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FIELD PEA

SECTION 5

PLANT GROWTH AND PHYSIOLOGY

KEY POINTS | FIELD PEA TYPE AND PHYSIOLOGY | FIELD PEA GROWTH STAGES | GERMINATION AND EMERGENCE | NODULATION AND NODULATION FAILURE | ABIOTIC STRESSES (ENVIRONMENTAL EFFECTS) ON PLANT GROWTH AND PHYSIOLOGY | CROP LODGING | REDUCED SHATTERING | NATIONAL FIELD PEA BREEDING OBJECTIVES

Plant growth and physiology

Key points

- Field pea varieties range in growth habit from trailing, leafy types to being semi-leafless and so erect at maturity. Trailing types can be difficult to harvest.
- More recent Australian-bred cultivars are predominantly semi-leafless and have been bred with traits such as: late flowering, early maturing, resistance to pod shattering, reduced disease risk, frost tolerance and ease of management at harvest.
- Field pea growth stages are divided into vegetative (V) and reproductive (R) stages.
- Field pea has hypogeal emergence (seed germination remains below the ground), which can be an advantage.
- Factors affecting emergence include: seed quality, sowing depth, plant density, seed treatments, diseases, nodulation, insects, waterlogging and herbicide wash.
- Field pea respond well to minimum temperatures of not less than 7°C during establishment and canopy expansion, and 25°C and less during critical reproductive phases.

5.1 Field pea type and physiology

Field pea varieties range in growth habit from trailing to erect at maturity. The trailing growth type can be difficult to harvest and were commonly grown until the early 2000s (e.g. early dun, Alma, Parafield). More recently there has been a shift across southern Australia towards uniquely Australian-bred field pea cultivars (e.g. Kaspa$^{\Phi}$, PBA Twilight$^{\Phi}$) that are semi-leafless/semi-dwarf, range from late flowering to early maturing, semi-erect at maturity and highly resistant to seed shattering. The development of semi-leafless/semi-dwarf types have given growers options with better standing ability which makes harvesting easier. In these semi-leafless pea cultivars the leaves have been modified into tendrils, which tend to wrap themselves together and hold the plant upright (Figures 1 and 2).

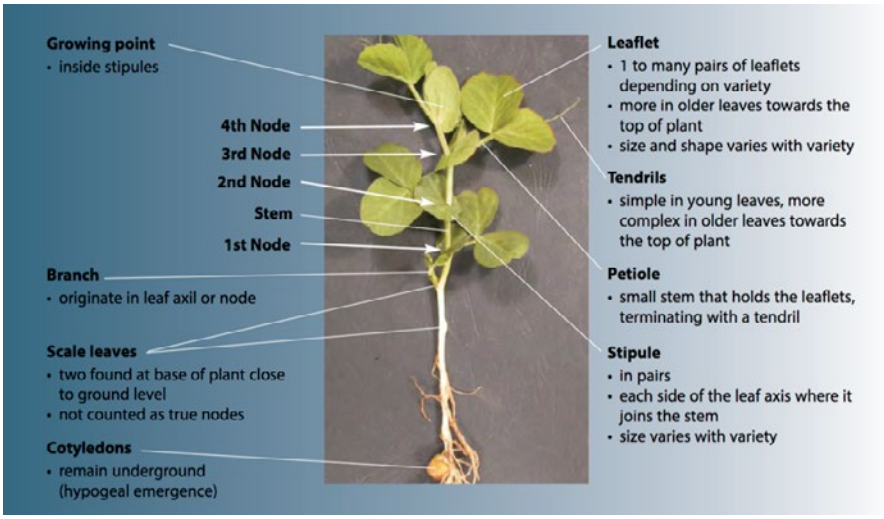

Figure 1: *Field pea (Pisum sativum) conventional leaf type e.g. Dundale, Parafield, Alma.*

Source G Brooke, C McMaster (2017) Weed control in winter crops 2017: NSW DPI Management Guide. NSW Government Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/weed-control-winter-crops

