Sunflower is an economically attractive summer crop that regularly achieves excellent gross margins per hectare. Suited to both rainfed and irrigated farming systems, sunflowers offer growers dual planting windows in most regions, adding flexibility and value to cropping rotations.

Spring (early) plant sunflower is the earliest summer crop option available, ideal for following a long fallow after cereals. A summer (late) plant enables double cropping where adequate starting soil moisture is available, as well as extending the ability to plant when other summer crop windows have closed.

Sunflowers provide an effective disease break for several key pathogens present in Australian cropping systems. They are resistant to both species of root lesion nematodes and do not host the pathogens that cause crown rot in cereals, fusarium stalk rot in sorghum or ascochyta blight in chickpea.

Sunflower plants develop an extensive, fibrous root system with a large taproot that can seek soil moisture and nutrients from depths of more than 1.5 m and can ameliorate compacted layers, leaving the soil soft and friable.

Growing sunflowers can be a valuable part of an integrated weed management strategy for controlling summer grasses and feather top Rhodes grass. Herbicide groups A, C, D, J, K and L can be used in sunflower production, removing some of the reliance on glyphosate for total summer grass control.

There are very few in-crop herbicide options for broadleaf control, however when planted into clean paddocks, the uniform emergence promotes rapid inter-row shading of weeds to maximise crop competition.

Sunflowers are very sensitive to sulfonylurea (SU) and picloram residual herbicides so avoid planting into a paddock where these herbicides have been used, until the recommended plantback interval has been reached.

Sunflowers will prosper in a wide variety of soils and climatic conditions. Compared to fibrous rooted summer crops, the sunflower plant has the ability to access deep soil moisture under dry conditions. Ensure sufficient moisture is available after budding to optimise yield and oil quality.

Sunflowers require adequate nutrition yet have a significantly lower requirement for several of the major nutrients when compared to other crops. Use soil fertility test results to manage nutrient inputs to achieve optimal oil yield and quality, and maximise grain yield.
Key management tips

Starting soil water
• Plant into 80–100 cm of wet soil to minimise the risk of crop failure and maximise economic returns.
• Prior to sowing, use a soil corer (preferred method) or push probe, to determine the amount of stored water in the soil profile.
• If there is less than 80 cm of wet soil (equivalent to ~135 mm plant available water in sandy loam soils of lower water holding capacity), consider not sowing sunflowers. The hotter the environment the more soil moisture is required to minimise production risk.

Paddock history
• Be aware of herbicide residues in the soil. Sunflowers are particularly sensitive to sulfonylurea and picloram herbicide residues.
• Sunflowers are suited to no-till farming systems. They are usually sown after a no-till long fallow to take advantage of stored soil moisture.
• If there is adequate sub-soil moisture, sunflowers can be sown as an opportunity crop following a winter cereal.
• Consider disease management strategies to limit risk of planting into a reservoir of pathogen inoculum.

Hybrid selection
• Select high yielding hybrids that have the desired traits for your growing conditions.
• Understand the end use requirements of the target market and ensure that your production system supports delivery of a high quality product that meets the market’s standards.

Planting equipment
• Establishment of a uniformly distributed, appropriately targeted plant population for paddock conditions will maximise the yield potential of any field.
• Sunflowers can be successfully sown with precision planters, air seeders and combines, however precision planters with press wheels are the recommended option to provide best seeding accuracy.

Sowing time
• Monounsaturated sunflower hybrids are suited to both spring and summer planting in most regions. Birdseed sunflower hybrids are better suited to sowing in summer in NSW, Victoria and southern Queensland.
• Avoid sowing summer crops too late because cooler conditions later in the growing season can favour the development of diseases such as sclerotinia. Late sown crops are also more likely to dry-down slowly and may require desiccation prior to harvest to meet delivery standards.

Crop nutrition
• At planting, ensure the crop can access sufficient soil moisture and nitrogen to achieve the target yield.
• Base your nitrogen fertiliser applications on target yield, soil test results, plant available water at sowing, previous crop yield and desired oil content in the seed. Excess nitrogen applications can reduce the oil content percentage of the seed.
• Use paddock records and soil tests to determine if other nutrients, such as phosphorus, sulfur and potassium are limiting.

Weed control
• Control weeds prior to planting. Weed control in the first seven weeks following emergence is critical. If left unchecked, weed competition in the early crop stages will restrict yield potential.
• Establish a uniform plant stand to maximise the crop’s ability to suppress weed growth.
• Use effective weed control options, especially for grasses. Rotate herbicide groups across the cropping sequence to reduce the risk of resistance to Group A herbicides establishing in grass weed populations.
• Avoid planting sunflowers into paddocks with a high broadleaf weed burden.

Insect control
• Prior to sowing and at establishment, monitor and control insects, especially wireworms.
• From budding to grain fill, monitor (and control where necessary) Rutherglen bugs and helicoverpa to reduce the damage to developing heads and kernels. Any sort of head damage can predispose the crop to rhizopus head rot in wet weather or heavy dews.
• Assess the potential for mice and bird damage and take steps to protect the crop if necessary.

Disease control
• Be aware of the disease history of each rotational crop for each paddock.
• Familiarise yourself with the biology of any pathogens to ensure you are not planting into an inoculum reservoir.

Harvest
• Aim to harvest and deliver seed as close to 9% moisture as possible. Typically, sunflower seed is drier than expected.
Sunflower seeds contain healthy unsaturated oils, protein and fibre, plus essential nutrients that contribute to good health. Sunflower seed is used to produce monounsaturated oil, confectionary (sunflower kernels), organic sunflower (grain and oil), birdseed and stockfeed (horse feed rations).

To fulfil the market requirements, producers must meet the receiveal standards when delivering harvested seeds. The standards define the physical and chemical parameters, and set maximum levels of contaminants and impurities, for delivered product.

Buyers may offer premiums for higher quality consignments. They may also impose deductions or, in the worst case, refuse to accept sunflower seed that does not meet the grade standard.

There are at least 17 companies in Australia that buy sunflower seed for sale or processing. Growers are advised to contact buyers prior to planting sunflower to arrange contracts.

**Monounsaturated oil**

The Monounsaturated Sunflower Standard requires an oil content base of 40%, a minimum test weight of 32 kg/HL and moisture not exceeding 9%. The minimum oleic acid content accepted is 80%. Dependant on the contract, the grower will receive a premium for seed 1.5% above, or a deduction for seed 1% below, the 40% oil content standard.

Monounsaturated sunflowers are the major marketing opportunity for Australian growers. Due to the oil’s high oleic acid content (80–85%) and low linoleic acid content (5–10%), it is sought after as a healthy, long-lasting medium for deep frying foods. Monounsaturated sunflower oil is also used in margarines and bottled oils.

Demand for high oleic sunflower oil in Australia has doubled from 2000, however 55–90% of that demand has been filled using imported oil.

The majority of high oleic sunflower (HOSUN) oil is currently imported from South America (predominantly Argentina) as well as Europe and the Black Sea regions. The oleic acid content of the imported HOSUN oil is usually in the low 80% range, considerably lower than the oleic acid content of Australian-grown sunflower seed, which is usually around 85% (Cargill 2015).

Current sunflower crush capacity is operated by Cargill Australia at its Narrabri and Newcastle plants in NSW, and Cootamundra Oilseeds at Cootamundra, NSW.

**Polysaturated oil**

The Australian sunflower industry has moved to almost exclusive production of monounsaturated hybrids.

Monounsaturated hybrids are no longer commercially available from Australian seed suppliers.

Imported monounsaturated sunflower oil is used to produce bottled oils and margarine.

**Organic sunflowers (grain and oil)**

To supply this niche market producers need to have organic certification and meet the relevant accreditation requirements. Organic sunflower seed is used in crushing, breakfast cereals, breads, confectionary and snacks, and is often sold through health food shops. There are at least two buyers of Australian organic sunflower seed.

