



SOUTHERN JUNE 2018

FIELD PEA SECTION 6 NUTRITION AND FERTILISER

KEY POINTS | NUTRIENTS | DECLINING SOIL FERTILITY | CROP REMOVAL RATES AND BALANCING INPUTS | TESTING FOR BALANCED NUTRITION | NUTRIENT IMBALANCES | FERTILISER



Nutrition and fertiliser

Key points

- Fertilisers are a major cost of growing a crop. Fertiliser decisions are complex and individual growers may have different objectives but, regardless of circumstances, growers need to know what nutrients are in short supply and which are adequate.¹
- Under-fertilisation and over-fertilisation can lead to economic losses due to unrealised crop potential or wasted inputs.
- Understanding the nutrient status of a paddock is essential for optimum plant growth.
- Nutrients are removed as grain and need to be replaced to ensure adequate soil fertility for following crop yields.
- Each tonne of field pea grain removes 40 kg/ha of nitrogen, 4 kg/ha phosphorus, 8 kg/ha potassium, 2 kg/ha sulfur and 1 kg/ha magnesium.
 Field pea should not normally require nitrogen fertiliser, except for 'starter' nitrogen in soils with extremely low levels.
- Fertilisers must supply a balance of required nutrients for a crop to achieve its potential yield. Nutrient budgeting and soil and plant tissue tests are tools to help determine fertiliser needs.
- Microbial activity in the soil is also affected by soil pH, with most activity occurring in soils of pH 5.0 to 7.0.
- Soil pH affects the availability of nutrients and affects how the nutrients react with each other. At a low pH, beneficial elements such as Mo, P, Mg and Ca become less available to plants. Other elements such as AI, Fe and Mn may become more available and AI and Mn may reach levels that are toxic to plants.
- Micronutrient deficiencies and toxicities show specific symptoms in field pea.
- Fertiliser applied too close to the seed can be toxic. Acid fertilisers can also inhibit rhizobia activity and nodulation.



GRDC (2013) Better fertiliser decisions for crop nutrition. GRDC Crop Nutrition Fact Sheet November 2013, <u>http://www.grdc.com.au/</u> GRDC-FS-BFDCN



FEEDBACK



6.1 Nutrients

Plant nutrients are categorised as either macronutrients or micronutrients (also called trace elements).

Macronutrients are those elements that are needed in relatively large amounts. They include nitrogen (N), phosphorus (P) and potassium (K), which are the primary macronutrients, with calcium (Ca), magnesium (Mg) and sulfur (S) considered as secondary. Higher expected yields of crops for grain or forage will place greater demand on the availability of major nutrients such as P, K and S. Nitrogen, P and at times S are the main nutrients commonly lacking in Australian soils. Others can be lacking under certain conditions. Each pulse type is different, with different requirements for nutrients and may display different symptoms of deficiency.

Micronutrients are those elements that plants need in small amounts, for example iron (Fe), boron (B), manganese (Mn), zinc (Zn), copper (Cu), chlorine (Cl) and molybdenum (Mo).

Macro- and micronutrients are taken up by the roots and certain soil conditions are required for that to occur. Soil must be sufficiently moist to allow roots to take up and transport the nutrients. Plants that are moisture-stressed from either too little or too much moisture (saturation) can often exhibit deficiencies even though a soil test may show these nutrients to be adequate.

The optimum range of temperature, pH and moisture can vary for different pulse species. Soil pH has an effect on the availability of most nutrients and must be within a particular range for nutrients to be released from soil particles.

Soil temperature must be within a certain range for nutrient uptake to occur.²

6.1.1 Understanding soil pH

A soil pH (CaCl₂) of 5.2 to 8.0 provides optimum conditions for most agricultural plants. All plants are affected by the extremes of pH but there is wide variation in their tolerance of acidity and alkalinity. Some plants grow well over a wide pH range, while others are very sensitive to small variations in acidity or alkalinity. Figure 1 provides a guide to the preferred pH (CaCl₂) for some common crops and pastures.

Microbial activity in the soil is also affected by soil pH with most activity occurring in soils of pH 5.0 to 7.0. Where the extremities of acidity or alkalinity occur, various species of earthworms and nitrifying bacteria are fewer. Legume root colonising bacteria (rhizobia) vary in their sensitivity to soil pH and have preferred ranges in which they are effective. In some crops and pastures (e.g. faba bean and lucerne) the rhizobia specific to these plants are more sensitive than the plant itself.

Soil pH affects the availability of nutrients and affects how the nutrients react with each other. At a low pH, beneficial elements such as Mo, P, Mg and Ca become less available to plants. Other elements such as Al, Fe and Mn may become more available and Al and Mn may reach levels that are toxic to plants (Figure 1).³

Lime can be applied to increase low pH levels. The pH-mapping process can deliver immediate lime savings of 20–60%, with an average saving of 30%. A 10% lime saving is generally required to cover the cost of the mapping process.⁴ See more in the GRDC Update paper pH-mapping and variable rate lime: 50,000 plus hectares of experience (<u>https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/08/ph-mapping-and-variable-rate-lime-50000-plus-hectares-of-experience</u>).

- 4 A Whitlock (2015) pH mapping and variable rate lime. GRDC Update Papers, 27 August 2015, <u>https://grdc.com.au/Research-and-</u> Development/GRDC-Update-Papers/2015/08/pH-mapping-and-variable-rate-lime-50000-plus-hectares-of-experience



For more information on crop-specific reactions to soil pH, download the NSW Department of Primary Industries leaflet Understanding soil pH:

http://www.dpi.nsw.gov.au/__data/ assets/pdf_file/0003/167187/soil-ph. pdf



² J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, <u>https://grdc.com.au/</u> grainlegumehandbook





Soil pH in calcium chloride

This is the standard method of measuring soil pH in all states other than Queensland. An air-dry soil sample is mixed with five times its weight of a dilute concentration (0.01 M) of calcium chloride (CaCl₂), shaken for 1 hour and the pH is measured using an electrode. The results are usually expressed as pH (CaCl₂).

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Soil pH in water

Distilled water is used in place of 0.01 M calcium chloride and results are expressed as pH (w).

The pH (CaCl₂) test is the more accurate of the two pH tests, as it reflects what the plant experiences in the soil. The values of $pH(CaCl_2)$ are normally lower than pH (w) by 0.5 to 0.9. A useful, but not consistently accurate, conversion is to subtract 0.8 from the pH (w) value to obtain a pH (CaCl₂) value. The difference between the methods can be significant when interpreting results and it is important to know which method has been used, especially if pH figures derived some years apart are being compared to assess any pH fluctuations.











6.2 Declining soil fertility

The natural fertility of cropped agricultural soils is declining over time. Grain growers must continually review their management programs to ensure the long-term sustainability of high-quality grain production. Pasture leys, legume rotations, fertilisers and the farming systems employed, all play an important role in maintaining the chemical, biological and physical fertility of soils.

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Nutrition programs should be reviewed regularly due to more frequent opportunity cropping from improved farming techniques and new higher-yielding varieties. Paddock records, fertiliser test strips, crop monitoring, and soil and plant tissue tests all assist in the formulation of an efficient cropping program.

