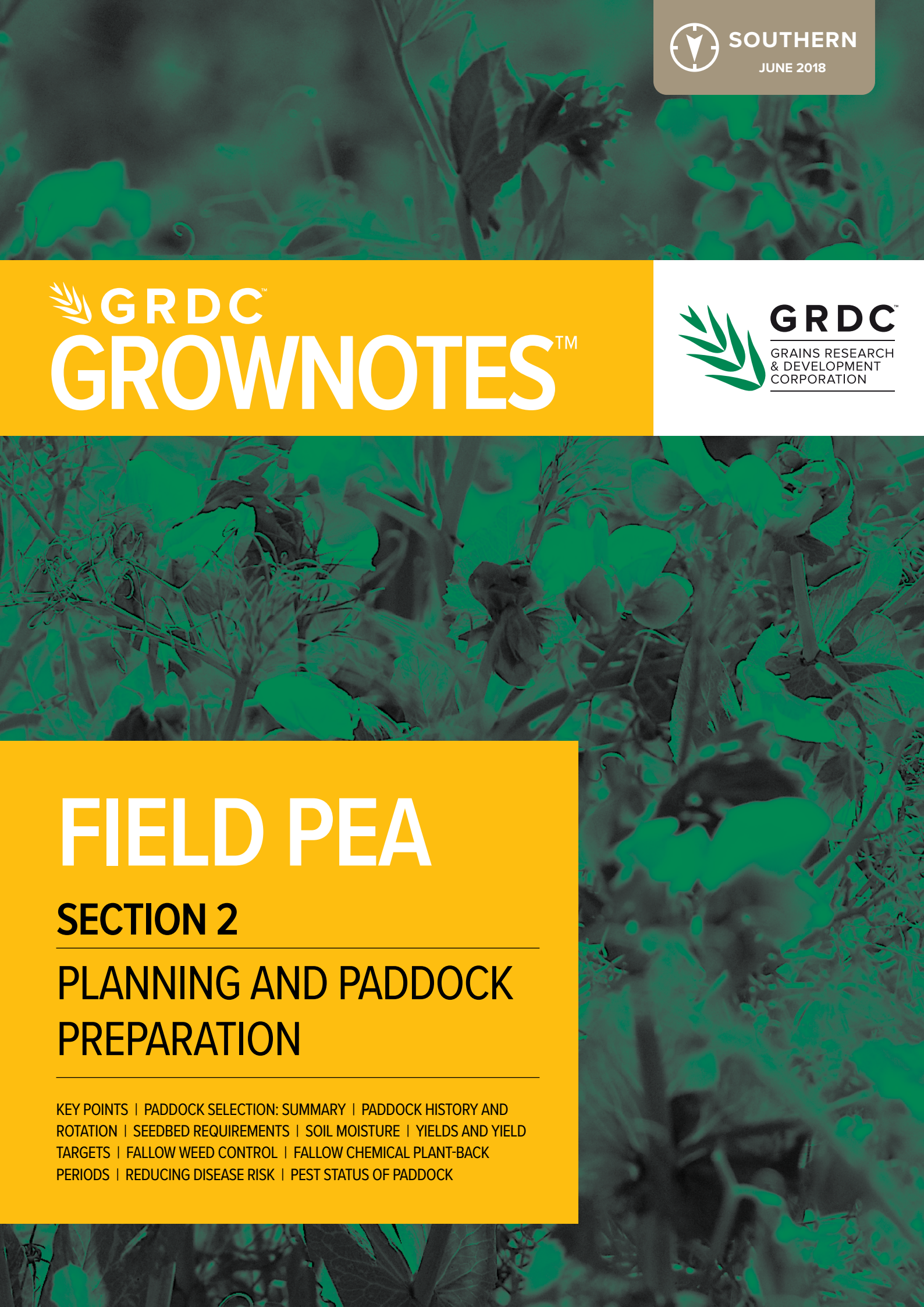

SOUTHERN
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GRDC GROWNOTES™

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GRAINS RESEARCH & DEVELOPMENT CORPORATION

FIELD PEA

SECTION 2

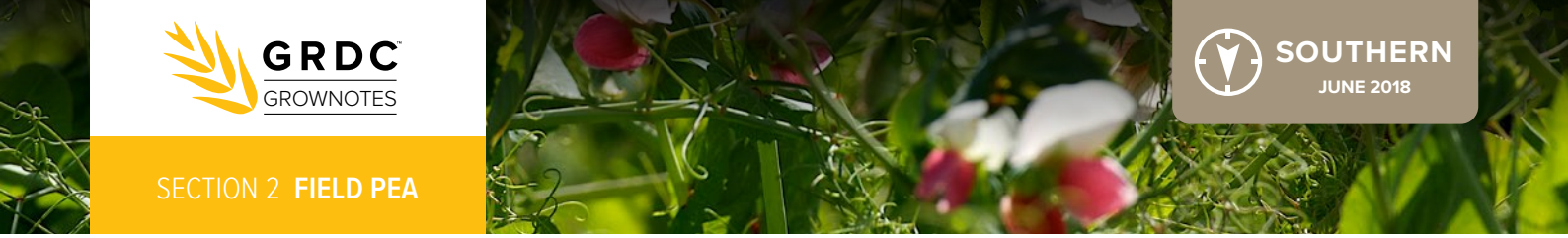
PLANNING AND PADDOCK PREPARATION

KEY POINTS | PADDOCK SELECTION: SUMMARY | PADDOCK HISTORY AND ROTATION | SEEDBED REQUIREMENTS | SOIL MOISTURE | YIELDS AND YIELD TARGETS | FALLOW WEED CONTROL | FALLOW CHEMICAL PLANT-BACK PERIODS | REDUCING DISEASE RISK | PEST STATUS OF PADDOCK

Planning and paddock preparation

Key points

- Field pea has the widest adaptation to soil types of all pulse crops, from sandy loams through to heavy clays, although prefers friable, well-draining soils (not hard-setting as they are prone to waterlogging).
- Field pea tolerates a wide range of pH, from 6.0–9.0 (water).
- Field pea is best grown in districts with 300–750 mm annual rainfall. It is the best adapted pulse to lower rainfall areas, but prone to frost and heat stress during flowering and podding.
- Field pea benefits from no-till with retained stubble, giving the crop structural support and greater standability at harvest.
- Field pea provide benefits in cropping rotations such as weed control, disease control, residual nitrogen and flexibility in timing of farm operations.
- A number of tools are available to estimate potential yield of field pea to manage inputs effectively.



FEEDBACK

Pulses have a role in a well-considered rotation. They are a cash crop in their own right and also a valuable part of the whole farming system, especially for weed control, nitrogen fixation and for a disease break. Field pea benefits from stubble retention for erosion protection and moisture retention, giving the crop structural support for the plant to climb on and greater standability at harvest. Seeding machinery used in no-till or minimum-tillage systems can now handle stubble retention to allow pulse crops to be sown after a cereal.

Diversity of crops in a rotation is important for continuous cropping systems to:

- handle herbicide-resistant weeds, or delay the onset by varying herbicide options and timings for weed control;
- control crop diseases in the rotation;
- spread the timing of farm operations;
- spread risk across commodities; and
- minimise the impact of increased nitrogen fertiliser and fuel costs.[1]

2.1 Paddock selection: summary

A suitable soil type, paddock surface condition and paddock topography are all important criteria in assessing whether country is suitable for field pea production.

Harvest losses are much higher in rough or uneven paddocks, particularly in dry seasons when crop height is reduced. Sticks or rocks, eroded gullies or gilgais ('melon holes' or 'crab holes') will prevent headers operating at low cutting height. The more level paddocks are the better, particularly when using headers with wide fronts. Small variations in paddock topography can lead to big variations in cutting height across a wide front and a subsequent increase in harvest losses.

Crop maturity can be significantly affected by moisture supply during the growing season. Any major changes in soil type and moisture storage capacity across a paddock can lead to uneven crop maturity, delayed harvest, and increased risk of weather damage and/or high harvest losses due to cracking and splits. Uneven crop development also complicates timing of some operations, such as the timing of herbicide applications.

Field pea crops should be separated from a previous year's crop by at least 500 metres and up to 1 kilometre in areas where old stubble is prone to movement, i.e. down slope and on flood plains. This helps to reduce the spread of Ascochyta blight (both foliar and stubble), bacterial blight and downy mildew diseases. (See Section 9 Diseases)

Avoid paddocks with high weed burdens, as field pea is poorly competitive against weeds. Be aware of those difficult-to-control weeds, particularly tares, wild radish, bedstraw, bifora and herbicide-resistant ryegrass. (See Section 7 Weed control)

Review herbicide use over the previous two seasons and assess any potential herbicide residue problems prior to sowing. (See Section 7 Weed control)

Review any soil tests and/or grower records, paying particular attention to the following soil characteristics:

- soil type – loams to self-mulching clays
- pH 6.0–9.0 (water)
- sodicity
- salinity/chloride
- bulk density
- potential waterlogging problems
- amount of stored soil moisture and received rainfall, noting their potential impact on herbicide residues.[2]

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

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

FEEDBACK

VIDEO

Over the Fence South: Chook poo breaks through clay soil's grip on crops
https://youtu.be/KKOTV3r6DtI

Photo 1: *Field pea needs to be rolled to minimise the impact of stones at harvest.*

Photo: P. Gibbs; Pulse Australia

2.1.1 Soil types

Field pea has the widest adaptation to soil types of all pulse crops, from sandy loams through to heavy clays (Table 1). Soils may be slightly acid to alkaline (pH water 6.0–9.0). Like all pulse crops, field pea is less productive on soils with a hard-setting surface or with heavy clay subsoils that drain poorly, but is the best suited of all the pulses to grow on these hard-setting soils.

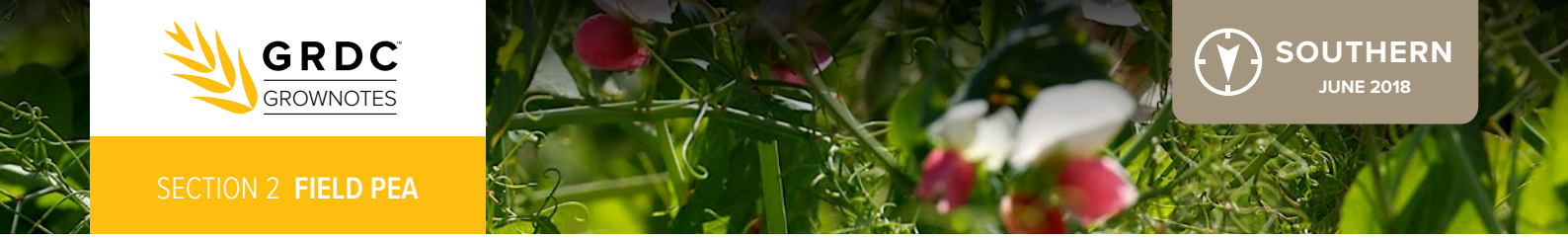
Field pea grows on a wide range of soil types, but best results can be expected from those with a heavier texture.