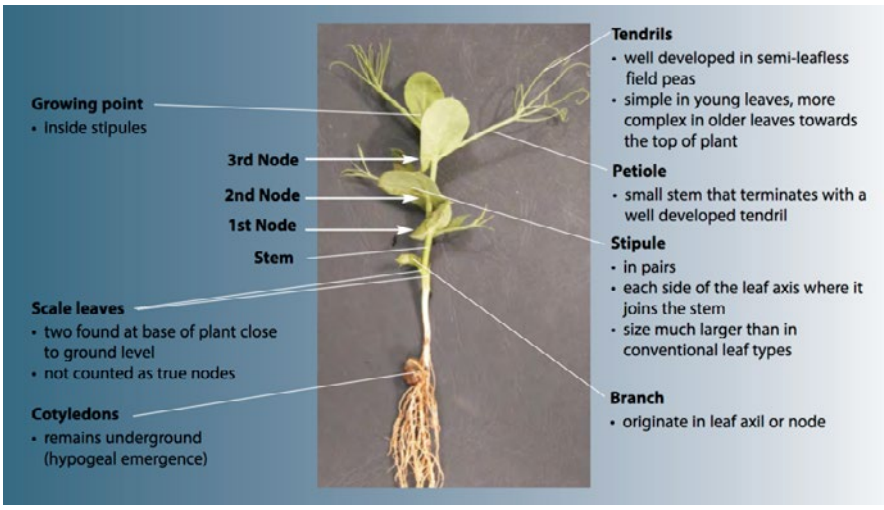

Figure 2: *Field pea (Pisum sativum) semi-leafless type e.g. Kaspa$^{\Phi}$, Excell, Snowpeak, Mukta, Morgan$^{\Phi}$.*

Source: G Brooke, C McMaster (2017) Weed control in winter crops 2017: NSW DPI Management Guide. NSW Government Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/publications/weed-control-winter-crops

5.2 Field pea growth stages

Field pea growth stages are based on counting the number of nodes on the main stem. This identifies various vegetative (V) and reproductive events (R).

When field pea emerges, two small scale or scar leaves appear. The scar leaves do not form stipules and are therefore not counted. This is best seen in Figure 3, which shows a field pea at the 3-node stage. When counting nodes, only count those where the stipule leaves are fully unfolded.[1]

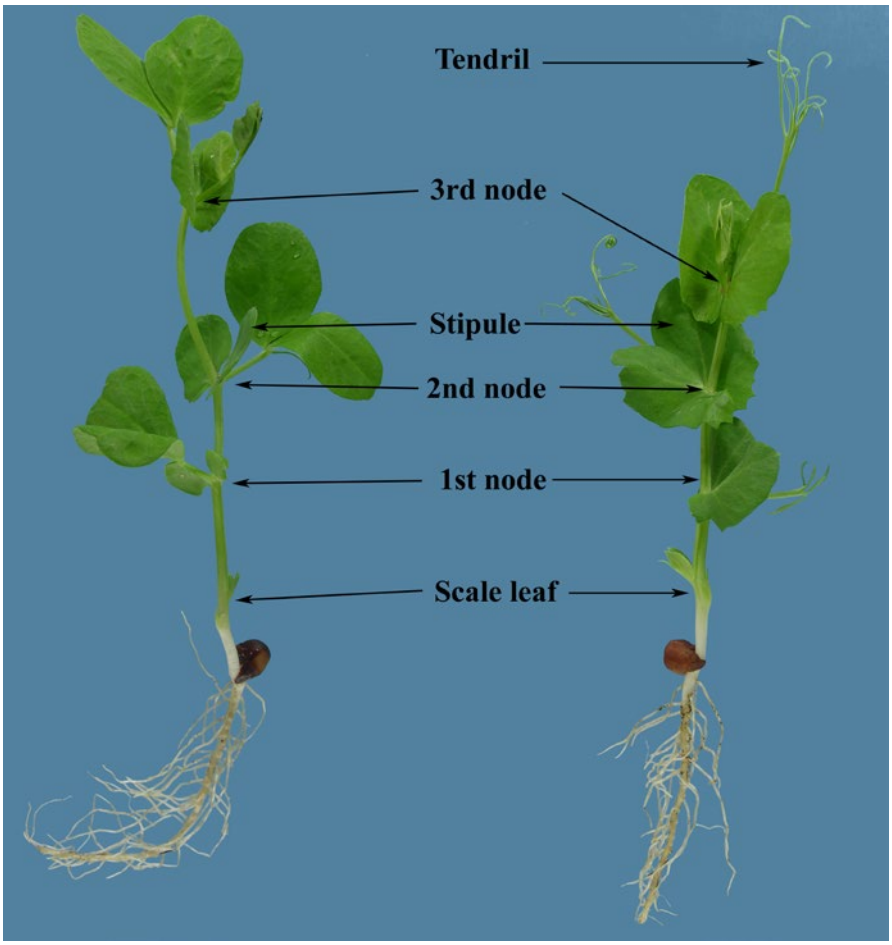

Figure 3: *Trailing field pea (left) and semi-leafless field pea (right) at 3-node stage.*