**Birdseed**

Generally the birdseed sunflower market has the same specifications as the oil based market. There are two key differences, being the visual aspect of the seed and the hectolitre weight. The birdseed standard requires a minimum 38 kg/HL test weight and growers should check their contract requirements as many buyers require test weights of 40 kg/HL or greater.

The birdseed market requires a striped sunflower seed, which is lower in oil and higher in protein than other seed hybrids. The market is small and variation in supply and demand can result in large price fluctuation. Containerised imports of birdseed generally increase once the price available to Australian growers exceeds $1000/t. Generally buyers will wait until the imported stocks are sold before purchasing Australian-grown seed again.

The birdseed industry continues to expand as evident from the wide variety of birdseed products available in local produce stores and supermarkets. There is often a significant shortage of hybrid birdseed available to plant, which limits supply potential in this market.

**Confectionary (sunflower kernels)**

Sunflower kernels are frequently added to products such as bread, muesli and snack foods. This market requires a large seed that is easy to dehull. Moisture stress during the growing season can negatively affect the hull to kernel ratio, making the dehulling process difficult. Large seed suited to dehulling is most reliably produced under irrigation and in favourable, rainfed areas.

Traditionally, inconsistency in kernel size, insect damage and general low domestic supply has forced buyers to import most of the sunflower kernels consumed in Australia. Some buyers specialise in sunflower kernel and contract domestic product, predominantly from irrigation farms that can ensure a consistent supply of large sunflower kernels. Demand for sunflower kernel is increasing in Australia.

**Stockfeed (horse feed rations)**

The racing, recreational and sporting sectors of the equine industry use sunflower seed as a source of protein and fibre that promotes a shiny coat on the horse and well-conditioned hooves. This industry has the potential to consume up to 15000 t of sunflower seed per year, and demand is increasing.

This market does not pay an oil bonus or discount and does not make deductions for admixture. The sample should be bright, large and even, as appearance is critical in this market.
Hybrid choice

When targeting the oil market, choose hybrids firstly on their yield potential and secondly on oil content. Use trial results as a guide but always try the hybrids on your farm and grow those that produce the best average results.

Other important considerations for hybrid choice include disease tolerance, maturity, head inclination, height and good agronomic type. Commercial availability of sunflower hybrids can vary by region, according to the time of the year and seed supply.

High oleic (monounsaturated) sunflowers are best sown in the spring to take advantage of the warm temperatures needed to produce oleic acid during grain fill. Controlled temperature studies show that low night temperatures suppress the production of oleic acid.

Monounsaturated sunflowers are required to have greater than 80% oleic acid content on delivery.

Characteristics of sunflower hybrids.

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>Maturity</th>
<th>Planting dates</th>
<th>End use</th>
<th>Height</th>
<th>Head inclination</th>
<th>Resistance to TSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>NuSeed</td>
<td>Medium</td>
<td>Spring and summer</td>
<td>Monounsaturated (high oleic) oil</td>
<td>Medium</td>
<td>Semi-erect</td>
<td>TSV: good</td>
</tr>
<tr>
<td>Ausigold 62</td>
<td>Medium</td>
<td>Spring and summer</td>
<td>Mid-oleic oil Confectionary and birdseed (grey stripe)</td>
<td>Medium–tall</td>
<td>Semi-erect</td>
<td>TSV: good*</td>
</tr>
<tr>
<td>Ausistripe 14</td>
<td>Medium</td>
<td>Spring and summer</td>
<td>Mid-oleic oil Confectionary and birdseed (grey stripe)</td>
<td>Medium–tall</td>
<td>Semi-erect</td>
<td>TSV: good*</td>
</tr>
<tr>
<td>Pacific Seed</td>
<td>Medium–slow</td>
<td>Spring and summer</td>
<td>Monounsaturated (high oleic) oil</td>
<td>Medium–tall</td>
<td>Semi-pendulous</td>
<td>TSV: moderately susceptible</td>
</tr>
<tr>
<td>Hyoleic 41</td>
<td>Medium–slow</td>
<td>Spring and summer</td>
<td>Monounsaturated (high oleic) oil</td>
<td>Medium–tall</td>
<td>Semi-pendulous</td>
<td>TSV: moderately susceptible</td>
</tr>
<tr>
<td>Sunbird 7</td>
<td>Medium</td>
<td>Spring and summer</td>
<td>Confectionary and birdseed</td>
<td>Medium–tall</td>
<td>Semi-pendulous</td>
<td>TSV: moderately susceptible</td>
</tr>
</tbody>
</table>

Source: Pacific Seeds and Nuseed websites, 2015. TSV rating provided by Dr Murray Sharman, Qld DAF (*only one year of testing data)

Australian production areas

The main sunflower growing areas are the Liverpool Plains, northern NSW, Darling Downs and central Queensland, with smaller areas in the Ord River Irrigation Scheme, Victoria and southern NSW. Areas shown in green are the main production zones. In some years, sunflowers are also grown in the areas shown in blue.

Recommended planting times for sunflower grown in different regions.

<table>
<thead>
<tr>
<th>Planting window</th>
<th>Early (spring) plant</th>
<th>Late (summer) plant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aug 1 2 3 4 1 2 3 4</td>
<td>Oct 1 2 3 4 1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>Nov 1 2 3 4 1 2 3 4</td>
<td>Dec 1 2 3 4 1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>Jan 1 2 3 4 1 2 3 4</td>
<td>Feb 1 2 3 4 1 2 3 4</td>
</tr>
<tr>
<td></td>
<td>Mar 1 2</td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Moore, Serafin and Jenkins, Summer crop production guide, 2014, NSW Department of Primary Industries and Summer crop production guide, 2011, NSW DPI.
Rotational fit and tillage practices

Rainfed sunflowers are most commonly sown in spring (except in Central Queensland), following a long fallow after either wheat or barley, and are highly suited to no tillage into cereal stubble. This sequence allows broadleaf weed control in the preceding cereal crop and cereal stubble provides adequate ground cover to minimise erosion. An alternative is to plant sunflower in spring following a short fallow from sorghum.

Double cropping in the summer immediately after a winter cereal is an option in seasons where there is sufficient post-harvest rainfall to fill the soil profile going into the summer planting window. Double cropping can provide a lower cost option than mungbeans, however this practice is not recommended if stored soil moisture is limited.

In a cereal-dominant cropping sequence, sunflowers provide an excellent break for cereal diseases such as crown rot and root lesion nematodes, and an opportunity to control grass weeds.

Sunflowers should not be planted following crops such as canola and rice, which do not host arbuscular mycorrhiza (AM, formerly known as VAM), a fungi that assists in nutrient availability (particularly phosphorus). AM fungi levels can also be low after a long fallow, potentially requiring the application of phosphorus and zinc fertiliser.

An overall understanding of disease pathogens and how they affect each crop in the rotation is important so that informed decisions can be made regarding potential disease risks. It is best to avoid sowing sunflowers in close succession with other broadleaf crops due to the risk of diseases carrying over from one broadleaf crop to the next. Best practice guidelines suggest not planting sunflowers more than once in a three-year period.

Preservation of the cereal stubble layer is very important for sunflowers. Stubble from winter cereals promotes water infiltration, protects seedlings from sand blasting and provides ground cover to reduce erosion while the sunflowers are growing and after the crop is harvested.

The use of Kelly-chains for weed control is not considered best practice because the implement can disturb the stubble, increasing the rate of soil moisture loss and may contribute to soil compaction and pathogen spread.

Use a precision planter suited to minimum or no-till systems to achieve an even plant spacing and avoid double seeds and gaps. The resulting even plant stand will maximise yield through uniform head and grain size.

Sunflowers leave the soil softer and more friable than other crops and their strong tap roots can break up compacted layers.

No-till farming

Combined with stubble cover, no-till aids moisture retention, leading to consistently higher yielding sunflower crops. No-till also provides a wider sowing window and stores more soil water. This enables a shorter fallow with more efficient water use, less runoff and less erosion.

However, no-till can encourage the build-up of stubble borne pathogens, soil insects and mice compared to conventional land preparation. Insecticidal seed treatment is recommended when planting into zero tillage fields. Monitor mice numbers and treat if necessary.