Table 1: Conditions suited to pulses with winter-dominant rainfall.[3]

	Soil type								
Crop	**Clay**	**Loam**	**Sand**	**Light sand**	**Clayed sand (low lime)**	**Clayed sand (free lime)**	**Water-logging tolerance**	**Optimum soil pH (H_2O)**	**Lower rainfall limit (mm)**
Bean									
Faba	excellent	excellent	poor	very poor	medium	medium	good	6.5–9.0	400
Broad	excellent	excellent	poor	very poor	poor	poor	good	6.5–9.0	450
Chickpea									
Desi	excellent	excellent	fair	poor	fair–good	fair–good	poor	6.0–9.0	350
Kabuli	excellent	excellent	fair	poor	fair	fair	poor	6.0–9.0	425
Lentils	good	good	fair	poor	medium	medium	very poor	6.5–9.0	400
Lupin									
N.L	fair	excellent	fair	excellent	fair–excellent	very poor	poor	4.5–7.5	375
Albus	excellent	excellent	poor	very poor	fair	fair	very poor	4.5–7.5	400
Yellow	poor	medium	good	good	medium	poor	good	4.0–7.0	400
Pea	excellent	excellent	fair	poor	medium	medium	fair	6.0–9.0	350
Vetch	excellent	excellent	fair	fair	excellent	excellent	poor	5.5–9.0	250

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

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



FEEDBACK

Field pea 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 pea can be sensitive to high levels of exchangeable aluminum in acid soils.

Level paddocks are preferred. Paddocks with gilgais, rocks or sticks, and hard-pans should be avoided as they can create issues at harvest time with contamination of the sample, damage to machinery or prevent collection/harvesting of the whole crop up.[4]

Field pea is best grown in districts with 300–750 mm annual rainfall. It is the best adapted pulse to lower rainfall ares, but prone to frost and heat stress during flowering and podding.

Checklist for field pea paddock selection:

- 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 and pH (water) is 6.0–9.0.
- Soil surface flat and free of undulations. Rolling will flatten clods, rocks and stones.
- Pea not sown in the previous 4 years and paddock not downwind of last year's pea stubble to avoid black spot.
- Few problem weeds like herbicide-resistant ryegrass, medics, vetch and tares.
- Maximum herbicide plant-back periods satisfied (e.g. Group Bs, clorpyralid, triazines).
- Stubble able to be sown into without leaving clumps.[5]

2.1.2 Soil pH

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

Danger levels for crops are when soil pH is <6.0 (water). Monitor changes in soil pH by regular soil testing. If severe acidity is allowed to develop, then irreversible soil damage can occur. Prevention is better than cure, so apply lime regularly to acidic soils. The most effective liming sources have a high neutralising value and have a high proportion of material with particle size <0.25 mm. More lime is required to raise pH in clays than in sands. Liming can induce manganese deficiency where soil manganese levels are marginal.

Low soil pH often leads to poor or ineffective nodulation in pulses because acid soil conditions affect rhizobia survival in the soil. Field pea, faba bean, lentil and chickpea are vulnerable, as is vetch. Lupin is an exception because its rhizobia (Group G) are acid-tolerant. Granular inoculants seem to provide greater protection to rhizobia in acid soil conditions.[6] (See Section 4 Planting.)

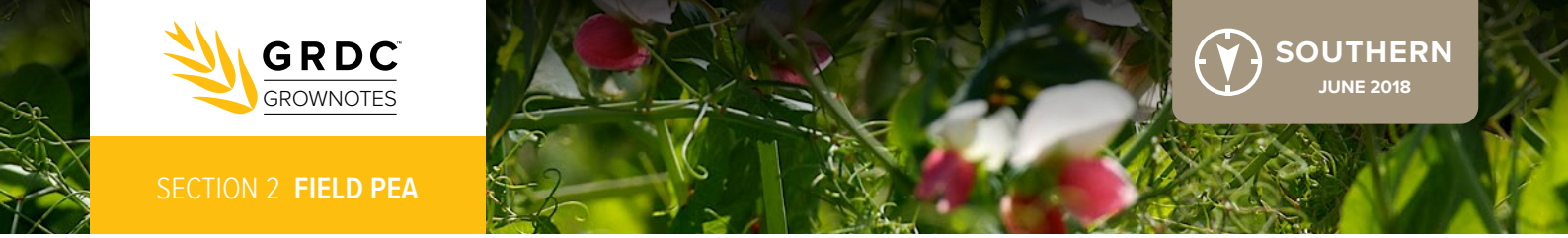
2.1.3 Sodicity

Soils high in sodium are structurally unstable, with clay particles dispersing when wet. This subsequently blocks soil pores, reduces water infiltration and aeration, and retards root growth. On drying, a sodic soil becomes dense and forms a hard surface crust up to 10 mm thick. This can also restrict seedling emergence and damage or break root structures.

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

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

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



FEEDBACK

Some indicators of surface sodicity include:

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

Exchangeable sodium percentage (ESP) is the measure for sodicity:

- ESP <3 – non-sodic soils
- ESP 3–14 – sodic soil
- ESP >15 – strongly sodic.[7]

Field pea can tolerate subsoil sodicity up to approximately 5 ESP in the surface layer and 8 ESP in the subsoil.[8]

Sodicity adversely affects cool-season pulses by reducing germination and seedling establishment with increasing ESP (15–20).

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

2.1.4 Salinity

Salinity is the presence of dissolved salts in soil and water. It causes iron toxicity in plants and impedes the plants' ability to absorb water.

Saline soils are defined as those with electrical conductivity (EC) of the saturated soil extract >4 deciSiemens per metre (dS/m) and sodic soils are those with a sodium adsorption ratio (SAR) >15. Winter pulses, particularly field pea and lentil, are relatively salt-sensitive compared to cereal crops. Yield reduction of about 20% has been reported in field pea at an EC of 2 dS/m) and 90–100% at an EC of 3 dS/m.[9]

Field peas are sensitive to waterlogging and moderately sensitive to soil salinity. Soil salinity affects plant growth by reducing the roots' ability to extract water from the soil. Soil salinity damage varies from season to season due to variations in the soil salt concentration. Waterlogging increases salinity damage.

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

8 C Mullen (2004) The right pulse in the right paddock at the right time. NSW Agriculture, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/winter-crops/general-information/right-pulse

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

FEEDBACK

Photo 2: *Salinity damage: marginal necrosis of older leaves that progresses up the plant, older leaf yellowing.*

Photo: DPIRD (2015). https://www.agric.wa.gov.au/mycrop/diagnosing-salinity-damage-field-peas

Glasshouse studies and field observations suggest that field pea and lentil may have greater salinity tolerance than faba bean and chickpea. Salinity tolerance of field pea and lentil are comparable to wheat, but less than that of barley.[10]

A glasshouse study in Western Australia to determine the influence of salinity (0 and 6 dS/m) and boron (5 and 20 milligrams per kilogram) and the combined effects of both on the early growth of two field pea varieties, Kaspa(ф) and Parafield, found salinity to be the main inhibitor of 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(ф) 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.[11]

10 K Siddique, Abiotic stresses of cool season pulses in Australia, University of Western Australia, http://www.bcg.org.au/members/download_trial.php?trial_id=295

11 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

FEEDBACK

Photo 3: *Poor weed and pea germination due to salinity and waterlogging.*

Photo: DPIRD (2015). https://www.agric.wa.gov.au/mycrop/diagnosing-salinity-damage-field-peas

2.2 Paddock history and rotation

Field pea, like other pulses, play an important, complementary role in cropping sequences by enabling better management of weeds, diseases, herbicide residues and soil nitrogen.

While the most suitable cropping sequence requires careful planning, there are no set rules and a separate rotation should be devised for each cropping paddock. The main aims should be sustainability and the highest possible long-term profit.

To achieve these, the sequence must be flexible enough to cope with key strategies such as maintaining soil fertility and structure, controlling crop diseases, and controlling weeds and their seedset.[12]

Recent research in Victoria and southern NSW showed that canola and pulse crops were frequently as profitable, and in some cases, considerably more profitable, than wheat. Furthermore, wheat following break crops was consistently more profitable than wheat after wheat.[13]

Some farmers have adopted a pulse–wheat–barley sequence for their basic rotation.

However, where a pulse can be grown with other crops, farmers are increasingly adopting a pulse–cereal–oilseed–cereal rotation, e.g. bean–wheat–canola–barley. Peas can be grown in place of beans in the next sequence. A hay cut is often also included for weed control, as preventing weed seedset is a major priority.

Successive cropping with the same pulse is likely to result in rapid build-up of root and foliar diseases and weeds. Take extreme care if growing the same crop in the same paddock without a break of at least three years. Where possible, alternate different pulse crops in a continuous rotation with cereals.[14]

Field pea is well-suited to no-till systems. The previous crop should preferably have been a cereal, resulting in low soil nitrogen and disease levels for pulses. This

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

13 M Peoples, T Swan, L Goward, J Hunt, A Glover, I Trevethan (2105) Key outcomes arising from the crop sequence project. GRDC Grains Research Update, Corowa, 19 February 2015

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

FEEDBACK

MORE INFORMATION

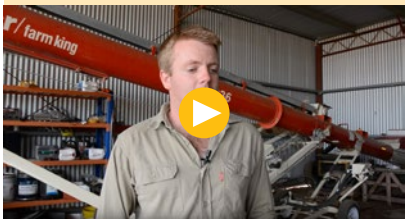
GroundCover™ Issue 115 – Profitable pulses and pastures, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-115-Profitable-pulses-and-pastures?pg=2&all=0

GRDC Update: Key outcomes arising from the crop sequence project

https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/02/key-outcomes-arising-from-the-crop-sequence-project

VIDEO

Growing profitable pulses.
https://youtu.be/6kuoiCmzMco



VIDEO

Crop Sequencing in the Mallee
https://youtu.be/OCGQ9mskxz8

maximises nitrogen fixation and helps minimise disease. Standing cereal stubble also inhibits aphid activity, providing a physical barrier that inhibits the insect flying through the crop. Aphid presence itself can be a problem to field pea, especially because they can transmit viruses. Cereal stubble also provides architectural support for the growing pea crop.

Broadleaf weed pressure should be low and the weed seedbank should have been reduced in previous crops. Avoid problem weed paddocks, considering both weeds that are difficult to control and weeds that may contaminate the grain sample.

Herbicide residues and herbicide history must also be considered. For example, herbicide residues of the Group B sulfonylurea herbicides, such as chlorsulfuron (e.g. Glean®) and metsulfuron methyl (e.g. Ally®), can be very damaging, particularly in alkaline soils after extended dry periods, and can stunt field peas.[15]

2.2.1 Rotational benefits of field pea

A survey of scientific research from across the world has revealed mean yield benefits to wheat production after a break crop to be 20% or more.

The reasons for this include:

- improved weed control;
- improved residual water and nitrogen supply;
- cereal root disease control;
- effects on soil biology and structure; and possibly
- allelopathy (the chemical inhibition of one plant by another).[16]

Importantly, the benefits of pulses and other break crops or pastures can only be captured if break crops are managed well.

A weedy, low-yielding pulse or canola crop is not really a 'break' crop, as weeds will host cereal diseases and set seeds that emerge in subsequent cereal crops. Nitrogen fixation by the legumes will also be poor.[17]

Yield gains in subsequent crops

A recent review of more than 900 experiments has quantified the yield benefits delivered by break crops.

When compared with wheat on wheat, wheat yields increased, on average, by:

- 1.0 tonne per hectare following pulses (ranging from 0.7 to 1.6 t/ha);
- 0.8 t/ha following canola; and
- 0.5 t/ha following oats.