Although crop rotations with pulses and ley pastures play an important role in maintaining and improving soil fertility, fertilisers remain the major source of nutrients to replace those removed by grain production. Fertiliser programs must supply a balance of the required nutrients in amounts needed to achieve a crop's yield potential. High-yielding crops remove large amounts of nutrients in the grain.

The yield potential of a crop will be limited by any nutrient the soil cannot adequately supply. Poor crop response to one nutrient is often linked to a deficiency in another nutrient or management technique. Sometimes, poor crop response can also be linked to acidity, sodicity or salinity, pathogens or a problem with beneficial soil microorganisms.⁵

6.3 Crop removal rates and balancing inputs

Ultimately, nutrients removed from paddocks will need to be replaced to sustain production.

The nutrient removal per tonne (t) of field pea is shown in Table 1. Actual values may vary by 30%, or sometimes more, because of differences in soil fertility, varieties and seasons.

Table 1: Amounts of macro- and micro-nutrients removed per tonne of field pea.

	Major nutrients (kg)
Nitrogen (N)	40
Phosphorus (P)	3.9
Potassium (K)	8
Sulfur (S)	1.8
Calcium (Ca)	0.7
Magnesium (Mg)	0.9
	Minor nutrients (g)
Copper (Cu)	7
Zinc (Zn)	28
Manganese (Mn)	14

*Representative products of many for most chemicals

Source: GRDC (2009) Field Peas: The Ute Guide

From the table it can be seen that a 3 t/ha crop of field pea will remove, on average, 3×4 kg/ha = 12 kg/ha of phosphorus. To maintain long-term soil fertility this is the amount of phosphorus that needs to be replaced. Higher quantities may be needed to build up soil fertility or overcome soil fixation of phosphorus.

5 Queensland DAF (2010) Nutrition management: overview. Queensland Department of Agriculture and Fisheries, <u>https://www.daf.gld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/nutrition-management/overview</u>





Soil types do vary in their nutrient reserves. For example, most black and red soils in the eastern states have sufficient reserves of potassium to grow many crops. However, grain crops grown on the light, white sandy soils which have less than 50 ppm (Bicarb test) of potassium will respond to applications of potassium fertiliser.

Other soils may have substantial nutrient reserves which vary in availability during the growing season or are unavailable due to the soil's pH. This can often be the case with micro-nutrients. Foliar sprays may correct micro-nutrient deficiencies if timing is appropriate.⁶

6.4 Testing for balanced nutrition

To obtain the maximum benefit from every dollar spent, fertiliser programs must provide a balance of required nutrients. There is little point in applying enough N if P or Zn deficiency is limiting yield. To make better crop nutrition decisions, growers need to consider the use of paddock records, soil tests, plant tissue tests and paddock test strips.

6.4.1 Paddock records

Paddock records help:

- establish realistic target grain yield/protein levels prior to planting;
- modify target yield/protein levels based on previous crop performance, planting soil moisture, planting time, fallow conditions, expected in-crop seasonal conditions and grain quality requirements;
- determine appropriate fertiliser type, rate and application method; and
- compare expected with actual performance per paddock and modify fertiliser strategies to optimise future yield/protein levels.

6.4.2 Soil testing

Soil test results are part of the information that support decisions about fertiliser type, rate, timing and placement. Principal reasons for soil testing for nutrition include:

- monitoring soil fertility levels;
- estimating which nutrients are likely to limit yield;
- measuring properties such as pH, sodium (sodicity) and salinity, which affect the crop water demand as well as the ability to access nutrients;
- zoning paddocks for variable fertiliser application rates; and
- as a diagnostic tool, to identify reasons for poor plant performance.

Types of test

The soil test for measuring N, P, K or S in the southern region are:

- bicarbonate extractable P (Colwell-P)
- diffusive gradients in thin-films (DGT) for P
- bicarbonate extractable K (Colwell-K)
- KCI-40 extractable S
- 2 M KCI extractable inorganic N, which provides measurement of nitrate-N and ammonium-N.⁷

DGT-P is the preferred test for calcareous soils in southern Australia and western Victoria. $^{\rm 8}$

- 7 GRDC (2014) Soil testing for crop nutrition, southern region. GRDC Crop Nutrition Fact Sheet, January 2014 <u>http://www.grdc.com.au/</u> <u>GRDC-FS-SoilTestingS</u>
- 8 GRDC (2013) Better fertiliser decisions for crop nutrition. GRDC Crop Nutrition Fact Sheet, November 2013, <u>www.grdc.com.au/GRDC-FS-BFDCN</u>



⁶ J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, <u>https://grdc.com.au/grainlegumehandbook</u>



FEEDBACK

The more consideration we give to all of the activities that contribute to the nutrient management process (Figure 2), the better the outcome we will get from the soil and plant testing. Testing may not provide a useful contribution if one or more of these



Figure 2: Nutrient management flow chart.

Source: GRDC (2013) Better fertiliser decisions for crop nutrition. GRDC Crop Nutrition Fact Sheet, November 2013, <u>http://www.grdc.com.au/</u> GRDC-FS-BFDCN

Sampling depth

Soil sampling depth for most nutrient analyses is 0-10 cm. For N and S, which are highly mobile in the soil, 0-60 cm is recommended. There is increasing evidence of the value of assessing soil-based physicochemical constraints to production, including sodicity, salinity and acidity/aluminium, from both the surface and subsoil layers.

In some regions, evidence suggests that deep soil samples should be analysed for nutrients other than N. This is still not fully supported for the soils in the Southern Region. Deep sampling especially for S, EC and B to the depth of any root barriers is now carried out regularly.

To ensure that a sample is representative:

- Check that the soil type and plant growth is typical of the whole zone or paddock.
- Avoid areas such as stock camps, old fence lines and headlands.
- Ensure that each subsample is taken to the full sampling depth.
- Do not sample in very wet conditions or within 2 weeks after significant summer rain.
- Do not take shortcuts in sampling, such as taking only one or two cores, a handful, or a spadeful of soil, as this will give misleading results.
- Avoid contaminating the sample, the sampling equipment and the sample storage bag with fertilisers or other sources of nutrients (e.g. sunscreen, which can contain Zn).

Soils must be sampled to the correct depth. Sampling depths of 0–10 and 10–60 cm are generally used. The 0–10 cm sample should be used for a comprehensive soil test (all nutrients, cations, pH, EC, sodium). The 10–60 cm sample (or known rooting depth) is more commonly used to determine levels of N, S, EC and boron (or other nutrient constraints) and moisture. Sulfur testing at 0–10 cm is not as indicative of crop needs as 0–60 cm, and this is more so on sandy soils where leaching of S from the topsoil readily occurs. If subsoil constraints are suspected, pH, EC, sodium and chloride are tested at intervals (e.g. 30 cm) to 120 cm where possible.







Critical values and ranges

A soil-test critical value is the soil test value required to achieve 90% of crop yield potential (Figure 3).

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The critical range around the critical value indicates the reliability of that single value. The narrower the range the more reliable the data. See Table 2 for Colwell-P test for field pea.

The critical value indicates whether nutrient supply is likely to result in a crop yield response.

Table 2: Critical soil test values at 0–10cm sampling for 90% of relative yield.