Growing sunflowers in a no-till system relies on effective weed control in the previous crop and fallow. In no-till farming, the options for some broadleaf weed control may be limited due to the inability to effectively incorporate pre-emergent herbicides. When applying pre-emergent herbicides in high stubble situations, increase the water volume and choose herbicides suited to the stubble load present.
Crop production cycle, paddock selection and sowing

Days to critical growth stages, such as flowering, have been recorded for several commercial sunflower hybrids. This information assists in matching hybrid maturity to sowing time.

The exact number of days required to reach specific growth stages can vary depending on temperature, day length, moisture and hybrid, so this information provides a guide only.

Flowering is a critical growth stage that growers can use to match hybrid maturity to planting date. Doing this helps to avoid high risk periods such as heat stress, frost risk and disease. The critical time for heat stress is 12–15 days after flowering.

Sunflower plants usually flower for 5–10 days, however high temperatures shorten the duration of flowering. Temperatures greater than 35°C during and after flowering can affect yield, fatty acid composition of the oil and the hull to kernel ratio. The temperature within a sunflower head is usually 5°C warmer than the ambient temperature.

Paddock selection
Choose paddocks that have:
- no herbicide residues
- been previously sown to a winter cereal or a sorghum crop
- a good level of stubble cover
- a full profile of moisture after rainfall or a long fallow
- minimal broadleaf weeds
- deep soil with minimal sub-soil constraints
- not had another broadleaf crop sown in the last three years.

Sunflowers are sensitive to several common residual herbicides, including sulfonylureas and picloram. The time since application, soil type, herbicide rate and rainfall all affect the plantback length.

To minimise any potential TSV risks, growers in Central Queensland should also consider selecting paddocks away from areas heavily infested with parthenium weed.

Sowing guidelines
For spring sowings, the soil temperature at 10 cm depth should exceed 10–12°C at 8.00 am (Eastern Standard Time) and the period of heavy frosts should be over. Aim to plant on rising soil temperatures.

In contrast, extremely high soil temperatures can reduce establishment, particularly if the air temperature is greater than 40°C, when soil temperatures can exceed 60°C. Lighter soils with a higher percentage of sand will be hotter than clay soils. Retained stubble and soil moisture assist in keeping the soil temperature relatively cooler and more even throughout the profile.

Sunflower establishment will be best when 7–10 days of favourable growing conditions follow planting. Extremes of heat or cold may result in patchy plant stands. Sunflowers can tolerate light frosts in the early and late stages of growth, and can tolerate high temperatures during the vegetative growth phases, but not during flowering and seed-filling.

Available moisture, the planter and the soil type dictate sowing depth, which may range from 2.5 to 7 cm, but is most commonly 3–5 cm.

Sunflowers may be successfully sown with precision planters, air seeders or even combines. However the preferred option is the precision planter, which can place the seed more accurately, with minimal double seeds or gaps.

Sowing time
Sunflowers have distinct advantages over many other summer crops due to the two sowing windows in most regions. The early, or spring, plant (mid-August to end of October) enables sowing of a percentage of the summer crop area before the main window for crops such as sorghum opens.

Conversely, the late summer plant (November to end of January) window allows double cropping after a winter cereal in favourable seasons and the ability to plant after other summer crop windows have closed.
Sunflower crop development phases.

<table>
<thead>
<tr>
<th>Vegetative phase</th>
<th>Floral phase</th>
<th>Seed filling phase</th>
<th>Dry down</th>
</tr>
</thead>
<tbody>
<tr>
<td>VE</td>
<td>V4</td>
<td>R1</td>
<td>R3</td>
</tr>
<tr>
<td>V4</td>
<td>R5</td>
<td>R6</td>
<td>R1</td>
</tr>
<tr>
<td>R1</td>
<td>R3</td>
<td>Heads turn over</td>
<td>R5.5</td>
</tr>
<tr>
<td>R3</td>
<td>R6</td>
<td>Physiological maturity</td>
<td>R6 (Flowering is complete)</td>
</tr>
<tr>
<td></td>
<td>R9</td>
<td>Harvest maturity</td>
<td></td>
</tr>
</tbody>
</table>

**VE (Vegetative Emergence)**

- Bud initiation
- 8–12 leaf seedling

**V4 (Vegetative stage 4 – number of true leaves at least 4 cm in length)**

- Head visible
- 16 leaves

**R1 (Reproductive stages)**

- Immature bud elongates more than 2 cm above the nearest level

**R3 (Immature bud elongates more than 2 cm above the nearest level)**

- Head visible
- 16 leaves

**R5.5 (R5 stage is the beginning of flowering. The decimal corresponds to the percentage of head area that has completed or is flowering – i.e. 50%)**

**R6 (Flowering is complete)**

**Source:** Adapted from NSW DPI Sunflower AgFact (1997), indicative of a sunflower crop planted in December.

Images: Loretta Serafin and Stephanie Belfield
Sowing time will always be a compromise. Early planted (spring) crops are at risk of late frost and low soil temperatures during establishment and heat during flowering and seed-fill. Crops sown in the spring use more water due to the summer heat and the longer growing season.

Late planted (summer) crops often experience extreme temperatures during establishment, and sowing after the end of January increases the risk of disease such as sclerotinia and powdery mildew. Late planted crops are also at risk of frost damage and slow crop dry down at the end of the season.

**Plant population**

Establishment of a uniform plant stand of adequate density is critical for a successful crop.

Target a plant population based on the depth of wet soil at sowing, the likely in-crop rainfall and growing conditions in your area. Seed suppliers can advise the optimal plant population for your situation.

When calculating your seed requirements, allow an extra 25% for establishment losses. Depending on planting conditions, machinery losses can be in the range of 20–50%.

**Row spacing and configuration**

Sunflowers may be planted on row spacings ranging from 50–150 cm, depending on the location in which they are grown, likely yield and planter configuration.

The majority of sunflowers sown on the Liverpool Plains in northern NSW and in southern Queensland areas are planted on 75 cm solid plant rows, whereas in Moree, NNSW and Central Queensland production regions, 100 cm is the preferred row spacing due to higher average temperatures and lower expected rainfall.

Row configuration impacts yield and oil content. NSW DPI trials (2007/08) indicated that yields of rainfed crops were reduced by sowing on wide rows (150 cm) and reduced further by single skip configurations on 100 cm row spacing. Row spacing and configuration did not affect oil content until sunflowers were planted on single skip configurations at 100 cm, when a significant reduction occurred.

**Crop nutrition**

Sunflowers are moderately tolerant of a range of soil constraints but prefer a friable soil surface for best crop establishment. They grow best in neutral soils but can be successfully grown on soils ranging from slightly acid to alkaline.

They do not tolerate acidic soils with pH$_{1:5}$ 5.0 or below. These soils tend to have more available aluminium and manganese, which can induce toxicities in sunflower.

Sunflowers tolerate high concentrations of manganese (Mn) in the root environment and are moderately tolerant to salinity, being 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 and the rate of yield decline is about 5% per dS/m above this level.

High sodicity does not appear to effect oil content but may delay germination and flowering. Sunflower is considered to have moderate tolerance to sodium (ESP 30–40%) however sodic top-soil will constrain production through soil surface instability, inhibiting crop establishment and restricting water infiltration. Sunflower roots do not efficiently extract water from sodic sub-soil so crop yield potential is restricted.

Ensuring the nutrient needs of the crop are met is critical to maximise profit. Nutrient management seeks a balance between grain yield and oil production and decisions should be based on soil test results.

**Nitrogen (N)**

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

Excess nitrogen promotes excessive vegetative growth and can cause a reduction in oil content. Insufficient nitrogen will limit crop yields through poor crop establishment, uneven crop growth and maturity, and increased susceptibility to disease and pests during the season.

