TIPS & TACTICS

NITROGEN FIXATION IN FIELD PEA

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Good inoculation and agronomy practices are crucial for optimising nitrogen fixation and reaping the benefits.

Pulses such as field pea, faba bean and lentil are an integral part of cropping systems in the Southern Region. Over 300,000 hectares of field pea crops are grown in Australia. In South Australia (SA) and Victoria, field pea (Photo 1) accounts for 40% of all pulses grown (GRDC 2017).

They can be profitable in their own right as well as providing critical disease and weed breaks.

Importantly, field peas provide an abundant, inexpensive and sustainable source of nitrogen (N) into the farm system through biological N fixation.

Good N fixation is important for the productivity of the pulse crop and to maximise the N benefit for cereal and oilseed crops in following rotations.

Approximately 22 kg/ha N can be fixed for each tonne of above-ground dry matter produced (shoot only, not root contributions). Effective inoculation and good agronomy are crucial to achieving this.

What is nitrogen fixation?

Biological (also known as 'symbiotic') N fixation is the mutually beneficial relationship between the pulse host and rhizobia bacteria. These bacteria colonise and infect the roots, after the seed germinates,

Photo 1: PBA Ouraⓓ field pea in flower. Source: Liz Farquharson, PIRSA-SARDI.

to form root nodules within 4–10 weeks.

The bacteria are dependent on the host plant for water, nutrients and energy, but in return supply the plant with N (ammonium, NH_4^+). This 'fixed' N is derived from the earth's atmosphere, which is around 80% N.

Nitrogen fixation by pulse crops does not happen as a matter of course. Compatible, effective rhizobia must be in the soil where the legume is growing before nodules can form and fix N.

When a pulse is grown for the first time in a soil, it is highly likely that compatible, effective rhizobia will not be present. In these circumstances, high concentrations of rhizobia must be supplied using inoculants.

KEY POINTS

- Field pea crops are often profitable in their own right as well as providing valuable benefits to the cropping system including nitrogen (N) through fixation by root nodule bacteria (rhizobia).
- To ensure a field pea crop yields well and provides N to following crop rotations, roots need to have adequate numbers of active nodules.
- Nodules can form from soil rhizobia or through inoculation: field pea will be most responsive to inoculation if it (or faba bean, lentil and vetch) has not previously been grown in the paddock or the soil is acidic (below pH_{Ca} 6.0).
- Aim for 50 to 100 pink nodules per plant after approximately 10 weeks' plant growth as an adequate level of nodulation.
- Optimise dry matter production of the pulse crop to drive N demand and encourage N fixation.
- Some pea cultivars contribute more fixed N to the following crops than others.
- Recent research showed that fixed N remaining in the stubble and roots ranged from 71 to 127 kg/ha between cultivars.

Management strategy 1: Inoculation

When to inoculate field pea

Field pea will be most responsive to inoculation when:

- It or faba bean, lentil, vetch has not previously been grown in the paddock
- It is grown on acidic soils. The rhizobia that nodulate pea (and also faba bean and lentil) are moderately sensitive to soil acidity. Pea rhizobia may be absent or their number may be insufficient where soil pH (measured in Ca) is less than 6.0, even where there has been recent history of legumes that support pea rhizobia (Figure 1).

Doubling the rate of inoculant applied at sowing has proven beneficial to nodulation between 4.5 pH and 5.0. Liming the soil is recommended to increase the pH to 5.0.

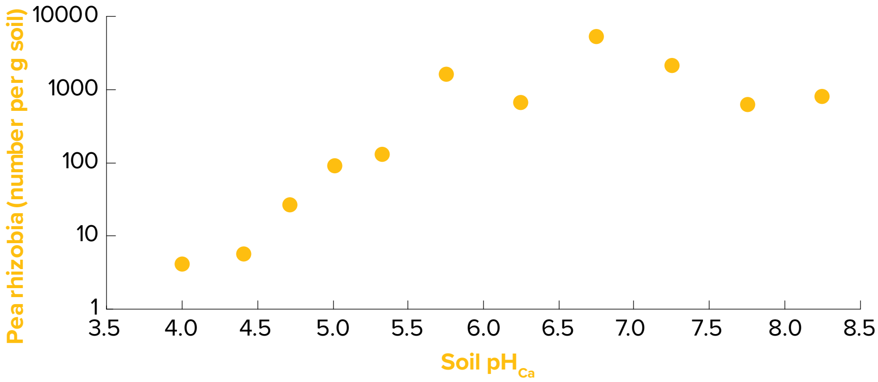

Figure 1: Relationship between soil pH (0–10 cm, 0.01 M Ca) and the number of nodulating rhizobia persisting in the soil. Source: adapted from Drew et al. 2012.

Table 1: Likelihood of response of field pea to inoculation.