Source: I Pritchard (2015) A visual guide to key stages in the growth and maturity of field pea. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/field-peas/visual-guide-key-stages-growth-and-maturity-field-pea

Field pea varieties exhibit either indeterminate or semi-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. For a semi-determinate growth habit, vegetative growth continues initially after the plant switches to reproductive mode and flowering begins, but can terminate before moisture becomes limiting.

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).

1 I Pritchard (2015) A visual guide to key stages in the growth and maturity of field pea. Department of Agriculture and Food, Western Australia, https://www.agric.wa.gov.au/field-peas/visual-guide-key-stages-growth-and-maturity-field-pea

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Vegetative (V) growth stages: these are described by counting nodes on the main stem and continuing the count 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 continuing 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 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.

Physiological maturity: this is when the seed can develop no further dry matter.

Table 1: Growth stages of a field pea plant.

Development phase	Growth stage (GS)	Description
Germination and emergence	VE	Seedling emerges from the soil.
	VS	Two small scale leaves appear on the stem, do not count this node.
Vegetative growth stages Count the number of visible nodes above the ground (VS) on the main stem, continuing the node count up the basal primary branch to include the highest fully developed pinnately compound leaf.	V1	The true leaf (pair of leaflets) has unfolded at the first node above VS, no tendril
	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 Field pea is indeterminate, and flower buds are initiated in leaf axils at the apical meristem approximately 20 days after they become visible.	R1	Flower bud present at one or more node
	R2	First open flower at one or more node
	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
	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.

For populations of plants; vegetative stages can be averaged. Reproductive stages should not be averaged.
For populations of plants; a reproductive stage is classified unchanged until 50% of the plants in the sample demonstrate the trait of the next reproductive (R) stage.
For a single plant the reproductive stage is set by the first occurrence of the specific trait on the plant.

Source: Erskine *et al*. (1990)

Field pea is classified as a hermaphroditic plant because its flowers have both male and female parts. All the flowering components that peas need to reproduce are contained in a single blossom, which is the site where the transfer of pollen is carried out in a process known as self-pollination.

Flower terminals develop from the auxiliary bud at the base of each node, with flowering commencing at approximately the 6th to 10th node, depending on the variety, time of sowing and temperature.Field pea flowers vary in colour from shades of purple, pink to white. Flowers are borne on a peduncle that arises from nodes.[2]

About half of the flowers are fertilised and capable of forming pods. The pods formed early are usually larger than those formed later in the season. Each pod usually develops 3–7 seeds. The seeds take 30–40 days after flowering to reach

2 Pulse Australia (2016). Southern/western field pea best management practices training course, module 2-2016. Draft. Pulse Australia Limited

physiological maturity. The crop is normally ready for harvest about 6 weeks after flowering.

Eighty per cent of field pea yield is off the main stem.

The first flower will form the bottom pods and, because they are the first and most advanced, are the fullest at any stage of plant growth. Development of pods at the flowering nodes becomes sequentially later as they go up the stem. The top 2–3 nodes are the latest to flower and rarely form pods in Australia due to hot weather or lack of moisture. An isolated frost event can have a great impact on the node flowering at that time. Therefore, sequential podding along a stem provides a good timeline and map of the plant's environmental history. All the above descriptions refer to the main stem, which is the continuation of the germinating shoot.

Basal branches often develop from the bottom three nodes, and these form a secondary flowering branch. This is like tillering in cereals and is variety, season and density dependent. A strongly branching type can make up for a lower seedling density. These basal branches also develop the typical node structure identical to the main stem, and start flowering at about node 5–8 and can develop 6–15 flowering nodes. In some varieties and in very good seasons, aerial branches can also develop from the three nodes immediately below the first flowering node. These can produce some yield but are rarely significant.[3]

5.3 Germination and emergence

Pulses are classed as 'epigeal' if the cotyledons appear above the ground (e.g. lupin) or 'hypogeal' (e.g. field pea) if they remain below the ground (Figure 4).