<table>
<thead>
<tr>
<th>Target plant population guide (‘000/ha).</th>
<th>Monounsaturated</th>
<th>Confectionary/Birdseed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dryland</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marginal</td>
<td>20–25</td>
<td>20</td>
</tr>
<tr>
<td>Favourable</td>
<td>25–35</td>
<td>25–35</td>
</tr>
<tr>
<td>Irrigation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limited</td>
<td>35–50</td>
<td>30–40</td>
</tr>
<tr>
<td>Full</td>
<td>50–75</td>
<td>35–45</td>
</tr>
</tbody>
</table>

Source: Adapted from Moore, Serafin and Jenkins, Summer Crop Production Guide, 2014, NSW Department of Primary Industries
Phosphorus (P)
Phosphorus is considered the second (after N) most frequently limiting deficiency to occur within sunflower crops. If arbuscular mycorrhizal (AM) fungi levels are low, such as following a long fallow, canola or rice, supplying adequate phosphorus and zinc fertiliser is very important. An application of foliar zinc can be beneficial in alkaline soils where zinc availability is often limited.

Potassium (K)
In older cropping soils, potassium can be limited or may accumulate in the surface layer. Potassium is fairly immobile in the soil so it is important to test K levels down the profile, not just in the surface layer. Sunflowers require sufficient potassium to ensure stalk strength and to boost the plant’s ability to cope with drought conditions.

Sulfur
In sunflowers there is an important interaction between nitrogen and sulfur. Seed weight, seed numbers per plant, quality and oil percentage are likely to suffer if the N:S balance is wrong.

Seed placement
Germinating sunflower seed is very sensitive to fertiliser burn. To avoid poor germination results, place fertiliser away from the seed at planting. If row crop equipment is used, side-band the majority of the phosphorus and potassium 50 mm beside and 50 mm below the seed at planting.

Some or all of the nitrogen can also be applied pre-plant or side-banded (as above), provided that the total amount of side-banded fertiliser does not exceed 330 kg/ha. Nitrogen can also be side-dressed before the plants are 30 cm tall.

Soil test guidelines at a 0–10 cm sample depth in medium-clay soils. (Adapted from Peverill et al, 1999)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Desired range</th>
<th>Attribute</th>
<th>Desired range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (1:5 water)</td>
<td>5.7 – 8.5</td>
<td>Electrical Conductivity (1:5 water) (dS/m)</td>
<td>less than 0.6</td>
</tr>
<tr>
<td>pH (1:5 CaCl2)</td>
<td>5.0 – 7.5</td>
<td>Copper (DTPA) (mg/kg)</td>
<td>greater than 0.3</td>
</tr>
<tr>
<td>Organic Carbon (W-B) %</td>
<td>greater than 1</td>
<td>Zinc (DTPA) (mg/kg)</td>
<td>greater than 0.8</td>
</tr>
<tr>
<td>Nitrate-N (1:5 water) (mg/kg)</td>
<td>greater than 20</td>
<td>Iron (DTPA) (mg/kg)</td>
<td>greater than 2</td>
</tr>
<tr>
<td>Sulfate-S (MCP) (mg/kg)</td>
<td>greater than 4</td>
<td>Manganese (DTPA) (mg/kg)</td>
<td>greater than 2</td>
</tr>
<tr>
<td>Phosphorus (Colwell) (mg/kg)</td>
<td>greater than 18*</td>
<td>Boron (Hot water) (mg/kg)</td>
<td>greater than 0.5</td>
</tr>
<tr>
<td>Potassium (exch.) (cmole/kg)</td>
<td>greater than 0.18</td>
<td>Exchangeable magnesium %</td>
<td>less than 30</td>
</tr>
<tr>
<td>Calcium (exch.) (cmole/kg)</td>
<td>greater than 1</td>
<td>Exchangeable sodium %</td>
<td>less than 6</td>
</tr>
<tr>
<td>Magnesium (exch.) (cmole/kg)</td>
<td>greater than 1</td>
<td>Electrochemical stability index</td>
<td>greater than 0.05</td>
</tr>
<tr>
<td>Chloride (1:5 water) (mg/kg)</td>
<td>less than 300</td>
<td>Electrical Conductivity (sat. ext.) (dS/m)</td>
<td>less than 4</td>
</tr>
</tbody>
</table>

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

Disease outbreaks in any crop occur when a pathogen comes in contact with a susceptible host and the environmental conditions favour the development and spread of the disease. To minimise the risk of disease in sunflowers, choose hybrids that have some resistance to common diseases in the area, plant within the range of optimal dates and follow the recommendations for irrigation, plant density, crop nutrition and drainage.

Healthy plants are generally better able to withstand more disease pressure than plants that are already under stress.

Some diseases that affect sunflower plants display very similar visual symptoms, making field identification of the cause difficult. For example, Phoma, Phomopsis and Tobacco Streak Virus (TSV) all exhibit as brown or black streaks or lesions on the plant stems.

Be prepared to seek advice and to send plant samples to a plant pathologist for diagnosis.

Currently, the dominant diseases in sunflowers are powdery mildew, sclerotinia rot, sclerotium base rot and crown rot, rhizopus head rot, phomopsis stem canker, phoma black stem and tobacco streak disease. These are summarised in the following table.

Other diseases that may cause management problems in some areas or seasons include:
- Rust (Puccinia helianthi)
- White blister (Albugo trogopogonis)
- Charcoal stem rot (Macrophomina phaseolina)
- Botrytis head rot or grey mould (Botrytis cinerea)
- Verticillium wilt (Verticillium dahliae)
- Septoria leaf spot (Septoria helianthi)

Sunflower diseases summary. (Sources: GRDC Sunflower Disease Management Tips and Tactics and the Big Yellow Sunflower Pack, 2015)

<table>
<thead>
<tr>
<th>Favourable conditions for infection</th>
<th>Symptoms</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Powdery mildew (Golovinomyces cichoracearum)</strong></td>
<td>All hosts of sunflower powdery mildew are members of the Asteraceae family, most significantly the wild sunflower. Spores are wind-borne and will remain viable after travelling long distances under cool conditions. A live host is required for this disease to survive.</td>
<td>High humidity, low light and temperatures 20-25°C. Spores germinate within 2-4 hours under ideal conditions. Short life cycle of 5-7 days under ideal conditions. Spores disperse by wind leading to rapid movement between leaves and crops. Free water (rain or irrigation) on the leaf inhibits spore germination but the resulting humidity favours infection once leaves dry.</td>
</tr>
<tr>
<td><strong>Sclerotinia rot (Sclerotinia sclerotiorum, S. minor)</strong></td>
<td>Both species of Sclerotinia produce hard black sclerotia that are composed of compacted fungal strands and can survive many years in the soil. Sclerotia can be physically transported in plant debris, boos, machinery, irrigation and flood waters. Sclerotia formed in the heads can be transported with seed and be difficult to sieve out from a seed sample if clumped together. Survives in stubble and as sclerotia in soil.</td>
<td>Cool (&lt;18°C) moist conditions favour the germination of sclerotia of S minor in the soil, which can either directly infect roots or produce airborne spores that infect flowers and sometimes stems and petioles. S. sclerotiorum prefers warmer conditions of 21°C or higher so is more common in CQ than S minor.</td>
</tr>
<tr>
<td><strong>Sclerotium base rot, crown rot (Sclerotium rolfsii)</strong></td>
<td>Similar to the Sclerotinia spp and survives for long periods in stubble and as a caramel brown sclerotie in the soil. Large number of broadleaf hosts as well as some dicots such as sorghum if conditions are very favourable.</td>
<td>Prefer warm wet conditions and in the mid to high 20°C. Found in NNSW and CQ, Lockyer. Increasing in incidence.</td>
</tr>
<tr>
<td><strong>Alternaria blight (Alternaria helianthi)</strong></td>
<td>Survives on infected sunflower residues, sunflower volunteers and wild sunflowers. Spores are airborne.</td>
<td>Prefers warm wet conditions and in the mid to high 20°C over 3–4 days. Seedlings and flowering plants are more susceptible. Roughly circular to angular dark brown to black necrotic spots seen on lower leaves. Can affect other plant parts is conditions are favourable for the disease. Similar to Septoria leaf spot.</td>
</tr>
</tbody>
</table>
Phomopsis stem canker (Diaporthe spp.)  