Soil test	Сгор	Soil type*	Critical values (mg/kg)	Critical range (mg/kg)
Colwell-P**	Wheat and barley	Vertosol	17	12–25
		Chromosol/sodosol	22	17–28
		Brown/red chromosol	25	18–35
		Calcarosol	34	26–44
	Barley	Ferrosols	76	46–130
	Canola	All soils	18	16–19
	Field pea	All soils	24	21–28
Colwell-K	Wheat	Chromosols	40	35–45
		Brown ferrosols	64	57–70
		Kandosols	49	45–52
		Tenosols	41	32–52
	Canola	All soils	45	43–47
	Lupin	Tenosols (WA data)	24	22–27
KCI-40 S+	Wheat	Chromosols/ kandosols/sodosols/ tenosols/vertosols	4.5	3.2–6.4
	Canola	NSW data (0 to 15cm)	8.6	4.8–15.0
		NSW data (0 to 60cm)	31	25–39

* Soil types are based on the Australian Soil Classification. ** Currently insufficient data to provide similar calibration criteria for DGT-P. Check BFDC Interrogator for DGT-P. + There was insufficient S data to measure 0 to 10cm

Source: GRDC (2014) Soil testing for crop nutrition, southern region. GRDC Crop Nutrition Fact Sheet, January 2014, http://www.grdc.com.au/GRDC-FS-SoilTestingS

The values used to determine the soil test and crop response relationship have been derived from fertiliser rate trials, where various fertiliser rates were applied and the crop yield response measured. With many of these experiments, soil test values and crop response graphed.

If a soil test value is less than the lower limit of the range (Figure 3), the site is highly likely to respond to an application of the nutrient. For values within the critical range, there is less certainty about whether a response will occur. If a response does occur, it will likely be small. Growers must exercise judgement about the costs and benefits of adding fertiliser in the forthcoming season versus those associated with not applying. If the soil test is outside the critical range, fertiliser must be considered to maintain soil levels or to lower the risk of encountering deficiency.⁹

To determine how much fertiliser to apply, soil test results need to be considered in combination with information about potential yield, soil type and nutrient removal in previous seasons.



⁹ GRDC (2014) Soil testing for crop nutrition, southern region. GRDC Crop Nutrition Fact Sheet, January 2014, http://www.grdc.com.au/GRDC-FS-SoilTestingS









MORE INFORMATION

For more information GRDC Crop Nutrition Fact Sheet: Soil testing for crop nutrition, Southern Region https://grdc.com.au/GRDC-FS-SoilTestingS

MORE INFORMATION

A number of local Grower Groups conduct nutrition trials.

For more information: Guidelines for Successful on Farm Trials http://www.spaa.com.au/files/ conducting_on_farm_trials.pdf

For more information Agriculture Victoria: Using fertiliser test strips on pasture http://agriculture.vic.gov.au/ agriculture/farm-management/ chemical-use/agricultural-chemical-

use/fertilisers/using-fertiliser-test-

strips-on-pasture

Figure 3: A generalised soil test/crop response relationship between soil test value and percent grain yield expected.

Source: GRDC (2014) Soil testing for crop nutrition, southern region, GRDC Crop Nutrition Fact Sheet January 2014 http://www.grdc.com.au/ GRDC-FS-SoilTestingS

In Figure 3, a critical value and critical range are defined from this relationship. The relative yield is the unfertilised yield divided by maximum yield, expressed as a percentage. Normally 90% of maximum yield is used to define the critical value but critical values and ranges at 80% and 95% of maximum yield can also be produced.

6.4.3 Fertiliser test strips

Test strips allow you to fine tune your fertiliser program. To gain the maximum benefit:

- Run them over a number of years, as results from any single year can be misleading.
- Obtain accurate strip yield weights.
- Protein test a sample of grain from each strip.
- Harvest strips before your main harvest, as the difference between the strips is more important than the moisture content.

When setting up a test strip area:

- Ensure you can accurately locate the strips, a GPS reading would be valuable. •
- Repeat each fertiliser treatment two or three times within the paddock to get a better average.
- Change only one product rate at a time.
- Separate each strip of fertiliser by a nil fertiliser strip.
- Ensure the tests are done over a part of the paddock with uniform soil types.
- Keep clear of shade lines, trees, fences, headlands and any known anomalies in the field.
- Ensure that the test strip area is around 100 m long, with each strip 1–2 header widths.10



¹⁰ Queensland DAF (2010) Nutrition management: Overview. Queensland Department of Agriculture and Fisheries, https://www.daf.qld. acre-field-crops/nutrition-manage







Choose the same soil test package each year (including methods), otherwise comparisons between years will be useless. For example, do not use Colwell-P in one year, then DGT-P the next. The two tests measure different forms of available P in the soil.

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If you do not use a standard approach to sampling, comparison of the data between different tests will not be reliable. Aim for data that have the best chance of representing the whole paddock, and mix the sample thoroughly.

For monitoring, sampling needs to cover roughly the same area each time to ensure comparisons between years are meaningful. Permanent markers on fence posts to mark a sampling transect or a handheld GPS or your smartphone, will serve this purpose.

Soil testing laboratories should be able to provide information on appropriate soil sampling and sample-handling protocols for specific industries and crop types. Refer to the Australian Soil Fertility Manual (<u>http://www.publish.csiro.au/book/5338</u>) from CSIRO Publishing or download the GRDC Fact sheet Better fertiliser decisions for crop nutrition (<u>https://grdc.com.au/GRDC-FS-BFDCN</u>).

Utilise the Australian Soil and Plant Analysis Council (ASPAC) or National Association of Testing Authorities (NATA) accredited testing services. The results are more likely to be statistically significant and have reduced variation between tests.¹¹

6.4.5 Plant tissue testing

Plant tissue testing is a helpful tool to diagnose nutrient deficiency and monitor general health of pulse crops. It is beneficial because the reliance on visible symptoms can take longer before problems are noticeable and crop yield can be markedly reduced.

As with soil tests, different plants have different critical concentrations (critical values and ranges) for a nutrient. In some cases, varieties can vary in their critical concentrations. Table 3 lists the critical nutrient levels for field pea at flowering. These should be used as a guide only. Care should be taken to use the plant tissue tests for the intended purpose. They cannot reliably indicate the effect on a particular deficiency on grain yield.

Table 3: Critical nutrient levels for field pea at flowering.

Nutrient	Plant part	Critical range*
Nitrogen (%)	YML**	0.25–0.30
Phosphorus (%)	YML	1.5–2.0
Potassium (%)	YML	0.6
Calcium (%)	YML	0.2
Magnesium (%)	YML	0.2
Sulfur (%)	Whole shoot	20
Boron (mg/kg)	YML	3.0–5.0
Copper (mg/kg)	YML	30
Manganese (mg/kg)	YML	18
Zinc (mg/ha)	YML	18

**Youngest mature leaf Note: Application of remedial fertiliser is much too late at the flowering stage, but an indicator for the following year.

Source: Grain Legume Handbook (update 2008). Grain legumeHandbookCommittee. GRDC https://grdc.com.au/grainlegumehandbook



¹¹ GRDC (2013) Better fertiliser decisions for crop nutrition. Crop Nutrition Fact Sheet, GRDC, 4 November 2013, <u>http://www.grdc.com.au/</u> GRDC-FS-BFDCN





The critical range can be difficult to use. Wide variations in tissue test results can be due to stress, such as frost or waterlogging, or even more subtle factors such as solar radiation or time of day sampling was carried out.¹²

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Plant tissue testing is a more reliable method than soil testing for diagnosing and monitoring micronutrient status.