Field pea plants are hypogeal, which means the cotyledons of the germinating seed remain below the ground and inside the seed coat. Seedlings with hypogeal emergence are less likely to be killed at emergence by frost, wind erosion or insect attack as new stems can develop from buds at nodes at or below ground level. Their growth may however be slowed considerably relative to unaffected shoots. In contrast, if an epigeal pulse is broken or damaged below the cotyledons, the plant will die as there are no buds from which to shoot.[4]

3 GRDC (2015) Field pea Northern Region GrowNotes™, https://www.grdc.com.au/grownotes

4 J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook

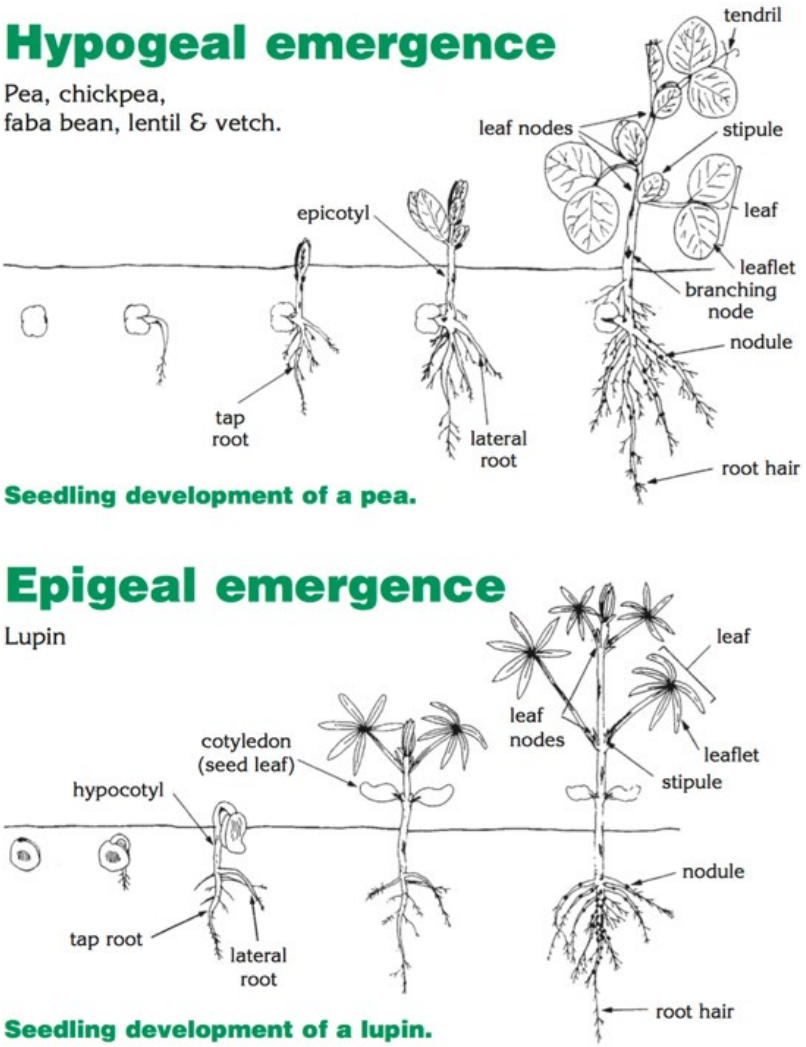

Figure 4: *Hypogeal and epigeal emergence patterns in pulses.*

Source: J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook

5.3.1 Emergence issues

Field pea seed is larger than the seed of many crops at around 13–24 grams per 100 seeds depending on variety. The seed size doubles in volume in the first 2 days of germination and requires three times the moisture for germination than smaller seeds.