Phomopsis survives in plant debris with small black/brown pycnidia (fruiting bodies) developing in the dry stalks as conditions become favourable. Spores can be dispersed by wind over short distances with raindrop splash and irrigation enhancing spread. Phomopsis can be seed-borne.

**Favourable conditions for infection**  
Phomopsis infection is favoured by wet conditions from late budding through to flowering. Disease severity depends primarily on climatic conditions and plant growth stage. Optimal temperatures are 23–25°C but the fungus will grow at temps between 14–32°C.

Characteristically, plants display brownish lesions dotted regularly up the stems at the nodes. Symptoms usually occur from budding through flowering to maturity. Depending on the severity of infection, mid-stem lodging may occur, not necessarily at a node or the site of infection.

**Symptoms**  
The first symptoms appear on the lower or middle leaves around the leaf margins usually around the time of budding or flowering. Small necrotic areas, sometimes showing a chlorotic border, quickly merge and infect the leaf veins. Leaves die off rapidly as the infection moves down the leaf petiole to the node where the characteristic light brown lesion develops. Lesions are always centred on the axis and start as small brown sunken spots which can rapidly develop into an elongated light tan to dark brown lesion up to 20 cm in length. Lesions may appear water-soaked and vary in colour from olive greenish brown (often water-soaked) to pale caramel brown to dark brown with a black edge. Small black fruiting bodies (pycnidia) may be visible in the lesion if infection is advanced. The fungus rots the pith behind the lesion eventually leaving the stem hollow. This results in stem weakness, sometimes wilting and leaf necrosis if infection is severe, and subsequent lodging as the head fills if pith damage is advanced.

**Control**  
Controlling insect pests at or before flowering is the most effective way to minimise disease incidence. Sources of genetic resistance have been identified but incorporating the resistance into commercial hybrids has not been considered a priority.

Phoma black stem (Phoma spp.)  

Not usually damaging under Australian conditions on Australian hybrids but has been known to cause lodging overseas.

**Favourable conditions for infection**  
Warm wet conditions, similar to Diaporthe/phomopsis. Can be found as a mix infection on the same plant. Lesions may be confused with those caused by Phomopsis stem canker and TSV.

**Symptoms**  
Usually a black surface lesion at the node - does not usually disrupt the vascular tissue or cause lodging in Australia.

**Control**  
Survives in stubble. Seed borne.

Tobacco streak disease (Tobacco Streak Virus, TSV)  

Currently only found in Central Queensland, TSV is no longer considered a significant risk in CQ due to the availability of resistant hybrids. TSV is only transmitted in pollen and seed of some hosts. It infects healthy plants via the feeding wounds of thrips, which allows TSV-infected pollen to enter. TSV disease is favoured by climatic conditions that enable high thrips populations to develop, and large amounts of infective pollen to be produced by some weeds nearby to crops such as parthenium, the major host of TSV in CQ. These conditions generally occur during warmer months and are highly dependent on rainfall and weed growth patterns.

**Favourable conditions for infection**  
TSV-infected pollen may be dispersed significant distances by wind or thrips. TSV is seed transmitted in some alternative hosts such as parthenium, crownbeard, cobbler's pegs and fleabane. Research to date indicates that TSV is not seed transmitted in sunflower. TSV can only survive in living plant hosts or in seed of some of those hosts (e.g. parthenium). It does not survive in soil or on dead plant material.

**Symptoms**  
The symptoms of TSV on sunflowers include black streaks on the stem and leaf stalks, stunted growth, deformed growing tip, yellow and/or necrotic blotches on leaves, shortened internodes, plant death (especially in plants that become infected in early stages of development) and lodging of older plants due to weakened stems and blackened pith.

**Control**  
Grow resistant varieties. It is important to maintain farm hygiene, by removing host weeds and avoiding planting in high risk locations such as downwind of major parthenium infestations. It is unlikely that in-crop applications of insecticides for thrips control will provide effective control of TSV transmission into the crop and may disrupt effectiveness of integrated insect management systems.
Integrated disease management

Disease management in sunflower relies heavily on cultural controls and a good understanding of the pathogens of all crops grown in the crop rotation.

The key elements of an IDM are to:

- Monitor and diagnose—this may require sending samples to a plant pathology laboratory.
- Follow the ‘Come Clean, Go Clean’ on-farm hygiene guidelines.
- Control alternative hosts and manage crop residues to reduce inoculum.
- Follow best practice crop management for plant population, nutrition, row spacing and weed control.
- Choose hybrids with the best available disease resistance profile and suited to the growing region and farming system.
- Apply fungicide treatment for powdery mildew if necessary.
- Control insects to reduce crop damage and disease entry points.
- Manage irrigation to minimise disease risk.

Sunflower as a disease break crop

Sunflowers provide an effective disease break for several key pathogens present in Australian cropping systems.

They are resistant to both species of root lesion nematodes and do not host the pathogens that cause fusarium crown rot in wheat, fusarium stalk rot in sorghum or ascochyta blight in chickpea.

**Integrated disease management strategies for sunflower.** (Adapted from Big Yellow Sunflower Pack, 2015)

**Before planting**

- Understand pathogen biology across all crops and plan broadleaf crop rotation with IDM in mind
- Choose disease resistant hybrid
- Control alternative hosts (i.e. weeds)
- Manage stubble

**In-crop**

- Follow best management agronomic practice
- Monitor and send samples for diagnosis
- Manage irrigation
- Control insects to minimise disease entry points

**Budding to harvest**

- Monitor for powdery mildew and apply fungicide to protect the top one-third of the leaves and the head (check the permit)
- Control insects to minimise entry points as Rhizopus sp. infects during the floral phase and progress to damaging levels during the seed filling stage under favourable conditions.
- Make note of all diseases in the crop so as to make informed decisions about future rotations.
- Beware of any stubble inoculum reservoirs.

**Harvest & storage**

- Harvest at correct moisture content
- Store seed in aerated silos to minimise the risk of mould development affecting quality
Weed control and herbicides

It is important to select paddocks with low weed populations, particularly broadleaf weeds, as registered herbicide options for use in-crop are limited.

Weed competition studies have shown control is critical in the first seven weeks following sunflower emergence, when sunflower plants are not competitive against weeds. Low to moderate levels of weed competition can reduce early crop biomass by 39% and final yield by 16%.

Uniform emergence in clean paddocks will support the plant structure to quickly provide inter-row shading (full canopy closure) and maximise crop competition.

Higher plant populations (e.g. > 30,000 plants/ha) and narrower row spacing (e.g. < 1.0 m) improve crop competition but are only suitable in high rainfall areas.

Summer-growing grass weed seedlings can be controlled with a post-emergent grass selective herbicide. Growing sunflowers can be a valuable part of an integrated weed management (IWM) strategy for controlling summer grasses and feather top Rhodes grass. Sunflower production allows the use of herbicides from the A, C, D, J, K, L mode of action (MOA) groups for high risk summer grasses, and removes some of the reliance on glyphosate for total summer grass control.

Unfortunately, all selective grass herbicides use the Group A mode-of-action and are at a high risk of developing resistance if IWM programs are not implemented. Resistant grasses can be controlled using a combination of crop rotation, pre-emergent herbicide and inter-row spraying or inter-row cultivation.

Perennial weeds pose a particular problem as they are very difficult to control once established. Often the herbicides most effective on perennial species have long plantback periods for sunflowers.

Integrated weed management

The aim of developing an integrated weed management (IWM) plan is to achieve and maintain low weed numbers, while remaining profitable. To lower weed numbers, aim to reduce the weed seed-bank, and in the case of perennials, the tubers, corms, bulbs or rhizomes (vegetative propagules). This relies on a ‘zero weed seed set’ policy, as opposed to short term economic weed control, where a few weeds are left to survive and to set seed.

