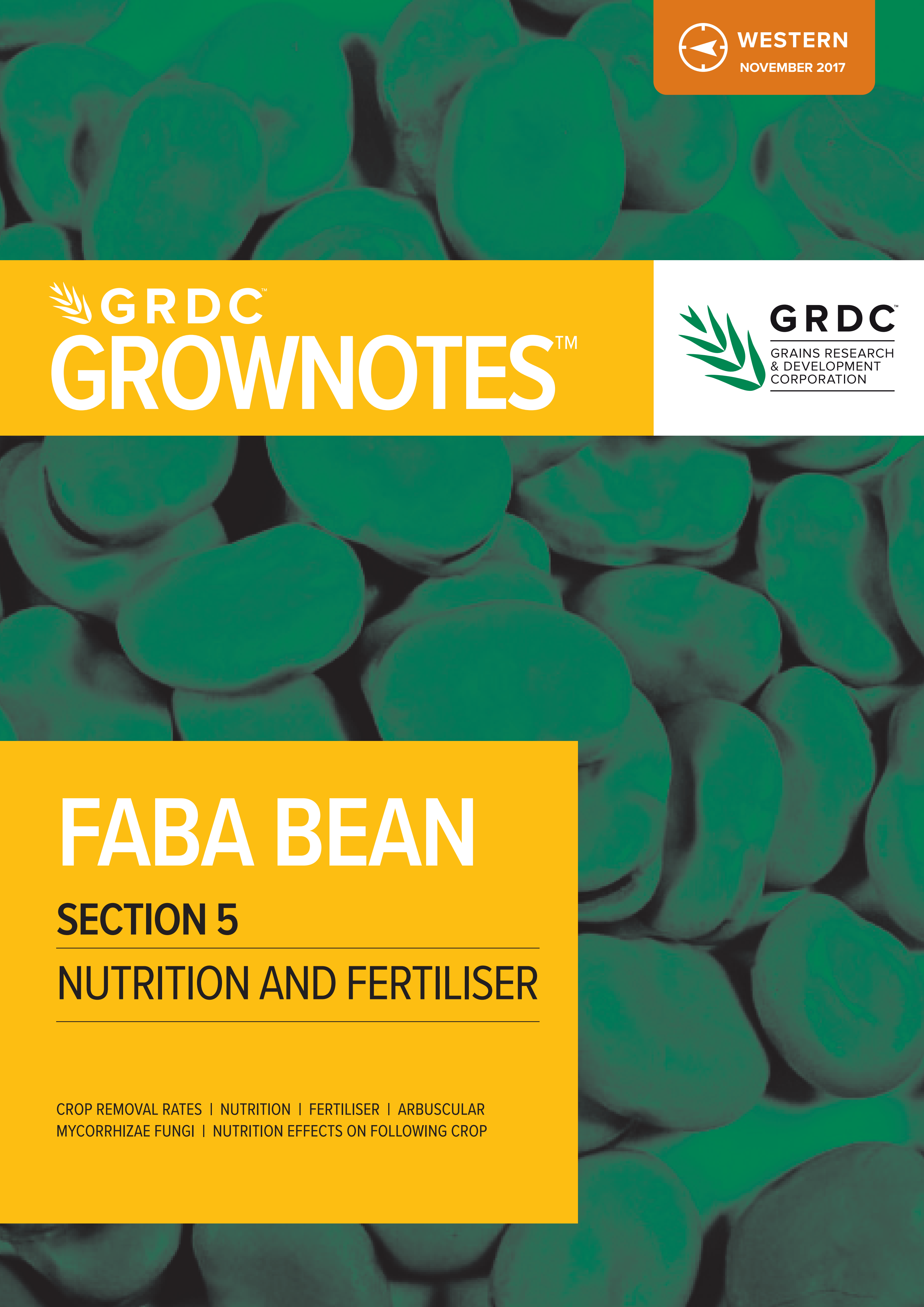

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GRAINS RESEARCH & DEVELOPMENT CORPORATION

FABA BEAN

SECTION 5

NUTRITION AND FERTILISER

CROP REMOVAL RATES | NUTRITION | FERTILISER | ARBUSCULAR MYCORRHIZAE FUNGI | NUTRITION EFFECTS ON FOLLOWING CROP

Nutrition and fertiliser

Key messages

- Nutrient balance is vital for profitable yield.
- The value of legumes in agricultural systems is measured by how well they grow and fix N_2.
- Soil pH has an effect on the availability of most nutrients.
- Faba beans have a high P requirement.