Although the yield benefit was variable, yield was rarely reduced. The average yield benefit was also constant across the full range of wheat yields, whether 1.0 t/ha or 6.0 t/ha.

This 'break-crop effect' often extended to a second wheat crop in the sequence, especially following legumes (a benefit of 0.2–0.3 t/ha), but rarely to a third crop, except under dry conditions.[18]

The individual factors contributing to the yield gains in cereal crops after break crops have been assessed. The most important components were found to be the suppression of the cereal disease take-all and the contribution of soil nitrogen by

15 L Jenkins, P Matthews, B Haskins, K Hertel, G Brooke, E Armstrong, D McCaffery, G Lane (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

16 J Kirkegaard, O Christen, J Krupinsky, D Layzell (2008) Break crop benefits in temperate wheat production, Field Crops Research, 107, 185–195, http://www.sciencedirect.com/science/article/pii/S0378429008000385

17 J Kirkegaard (2015) Grain legumes can deliver an extra 1t/ha yield to wheat crops, Ground Cover™ Supplement: Profitable Pulses and pastures. Ground Cover™ Issue 115, https://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

18 J Kirkegaard (2015) Grain legumes can deliver an extra 1t/ha yield to wheat crops, Ground Cover™ Supplement: Profitable Pulses and pastures. Ground Cover™ Issue 115, https://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

FEEDBACK

legume crops. These two factors were each estimated to increase the yield of a 4 t/ha wheat crop by 0.5 t/ha.[19]

Financial benefits over the rotation

The financial benefit of well-managed break crops to subsequent cereal crops is an important reason for growers to choose to sow pulses or other break crops, especially where break crops are considered more risky or less profitable than the main cereal crop.

Consider the economic benefits of break crops over a full 2 to 3-year cropping sequence, rather than just the year it is grown.

Another important benefit of break crops is having a diversified income to manage price variations.[20]

Managing weeds including herbicide-resistant weeds

Break crops such as field pea can be used for weed control, by providing additional herbicide group options to reduce the potential development of herbicide resistance. They are one of the best weed competitors of all the pulses and have more chemical options for broadleaf weed control than chickpea or lentil.

The prevalence of herbicide-resistant weeds (especially annual ryegrass) due to intensive cereal production with selective herbicides now dictates crop sequence decisions for many growers.[21] One of the main reasons for southern region growers to switch from a cereal to a break crop is the availability of more herbicide options to manage grass weeds.[22]

For more information, go to Section 7.7 Herbicide types, Section 7.7.2 Knockdown herbicides, Section 7.7.3 Pre-emergent herbicides, Section 7.7.4 Post-emergent herbicides and Section 7.7.6 Crop-topping.

Random sampling of paddocks in southern NSW, South Australia and Victoria has revealed widespread resistance or partial resistance of some grasses and broadleaf weeds to a broad range of herbicide groups (up to 70–80%) of samples in some areas.[23]

Nitrogen fixation

Pulses (and pasture legumes) play an essential role in the nitrogen (N) supply chain of field crops, especially since soil nitrogen is one of the most limited plant nutrients worldwide. By fixing their own nitrogen during growth, pulses become independent of soil mineral nitrogen and thereby conserve or spare it. When combined, these two sources (fixed and spared N) produce large amounts of residual nitrogen for following crops, boosting their grain yield and grain protein.[24]

A well nodulated field pea crop with good weed control can provide nitrogen to the crop rotation by means of fixing nitrogen through rhizobia and from nitrogen released from crop residues. Larger benefits to the following crop in the rotation are more likely where soil fertility is low to medium, because in the presence of available nitrogen field pea will be 'lazy' and use this nitrogen as opposed to producing their own via their symbiotic relationship with the rhizobia. The better the field pea crop,

19 J Angus, M Peoples, J. Kirkegaard, M Ryan, L Ohlander (2008) The value of break crops for wheat. Proceedings 14th Conference, Australian Society of Agronomy, Adelaide, SA, Australian Society of Agronomy. www.regional.org.au/au/asa/2008/concurrent/rotations/5786_angusjf.htm

20 J Angus, M Peoples, J. Kirkegaard, M Ryan, L Ohlander (2008) The value of break crops for wheat. Proceedings 14th Conference, Australian Society of Agronomy, Adelaide, SA, Australian Society of Agronomy. www.regional.org.au/au/asa/2008/concurrent/rotations/5786_angusjf.htm

21 J Kirkegaard (2015) Grain legumes can deliver an extra 1t/ha yield to wheat crops, Ground Cover™ Supplement: Profitable Pulses and pastures. Ground Cover™ Issue 115, https://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

22 M Peoples, T Swan, L Goward, J Hunt, A Glover, I Trevethan (2105) Key outcomes arising from the crop sequence project, GRDC Grains Research Update, Corowa, 19 February 2015, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Key-outcomes-arising-from-the-crop-sequence-project

23 C Preston *et al.* (2013) Maintaining the best options with herbicides. NSW GRDC Grains Research Update for Advisers 2013, Temora, NSW, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Maintaining-the-best-options-with-herbicides

24 E Armstrong, D Holding (2015) Pulses: putting life into the farming system. NSW Government Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_ le/0004/558958/Pulses-putting-life-into- the-farming-system.pdf

FEEDBACK

i.e. one that has a thick plant stand, healthy plants with good nodulation and good bulk, the greater the amount of N that will be fixed.

A 10-year study researching the contributions to farming systems of eastern Australia of nitrogen fixed by legume crops found that where southern pulse crops followed several years of cereal cropping, concentrations of mineral N at sowing were generally low and legume reliance upon N fixation was consistently high. Therefore, the amounts of N fixed were closely linked to biomass production, with around 20–25 kg of shoot N being fixed for every tonne of legume shoot of dry matter (DM) accumulated.[25]

The availability of nitrogen following a field pea crop depends on seasonal conditions, as moisture and warm temperatures are required to convert the organic nitrogen in the legume residues to nitrate. Most of the short-term nitrogen benefit following field pea comes from spared mineral nitrogen and the breakdown of fine roots and nodules.

The nitrogen benefit from field pea is typified by two experiments in central-west NSW that measured the amount of nitrogen fixed by field pea, the effect of management on nitrogen cycling and the response of two subsequent wheat crops (Tables 2 and 3).

Table 2: First and second year wheat yields and protein responses to crop types and management at Parkes, NSW.

Treatment in 1997	Wheat in 1998	Wheat in 1999	
	Yield (t/ha)	Yield (t/ha)	Protein (%)
Oats – grain	2.83	2.80	11.6
Oats – hay	3.58	3.36	12.0
Pea – grain	3.78	3.43	12.3
Pea – hay	3.70	3.21	11.9
Pea – ploughed in	4.15	3.56	12.2
Pea – sprayed out	4.09	3.44	12.2

Source: GRDC (2015) Field pea Northern Region GrowNotes™, https://grdc.com.au/GrowNotes, chapter 1, p 8

Table 3: First and second year wheat yields and protein responses to crop types and management at Condobolin, NSW.

Treatment in 1998	Wheat in 1999		Wheat in 2000	
	Yield (t/ha)	Protein (%)	Yield (t/ha)	Protein (%)
Oats – grain	2.63	12.2	2.02	9.2
Pea – grain	3.05	13.1	2.33	10.4
Pea – hay	3.15	13.4	2.38	10.5
Pea – ploughed in	3.41	13.6	2.53	10.9
Pea – sprayed out	3.20	13.7	2.48	10.7

Source: GRDC (2015) Field pea Northern Region GrowNotes™, https://grdc.com.au/GrowNotes, chapter 1, p 8

Field pea crops resulted in higher wheat yield and protein in each of two following crops than after oats, and this was related to higher soil mineral nitrogen levels. Green or brown manuring by either ploughing in or spraying the crop out gave the highest yield, but this advantage over harvesting the pulses for grain was less than expected.

25 M Peoples, R Gault, D Herridge, M McCallum, K McCormick, R Norton, G Scammell, G Schwenke, H Hauggaard-Nielsen (2001) Contributions of Fixed Nitrogen by Crop Legumes to Farming System of Eastern Australia. Australian Agronomy Conference 2001, http://www.regional.org.au/au/asa/2001/1/c/peoples.htm

FEEDBACK

The higher yield after green manuring needs to be balanced against the income from hay or harvested legume grain. Additional benefits from making hay or manuring could include the prevention of weed seedset in and the storage of additional soil moisture for the following crop. Above-average growing-season rainfall in both 1998 and 1999 minimised this 'fallow' effect in these trials.[26]

Soil conditioning

Field pea roots are small and fibrous and upon breakdown can create a more friable soil for the following year's crop; that is, they condition the soil or improve soil tilth.

Versatility – soil type & soil pH, temperature, rainfall, management & harvest

Field pea is the most versatile pulse with regard to soil type and soil pH. It will grow on soils from sand through to heavy clays, medium and low-rainfall environments, and from pH (water) 6.0–9.0.

Field pea has unique farming system advantages 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.

The early maturity of some field pea varieties also makes them ideally suited to crop-topping to prevent seedset of surviving in-crop weeds. The reduced reliance on selective herbicides provides a very useful tool in the battle against herbicide-resistant weeds. Late sowing and early harvest also mean the planting and harvest windows of the cropping program as a whole can be widened, thus allowing more efficient labour and machinery use.[27]

Cereal disease management

Grass-free pulse crops are generally effective disease breaks, usually more so than pastures due to the potential of grasses to host root diseases.

Field pea is a pulse break crop that can be used in rotations to effectively break the life cycle of cereal root diseases like take-all, crown rot, root-lesion nematode and cereal cyst nematode.[28]

Take-all

All grass-free pulse and oilseed crops can provide a disease break from take-all. Remove grass weeds from field pea before the end of July (or the end of June in the Mallee) to prevent the fungus multiplying and being carried into the next crop.[29]

Crown rot

For crown rot, a two-year break with a non-susceptible crop such as field pea or canola can reduce the severity of crown rot in subsequent wheat or barley crops.[30] Break crops allow for the natural decomposition of cereal residues that harbour the crown rot fungus.

Root-lesion nematode

Root-lesion nematode (RLN) is another important cereal disease that can be managed with the inclusion of field pea in the rotation. At least one in five cropping paddocks in south-eastern Australia have enough RLN to reduce yield.

