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GRAINS RESEARCH & DEVELOPMENT CORPORATION

# LENTIL

## SECTION 7

## NUTRITION AND FERTILISER

KEY POINTS | ESSENTIAL NUTRIENTS FOR PLANTS | CONSIDERATIONS WHEN DIAGNOSING NUTRIENT DISORDERS | SOIL AND PLANT TISSUE TESTING | NITROGEN (N) | PHOSPHORUS (P) | POTASSIUM (K) | CALCIUM, MAGNESIUM AND SULFUR | BORON | COPPER (CU) | IRON (FE) | MANGANESE (MN) | MOLYBDENUM (MO) | ZINC (ZN) | LIME | COBALT (CO) | SOIL PH AND TOXICITIES | DETERMINING FERTILISER REQUIREMENTS | NUTRIENT BUDGETING | NUTRITION REQUIREMENTS OF LENTIL | KEYS FOR SUCCESSFUL UPTAKE OF NUTRIENTS BY LENTIL

# Nutrition and fertiliser

## Key points

- **Lentil nutrition requirements are similar to other pulses.**
- **Lentil is generally responsive to phosphorus and some trace elements (managnese and zinc in particular).**
- **Lentil can benefit from nitrogen at sowing if following a 'nitrogen-hungry' crop like cereal or canola.**
- **Symptoms of nutrient deficiency in lentil appear to be similar to the other pulses.**
- **Soil must be moist to allow roots to take up and transport nutrients.**
- **Soil pH influences the availability of most nutrients.**
- **Soil temperature must lie within a certain range for nutrient uptake to occur.**

## 7.1 Essential nutrients for plants

There are 16 nutrients that are essential for the healthy growth of all plants. They are classified as mineral nutrients and non-mineral nutrients.

**Non-mineral nutrients** are carbon (C), hydrogen (H) and oxygen (O). These nutrients are found in the atmosphere and water and used in the process of photosynthesis. The main product of photosynthesis is carbohydrate (as well as oxygen and water, to a lesser extent); it is carbohydrate that drives the growth and development of plants.

**Mineral nutrients** are absorbed by plants from the soil. Mineral nutrients can be classed as either macronutrients or micronutrients.

**Table 1:** The classification of mineral nutrients.

| Macronutrients | Micronutrients |
|---|---|
| Nitrogen (N) | Boron (B) |
| Phosphorus (P) | Chlorine (Cl) |
| Potassium (K) | Copper (Cu) |
| Calcium (Ca) | Iron (Fe) |
| Magnesium (Mg) | Manganese (Mn) |
| Sulfur (S) | Molybdenum (Mo) |
| | Zinc (Zn) |

Source: CSIRO Publishing, 2006, Australian Soil Fertility Manual

Five other elements are also essential to plant growth. These are sodium (Na), cobalt (Co), silicon (Si), nickel (Ni) and vanadium (Va). These nutrients are almost never found to be deficient in the soil; problems with these elements are generally due to toxicity and not deficiency.[1]

### Macronutrients

Macronutrients are those elements that are needed in relatively large amounts. Nitrogen, phosphorus and potassium are classed as primary macronutrients and calcium, magnesium and sulfur are considered secondary macronutrients.

Macronutrients are used in the greatest quantity by plants and usually become deficient first.

High yields of crops for grain or forage will place greater demand on the availability of major nutrients such as phosphorus, potassium and sulfur. Nitrogen, phosphorus and, at times, sulfur are the main nutrients that are commonly lacking in Australian soils. Other nutrients can be lacking under certain conditions. Each crop type is different in its requirement for nutrients and may display different symptoms indicating this requirement.

### Micronutrients

Micronutrients are those elements that plants need in small amounts such as iron, boron, manganese, zinc, copper, chlorine and molybdenum.

1 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing

### A healthy plant

Healthy plants have a greater potential to ward off disease, pests, and environmental stresses leading to higher yields and improved grain quality.

Too little, too much, or the incorrect proportion of nutrients, can cause nutritional problems in lentil. If the condition is extreme, plants will show visible symptoms that can sometimes be identified. Visual diagnostic symptoms are readily obtained and provide an immediate evaluation of nutrient status. Visual symptoms do not develop until a major effect on yield, growth or development has occurred. Unfortunately, damage can be done before there is visual evidence.

## 7.2 Considerations when diagnosing nutrient disorders

There is limited nutritional information about lentil in Australia. However, lentil nutrition is like other pulses in that crop is generally is generally responsive to phosphorus and sulfur. It can require nitrogen at sowing if following a 'nitrogen hungry' crop like cereals or canola.

Symptoms of nutrient deficiency appear to be similar to the other pulses.[2]

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 lentil 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.
- 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.

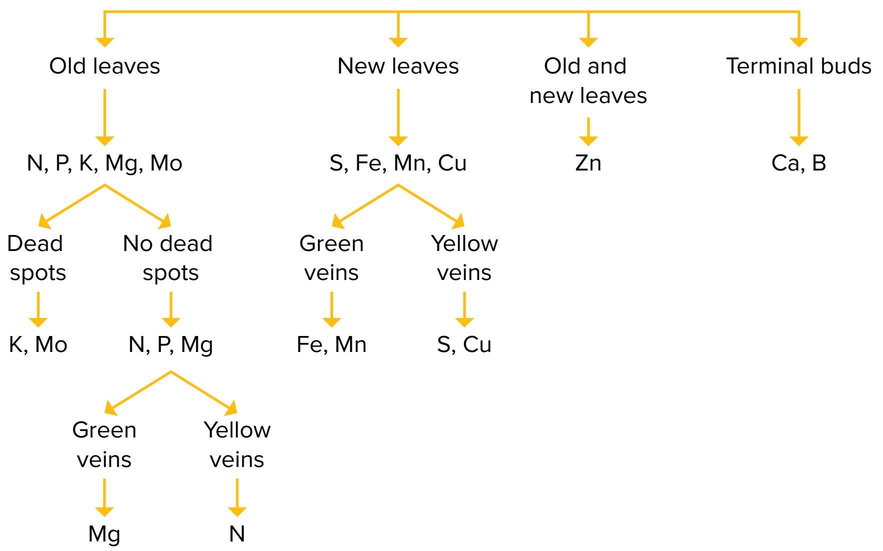


**Figure 1:** *Flow chart for the identification of deficiency symptoms.*[3]

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

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

### Identifying nutrient deficiencies

To differentiate between nutrient deficiency symptoms that appear similar, the following should be undertaken:

- know what a healthy plant looks like in order to recognise symptoms of distress;
- the affected area of the crop needs to be identified and its appearance noted. For example, plants should be checked for discolouration (yellow, red, brown etc), death (necrotic), wilted or stunted etc.;
- the pattern of symptoms in the paddock needs to be identified (patches, scattered plants, crop perimeters);
- affected areas need to be assessed in relation to soil type (pH, colour, texture) or elevation; and
- individual plants need to be examined closely to identify 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' a nutrient deficiency.

