NORTHERN
MARCH 2016

GRDC GROWNOTES™

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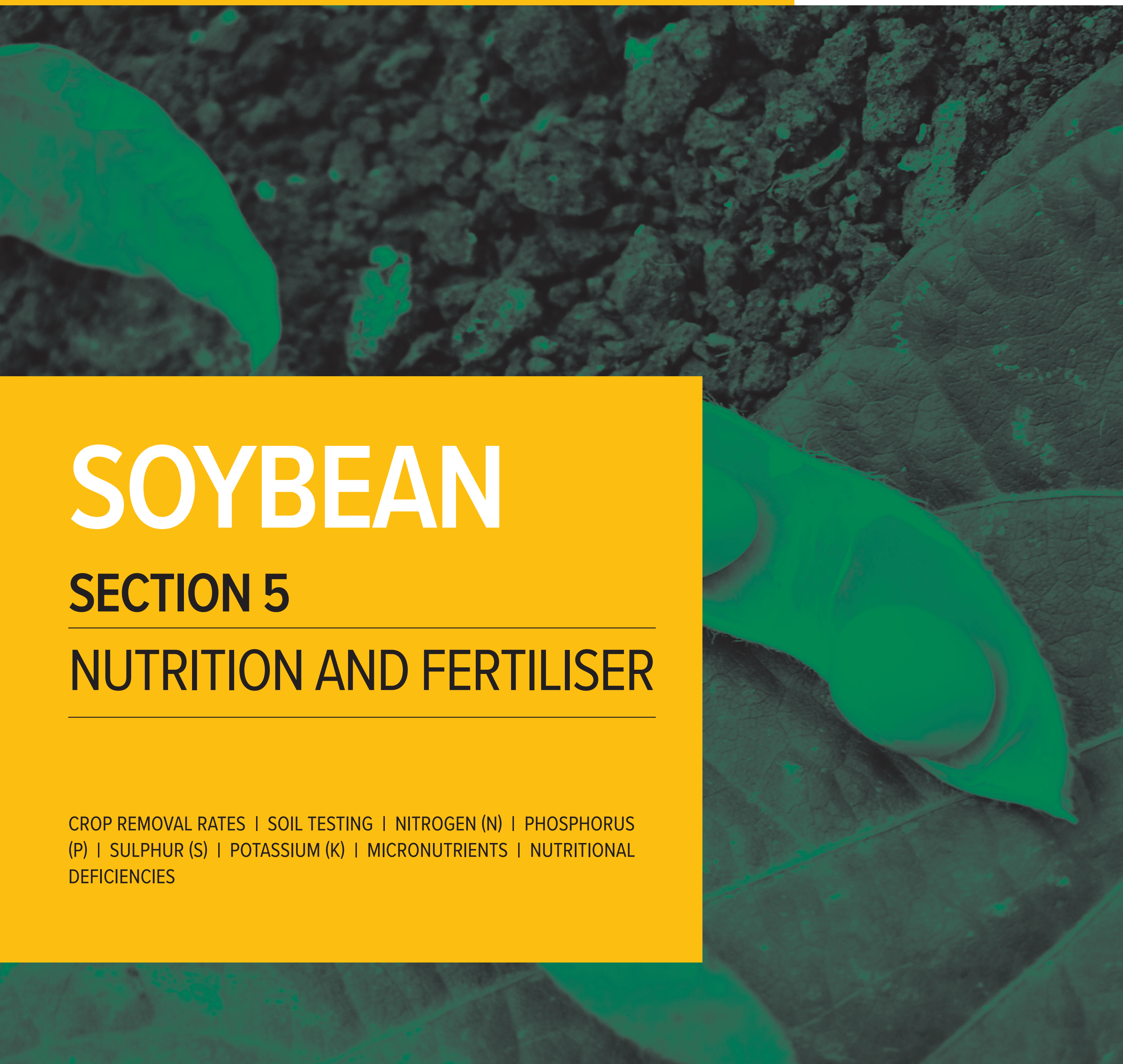

SOYBEAN

SECTION 5

NUTRITION AND FERTILISER

CROP REMOVAL RATES | SOIL TESTING | NITROGEN (N) | PHOSPHORUS (P) | SULPHUR (S) | POTASSIUM (K) | MICRONUTRIENTS | NUTRITIONAL DEFICIENCIES