Field pea is a poor host of the two important species that are common in southern region cropping soils: *Pratylenchus neglectus* and *P. thornei* (see Table 4). The two

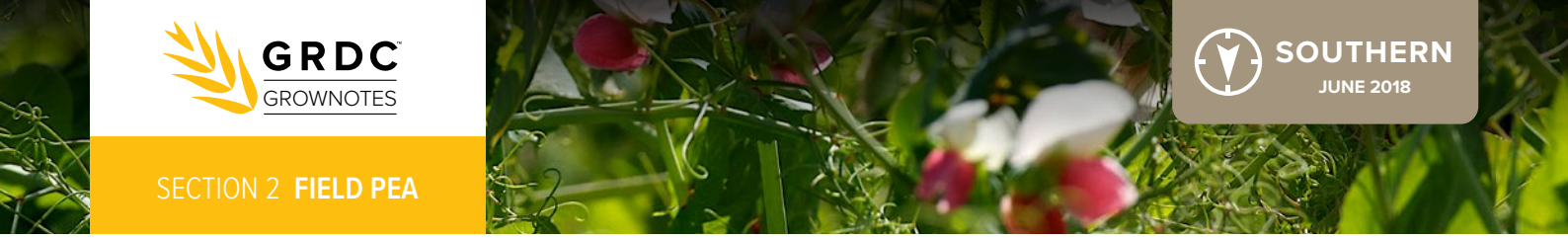
26 GRDC (2015). Field Peas Northern Region GrowNotes™, https://grdc.com.au/Resources/GrowNotes

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

28 G Holloway (2013) Cereal Root Diseases, Agnote AG0562, June 2013, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

29 G Holloway (2013) Cereal Root Diseases, Agnote AG0562, June 2013, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

30 G Holloway (2013) Cereal Root Diseases, Agnote AG0562, June 2013, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases



FEEDBACK

species often occur together. Rotations are the best way of controlling RLN. Resistant crops can potentially halve nematode populations each year. A 2-year break (or more) from susceptible crops may be necessary to minimise yield loss if nematode numbers were high to begin with.[31] For more information on nematode status for paddock selection, go to Section 2.8.3 Nematode status of paddock.

Table 4: Field pea is a poor host of the two important root-lesion nematode species, making it particularly useful crop in rotations.[32]

Crop	*P. thornei*	*P. neglectus*
Wheat	Intermediate – good*	Intermediate – good
Faba bean	Poor	Poor
Barley	Poor – intermediate	Poor – intermediate
Canola	Intermediate	Good
Field pea	Poor	Poor
Lentil	Poor	Poor
Vetch	Good	–

* In some crops the hosting ability varies between varieties.
Source: G Holloway (2013) Cereal Root Diseases. Agnote AG0562, June 2013, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

Cereal foliar disease

Break crops such as field pea can also play a role in cereal foliar disease management such as yellow leaf spot or tan spot (*Pyrenophora tritici-repentis*). For example, reducing the number of susceptible crops grown in a district will reduce inoculum load from season to season.[33]

2.2.2 Rotational disadvantages of field pea

As a crop field pea has few disadvantages but it is worth considering the following:

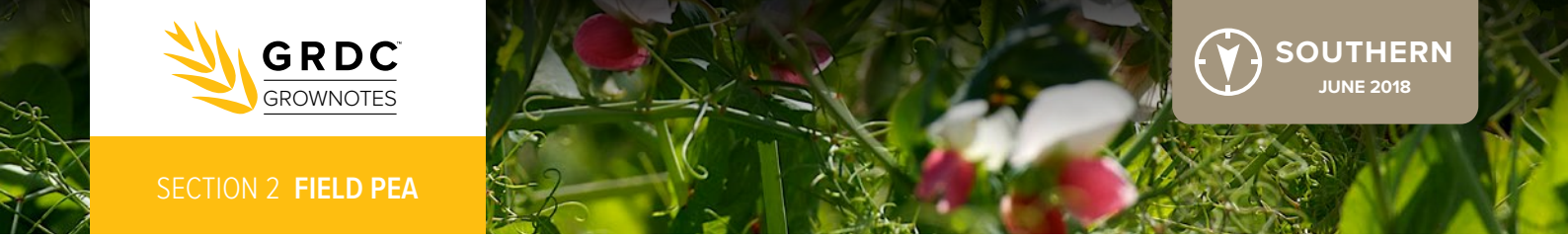
- Compared to cereals, field pea provides little groundcover over the summer period. Being weak-stemmed with fragile surface roots, they leave little stubble after harvest to hold the soil. If grown on erosion-susceptible soils, pea stubble should either not be grazed or carefully grazed to ensure adequate stubble cover is maintained.[34]
- Like other crops, self-sown field pea plants can emerge after harvest.
- Field pea is less productive on soils with a hard-setting surface, or heavy clay subsoils.
- Among the pulses field pea seems to be the most susceptible to frost injury during the reproductive stages.
- Field pea does not tolerate waterlogging at sowing or at the seedling phase.
- Field pea is susceptible to hostile subsoils, with boron toxicity, sodicity and salinity.
- Field pea is susceptible to insect attack, especially native budworm.
- Sand blasting by wind can severely damage seedling crops.
- Crops can lodge prior to harvest.

31 G Holloway (2013) Cereal Root Diseases. Agnote AG0562, June 2013, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

32 G Holloway (2013) Cereal Root Diseases. Agnote AG0562, June 2013, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/cereal-root-diseases

33 G Hollaway (2014) Yellow Leaf Spot of Wheat. Agnote AG1114 May 2014, Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/yellow-leaf-spot-of-wheat

34 I Pritchard (2015) Field pea stubble: wind erosion control and grazing management. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/402



FEEDBACK

- Weed control, particularly of broadleaf weeds, can be an issue, especially for weeds such as medic and clover.
- Harvest can be slow and expensive.
- Marketing of the crop can be challenging but some new avenues have emerged in the past few years.
- Field pea is susceptible to fungal diseases such as Ascochyta blight and chocolate spot.
- Volunteer field pea, particularly if a traditional dun type, can be a weed in subsequent crops and contaminate harvested grain with pea seed, which may contain pea weevil.

2.3 Seedbed requirements

Sowing depth of pulse seeds needs to be varied to take into account the crop type, soil type (Table 1), soil residual herbicide used, diseases likely to be present and soil temperature at sowing time, i.e. how long the crop will take to emerge. Lighter-textured soils can be more prone to herbicide leaching in wet winters, hence deeper sowing in sandier soils is recommended if applying a pre-emergent herbicide. The deepest sowings tend to be in sandy soil with warm soil temperatures and if dry sowing, while the shallowest sowings will be in heavy soils with cold soil temperatures or late sowing – however, there are exceptions.

The maximum depth at which the pulse crop can be safely sown to avoid poor establishment and lower seedling vigour is shown in Table 5. Sowing seed outside the suggested range may delay emergence and slow seedling growth. Actual sowing depth should be shallower on clay soils and hard-setting soils and deeper on sands. Lupin, with its epigeal emergence, is the pulse least tolerant of deep sowing; crops with hypogeal emergence (lentil, field pea, chickpea and vetch) are intermediate; and faba bean (also hypogeal emergence) is the most tolerant.

Table 5: Sowing depth ranges (in centimetres).[35]

Crop	General recommended sowing depth range*
Chickpea	3–5 cm
Faba bean	5–8 cm
Lentil	2–6 cm
Lupin	1–3 cm
Pea	3–5 cm
Vetch	3–5 cm

* Note: if applying a pre-emergent herbicide, the deeper depth should be used.
Source: J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook

Burying seed too deep to chase seedbed moisture for early sowing is not recommended, particularly as weed control, establishment and possibly nodulation is more likely to be poor. Deeper sowing may be needed in some districts to reduce the damage caused by birds and mice.[36]

If sowing deep to chase seedbed moisture, adopting a practice of 'sow deep, cover shallow' may be required, bearing in mind the risk of herbicide wash into seed furrows after rainfall.

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

36 Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 4-2016

FEEDBACK

Sowing depth and herbicide interaction

Pulses can be more tolerant of some soil residual herbicides if not sown shallow. For example, field pea is less affected by metribuzin applied either pre-sowing or post-sowing pre-emergent if they are sown deeper.

The actual depth of sowing will depend on the soil type. Herbicides leach deeper in sands than in clay soils. Some herbicides leach more than others. Heavy rain onto a dry soil surface, particularly on a sand, makes leaching worse.

Leaving the soil ridged increases the risk of a post-sowing pre-emergent herbicide washing into the furrow, especially on sands. As pre-sowing applications of herbicide may be less effective in the furrows, a split herbicide application is suggested to ensure effective weed control while avoiding the risk of herbicide damage.

Rolling

- Leaving a flat, firm soil surface free of sticks, stones and clumps is essential when growing most pulse crops. Rolling field pea after sowing to aid harvestability is required where height to bottom pods is often low, particularly in lower-rainfall areas or late-sown crops.
- 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 will normally achieve this.
- Rolling of paddocks sown to pulses in the past has generally occurred before crop emergence. However, some growers have rolled their pulses post-emergence. This is particularly common in peas and lentils but has also been used in other crops, although more sparingly and dependent upon soil type and conditions.[37]
- Field pea can be rolled post-emergent when it is best, between the 3 and 10 node stages. The disadvantage of this technique is that it could increase foliar disease, especially bacterial blight, and it requires a second pass over the paddock during a labour-intensive period. Most southern region field pea growers would consider a roller as a most essential piece of equipment. New growers may not possess this piece of machinery.[38]

Photo 4: *Rollers being used on an emerging lentil crop.*

Photo: Pulse Australia (2016)

37 Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 5

38 GRDC (2015) Field pea Northern Region GrowNotes™, https://grdc.com.au/Resources/GrowNotes

FEEDBACK

Undulating paddocks and gilgai (crab holes) can also cause harvest issues for field pea. This can lead to uneven crop maturity due to a variation in soil water supply across the paddock. Many dryland field pea crops require the header front to be set close to ground level. Small variations in paddock topography can lead to differences in cutting height across the header front, creating significant harvest losses. Cloddy or badly ridged paddocks and sticks and stones can contaminate the harvested grain and downgrade quality. The header may also be damaged.[39]

Photo 5: *Stones in pulse crops are a hazard, so rolling is suggested.*

Photo: W. Hawthorne, formerly Pulse Australia

VIDEO

Watch GCTV 5: Manage Summer Fallows:
https://youtu.be/5Kp5woTOo7c

2.4 Soil moisture

2.4.1 Dryland/fallow moisture

For a growing crop there are two sources of water: first, the water stored in the soil during the fallow; and second, the water that falls as rain while the crop is growing. Southern growers have little control over stored soil water, but can help to retain as much as possible through summer weed control and stubble retention. Soil moisture can be measured before planting and long-range forecasts and tools such as the Southern Oscillation Index (SOI) can indicate the likelihood of the season being wet or dry.[40]

Measure stored soil moisture depth

Soil moisture probes can be used to monitor soil water during the growing season.

Plant-available water capacity (PAWC)

PAWC is a measure of the ability of a soil to store water for later crop production. Figure 1 shows the water components that are measured to determine a soil's PAWC, or as it is often called, 'the size of its water bucket'. The two most important are the drained upper limit (DUL), which is related solely to the physical properties of the soil,

39 Pulse Australia (2014) Northern Faba Bean – Best Management Practices Training Course

40 J Whish (2013) Impact of stored water on risk and sowing decisions in western NSW. GRDC Update Papers 23 July 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Impact-of-stored-water-on-risk-and-sowing-decisions-in-western-NSW

and the crop lower limit (CLL), which is related both to soil physical properties and to the ability of the particular crop to extract water from the soil.