If two nutrients are simultaneously deficient, symptoms may differ to when there is one nutrient deficiency alone.

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

Table 2 highlights symptoms of key nutrient deficiencies.

FEEDBACK

**Table 2:** Key to nutrient deficiencies in field pea that may be applicable to lentil.

| Symptom | Old to middle leaves | | | | | Middle to new leaves | | | | | New leaves to terminal shoots | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Deficiency** | **N** | **P** | **K** | **Mg** | **Zn** | **N** | **Zn** | **Ca** | **Mn** | **B** | **S** | **Mg** | **Mn** | **Fe** | **Cu** | **Ca** | **B** |
| **Chlorosis (yellowing)** | | | | | | | | | | | | | | | | | |
| Complete | | | | | | | | | | | x | | | x | | | |
| Mottled | x | x | | x | | | x | x | x | | | | x | | | | |
| Interveinal | | | | | | | | | | x | | | x | | | | |
| Cresent form | | | | | | | | x | | | | | | | | | |
| **Nercosis (tissue death)** | | | | | | | | | | | | | | | | | |
| Complete | | | x | | x | | | | | | | | | | | | x |
| Distinct areas (including spotting) | x | | x | x | | | x | | | | x | x | x | | | | |
| Margins | | x | x | | x | x | | | | x | | | | | | | x |
| Tips | | x | | | x | x | | x | | | x | | x | x | x | | x |
| **Pigmentation within necrotic (yellow) or chlorotic (dead) areas** | | | | | | | | | | | | | | | | | |
| Opaque | | | | | | | | | | | | | | x | | | |
| Light brown | | | | | x | x | | | | | x | | x | | | | |
| Brown | | x | | | | | | x | | | | | | | | | |
| Pink | | | x | x | | | x | x | | | | x | | x | | | |
| **Malformation of leaflets** | | | | | | | | | | | | | | | | | |
| Rolling in of margin | | | x | x | | | | | | | | | x | x | | | |
| Wilting | | | | | x | x | | | | | | | | | x | | |
| Twisting | | x | | | | | | x | | | | | | | | x | |
| Puckering | | | | | | | | | | | | | x | | x | | |
| **Malformation of leaves** | | | | | | | | | | | | | | | | | |
| Cupping | | | | | | | x | | | | | | | | | | |
| Rosetting | | | | | | | x | | | | | | | | | | x |
| Tendril distortion | | | | | x | | | | | | | x | x | | | | x |
| Internode shortening | | x | | | | | x | | | | | | | | | | x |
| Stem lesions | | | | | | | x | | | | | | | | | | x |
| Petiole collapse | | | | | | | | | | | | | | | | x | |
| Root distortion | | | | | | | | x | | x | | | | | | x | x |

Source: Symptoms of nutrient deficiencies, (1991), Soil Science and Plant Nutrition, School of Agriculture, University of Western Australia, http://trove.nla.gov.au/work/20308916

FEEDBACK

MORE INFORMATION

For more about DGT-P, see: http://soilquality.org.au/factsheets/dgt-phosphorus

## 7.3 Soil and plant tissue testing

Soil or plant tissue tests provide information on nutrients that are present and the level of concentration. They also show critical nutrient levels required for that crop type and whether the plant will or will not respond to that nutrient.

Pulse crops can have different requirements for critical nutrients levels, meaning test results for one crop are not necessary correct for another crop type.[4]

Plant tissue testing can be used to diagnose a deficiency or monitor the general health of the pulse crop.

Tissue tests are useful for identifying what is causing plant symptoms being expressed by plants but not readily identified. This is important because by the time noticeable symptoms appear in a crop, the yield potential can be markedly reduced. Technology is enabling quicker analysis and results reporting, which enables foliar or soil-applied remedies to be applied in a timely manner for a quick crop response.

Plant tissue tests are very useful when fine-tuning nutrient requirements, particularly when aiming to fully capitalise on available moisture. Diffuse Gradient Technology Phospohorus (DGT-P) is a relatively new method being tested for use with Australian soils, and mimics the action of the plant roots in access. However, there are no published DGT-P levels for lentil.

Most plant tissue tests diagnose the nutrient status of the plant at the time it is sampled. Results cannot reliably indicate the effect of a particular deficiency on grain yield.

**Table 3:** Adequate levels for various soil test results.

| **Nutrient** | | **Test used** | |
|---|---|---|---|
| **Phosphorus** | | | |
| | **Colwell P*** | **Olsen P*** | |
| Sand | 20–30 | 10–15 | |
| Loam | 25–35 | 12–17 | |
| Clay | 35–45 | 17–23 | |
| **Potassium** | | | |
| | **Bi-carb**** | **Skene**** | **Exchangeable K** |
| Sand | 50 | 50–100 | Not applicable |
| Other soils | 100 | - | 0.25 me/100g |
| Sandy loam | - | - | - |
| - Faba bean | 100–120 | - | - |
| - Field pea | 70–80 | - | - |
| - Lupin | 30–40 | - | - |
| - Canola | 40 | - | - |
| - Cereals | 30 | - | - |
| **Sulfur***** | | | |
| | **KCl** | | |
| Low | 5 ppm | | |
| Adequate | 8 ppm | | |

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

Notes: *Colwell P or Olsen P are measured in mg/kg. , **Potassium Bi-carb and Skene are mg/kg or exchangeable K as milliequivalents per 100g of soil (meq/100g). ***For Sulphur The Kcl test reports in mg/kg (in this case ppm = mg/kg)

MORE INFORMATION

Refer to: *Lentils: The Ute Guide* for detailed descriptions and images of nutrient deficiencies. Available from the GRDC book shop on the GRDC website: https://grdc.com.au/Resources/Apps

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

## 7.4 Nitrogen (N)

Nitrogen is essential for plant growth as it is a part of every living cell. Plants require large amounts of nitrogen for normal growth and development.