Most Western Australian cropping soils are ancient and were formed from granitic parent rock. Weathering over geological time has leached minerals and clay from the topsoils leaving them sandy and chemically infertile. Low buffering capacity makes the soils prone to nutrient leaching and rapid acidification.

Many WA soil profiles are duplex, consisting of a thin sandy or loamy topsoil overlaying a thicker clay layer. The sandy topsoils have weak structure and are prone to compaction and a low water and nutrient holding capacity. The clay subsoil can store large amounts of water but its poor structure and small pore size distribution makes it difficult for crop roots to access.

The positive aspect of low fertility soils is that crop nutrient supply and timing is almost entirely in the hands of the farmer. This is increasingly the situation for all cropping soils, not just in WA, as nutrients are depleted by crops.

5.1 Crop removal rates

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

Knowing the nutrient demand of crops is essential in determining nutrient requirements. Soil testing and nutrient audits assist in matching nutrient supply to crop demand. [1]

Balancing inputs

The nutrients removed by 1 t of grain by the various pulses is shown in Table 1. Actual values may vary by 30%, or sometimes more, due to the differences in soil fertility, varieties and seasons. For example, the P per tonne removed by faba bean grain can vary from a low 2.8 kg on low-fertility soils to 5.4 kg on high-fertility soils.

From Table 1, it can be seen that a 3 t/ha crop of faba beans will remove (on average) 12 kg/ha of P. This, then, is the minimum amount of P that needs to be replaced. Larger quantities may be needed to build up soil fertility or overcome soil fixation of P.

1 P Matthews, D McCaffery, L Jenkins (2013) Winter Crop Variety Sowing Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/aboutus/news/all/2013/2013-wcvsg

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

Grain	N	P	K (kg)	S	Ca	Mg	Cu	Zn (g)	Mn
Pulses									
Chickpea (Desi)	33	3.2	9	2.0	1.6	1.4	7	34	34
Chickpea (Kabuli)	36	3.4	9	2.0	1.0	1.2	8	33	22
Faba bean	41	4.0	10	1.5	1.3	1.2	10	28	30
Lentil	40	3.9	8	1.8	0.7	0.9	7	28	14
Lupin	53	3.0	8	2.3	2.2	1.6	5	35	18
Field pea	38	3.4	9	1.8	0.9	1.3	5	35	14
Cereals									
Wheat	23	3.0	4	1.5	0.4	1.2	5	20	40
Barley	20	2.7	5	1.5	0.3	1.1	3	14	11
Oats	17	3.0	5	1.6	0.5	1.1	3	17	40

Source: Grain Legume Handbook, 2008

5.2 Nutrition

Too little or too much of a nutrient, or incorrect proportions of nutrients, can cause nutritional problems. Visual symptoms do not develop until a major effect on yield, growth or development has occurred; therefore, damage can be done before there is visual evidence.

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

Tissue tests also help to identify the cause of plant symptoms that are expressed by plants. Technology is enabling quicker analysis and reporting of results to enable foliar- or soil-applied remedies to be used in a timely manner for a quick crop response. [2]

Identifying nutrient deficiencies

Many nutrient deficiencies may look similar:

- 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 etc.), 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 or 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 a nutrient deficiency. If two nutrients are simultaneously deficient, symptoms may differ from those when one nutrient alone is deficient. Micronutrients are often used by plants to process other nutrients, or work together with other nutrients, so a deficiency of one may look

2 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

MORE INFORMATION

R S Jessop and J Mahoney (1982) Effects of lime on the growth and nodulation of four grain legumes. Australian Journal of Soil Research 20(3) 265–268.

GRDC (2013) Micronutrients and trace elements. Fact sheet.

like a deficiency of another. For instance, molybdenum (Mo) is required by pulses to complete the N_2-fixation process. [3]

Nutrient types

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

Macronutrients are those elements needed in relatively large amounts. They include N, P and K, which are the primary macronutrients, with calcium (Ca), magnesium (Mg) and S considered 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, has different requirements for nutrients, and may display different symptoms.