SECTION 5

Nutrition and fertiliser

5.1 Crop removal rates

Soybeans have a large requirement for phosphorous (P). For every tonne of grain produced the crop will take up 11 kg P/ha and the grain will remove 7 kg P/ha. Soybeans have an extended period of P uptake right up until mid pod-fill. High fertility paddocks may be better at providing extended P availability, rather than extra large doses of starter P fertiliser.[1]

Soybeans are a crop that removes a lot of potassium (K) in harvested grains (on average, 20 kg K/t). Therefore, in high yielding irrigated crops removal rates can be high and the resultant K-fertiliser rate to maintain soil K-status can be significant.[2]

5.2 Soil testing

Soybeans have a high demand for plant nutrients, in particular nitrogen, phosphorus and potassium. When deciding how much fertiliser to apply to a soybean crop it is important to know the nutrient status of the soil and the critical level of soil nutrients, particularly phosphorus and potassium, that are needed to give the maximum economic yield. A soil test is the best way to determine soil nutrient status.[3]

Table 1: The approximate quantities of major nutrients utilised by a soybean grain crop

Plant part	Yield 2.5t/ha			
	Plant nutrient (kg/ha)			
	N	P	K	S
Total plant uptake	220-270	15-20	100-120	15-20
Nutrients removed in seed	150-170	12-15	40-50	9-12

NOTE: This table should not be used as a direct indicator of crop fertiliser requirements, but it is a useful guide to soil maintenance requirements – an important consideration for low fertility soils.

5.3 Nitrogen (N)

More information

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Soybeans have a large requirement for nitrogen, but can obtain the majority of this from the air via *Rhizobium* bacteria forming nodules on their root system. Soybean seed needs to be inoculated with Group H *rhizobia* to get effective nodulation and ensure adequate nitrogen nutrition to the plant. *Rhizobium* bacteria need low nitrogen soils for optimum effectiveness and soybeans grown after cereal crops rather than pasture provide these conditions.[4]

1 Agriculture Victoria (2006) Growing Soybean http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-soybean

2 QDAF (2010) Growing soybeans https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/soybeans/growing-guide

3 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

4 Agriculture Victoria (2006) Growing soybean http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-soybean

Once established the nitrogen fixing bacteria (rhizobia) in the root nodules can supply soybean plants with all their nitrogen requirements, provided soil mineral N is low. Soybean N fixation tends to decrease as soil mineral N increases, as the plant prefers to accumulate 'easy' soil nitrate rather than support rhizobium to fix atmospheric N_2. High mineral N in the early stages of crop establishment can delay early nodule development (possibly causing an N deficiency when the soil N runs out and the plant has to then allow nodules to develop), while mineral N late in the season (e.g. from a decomposing cane trash blanket) can prematurely shut down N fixation but also contribute to high yields and grain protein.

A small amount (up to about 15 kg of N per hectare) of 'starter' nitrogen may be beneficial when the crop is sown into high crop residue loads with high C:N ratios (e.g. wheat straw or sugarcane trash), as the establishing soybeans need some soil N to grow while nodules are developing. Another situation where some starter N may benefit is in late sown crops, as it helps to ensure good early growth of seedlings and adequate height to the lowest pod. Care must be taken not to apply too much starter N as this will raise soil mineral N concentrations and have a detrimental effect on the growth of nodules that supply nitrogen to the plant later in its growth cycle.[5]

5.4 Phosphorus (P)

Soils predominantly derived from sedimentary and granitic rocks are extremely low in phosphorus and high rates of phosphatic fertiliser are required for economic yields. The heavy clay flood plain soils of the NSW Richmond Valley have high levels of reactive iron (that fixes phosphorus), and this will be reflected in high Phosphorus Buffer Indices (PBI) in soil tests. In these types of soils, a large proportion of the phosphorus applied in fertiliser can be fixed (strongly sorbed) in a form that is unavailable to the current crop. The same applies in the red volcanic soils of the inland and coastal Burnett regions of Queensland, where iron and aluminium oxides sorb (fix) the P. Soybeans grown on podsolic soils will probably require P fertilizer to maximise yields depending on their P status and P fixing ability.

Because of the variability in soil P status and P fixing ability of the soils in which soybeans are grown, it is essential that soil P tests are undertaken. Two soil P analyses are required - Colwell-P to determine the soil P status and PBI to determine the P fixing ability of the soil (Table 2).

