Tips and Tactics

Sunflower nutrition

Northern and Southern Regions

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Sunflower nutrition: maximising yield and oil quality for profit

Crop nutrition is a vital management consideration for profitable sunflower production. Getting the right balance and supply of nutrients will maximise sunflower yield and oil quality.

KEY POINTS

- Sunflower are moderately tolerant to a range of soil constraints and prefer a friable soil surface for best crop establishment.
- Use soil tests to target nutrient management for both optimal oil and maximum grain yields.
- Nitrogen (N) is the nutrient taken up in the greatest quantities by sunflower and is essential for many plant processes.
- Excessive levels of N can reduce oil content while insufficient N will limit crop yields.
- Phosphorus (P) is the second most frequently limiting nutrient for sunflower crops.
- If arbuscular mycorrhizal (AM) fungi levels are low, supplying adequate P and zinc is very important.
- Germinating sunflower seed is very sensitive to fertiliser placed in the seed trench; growers should aim to limit the amount of fertiliser placed in close contact with the seed and use side banding to limit contact.

Introduction

Ensuring the nutrient needs of the crop are met is critical to maximise profit.

Inappropriate fertiliser application can reduce oil content and yield through poor crop establishment, uneven crop growth and maturity, increased susceptibility to disease and pests during the season, and by generally limiting crop potential.

The relationship between starting soil nitrogen, soil water and yield expectations is important. Nitrogen fertiliser programs should target a realistic yield, and consider soil tests, plant available water at sowing, and previous crop yield and protein contents.

Use paddock records to identify if other nutrients such as P, sulfur (S) and potassium (K) are adequate for the potential yield.

Fertiliser applications should be based on a soil test.

Table 1 provides soil test guidelines for some key nutrients at 0–10 cm sample depth.

Sunflowers. (Photo: Neil Weier, NuSeed)

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Table 1: Soil test guidelines for a 0–10 cm sample depth in medium-clay soils (adapted from Peverill et al, 1999).

Attribute	Desired range
pH (1:5 water)	5.7–8.5
pH (1:5 $CaCl_2$)	5.0–7.5
Organic Carbon (W-B) %	greater than 1
Nitrate N (1:5 water) (mg/kg)	greater than 20
Sulfate S (MCP) (mg/kg)	greater than 4
Phosphorus (Colwell) (mg/kg)	greater than 18*
Potassium (exch.) (cmole/kg)	greater than 0.18
Calcium (exch.) (cmole/kg)	greater than 1
Magnesium (exch.) (cmole/kg)	greater than 0.5
Chloride (1:5 water) (mg/kg)	less than 300
Electrical Conductivity (1:5 water) (dS/m)	less than 0.6
Copper (DTPA) (mg/kg)	greater than 0.3
Zinc (DTPA) (mg/kg)	greater than 0.8
Iron (DTPA) (mg/kg)	greater than 2
Manganese (DTPA) (mg/kg)	greater than 2
Boron (Hot water) (mg/kg)	greater than 0.5
Exchangeable magnesium %	less than 30
Exchangeable sodium %	less than 6
Electrochemical stability index	greater than 0.05
Electrical Conductivity (sat. ext.) (dS/m)	less than 4

**Higher values are required for Colwell P in southern Australian growing regions. In Central Queensland the desired (critical) value is reported at 6 mg/kg (Hibberd et al, 1991).*

Soil requirements

Crop response to fertiliser can be limited by soil chemical factors such as pH, salinity, sodicity and their effect on nutrient availability and soil structure. The first step to developing a fertiliser plan is to understand soil background limitations. Establish a realistic yield target by allowing for their negative impacts on fertiliser performance.

pH

Sunflowers grow best in neutral soils but a pH range from slightly acid to alkaline is suitable.

They are generally not tolerant of acidic soils with a pH_{Ca} of 5.0 or below. Sunflower are very sensitive to aluminium (Al) toxicity. In the field, sunflower commonly respond to liming on soils with surface Al saturation > 5%. However, if the Al levels are high in the subsoil, limited options for amelioration are available. Aluminium toxicity is most evident in plant roots displaying distinct shortening and thickening, and a reduction in root hair density.

Despite sensitivity to Al, sunflowers tolerate high concentrations of manganese (Mn) in the root environment. Manganese availability can also increase with soil acidity.