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

Both macronutrients and micronutrients are taken up by roots and they require certain soil conditions for uptake to occur:

- Soil must be sufficiently moist to allow roots to take up and transport the nutrients. Plants that are moisture-stressed from too little or too much (saturation) moisture can often exhibit deficiencies even though a soil test may show these nutrients to be adequate.
- Soil pH affects the availability of most nutrients and must be within a particular range for nutrients to be released from soil particles. On acid soils, (Al) and Mn levels can increase and may restrict plant growth, usually by restricting the rhizobia and thus the plant's ability to nodulate.
- Soil temperature must be within a certain range for nutrient uptake to occur. Cold conditions can induce deficiencies of Zn or P.

The optimum range of temperature, pH and moisture can vary for different pulse species. Thus, nutrients may be physically present in the soil, but not available to those particular plants. Knowledge of a soil's nutrient status (soil test), pH, texture, history and moisture status can be useful for predicting which nutrients may become deficient. Tissue tests can help to confirm the contents of individual nutrients in the plant. [4]

5.2.1 Detecting nutrient deficiencies

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

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

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

Table 3 lists the plant analysis criteria for faba beans. These should be used as a guide only, and plant-tissue tests should be used for the purpose for which they have been developed. Most tests diagnose the nutrient status of the plants only at the time

3 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

4 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

they are sampled, and cannot reliably indicate the effect of a particular deficiency on grain yield. [5]

Table 2: *Critical nutrient levels for faba beans at flowering.*

Nutrient	Plant part	Critical range
Nitrogen (%)	YOL	4.0
Phosphorus (%)	YOL	0.4
Potassium (%)	YML	1.0
Calcium (%)	YML	0.6
Magnesium (%)	YML	0.2
Sulfur (%)	Whole shoot	0.2
Boron (mg/kg)	YOL	10
Copper (mg/ka)	YML	3.0–4.0
Manganese (mg/kg)	YML	<40
Zinc (mg/kg)	YOL	20–25

YOL, youngest open leaf blade; YML, youngest mature leaf. Any nutrient level below the critical range will be deficient; any level above will be adequate

5.2.2 Diagnosing nutrient disorders

Table 4 summarises the symptoms of nutrient deficiencies in faba bean leaves of various ages.

Table 3: *Key to nutrient deficiencies in faba beans.*

Symptom	Old to middle leaves						Middle to new leaves					New leaves to terminal shoots					
Deficiency:	**N**	**P**	**S**	**K**	**Mg**	**Zn**	**N**	**Mg**	**Mn**	**Zn**	**B**	**Mn**	**Fe**	**Zn**	**Cu**	**Ca**	**B**
Chlorosis (yellowing)																	
Complete	x		x									x#	x				x#
Mottled	x	x	x		x					x	x						
Interveinal					x						x						
On margins			x		x												
Necrosis (tissue death)																	
Complete		x				x											
Distinct areas (including spotting)				x		x		x	x		x	x		x			
Margins													x			x	
Tips				x		x			x			x		x	x		
Pigmentation within necrotic (yellow) or chlorotic (dead) areas																	
Purple	x	x	x	x		x		x	x	x		x				x	
Dark green		x									x						
Brown		x	x						x		x	x	x	x			
Red					x						x			x			
Malformation of leaflets																	
Rolling in of margin				x				x					x			x	x

5 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

Symptom	Old to middle leaves						Middle to new leaves					New leaves to terminal shoots					
Deficiency:	**N**	**P**	**S**	**K**	**Mg**	**Zn**	**N**	**Mg**	**Mn**	**Zn**	**B**	**Mn**	**Fe**	**Zn**	**Cu**	**Ca**	**B**
Wilting		x													x		
Twisting									x			x			x		x
Malformation of leaves																	
Cupping	x						x								x		
Umbrella formation								x			x						
Malformation of stems and roots																	
Internode shortening											x			x			x
Petiole collapse																x	
Root distortion											x		x			x	x

= Mild
Source: Snowball and Robson 1991

5.2.3 Nutrient toxicity

Soil pH has an effect on the availability of most nutrients. Occasionally, some nutrients are so available they inhibit plant growth. For example on some acid soils, Al and Mn levels may restrict plant growth, usually by inhibiting the rhizobia and consequently, the plant's ability to nodulate (Table 5, Photo 1).