Field pea germination requires a minimum of 5°C. The warmer the soil temperature the quicker emergence occurs:

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

Approximate time to reach growth stages:

- 1st node/leaf stage: depends on soil temperature, approximately 14 days
- 2nd node/leaf stage and after: every 4–5 days.[5]

5 K McKay, Growing Peas and Lentils, Key Growth Stages, NCREC, Minot, ND, https://www.ag.ndsu.edu/NorthCentralREC/crop-production-extension/Pea%20Growth_Stages_Considerations.pdf

Other factors that can affect the emergence of field pea include:

- poor seed quality, see Section 3.4 Planting seed quality
- plant density, see Section 4.3 Sowing rate and plant density
- seed treatments, see Section 4.10 Seed treatments and Section 9.6.1 Seed dressings
- diseases, see Section 9 Diseases and Section 10 Pre-harvest treatments
- nodulation, see Section 4.8 Inoculation
- waterlogging, see Section 5.5 Abiotic stresses (environmental effects) on plant growth and physiology and Section 13.2 Waterlogging,
- insects both above and below ground level, see Section 8.3 Key pests of field pea
- herbicide wash and concentration, see Section 2.3 Seedbed requirements
- sowing depth, see Section 2.3 Seedbed requirements and Section 4.4 Sowing depth.

5.4 Nodulation and nodulation failure

The taproot and lateral roots near the soil surface carry small round or oblong shaped nodules if the correct strain of Rhizobium is present. Group E (SU303) is preferred for field pea but group F (WSM1455) can be used in its place because it is only marginally less effective. For more information, see Section 4.9 Check for nodulation.

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 (haem-containing protein binding and/or transporting oxygen or nitrogen).[6]

Nitrogen deficiency from nodule dysfunction can be caused by lack of rhizobia, soil acidity (pH (($CaCl_2$) less than 6.0), herbicide toxicity, or molybdenum or sulfur deficiency.

Symptoms may appear within a month of seeding. The signs of nodulation failure are when the plants are smaller and paler with a pink shade, with restricted growth, especially during cold, wet periods through the seedling stages. Oldest growth is first and the worst affected. As deficiency worsens plants becomes stunted and pale; older leaves become progressively pinkish pale and die, leaving green new growth (Photo 1). Nodules are reduced or absent. If nodules are present they are small, and when split have a pale or white interior rather than the pink-red interior.[7]

6 Pulse Australia (2016) Southern/western field pea best management practices training course, module 2-2016. Pulse Australia Limited

7 I Pritchard (2015) Diagnosing dysfunction in field peas, Department of Agriculture, Western Australia https://agric.wa.gov.au/n/4476

Photo 1: *Both plants show poor nodulation, but the plant on the left has had adequate soil nitrogen.*

Photo: R Yates (2015) Diagnosing nodule dysfunction in field peas. DPIRD, https://www.agric.wa.gov.au/mycrop/diagnosing-nodule-dysfunction-field-peas

The easier and best way to identify nodulation failure is to dig up several plants, keeping intact as much root material as possible. Be careful as root nodules are very fragile and will break off easily. Wash off any residual soil and stones very carefully not to knock off nodules. Slice the nodules open with a pocket knife or thumbnail and look at the colour of the nodules. Red and pink coloured interior nodules depict healthy nodules fixing nitrogen. Yellow, green, black or brown nodules depict poor or low N fixation potential.

As a salvage operation, apply nitrogen to affected crops if economic. Ensure future crops are adequately covered with viable Group E inoculum.[8]

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

5.5 Abiotic stresses (environmental effects) on plant growth and physiology

The major abiotic stresses of pulses such as field peas in Australia are those associated with cold, frost, waterlogging, drought, heat, soil pH, salinity, sodicity and boron toxicity.

The extent of the damage caused by abiotic stress depends on the pulse species (Table 2), the prevailing environmental conditions and stage of crop growth.

Table 2: Importance of major abiotic stresses affecting cool-season pulse crops in Australia.

Stress	Field pea	Chickpea	Faba bean	Lentil
Cold	X	XXX	X	X
Frost	XXX	XXX	XX	XX
Waterlogging	XX	XXX	X	XXX
Drought	XXX	XX	XXX	XX
Heat	XXXX	XX	XXX	XXX
Salinity	XX	XXX	XX	XX
Boron toxicity	XX	XXX	XX	XXX

XXX = very important, XX = important, X = not very important

Source: K Siddique (1999) Abiotic stresses of cool season pulses in Australia. University of Western Australia, http://www.farmtrials.com.au/trial/13486

For a particular stress, the time at which it occurs in the plant's life cycle will affect plant production through its yield components (total biomass, number of pods, number of seeds, seed weight and harvest index).