Phosphorus drilled with or banded close to the seed is the most effective way to supply this nutrient to the soybean plant. Soybeans are very efficient at developing roots in and around a P fertilizer band. For practical and economic reasons, most growers with soils of moderate P status (as indicated by Colwell-P) and a low P sorbing ability (indicated by PBI) broadcast and incorporate the entire fertiliser requirement prior to sowing. However this will not be appropriate in soils with a strong P sorbing capacity (i.e. high PBI), and P fertilizer will need to be banded to maximize crop recovery.

5 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Table 2: Indicative phosphorus application rates (kg P/ha) and preferred application method in soils with contrasting soil phosphorus status (measured using the Colwell method) and Phosphorus Buffer Indices (PBI). Phosphorus fertilizer should always be incorporated into soil, rather than be left on the soil surface.

Colwell P (mg/kg)	Rate of P fertilizer (kg P/ha)		
	PBI <100	PBI 100-200	PBI >200
<10	40P broadcast	30P banded or 40P broadcast	30P banded
10-20	30P broadcast	25P banded or 30P broadcast	30P banded
20-30	20P broadcast	20P banded or broadcast	20P banded
30-40	10P broadcast	10P banded or broadcast	10P banded
>40	0	0	0

Some P fertilizer can be placed in the seeding row with the seed at planting, but there are limits to how much can be applied in this fashion. Both the germinating seedling and the rhizobium inoculant can both be damaged if rates are too high. The maximum safe rate with seed will depend on the amount of soil mixing occurring at planting, the distance between the seed and the fertilizer and the type of fertilizer product used. When direct drilling with minimal soil disturbance (e.g. disc seeders), safe rates will be lower than with tine planters that cause more soil disturbance. Your local advisor or fertilizer reseller can help you with the maximum safe rates of the fertilizer product you intend to use. The amount of P that can be applied with or near the seed will be reduced if the fertilizer product contains N. If you cannot apply sufficiently high rates in the planting furrow, pre-plant band applications or additional tines that place fertilizer below and beside the seed can be effective.[6]

5.5 Sulphur (S)

Soybeans are a high protein legume and insufficient sulphur limits yield. Typically, soybean grain contains N:S ratios of about 20:1, so grain containing 40-41% protein (6.4-6.5% N) will contain about 0.3-0.35% S. Generally, single superphosphate applications supply adequate sulphur, but this is often not used as a phosphorus fertilizer. Gypsum is a cheap alternative to improve soil S status while potassium sulphate is a source of potash (K) and S. On high phosphorus testing soil, inadequate sulphur can frequently limit yields, especially with direct drilled crops. The KCl-40 soil test is a good guide for sulphur fertiliser requirements – it is suggested if KCl-40 S test levels are below 8-10 mg/kg, apply fertiliser containing sulphur at rates that will supply up to 15 kg S/ha.[7]

5.6 Potassium (K)

Soybeans require large amounts of potassium (K) to achieve good yields and so soil K-status is important. Soils that have low exchangeable K-levels prior to planting (i.e. <0.3 meq/100g) are likely to respond to K-fertiliser application. In coastal areas with sugarcane-dominant cropping systems, K is usually one of the main nutrients required for good soybean growth during a fallow.

Soybeans are capable of accumulating large amounts of K in the plant material (100-150 kg K/ha), and if the soil K-status is good, this accumulation may be well in excess of the minimal requirements for growth and yield.[8]

[6] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[7] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[8] QDAF (2010) Growing soybeans https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/soybeans/growing-guide

Soybean yields may be limited by potassium deficiencies on sandy soils and those soils with a long history of intensive cropping where heavy export of K in hay, silage, grain or sugarcane has occurred. Table 3 gives a guide to potassium fertiliser requirements for soybean crops, although the critical soil test value for exchangeable K is affected by things like the soil cation exchange capacity and the relative availability of sodium (Na) to potassium in some heavy clay soils. The apparent effect of high exchangeable Na on K availability is probably caused by poor soil structure restricting the soil volume from which roots can extract K as well as their ability to take up K. The result is that higher soil K concentrations are needed for optimum yield.