Salinity

Sunflowers are moderately tolerant to salinity; they are less tolerant than cotton, wheat or sorghum but more tolerant than soybean or maize. The threshold soil salinity level for sunflowers is 4–5 dS/m (conductivity measure) and the rate of yield decline about 5% per dS/m above threshold.

Sunflowers affected by salinity display symptoms of stunting, thin stems, dull yellow-green leaves and look moisture stressed and wilted. Symptoms appear first on older leaves which appear dull and develop leaf tip margin necrosis, which spreads over the whole leaf surface. Under high levels of salinity, young leaves are also affected, causing browning off which may eventually lead to plant death.

Paddocks with salinity as a subsoil constraint should be identified and the depth to the subsoil constraint noted in order to calculate the reduction in plant available water and mineral N. Subsoil constraints effectively reduce the amount of soil water available and mineral N to the crop as the root exploration will be limited.

Soil cations and structural stability

In soils with high clay contents (i.e. greater than 15%), an excess of sodium, potassium or magnesium on cation exchange sites can result in surface soil dispersion and crusting. This structural instability commonly reduces crop establishment and can also occur at depth, limiting root growth, which in turn inhibits the plants' access to water and nutrients.

In the absence of sodicity-driven soil structural effects, sunflower is categorised as having moderate tolerance to sodium (ESP 30–40%). High sodicity does not appear to affect oil content but may delay germination and flowering.

Key nutrients

Sunflowers require adequate nutrition yet have a significantly lower requirement for several of the major nutrients when compared to other crops. Table 2 contains the amount of some of the nutrients removed in the largest quantity in seed, stubble and the plant total.

Table 2: Nutrient uptake and removal at two levels of production (Source: Australian Soil Fertility Manual).

Sunflower nutrient removal (kg/ha)						
Yield	1 t/ha			2.5 t/ha		
	Seed	Stubble	Total	Seed	Stubble	Total
Nitrogen	26	14	40	60	35	95
Phosphorus	4	1	5	9	3	12
Potassium	8	22	30	18	55	73
Sulfur	1.7	3.0	4.7	4	8	12

Nitrogen

Nitrogen (N) is the major nutrient required by sunflower. N has the greatest impact on:

- size and number of leaves
- seed size and weight
- yield and oil content.

There is an N and sulfur (S) interaction for many of these attributes, however, if the plant is deficient in N then additional S will not help.

Sunflower responds to N applied before head initiation by increasing head size, seed number, leaf number and size.

Excess N causes a reduction in oil content while insufficient N will limit crop yield. Growers and agronomists can target the optimum level by using a nitrogen budget.

Sunflower has a high N requirement per tonne of grain but the overall crop demand is generally lower than sorghum or winter cereals.

The quantity of N removed in 1 tonne of grain is approximately 40 kg, of which 26 kg is in the seed and 14 kg in crop residues (Table 2). The quantity of N required to grow the crop is about 1.7 times the amount removed in the seed. The rate of fertiliser required is the difference between crop N demand, soil mineral N at sampling (preferably to 120 cm depth) and net N mineralisation between soil sampling and just prior to harvest (Figure 1).

N removed in seed (kg/ha): target yield (t/ha) × N removed kg/t

N required for crop (kg/ha): N removed in seed × 1.7

Example:

2t/ha (target yield) × 26 (kg N removed/t seed) × 1.7 = 88 kg N/ha

Efficiency of applied fertiliser nitrogen is only around 51%.

If a soil test results indicated 50kg/ha nitrate-N available

88 kg required for the crop – 50kg available

= 38 kg N/ ha needed x 51% (fertiliser efficiency)

= 76 kg N will need to be applied as fertiliser

Figure 1: Example of a nitrogen budget for sunflower (Source: Big Yellow Sunflower Pack 2015).

Pre–plant application of N fertiliser or banding of fertiliser 5 cm below and to the side of the seed is recommended. Germinating seed is very susceptible to N fertiliser burn if sown in contact with it.

Sunflower roots are able to extract water and N from depths of 1.5 m or greater in the soil profile so can be a useful crop in tapping deep N bulges.

For monounsaturated sunflower markets, a bonus/discount system applies for oil content above or below 40%. Protein and oil content of grains are inversely related, therefore too much N can reduce oil content.