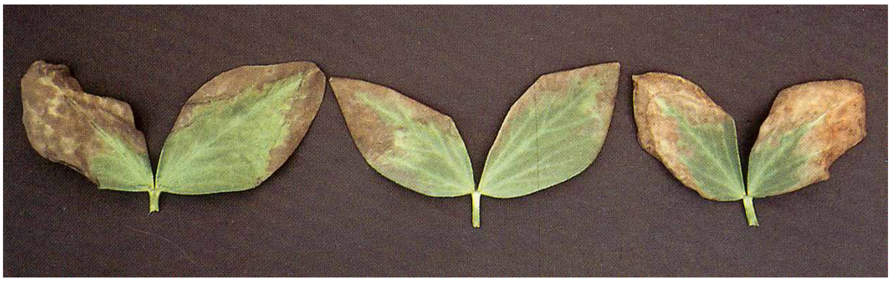

Photo 1: *Similarity of visual toxicity symptoms of manganese (left), boron (centre) and phosphorus (right) in old and middle-aged leaves of faba bean.*

Photo: A. Robson

5.2.4 Boron toxicity

Boron toxicity can occur on more alkaline soil types. The most characteristic symptom of boron toxicity in pulses is chlorosis (yellowing), and if severe, some necrosis (death) of leaf tips or margins (Photo 2). Older leaves are usually more affected. There appears to be little difference in reaction between current varieties of faba beans. [6]

5.2.5 Manganese toxicity

Manganese toxicity can occur in well-nodulated faba beans grown on soils of low pH.

Symptoms

Symptoms appear on new leaves first and can then develop in middle-aged and older leaves, the opposite to other toxicities such as Mn or P. Small purple spots appear from the margins on young leaves, and in slightly older leaves take on a reddish colouration (Photo 3).

6 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

Photo 2: *Manganese toxicity in young leaves (left) and in middle-aged leaves (right) of faba bean.*

Photos: A. Robson

5.2.6 Aluminium toxicity

Like Manganese toxicity, aluminium toxicity can also occur in faba beans that are grown in low pH soils.

Visual symptoms

There are no visual symptoms of Al toxicity in faba beans other than delayed germination and plants appearing miniature and dark green. Roots are extremely stunted, with many laterals appearing dead. Symptoms may be confused with P deficiency. [7]

FAQ

5.3 Fertiliser

5.3.1 Overview

Fertiliser recommendations should take into account:

- soil type
- rotation (fallow length and impact on arbuscular mycorrhizae fungi (AMF) levels)
- yield potential of the crop
- plant configuration (row spacing, type of opener and risk of seed burn)
- soil analysis results
- effectiveness of inoculation techniques

Faba beans have a high P requirement. Phosphorus should be applied at rates of at least 12 and up to 22 kg/ha.

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

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

Faba beans appear more susceptible to K deficiency than other pulses such as field peas, and especially lupins.

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

Excessive applied N will restrict nodulation and reduce N_2 fixation. High background levels of soil N can have similar effects or delay nodulation until N levels are depleted.

7 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

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 included
- MAP (also known as 11:23:0 and Starter 12)

Alkaline fertilisers include:

- DAP (also known as 18:20:0)
- starter NP
- lime [8]

5.3.2 Pulses and fertiliser toxicity

Practically all fertilisers are capable of causing damage to germinating seeds if they are in close proximity to each other and in a concentrated band. [9]

Drilling 10 kg/ha of P with the seed at 18-cm row spacing through 10-cm points rarely causes problems. However, changes in sowing techniques to narrow sowing points or disc-seeders with minimal soil disturbance, and wider row spacing, have increased rates of fertiliser (all of which concentrate the fertiliser near the seed in the seeding furrow) and increase the risk of toxicity.

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

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 of N at 18-cm row spacing. [10]

5.3.3 Nitrogen

Fertilisation with N is unnecessary for faba beans, because the crop can meet its N needs through biological N_2 fixation in nodules formed on the roots, unless a nodulation failure has occurred.