A ‘zero weed seed set’ policy involves using a number of weed control tactics to target the same species, or group of species, within the one season. The ‘double knock’ technique, which involves the use of two herbicide applications from different mode of action (MOA) groups in close succession, e.g. within 7–10 days of each other, is a useful technique to stop seed set in hard to kill weeds.

As there are few in-crop weed control options for sunflowers, weed seed-banks must be targeted in the fallow and in other phases of the crop rotation. Desiccation of the sunflower crop as an aid to harvest also provides an opportunity for non-selective knockdown control of weeds present at harvest.

Herbicide application for weed control. (Adapted from Big Yellow Sunflower Pack, 2015)

![Herbicide application chart](image-url)

**Herbicide application chart**

<table>
<thead>
<tr>
<th>Phase</th>
<th>Application Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-emergent</td>
<td>Metolachlor°F1, pendimethalin°F1, trifluralin°F1</td>
</tr>
<tr>
<td>PSPE</td>
<td>Metolachlor, pendimethalin, prometryne</td>
</tr>
<tr>
<td>Post-emergent</td>
<td>Butoxydim, fluazifop-p, haloxyfop, propaquizafop, quizalofop, sethoxydim</td>
</tr>
<tr>
<td>Pre-harvest desiccation</td>
<td>Diquat, glyphosate (check permit)</td>
</tr>
</tbody>
</table>

Pre-Sow Incorporated (PSI), Incorporated by sowing (IBS), Post Sowing Pre-Emergent (PSPE)
Insect pests and insecticides

Monitor and manage insect pests, in particular Rutherglen bug and helicoverpa.

Seedling pests
The main seedling pests are brown cutworms, wireworms, false wireworms and brown field crickets. Check for insect pests regularly and thoroughly before planting and during establishment. Use germination seed baits (gsb) prior to planting. If there is a history of soil pests, use insecticide seed dressings where possible and spray when insect populations exceed the economic threshold.

Reproductive stage pests
The major pests of sunflower are Rutherglen bug (\textit{Nysius vinitor}) and Helicoverpa spp. Green vegetable bug (\textit{Nezara viridula}) is a minor pest.

\textbf{Rutherglen bug (\textit{Nysius vinitor})}
Rutherglen bugs (RGB) reduce sunflower yield and oil content by sucking the developing seed, which reduces seed weight and changes oil composition. The critical times to monitor Rutherglen bug populations are at budding and seed fill. Moisture stress will exacerbate the effect of Rutherglen bug damage.

When a Rutherglen bug pierces the seed it leaves brown marks on the seed that make confectionary seed visually unattractive. It can be difficult to maintain numbers below the threshold of five adult Rutherglen bugs per plant.

Rutherglen bugs breed in inland areas on a wide range of host plants, including winter weeds. They move into crops when these weeds dry off. Female Rutherglen bug lay up to 400 eggs, which hatch approximately one week later. The nymphs are wingless, with a pear shaped body and are reddish brown in colour. Nymphs develop over three weeks, before gaining wings, changing their shape and size and becoming adults.

Females use the developing sunflower seed as a protein source to initiate egg laying. Eggs are laid between the seeds and dead florets up to two weeks post-flowering. This means a second generation could be mature enough to lay a third generation by the time the crop reaches physiological maturity. Damage can continue until harvest, depending on seed hardness.

RGB management aims to prevent population explosions, so an understanding the lifecycle of the Rutherglen bug helps when making spray decisions. Adults will not start breeding until a protein source is available in the form of developing sunflower seed and by late February breeding ceases, even if crops are still available.

Rutherglen bug infestations can be extremely patchy making monitoring difficult, however DAFQ recommends random sampling of 20 heads per field to estimate the number of bugs per head and calculate a field average.

The most effective pesticides are synthetic pyrethroids, which have 3–5 day residual effect and severely disrupt natural predator populations. As adults are winged, re-infestation can occur rapidly after treatment. If crops require spraying, best results are achieved with application prior to petal drop and before the heads turn toward the ground.

\textbf{Helicoverpa spp.}
There are two species of helicoverpa that occur in sunflower—\textit{Helicoverpa armigera} and \textit{H. punctigera}. Heicoverpa cause damage from late budding until late seed-fill by:
- leaf feeding and feeding on the stem during budding
- eating florets and developing seeds
- boring holes into the back of sunflower heads.

Sunflower can tolerate large numbers of helicoverpa caterpillars. There is no significant yield reduction from helicoverpa feeding on leaves, seeds or florets in the absence of secondary head rots.

At budding, more than four 7 mm long larvae per head is the threshold for spraying. Natural mortality rates of 30% for larvae less than 7 mm are common and should be taken into account. When expected mortality is included in the calculation, the threshold for <7 mm long larvae is 6 larvae per head.

Select control options that are compatible with the insecticide resistance management strategy for your region. Larvae are difficult to control when they are feeding on the sunflower face and under bracts, especially once the heads turn to face the ground. Crops should therefore be sprayed before the heads turn down.
Green vegetable bug (*Nezara viridula*)

Green vegetable bugs (GVB) tend to feed on the upper stems and heads and when present in large numbers cause wilting, shrivelling and deformed heads. Occasionally they feed on developing seed. The current threshold is one mature bug or 5th instar nymph per plant.

Females lay 30–130 eggs in a raft on the leaf surface. The eggs hatch in 5–21 days and it takes 30 days to progress through the five nymphal instars. Adult life spans vary from several weeks to four months, with summer reducing their longevity.

Green vegetable bugs are sap sucking insects that have a wide host range. If they gather around the peduncle, water and nutrient supply to the developing head will be reduced.

**Integrated pest management**

IPM is the term used for a range of tactics to prevent pests from reaching damaging levels in crops. Insect pest management in the grains industry is heavily reliant on insecticides to control insect pests. However, for some pests there are non-chemical options or monitoring strategies that can help avoid pest outbreaks and damage. Using as wide a range of tactics as possible to deal with pests reduces the reliance on a single method of control, such as insecticide sprays.

Timing is critical in sunflower pest management as different insect pests attack sunflowers during the seedling, budding and seed-fill stages.

Identifying when sunflowers crops are susceptible to pests is the first step in good pest management. Sunflower growers throughout Australia contend with a number of insect pests at various stages of crop development. Most of these pests feed and breed on other crops and weeds but also infest sunflowers; causing damage at susceptible crop growth stages.

**Pest monitoring**

The basic sampling recommended is the examination of at least five consecutive plants in a row at six widely spaced locations throughout the crop.

The six locations chosen for sampling should represent areas that are typical of the field and should not include areas such as atypical wet/low areas, hills or outside rows, which are not likely to be representative of the rest of the field.

**Insecticide use (best practice)**

Insecticides are a key tool in an integrated pest management (IPM) program for sunflowers. However, unnecessary or poorly timed spray applications, or selection of the wrong pesticides can flare secondary pests, hasten the development of disease, and select for resistant pests.

Critical control growth phases for insect pests of sunflower. (Adapted from Big Yellow Sunflower Pack, 2015)

---

**Pest** | **Emergence and Vegetative** | **Budding and Flowering** | **Grainfill** |
--- | --- | --- | --- |
False wireworm, true wireworm, cutworm, thrips, black scarab, cockroaches, earwig | | | |
Black field cricket | | | |
Loopers | | | |
Helicoverpa | | | |
Whitefly (greenhouse, silverleaf) | | | |
Rutherglen bug | | | |
Green vegetable bug | | | |

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of pesticide resistance, contaminate the harvested product, increase costs and reduce profitability.

Be aware of the potential of synthetic pyrethroids and carbamates to flare helicoverpa, whitefly, and loopers. Repeated synthetic pyrethroid use will select for higher levels of resistance in *H. armigera*. Both short and long term factors must be considered when using insecticides in sunflowers.

### Protecting beneficial species

Beneficial insect species include natural enemies of insect pests (e.g. predators, parasites and parasitoids), pollinators and stubble decomposers.

