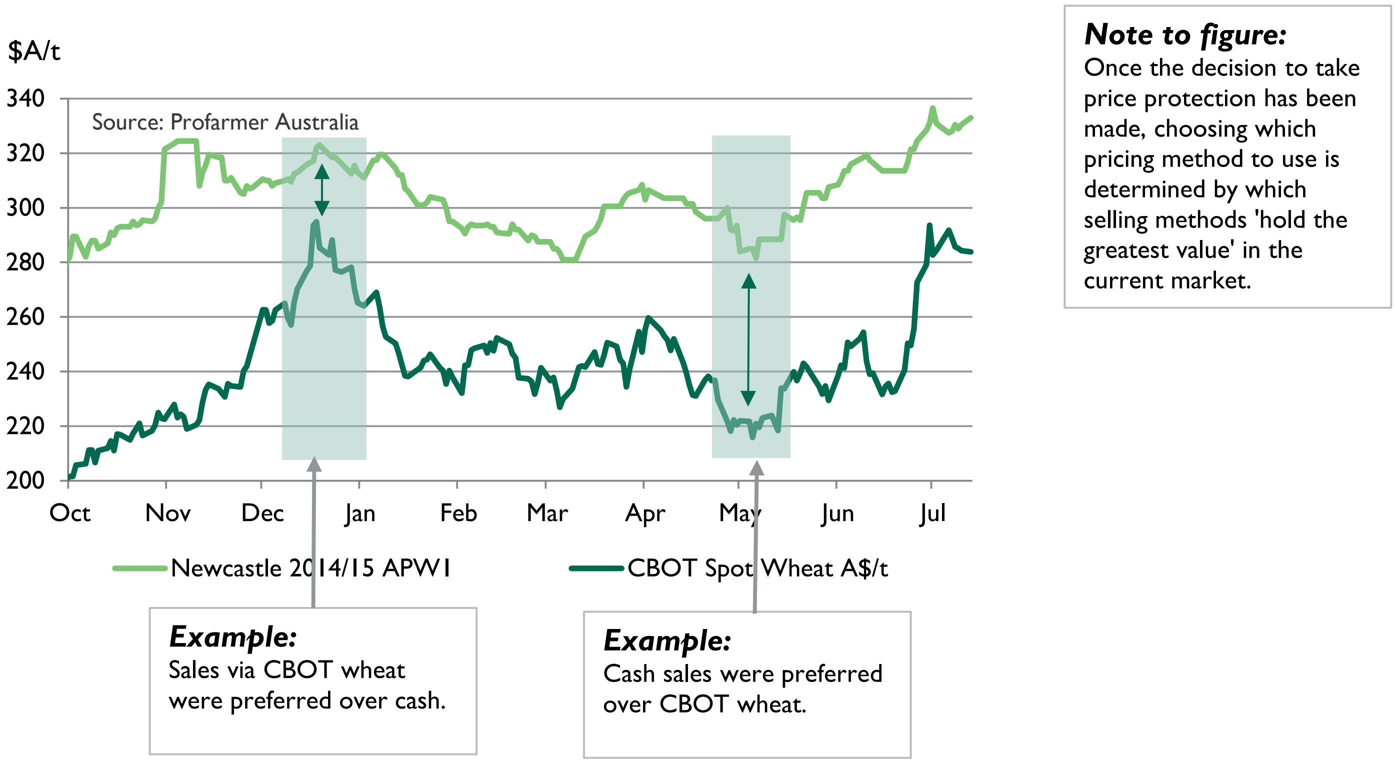



**Figure 19:** *By comparing prices for Newcastle APWI vs CBOT wheat, the grower can see which market to sell into.*

## Contract allocation

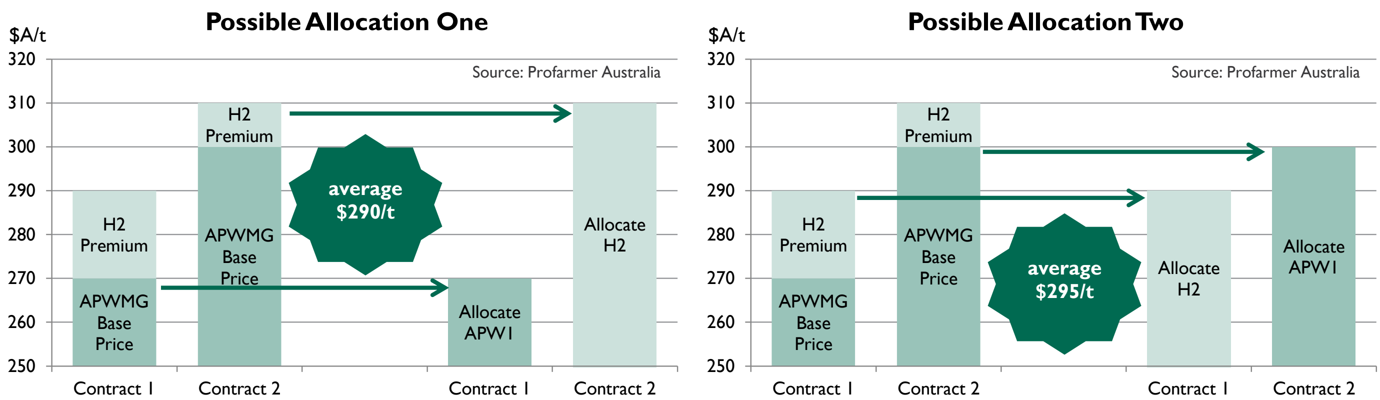
Contract allocation means choosing which contracts to allocate your grain against come delivery time. Different contracts will have different characteristics (e.g. price, premiums-discounts, oil bonuses), and optimising your allocation reflects immediately on your bottom line.

**Principle:** Don't leave money on the table.

Contract allocation decisions don't take long, and can be worth thousands of dollars to your bottom line.

To achieve the best average price for their crop growers should:

- Allocate lower grades of grain to contracts with the lowest discounts.
- Allocate higher grades of grain to contracts with the highest premiums (Figure 20).




***Note to figure:***
In these two examples the only difference between acheiving an average price of $290/t and $295/t is which contracts each parcel was allocated to. Over 400/t that equates to $2,000 which could be lost just in how parcels are allocated to contracts.

**Figure 20:** *How the crop is allocated across contracts can have an impact of earnings from the crop. Although this example uses wheat, the same principle applies to field peas.*

Source: Profarmer Australia

## Read market signals

The appetite of buyers to buy a particular commodity will differ over time depending on market circumstances. Ideally growers should aim to sell their commodity when buyer appetite is strong, and stand aside from the market when buyers are not very interested.

**Principle:** Sell when there is buyer appetite.

When buyers are chasing grain, growers have more market power to demand the price they want.

Buyer appetite can be monitored by:

- The number of buyers at or near the best bid in a public bid line-up. If there are many buyers, it could indicate that buyer appetite is strong. However, if one buyer is offering $5/t above the next best bid, it may mean that cash prices are susceptible to falling $5/t as soon as that buyer satisfies their appetite.