Soil nitrate levels greatly affect legume nodulation and N_2 fixation. At low nitrate levels of <50 kg N/ha in the top 1.2 m of soil, the legume's reliance on N_2 fixation is generally high. As soil nitrate levels increase, legume nodulation and N_2 fixation become increasingly suppressed.

Deficiency symptoms

First sign of N deficiency in faba beans is a general paleness of the whole plant, even before a reduction in plant growth. There may be a cupping of the middle-aged to new leaves. With time, a mottled chlorosis of old leaves slowly develops with little sign of necrosis (Photo 4).

Check for nodulation and for whether nodules are fixing N_2 (nodule colour), to confirm suspected N deficiency from visual plant symptoms. [11]

8 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

9 GRDC (2011) Fertiliser Toxicity Fact sheet. https://grdc.com.au/Resources/Factsheets/2011/05/Fertiliser-Toxicity

10 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

11 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

Photo 3: *Nitrogen deficiency: plants show signs of stunting, yellowing and poor growth relative to well-nodulated plants. Check nodulation and internal nodule colour to confirm nodulation failure and deficiency.*

Photo: W. Hawthorne, Pulse Australia

Some situations where N fertiliser may warrant consideration include:

- The grower is unwilling to adopt recommended inoculation procedures.
- Late or low-fertility situations, where rapid early growth is critical in achieving adequate height and sufficient biomass to support a reasonable grain yield (Table 6).

Faba bean grain contains about 40 kg N/t.

Table 4: *Nitrogen balance.*

Total plant dry matter (t/ha)	Total shoot dry matter yield (t/ha)	Grain yield (t/ha) 40% HI	Total crop nitrogen requirement (2.3% N) kg/ha	Nitrogen removal in grain (kg/ha)
1.75	1.25	0.5	40	17
3.50	2.50	1.0	80	33
5.25	3.75	1.5	120	50
7.00	5.00	2.0	160	66
8.75	6.25	2.5	200	83
10.50	7.50	3.0	240	100

HI, Grain harvest index—grain yield as a percentage of total shoot dry matter production (averages ~40%

5.3.4 Phosphorus

Deficiency symptoms

Symptoms of P deficiency take time to develop because of initial seed reserves of P. When symptoms start to appear, large differences in growth are apparent and the plant has smaller leaves compared with P-adequate plants. Visual symptoms appear first on the oldest pair of leaves as a mildly mottled chlorosis over much of the leaf.

MORE INFORMATION

L Barton, C Scanlon and F Hoyle (2016) Where does the nitrogen go? Soil sources and sinks in Western Australia cropping soils. GRDC Research Update.

GRDC (2012) Crop nutrition phosphorus management. Fact sheet.

These symptoms could be confused with N or S deficiency, but middle-aged and new leaves remain a healthy green, so the whole plant does not appear pale.

As symptoms on old leaves develop, round purple spots may appear within areas of dark green in an otherwise mildly chlorotic leaf (Photo 5).

Faba beans are very responsive to P fertiliser, but Zn status must be adequate to achieve a P response. [12]

Photo 4: *Symptoms of phosphorus deficiency in old leaves of faba bean. Note the spotting within darker green areas of an otherwise mildly chlorotic leaf.*

Photo: A. Robson

5.3.5 Potassium

Deficiency symptoms

Older leaflets show symptoms first, and initially growth is stunted compared with other parts of the paddock, e.g. in old stubble rows. Older leaves show a slight curling and then a distinct greying of leaf margins, eventually dying.

12 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

Photo 5: *Potassium deficiency in faba bean (left and middle), alongside a plant with adequate K taken from the same paddock but from within old stubble rows left by the harvester when taking off previous cereal crop. Note the necrosis of leaf margins and purple blotching.*

Photo: W. Hawthorne, Pulse Australia

Photo 6: *Potassium deficiency in faba beans. Note loss of lower leaves and general poorer height and vigour compared with K-adequate plants.*

Photo: W. Hawthorne, Pulse Australia

Responses to K are unlikely on most stronger soils but should be based on soil analysis.

Fertiliser responses are likely where soil test levels using the ammonium acetate test fall below:

- 0.25 cmol(+)/kg of exchangeable K on black earths and grey clays
- 0.40 cmol(+)/kg of exchangeable K on red earths and sandy soils

Applying 20–40 kg/ha K banded 5 cm to the side of, and below the seed line, is recommended where soil test levels are critically low. [13]

5.3.6 Sulfur

Deficiency symptoms

Youngest leaves turn yellow, and plants are slender and small (Photo 9).