It is essential to collect a proper sample for tissue testing. The distribution of micronutrients can be different in leaves, stems or whole plants.

Plant nutrient status may also vary according to the age of the plant, the variety and the weather conditions. $^{\rm 13}$

The successful use of plant tissue analysis depends on sampling the correct plant part at the appropriate growth stage. Use the guide provided from the lab to collect your sample as your samples results will be assessed against these interpretative guidelines.¹⁴ Cleanliness is paramount. Do not contaminate samples with dirt or extraneous material.

Although a valuable tool, tissue testing must be used as only one part of the integrated nutrition ${\rm program}.^{\rm 15}$

6.5 Nutrient imbalances

Grain cropping is about converting rainfall into a harvestable commodity as often and as efficiently as possible. Adequate nutrition is a constraint that can have a significant influence on the overall productivity of the system.¹⁶

Incorrect levels of nutrient (too little, too much or in the wrong proportion) can cause problems. If the condition is extreme, plants will show visible symptoms that can sometimes be identified, however visual symptoms do not develop until a major effect on growth, development or yield has occurred.

Plant tissue analysis can play an important role in detecting non-visible symptoms and in fine-tuning nutrient requirements.

Tissue tests also help to identify the cause of symptoms being expressed by plants but not fitting a visual diagnosis. Technology is enabling quicker analysis and reporting of results to enable foliar or soil-applied remedies to be applied in a timely manner for quick crop response.¹⁷

6.5.1 Considerations when diagnosing nutrient disorders

Visual symptoms of nutrient disorders can assist in diagnosis. However, considerable yield loss can occur without there necessarily being any visual symptoms present.

The following points should be considered when diagnosing nutrient disorders:

- Visual symptoms on field pea may be caused by damage from herbicides, insects and pathogens. Damage may also be from physiological disorders arising from adverse environmental effects such as salinity, drought, cold, heat or high temperature stresses. Such symptoms can be indistinguishable from nutrient deficiency, although it should be obvious if environmental conditions are limiting (moisture stress).
- Factors that influence both nodulation and nitrogen fixation can result in symptoms of nitrogen deficiency.
- 12 GRDC Chickpea Northern Region GrowNotes™, <u>https://www.grdc.com.au/grownotes</u>

13

- GRDC (2013) Micronutrients. GRDC Crop Nutrition Fact Sheet, November 2013, http://www.grdc.com.au/GRDC-FS-CropNutrition-Micronutrients
- 14 GRDC (2010) Research & Development: Plant tissue testing an under-utilised tool for diagnosing hidden hunger in crops, <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2010/09/PLANT-TISSUE-TESTING-AN-UNDER-UTILISED-TOOL-FOR-DIAGNOSING-HIDDEN-HUNGER-IN-CROPS</u>
- 15 Pulse Australia (2013) Northern chickpea best management practices training course manual-2013, Pulse Australia Limited
- 16 GRDC (2010) Research & Development: Plant tissue testing an under-utilised tool for diagnosing hidden hunger in crops, <u>https://ardc.com.au/Research-and-Development/GRDC-Update-Papers/2010/09/PLANT-TISSUE-TESTING-AN-UNDER-UTILISED-TOOL-FOR-DIAGNOSING-HIDDEN-HUNGERS-IN-CROPS</u>
- 17 Pulse Australia (2013) Northern chickpea best management practices training course manual-2013, Pulse Australia Limited





There can be differences between cultivars in the manifestation of symptoms. Visual symptoms in one pulse do not necessarily mean that it is the same in other pulses.



Figure 4: Flow chart for the identification of deficiency symptoms.

Source: T Reddy, G Reddi (1997) Mineral nutrition, manures and fertilizers. In Principles of Agronomy. Kalyani Publishers, Ludhiana, India; pp. 204–256

6.5.2 Identifying nutrient deficiencies

Many nutrient deficiencies may look similar. To identify deficiencies:

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

If more than one problem is present, typical visual symptoms may not occur. For example, water stress, disease or insect damage can mask or be confused with a nutrient deficiency.

If two nutrients are simultaneously deficient, symptoms may differ from the deficiency symptoms of the individual nutrients.

Micronutrients are often used by plants to process other nutrients or work together with other nutrients, so a deficiency of one may look like deficiency of another. For instance, molybdenum (Mo) is required by pulses to complete the process of nitrogen (N) fixation.

Soil pH has an effect on the availability of most nutrients and must be within a particular range for nutrients to be released from soil particles (see <u>Figure 1</u>). On acid soils, aluminium (AI) and Mn levels can increase and may restrict plant growth, usually by restricting the rhizobia and so the plant's ability to nodulate.

Soil temperature must lie within a certain range for nutrient uptake to occur. Cold and wet conditions can induce deficiencies of nutrients such as Fe, Zn or P. Iron deficiency is common in field pea mid-winter on calcareous soils (see <u>Section 6.6.8</u>).





FEEDBACK

The optimum range of temperature, pH and moisture can vary for different pulse species. Nutrients may be physically present in the soil, but not available to those particular plants.

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Knowledge of a soil's nutrient status (soil test) pH, texture, history and moisture status can be very useful for predicting which nutrients may become deficient. Tissue tests can help to confirm the plant nutrient status.¹⁸

Table 4: Key to nutrient deficiencies in field pea.

Symptom	Old to middle leaves			Middle to new leaves			New leaves to terminal shoots										
Deficiency	Ν	Р	к	Mg	Zn	Ν	Zn	Ca	Mn	в	S	Mg	Mn	Fe	Cu	Ca	в
Chlorosis (yellowing)																	
Complete											х			х			
Mottled	х	Х		х			х	х	Х				х				
Interveinal										х			х				
Cresent form								х									
Nercosis (tissue death))																
Complete			х		х												х
Distinct areas (including spotting)	Х		Х	×			х				х	х	×				
Margins		Х	х		х	х				х							х
Tips		х			х	х		х			х		х	х	х		х
Pigmentation within ne	ecrotic	(yellov	v) or c	hloroti	c (dead	d) area	as										
Opaque														х			
Light brown					х	х					х		х				
Brown		Х						х									
Pink			х	х			х	х				х		х			
Malformation of leaflet	s																
Rolling in of margin			х	х									х	х			
Wilting					х	х									х		
Twisting		Х						Х								х	
Puckering													х		х		
Malformation of leaves	;																
Cupping							х										
Rosetting							х										х
Tendril distortion					Х							х	Х				х
Internode shortening		Х					х										х
Stem lesions							х										х
Petiole collapse																х	
Root distortion								х		х						х	х

Source: K Snowball and AD Robson (1991) Symptoms of nutrient disorders: Faba beans and Field peas. University of WA





FEEDBACK

(i) MORE INFORMATION

More information on diagnosing nutrient deficiencies and toxicities see:

Field peas: The Ute Guide by GRDC at the iTunes or App Store

Field pea diagnostic tool, DPIRD https://agric.wa.gov.au/n/4505



6.5.3 Field pea nutrient deficiencies

The main deficiencies encountered in field pea are:

- Nitrogen, when nodulation is poor or ineffective (e.g. in acid soils).
- Phosphorus, on high production or calcareous ground with inadequate history of phosphorus input.
- Zinc, on many alkaline cropping soils.
- Manganese, on soils with high lime content.¹⁹
- Iron, on soils of high pH, especially where soils are wet and cold conditions exist.