Conserving or encouraging natural enemies helps to regulate pest densities, particularly of minor pests. To achieve a healthy population of natural enemies in a crop, keep in mind the following:

- Where possible, use the least disruptive option/s first. This strategy allows natural enemy populations to build up in the crop and have maximum impact on the pests.
- Non-chemical control options that disrupt pest build up (e.g. pupae busting, planting into stubble, strategic cultivation, crop rotation) are extremely useful in avoiding pest outbreaks, reducing the need for in-crop spraying.
- Non-crop vegetation, particularly native vegetation, provides important habitat (e.g. shelter, pollen, nectar, prey) for natural enemies. There is evidence that weedy vegetation hosts more pests than natural enemies, and that there is movement between native vegetation and crops (Shellhorn et al. CSIRO).
- Even selective insecticides will kill one or more groups of natural enemies (e.g. bugs, wasps). The more applications, the greater the cumulative impact on natural enemy populations. Eggs and/or larvae may escape the first application, but not subsequent ones.

Current hybrid sunflowers are largely self-pollinated however several types of native, wild and hive bees forage in sunflower crops. To prevent killing bees, avoid spraying products that are broad-spectrum, or have impact on bees, during flowering. Use chemicals with a short residual pre-flowering. If possible, spray while bees are not actively feeding and close up or move any nearby hives when spraying occurs.

### Sunflower insect pest thresholds.

(Source: DAF Queensland)

<table>
<thead>
<tr>
<th>Pest</th>
<th>Crop stage</th>
<th>Threshold</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>False wireworm</td>
<td>Seedling</td>
<td>1 larvae/gsb – summer</td>
<td>Use treated seed* (or grain baits for beetles).</td>
</tr>
<tr>
<td>True wireworm</td>
<td>Seedling</td>
<td>1 larvae/gsb – summer</td>
<td>Use treated seed.</td>
</tr>
<tr>
<td>Cutworm</td>
<td>Seedling</td>
<td>When 90% plants infested or 50% have 75% leaf tissue loss</td>
<td>Treated seed offers some protection. Specific chemical sprays may be required.</td>
</tr>
<tr>
<td>Black scarab beetles</td>
<td>Seedling</td>
<td>4 beetles/m²</td>
<td>Insecticide sprays or baits for beetles.</td>
</tr>
<tr>
<td>Wingless cockroaches</td>
<td>Seedling</td>
<td>1/gsb – summer</td>
<td>Use treated seed* or grain baits.</td>
</tr>
<tr>
<td>Black field earwigs</td>
<td>Seedling</td>
<td>5/gsb – summer</td>
<td>Treated seed* provides limited control; use grain baits.</td>
</tr>
<tr>
<td>Thrips</td>
<td>Seedling</td>
<td></td>
<td>Control if TSV risk is high in the region.</td>
</tr>
<tr>
<td>Field crickets</td>
<td>Seedling</td>
<td>1/gsb – summer</td>
<td>Use treated seed* or grain baits.</td>
</tr>
<tr>
<td>Greenhouse whitefly</td>
<td>Vegetative</td>
<td></td>
<td>No chemical options registered.</td>
</tr>
<tr>
<td>Bemisia tabaci whitefly</td>
<td>Vegetative</td>
<td></td>
<td>Control rarely warranted.</td>
</tr>
<tr>
<td>Loopers</td>
<td>Vegetative</td>
<td></td>
<td>Control if defoliation &gt;50% during R1–R7.</td>
</tr>
<tr>
<td>Helicoverpa</td>
<td>Budding</td>
<td>1 medium or 3 small larvae/terminal bud</td>
<td>Aim to control larvae &lt;7 mm in length.</td>
</tr>
<tr>
<td>Helicoverpa</td>
<td>Flowering Seed set</td>
<td></td>
<td>Control only if numbers are extremely high.</td>
</tr>
<tr>
<td>Rutherglen bug</td>
<td>Budding</td>
<td>Aug to Dec 10–15/plant</td>
<td>Constant immigration may necessitate repeated treatments.</td>
</tr>
<tr>
<td>Rutherglen bug</td>
<td>Flowering Seed set</td>
<td>Aug to Dec 20–25/plant Confectionary 5/plant</td>
<td>Apply control at petal fall to prevent breeding and damage to developing seed.</td>
</tr>
<tr>
<td>Green vegetable bug</td>
<td>Flowering Seed set</td>
<td>1 adult or 5th instar per plant</td>
<td></td>
</tr>
</tbody>
</table>

gsb – germinating seed baits

* Insecticide treated seed offers some protection against surface active insects such as false wireworm beetles, black field earwigs, wingless cockroaches and field crickets, but if pest densities are high, treated baits may be necessary to protect the establishment of seedlings.
Harvesting sunflowers can be challenging but, with attention to detail, a high quality sample can be achieved. In all markets, a quality sample is required, with discounts applied if the admixture is over 4% in the oilseed market and in the birdseed market there is a reluctance to purchase the product if it is not a clean bright sample.

Identifying physiological maturity
Physiological maturity occurs when the maximum seed weight has been reached. The crop can be harvested once sufficient dry down has occurred, where the seed moisture content is suitable for storage or delivery.

Identifying physiological maturity
Physiological maturity is identified when the bracts surrounding the sunflower head change to brown. The seed moisture content at physiological maturity is usually between 30–40% and the crop is suitable for desiccation to aid in quicker dry down.

Desiccation
Pre-harvest desiccation can increase harvest speeds, reduce admixture in the grain sample and reduce the seed set of late ripening weeds. Diquat is the only herbicide registered for pre-harvest desiccation in sunflowers. An emergency use permit (PER13118) is in place for the use of glyphosate for pre-harvest desiccation and weed control in sunflowers (check the permit date before use).

Harvest timing
The receival standard for moisture is 9%. Often, crops are not harvested until the moisture content is much lower, around 5–6%, which represents lost yield. Aim to harvest and deliver as close as possible to 9% moisture. Harvesting above 9% moisture will increase the risk of fire in storage.

Harvesting at low moisture contents (< 6%) may cause an increase in admixture as the plant stalks and heads become dry and brittle, easily shattering into small pieces. This added trash is difficult to separate from the seed and penalties apply for excess admixture.

Commence harvest when some 5–10% of heads are still soft (some cream colour on the back). This will reduce trash levels and enable a faster harvest speed. Don’t wait until all heads are black as low moisture levels may cause harvest difficulties.

Header set up
To harvest sunflowers effectively, conventional headers require some alterations. The following header attachments are strongly recommended:

• Sunflower trays – are essential to retain heads and seeds in the header front. In modern headers with high comb lift heights, the use of a reel (preferably a bat reel) can stop some heads falling out the front.

• Sullivan reel – works at the machine’s ground speed to help prevent blockages and reduce seed shattering.

• Head snatcher (push bar under the cutter bar) – can speed up harvesting and reduce trash levels in the sample. This is not as important when using a rotary header and will not work if conditions are dry and stalks are brittle.

Use as slow a drum/rotor speed (~ 450 rpm for conventional headers and 250–350 rpm for rotaries) as possible without plugging of the drum/rotor. If this speed is too high, seed will be split in the separation area and excess trash will be produced. Check this setting by inspecting grain entering the sieve area.

Rotary headers should use large wire concaves and slotted grates. If the crop is over-ripe, use blanking sheets in the grate area to help reduce the amount of trash on the sieves as the threshing will all take place over the concave.

The drum/rotor must be set as wide as possible without allowing unthreshed grain to remain in the head. In most cases this setting is as wide as the harvester can go. Check the condition of the trash for over thrashed or unthreshed heads.

There are three basic adjustments required for the cleaning system:

• The chaffer should be set at about 12 mm. Set the rear chaffer, if fitted, at 15 mm.

• Begin with the shoe sieve set to 6–8 mm. For headers fitted with fixed perforated sieves, sieves of 10–12 mm are suitable. Check the contents and quantity of the repeats. If a high proportion of seed is present in the repeats, the shoe sieve needs to be opened. This is sometimes a very fine setting with a very slight change taking the sample from dirty to very clean, but the repeats are overloaded with good seed when the change is made.