Likelihood of response to inoculation for sown field pea, faba bean, lentil and vetch	
High	• soils with pH(Ca) below 6.0 and high summer soil temperatures (>35°C for 40 days) AND/OR • legume host (pea, faba bean, lentil, vetch) not previously grown.
Moderate	• no legume host (pea, faba bean, lentil, vetch) in previous 4 years (recommended pulse rotation) OR • prior host crop not inoculated or lacked good nodulation.
Low	• loam or clay soils with neutral or alkaline pH AND • well-nodulated pea (or faba bean, lentil and vetch) grown in the preceding five years.

Source: Adapted from Drew et al. 2012.

Which inoculant to use

Field pea (as well as faba bean, lentil and vetch) is nodulated by *Rhizobium leguminosarum* bv. *viciae*.

This species of rhizobia is produced and sold commercially in two strains, as inoculant groups E and F (Table 2). Group E inoculant is preferred for field pea, but group F can be used in its place as it is only marginally less effective at fixing N (Drew et al. 2012).

Table 2: Rhizobia strains and inoculant groups.

Crop	Strain and inoculant group
Field pea and vetch	Strain: SU303 (group E)
Faba bean and lentil	Strain: WSM1455 (group F)

Source: Drew et al. 2012.

How much nodulation is enough?

A general rule of thumb is that 70% or more of plants should have a nodulation score of ‘adequate’.

An adequate number of nodules for a field pea plant is 50–100 nodules after approximately 10 weeks’ growth (Photo 2, Figure 2).

Below 50 nodules per plant there is a much greater chance that N fixation will be below the optimal benchmark of 22 kg fixed per t above-ground dry matter produced (i.e. shoots only, not roots). Early in the season (10 weeks) nodules should be pink in colour, which indicates the rhizobia are actively fixing N for use by the plant. Yellow or brown nodules are not actively fixing N.

Read more about doing ‘nod checks’ in the Tips & Tactics fact sheet: Legumes and Nitrogen fixation.

WHAT TO WATCH OUT FOR

- Many nodulation failures have been associated with improperly applying inoculant.
- Avoid mixing inoculants with fungicides, insecticides and fertilisers where possible.
- If seed is to be treated with a fungicide, carry this out first and then apply the inoculant separately, immediately prior to planting. Another option is to use a granular inoculant and separate the chemical treatment from the rhizobia inoculant.

Photo 2: Well-nodulated roots of field pea showing active pink nodules. Source: Liz Farquharson, PIRSA-SARDI.

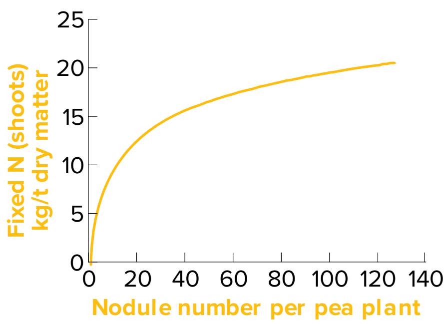

Figure 2: Relationship between nodule number per pea plant and the amount of fixed N/t pea (above-ground dry matter).

Management strategy 2: Agronomy practices

Choose the right cultivar

While N fixation can vary considerably across sites and seasons, irrespective of this, some cultivars consistently outperform others. Field trials across several seasons have shown variation between pea cultivars in the amount of total N they fix and leave behind in the stubble after grain harvest (Table 3).

Lower harvest index varieties fix more N: Conventional tall pea varieties such as PBA PercyⓅ and PBA CoogeeⓅ fix more N per tonne of above-ground (shoot) dry matter and leave more behind in the stubble and roots, in part due to their lower harvest index (the ratio of harvested grain to total above-ground dry matter).

Some of the new semi-leafless, semi-dwarf varieties are highly productive in terms of yield, however, they tend to fix less total N and a greater proportion of that N is removed in the grain at harvest (Table 3, Photo 3).

Growers should first select a cultivar based on climate suitability, disease tolerance and end use requirements. Nitrogen contributions can then be considered.

Table 3: Measures of fixed N for different field pea cultivars (means of 7 field trials in project DAS00128).

Cultivar	Growth form*	Rating of N fixation	Fixed N kg/t above-ground dry matter (shoots)	Fixed N remaining (stubble and roots) kg/ha
PBA PercyⓅ	C-T	High	19	110
Parafield	C-T		18	107
PBA CoogeeⓅ	C-T		18	109
KaspaⓅ	SD-SL	Moderate	17	91
MorganⓅ	SL-T		17	99
PBA PearlⓅ	SD-SL		16	86
PBA HaymanⓅ	MB		16	127
PBA GunyahⓅ	SD-SL		16	79
PBA OuraⓅ	SD-SL		16	78
PBA TwilightⓅ	SD-SL	Low	15	76
PBA ButlerⓅ	SD-SL		15	71
PBA WhartonⓅ	SD-SL		15	84

* C=conventional, SL=semi-leafless, T=tall growth form, SD=semi-dwarf growth form, MB=multi-branch