6.5.4 Nutrient toxicity

Soil pH affects the availability of most nutrients (<u>Table 1</u>). Occasionally some nutrients are so available that they inhibit plant growth. For example, on some acid soils, aluminium (AI) and manganese (Mn) levels may restrict plant growth, usually by restricting the rhizobia and so the plants' ability to nodulate (Table 5).

Table 5: Pulse reactions to nutrient toxicities.

	Boron	Aluminium	Manganese
Chickpea	sensitive	very sensitive	very sensitive
Faba bean	tolerant	sensitive	sensitive
Lentil	very sensitive	very sensitive	very sensitive
Lupin	*	tolerant	tolerant
Field pea	sensitive	sensitive	sensitive

*This crop not usually grown on alkaline - high boron soils.

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

Field peas are affected by high salinity and boron levels, often found in subsoils in many areas of the southern cropping zone. They are also sensitive to aluminium and manganese toxicity, which affect acidic soils generally, making them unsuitable for peas.²⁰

Boron (B) toxicity occurs on many of the alkaline soils of the southern cropping areas (Figure 5). The most characteristic symptom of B toxicity in pulses is chlorosis (yellowing) and, if severe, some necrosis (death) of leaf tips or margins. Older leaves are usually more affected.



¹⁹ GRDC (2009) Field peas: The Ute Guide, Southern region. GRDC Ground Cover Direct

²⁰ GRDC (2009) Field peas: The Ute Guide, Southern region. GRDC Ground Cover Direct







Figure 5: Symptoms of boron toxicity in field pea.

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

Manganese toxicity (Figure 6) is worse in acidic, heavy textured parts of paddocks. New leaves and tendrils are first and most severely affected.



Figure 6: Symptoms of manganese (Mn) toxicity in field pea.

Photo: © A Robson, DPIRD (2015). <u>https://agric.wa.gov.au/n/4475</u>

Aluminium toxicity in field pea is often associated with acid soils. Old and middle leaves develop large, cream coloured necrotic patches (Figure 7).



Figure 7: Symptoms of aluminium (AI) toxicity in field pea. Photo: © A Robson, DPIRD 2015 <u>https://agric.wa.gov.au/n/44872014</u>



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6.6 Fertiliser

Fertiliser recommendations for field pea, as with most pulses, tend to be generic, with an over-reliance on the recommendation of MAP-based starter fertilisers across nearly all situations. This is often driven by convenience and availability, rather than meeting the specific nutrient requirements of the crop.

Fertiliser recommendations need to be more prescriptive and should take into account:

- soil type;
- rotation (fallow length and impact arbuscular mycorrhizal fungi (AMF), <u>http://www.soilquality.org.au/factsheets/arbuscular-mycorrhizas-s-a-levels</u>);
- yield potential of the crop;
 - plant configuration (row spacing, type of opener and risk of 'seed burn');
- soil analysis; and
- effectiveness of inoculation techniques.

Molybdenum and cobalt (Co) are required for effective nodulation and should be applied if needed.

Soil P levels influence the rate of nodule growth. Phosphorus-based fertilisers with nitrogen i.e. monoammonium phosphate (MAP) and diammonium phosphate (DAP) can be used in small amounts (5–15 kg N/ha). They are not harmful to nodulation and can be beneficial by enhancing early root growth to establish a stronger plant. MAP or DAP fertilisers can be used.

However, excessive amounts of N will restrict nodulation and thereby reduce N fixation.

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

Acid fertilisers include:

- superphosphates (single, double, triple)
- fertilisers with Cu and/or Zn
- MAP, also known as 11:23:0 and Starter 12.

Neutral fertilisers include:

• 'Super lime'.

Alkaline fertilisers include:

- DAP, also known as 18:20:0
- starter NP
- lime.²¹

6.6.1 Pulses and fertiliser toxicity

All pulses can be affected by fertiliser toxicity. Lupins are especially susceptible. Higher rates of P fertiliser can be toxic to lupin establishment and nodulation if drilled in close contact with the seed at sowing.

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

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



²¹ Pulse Australia (2016) Southern Field Pea – Best management practices training course manual-2014, Module 4, General Agronomy, Draft. Pulse Australia Limited (2016)



The use of starter N (e.g. DAP) banded with the seed when sowing pulse crops may reduce establishment and nodulation if higher rates are used. On sandy soils, up to 10 kg/ha of N at 18 cm row spacing can be safely used. On clay soils, do not exceed 20 kg/ha at 18 cm row spacing.

Deep banding of fertiliser is often preferred for lupin, otherwise broadcasting and incorporating, drilling pre-seeding or splitting fertiliser application so that a lower P rate or no P is in contact with the seed.²²

6.6.2 Nitrogen (N)

Field pea should not normally need nitrogen fertiliser provided plants have effectively nodulated. However, field pea crops may benefit from nitrogen fertiliser applied at seeding, particularly where crop fertility is low and where nodulation may be restricted through late sowing, acid soils or waterlogging. Nitrogen should be applied at rates of 5–10 kg/ha as at this rate, nodulation will not be affected.

Key points

- If field pea plants have effectively nodulated, they should not normally need N fertiliser.
- Nitrate (NO₃-) is the highly mobile form of inorganic nitrogen in both the soil and the plant (Figure 8).
- Sandy soils and nitrogen models will help determine seasonal nitrogen requirements.²³



Figure 8: The soil nitrogen cycle showing the role of mineralisation in making organic nitrogen in soil available for plants to take up.

Source: Soil Quality Pty Ltd 2017 http://www.soilquality.org.au/factsheets/soil-nitrogen-supply

Factors influencing nitrogen supply from soils and stubbles

Nitrogen is the key major nutrient influencing crop production in Australian agricultural systems, and maintaining a close balance between inputs and outputs, as well as better synchronisation between N supply and plant demand, is the role of soil management, fertiliser, crop residues and crops.

Fertiliser N use in Australia has increased at an annual rate of approximately 14% compared to use in 1992, which is not only considered economically unsustainable but also environmentally undesirable. Most of the N-cycling processes such as N fixation, mineralisation and gaseous loss are biologically mediated. A diverse group of microbial communities are involved in the release of nitrate N from soil organic matter and they are present in all agricultural soils. There are direct links between processes involved in soil organic N cycling that also play a role in the transformation of fertiliser nitrogen (Figure 1). Therefore, management strategies that manipulate



²² Pulse Australia (2016) Southern Field Pea – Best management practices training course manual-2014, Module 4, General Agronomy, Draft. Pulse Australia Limited (2016)

²³ Soilquality.-.Nitrogen - Western Australia, http://www.soilquality.org.au/factsheets/mineral-nitrogen





microbial communities controlling organic N cycling would help optimise both organic and fertiliser N use efficiency.

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Soil type, crop rotation and management practices associated with tillage, stubble retention and fertiliser application can influence the diversity of microbial populations and, along with the environment, they affect biological processes involved in nitrogen fixation, mineralisation, and availability and losses. All of these processes and the associated microorganisms can be manipulated to optimise N use efficiency both by improving the supply of N from organic N and decreasing the losses via denitrification and leaching.