The optimal temperatures for cool-season pulses range between 10°C and 30°C. Temperatures that fall outside the optimum range cause stress. Daily maximum temperatures above 25°C are considered the threshold for heat stress in cool-season pulse crops.

Pulses are particularly sensitive to heat at the full bloom stage. A few days of exposure to high temperatures (30–35°C) causes heavy yield losses through flower drop and pod abortion.[9]

An Australia-wide research project 'Improving yield and reliability of field peas under water deficit' confirmed this and found a correlation between yield and temperature indicated by two distinct stages.

In the first stage, field pea yield was positively associated with minimum temperatures during crop establishment and canopy expansion, before flowering. Temperatures below 7°C had a negative effect on growth. In the second stage, grain yield was negatively associated with maximum temperature over 25°C during critical reproductive phases.[10]

9 K Siddique (1999) Abiotic stresses of cool season pulses in Australia. University of Western Australia, http://www.farmtrials.com.au/trial/13486

10 V Sadras (2013) Improving yield and reliability of field peas under water deficit. Grains Research & Development Corporation, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/01/Improving-yield-and-reliability-of-field-peas-under-water-deficit

Drought and heat stress

Drought stress during vegetative stages of growth alone does not appear to cause a significant yield loss in chickpea or field pea. Flowering is the most sensitive stage to drought.

Cold

Reproductive organs, mainly flower buds and flowers, are most susceptible to cold or chilling injury.

Frost

The threshold level for frost injury in winter pulses occurs when the daily minimal temperature is below 0°C. Frost damage in spring (radiation frost) is a major cause of yield loss in crops including pulses in Australia. The most important stress in the freezing process is ice formation and the associated mechanical damage of the tissue. Flowering, early pod formation and seed filling are the most sensitive stages in winter pulses. Critical temperatures for frost injury appear to be higher for chickpea than field pea, lentil or faba bean. Among the pulses, field pea seems to be the most susceptible to frost injury during the reproductive stage.

Waterlogging

Transient waterlogging is common in winter on fine-textured (clay) soils in Australia. Seed germination is very susceptible to waterlogging. Poor crop establishment is a common problem when waterlogging occurs at seedling emergence. Among cool-season pulses faba bean is relatively tolerant to waterlogging at germination compared with lentil, field pea or chickpea. Waterlogging 6 days after germination of field pea can delay the emergence by up to 5 days and reduce the final plant density by 80%. Waterlogging depresses vegetative growth of plants but affects root growth more than shoot growth.[11]

Field pea are most sensitive to waterlogging at flowering, with flower and pod abortion, and leaf senescence (ageing).[12]

Soil pH

Cool-season pulses are sensitive to acid soil conditions and require a neutral to alkaline soil pH for optimum growth and yield.

Nutrient availability can change with increments in soil pH, particularly in soils low in organic carbon. On such soils, toxicity of aluminum (Al), iron (Fe) and manganese (Mn) occur when the pH falls from 5.5 to 4.5. Root growth of pulses is severely restricted on acid soils. Symptoms of nutrient deficiency and water stress, therefore, commonly occur in pulse crops growing on unsuitably acid soils.

Salinity and sodicity

Cool-season pulses are relatively sensitive to salinity compared with cereals and canola. Yield reduction in field pea has been reported at about 20% at an electrical conductivity (EC) of 2 dS/m, and 90–100% reduction at an EC of 3 dS/m.[13]

Crop response to salinity changes with crop stage of growth. For example, lentil and faba bean are more sensitive at germination than at subsequent growth stages and the converse is true for chickpea.[14]

A study (Leonforte 2013) found that Chinese landrace lines of field pea were far more tolerant of salinity than Australian cultivars. Salinity-induced symptoms were closely

11 K Siddique (1999) Abiotic stresses of cool season pulses in Australia. University of Western Australia ,http://www.farmtrials.com.au/trial/13486

12 Pulse Australia (2016). Southern/western field pea best management practices training course, module 2-2016, Draft. Pulse Australia Limited

13 Pulse Australia (2016) Southern/western field pea best management practices training course, module 2-2016, Draft. Pulse Australia Limited

14 A Leonforte (2013) A study of salinity tolerance in field pea. University of Melbourne Australia, https://minerva-access.unimelb.edu.au/handle/11343/38605

related to reductions in growth rate, height, root and shoot dry matter, and with increased concentration of sodium ions (Na+) at the plant growing tip. The variety Kaspa[4] was quicker to suffer from salinity than Parafield and Yarrum. Helena showed slightly slower susceptibility. It was the line ACT01836 that was least sensitive of several introduced landrace lines.