Photo 7: *Sulfur deficiency in faba beans shows up as chlorosis of leaf edges (left photo) and can progress to necrosis within those chlorotic areas (right photo).*

Photos: A. Robson

5.3.7 Zinc

Faba beans are very responsive to Zn fertiliser, but P status must be adequate to achieve a Zn response.

Deficiency symptoms

Plants are small; the areas between veins turn yellow, becoming yellower on the lowest leaves. Maturity can be delayed (see Photos 10 and 11).

Faba beans have a relatively high demand for Zn, but have evolved highly efficient mechanisms for extracting Zn from the soil.

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

There is a lack of Australian and overseas research on Zn responses in faba bean. Zn fertiliser recommendations are conservatively based on a general recommendation used for all crops, based on DTPA analysis of soil samples 0–10 cm:

- <0.8 mg/kg on alkaline soils
- <0.3 mg/kg on acid soils

Arbuscular mycorrhizal fungi (AMF) can be extremely important to Zn nutrition in faba beans, and responses can be expected in situations where AMF levels have become depleted after long fallows (8–10 months).

Pre-plant treatments

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

13 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

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 zinc sulfate monohydrate may be not fully effective and a foliar Zn spray may also be required.

Foliar zinc sprays can correct a mild zinc deficiency if applied within the first 6-8 weeks of emergence.

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

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

Photo 8: *Zinc-deficient faba beans (far left and centre right) are paler and poorer in growth than those with adequate Zn applied (centre left).*

Photo: Grain Legume Handbook, 2008

Photo 9: *Zinc-deficient middle-aged leaves of faba bean (right).*

Photo: A. Robson

5.3.8 Iron

Iron (Fe) deficiency can be confused with Mn and Mg deficiency. Iron is strongly immobile in plants.

Deficiency symptoms

Yellowing between leaf veins can progress to completely yellow plants (Photo 12). Contrast in colour between old and new leaves is much stronger with Fe deficiency than with Mn deficiency.

Photo 10: *Bean varieties have different tolerances to Iron deficiency. Aquadulce (between the pegs) is more tolerant, but not immune compared to many other faba beans (e.g. left).*

Photo: Grain Legume Handbook, 2008

Occurrence

Iron deficiency is observed occasionally on alkaline (high pH) soils. It is usually associated with a waterlogging event following heavy rainfall, and is attributed to interference with Fe absorption and translocation to the foliage.

Symptoms include a general yellowing of young leaves, which can develop in severe cases to distortion, necrosis and shedding of terminal leaflets (pinnae).

A mixture of 1 kg/ha of iron sulfate + 2.5 kg/ha of crystalline sulfate of ammonia (not prilled) + 200 mL non-ionic wetter/100 L water has been successfully used to correct Fe deficiency.

The addition of sulfate of ammonia will improve absorption of Fe, with a significantly better overall response.

Cultivars exhibit marked differences in sensitivity to iron chlorosis, and major problems with Fe deficiency have largely been overcome through the efforts of the plant breeders. Most current varieties are considered tolerant to all but extreme situations.

Iron deficiency symptoms tend to be transient, with the crop making a rapid recovery once the soil begins to dry out. [14]

MORE INFORMATION

For detailed descriptions and images of nutrient deficiencies, see Faba beans: The Ute Guide', available from the GRDC bookshop on the GRDC website.

14 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

5.3.9 Manganese

Deficiency symptoms

Deficiency appears in new leaves, which first show mild chlorosis, followed by small dead spots or purple spotting at each side of the mid-rib and lateral veins. The leaves can turn yellow and die.

Some plants may have only a few brown spots on unopened new growth, whereas in other plants symptoms may extend to middle-aged leaves and range from blackened tops of leaves and new growth to purple necrosis over much of the leaf (Photo 13).