Nitrogen mineralised from soil organic matter and crop residues contributes to a large part of crop N requirements in the rainfed cropping regions across southern Australia. For example, in the year of application, fertiliser N contributes approximately 20–40% of the total N supply of wheat. Soil N supply comes from soil organic matter and recent crop residues and the rate of supply is influenced by the soil biological capacity and modulated by management and environmental factors.

The nitrogen mineralisation potential of the top 10 cm of soils generally ranges from 10-35 kg N/ha/season in sandy soils, 25-70 kg N/ha/year in clay and loam soils, and 30-100 kg N/ha/year in red-brown earth soils.

The magnitude of soil biological processes and their impact on the farming system varies seasonally due to the variation in the time of their occurrence relative to the crop growth and demand. The effect of soil organisms involved in N mineralisation can be seen in both the off-season (fallow) and in-crop season (Figure 8). Nitrogen mineralised during the off-season may accumulate and/or be lost through leaching, denitrification or weed uptake, whereas the N mineralised during the growing season in the rhizosphere may be utilised immediately by the crop. In a farming system, factors influencing nutrient mineralisation/immobilisation processes need to be understood in order to synchronise nutrient availability to plant needs and also to reduce nutrient losses. Additionally, critical periods of biological activity must be taken into consideration to optimise management strategies that help synchronise N supply and availability to crops.

Critical periods of biological activity



Figure 9: A conceptual diagram showing functionally important periods for different N-cycling biological processes and their impact within the farming systems in Australian winter-cropping growing regions.

Source: V Gupta (2016). https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/ factors-influencing-nitrogen-supply-from-soils-and-stubbles







Decomposition and N mineralisation

In low-fertility Australian agricultural soils, crop residues are one of the major sources of carbon (C) for soil biota and retention of stubble after harvest contributes to the conservation of nutrients taken up by the plant within the cropping system. A large portion of N used by crops is mineralised from previous crop and pasture residues through the activity of soil microorganisms (microbial biomass, MB).

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Decomposition of crop residues is mainly a biological process involving diverse groups of microbial communities and facilitated by the activity of soil fauna. Land use changes from mixed farms where crop rotation with legume pastures was common to continuous cereal cropping generally resulted in a decline in crop-residue-based N mineralisation (Angus *et al.* 2006). The decline occurred mainly through altered crop residue quality, e.g. wider C:N ratio (100:1) cereal residues replacing N-rich legume residues (15:1 to 25:1). It is considered that crop residues with a C:N ratio >22:1 generally result in immobilisation (tie-up) of mineral N in microbial biomass.

The rate and timing of availability of nutrients from stubble to the following crops is determined by the rate of decomposition and immobilisation (tie-up) by soil microorganisms (N in microbial biomass, MB-N). The amount of N in microbial biomass varies with soil type, crop rotation, tillage and other management practices that can influence microbial populations (Table 6). In southern Australian cropping regions, the effect of loss of nutrients from stubble removal may be greater than the temporary tie-up of the nutrients during decomposition when retained. However, the scale of these effects varies depending upon stubble load, time and type of burning and tillage.

Table 6: Amount of nitrogen in microbial biomass and the soil N supply potential as influenced by soil type.

Location	Soil type	Microbial biomass (MB) (kg N/ha)	N supply potential (kg N/ha)				
Waikerie/Karoonda,SA	Sand and sandy loam	25-45	10-35				
Streaky Bay, SA	Calcarosol	30-60	15-50				
Kerrabee, NSW	Loam	60-75	35-50				
Temora, NSW	Red earth	75-105	50-100				
Rutherglen, Victoria	Red-brown earth	50-100	30-100				
Leeton/Warialda, NSW	Clay	50-110	25-75				
N supply potential is calculated from N in MR plus N minoralisation measured in a lab insubation assay							

Source: V Gupta (2016) https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/ factors-influencing-nitrogen-supply-from-soils-and-stubbles

Stubble retention can provide benefits through changes in soils' physical, chemical and biological properties. However, the selection of stubble-management strategy has a substantial impact on the potential benefits to be gained from the activity of soil biota in their role in carbon turnover, nutrient mineralisation and subsequent availability of nutrients to crops. For example, tillage practices accelerate the decomposition and microbial turnover resulting in quick accumulation of mineral N, especially in soils with lower microbial biomass levels.

In addition, research from Victoria and South Australia has shown that tillage can disrupt the linkages between the activity of microbes processing organic N and those related to fertiliser and mineral N transformations influencing the rate of release and accumulation of mineral N in soil (Phillips *et al.* 2015; Gupta *et al.* 2011). This means strategic tillage practices could be developed to manipulate N release and losses (especially from legume residues), for example to synchronise the release of N to plant demand and avoid losses through leaching and denitrification.

Nitrogen released during decomposition and soil organic matter turnover is rapidly assimilated by MB, which is subsequently released through microbial turnover and microbe/fauna interactions. Results from field experiments in SA indicated that in the







sandy soils in the Mallee with lower levels of MB, there can be substantial movement (leaching) of mineral N (25–50 kg N/ha; P<0.05) down the soil profile following summer rainfall (Figure 8). Retention of stubble, which generally increases the amount of MB, can therefore arrest the leaching of mineral N to lower depths.

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Research at Karoonda in SA, on a dune–swale landscape, has shown that plant type (e.g. wheat, cereal rye, canola or pasture) can cause large changes in the functional diversity of microorganisms, i.e. microbial communities involved in various biological functions including N-cycling processes. Thus, in a crop rotation such changes, coupled with differences in the quantity and quality of organic residues (tops and roots), can significantly modify the N mineralisation/immobilisation processes and availability of N (McBeath *et al.* 2014). The magnitudes of these effects varies with soil type and region, which needs to be considered when designing fertiliser N management strategy in a cropping sequence.

Nitrogen fixation – free-living N fixation

Biological nitrogen fixation by symbiotic and free-living (FL) bacteria can provide economic and environmental sustainability to N management in Australian agriculture. Free-living N fixation refers to N fixation by bacteria growing independently in soil or in close association with plant roots where symbiotic N fixation occurs through legume-rhizobia interaction in nodules. Research has shown that communities of free-living and endophytic N-fixing bacteria have been found in association with cereal crops, grasses (including summer-active perennial pastures) and nonleguminous plants. With the increased adoption of intensive cropping and area under consecutive cereal crops (>50%), FL-N fixation has the potential to make a major contribution to N requirements in cereal crops.

Additionally, current day conservation farming systems support a habitat that promotes activity of FL-N fixing (nifH gene harbouring) bacterial communities both during off-season and in-crop, i.e. increased microsites with C availability, wide C/N ratio etc. Improvements in FL-N fixing capacity in soils can provide multiple benefits through reduced requirement for N inputs, disease suppression, C sequestration, etc.

Estimates of FL-N fixation, measured using a laboratory based incubation (15N isotope) assay, ranged from less than 0.15 to 2.3 kg N fixed/ha/day under optimal soil moisture and temperature conditions. FL-N fixation ranged from 0.2 to 1.5 kg N/ha/day in sand and sandy loam soils in low to medium-rainfall regions of southern Australia and Western Australia compared to 0.5 to 2 kg/ha/day in the clay and loam soils in high-rainfall regions. The number of optimal days per season does vary in different agricultural regions. The amount of N fixed varied with soil type and influenced by the time of sampling (in-crop versus non-crop/fallow period), crop type and mineral nitrogen levels. The amount of FL-N fixed during summer significantly increases (>50%, P<0.05) in the presence of summer-active grasses such as Rhodes grass and Panicum species, compared to winter-cereal crop only systems (Figure 10).