Table 3: Potassium fertiliser recommendations (kg K/ha) for soybean crops grown in soils with differing exchangeable potassium and cation exchange capacity (CEC)

Soils with CEC < 20 cmol/kg		Soils with CEC > 30 cmol/kg	
Exchangeable potassium (c mol/kg)	K recommendation (kg K/ha)	Exchangeable potassium (c mol/kg)	K recommendation (kg K/ha)
0 – 0.1	25–40	0 – 0.2	50–75
0.1–0.2	15–25	0.2 – 0.4	25–50
0.2–0.4	5–15	0.4 – 0.6	10–25
Over 0.4	Nil	Over 0.6	Nil

Muriate of potash (MOP, containing 50% K) and potassium sulphate (SOP, containing 41% K and 18% S) are the most common forms of K fertilizer.

Soils can also contain some slow release forms of K that are not measured in the commercial soil test for exchangeable K, and there is an active soils research program investigating new soil tests to fill this gap. The greatest amounts of these reserves (which are present as slowly dissolvable soil minerals) tend to be in 'young' alluvial soils in creek flats or at the lower end of river valleys, while these reserves are not present in granitic soils, soils produced from in situ weathering of basalt (i.e. eastern Darling Downs) or on red volcanic soils. In these situations, and perhaps more generally, it is safer to assume that exchangeable K is all there is, and fertilize accordingly.

When sowing, never place any muriate of potash (MOP) fertiliser in contact with the seed, as plant establishment will be impaired by the salt effect (rapid dissolution of the fertilizer, resulting in a high concentration of dissolved ions around the fertilizer band) of the fertiliser. There is a little more flexibility in application if using potassium sulphate (SOP), which does not produce as strong a salt effect. However, SOP application rates need to be 20% higher to apply the same amount of K, and are generally much more expensive than MOP. There is no need to band K fertilizers, or to put them in close proximity to the seeding trench, so application and incorporation during land preparation or banding away from the immediate seeding area in minimum tillage systems are preferred.

Rates of K removal in soybean grain are as high or higher than any other grain or grain legume crop, with ~ 20 kg K/t of grain removed at harvest. This compares to 3-4 kg K/t in grains and 8-10 kg K/t in other grain legumes like mungbeans and chickpeas. Removal rates in high yielding soybean crops are comparable to that in irrigated cotton at 60-80 kg K/ha.[9]

5.7 Micronutrients

5.7.1 Zinc (Zn)

Zinc deficiency is widespread on the alkaline grey clays of inland irrigation areas and can also be low on some of the sandier soils in the coastal sugarcane areas. These differences may be due to low soil Zn (acidic, sandy soils) or to low availability of Zn to plants (alkaline clays), and each soil type responds differently to soil applications.

[9] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Although it is a well-known problem with soybeans, zinc deficiency is still occasionally found. Some varieties may be more sensitive than others. Soil tests provide an indication of plant available Zn status, but are not very precise and more work is needed to define a soil test critical value. At this stage, critical values lie somewhere between 0.4 (acidic soils) and 0.8 (alkaline soils) mg DTPA-extractable Zn/kg soil, with the higher critical value in the alkaline soils reflecting the reduced plant availability at higher soil pH.

Zinc can be applied either to the soil or to the foliage, although the effectiveness and residual value of the soil strategies will vary depending on whether you are fixing a low soil Zn situation in acidic sand or trying to make some Zn available to plants in alkaline clay. In lighter textured, neutral to acidic soils applications to soil are very effective and have a good residual value (e.g. an application of 30 kg/ha of zinc oxide to the soil every 5–7 years will fix any problems). However in heavier, alkaline clays it is more effective to apply small amounts with your starter P fertilizer in the seeding trench to ensure early plant access. Large applications mixed through the soil may be rendered unavailable to plants, limiting residual values. Foliar applications of zinc sulphate heptahydrate at 4 kg/ha 6–8 weeks after planting are always effective, but in soils with very low Zn, deficiencies may be evident well before the plants get enough leaf area to absorb this foliar application. In these low Zn soils, some Zn in the starter fertilizer in the seeding row will help.[10]

5.7.2 Molybdenum (Mo)

Root nodule bacteria require molybdenum as part of an enzyme to convert atmospheric nitrogen to a form that is used by the plant. Most soils on the NSW North Coast and Northern Tablelands are acidic and deficient in plant available molybdenum, and levels can also be marginal in many of the acidic, sandier coastal sugarcane soils in Qld. Soil tests for Mo are not reliable, and so low rate applications of products like sodium molybdate (dissolved and sprayed onto the soil before planting, or as a foliar spray early in the season) can be an effective insurance policy to ensure good N fixation. Mo can also be applied as a seed dressing of molybdenum trioxide (although check for effects on efficacy of inoculants if considering this method), or as a blend with things like superphosphate fertilizers, which are used to enhance N fixation of legumes in pastures. Application rates of 50-100 g Mo/ha are only required every 2-3 years.[11]