Photo 11: *Manganese-deficient faba bean new leaves as they are opening (right).*

Photo: A. Robson

5.3.10 Copper

Deficiency symptoms

Copper (Cu) deficiency does not appear until flowering; hence, there is little effect on vegetative growth. The first symptom of Cu deficiency is an apparent wilting and rolling of the leaflet ends of fully opened leaves. Wilting symptoms are followed by a partial opening of new leaflets, which in some cases appear puckered and kinked over towards the leaf ends. If the deficiency is severe, wilting of fully formed leaves develops into a withertip, as often seen in Cu-deficient wheat. The tips of each leaflet become pale green with a dried-up appearance, and then become twisted and necrotic (Photo 14).

Flowering is not delayed in faba bean as it is in field peas, and flowers appear quite normal, but few pods and seeds form. [15]

15 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

Photo 12: *Copper deficiency in faba beans -- new leaves (left) and fully opened leaves (right), both showing withertip.*

Photo: A. Robson

5.3.11 Molybdenum

Molybdenum (Mo) is an important trace element in faba bean growth. It is the least abundant of the trace elements in soils, and very little is present in forms available to plants. Sandy soils, and those which are inherently infertile in their natural state, e.g. soils low in P, are typically low in Mo. It can be deficient when the pH in the paddock is low.

Mo is important in N metabolism, and the synthesis of protein. Two important processes are:-

- the reduction of nitrate (NO3-) to nitrite (NO2-), the first step in the synthesis of amino acids and protein; and
- in root nodules in legumes, Rhizobium bacteria require Mo to fix atmospheric or molecular nitrogen (N_2). [16]

Deficiency symptoms

Leaves are pale green and mottled between veins, with brown scorched areas developing rapidly between the veins.

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

5.3.12 Boron

As with calcium, B has a dramatic effect on the root system of faba beans.

Deficiency symptoms

Roots become brown with lateral extremities showing shortening and thickening. The first leaf symptoms are a reduction in growth, with the development of a waxy look and a darkening of colour. This is followed by a folding back of these leaves in an umbrella fashion, leaving the leaflet folded over and twisted. Stem internode length is shortened. As the deficiency progresses, middle-aged leaves develop a mottled chlorosis that forms between the veins (Photo 15).

16 Incitec Pivot Fertilisers (2016) Molybdenum. http://www.incitecpivotfertilisers.com.au/News/Nutrient%20Facts/Molybdenum

Photo 13: *Boron-adequate left on left, with B-deficient leaves (older to youngest, left to right) of faba bean.*

Photo: A. Robson

As B becomes deficient, the vegetative growing point of the affected plant becomes stunted or deformed, or disappears altogether. When this occurs, apical dominance of the growing point ceases to exert control over lateral shoot development. Thus, a proliferation of side shoots can occur resulting in a 'witches broom' condition. Deformed flowers are a common symptom of B deficiency. Many plants may respond by reducing flowering and pollinating improperly, as well as developing thickened, curled, wilted and chlorotic new growth. [17]

5.4 Arbuscular mycorrhizae fungi

The symbiotic relationships between some soil fungi and plant roots are known as arbuscular mycorrhizae (AM) or arbuscular mycorrhizal fungus (AMF). These can help plants to take up nutrients such as P and Zn from the soil and from fertiliser. AMF colonises and builds up on the faba bean root system. The fungi produce hyphae that colonise the root and then grow out into the soil (much further than root hairs do). Phosphorus and Zn are taken up by the hyphae and transported back for use by the plant.

Crops vary in their AM dependency and crops such as faba beans, chickpeas, safflower and linseed have a high AM dependency and promote AM build-up. Winter cereals and field peas are less AM-dependent, but do allow AM to build up. Canola and lupins, and paddocks under extended fallow, do not host AM, so AM levels are reduced under these crops in rotation.

Products containing AMF are available as seed treatments, often in association with other seed enhancers, which in combination can give the most potent means to ensure a highly successful AMF spore inoculation.

MORE INFORMATION

Seed Enhancer™VAM from Ferti-Tech Australia,

5.5 Nutrition effects on following crop

5.5.1 Nitrogen

Legume growth is the major driver of legume N_2 fixation, the bulk of which occurs during pod-filling. Faba beans fix similar amounts of N to field peas (110kg/ha N compared to 105kg/ha N) while lupins fix 130kg/ha N (Table 5).

17 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.