The abundance of FL-N fixing bacteria, percentage clay content (soil type), soil moisture content and carbon availability are some of the major factors influencing FL-N fixation in cropping soils. Therefore, removal of stubble (one of the major sources of available C) either by burning or grazing would have negative impact on the amount of N fixed by FL-N₂ fixing bacteria. Research in the southern Australian agricultural region has shown that FL-N₂ fixation was higher immediately after harvest and decreased as summer progresses (Figure 9). Thus, careful consideration should be given to how stubble is managed in order to maximise FL-N fixation in cropping soils. Free-living N fixation is generally higher soon after rainfall when the water content is adequate to provide the required low-oxygen conditions (to protect O_2^- sensitive N fixing enzymes) and carry the carbon to where these bacteria are located. Higher levels of mineral N in the surface soil (0–10cm) could have a negative effect on the amount of fixation by free-living bacteria, but this varies with soil type so needs region-specific solutions.









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Figure 10: Amount of FL-N fixation in soils collected from field experiment at Karoonda, SA, during summer 2011–12 (left) and with summer-active perennial grasses (right).

Source: V Gupta (2016) https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/ factors-influencing-nitrogen-supply-from-soils-and-stubbles

Soil type and stubble retention have a large influence on the abundance of nifH-gene harbouring bacteria, for example abundance increased with clay content (P<0.01) and stubble retention (P<0.05). Populations of FL-N fixing bacteria are generally higher in the rhizosphere soil (soil closely surrounding roots) than those found in the bulk soil.

Genetic profiling of N₂-fixing bacteria (nifH gene sequencing analysis) in cereal crop field soils (from Queensland, NSW, SA and WA) indicated the presence of a diverse group of free-living community (112 genera) in different agricultural regions indicating differences based on soil type and environment. Crop and variety types can influence the abundances of various groups thereby affecting the amount of FL-N fixation. Further research could suggest specific management strategies and identify crop varieties that help promote FL-N fixation by specific communities of N₂-fixing bacteria in different soils and regions.

Denitrification and gaseous N losses

The composition and abundance of soil bacteria involved in gaseous N losses (e.g. denitrification and nitrification) varies with soil type, and the denitrification losses are highest where soil nitrate N levels are high and when sufficient biologically available C is present along with low oxygen (O_2) concentrations e.g. waterlogging. In the southern Australian cropping regions, N losses are sporadic in time and space and vary widely in different agricultural systems (Grace *et al.* 2015). In cropping soils, the primary consideration for reducing gaseous N losses is by matching the supply of mineral N to crop demand and management practices that promote tie-up of N in microbial biomass (immobilisation) generally reduce N losses both through denitrification and leaching.

Nitrification of N fertilisers

The conversion of ammonia and urea N found in commonly used N fertilisers into nitrate N is a biological process mediated by specific group of microorganisms, i.e. nitrifiers, which are mostly abundant in surface soils. The abundance and type of nitrifiers present varies with soil type and depth and their activity can be influenced by management practices. Research has shown that banding fertilisers can influence the activity of these microbes and the accumulation of nitrate N (Angus *et al.* 2014). Thus, fertiliser N use efficiency could be manipulated by targeting fertiliser placement or the







Watch Nitrogen Deficiency https://youtu.be/EWeZGHYpJcs





Watch GCTV13: Phosphorus Uptake https://youtu.be/qSiQIKRb9bA





For more information GRDC Fact Sheets: Crop nutrition-phosphorus management <u>https://grdc.com.au/GRDC-FS-</u> <u>PhosphorusManagement</u>

Watch Improving phosphate use efficiency https://youtu.be/IHo9FDGTqAY





use of nitrification inhibitors. Immobilisation of fertiliser N in MB, becoming unavailable to plants, is generally short term and has been found to be available to crops later in the crop season or to the following crop, provided it is not leached or lost through gaseous losses.

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Conclusions

- Nitrogen mineralised from soil organic material (SOM) and crop residues makes a large contribution to crop N uptake (>50%)
- A diverse group of microbial communities are involved in the release of nitrate N from SOM and they are present in all agricultural soils
- Management strategies (such as stubble retention, tillage, fertiliser application and green manuring) and crop and variety selection can help manipulate microbial communities involved in N mineralisation from organic matter and crop residues and also influence fertiliser N use efficiency
- Free-living N fixation can make an agronomically important contribution to the available N pool in stubble-retained, cereal-based systems and perennial grass systems.²⁴

Deficiency symptoms

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

Check for nodulation and if nodules are fixing nitrogen to confirm suspected nitrogen deficiency from visual plant symptoms.²⁵

See Section 4.9 Check for nodulation.

6.6.3 Phosphorus (P)

Ancient and highly weathered soils with very low levels of natural phosphorus (P) dominate much of Australia. Many of our agricultural soils are among the most acutely phosphorus deficient in the world, and profitable crop production has only been possible through significant applications of P fertilisers.

Phosphorus is an essential element for plant and animal growth and important during cell division and growth.

Complex soil processes influence the availability of phosphorus applied to the soil, with many soils able to 'tie up' phosphorus, making it unavailable to plants. Each soil's ability to do this must be measured when determining requirements for crops and pastures.²⁶

Like other pulses, field pea requires high levels of phosphorus for growth and also removes large amounts of phosphorus in the grain. Adequate phosphorus is essential for seed germination, root development and in the ripening process of fruits and seeds.

Phosphorus is best applied at planting in a band to the side of or 2–3 cm below the seed. Placing fertiliser away from the seed prevents acid scorching. Nutrient release from deeper placement coincides well with root development.²⁷

26 Soilquality.org.Phosphorus – Western Australia <u>http://www.soilquality.org.au/factsheets/phosphorus</u>

²⁴ V Gupta (2016) Factors influencing nitrogen supply from soils and stubbles. GRDC Update papers, <u>https://grdc.com.au/resources-and-publications/grdc-update-papers/2016/02/factors-influencing-nitrogen-supply-from-soils-and-stubbles</u>

²⁵ Pulse Australia (2016) Southern Field Pea – Best management practices training course manual-2014, Module 4, General Agronomy, Draft. Pulse Australia Limited (2016)

²⁷ C Scanlon (2015) Diagnosing phosphorus deficiency in field peas. Department of Agriculture and Food, Western Australia https://agric.wa.gov.au/n/4478







Symptoms of phosphorus deficiency may take time to develop because of initial seed reserves of P. When symptoms start to appear, there are growth differences apparent and smaller leaves compared with P adequate plants. Visual symptoms appear first on the oldest leaves as a mildly mottled chlorosis (yellowing of leaf tissue due to lack of chlorophyll) over much of the leaf. These symptoms could be confused for either nitrogen or sulfur deficiency, but middle and new leaves remain a healthy green such that the whole plant does not appear pale.