- Monitoring actual trades against public indicative bids. When trades are occurring above indicative public bids it may indicate strong appetite from merchants and the ability for growers to offer their grain at price premiums to public bids. The chart below plots actual trade prices on the Clear Grain Exchange against the best public indicative bid on the day.

The selling strategy is converted to maximum business revenue by:

- Ensuring timely access to information, advice and trading facilities.
- Using different cash-market mechanisms when appropriate.
- Minimising counterparty risk by conducting effective due diligence.
- Understanding relative value and selling commodities when they are priced well.
- Thoughtful contract allocation.
- Reading market signals to extract value from the market or to prevent selling at a discount.

## 15.2 Western field peas: market dynamics and execution

### 15.2.1 Price determinants for western field peas

Field-pea pricing is highly volatile by nature, with a large variation both within and between seasons. Contributing factors include subcontinental market dynamics and trading culture, chickpea–field pea substitution, and the size of the chickpea and field pea crops in Australia, competitor countries and the subcontinent.

Field-pea pricing influences affecting western growers stem from the forces of both the global human consumption market and also the domestic feed market, where they are an important source of protein in feed rations.

The factors that determine field-pea stockfeed demand and feed-quality price include:

1. The price of field peas relative to other sources of protein and energy that make up a least-cost ration—the prices of imported soybean meal (protein) and cereal grain (energy) are the major factors.
2. Export price opportunities—high export demand and prices of field peas flow through to domestic pricing.
3. The value of the Australian dollar—a low $A increases the import price of soybean meal and increases the export price of field peas.