Table 5: *Estimates of the amounts of N_2 fixed annually by crop legumes in Australia.*

Legume	%Ndfa	Shoot DM[1] (t/ha)	Shoot N (kg/ha)	Root N_2 (kg/ha)	Total crop N (kg/ha)	Total N fixed[3] (kg/ha)
Soybeans	48	10.8	250	123	373	180
Lupins	75	5.0	125	51	176	130
Faba beans	65	4.3	122	50	172	110
Field peas	66	4.8	115	47	162	105
Peanuts	36	6.8	190	78	268	95
Chickpeas	41	5.0	85	85	170	70
Lentils	60	2.6	68	28	96	58
Mungbeans	31	3.5	77	32	109	34
Navy beans	20	4.2	105	43	148	30

%Ndfa, % of legume N derived from N_2 fixation

1 DM = dry matter
2 Root N = shoot N x 0.5 (soybeans), 1.0 (chickpeas) or 0.4 (remainder)
3 Total N fixed = %Ndfa x total crop N

Source: Primarily Unkovich et al. 2010; D Herridge 2013.

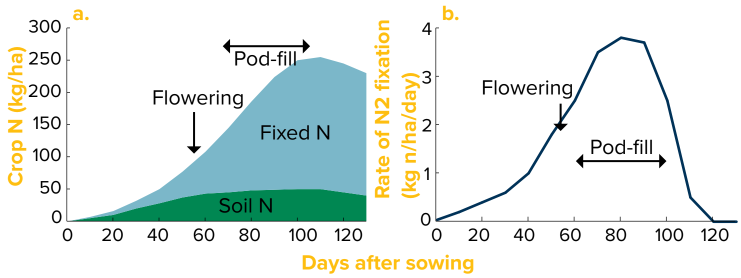

Figure 1: *Typical patterns of nitrogen accumulation and N2 fixation by annual crop legumes. In (a), total crop N is shown to have two sources, soil N and fixed N, and the bulk of N accretion occurs after flowering. In (b), rates of N2 fixation are shown to peak at 4 kg/ha N per day during mid-podfill, then decline as the crop matures.*

Source: D Herridge 2013

Benefits of nitrogen fixation

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

The N available to the cereal is a combination of the N mineralised as part of the decomposition of legume residues and soil humus, and from applied fertiliser N. A fourth source of N is the mineral N not used by the legume during its growth, but spared. The residue N that is not released as mineral N remains in the soil as organic matter (Figure 3).

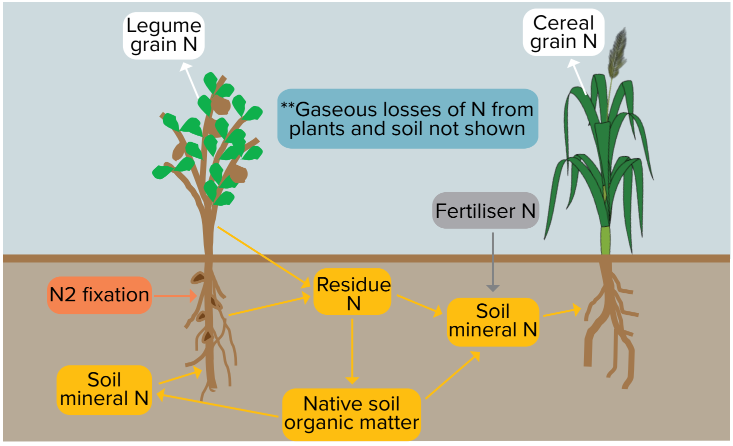

Figure 2: *Nitrogen cycling through a grain legume to the following cereal crop. Gaseous losses of N are not shown, nor are potential leaching losses. All of the flows of N are facilitated by the action of the soil biota.*

Source: D Herridge 2013

Researchers believe that in lupin-growing areas of WA, N fixed by lupins supplies the plants own requirements in addition to enough N for a 1.0t/ha cereal crop.

Cereals grown after crop legumes commonly yield 0.5–1.5 t/ha grain more than cereals grown after cereals that had not had fertiliser N applied. To generate equivalent yields in the cereal–cereal sequence, research has also shown that 40–100 kg/ha fertiliser N needs to be applied. [18]

MORE INFORMATION

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

18 Pulse Breeding Australia (2013) Southern/Western Faba & Broad Bean–Best Management Practices Training Course Module 4–General Agronomy.