• Most headers require a fan speed of 800 rpm or greater. Fan settings need to have the chaff floating above the sieves and the grain not being thrown over the end. Set the fan speed as fast as practical without lifting seed over the sieve. A common fault in sunflower harvesting is to use insufficient air for fear of losing seeds over the chaffer.

In all markets, a quality sample is required, with either discounts applied or a reluctance to purchase grain that has excessive admixture.
Storage

For safe storage and optimum quality, sunflowers should be stored ‘cool and dry’.

Cool temperatures minimise the conditions that encourage storage pests, including rust red flour beetle and a range of grain storage moths. Dry storage minimises the risks of mould development and hot spots.

The ideal storage for sunflower is an above ground, cone-based, aerated and sealable silo. Above ground storages are easier to clean out once they are empty, reducing carry over of storage pests. Aeration can reduce grain temperatures in the silo, which slows the pest breeding lifecycle and reduces population build up. Keep silos aerated, however when insects are detected, seal up the silo to achieve an effective pest fumigation.

Effective and safe storage of sunflower seed requires close attention to storage hygiene, aeration and monitoring for pests and moulds.

Hygiene

Clean out empty silos, grain handling equipment, such as field bins and augers, and headers to reduce the carry over of storage pests from one season to the next, and minimise early infestation pressure. Winter is a good time to undertake storage hygiene as pests are not moving or flying out. As with other oilseeds, there are few insecticides registered to be used as a hygiene treatment of stored sunflower seed. If possible, use diatomaceous earth products, e.g. Dryacide®, to provide suitable control, rather than any of the other insecticides for structural surface treatment prior to filling storages with sunflower seed. As with any product, before applying treatments, check with your buyer or bulk handler (depot) for acceptability of treatments, and read labels carefully.

Aeration

Aeration, preferably using an automatic controller, promotes uniform, cool storage conditions and is a key best practice strategy for maintaining oil and seed quality.

During autumn, aim for stored sunflower temperatures in the range of 18–23°C. For the winter months 10–18°C is achievable. Using aeration it should be possible to reduce grain harvest temperature (typically around 30°C) to below 20°C, making it difficult for storage pests to breed. The insects do not die under these cooler conditions, but their breeding stops or slows, avoiding pest outbreaks.

Aeration provides uniformity of moisture content through the bulk of the silo. The safe delivery standard is 9% moisture content (mc) for a typical sunflower seed sample with an oil content of 40%. If samples have an oil content of greater than 45% or an extended storage period is planned, aim for 8% moisture content.

The seed sample from the header has an important impact on safe storage of sunflower seeds. Large pieces of stalk or damp pieces of head coming in with the sample can encourage the development of mould in grain around the storage edges. A high percentage of ‘fines’ coming from the header can cause a core to form from the point of fill in the storage, which can restrict the aeration air flow.

Monitoring

Check stored sunflower and other oilseed at least once a fortnight, as opposed to monthly inspection of cereal grains. To monitor for insects, collect and sieve a sample of seed taken from the bottom and top of storages (if safe). Look at the top surface of the sunflower seed for pest movement, such as moths, and check for any bad odours that may indicate the presence of moulds or moisture.
Irrigated production

Research and grower experience indicate that sunflowers respond to irrigation with 2–3 fold yield increases over dryland production. Target yields of 2.5–4.5 t/ha are typical in irrigated systems.

Sunflowers have a lower water use than other summer crops, such as corn, cotton and soybean, and are suited to a range of irrigation systems, including spray, furrow and subsurface drip irrigation. Water application will depend on soil type and environmental conditions, and on water availability. However as a guide, surface irrigated sunflowers will use approximately 4 ML/ha in total, including pre-irrigation, and irrigations at budding and at petal drop. Spring sown sunflowers are likely to have higher water requirements of up to 7.5 ML/ha (NSW DPI 2013).

Commodity water requirement (4 yrs out of 5).

| Commodity water requirement/ha | Sunflowers 3.90 ML | Cotton 7.25 ML | Corn 7.15 ML | Soybeans 6.00 ML | Sorghum 3.80 ML |

Source: CSD 2008

Row spacing in irrigated systems on raised beds is usually 100 cm, with some variation depending on the bed width, which is usually 1.8–2.0 m.

Calculate planting rates to achieve the optimal population for the region (see Plant Population section in this guide for more information). If full irrigation is planned, the target plant population is 50–75 thousand plants per ha. If irrigation is limited aim for a plant population of 35–50 thousand plants per ha.

Irrigation management

Irrigation scheduling has a significant impact on the yield and quality of sunflower seed. Targeting irrigation to critical growth phases in NSW DPI trials (2012) achieved yield gains of 40%.

Sunflowers have a relatively low water demand until 10 days after buds are visible. Demand then increases rapidly, until approximately 26 days after 50% flowering. Adequate soil moisture is required through until maturity.

During the vegetative stages water stress does not significantly affect sunflower yield potential and in most cases delaying irrigation will increase the harvest index. The greater the leaf area at flowering the higher the yield potential, but it is the top half to one-third of leaves that contribute the most to yield.

Research conducted in the USA suggests that maximum yield and highest water use efficiency is obtained from three irrigations, timed to coincide with pre-planting, budding and petal drop. In limited irrigation systems, irrigating pre-plant and at full bloom optimises yield potential and total water use.

Irrigation scheduling depends on three factors:

- extractable soil water (ESW) capacity, measured as mm/m of soil
- daily evaporation rates (pan evaporation), measured in mm/day
- effective rainfall (in-crop).

The optimal irrigation interval is the time taken for the crop to use 50% of the ESW (may be 60–65% in limited irrigation situations). Daily root growth (3.2–3.5 cm per day) is also a consideration.

Irrigating prior to planting, or starting with a full profile, should provide sufficient moisture to avoid crop stress until after bud initiation.

Irrigation scheduling for sunflower.

<table>
<thead>
<tr>
<th>No. irrigations</th>
<th>Application timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pre-plant</td>
</tr>
<tr>
<td>2</td>
<td>pre-plant and full bloom</td>
</tr>
<tr>
<td>3</td>
<td>pre-plant, budding and petal drop</td>
</tr>
</tbody>
</table>

Daily crop water use (ETC mm) for sunflower in Queensland regions.

(Source: Trevor Philp, Pacific Seeds)
Monitor crops to ensure excessive moisture stress does not occur. Sunflowers may show signs of moisture stress (wilting) up until bud initiation during the heat of the day but should recover at night. Commence irrigation if recovery does not occur in the evenings.

Excessive vegetative growth can pose two key risks for irrigated sunflower crops. Firstly, it increases the risk of lodging and secondly, a dense, humid canopy can be conducive to disease development.

Where very high plant populations are targeted, root lodging can occur when the root system in wet soil is unable to support the weight of the heads and the plants begin to lean over.

Diseases such as sclerotinia, rhizopus head rot and powdery mildew are of most concern in overhead irrigation systems, such as centre pivots or lateral move irrigators (see Disease management section of this guide). Avoid applying overhead spray irrigation during flowering as the spray can wash pollen off the flowers and disrupt pollination.

**Waterlogging**

Avoid waterlogging while sunflower seeds are germinating and the seedlings are young as the plants in these growing stages are more susceptible to pythium and rhizoctonia under wet, cool conditions and poor drainage. This is common on heavy vertosols, especially in low lying or compacted areas of the paddock. Affected seeds and seedlings will rot and die, leaving bare areas where weeds can thrive.

Once sunflowers are growing well they are quite tolerant of large rainfall events and temporary waterlogging for 24–48 hours. These events do not usually cause plant death, however temporary waterlogging events during grain filling can cause reductions in grain yield of 10–60%. The impact is greatest in heavier soils that take longer to regain adequate soil aeration after being inundated. Waterlogging causes the root growing tips to die and disrupts the aerobic photosynthetic processes—restricting plant growth and crop yield.

**Acknowledgements & Further reading**

This publication has been compiled using information drawn from various sources including:


Links to these resources and more can be found at www.bettersunflowers.com.au

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**Cover image:** Sue Thompson

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