Lentil should not normally need nitrogen fertiliser if the plant has achieved effective nodulation.[5]

Lentil seed should be inoculated with the correct strain of rhizobia, particularly when:

- lentil has not been grown in a paddock for five or more years; or
- the soil pH is less than 5.7.

Lentil does take up residual soil nitrates (nitrogen not used by the preceding crops). This, therefore, reduces the potential for nitrogen losses by leaching. Leaching is the loss of nitrogen due to it being washed down with water into the soil profile below the plant root zone meaning it is unable to be accessed by the plant. Thus, in some countries where it is important, growing lentil can have a positive impact on groundwater quality due to reduced leaching.[6]

**MORE INFORMATION**

See Section 3: Pre-planting for more information on inoculation.

### Deficiency symptoms

The first sign of nitrogen deficiency in lentil is the appearance of overall 'paleness' of the plant. This will occur 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 (plant death).

If, based on visual plant symptoms, nitrogen deficiency is suspected, the next step is to check the nodules of the plant. Nodules should be healthy and plentiful.

**MORE INFORMATION**

See Section 6: Plant growth and physiology

**Photo 1:** *Nitrogen deficiency (left) relative to a well-nodulated plant (right).*

Photo: ICARDA

5 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

6 R Mahler (2005) Northern Idaho Fertilizer Guide: Lentils. University of Idaho, CIS1083, http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1083.pdf

**Photo 2:** *In nitrogen deficiency the plant shows signs of stunting, yellowing and poor growth.*

Photo: C. Toker

**Photo 3:** *In nitrogen deficiency the plant shows signs of stunting, yellowing and poor growth.*

Photo: W. Hawthorne, formerly Pulse Australia

Some situations where nitrogen fertiliser may warrant consideration include:

- when recommended inoculation procedures have not occurred; and
- late sowing or low fertility situations where rapid early growth is critical for achieving adequate height and sufficient biomass to support a reasonable grain yield.

Table 4 shows the harvest index for lentil. Harvest index is the yield of a crop versus the total amount of biomass produced. Harvest index varies with crop types and is a factor that is targeted in plant breeding programs. The table highlights that for one tonne per hectare of lentil biomass, 33kg/ha of nitrogen will be removed in grain, and, overall, the total crop nitrogen requirement is 80 kg/ha.

**Table 4:** Harvest index and nitrogen requirements for lentil.

| 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 | 40 |
| 7.00 | 5.00 | 2.0 | 160 | 66 |
| 8.75 | 6.25 | 2.5 | 200 | 83 |
| 10.50 | 7.50 | 3.0 | 240 | 100 |

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

### Application

The use of starter nitrogen (e.g. daimmonium phosphate, or DAP), banded with the seed (i.e. sown with seed, but without touching the seed) when sowing pulse crops has the potential to reduce establishment and nodulation if high rates are used. Hence, caution needs to be taken with rates of application.

## 7.5 Phosphorus (P)

Phosphorus is essential for many growth processes in plants. Soil phosphorus levels influence the rate of nodule growth. The higher the phosphorus level the greater the nodule growth. Adequate phosphorus is essential for seed germination, root development and in the ripening process of grain (and seed).

### Deficiency symptoms

Phosphorus deficiency is usually denoted by a stunted plant: small leaf size and leaf colour.

Symptoms of phosphorus deficiency may take time to develop due to the initial reserves of phosphorus in the seeds still supporting the plant. When symptoms do start to appear, they may sometimes appear similar to that of a plant with adequate levels of phosphorus.

Visual symptoms appear first on the oldest leaves as a mildly mottled chlorosis over much of the leaf. These symptoms might be confused with either nitrogen or sulfur deficiency. However, the middle and new leaves remain a healthy green, meaning the plant overall 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.

FEEDBACK

## MORE INFORMATION

Further information on arbuscular mycorrhiza can be found at: https://grdc.com.au/resources-and-publications/groundcover/ground-cover-supplements/gcs96/phosphorus-uptake-and-mycorrhizal-colonisation-what-is-the-link

It is important to note that lentil is deemed medium in its responsiveness to phosphorus fertiliser. However, zinc status must be adequate to achieve a response to phosphorus.[7]

Arbuscular mycorrhiza (AM) is a fungi involved in a symbiotic relationship with plant roots. AM assists plants in taking up nutrients such as phosphorus, zinc and copper from both the soil and fertiliser. In Australia, there is little recognition of the need for AM in lentil.[8]

### Lentil requirements

Phosphorus requirements can be established with a soil test and appropriate rates of required fertiliser determined (Table 5).

**Table 5:** Phosphorus fertiliser rates for lentil.

| Soil test P (0–12 inches/30.5 cm)[1] | | | Application rate[2] | |
|---|---|---|---|---|
| NaOAc (ppm) | Bray I (ppm) | $NaHCO_3$ (ppm) | $P_2O_5$ (kg/ha) | P (kg/ha) |
| 0 to 2 | 0 to 20 | 0 to 8 | 56 | 25 |
| 2 to 3 | 20 to 30 | 8 to 10 | 34 | 15 |
| 3 to 4 | 30 to 40 | 10 to 12 | 11 | 6 |
| over 4 | over 40 | over 12 | 0 | 0 |

1. Soil test P can be determined by three different procedures: sodium acetate (NaOAc), Bray I method or sodium bicarbonate ($NaHCO_3$). Sodium bicarbonate should not be used on soils with pH values less than 6.2.

2. $P_2O_5$ x 0.44 = P, or P x 2.29 = $P_2O_5$

Source: Northern Idaho Fertilizer Guide: Lentils (2005), University of Idaho, http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1083.pdf

### Application

Lentil has a reasonably high phosphorus requirement.

Phosphorus can be incorporated into the seedbed by whatever method is most convenient for the grower. Acceptable methods include:

- broadcast (scatter) and plough-down or disc-in;
- band (direct placement around 2.5 cm below the seed); and
- drill (sow) with seed (without allowing direct contact with the seed if fertiliser contains nutrients other than phosphorus).

Germinating lentil is extremely sensitive to salts in fertilisers containing nitrogen, potassium and sulfur. If heavy phosphorus applications are required to correct nutrient deficiencies, fertiliser (containing salts) should be applied before or during seedbed preparation to prevent potential damage to the lentil seedling.[9]

Starter fertilisers (phosphorus and nitrogen) have been recorded as most effective when soils are cold. This results in root growth being stimulated by a readily available supply of phosphorus. Banding fertiliser improves efficiency of phosphorus uptake. Consequently, if applying phosphorus in a band, the recommended rate of fertiliser can be reduced by 10–15%.[10]

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. This, in turn, increases the risk of toxicity.