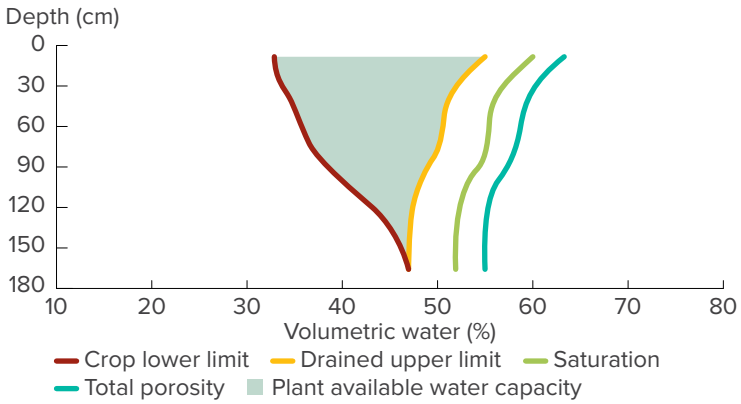


Figure 1: *A typical storage profile for a heavy-textured clay soil showing the potential water storage of the soil (plant-available water capacity, PAWC) as defined by the drained upper limit (DUL, blue shading), crop lower limit (CLL), saturation (SAT) and total porosity (PO).*[41]

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

Fallow

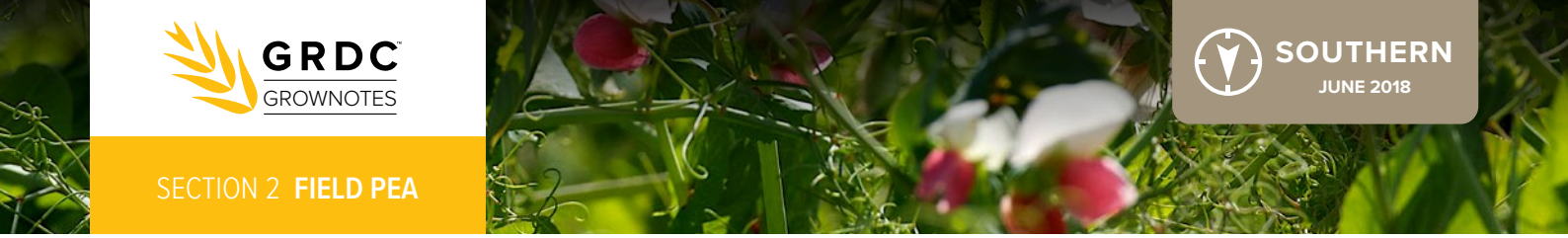
Fallowing captures out-of-season rainfall and can increase the amount of water available for crop growth. However, the proportion of rainfall retained by fallowing (also referred to as fallow efficiency) can be small, typically about 20%. Nevertheless, despite the low efficiency of many fallows, storage of moisture can help with managing the risk associated with variable rainfall. Soil mineral nitrogen can also increase under fallows as cultivation stimulates the mineralisation of soil organic matter and yield improvements following fallow can be associated with increases in nitrogen more so than moisture.

Fallowing is very important for winter crop production in the northern cereal zone where rainfall shows a strong summer incidence. In the southern and western regions fallowing is less important because the accumulation of moisture by fallowing is often much less and yield gains are frequently small over in-crop rainfall. The benefit of fallowing in regions with a winter-dominant rainfall pattern is influenced by the timing of rainfall. In these southern regions very little of the summer (December to March) rainfall is stored and the value of fallowing depends more on rainfall captured and retained from the previous growing season. Control of summer weeds is however very important for retaining as much stored moisture as possible.

Soil texture is also important. In a study in the 1960s in South Australia using cultivated fallows, the average increase in soil moisture after a 9–10 month fallow was only 9 mm (maximum 38 mm) on sandy soils and 38 mm (maximum 125 mm) on fine-textured soils. Each additional millimetre of moisture stored by the fallow increased grain yield by 8 kg/ha. This yield benefit from fallowing was confirmed in a more recent survey of commercial wheat crops in the Mallee region of NSW, Victoria and South Australia. It was found that the initial moisture in the top metre of soil after fallowing was 39 mm higher than after a cereal crop and 15 mm higher than after pasture. However, in both cases yield after fallow was increased by 10 kg/ha per mm of additional soil moisture.

Retaining stubbles on the fallow and controlling summer weeds may help to reduce water loss from the fallow and improve fallow efficiency, although the value of stubble retention appears to vary with soil texture and rainfall. On sandy soils, there may be little benefit from stubble retention on water capture over summer and in some

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



FEEDBACK

cases standing stubble may enhance evaporative losses. In contrast, on clay soils in southern Australia fallow efficiencies of up to 40% have been measured with retained stubbles.

The ability to store summer rainfall may also depend on the size of the rainfall events, 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.[42]

Fallowing – implications for water use efficiency

While fallowing efficiency is often low, leading to only small increases in available soil moisture and crop water use, the benefits of this moisture can still be high because it is not subject to additional evaporative loss, and is stored at depth and likely to be used during the critical phase of growth immediately prior to flowering and during the grain-filling period.

Work in southern NSW has indicated that the conversion efficiency of subsoil moisture used during grain filling can be up to 60 kg grain/ha/mm compared to a reference 20 kg grain/ha/mm for growing-season rainfall. Thus, small amounts of additional moisture may result in significant improvements in yield.[43]

2.4.2 Irrigation

Irrigating field pea, with either full or supplementary irrigation, is not widely practiced in Australia, and is considered risky because field pea is very susceptible to waterlogging. Nevetheless irrigating field pea may be economical if grown in an excellent irrigation layout, with good quality water and managed carefully in rotation with other winter and summer crops. Management requirements for irrigated field pea are the same as for dryland crops, with a greater emphasis on disease control as they will have a greater sensitivity to foliar diseases under irrigation. Field pea sensitivity to waterlogging under irrigation must be carefully considered and managed. Even waterlogging for a short time can result in severe losses, particularly if the crop is stressed (from herbicides, disease, moisture, etc). Irrigation type and layout will be critical to success.[44]

2.5 Yields and yield targets

Increasing production costs and increasing supplies of pulses will mean that future success with pulses will depend on greater productivity per hectare and per millimetre of rainfall.

Best management practices for the crop in relation to tillage, time of sowing, weed control and fertilising are needed and there is room for improvement. Under ideal conditions pulse crops should be able to produce 15 kg/ha of grain for every millimetre of growing season rainfall above 130 mm. By comparison wheat can produce up to 25 kg/ha for every millimetre of rainfall above 110 mm.[45]

Australia's climate, and in particular rainfall, is among the most variable on Earth; consequently, crop yields vary from season to season. In order to remain profitable, crop producers must manage their agronomy, crop inputs, marketing and finance to match each season's yield potential.[46]

MORE INFORMATION

GRDC Water Use Efficiency of Grain Crops in Australia: Principles, Benchmarks and Management, https://grdc.com.au/__data/assets/pdf_file/0030/159186/grdcpublicationwateruseefficiencyofgraincropsinaustraliapdf.pdf.pdf

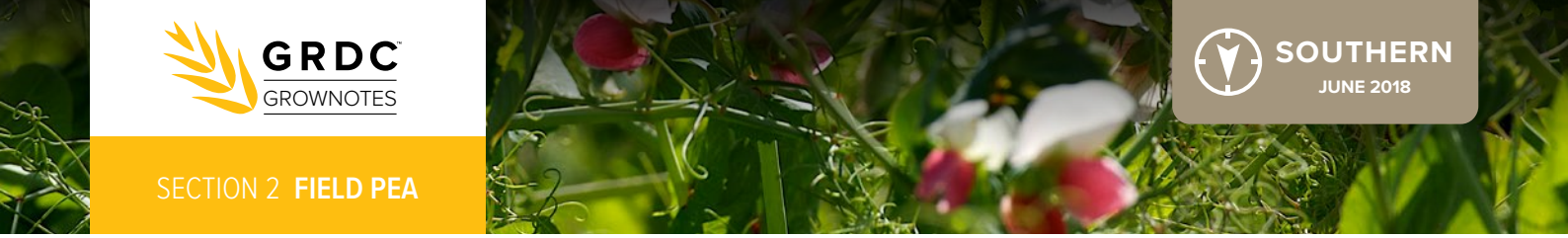
42 V Sadras, G McDonald (2012) Water use efficiency of grain crops in Australia: principles, benchmarks and management. Grains Research & Development Corporation, https://grdc.com.au/__data/assets/pdf_file/0030/159186/grdcpublicationwateruseefficiencyofgraincropsinaustraliapdf.pdf.pdf

43 V Sadras, G McDonald (2012) Water use efficiency of grain crops in Australia: principles, benchmarks and management. Grains Research & Development Corporation, https://grdc.com.au/__data/assets/pdf_file/0030/159186/grdcpublicationwateruseefficiencyofgraincropsinaustraliapdf.pdf.pdf

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

45 V Sadras, G McDonald (2012) Water use efficiency of grain crops in Australia: principles, benchmarks and management. Grains Research & Development Corporation, https://grdc.com.au/__data/assets/pdf_file/0030/159186/grdcpublicationwateruseefficiencyofgraincropsinaustraliapdf.pdf.pdf

46 T McClelland (2013) Yield Prophet®-What difference can it make to crop decision making? GRDC Update Papers, 6 February 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/02/Yield-Prophet-What-difference-can-it-make-to-crop-decision-making



FEEDBACK

Before planting identify the target yield required to be profitable:

- Do a simple calculation to see how much water you need to achieve this yield.
- Know how much soil water you have (treat this water like money in the bank).
- Think about how much risk your farm can take.
- Consider how this crop fits into your cropping plan – will the longer-term benefits to the system outweigh any short-term losses?[47]

2.5.1 Variety yield comparisons

See the National Variety Trials website (http://www.nvtonline.com.au) to compare the performance of current field pea varieties across the southern region. Also see Section 3.1 Evaluation of yield potential and Section 3.2.1 Characteristics of field pea varieties for southern Australia for more information.

2.5.2 Seasonal outlook

'The Break' newsletter is a good source of climate information for southern regions. It is produced by Agriculture Victoria regularly through the season and reviews climate models and changes to key influences on southern rainfall. To view issues and to subscribe, visit: The Break, The Fast Break and The Very Fast Break Newsletters (http://agriculture.vic.gov.au/agriculture/weather-and-climate/newsletters)

For tips on understanding weather and climate drivers including the Southern Oscillation Index (SOI), visit the Climate Kelpie website (http://www.climatekelpie.com.au/). Case studies of 43 farmers across Australia recruited as 'Climate Champions' as part of the Managing Climate Variability R&D Program can be accessed at: Climate Kelpie MCV Climate Champion program (http://www.climatekelpie.com.au/farmers-managing-risk/climate-champion-program).

Australian CliMate (http://www.australianclimate.net.au/) is a suite of climate-analysis tools delivered on the web, iPhone, iPad and iPod Touch devices. CliMate allows you to interrogate climate records on questions relating to rainfall, temperature, radiation, and derived variables such as heat sums, soil water and soil nitrate, as well as El Niño/SOI status. It is designed for decision-makers such as farmers whose businesses rely on the weather.

Download from the Apple iTunes store at: https://itunes.apple.com/au/app/cropmate-varietychooser/id476014848?mt=8 or visit http://www.australianclimate.net.au

Season's progress?

One of the CliMate tools, *Season's progress?*, uses long-term (1949 to present) weather records to assess the progress of the current season (rainfall, temperature, heat sums and radiation) compared with the average and with all years. It explores the readily available weather data, compares the current season with the long-term average, and graphically presents the spread of experience from previous seasons.

Crop progress and expectations are influenced by rainfall, temperature and radiation since planting. *Season's progress?* provides an objective assessment based on long-term records and helps to answer the following questions:

- How is the crop developing relative to previous seasons, based on the heat sum?
- Is there any reason why my crop is not doing as well as usual because of below-average rainfall or radiation?
- Based on *Season's progress?* (and starting conditions from *How wet?*), should I adjust inputs?