5.7.3 Other trace elements

Except for molybdenum on the NSW North Coast and Tablelands, and zinc on the grey clays of inland irrigation areas, fertiliser trace elements are generally not required for soybean crops. The exceptions may be on the sands and Wallum soils found in coastal areas, where copper, zinc and manganese deficiencies may occur. In these situations, the lack of reliable soil test diagnostics means that foliar applications of a mix of trace elements can sometimes provide useful insurance.[12]

5.8 Nutritional deficiencies

5.8.1 Boron (B) deficiency

Description: Plants grow poorly, lack vigour and are stunted, with stout stems. Symptoms develop first on younger leaves, turning pale green and yellow tissue. Later, dark brown necrotic spots develop in the yellow tissue. The tips and edges of young expanding leaves often curl down and under. Older leaves remain dark green. The buds at the top of the plant and at the nodes may die and the young underdeveloped leaves

10 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

11 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

12 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

or flowers turn pale brown. Pollination and seed set are reduced, and in severe cases plants may die.

Conditions: Boron deficiency can occur in sandy soils leached of boron, alkaline soils containing free lime, soils low in organic matter, acid peat soils and in soils of acid igneous or fresh-water sediment parent material.

Management: Soil test for available boron. Boron may be applied to the soil as borax, boric acid and chelated boron compounds. Boric acid or chelated B compounds may be applied as a foliar spray 5 to 6 weeks after seedling emergence or as soon as symptoms appear. Over fertilization with B can result in toxicity, so be careful with applications to soil. Applying products in solution sprayed onto soil is an effective strategy of getting uniform distribution of relatively low rates of product.[13]

5.8.2 Calcium (Ca) deficiency

Description: Calcium deficiency causes stunting of plants, with short internodes, stout stems and dark green leaves. Symptoms first appear on young leaves. The leaves fail to expand the tips, margins cup up or down, leaves may turn yellow developing necrotic pale brown areas. The entire forming bud will often die if the deficiency is severe. On older plants the veins of the upper leaves die and turn brown, and the areas beside these veins turn yellow. Pod set is reduced resulting in low yields.

Conditions: Ca is important for normal plant growth and development. It is also involved in nitrogen fixation. Ca deficiency may occur in acidic sandy soils leached of Ca, strongly acid peat soils of low Ca, alkaline or sodic soils where sodium and pH are high, or soils with high aluminium levels and low exchangeable Ca levels. It is unusual to encounter Ca deficiency in most cropping soils.

Management: Apply lime or dolomite if the soil pH is low, or gypsum if only Ca is lacking. Over liming can cause deficiency in other nutrients such as potassium, magnesium, iron, zinc and copper.[14]

5.8.3 Iron (Fe) deficiency

Description: Affected crops are unthrifty, lack vigour, stunted with thin, spindly stems, yellow young leaves and dark green older leaves. Symptoms develop first on young expanding leaves, with pale yellowing in the interveinal area. The veins remain green for a while but later turn yellow. On severely affected plants dark brown lesions develop on the veins and pale brown lesions develop on the leaf margins and on petioles. The underside of the leaflet develops more prominent symptoms. These lesions occur after the whole leaf has turned yellow, distinguishing Fe deficiency from sulphur deficiency (see below). Older leaves remain green.

Conditions: Iron deficiency occurs on alkaline soils with low soluble Fe levels, waterlogged soils, acid soils with excess levels of soluble manganese, zinc, copper or nickel, in sandy soils low in total Fe and in peat soils.

Management: Inorganic Fe salts can effectively control deficiencies, but will quickly become insoluble and unavailable to plants if placed into soil. Foliar sprays of inorganic salts or chelates need to be applied every 10 to 15 days to provide Fe to the new leaves. Apply Fe salts of organic chelates to the soil to keep Fe in solution. Apply the chelate most appropriate for the soil type.[15]

5.8.4 Magnesium (Mg) deficiency

Description: Affected crops are pale green, shorter than usual with thin spindly stems and pale green-yellow leaves. Symptoms start on the middle leaves as pale yellow

13 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

14 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

15 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

interveinal mottling, spreading to older leaflets and advancing up the plant to younger leaves. If deficiency is severe, light brown lesions develop in the interveinal areas spreading towards the margins, veins remain green and the interveinal area may become puckered.