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

8 A Smith, S Smith, M Manjarrez (2012) Phosphorus uptake and mycorrhizal colonisation: what is the link? Grains Research and Development Corporation, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-96-Supplement-Soil-Biology-Initiative/Phosphorus-uptake-and-mycorrhizal-colonisation-what-is-the-link

9 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

10 R Mahler (2005) Northern Idaho Fertilizer Guide: Lentils. University of Idaho, CIS1083, http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1083.pdf

## 7.6 Potassium (K)

Potassium is one of the three primary macronutrients. It is required by plants in greater quantities than phosphorus.[11]

### Deficiency symptoms

When suffering from potassium deficiency, older leaflets of the plant show symptoms first. Initially growth is stunted compared with other parts of the paddock. Margins and tips of leaflets lose their green colour and become yellow-green. Reddish pigmentation is also seen on some leaflets. These leaflets often drop from the plant.

Symptoms progress up the plant when deficiency persists. Necrotic patches may develop on leaflets. Stems of some plants may also develop reddish-brown anthocyanin pigmentation (blue, violet or red pigment found in plants). Older leaves may show slight curling and then a distinct browning of leaf margins before eventually dying.[12]

### Lentil requirements

Lentil appears to be similar to other pulses, like field pea and especially lupin, that are less susceptible to potassium deficiency compared with faba bean, which is quite susceptible.

Potassium fertilisers on lentil may be warranted on occasional circumstances; however, it should be determined with a soil test (Table 6). Fertiliser responses are likely where soil test levels, using the ammonium acetate test, fall below critical levels (<70 parts per million).[13]

**Table 6:** Potassium fertiliser rates for lentil.[14]

| Soil test K (0–30cm)[1] (ppm) | Application rate[2] | |
|---|---|---|
| | $K_2O$ (kg/ha) | K (kg/ha) |
| 0–50 | 75 | 63 |
| 50–75 | 45 | 38 |
| >75 | 0 | 0 |

1 Sodium acetate-extractable K in the 0–30 cm depth.
2 $K_2O$ x 0.83 = K, or K x 1.20 = $K_2O$

### Application

Potassium can be incorporated into the seedbed by whatever method is most convenient for the grower. Acceptable methods include:

- broadcast (scatter) and plough-down or disc-in;
- band (direct placement around 2.5 cm below the seed); and
- drill (sow) with seed (without allowing direct contact with the seed if fertiliser contains salt-based nutrients other than phosphorus. Lentil seedlings are extremely sensitive to salts).

If heavy potassium applications are required to correct nutrient deficiencies, fertiliser should be applied post-emergent, otherwise before or during seedbed preparation.

11 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing

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

13 R Mahler (2005) Northern Idaho Fertilizer Guide: Lentils. University of Idaho, CIS1083, http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1083.pdf

14 R Mahler (2005) Northern Idaho Fertilizer Guide: Lentils. University of Idaho, CIS1083, http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1083.pdf

## 7.7 Calcium, magnesium and sulfur

Calcium, magnesium and sulfur are secondary macronutrients. They are as important to plant growth as the primary macronutrients.

Plants usually require less of these nutrients as fertiliser. Nutrient deficiencies of these three elements can depress plant growth as much as the primary macronutrients.[15]

### Calcium (Ca)

Calcium function is mainly in the leaves of the plant and as part of the cell walls. Calcium is important for root development and in developing growing points.

Calcium does not move freely from older to younger tissue, resulting in younger tissue always being lower in calcium content.

### Deficiency symptoms

Deficiencies are first shown at the tips of young shoots and are usually denoted by reduced plant height. In pulses, there is a broad yellowing of the leaves between the veins at the centre of the base of leaflets.[16] Also plant roots are less numerous, less branched, and the root tips are thickened.

### Magnesium (Mg)

Magnesium serves many functions in the plant. Magnesium is actively involved in photosynthesis. Magnesium and nitrogen are the only nutrients that are constituents of chlorophyll.[17]

### Deficiency symptoms

Magnesium is generally deficient in acid and sodic soils. Deficiency can occur in sandy and sandy loam soils.

In lentil, magnesium deficiency first appears on young leaves as a chlorosis (loss of chlorophyll meaning loss of green colour). This chlorosis can extend down the sides of the leaflets. The symptom on leaflets is yellow to yellow-green with a green area remaining around the central leaf vein.

Prevalence of magnesium deficiency results in light brown necrotic areas developing on the leaf tips or margins of the plant. The basal leaves usually remain green in severely affected plants. There is no evidence of anthocyanin pigmentation (blue, violet or red pigment) on magnesium deficient plants.

### Application

To enhance crop yields in a magnesium deficient scenario, magnesium oxide (MgO) can be applied.[18]

### Sulfur (S)

Sulfur is present in proteins, in some oils, and as sulphates. Without adequate sulfur, the lentil plant is unable to ‘fix’ enough atmospheric nitrogen to meet its needs.

Some forms of sulfur will acidify the soil (reduce soil pH). Superphosphate is acidic whereas gypsum (calcium sulfate) does not affect soil pH. Lighter, sandier soils, compared to heavier clays, will be more affected by sulfur due to less buffering capacity.[19]

15 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing

16 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

17 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing

18 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

19 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing

### Deficiency symptoms

Symptoms of sulfur-deficient plants can resemble those of nitrogen deficiency. Chlorosis (yellowing) on sulfur-deficient plants firstly affects the leaves near the top of the plant, while leaves near the base remain green.

With increased severity of sulfur deficiency, chlorosis extends over the entire plant. The pattern of chlorosis development enables the differentiation of sulfur deficiency compared to nitrogen deficiency. Some leaflets become completely yellow, wither and drop from the plant. Reddish-brown pigmentation can appear on the stems and leaves and the plants are slender and small.

Certain soil types are prone to sulfur deficiency, for example some basaltic, black earths. On these soils with marginal sulfur levels, deficiency is most likely to occur in double-crop situations where levels of available sulfur have become depleted to very low levels.[20]

### Lentil requirements

The need for sulfur is closely related to the amount of nitrogen available to the plant. This is because both nutrients are constituents of proteins and associated with the formation of chlorophyll.[21]

**Table 7:** Sulfur fertiliser requirements of lentil.

| Soil test S (0–12 inches/30.5 cm) | | S application rate |
|---|---|---|
| (ppm $SO_4$-S) | (ppm S) | (kg/ha) |
| 0–10 | 0–4 | 17 |
| >10 | >4 | 0 |

Source: Northern Idaho Fertilizer Guide: Lentils (2005), University of Idaho, http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1083.pdf

### Application

Soil sampling to a depth of 60 centimetres is the suggested procedure when soil testing for sulfur.