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As symptoms on old leaves develop, round purple spots may appear within areas of dark green in an otherwise mildly chlorotic leaf.28



Figure 11: Phosphorus deficiency in field pea. Photo: © A Robson 2014, DPIRD https://agric.wa.gov.au/n/4478

6.6.4 Sulfur (S)

Sulfur is important to legumes for the nodulation and nitrogen-fixation process. Sulfur is required at higher rates for field pea than for cereals. If soil sulfur levels are low, then an appropriate legume mix could be applied. Consider the application of a sulfur-based fertiliser where the soil S level is <10 mg/kg KCL40.²⁹

Deficiency symptoms

Sulfur deficiency symptoms on younger leaves include the veins turning yellow. In severe deficiency situations the older leaves also turn yellow, and the plants tend to be small and slender.³⁰



Figure 12: Sulfur deficiency in field pea. Growth and colour are both affected and new leaves and tendrils become evenly chlorotic.

Photo: 2014 © A. Robson, DPIRD 2015 https://agric.wa.gov.au/n/4488

AWB Seeds. KaspaA: Field Pea Factsheet. AWB Seeds, http://modraseeds.com.au/pdf/KaspaFactSheet.pdf

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



Pulse Australia (2016) Southern Field Pea - Best management practices training course manual-2014, Module 4, Draft, Pulse Australia 28 Limited (2016).







6.6.5 Potassium (K)

Field pea have a high potassium (K) requirement, but deficiency has been rare because they are mainly grown on heavy-textured soils.

Deficiency symptoms

The earliest symptom is pale grey necrosis of leaf veins (particularly the midrib) of the second oldest leaf. This is followed by pale to pink necrotic spots on older leaves, which spread until the leaf shrivels and dies. New growth is darker than normal.³¹



Figure 13: Potassium deficiency in field pea. Photo: © A. Robson 2014, DPIRD <u>https://agric.wa.gov.au/n/4480</u>

6.6.6 Zinc (Zn)

Most pulse crops have comparable requirements for zinc and the requirements of field pea are thought to be similar to chickpea.

Zinc should be applied to soil every 2–7 years, depending on soil type, as it lasts longer on loamy soils than on heavy, calcareous clays.³²

Pre-plant treatments

Severe Zn deficiency can be corrected for a period of 5–8 years with a soil application of 15–20 kg/ha of zinc sulfate monohydrate, worked into the soil 3–4 months before sowing.

Zinc is not mobile in the soil and needs to be evenly distributed over the soil surface, and then thoroughly cultivated into the topsoil. In the first year after application, the soil-applied Zn may not be fully effective and a foliar Zn spray may be required.

Seed treatments

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

- Broadacre Zinc (Agrichem): contains 650 g/L of Zn and is applied as 4 L product/t seed. Pre-mix with 1 L water prior to application. To minimise damage to the rhizobia, the Broadacre Zinc treatment needs to be applied first and then allowed to dry before applying the inoculum.
- Teprosyn Zn (Phosyn): contains 600 g/L of Zn and is applied as 4 L product/t seed. Pre-mix with 2–3 L water to assist coverage. Apply inoculum first and allow to dry before applying the Teprosyn.

Fertilisers applied at sowing

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



³¹ C Scanlon (2015) Diagnosing potassium deficiency in field peas. Department of Agriculture and Food, Western Australia, https://agric. wa.gov.au/n/4480

³² AWB Seeds. KaspaA: Field Pea Factsheet. AWB Seeds, <u>http://modraseeds.com.au/pdf/KaspaFactSheet.pdf</u>







Foliar zinc sprays

A foliar spray of 1 kg zinc sulfate heptahydrate + 1 kg urea + 1200ml of non-ionic wetter (1000 g/L) in at least 100 L of water per hectare will correct a mild deficiency. One or two sprays will need to be applied within 6-8 weeks of emergence.

Hard water (high in carbonate) will produce an insoluble sediment (zinc carbonate) when the zinc sulfate is dissolved, with the spray mix turning cloudy. Buffer back with L1-700 of Agri Buffa® if only hard water is available; zinc oxide products are highly alkaline, with a pH of 9.5-10.5.33

Zinc deficiency

Zinc deficiency will vary with soil type, being worst on highly alkaline soils and worse in cold, wet weather.

Symptoms include older leaves of young plants initially wilting. Cream coloured necrosis on older leaf margins moves to the midrib, leaving a small green residual at the leaf base. The whole leaf turns white and dies. Tendrils go limp, curl and finally die. Later, new leaves are small, pale and cupped. Red-brown lesions develop on new leaf and upper main stems.³⁴



Figure 14: Zinc deficiency in field pea. Photo © A Robson 2014, DPIRD https://agric.wa.gov.au/n/4490

6.6.7 Manganese (Mn) deficiency

Manganese (Mn) deficiency is common on highly alkaline calcareous soils. Younger leaves show yellowing between the veins, often specks.³⁵ Figures 15 and 16 show manganese deficiency in dun and white seed field pea varieties.



Figure 15: Manganese deficiency in dun-type field pea.

Source: DPIRD (2015) https://agric.wa.gov.au/n/4473

- R Brennan (2015) Diagnosing zinc deficiency in field peas. Department of Agriculture and Food, Western Australia, https://agric.wa.gov. au/n/4490
- 35 GRDC (2009) Field peas: The Ute Guide, Southern region. GRDC Ground Cover Direct



Pulse Australia (2016) Southern Field Pea - Best management practices training course manual-2014, Module 4, Draft. Pulse Australia 33 Limited (2016)





New leaves become puckered and narrowly cupped with necrotic tipping on leaves and tendrils. $^{\rm 36}$

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Figure 16: Manganese deficiency in white-seed-type field pea.

Photo: DPIRD 2015, https://agric.wa.gov.au/n/4472

In white-seed varieties, affected leaves curl downwards along the length of the leaf. Yellowing between the veins turns to light brown spotting. Tendrils on new leaves have pale and excessively curled ends.³⁷

6.6.8 Iron (Fe) deficiency

Iron deficiency often appears in young plants and is related to soil type where there is a high lime content under cold, wet conditions. Plants often recover as conditions warm.

Deficiency shows as yellowing leaves and poor growth. New leaves and growth become yellow, causing smaller unfolded leaves (Figure 17). The deficiency then spreads to older leaves and young growth stops. Stems become slender and shortened.³⁸



Figure 17: Iron deficiency in field pea. Photo: DPIRD 2015, <u>https://agric.wa.gov.au/n/4472</u>



³⁶ R Brennan (2015) Diagnosing manganese deficiency in field peas. Department of Agriculture and Food, Western Australia, <u>https://agric.</u> wa.gov.au/n/4473

³⁷ R Brennan (2015) Diagnosing manganese deficiency in field peas. Department of Agriculture and Food, Western Australia, <u>https://agric.</u> wa.gov.au/n/4473g

³⁸ GRDC (2009) Field peas: The Ute Guide, Southern region. GRDC Ground Cover Direct







Copper deficiency is worse on alkaline soils, very infertile siliceous sands and soils with a low zinc fertiliser history.

SOUTHERN

<u>JUNE 2018</u>

Symptoms include old to middle leaves becoming mottled yellow and brownish pink, with dead tissue around the edges and tips. Light yellow-green spots form on the leaf. Plants are shortened with wilting and puckering distortion of new leaflets. Shrivelling of the leaf tip and aborted flowers.

Determine the copper status of the plant by tissue testing. Copper can be applied at seeding in fertiliser, by liquid injection on the seed or as a foliar application.³⁹



Figure 18: Copper deficient (right) and copper adequate (left) new leaves of field pea. Photo: © A. Robson.