Global influences on Australian field-pea pricing are:

1. Canadian field-pea planting intentions.
2. Canadian production totals.
3. Canadian, USA and European excess production in the previous season. i.e. stocks on hand or carried over.
4. Pulse production in the Indian domestic *rabi* cropping season (where harvest is in April–May)—any negative influences will increase the need for imports of either chickpeas or field peas.
5. The world price of chickpeas—field peas are purchased as a substitute pulse when the chickpea price is high.
6. Timing of festivals in importing countries—Ramadan is the most important festival. It occurs in the ninth month of the Islamic calendar and goes for 29 days. Ramadan occurs around June then May for the next few years then will get closer to the end of the Australian harvest. This is favourable for supplying the Ramadan market post-harvest.

Because prices for field peas are so heavily influenced by global production and prices, and because chickpeas can easily be substituted for field peas, it is important for growers to understand the world field pea and chickpea production calendar (Figure 21). It is also important that they keep an eye on prices and trends (Figures 22, 23 and 24).

Western field peas may find buyers in the export market or in the domestic stockfeed market. The majority of exports are conducted via containers rather than bulk.

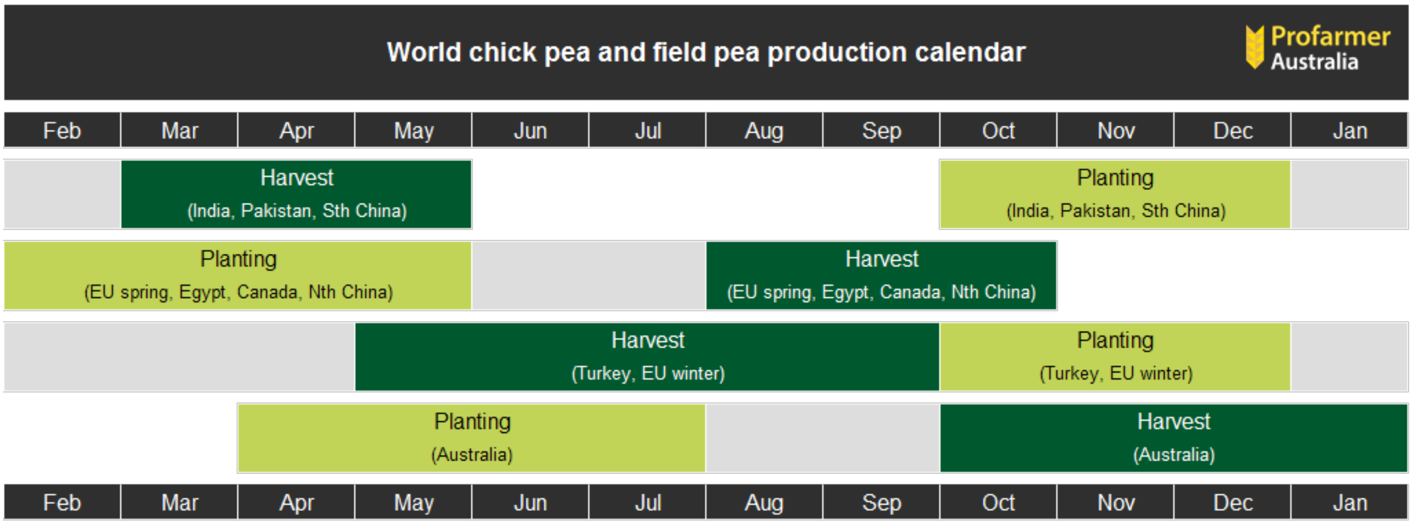



**Figure 21:** *Global field pea production calendar.*

Source: Profarmer Australia

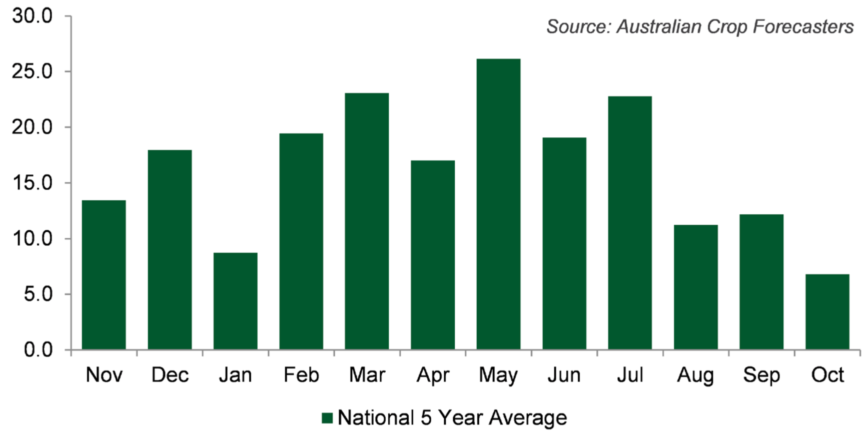



**Figure 22:** *Monthly export pace ('000t) for Australian field peas, averaged over five years.*

Source: Australian Crop Forecasters

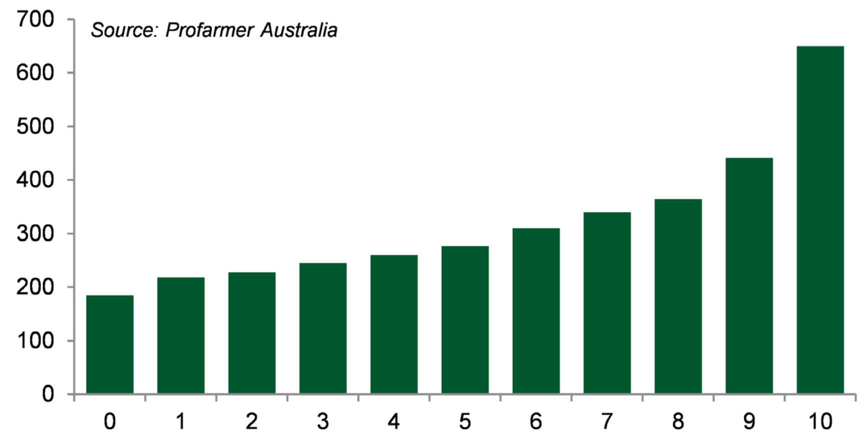



**Figure 23:** *Port Adelaide field pea deciles. Decile charts provide an indication of how current values are performing relative to historical value. For example, a decile 8 or above indicates values are in the top 20% of historical price observations.*

Source: Profarmer Australia

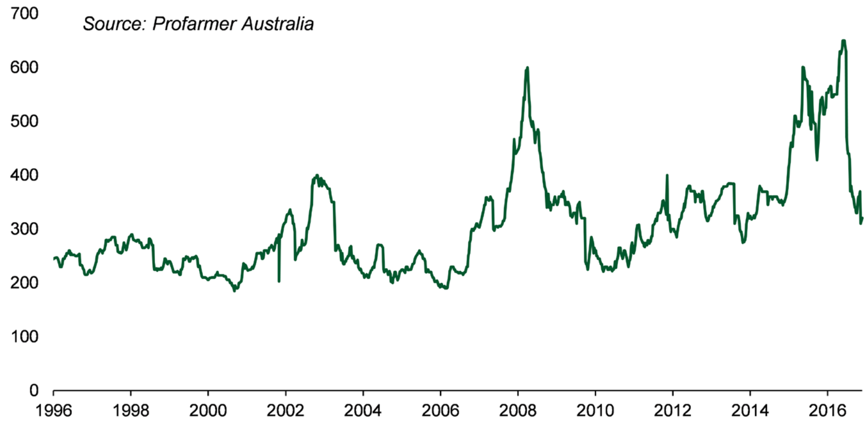



**Figure 24:** *Long-term Port Adelaide field pea price history.*

### 15.2.2 Ensuring market access for western field peas

The major food markets for field peas are in southern India and Sri Lanka. However, field peas in these markets face strong competition from Canadian yellow peas and chickpeas.

In domestic markets, field peas are an important source of protein in stockfeed rations, and in this instance face competition from alternative protein sources such as other pulses and imported soybean meal.

By and large, whether finding homes in export (generally via container) or domestic markets, private commercial storage and on-farm storage both provide efficient paths to market.