Where soil phosphate levels are adequate, an application of a low rate of gypsum is a cost-effective, long-term method of correcting sulfur deficiency.[22]

Granular sulfur fertiliser should be avoided on lentil as this form of sulfur becomes available too slowly for the plants' actual requirements.[23]

Granulated sulfate of ammonia is another effective option when low rates of nitrogen are also required by the plant.

20 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

21 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing

22 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

23 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

## 7.8 Boron

Boron is essential in the formation of new plant tissue: the growing points. It is also essential for effective nodulation and nitrogen fixation in pulses, and in satisfying rhizobial requirements.[24]

### Toxicity symptoms

Boron toxicity occurs on many of the alkaline soils of the southern cropping areas. Lentil is very vulnerable to boron toxicity, particularly as a seedling.[25]

Shallow (0–10 cm) and deep (10–90 cm) soil tests provide a good indication as to the suitability of soils (paddocks) for growing lentil. Soil testing will also provide an indication as to the impact boron (in toxic levels) might have on plant growth and rooting depth.

The most characteristic symptom of boron toxicity in lentil is chlorosis (yellowing) of the tip and serrated margins of leaflets, and the tip of stipules on lower leaves. Older leaves are usually most affected. Light brown necrotic patches occur and later develop on yellow areas. The necrotic areas expand to one-third of leaflets and, if severe, some withering, necrosis (death) of leaf tips or margins occurs. Leaflets can separate. Anthocyanin pigmentation (blue, violet or red pigment) does not appear with boron toxicity.

All current varieties of lentil are rated as intolerant or moderately intolerant of the high levels of boron that are associated with soil acidity and alkaline soil.[26] These slight differences in intolerance can be of practical significance for variety performance in the field.

**Photo 4:** *Boron toxicity in lentil showing typical leaf tip symptoms.*

Photo: M. Raynes, formerly Pulse Australia

24 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing

25 Grains Research and Development Corporation (2016) Lentils: The Ute Guide. Grains Research and Development Corporation, https://grdc.com.au/resources-and-publications/all-publications/publications/2008/11/lentils-the-ute-guide

26 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

**Photo 5:** *Boron toxicity in lentil.*

Photo: W. Hawthorne, formerly Pulse Australia

### Deficiency symptoms

Boron deficiency has a dramatic effect on the root system of lentil.

The first symptom on a boron-deficient plant is yellowing on the tip and margins of leaflets of young entire expanded leaves. This 'bronzing' effect is partially due to red-brown pigmentation on the upper surfaces of leaflet margins. The tips and margins of affected leaflets start to die and the terminal buds turn rusty brown in colour.

The young buds and leaflets die progressively from the tip. Thus, axillary bud development is enhanced. Plant roots are also stunted and thick, with dark tips like those occurring on calcium deficient plants. Roots become brown with lateral extremities showing shortening and thickening.

Deformed flowers are a common plant symptom of boron deficiency. Many plants may respond by reduced flowering and improper pollination as well as thickened, curled, wilted and chlorotic new growth.

### Application

Lentil grown in some circumstances can respond to boron applications. **It is always critical to consider that, as lentil is very vulnerable to boron toxicity, a correct deficiency diagnosis must be made before considering boron applications.**

Soil-applied boron fertiliser should always be broadcast, never banded.[27]

27 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

## 7.9 Copper (Cu)

Both copper and zinc deficiencies have a major effect on flowering and seed production. When very deficient, plant growth will also be affected.

Copper and zinc both have an important role in legume nodulation and nitrogen fixation. Copper has a role in cell wall constituents of plants.

### Lentil requirements

Lentil has a greater requirement for copper than chickpea. The critical concentration of copper in the youngest tissue of lentil is estimated as 4.6 mg copper per kilogram (2.6 mg cu/kg in chickpea).

### Deficiency symptoms

Symptoms of copper deficiency may not appear until flowering, hence there may be little effect on vegetative growth.

Copper-deficiency symptoms appear on the younger leaves of the plant, whilst the rest of the plant remains a normal green colour. Wilting and rolling of the leaflet ends of fully opened leaves becomes apparent.

The leaflets on the top leaves of each stem are smaller than usual. Plants produce small leaves with fewer leaflets on the young shoots. In these circumstances, leaves usually wither and appear rust-brown in colour. Shoot elongation is also reduced due to insufficient development of the terminal growing point.

Flowering may be delayed in lentil, as it is in field pea. Flowers can appear quite normal; however, few pods and seeds form.

## 7.10 Iron (Fe)

Iron is a catalyst in the formation of chlorophyll, and also acts as an oxygen carrier in the plant[28].

**Iron is strongly immobile in plants.**

Iron deficiency is observed occasionally on alkaline, high pH soils. It is usually associated with a waterlogging event, following irrigation or heavy rainfall.[29]

### Deficiency symptoms

Iron deficiency can be confused with manganese and magnesium deficiency. Lentil appears more prone to iron deficiency compared to faba and broad beans.

Due to iron being immobile, symptoms appear first on younger leaves at the top of the plant. These leaves become chlorotic (even bright yellow) over the entire leaf. The deficiency can spread to older leaves and new growth can cease. Stems become slender and shortened.

If the deficiency becomes more severe leaflets can wither and die; withering occurs from the leaf tip back towards the base.

Yellowing between leaf veins can progress to completely yellow plants (Photo 7). Contrast in colour between old and new leaves is much stronger with iron deficiency compared with that of manganese deficiency.

Iron chlorosis can be transient, with deficiency symptoms largely disappearing at a time coinciding with increases in soil temperature and day length during reproductive growth.

28 CSIRO Publishing 2006

29 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

Iron deficiency symptoms tend to be very transient. An iron deficient lentil crop can achieve a rapid recovery once the soil begins to dry out.[30]

## Application

Sulfate of ammonia improves absorption of iron and so should be considered in fertiliser applications to overcome iron deficiency.

Lentil varieties can exhibit a marked difference in sensitivity to iron chlorosis; this can be overcome through plant breeding. Most current lentil varieties are considered tolerant to all but extreme situations.