The relationship between soil nitrate-N and soil water (0–120 cm) has been found useful in managing oil content. Limited studies in New South Wales (NSW) suggested that matching nitrate:water at ratios 0.5–1.0 optimised oil content above the required industry standard of 40%, as well as grain yield. Oil contents were, on average, less than 40% when the nitrate: water ratio was more than 1.0 (Figure 2).

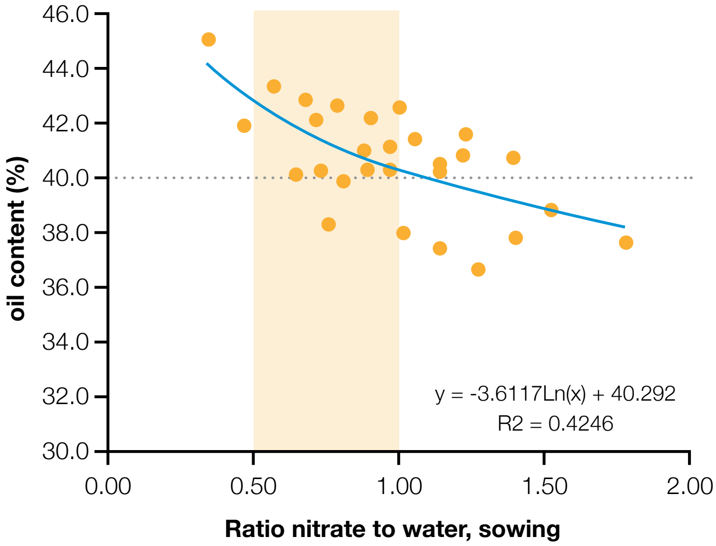

Figure 2: The relationship between the starting soil nitrate: water ratio and oil content of sunflower (Source: Serafin, Belfield and Herridge, 2010).

Phosphorus

Phosphorus (P) is the second most frequently limiting nutrient for sunflower production. Sunflowers respond to P deficiency by flowering and maturing faster.

The quantity of P removed in 1 tonne of grain is approximately 5 kg, of which 70–80% is in the seed and 20–30% in crop residues.

Phosphorus fertiliser needs are best determined by soil tests, soil type, test strips, consideration of likely arbuscular mycorrhizal (AM) fungi levels, paddock history and local experience. In paddocks where P is needed, apply at least 10 kg P/ha or at a rate to match P removal. In southern NSW at least 20 kg P/ha is usually required, increasing to 40–50 kg P/ha if sunflowers follow a rice crop. At high rates, alternative application methods to sowing with the seed may need to be considered to prevent fertiliser burn.

The value of deep application of P and potassium (K) has been demonstrated on a range of cereal crops in vertosol soils. To date there is little research data to demonstrate responsiveness in sunflower as measured in other tap-rooted crops such as chickpea and mungbean.

If AM fungi levels are low—such as after a long fallow canola or rice—supplying adequate phosphorus and zinc fertiliser is very important.

Dark green healthy leaf (right) compared with P-deficient leaf showing dull yellow chlorosis and dark grey necrotic lesions (left). (Photo: NJ Grundon)

Potassium-deficient leaf showing marginal and interveinal chlorisis and necrosis. (Photo: NJ Grundon)

Potassium

Potassium (K) is required for stalk and tissue strength.

Sunflowers are a high user of K, with a 1 t/ha crop of sunflowers taking up 30 kg of K/ha with 25% in the seed and the remaining 75% in the crop residues. While low K has been associated with increased crop lodging in other countries, K responses are generally not seen in sunflowers in Australia.

Sulfur

Sulfur (S) forms partnerships with N to determine leaf area and plant height. Combined N and S deficiencies reduce yield as seed weight and the number of seeds per plant declines. Floret number and hence seed number is determined by S before budding (18–20 days before anthesis).

The amount of S removed in the seed of a 1 tonne crop is 5 kg/ha, with uptake highest between budding and anthesis; a large proportion is also taken up post-anthesis. Sulfur has not been identified as a problem to date on the cracking clay soils of northern NSW and Queensland, which usually contain ample amounts of S as gypsum in the subsoil.

Responses are most likely on shallow soils, deep sands and where sunflowers are double cropped.

If N is adequate but S is deficient:

- Sulfur stress at budding will decrease oil yields by 30% due to lower single seed weight and less seeds per plant
- Sulfur stress at anthesis will produce a 17% decrease in oil yield due to reduced seeds per plant due to floret abortion.