With the majority of Western Australia's container packing facilities being located in or around Perth, WA growers looking to market field peas should consider their access to these facilities as part of their overall marketing plan. Pulse Australia provides information about pulse exporters in Australia. If targeting homes in domestic stock feed markets, it is important to explore how strong and where the appetite is before planting a field pea crop.

Price discovery for field peas in the west can be difficult given the small size of the market, particularly relative to other grains produced. Hence South Australian markets, which have much greater market depth, can be an important source of price discovery, especially for those looking to understand export values.

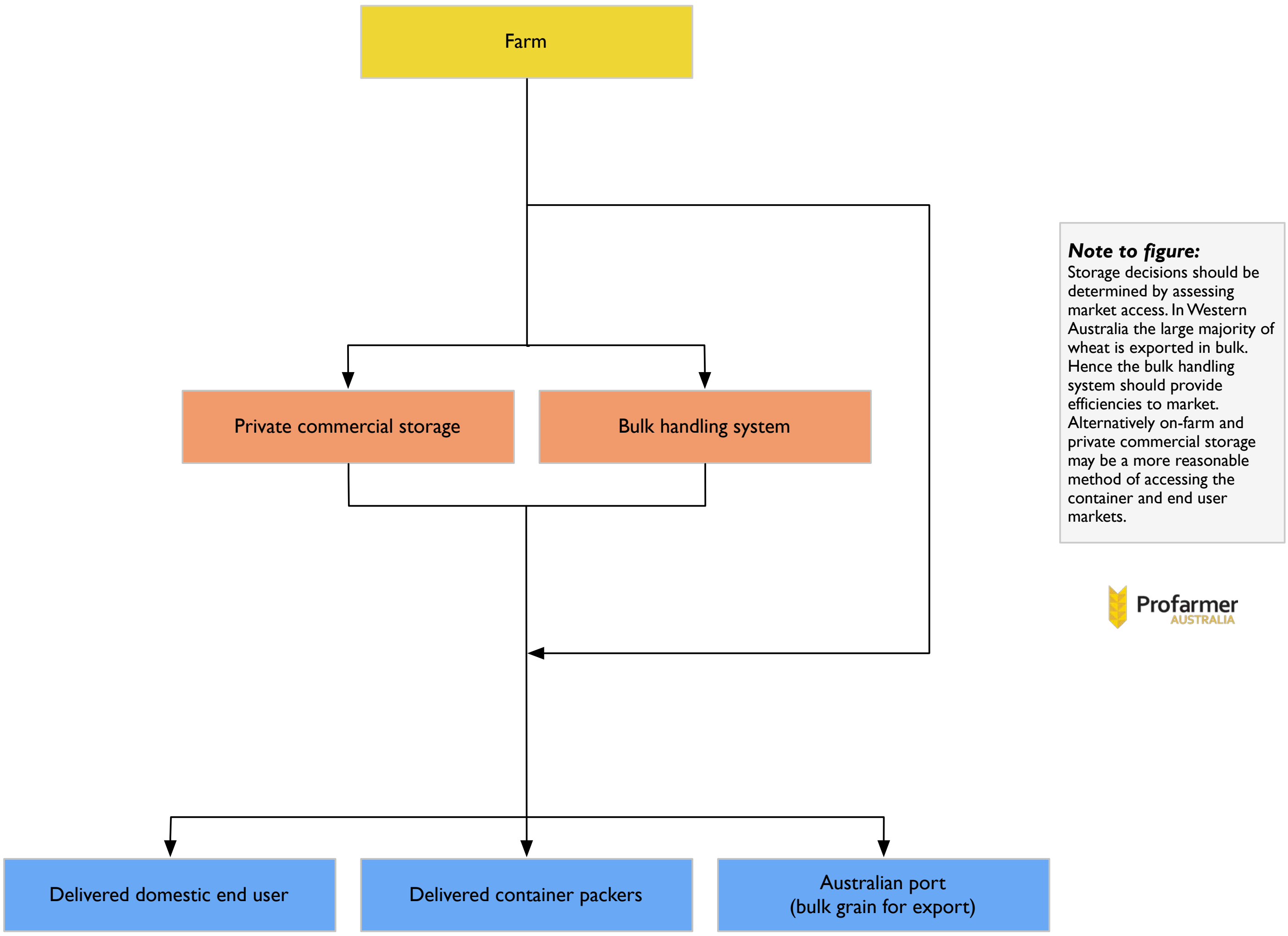



**Figure 25:** *Australian supply chain*

## 15.2.3 Converting tonnes into cash for western field peas

Field pea marketability commences in the paddock. To have field peas acceptable to the desired market, the grower must:

- Control weeds to minimise weed-seed contamination.
- Control insect pests and diseases to ensure a good quality peas.
- Use a harvest technique that minimises seed damage.
- Ensure chemical withholding periods have been met.