**Photo 6:** *Lentil suffering from waterlogging, not to be confused with iron deficiency.*

Photo: W. Hawthorne, formerly Pulse Australia

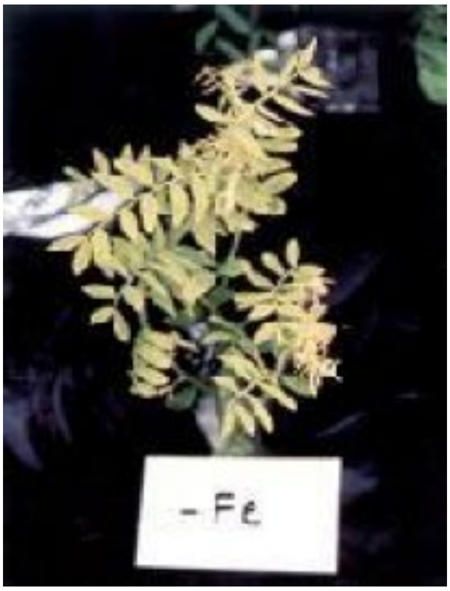


**Photo 7:** *Iron deficiency in lentil.*

Photo: ICARDA

30 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

**Photo 8:** *Iron deficiency in lentil.*

Photo: W. Hawthorne, formerly Pulse Australia

## 7.11 Manganese (Mn)

Manganese promotes germination and accelerates maturity of the plant. Furthermore, the presence of manganese increases the availability of phosphorus and calcium.[31]

### Toxicity symptoms

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

Symptoms appear on new leaves first and then develop in mid and older leaves. This is the opposite to toxicities such as phosphorus.

Small purple spots appear from the margins on young leaves (Photo 9) and in slightly older leaves take on a reddish colouration (Photo 11).

**Photo 9:** *Manganese toxicity.*

Photo: ICARDA

31 CSIRO Publishing (2006) Australian Soil Fertility Manual. CSIRO Publishing


**Photo 10:** *Manganese toxicity.*

Photo: ICARDA

## Deficiency symptoms

Manganese deficiency is usually associated with drier, fluffy soil conditions; for example, rolled areas or wheel tracks in a paddock may appear healthy whilst the remainder might show manganese deficiency.

Manganese deficiency has been observed occasionally on alkaline, high pH soils.

Manganese-deficient plants are a lighter green colour on younger expanded leaves. Very small spots can develop later on both the surface of leaflets and the stipules of these leaves. Spots are generally found between the leaflet veins on the leaf surface.

Manganese deficient plants often lose many of their leaflets. In some circumstances, symptoms can extend to the middle leaves. Colour ranges from browning on tops of leaves and new growth, to necrosis over much of the leaf.

Deficiency later in the growing season can lead to seeds being discoloured, split, deformed, or having a brown spot or cavity in the centre.

## Application

Manganese fertiliser can be applied at sowing on the seed, or as a foliar application later.

## 7.12 Molybdenum (Mo)

Molybdenum is required by rhizobia in root nodules and also for growth of the plant, particularly under acid soil conditions.

Molybdenum is often deficient in acid soils. Lentil grown on acid soils can respond to molybdenum fertiliser applications as it is present in the soil in only small amounts.

### Deficiency symptoms

Due to its role in nitrogen fixation, molybdenum deficiency causes symptoms of nitrogen deficiency.

Leaves of nitrogen-deficient plants are lighter yellow than those of molybdenum-deficient plants. Symptoms start with chlorotic interveinal mottling of older leaves. Leaves, flowers and pods are reduced, as well as biomass and yield.

In severe deficiency conditions, molybdenum causes leaf wilting and disorders. In addition to growth depression, there are fewer and smaller flowers, and many fail to open or mature. Again, this leads to lower grain yield.

Molybdenum-deficient plants may contain high nitrogen levels. The presence of high nitrogen in a chlorotic, apparently nitrogen-deficient plant, is thus evidence for molybdenum deficiency.

### Application

Soil testing to assess the molybdenum status of the soil is currently not commercially available. However, molybdenum can easily be applied to fertiliser (Mo Super) or as a liquid when planting the crop. It should not be applied to seed.

Molybdenum can be applied as a liquid (to soil or foliage), granular fertiliser inclusion, or as a seed treatment on lentil. When determining the rate of application soil pH needs to be considered. The history of the number of times lentil has been grown in that particular paddock also needs to be considered.

When applying molybdenum as a seed dressing, consideration needs to be given to rates, as higher rates can cause nitrogen-fixing bacteria to die.

## 7.13 Zinc (Zn)

Both zinc and copper are important in nodulation and nitrogen fixation in pulses.

Deficiencies in these two micronutrients have a major effect on flowering and seed production. When extremely deficient, plant growth can be affected.

On 'black' soils with a pH 8 or greater, zinc deficiencies can be caused by high phosphorus rates.[32]

### Deficiency symptoms

Zinc deficiency appears as a reduction in inter-nodal growth and results in a rosette growth habit. The younger leaves of zinc-deficient plants initially become pale green in colour. Pigmentation (reddish-brown) takes place on the margins of upper surfaces of leaflets and on the lower portions of the stems.

Plants are small. The areas between veins turn yellow, becoming yellower on the lowest leaves. Maturity can be delayed.

### Lentil requirements

There is a lack of Australian research on zinc responses in lentil. Lentil is considered to have a relatively medium demand for zinc. Lentil is efficient at extracting zinc from the soil as long as the phosphorus status adequate.

32 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

Zinc fertiliser recommendations for lentil are conservatively based on a general recommendation for all crops:

- <0.8 mg/kg on alkaline soils; and
- <0.3 mg/kg on acid soils.[33]

### Application

Zinc can be applied in numerous ways:

- incorporated into the soil prior to sowing;
- as a seed treatment;
- as a fertiliser at sowing; and
- as a foliar spray.

Severe zinc deficiency can be corrected for a period of 5–8 years with a soil application of zinc sulfate monohydrate. This fertiliser should be incorporated into the soil 3–4 months prior to sowing.

As zinc is not mobile in the soil, fertiliser application must result in even distribution over the soil surface, after which it can be thoroughly cultivated into the topsoil.

In the first year after application, this form of zinc may not be not fully effective; a foliar zinc spray may be required.

### Seed treatments

Zinc seed treatments may be a cost-effective option in situations where soil phosphorus levels are adequate but zinc levels are likely to be deficient.

### Fertilisers applied at sowing

A range of phosphate-based fertilisers either contain, or can be blended with, a zinc additive which can then be applied at sowing.

### Foliar zinc sprays

Foliar application of zinc is relatively common as this method often fits in with herbicide or early fungicide applications.