Conditions: Mg deficiency inhibits nitrogen fixation. Deficiency is likely to occur in acidic sandy soils leached of Mg, strongly acidic peat soils and soil over-fertilised with Ca or K.

Management: Dolomite can be broadcast and mixed into soils several months before planting. Apply magnesium sulphate or magnesium chloride in a band at or before planting. Apply soluble salts in irrigation water. Foliar sprays are not recommended.[16]

5.8.5 Manganese (Mn) deficiency/toxicity

Deficiency: Symptoms are similar to the early stages of Fe deficiency (see above). Affected plants tend to be in patches, and are stunted with short, thin stems and pale green-yellow foliage. Young leaves turn pale green with a yellow mottle developing between the veins. The veins remain green. Later, small dark brown dead spots form in the yellow areas of leaves. If the deficiency becomes severe the youngest leaves may falloff. Older leaves remain green.

Toxicity: Mn toxicity develops first on older leaves. Plants are stunted with short stout stems and dark green leaves. Pinpricked red-brown dead lesions develop on the upper surface between the veins. With severe toxicity red-brown areas develop on the veins, being prominent on the underside of the leaves. The younger leaves are smaller than usual and develop yellow mottling changing to red-brown necrotic lesions.

Conditions: Mn deficiency may occur in strongly alkaline soils, poorly drained soils with high organic matter, strongly acid soils leached of Mn and in soils formed from rocks low in Mn.

Mn toxicity can develop on strongly acid soils or in waterlogged soils where the lack of oxygen has increased the availability of the soil Mn.

Management: Deficiency can be controlled by foliar sprays or soil dressings of Mn salts, such as manganese sulphate. Foliar sprays should be applied 3-5 weeks after emergence and again if symptoms occur.

Toxicity can be controlled by applying lime to acid soils to raise pH and thus reduce Mn availability to plants. Improve drainage and avoid over fertilising with Mn fertilisers. Applying irrigation water low in Mn or mulching with organic materials can also remove soluble Mn from the soil and decrease Mn toxicity.[17]

5.8.6 Nitrogen (N) and Molybdenum (Mo) deficiency

Description: N deficiency makes older leaves turn pale or yellowish-green, and in severe cases the whole plant can appear a pale yellow green colour. If N deficiency occurs during seed filling, the ‘self-destruct’ process seen during maturation (i.e. leaf browning and shedding) is accelerated and seed fill can be affected.

Conditions: Deficiency can occur during early growth, before the nodules are well developed and capable of fixing N. This is often the situation when soil mineral N reserves are low – perhaps as a result of microbial immobilization of available N during decomposition of heavy crop residues like cane trash. In later crop stages deficiency develops commonly because of poor nodulation, which can be the result of ineffective inoculation practices (i.e. low numbers of rhizobia added or surviving long enough to infect roots), extreme soil acidity (leading to toxic levels of aluminium or manganese) or wet or cool soil temperatures. Typically, if soybean has been grown in the field in the

16 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

17 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

recent past, there should not be a problem related to insufficient bacteria present in the soil to properly inoculate the roots.

Management: If you suspect there has been an N deficiency or nodulation problem in the past, it would be important for the future to plant inoculated seeds. Most often, inoculation problems are related to poor growth conditions. Soybeans do not grow very well in periodically wet or very acidic soils; ensuring adequate soil pH and good drainage are probably the best ways to reduce the problem of poor nodulation.

Figure 1: Normal soybean canopies in the foreground, compared to P deficient, stunted canopies with yellow spotting on leaves in the background. (Photo: Australian Oilseeds Federation)

The problem of heavy residue loads and soil N unavailability can be addressed by applying a low rate of starter N fertilizer to aid early stages of crop growth (until nodules are functional). If nodulation is poor and N deficiency becomes obvious later in crop growth (e.g. after a water logging event) topdressing with N fertilizer may provide some benefits – especially if not too late in crop development (i.e. during seed filling).[18]

5.8.7 Phosphorus (P) deficiency

Description: Phosphorus deficiency may cause stunted growth, dark green coloration of the leaves and leaf cupping. Symptoms occur first on older leaves. Severe deficiency can result in fine yellow spotting on older leaves, with these yellow spots subsequently coalescing into necrotic patches. Older leaves and petioles will sag and be shed prematurely.