Selling options for field peas include:

1. Store on farm then sell—this is the most common option used. Field peas are relatively safe to store and require less maintenance than cereal grains. It is still important to monitor and maintain quality, as field peas must meet strict quality specifications for export in order to avoid being discounted at the time of delivery. The grower must take into account the cost of storage when setting target prices.
2. Cash sale at harvest—this is the least preferred option as buyer demand does not always coincide with harvest. Values can come under pressure at harvest time if a sudden increase in grower selling occurs in a small window, providing

## MORE INFORMATION

World pulse production calendar, in Pulses: Understanding global markets

Australian pulse traders

Understanding global markets: field peas

Field peas marketing and standards

AEGIC, Australian pulses

DAFWA, Field peas

buyers with the confidence that they can meet their short- and medium-term commitments.

3. Warehouse then sell—this option provides flexibility for sales if on-farm storage is not available. The grower must take into account warehousing costs as part of the cost of production when setting target prices. Warehousing is to be avenue available to western growers, as the major bulk handlers do not provide this option due to the low volume of production. The availability of this option from packers within the 'delivered' market will vary depending on the individual buyer.

As with all sales, a thorough understanding of counterparty risk and the terms of the contract of sale is essential. Counterparty risk considerations are especially important for pulse marketing, as there is often a higher risk of contract default in international pulse markets than for canola or cereals. This is due to the markets they are traded into; the lack of appropriate price-risk tools (such as futures); and, often, the visual and subjective nature of quality determination. This can place extra risk on Australian-based traders endeavouring to find buyers for their product.

# Current and past research

## Project Summaries

As part of a continuous investment cycle each year the Grains Research and Development Corporation (GRDC) invests in several hundred research, development and extension and capacity building projects. To raise awareness of these investments the GRDC has made available summaries of these projects.

These project summaries have been compiled by GRDC's research partners with the aim of raising awareness of the research activities each project investment.

The GRDC's project summaries portfolio is dynamic: presenting information on current projects, projects that have concluded and new projects which have commenced. It is updated on a regular basis.

The search function allows project summaries to be searched by keywords, project title, project number, theme or by GRDC region (i.e. Northern, Southern or Western Region).

Where a project has been completed and a final report has been submitted and approved a link to a summary of the project's final report appears at the top of the page.

The link to Project Summaries is https://grdc.com.au/research/projects

## Final Report Summaries

In the interests of raising awareness of GRDC's investments among growers, advisers and other stakeholders, the GRDC has available final reports summaries of projects.

These reports are written by GRDC research partners and are intended to communicate a useful summary as well as present findings of the research activities from each project investment.

The GRDC's project portfolio is dynamic with projects concluding on a regular basis.

In the final report summaries there is a search function that allows the summaries to be searched by keywords, project title, project number, theme or GRDC Regions. The advanced options also enables a report to be searched by recently added, most popular, map or just browse by agro-ecological zones.

The link to the Final Report Summaries is http://finalreports.grdc.com.au/final_reports.php

## Online Farm Trials

The Online Farm Trials project brings national grains research data and information directly to the grower, agronomist, researcher and grain industry community through innovative online technology. Online Farm Trials is designed to provide growers with the information they need to improve the productivity and sustainability of their farming enterprises.

Using specifically developed research applications, users are able to search the Online Farm Trials database to find a wide range of individual trial reports, project summary reports and other relevant trial research documents produced and supplied by Online Farm Trials contributors.

The Online Farm Trials website collaborates closely with grower groups, regional farming networks, research organisations and industry to bring a wide range of crop research datasets and literature into a fully accessible and open online digital repository.

Individual trial reports can also be accessed in the trial project information via the Trial Explorer.

The link to the Online Farm Trials is http://www.farmtrials.com.au/

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