33 W Lindsay, W Norwell (1978) Development of a DTPA soil test for zinc, iron, manganese and copper. Proceedings from the Soil Science Society of America 42: 421-428, https://dl.sciencesocieties.org/publications/sssaj/abstracts/42/3/SS0420030421


**Photo 11:** *Zinc-deficient lentil.*

Photo: ICARDA

## 7.14 Lime

Lime is used to reduce acidity in soil (raise pH) and provide calcium.

If lentil is grown on acidic soils, lime applications may be necessary as lentil yield can be reduced on soils with a pH 5.4 or lower. A key limiting factor is poor nodulation on low pH soils that, consequently, limits lentil production. In some areas, growing lentil on low pH acidic soils may not be considered economical.[34]

## 7.15 Cobalt (Co)

Cobalt is essential for growth of the rhizobium and hence nodulation of pulses and fixation of atmospheric nitrogen. Cobalt is also important in animal nutrition.

Soil testing for cobalt is not commercially available. Consequently, the decision to apply cobalt fertiliser needs to be based on paddock history and soil pH.

Cobalt fertiliser is applied before or at sowing. It can be applied as a liquid to soil or as a granular inclusion in fertiliser.

## 7.16 Soil pH and toxicities

Soil pH influences the availability of most nutrients. Occasionally some nutrients are made so available that they inhibit plant growth. For example, on some acid soils, aluminium and manganese levels may restrict plant growth, usually by restricting the rhizobia, and hence, the plants ability to nodulate.

34 R Mahler (2005) Northern Idaho Fertilizer Guide: Lentils. University of Idaho, CIS1083, http://www.cals.uidaho.edu/edcomm/pdf/CIS/CIS1083.pdf

**Table 8:** 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 |

* Lentil and lupin are not usually grown on high boron soils

Source: Southern Lentil: Best Management Practices Training Course (2016), Pulse Australia

### Aluminium (Al)

Aluminium toxicity can develop in lentil that is well nodulated but grown on soils of low pH.

There are no visual symptoms of aluminium toxicity in lentil 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 phosphorus deficiency.

### Salinity

Delays in germination occur with increasing levels of salinity in lentil (and chickpea). After germination, the first signs of salinity damage, due to excess ion accumulation in saline conditions, are necrosis of the outer margins and yellowing of the older leaves.

Salinity intensifies anthocyanin pigmentation (blue, violet or red pigment) in leaves and stems in red lentil and desi chickpea; while leaves and stems of green lentil and Kabuli chickpea appear yellow. Leaves die and separate due to accumulation of ions. Salinity also reduces flower production and pod-setting.

Lentil varieties differ in their tolerance to salinity. Nipper⁽ᶲ⁾ is the only variety that shows any salt tolerance. All other varieties are intolerant.

## 7.17 Determining fertiliser requirements

Prior to the planting of lentil, fertiliser requirements for that paddock must be determined. Specifically, this refers to the types of fertiliser required and the recommended rate(s).

Fertiliser required is a combination of knowing:

- the current nutritional status of the soil; and
- the nutrient removal by the crop.

### Current nutritional status of the soil

Soil types vary in terms of nutritional status.

Different soil types may have different nutrient reserves which vary in availability during the growing season, or are unavailable due to the soil's pH. This is often the case with micronutrients; in this case, foliar sprays can be used to correct any deficiencies.

Important factors that contribute to determining the current nutritional status of the soil include:

- a soil test;
- paddock history;
- soil type; and
- personal or local experience.

Plant tissue tests are also helpful in identifying the nutritional status of the plant (which is based on the nutritional status of the soil) once the crop is growing. These tests can assist in fine-tuning nutrient requirements later in the growing season.

## Nutrient removal by crops

When grain is harvested from the paddock, nutrients are removed in the grain (Table 9). If, over time, more nutrients are removed (via grain) than are replaced (via fertiliser) then the fertility of the paddock will decline.[35]

**Table 9:** Nutrients removed by 1 tonne of grain.

| Grain | Kilograms (kg) | | | | | Grams (g) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | N | P | K | S | Ca | Mg | Cu | Zn | 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 (sweet) | 53 | 3.0 | 8 | 2.3 | 2.2 | 1.6 | 5 | 35 | 18 |
| Lupin (white) | 60 | 3.6 | 10 | 2.4 | 2.0 | 1.4 | 5 | 30 | 60 |
| 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 |
| Oat | 17 | 3.0 | 5 | 1.6 | 0.5 | 1.1 | 3 | 17 | 40 |

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

Actual values for nutrient removal via grain may vary by 30% or sometimes more. This is due to differences in soil fertility, varieties and seasons. For example, phosphorus per tonne removed by lentil grain can vary from 2.7 kg on low fertility soils to 5.1 kg on high fertility soils.

To prevent this, fertiliser inputs must be matched to expected yields and the nutritional status of the soil. The higher the expected yield, the higher the fertiliser input, particularly for the major nutrients, phosphorus, potassium and sulfur.

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

## 7.18 Nutrient budgeting

Nutrient budgeting is a simple way to calculate the balance between nutrient removal (via grain) and nutrient input (via fertiliser).

Table 10 shows an example of nutrient budgeting. The values used for nutrients removed are taken from Table 9.

**Table 10:** An example of nutrient budgeting.

| Year | Crop | Yield (t/ha) | Nutrients removed (kg/ha) | | | |
|---|---|---|---|---|---|---|
| | | | N | P | K | S |
| 2009 | Faba bean | 2.2 | 90 | 8.8 | 22 | 3.3 |
| 2010 | Wheat | 3.8 | 87 | 11.4 | 15 | 5.7 |
| 2011 | Barley | 4.2 | 84 | 11.3 | 21 | 6.3 |
| 2012 | Chickpea | 1.8 | 59 | 5.8 | 16 | 3.6 |
| | | Total | 320 | 37.3 | 74 | 18.9 |
| **Year** | **Fertiliser** | **Rate** | **Nutrients applied (kg/ha)** | | | |
| | | | **N** | **P** | **K** | **S** |
| 2009 | 0 : 20 : 0 | 50 | 0 | 10 | 0 | 1 |
| 2010 | 18 : 20 : 0 | 70 | 12.6 | 14 | 0 | 1 |
| 2011 | 18 : 20 : 0 | 70 | 12.6 | 14 | 0 | 1 |
| | Urea | 60 | 27.6 | 0 | 0 | 0 |
| 2012 | 0 : 16 : 0 : 20 | 80 | 0 | 12.8 | 0 | 16 |
| | | Total | 52.8 | 50.8 | 0 | 19 |
| **Balance** | | | **–267.2** | **+13.5** | **–74** | **0** |

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

From Table 9, a 2 t/ha crop of lentil will, on average, remove approximately 7.8 kg/ha of phosphorus. This then is the minimum amount of phosphorus that needs to be replaced. Higher quantities may be needed to build up soil fertility or overcome soil fixation of phosphorus.