Sulfur deficiency can be corrected before anthesis, which will increase seed weight, providing N is adequate.

Zinc

Fertiliser responses to zinc (Zn) often occur on heavy textured alkaline soils. However they are more easily detected in crops such as maize and sorghum. Plant tissue analysis is a more reliable indicator of sunflower responsiveness than soil testing. Using starter fertilisers containing Zn or using foliar Zn applications can assist in addressing deficiencies.

Boron

Sunflower is a crop that has a high boron (B) requirement and is very sensitive to boron deficiency. Despite the majority of sunflowers being grown on alkaline calcium rich soils which lower B availability, B deficiency is rare. Transitory B deficiency may occur as a result of climatic conditions that limit uptake and translocation of B from soil to plant structures undergoing rapid growth.

Boron content of many soils increases with depth making deep soil sampling and plant tissue analysis necessary after root extension has reached at least 60 cm. Sunflower is tolerant of high soil B.

Fertiliser application guidelines

Germinating sunflower seed is very sensitive to fertiliser placed in the seed trench, and fertiliser should therefore be placed away from the seed, or consideration given to the amount and type of fertiliser placed in close contact with the seed (Table 3).

If sunflowers are planted using row crop equipment, the majority of the P and K should be side-banded 5 cm beside and 5 cm below the seed during planting.

Some or all of the N can also be applied pre-plant or side-banded, provided that the total amount of fertiliser material (NPKS) side-banded does not exceed 330 kg/ha of product. Nitrogen can also be side-dressed before the plants are 30 cm tall (6–8 leaf stage).

If applying some starter fertiliser in the seed trench, the rates in Table 3 provide guidelines (kg/ha) for two common seed-bed utilisation (SBU) factors for a light clay soil with good soil moisture in the seed zone.

SBU is the opener width divided by row spacing times 100. For example 2.5% SBU is 2.5 cm opener with 100 cm row spacing.

Table 3: Starter fertiliser rates based on common sunflower seed bed utilisation factors for a light clay soil with good soil moisture (Source: Seed-Placed Fertilizer Decision Aid, International Plant Nutrition Institute).

Product (kg/ha)	Seed Bed Utilisation (%)	
	2.5%	3.3%
MAP	11.5	15
DAP	14	18

Diagnosis of limiting nutrients in crop

Diagnosing sunflower nutrient deficiencies or toxicities can be confusing as symptoms may appear similar to other environmental or disease conditions. Use soil and plant tissue testing as a guide as well as consulting with reference literature and industry resources to assist in correct identification. Table 4 contains a guide to some nutrient deficiencies and toxicities.

Table 4: Symptoms of nutrient deficiency and toxicity in sunflowers (Source: Big Yellow Sunflower Pack 2015).

Deficiencies	Symptoms	Occurrence	May be confused with...	Management
Nitrogen (N)	Pale older leaves, stunting, less leaves, thin stems.	Sandy soils, low organic matter, long history of cropping, incorrect N budgeting, water logging.	S deficiency (first displays on new growth) which is opposite to N deficiency.	Create an N budget before sowing to ensure adequate N applied at or before sowing for target yield. Foliar in crop if deficient before bud initiation.
Phosphorus (P)	Lack vigour, smaller plants and heads; slow maturity, thin stems, older leaves with grey necrosis initially on leaf tip margins. Water soaked necrotic concentric circles.	Low organic matter, highly acidic or alkaline soils where P is more strongly adsorbed, long cropping history, low arbuscular mycorrhizal (AM), eroded topsoil.	Reduced plant growth is very difficult to diagnose; leaf necrotic symptoms may be confused with Alternaria or Septoria.	Preferably apply P at sowing banded below the seed as starter fertiliser also containing Zn.
Potassium (K)	Stunted plants, poor vigour, delayed maturity, oldest leaves interveinal chlorosis that develops necrosis. Leaves point down and may be cupped up or down.	Low organic matter, long history of cropping or haymaking, sandy low K soils, leached soils.	Magnesium (Mg) deficiency.	K fertiliser at or before sowing, not in contact with seed. Foliar spray possible but not usually required.
Sulfur (S)	Chlorosis of young leaves.	Low organic matter, acid sandy soils, long cropping history.	N deficiency; Molybdenum (Mo) deficiency.	No field reports known but suspected. Apply gypsum or sulfate of ammonia pre sowing.
Zinc (Zn)	Stunted plants, young leaves narrow, wavy leaf margin, leaf wilting, brown spot necrosis.	Highly alkaline soils, leached sandy soils, loss of topsoil, low AM soils.	Moisture stress – wilting.	Starter fertiliser with P and Zn banded at sowing, foliar Zn chelate in crop.
Boron (B)	Youngest leaves and bud leaves pale yellow. Bud ceases to expand, develops grey necrotic area near leaf base, yellow mid leaf, green leaf tip.	Leached sandy soils, alkaline soils with free lime, low organic matter.	Calcium (Ca) or copper (Cu) deficiency in vegetative state.	Chelated B sprays in crop.
Toxicity	**Symptoms**	**Occurrence**	**May be confused with...**	**Management**
Aluminium (Al)	Roots discoloured, multiple short, thick lateral roots. Poor seedling emergence, stunted plants, low vigour and yield.	Highly acidic soils (pH<5).	P and Mg deficiency on leaves.	Lime acid soils to raise pH.
Manganese (Mn)	Brown/black spots on lower stem, petioles, leaf blade hairs. Severe symptoms are interveinal chlorosis upper leaves, white necrotic patches, leaf crinkling.	Highly acid soils or poorly drained soils high in Mn.	Distinctly individual except petiole necrosis may look like Ca deficiency or disease.	Lime acid soils, improve drainage. Don't grow sunflower in poorly drained soils.