Phosphorus deficiency can delay flowering, although not as much as in some cereal crops, but conversely can accelerate senescence and maturation during pod filling. This results in small seed size and reduced yields. The combination of stunted plants and premature senescence can result in greater difficulty recovering grain at harvest.

Figure 2: Prematurely senesced P deficient soybean canopies in mid pod filling on the left of this image, compared to canopies with adequate P on the right. (Photo: Australian Oilseeds Federation)

Conditions: Phosphorus deficiency often occurs in early stages of growth, when root systems are small and only able to access small soil volumes. The deficiency can be accentuated when soils are cool and wet, due to slower root system development and decreased phosphorus uptake. Long bare fallows can also reduce populations of

18 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

mycorrhizal fungi that assist plants in uptake of phosphorus, increasing the reliance on P fertilizers.

Management: Phosphorus deficiency is best prevented by regularly soil testing to monitor soil P status and applying the appropriate rate and form of P fertilizer at or before sowing. It is difficult to address a P deficit once the soybean crop has established.[19]

5.8.8 Potassium (K) deficiency

Figure 3: Potassium deficiency in soybeans. Note the yellowing and marginal necrosis (scorching) on leaves lower in the canopy. (Photo: Australian Oilseeds Federation)

Description: Potassium deficiency is observed as yellowing or browning and necrosis (death) of the edge of older leaves. When the problem persists, this deficiency will continue to move up from older to newer leaves, while the top leaves may look completely green.

Conditions: Potassium deficiencies develop more often at early stages of development when the root system is small. However, symptoms may also start to appear during seed filling, when the plant is trying to re-distribute K in the vegetative plant parts to meet the demand of the developing seeds. Soil K concentrations are often highest in topsoil layers, due to accumulation of K from crop residues and fertilizer – K will only leach in light, sandy soils. As a result, K deficiency may appear in crops during a dry spell (when top soil root activity is reduced and roots are active in subsoils with lower K status), but disappear when rain falls and topsoil moisture (and root activity) are restored. While this may be visually pleasing, yield may already have been compromised.

Management: Management is similar to that for P. The best way to manage K fertility is by understanding the soil K status and applying the appropriate rate of K fertilizer to the soil prior to sowing. Fertilizer K has excellent residual value in soil so applying excess K fertilizer (e.g. if the yield is lower than expected) is still money in the soil fertility bank.[20]

19 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

20 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

5.8.9 Sulphur (S) deficiency

Description: Symptoms appear first on the youngest leaves. In young crops the whole plant may be pale green. Older crops are stunted with thin stems, the young leaves are pale green to yellow and the older leaves remain green.

Conditions: Deficiency occurs in soils low in organic matter, soils formed from parent material low in S or acidic sandy soils leached of S.

Management: Elemental S should be applied to soils about 4 months, while S can also be supplied more rapidly by pre-planting applications of gypsum and/or sulphur fertilisers (e.g. potassium sulphate, or sulphate of ammonia). Soluble salts can be applied in irrigation water. If phosphorous is also low, application of single superphosphate may correct both deficiencies.[21]

5.8.10 Zinc (Zn) deficiency

Description: Affected plants are stunted with thin short stems, lack vigour, mature slowly and have pale green to bronze foliage. The first symptoms are a pale mottling in the interveinal areas of the middle leaves. In later growth stages older leaves become affected while the younger leaves remain green. If the deficiency is severe the older leaves develop small bronze spots in the interveinal areas, the leaf edges cup downwards and the leaflets point towards the ground. The leaflets die and drop off.

Conditions: The deficiency is likely to occur in strongly alkaline soils, leached sandy soils and soils that have been recently levelled, exposing Zn deficient sub soils. Soils heavily fertilised with phosphates can induce Zn deficiency.

Management: Soil dressings of Zn chelates, sulphates or oxides should be mixed into deficient soils 2-3 months prior to planting. Compound Zn fertilisers can be applied in a band at planting. Deficiencies identified in-crop can be treated with foliar sprays provided the deficiency is identified within 6 weeks of emergence.[22]

21 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

22 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production