Salinity tolerance score (1–10):

1. Plant healthy green, no obvious salinity symptoms.
2. Beginning to yellow, not very many symptoms.
3. Some chlorosis bottom half of plant, no necrosis, overall yellowing.
4. Necrosis beginning on bottom half of plant.
5. Chlorosis and necrosis bottom half of plant, yellowing overall (50% affected).
6. Chlorosis becoming more severe on upper part of plant, not necrotic on upper plant.
7. Chlorosis and necrosis more than half of plant.
8. More necrosis than 7, but still some green leaves.
9. Stem and very young leaves green, rest dead (all leaves may be dead).

9.5 Only top of stem (or small part stem) and very youngest leaves still green, rest dead (all leaves may be dead).

10. Plant dead.

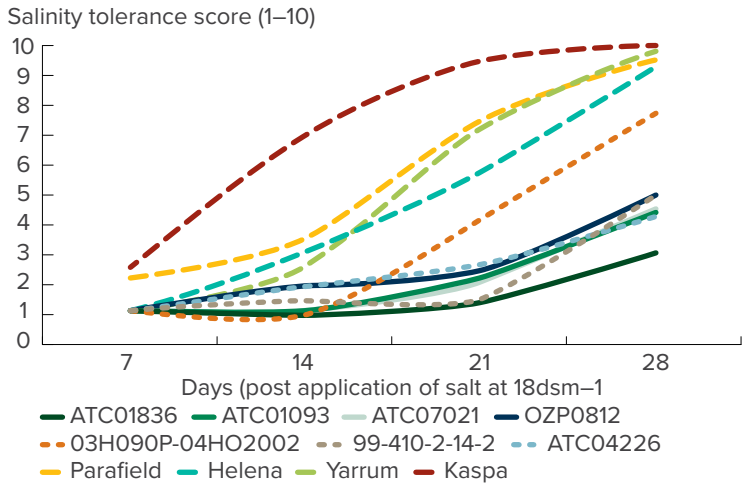

Figure 5: *Salinity tolerance comparisons of three categories of field pea (unadapted accessions - solid lines, adapted breeding lines - dotted lines and Australian commercial varieties - dashed lines).*

Source: A Leonforte (2013) A study of salinity tolerance in field pea. University of Melbourne Australia, https://minerva-access.unimelb.edu.au/handle/11343/38605

5.6 Crop lodging

Erectness

Field pea production across southern Australia was originally based on the 'dun types' that grow vigorously over winter: tall (long internodes), conventional-types that exhibit indeterminate flowering. The scrambling plant growth habit characteristics of these varieties can make management of weeds and diseases and harvest difficult, and result in poor and variable grain quality for export to human consumption markets.

The development of semi-leafless, semi-dwarf determinate types that grow more erect to seed maturity combines genes that control absence of leaflets and reduce plant internode length. Several dwarf, semi-leafless types were released but these were not commercially a success, largely because of low yields. Twenty years of breeding have led to the semi-leafless, semi-dwarf types for Australia (e.g. Kaspa$^{\Phi}$). Traits include: reproductive commencement in mid spring to avoid frost risk, lodging resistance and reduced pod shattering. More recent varieties PBA Twilight$^{\Phi}$ and PBA Gunyah$^{\Phi}$ have been developed for shorter-season climates.[15]

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$^{\Phi}$, PBA Percy$^{\Phi}$) are more likely to fall over in spring. Areas of ground exposed by lodging enable late spring weeds to grow and set seed, of particular concern for the management of annual ryegrass.

Difficulty in lifting the crop at harvest makes harvesting more difficult, slower and less efficient.

Grow varieties with greater resistance to lodging. These are likely to be the more erect types. Plant peas into standing cereal stubble, which will help anchor the plant and provide a natural trellis for the crop to grow up.[16] Narrower row spacings and higher sowing rates can also aid in standability.