Plant tissue sampling

Plant tissue testing is an underused crop nutrition management tool. It is more reliable than soil testing for nutrients where local soil test calibrations are not available, or when checking on the effectiveness of a change to a fertiliser program. The key to successful plant tissue testing is ensuring the crop is sampled when actively growing, and the sample is collected from the appropriate plant part, at the correct growth stage and time. For example, time of day and soil moisture availability are important for some nutrients for consistency of results when doing consecutive tissue tests. Some plant tissue diagnostic values are presented in Table 5.

Table 5: Plant tissue sampling guidelines for top 1 to 3 mature leaves of sunflower at bud stage (Source: Reuter and Robinson, 1996).

Nutrient	Sufficient Range
Nitrogen %	2.0–3.4
Phosphorus %	0.25–0.49
Potassium %	1.5–2.9
Sulfur %	0.2–0.39
Calcium %	0.3–1.9
Magnesium %	0.2–1.4
Zinc mg/kg	15–69
Copper mg/kg	6–24
Iron mg/kg	20–249
Manganese mg/kg	15–99
Boron mg/kg	35–150

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Useful resources

Agronomy and Irrigation
www.bettersunflowers.com.au/bysp/agronomy

The Big Yellow Sunflower Pack, Module 2 Agronomy including Irrigation Management AOF Better Sunflowers Agronomic manual, March 2015.

Summer Crop Production Guide 2014, NSW DPI Management Guide, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/303485/Summer-crop-production-guide-2014.pdf

GRDC GrowNotes Sunflowers
http://www.grdc.com.au/Resources/GrowNotes

English M and Cahill M 2006 Sunflower Disorders: The Ute Guide, DPI&F & GRDC.

Grundon NJ 1987 Hungry crops: a guide to nutrient deficiencies in field crops, Queensland Department of Primary Industries.

Hibberd DE, Want PS, Hunter MN, Standley J, Moody PW and Blight GW 1991 "Marginal responses over six years by sorghum and sunflower to broadcast and banded phosphorus on a low P Vertisol, and changes in extractable soil phosphorus", Australian Journal of Experimental Agriculture, 3l, pp 99-106.

Peverill KI, Sparrow LA and Reuter DJ 1999 Soil Analysis – an Interpretation Manual. CSIRO Publishing.

Reuter DJ and Robinson JB 1996 Plant Analysis – an Interpretation Manual, CSIRO Publishing.

Useful resources

Serafin L, Belfield S and Herridge D 2010 Managing Nitrogen to Optimise Sunflower Yield and Oil content, Proceedings of the 1st Australian Summer Grains Conference, Gold Coast, Australia.
http://www.grdc.com.au/uploads/documents/2010ASGCEditedPapersPDF/Serafin_ManagingNitrogen_edited_paper.pdf

More information

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Sunflowers at bud stage. (Photo: Loretta Serafin, NSW Department of Primary Industries)

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