47 J Wish (2013) Impact of stored water on risk and sowing decisions in western NSW. GRDC Update Papers, 23 July 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Impact-of-stored-water-on-risk-and-sowing-decisions-in-western-NSW#sthash.2h5bo1Tp.dpuf

FEEDBACK

Inputs:

Season's progress? asks for the weather variable to be explored (rainfall, average daily temperature, radiation, heat sum with base temperatures of 0°C, 5°C, 10°C, 15°C and 20°C), a start of each month and a duration.

Outputs:

Text and two graphical presentations are used to show the current season in the context of the average and all years. Departures from the average are shown in a fire-risk chart as the departure from the average in units of standard deviation.[48]

The Bureau of Meteorology has moved from a statistics-based to a physics-based (dynamical) model for its seasonal climate outlooks. The new system has better overall skill, is reliable, allows for incremental improvements in skill over time, and provides a framework for new outlook services including multi-week and monthly outlooks and the forecasting of additional climate variables.[49]

How wet? – a climate analysis tool

How wet? is a climate-analysis tool (from CliMate) that uses records from a nearby weather station to estimate how much plant-available water (PAW) has accumulated in the soil and the amount of organic nitrogen that has been converted to an available nitrate during a fallow. *How wet?* tracks soil moisture, evaporation, runoff and drainage on a daily time-step. Accumulation of available nitrogen in the soil is calculated based on surface soil moisture, temperature and soil organic carbon.

How wet? estimates how much:

- rain has been stored as plant-available soil water during the most recent fallow period;
- nitrogen has been mineralised as nitrate-N in soil; and
- provides a comparison with previous seasons.

This information aids the decision about what crop to plant and how much N fertiliser to apply.

Many grain growers are in regions where stored soil water and nitrate at planting are important in crop-management decisions.

Questions this tool answers:

- How much longer should I fallow? If the soil is nearly full, perhaps the fallow can be shortened.
- Given my soil type and local rainfall to date, what is the relative soil moisture and nitrate-N accumulation over the fallow period compared with most years? Relative changes are more reliable than absolute values.
- Based on estimates of soil water and nitrate-N accumulation over the fallow, what adjustments are needed to the N supply?

Inputs:

- A selected soil type and weather station.
- An estimate of soil cover and starting soil moisture.
- Rainfall data input by the user for the stand-alone version of *How often?*.

Outputs:

- A graph showing plant-available soil water for the current year and all other years and a table summarising the recent fallow water balance.
- A graph showing nitrate accumulation for the current year and all other years.

48 Australian CliMate, Commonwealth of Australia, http://www.australianclimate.net.au

49 J Sabburg, G Allen (2013) Seasonal climate outlook improvements changes from historical to real time data. GRDC Update Papers 18 July 2013, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Seasonal-climate-outlook-improvements-changes-from-historical-to-real-time-data

FEEDBACK

MORE INFORMATION

For more information visit:
http://www.australianclimate.net.au/About/HowWetN

MORE INFORMATION

Water use efficiency, southern/western regions GRDC Fact Sheet
http://www.grdc.com.au/GRDC-FS-WaterUseEfficiencySouthWest

Reliability How wet?

uses standard water-balance algorithms from *How leaky?* and a simplified nitrate mineralisation based on the original version of *How wet?* Further calibration is needed before accepting with confidence absolute value estimates.

Soil descriptions are based on generic soil types with standard organic carbon (C) and C:N ratios, and as such should be regarded as indicative only and best used as a measure of relative water accumulation and nitrate mineralisation.[50]

2.5.3 Water use efficiency

Water use efficiency (WUE) is the measure of a cropping system's capacity to convert water into plant biomass or grain. It includes both the use of water stored in the soil and rainfall during the growing season. It relies on:

- the soil's ability to capture and store water;
- the crop's ability to access water stored in the soil and rainfall during the season;
- the crop's ability to convert water into biomass; and
- the crop's ability to convert biomass into grain (harvest index).[51]

2.5.4 Setting target yields

French–Schultz model

Rainfall is the main driver of potential yield in the dryland cropping environment of Australia.

A simple model to estimate water-limited potential yield was developed by scientists French and Schultz in South Australian for cereals, and is widely used in Australia.

The model is:

Potential yield (kg/ha) = (crop water supply (mm) – 110 mm) x 20 kg/ha/mm[52]

The 110 mm is the estimated soil evaporation and 20 kg/ha/mm is the potential water use efficiency for wheat. Crop water supply (mm) in the medium and low-rainfall zones of the southern region is growing-season rainfall plus stored moisture.

For pulses and canola, the typical parameters used are 15 kg/ha/mm for WUE and 130 mm for soil evaporation. Of note, for pulses this could now be less than the original 130 mm given that modern stubble-retention systems retain more soil moisture.[53]

50 Australian CliMate: HowWet/N? http://www.australianclimate.net.au/About/HowWetN

51 GRDC (2009) Water Use Efficiency Fact Sheet, Southern and Western Regions, https://grdc.com.au/Resources/Factsheets/2010/02/Water-Use-Efficiency-SouthWest

52 R French, J Schultz (1984) Water use efficiency of wheat in a Mediterranean-type environment. Part I: The relation between yield, water use and climate. Australian Journal of Agricultural Research, 35, 743–764

53 W Hawthorne. pers. comm.

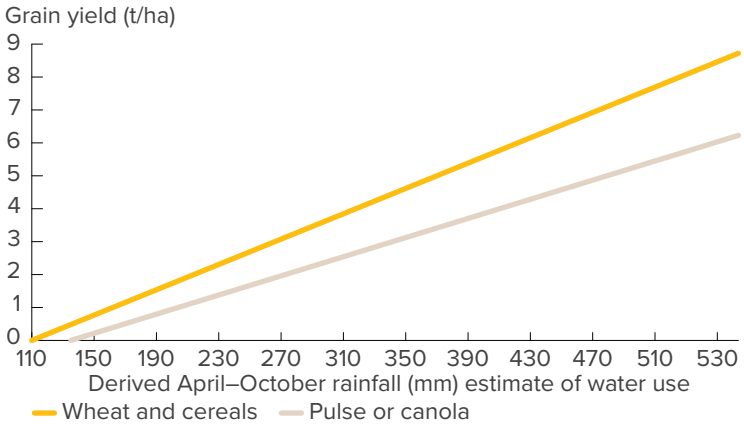


Figure 2: *Relationship of grain yield (t/ha) to estimated water use April–October. Pulses, 15 kg/ha/mm water available over 130 mm; cereals, 20 kg/ha/mm available over 110 mm.*

Source: J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook from French and Schultz model. https://grdc.com.au/resources-and-publications/all-publications/publications/2008/03/2008-grains-legume-handbook

In practice, growers typically use a variation of the French–Schultz method, such as:

Potential yield (kg/ha) = (available rainfall* – 110 mm) x WUE*****

where

*available rainfall = GSR + 25% summer rainfall

** or 60 mm evaporation for stubble-retained systems
*** WUE = 15 kg/ha/mm

While the French and Schultz model can be used to determine an upper limit of water-limited potential yield, it often overestimates actual yield as it does not account for rainfall distribution, runoff, drainage, or stored soil water.[54]

The different pulses and their systems do differ though in their water-limited yield potential (see Figure 3). Faba bean has the highest yield potential of the pulses at high-yielding locations, whereas field pea has the highest yield potential at low-yielding, water-restricted locations. Newer, earlier-maturing varieties of field pea and lentil will have improved yielding ability in lower-rainfall sites[55].

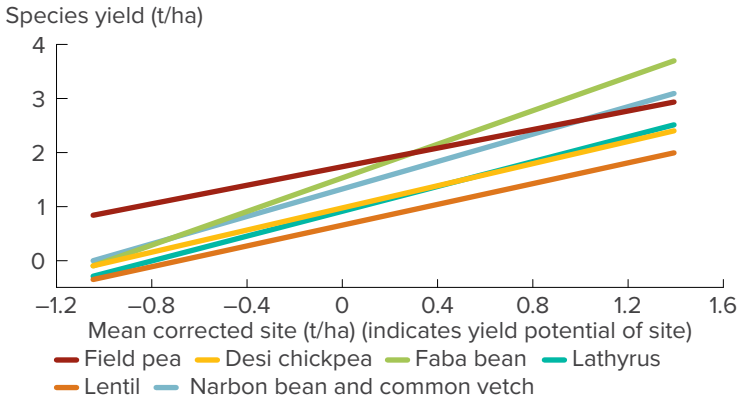


Figure 3: *Variation in grain yield of different grain legume species across sites with different yield potential in Western Australia.*

Source: K. Siddique (2016)

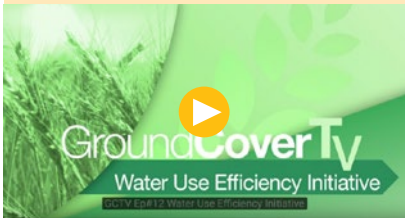
54 Y Oliver, M Robertson, P Stone, A Whitbread (2009) Improving estimates of water-limited yield of wheat by accounting for soil type and within-season rainfall. Crop & Pasture Science, 2009, 60, 1137–1146, www.publish.csiro.au/CP/pdf/CP09122

55 W Hawthorne. pers. comm.

FEEDBACK

VIDEO

Watch GCTV 12: Water Use Efficiency Initiative
https://youtu.be/a6QbVs7g3B4



VIDEO

Over the Fence South: Summer weed control saves moisture for winter crops
https://youtu.be/97gRnGHP2hM

VIDEO

Watch GCTV 10: Grazing Stubbles and Water Use Efficiency
https://youtu.be/GCn7M45gh5k

APSIM

Sophisticated crop-simulation models such as APSIM (and its commercial interfaces Yield Prophet® and WhopperCropper®) can combine detailed data about soil water-holding capacity, soil moisture at sowing, long-term climate data, weather data, potential crop responses to available moisture and additional inputs in order to estimate potential yield.[56]

2.6 Fallow weed control

Summer weed control stands out as the most effective way to conserve summer rain and soil nitrogen for use by subsequent crops.

Does summer weed control pay?

Trials in the southern and western regions have shown that summer weed control helps conserve soil moisture and/or soil nitrogen, to boost yields in subsequent crops. Economic returns varied but generally the return on investment in herbicides and their application can be positive. In high-rainfall areas or where less summer rainfall is received, the nitrogen benefit can outweigh improved soil moisture conservation.

More than 3–4 t/ha of stubble cover is required to significantly reduce evaporation of moisture from the topsoil. Trials have found that crops producing higher stubble loads have taken more water from the soil, so that by sowing time the balance of used and lost soil water is the same. Retaining stubble does increase infiltration, protect the soil from erosion and slow evaporation of early-sown crops.[57]

Can I control summer weeds with cultivation and conserve soil moisture?

Controlling summer weeds either with herbicides or cultivation has produced similar results in the trials in south-eastern Australia. However, cultivation may leave the soil surface more vulnerable to erosion. If, prior to cultivation, the surface is smooth and has poor stubble cover, cultivation makes the surface rougher and provides some erosion protection.[58]

2.6.1 Double-knock strategies

Double-knock refers to the sequential application of two different weed-control tactics applied in such a way that the second tactic controls any survivors of the first. Most commonly used for pre-sowing weed control, this method can also be applied in-crop.[59]

Double-knock herbicide strategies are useful tools for managing difficult-to-control weeds, including herbicide-resistant ryegrass, but there is no ‘one size fits all’ treatment.

The interval between double-knock applications is a major management issue. Shorter intervals can be consistently used for weeds where herbicides appear to be translocated rapidly (e.g. in grasses) or when growing conditions are very favourable. Longer intervals are needed for weeds where translocation appears slower (e.g. in fleabane, feathertop Rhodes grass and windmill grass).

56 GRDC (2009) Water Use Efficiency Fact Sheet, Southern and Western regions, https://grdc.com.au/Resources/Factsheets/2010/02/Water-Use-Efficiency-SouthWest

57 GRDC (2012) Making summer weed control a priority Southern Region: Summer Fallow Management Fact sheet. GRDC, https://grdc.com.au/__data/assets/pdf_file/0028/98632/summer-fallow-weed-management-manual.pdf.pdf

58 GRDC (2012) Making summer weed control a priority Southern Region: Summer Fallow Management Fact sheet. GRDC, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/winter-crops/general-information/pre-emergent-herbicides

59 C Borger, V Stewart, A Storrie. Herbicides: knockdown herbicides for fallow and pre-sowing control. Department of Agriculture and Food, Western Australia, https://agric.wa.gov.au/n/59

FEEDBACK

VIDEO

Watch IWM: Double Knock Applications – Double Knock Strategies for Resistant Weed Populations
https://youtu.be/bL0sbdQAYK0

VIDEO

IWM: Double Knock Applications – a Grower's Experience
https://youtu.be/pElEGsQDzBg

VIDEO

Glyphosate-resistant weeds
https://youtu.be/Ke8klYNQzl8

Critical factors for successful double-knock approaches are for the first application to be on small weeds, and to ensure good coverage and adequate water volumes, particularly when using products containing paraquat. Double-knock strategies are not fail-proof and are rarely effective for salvage weed-control situations unless environmental conditions are exceptionally favourable.

2.7 Fallow chemical plant-back periods

Plant-back periods are the obligatory times between the herbicide spraying date and safe planting date of a subsequent crop. Some herbicides have a long residual. The residual is not the same as the half-life. Although the amount of chemical in the soil may break down rapidly to half the original amount, what remains that can still cause crop damage can persist for long periods. This is the case with sulfonylureas (SUs, e.g. chlorsulfuron).

Residual persistence and the half-life of common herbicides are shown in Table 6. Herbicides with long residuals can affect subsequent crops, especially if they are effective at low levels of active ingredient, such as the SUs. On labels this will be shown by plant-back periods, which are usually listed under a separate plant-back heading or under the heading 'Protection of crops, etc.' in the 'General Instructions' section of the label.[60]

60 B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/winter-crops/general-information/pre-emergent-herbicides

FEEDBACK

Table 6: Half-life of common pre-emergent herbicides and residual persistence from broadacre trials and paddock experiences.[61]

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 Longran®
Diuron	90 (range: 1 month–1 year, depending on rate)	High. Weed control will drop off within 6 weeks, depending on rate. Long-lasting activity observes on grass weeds such as black/stink grass (*Eragrostis* spp.) and to a lesser extent broadleaf weeds such as fleabane
Atrazine	60–100; up to 1 year if dry	High. Long-lasting (>3 months) activity observed on broadleaf weeds such as fleabane
Simazine	60 (range: 28–149)	Medium/high. 1 year of residual in high-pH soils. Long-lasting (> 3 months) activity observed on broadleaf weeds such as fleabane and sow thistle.
Terbyne® X (terbuthlazine)	6.5–139	High. Long-lasting (>6 months) activity observed on broadleaf weeds such as fleabane and sow thistle.
Triflur® (trifluralin)	57–126	High. 6–8 months residual. Higher rates longer. Long-lasting activity observed on grass weeds such as black/stink grass
Stomp® (pendimethalin)	40	Medium. 3–4 months of residual.
Avadex® Xtra (triallate)	56–77	Medium. 3–4 months of residual.
Balance® (isoxaflutole)	1.3 (metabolite: 11.5)	High. Reactivates after each rainfall event. Long-lasting (>6 months) activity observed on broadleaf weeds such as fleabane and sow thistle.
Boxer Gold® (prosulfocarb)	12–49	Medium. Typically quicker to break down than trifluralin, but tends to reactivate after each rainfall event.
Sakura® (pyrozasulfone)	10–35	High. Typically quicker breakdown than trifluralin and Boxer Gold®; hoever, weed control persists longer than Boxer Gold®.
Ally® (metsulfuron-methyl)	30 (range: 14–180)	Persists longer in high-pH soils and after a dry year.

Source: CDS Tomlinson (ed) (2009) via B Haskins (2012)[60]

2.7.1 Herbicide residues in the soil

Pulse growers need to be aware of possible herbicide residues that may affect crop rotation choices or cause crop damage. Herbicide residue impacts are more pressing where rainfall has been minimal and in many cases where the soil type is heavier. After a dry season, herbicide residues from previous crops could influence choice of crop and rotations more than disease considerations. The opposite occurs after a wet year.

Weed burden in the new crop will depend on the seedset from last year and residual herbicide efficacy. Pulse crop types differ in their sensitivity to residual herbicides, so check each herbicide used against each pulse type.

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. Here 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. Photo 6 shows an affected field pea plant. Lentil is

61 CDS Tomlinson (ed) (2009) The pesticide manual. 15th edn. British Crop Protection Council, Farnham, UK. Extoxnet: http://extoxnet.orst.edu/. California Dept Pesticide Regulation Environmental Fate Reviews, http://www.cdpr.ca.gov/

FEEDBACK

among the most sensitive pulses to chlorsulfuron residues in soil and faba bean is one of the least sensitive. Faba bean and vetch are more sensitive than other pulses to Logran® than to Glean® residues.

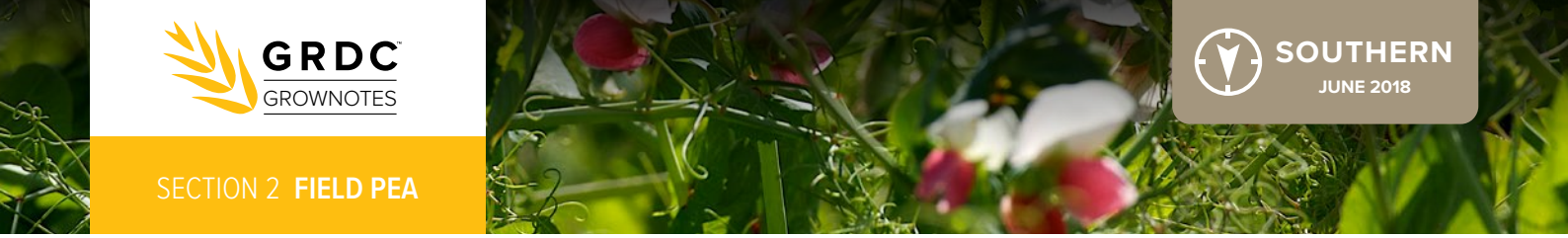
Refer to the labels for recommendations on plant-back periods for pulses following use of any herbicides. See Section 7.8 Herbicide residues.

Photo 6: *(Left) field pea plant affected by sulfonylurea (chlosulfuron) damage, stunted with reduced root system, and (right) a healthy field pea plant .*

Photo: DPIRD (2015) https://agric.wa.gov.au/n/4467

Sulfonylurea breakdown occurs by hydrolysis and is favoured by warm, moist conditions in neutral to acid soils. 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.

Picloram (e.g. Tordon® 75-D) residues from spot-spraying can stunt any pulse crop grown in that area. This damage is especially marked in faba bean, where plants are twisted and leaves shrunken. In more severe cases, bare areas are left in the crop where this herbicide had been used, in some instances more than 5 years ago. This



FEEDBACK

damage is usually over a small area or patches in the paddock that can relate either to soil type or spray patterns from the year before.[62] [63]

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

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.[64]

MORE INFORMATION

For more information on diseases see Section 9 Diseases and Section 10 Pre-harvest treatments

2.8 Reducing disease risk

Disease risk can be greatly reduced by making some informed management decisions around paddock and seed selection.

Paddock selection

Selecting the paddock with the lowest disease risk:

1. Paddock history

Determine the time since the last crop of the same species was planted. Spores of several fungal pathogens can survive in the soil for many years. These include those that cause black spot in field pea. Leave at least 4 years between pulse crops to allow fungal spore numbers to decline.

2. Paddock position

Avoid sowing this year's crop in a paddock adjacent to last year's pulse. Fungal spores can be carried into adjacent paddocks on infected trash and dust, even if a pulse has never been grown in the paddock 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 pea, the previous year as spores will travel on the prevailing winds. Spores of some pathogens can also be carried on pea residues in water; therefore, floodwater can be a source of the contaminant.

3. Soil structure

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.

4. Stubble retention

Cereal stubble should be retained when sowing pulses. Stubble presence reduces rain splash of soil-borne spores onto plant foliage, and so helps to reduce foliar disease and its spread.

In field pea, cereal straw acts as a trellis allowing plants to grow up off the ground, reducing disease and soil contamination of the seed sample.

The straw layer helps conserve soil moisture by acting as a mulch for all pulses.

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

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

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

FEEDBACK

Seed management

High quality seed is the first step towards a successful crop and to minimise disease risk.

1. Consider testing seed for disease – bacterial blight in field pea, Cucumber mosaic virus (CMV) in lupin, Ascochyta blight in chickpea and Ascochyta in faba bean are all seed-borne.
2. Grading removes small, damaged seeds from the seed lot. These seeds often produce poor seedlings, which die from pathogen attack first. Grading also removes sclerotes (fruiting bodies of the fungus that causes Sclerotinia), which would otherwise be sown with the seed.
3. Treat seed with fungicide prior to sowing. Seedlings will be protected from a number of fungal pathogens for the first 4–6 weeks after sowing. Seed treatment used with stubble retention greatly reduces blackspot infection in field pea.[65]

Black spot (also known as Ascochyta blight of field pea) is the most common and often most damaging foliar disease of field pea. The disease is caused by a complex of four fungi, which between them can survive on seed, stubble and in soil (see Section 9 Diseases and Section 10 Pre-harvest treatments). Management options include crop rotation, paddock selection, sowing time (avoidance of ascospore showers early in the season from old stubble), fungicide seed dressing and foliar fungicides.[66]

2.8.1 Soil testing for disease

PreDicta® B (B = broadacre) is a DNA-based soil-testing service for identifying which soil-borne pathogens pose a significant risk to broadacre crops prior to seeding.

It has been developed for cropping regions in southern Australia and includes tests for:

- Cereal cyst nematode CCN (*Heterodera avenae*)
- Take-all (caused by *Gaeumannomyces graminis* var. *tritici (Ggt)* and *G. graminis* var. *avenae (Gga))*
- Rhizoctonia bare patch (caused by *Rhizoctonia solani* AG8)
- RLN (*Pratylenchus neglectus* and *P. thornei*)
- Crown rot (caused by *Fusarium pseudograminearum* and *F. culmorum*)
- Stem nematode (*Ditylenchus dipsaci*)
- Blackspot of peas (*Mycosphaerella pinodes, Phoma medicaginis* var. *pinodella* and *Phoma koolunga*).

Grain producers can access PreDicta® B sampling kits from accredited agronomists and from Primary Industries and Regions SA/the South Australian Research and Development Institute. Samples are processed weekly from February to mid-May (prior to crops being sown) to assist with planning the cropping program.

In some cases, PreDicta® B can be used for in-crop diagnosis, although in most cases this is best achieved by sending samples of affected plants to your local plant pathology laboratory.

2.8.2 Cropping history effects

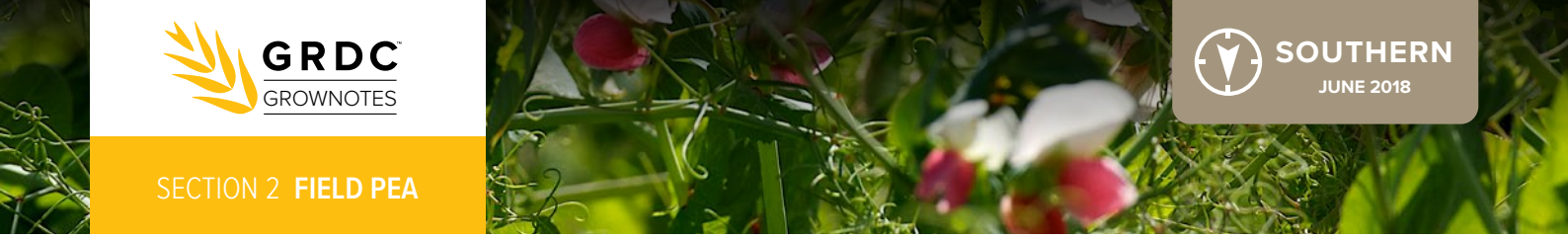
The general rule of thumb is to have a 4-year interval between pulse crops, regardless of the pulse species. Many of the pulse diseases, such as Sclerotinia, are not host-specific and will infect a wide range of pulse species as well as canola. Ideally, do not plant a pulse crop adjacent to a previous year's pulse paddock.

MORE INFORMATION

For more information on PreDicta® B visit:
http://pir.sa.gov.au/research/services/molecular_diagnostics/predicta_b

65 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

66 K Lindbeck (2016) Pulse disease the watch outs for 2016. GRDC Update Papers 16 February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Pulse-diseases-the-watch-outs-for-2016



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2.8.3 Nematode status of paddock

It is important to have paddocks diagnosed for plant parasitic nematodes so that optimal management strategies can be implemented. Testing will tell:

- if nematodes are present in paddocks and at what density; and
- what species are present.

It is important to know what species are present because some crop-management options are species-specific. If a particular species is present in high numbers, it is important to make immediate decisions to avoid losses in the next crop to be grown. With low numbers it is important to take decisions to safeguard future crops. Learning that a paddock has low nematode numbers is valuable information because it may be possible to take steps and avoid future contamination of that field.[67]

Testing both soil samples taken before a crop is sown or while the crop is in the ground provides valuable information.

2.8.4 Effects of cropping history on nematode status

Root-lesion nematode (RLN) numbers build up steadily under susceptible crops and cause decreasing yields over several years. The amount of damage caused will depend on:

- the numbers of nematodes in the soil at sowing (Table 7);
- the tolerance of the variety of the crop being grown (Table 8);
- the environmental conditions; and
- in-season management decisions.

See Table 9 for a summary of the disease risk interactions pertaining to *Pratylenchus* species.

Table 7: Yield loss risk categories – southern region.

Risk rating*	*Pratylenchus thornei*/g soil	*Pratylenchus neglectus*/g soil	% Yield loss
Below detection	<1	<1	<2
Low	1–20	1–20	0–10
Medium	20–60	20–60	5–20
High	>60	>60	10–40

* Use risk categories as a guide only, seasonal condition and variety tolerance influence yield loss.

Source: A McKay, D Roget, R J Hannam, K Ophel Keller (2015) Root Disease, Risk Management, Resource Manual, SARDI, Version 7.2

Yield losses caused by RLN are correlated with the population of these nematodes present in the soil at sowing, the tolerance of the wheat variety and the date of sowing. The root-lesion nematodes *Pratylenchus neglectus* and *P. thornei* are common in broadacre field crops of southern Australia and can cause damage of up to 40% if populations are high and intolerant varieties are sown late, but most losses are less than 15%.[68]

A tolerant crop yields well when high populations of RLN are present (the inverse is intolerance). A resistant crop does not allow RLN to reproduce and increase in number (the opposite is susceptibility).

The main means of controlling nematodes is growing resistant crops. In the case of susceptible crops, such as wheat or chickpea, choose the most tolerant variety available and rotate with resistant crops like field pea to keep nematode numbers at low levels. Information on the responses of crop varieties to RLN is regularly updated

67 Queensland Primary Industries and Fisheries (2009) Root lesion nematodes: management of root-lesion nematodes in the northern grain region. Queensland Government, https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

68 A McKay, D Roget, R J Hannam, K Ophel Keller (2015) Root Disease, Risk Management, Resource Manual, SARDI, Version 7.2

FEEDBACK

in grower planting guides. Note that crops and varieties have different levels of tolerance and resistance to *P. thornei* and *P. neglectus* (Table 8).[69]

For more detail see Section 3 Table 3 Disease resistance characteristics of field pea varieties..

Table 8: Susceptibility and resistance of various crops to root-lesion nematodes.[70]

RLN species	Susceptible	Intermediate	Resistant
P. thornei	Wheat, chickpea, faba bean, barley, mungbean, navy bean, soybean, cowpea	Canola, mustard, triticale, durum wheat, maize, sunflower	Canary seed, linseed, oats, sorghum, millet, cotton, field pea
P. neglectus	Wheat, canola, chickpea, mustard, sorghum (grain), sorghum (forage)	Barley, oat, canary seed, durum wheat, maize, navy bean	Linseed, field pea, faba bean, triticale, mungbean, soybean

Source: K Owen *et al.* (2013)

Table 9: Summary of disease risk interactions – Pratylenchus species.[71]

Lower		Higher
Early break Good growing season rainfall Soft finish to season	**Environment**	Late break, cold soil Light soils, low fertillity Low rainfall year Hard finish to season
Early sowing Adequate nutrition Good summer/autumn weed control Break with non-host crop/ pastures	**Management**	High frequency of susceptible crops Poor control of summer/ autumn weed Inadequate fertilister
Tolerant crop to reduce yield loss Resistance to reduce multiplication	**Crop variety**	Intolerant crop varieties Susceptible crops and varieties increase populations
Below detection – low	**Pathogen level**	High High level of other soil/ stubble-borne pathogens

Source: A McKay, D Roget, R J Hannam, K Ophel Keller (2015) Root Disease, Risk Management, Resource Manual, SARDI, Version 7.2

For more information, download GRDC Tips and Tactics Root-lesion nematodes and see Section 9.19 Root-lesion nematodes (RLN) (*Pratylenchus neglectus* and *P. thornei*)

2.9 Pest status of paddock

2.9.1 Insect sampling of soil

Soil-dwelling insect pests can seriously reduce plant establishment, early growth and subsequent yield potential. Soil insects are often difficult to detect as they hide under trash or in the soil. Immature insects such as false wireworm larvae are usually found at the moist/dry soil interface.

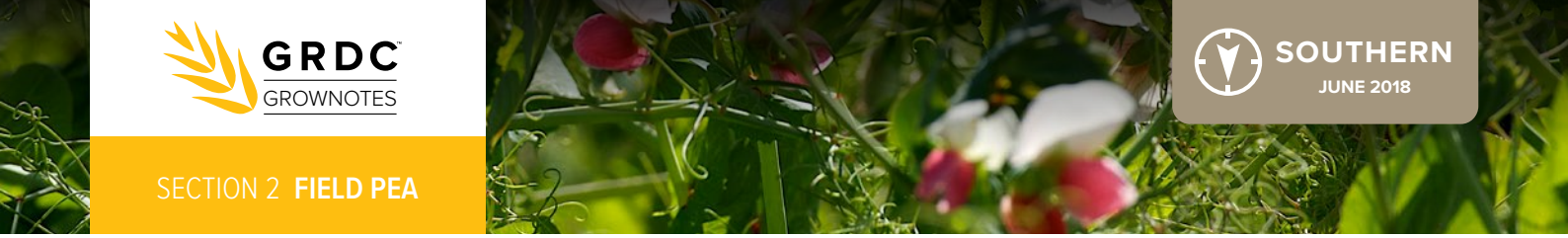
Soil insects include:

- **black field cricket**, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/black-field-cricket

69 K Owen, T Clewett, J Thompson (2013) Summer crop decisions and root-lesion nematodes. GRDC Update Papers, https://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

70 K Owen, J Sheedy, N Seymour (2013) Root lesion nematode in Queensland. Soil Quality Pty Ltd Fact Sheet, http://www.soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

71 A McKay, D Roget, R J Hannam, K Ophel Keller (2015) Root Disease, Risk Management, Resource Manual, SARDI, Version 7.2



FEEDBACK

- **black scarab beetles**, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/black-sunflower-scarab
- **cut worm**, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Cutworm
- **slaters**, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/slaters
- **false wireworms and true wireworms**, http://www.cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/past-issues/2011/pestfacts-issue-no-4-10th-june-2011/false-wireworms-and-true-wireworms/

Different soil insects occur under different cultivation systems and farm management can directly influence the type and number of these pests:

- Weedy fallows and volunteer crops encourage soil insect build-up.
- Insect numbers decline during a clean long fallow due to lack of food.
- High stubble levels on the soil surface can promote some soil insects due to a food source, but this can also mean that pests continue feeding on the stubble instead of germinating crops.
- Zero-tillage encourages beneficial predatory insects and earthworms.
- Incorporating stubble promotes black field earwig populations.
- False wireworms are found under all intensities of cultivation but decline if stubble levels are very low.

Soil insect control measures are normally applied at sowing. Since different insects require different control measures, the species of soil insects must be identified before planting. Methods used to detect soil insects present include using a spade – which can be laborious, time-consuming and difficult in heavy clay or wet soil – or using a seed bait technique.

2.9.2 Key pests of field pea

The key pests of field pea in southern Australia are native budworm (*Helicoverpa punctigera*), pea weevil (*Bruchus pisorum*), snail, slugs, aphids, mites, lucerne flea and lucerne seed web moth (*Etiella behrii*). (See Section 8 Pest management.) Table 10 shows the timing of damaging effects of the key and other pests in field pea crops.

FEEDBACK

Table 10: Incidence of insect pests in field pea.

	Crop stage				
	Emergence/ Seedling	Vegetative	Flowering	Podding	Grain fill
Earth mites	Damaging	Present	Present		
Lucerne flea	Damaging	Present			
Cutworms	Damaging				
Slugs and snails*	Damaging	Damaging			
Aphids	Damaging	Damaging	Present	Present	
Thrips		Present	Present		
Pea weevil		Present	Damaging	Damaging	Damaging
Helicoverpa		Present	Damaging	Damaging	Damaging
Etiella		Present	Present	Damaging	Damaging

Present = Present in crop but generally not damaging Damaging = Crop susceptible to damage and loss
Source: NIPI & field pea IPM, http://ipmguidelinesforgrains.com.au/crops/winter-pulses/field-peas/

MORE INFORMATION

For more information, see Section 8.3 Key pests of field pea