For more information on harvest see Section 11 Harvest.

15 A Leonforte (2013) A study of salinity tolerance in field pea. University of Melbourne Australia, https://minerva-access.unimelb.edu.au/handle/11343/38605

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

5.7 Reduced shattering

The introduction of the sugar-pod trait into field pea varieties has meant shatter resistance is present now in the semi-leafless Kaspa-type field peas (e.g. PBA Wharton[Φ]). Other conventional, trailing-type field peas have also had some degree of shatter resistance incorporated by breeding, but not with the sugar-pod trait (e.g. PBA Oura[Φ]).

Photo 2: *Kaspa-type field pea with the sugar-pod trait to minimise shattering.*

Photo: W. Hawthorne, formerly Pulse Australia

5.8 National field pea breeding objectives

For a summary of field pea breeding objectives and techniques, see A Fresh Look at Field Pea Breeding by Dr Garry Rosewarne Agriculture Victoria, https://www.csu.edu.au/__data/assets/pdf_file/0003/2647650/CSU-symposiumRosewarne.pdf

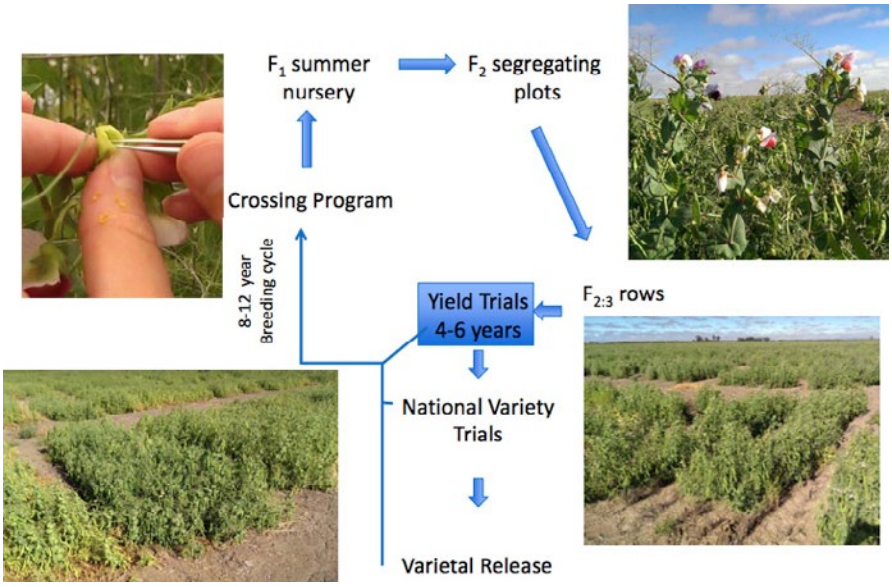

Figure 6: *Field pea breeding stages.*

Source: Rosewarne 2015, https://www.csu.edu.au/__data/assets/pdf_file/0003/2647650/CSU-symposiumRosewarne.pdf

The existing Pulse Breeding Australia (PBA) field pea breeding strategy has worked well in the past, but now breeding uses:

- statistical analysis to improve understanding of genotype and environmental interactions (GxE);
- alternative strategies to better combine multiple traits;
- advance generations to fixation to improve yield and incorporate molecular markers; and
- new technologies to dramatically shorten the breeding cycle.[17]

The PBA breeding programs, including for field pea, are delivering new pulse varieties with:

- improved regional adaptation;
- higher yield;
- superior resistance to diseases (such as Ascochyta and bacterial blight, Botrytis grey mould);
- outstanding quality parameters for mainstream and special purpose end users; and
- improved abiotic stress tolerance (such as salt, boron, heat, frost) compared to currently available varieties.

Together with its commercial partners, PBA has developed models of variety release that ensure varieties are available to Australian growers up to 3 years faster by providing commercial parties with access to a pipeline of varieties and by ensuring:

- seed production begins earlier in the development process; and
- crop-specific release advisory groups critically review data to identify varieties that can be fast-tracked to commercial release.

17 G Rosewarne (2015). A Fresh Look at Field Pea Breeding. Agriculture Victoria, https://www.csu.edu.au/__data/assets/pdf_file/0003/2647650/CSU-symposiumRosewarne.pdf