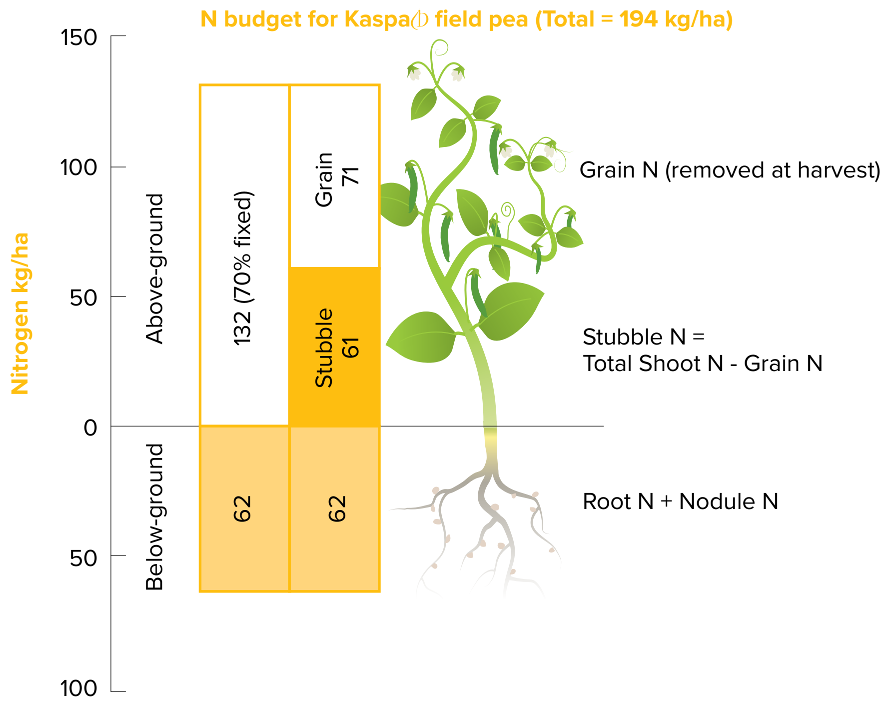

Figure 3: Distribution of N in field pea based on an average crop of KaspaⓅ.

Where is the N in a pea crop, and how much is left after harvest?

N is distributed above- and below-ground in different parts of the crop. Figure 3 expands an N budget for KaspaⓅ field pea:

- On average 70% of N comes from fixation.
- 40% of the total N is removed at harvest (71 kg in grain out of 194 kg/ha total below- and above-ground).
- Pea roots alone can be a significant contributor to N for the following crop as grain N is generally removed and stubbles sometimes grazed. After harvest roots contribute about half the remaining N.

Optimise crop biomass to maximise N fixation

A larger legume biomass will have a greater demand for N, generally resulting in more N fixation. Therefore, it is is important to manage time of sowing, crop nutrition and disease and weed pressures to optimise dry matter production.

High residual soil N, soil acidity and herbicide residues can reduce nodulation and subsequently the amounts of N fixed.

If soil N levels in the root zone are > 50kg/ha, fewer nodules will form and the plant will opt to take up the available N from the soil.

Residues from some herbicides, e.g. Group B, are known to damage the growth and development of roots and the ability of roots to form nodules and fix N. This is more often seen on alkaline soils where herbicides tend to persist. Growers should strictly adhere to herbicide labels and recommended legume plantback times.

Photo 3: Low harvest index forage variety PBA HaymanⓅ (left) and high harvest index, semi-dwarf variety KaspaⓅ (right). Source: Liz Farquharson, PIRSA-SARDI.

RESOURCES

E Farquharson, N Charman and R Ballard (2016) Optimising nitrogen fixation in southern farming systems. GRDC, 9 February 2016, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/optimising-nitrogen-fixation-in-southern-farming-systems.

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School of Agriculture, Food and Wine (2017) Useful Resources for Legume Growers. University of Adelaide, www.ua.edu.au/legume-inoculation.

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MORE INFORMATION

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GRDC PROJECT CODES

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FAQS

How can I be sure that the inoculant I'm considering is effective?

Inoculants that carry the 'Green Tick' logo (approved by the Australian Inoculants Research Group) meet minimum quality standards (purity and number of rhizobia per gram of product). It is recommended you choose inoculants displaying this 'Green Tick'.

When will the N from my pulse crop be available to the next crop?

Not all N fixed in a pulse crop will be available in the following year, rather it will gradually become available over the following three seasons.

Do legume roots contribute N to the soil?

Yes, roots and nodules will contribute around half of the crop N remaining after grain harvest.

Should I apply starter N?

Field pea crops may benefit from a small amount of N fertiliser applied at seeding, particularly where soil fertility is low and where nodulation may be restricted by late sowing, acid soils or waterlogging. Nitrogen should be not applied a rate greater than 5–10 kg/ha.

Higher rates of mineral N at sowing may reduce the number of nodules that form per plant and will reduce N fixation.

In field trials conducted by SARDI across SA and Victoria (between 2012–2014) applying 30 kg/ha of N (as Urea) at sowing reduced nodulation by 10% and N fixation by an average of 10 kg/ha.