As can be seen from Table 10, a simple nutrient budget, interpretation is required to establish the true situation:

**Nitrogen:** the nitrogen deficit of 267 kg needs to be countered by any nitrogen fixation that occurred.

This may have been 50 kg/ha per pulse crop, meaning the deficit might be more along the lines of 217 kg/ha (267 minus 50 kg/ha). Regardless, it still shows that the nitrogen status of the soil is decreasing and nitrogen fertiliser needs to be applied to reduce this deficit.

Estimating nitrogen fixation is not an easy process. One rule is: 20 kg of nitrogen is fixed for every tonne of plant dry matter at flowering.[36]

**Phosphorus:** Table 10 shows a surplus of 13 kg of phosphorus. This surplus will be used by the soil in building phosphorus levels, hence increasing soil fertility.

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

**Potassium:** Australian soils generally have adequate levels of potassium. Therefore, reducing the level of potassium without replacing it with fertiliser is accepted practice. However, some Australian cropping soils (usually white sandy soils) do show a positive response to potassium; fertiliser application should at least be considered to replace the potassium used by the crop.[37]

**Sulfur:** The sulfur applied as fertiliser matches sulfur removed by the crop.

Other nutrients, such as zinc and copper, should also be included in a nutrient-balancing exercise.

Nutrient budgeting is a useful tool; however, it must be considered in conjunction with other nutrient management tools such as soil and tissue testing, soil type, soil fixation and potential yields.

As phosphorus is the basis of soil fertility and hence crop yields, all fertiliser regimes are based initially on the phosphorus requirement. Table 11 shows various fertilisers and the rates required to meet phosphorus requirements.

**Table 11:** Fertiliser application rate ready reckoner (all rates are read as kg/ha).

| Phosphorus | Some of the fertilisers used on pulses | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Superphosphate | | | | | | | | | | | | | | | |
| | Single 8.6% P | | Gold Phos 10 18% P | | Triple 20% P | | 6 : 16 : 0 : 10 Legume Special | | | 10 : 22 : 0 MAP | | 18 : 20 : 0 DAP | | 0 : 15 : 0 : 7 Grain Legume Super | |
| | fert | S | fert | S | fert | S | fert | N | S | fert | N | fert | N | fert | S |
| 10 | 116 | 13 | 50 | 5 | 45 | 0.7 | 62 | 4 | 6 | 46 | 5 | 50 | 9 | 69 | 5 |
| 12 | 140 | 15 | 67 | 7 | 60 | 0.9 | 75 | 4 | 8 | 55 | 6 | 60 | 11 | 83 | 6 |
| 14 | 163 | 18 | 78 | 8 | 70 | 1.1 | 87 | 5 | 9 | 64 | 6 | 70 | 13 | 97 | 7 |
| 16 | 186 | 20 | 89 | 9 | 80 | 1.2 | 99 | 6 | 10 | 73 | 7 | 80 | 14 | 110 | 8 |
| 18 | 209 | 23 | 100 | 10 | 90 | 1.4 | 112 | 6 | 11 | 82 | 8 | 90 | 16 | 124 | 9 |
| 20 | 223 | 25 | 111 | 11 | 100 | 1.5 | 124 | 7 | 12 | 91 | 9 | 100 | 18 | 138 | 10 |
| 22 | 256 | 28 | 122 | 12 | 110 | 1.7 | 137 | 8 | 14 | 100 | 10 | 110 | 20 | 152 | 11 |
| 24 | 279 | 31 | 133 | 13 | 120 | 1.8 | 149 | 8 | 15 | 110 | 11 | 120 | 22 | 166 | 12 |

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

**Growers should always consult an agronomist when determining fertiliser applications for lentil.**

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

## 7.19 Nutrition requirements of lentil

**Table 12:** Critical nutrient levels for lentil at flowering.

| Nutrient | Plant part | Critical range* |
|---|---|---|
| Phosphorus (%) | YML** | 0.3 |
| Potassium (%) | YML | 1.8 |
| Sulfur (%) | YML | 0.2 |
| Boron (mg/kg) | YML | 20 |
| Copper (mg/ka) | YML | 3 |
| Zinc (mg/kg) | YML | 20 |

* Any nutrient level below the critical range will be deficient; any level above will be adequate. ** YML = youngest mature.

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

Fertiliser recommendations for lentil, as with most pulses, tend to be very generic. Some say this is often based more on convenience and availability, rather than meeting the specific nutrient requirements of the crop.[38] Fertiliser recommendations need to be more prescriptive, and should consider:

- soil type;
- rotation;
- yield potential of the crop;
- plant configuration (row spacing, type of opener and risk of 'seed burn');
- soil analysis results; and
- effectiveness of inoculation techniques.

### Fertiliser toxicity

All pulses can be affected by fertiliser toxicity which, essentially, is the application of nutrients at a higher level than is required by the plant.

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

**MORE INFORMATION**

A GRDC Fact Sheet on care with fertiliser and seed placement can be found at: www.grdc.com.au/GRDC-FS-FertiliserToxicity

38 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia

## 7.20 Keys for successful uptake of nutrients by lentil

### IN FOCUS

Both macronutrients and micronutrients are taken up (absorbed) by roots and require certain soil conditions 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.
- Soil pH influences the availability of most nutrients and must be within a range (6 to 8 in $CaCl_2$) for nutrients to be released from soil particles. On acid soils, aluminium and manganese levels can increase and may restrict plant growth, usually by restricting the rhizobia and so the plants' ability to nodulate.
- Soil temperature must lie within a certain range for nutrient uptake to occur. Cold conditions can induce deficiencies such as zinc or phosphorus.

The optimum range of temperature, pH and moisture can vary for different pulse crops. Thus, nutrients may be physically present in the soil, but not available to those plants. Knowledge of a soil nutrient status (soil test), pH, texture, history and moisture status are all very useful for predicting potential nutrient deficiencies. Tissue tests, later on, help to confirm the level of individual nutrients in the plant.[39]

39 Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia