Planning/Paddock preparation

1.1 Paddock selection

Sunflower paddocks should be selected to maximise crop performance. This includes selecting paddocks with low populations of broadleaf weeds (Figure 1) which compete for water, light and nutrients. In-crop control options for broadleaf weeds are limited.

Paddock selection also plays a role in minimising the risk of disease, primarily from *Sclerotinia*, which is hosted by many other broadleaf crops such as chickpea and canola. Under favourable conditions, *Sclerotinia* can build up and cause lodging and head rot in sunflower. [1]

Sunflowers are a good rotation crop, highly suited to no-till sowing into stubble-retention. Sunflowers are most often sown after a long fallow following a winter cereal; wheat or barley. Sunflowers leaves minimal stubble cover following harvest so are best sown into standing cereal stubble to maintain erosion control. Sunflowers are suitable for use in a short fallow following sorghum, or as a double-crop option provided the soil moisture profile is near full. Select paddocks that were previously sown to a rotation crop.

A rotation from a cereal is preferred, as broadleaf weed control will usually have been carried out in the previous crop and fallow, thus reducing the weed seedbank for the sunflower crop. Consider previously applied residual herbicides. Sunflowers can be affected by herbicides such as the sulfonylureas and atrazine.

Crops of monounsaturated hybrids should be isolated from other sunflower crops to reduce the risk of cross-pollination, which lowers the oleic acid content. Never sow adjoining crops of monounsaturated and polyunsaturated sunflowers where flowering may coincide.

Sunflowers have a strong taproot capable of extracting water from a depth of 1.5–2 m in ideal situations. They are best suited to deep clay soils, with high water-holding capacities. They do not tolerate lengthy periods of waterlogging without suffering yield penalties. [2]

Sunflowers play a small but important role in crop rotation in the northern grains region, where they are typically placed into a long-fallow situation following a winter crop or a short fallow following a summer crop. A survey of 134 paddocks across the northern grains region during 2003–06 found that 41% of sunflower crops were sown into a long fallow following a winter cereal (wheat or barley), 25% of crops were sown into a short fallow following sorghum, and just 13% were double-cropped into wheat or barley stubble (L Serafin and S Belfield, unpublished data). [3]

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1 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

2 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

3 L Serafin, S Belfield, D Herridge (2011) Sunflower yield performance and agronomy: Where and when do they fit best in the northern grains region? GRDC Update Papers, 13 Sept. 2011

Figure 1: *Identify paddocks with low populations of broadleaf weeds.*

Photo: Drew Penberthy, Penagcon

Soil management

Sunflowers are best suited to deep soils in a no-till system. No-till relies on effective weed control in the previous crop and fallow. Combined with stubble cover, it improves moisture retention, leading to consistently higher yielding sunflower crops. No-till also provides a wider sowing window and stores more soil water by reducing runoff. This enables a shorter fallow with more efficient water use, less runoff and less erosion. However, no-till can encourage the build-up of mice compared with conventional land preparation and limits some broadleaf weed control options because of the inability to incorporate pre-emergent herbicides. [4]

Sunflowers can use up to 7.5 mm/day during peak water use at flowering and can extract water from soil with chloride levels of 1200 mg/kg and sodicity (exchangeable sodium percentage, ESP) of 17% (B & W Rural Pty Ltd). [5]

Sowing into standing stubble is important as sunflowers do not leave high levels of stubble and this can expose paddocks to the risk of soil erosion.

1.2 Paddock rotation and history

In northern NSW, sunflowers typically follow a cereal crop. There are few instances where sunflowers are planted after a pulse or oilseed. There are two main reasons for this. First, sunflowers do not provide good stubble cover, an important feature in limiting erosion. As such, it makes sense to plant them after a cereal, which does provide good stubble cover. Second, planting sunflowers after a cereal gives the best rotation break. Sunflowers do not host the same diseases as cereal crops such as crown rot. They also allow the use of alternative herbicide groups to those used in the cereal crop. They are a good option where glyphosate-resistant summer grass paddocks are present and alternative herbicide options are required.

4 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

5 R Long. Water Use Efficiency in sunflowers—an on farm perspective. How do sunflowers compare with other summer crops. B & W Rural Pty Ltd. Australian Oilseed Federation, http://www.australianoilseeds.com/__data/assets/pdf_file/0016/907/Long_Read-Only.pdf

Sunflowers also have a role where nematode populations are limiting crop production, because the crop is resistant to both types of root-lesion nematode, *Pratylenchus thornei* and *P. neglectus*. [6]

Crop history in a paddock can determine the likelihood of disease having a major impact on the current sunflower crop. For example, many broadleaf crops host *Sclerotinia* and can increase inoculum levels for the following sunflower crop. [7]

Stubble can aid survival of pathogens. Growers should be familiar with the pathogens of sunflower as well as those of the other crops in the rotational sequences. [8]

1.3 Benefits of sunflower as a rotation crop

The optimum place for sunflower in the rotation is following a cereal, to maximise the benefit from an integrated weed and disease management perspective.

Sunflowers are most commonly sown following a long fallow from either wheat or barley. This allows broadleaf weed control in the preceding crop and provides adequate stubble cover to minimise erosion. In the 2005–06 season, 51% of paddocks in the above survey were sown into this situation. An alternative is to plant following a short fallow from sorghum, as was the case for 22% of paddocks in the 2005–06 season. (L Serafin and S Belfield, unpublished data)

Sunflowers make the soil softer and more friable than sorghum and also aid in restoring soil structure by breaking up compacted layers with their deep roots. Yield responses from applied nitrogen (N) are variable in sunflowers because of their ability to forage deeper in the soil profiles and tap into N 'bulges' at depth. [9]

1.4 Disadvantages of sunflower as a rotation crop

Sunflowers leave very little residual groundcover following harvest, and the remaining stalks are often difficult to manage because of their high stalk strength and slow breakdown. This results in the need to knock down and break up stubble manually, many growers choose to either slash or mulch stalks following harvest. Stubble breakdown also aids in the release of nutrients, such as potassium (K) and N, which are present at high levels in the stover. [10]

Stubble cover is an important means of limiting erosion. As such it is recommended to plant sunflower after a cereal, which does provide good stubble cover. [11]

1.5 Fallow weed control

The increasing use of herbicides during the fallow period provides the same benefits to sunflower that it does to other crops. However, sunflower is sensitive to some commonly used residual herbicides such as atrazine, chlorsulfuron, picloram, imazethapyr, metsulfuron methyl and imazapic. These products should be avoided in areas that might be planted to sunflower or careful consideration given to plant-back periods and conditions.

Some other chemicals used in fallow weed control have the potential to affect crop emergence if the crop is sown too soon after the chemical application. To reduce

6 L Serafin, S Belfield, D Herridge (2011) Sunflower yield performance and agronomy: Where and when do they fit best in the northern grains region? GRDC Update Papers, 13 Sept. 2011

7 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

8 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

9 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

10 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

11 L Serafin, S Belfield, D Herridge (2011) Sunflower yield performance and agronomy: Where and when do they fit best in the northern grains region? GRDC Update Papers, 13 Sept. 2011

this risk, a plant-back period is recommended. Table 1 provides a guide to some commonly used chemicals. [12]

Sunflowers are sensitive to several common residual herbicides, including sulfonylureas (SU). Often there can be residues in the soil from a previous application, which may damage the next crop. The plant-back period will be affected by the time since application, soil type, herbicide rate and rainfall. [13]

Rainfall or irrigation after herbicide application has major implications for most plant-back periods. Consult the label, or a local agronomist, for an accurate assessment of your situation which may include these constraints:

- Glean® and Siege® are not recommended for use on soils of pH ≥6.5.
- Longer intervals are needed in soils of pH >7.8 with Harmony® M.
- No less than 400 mm of rainfall should occur between application of Harmony® M and sowing of rotation crop.
- Do not use Spinnaker® 400 mL/ha in dryland situations unless you intend to recrop with a leguminous crop.
- On shallow soils <30 cm depth, do not plant until 2 years after application. [14]
- Flame® can be used in summer fallow with a 24-month plant-back interval.

Sunflower plant-back intervals can be checked individually on labels or for more information see Weed Management section of the Big Yellow Sunflower Pack at https://bettersunflowers.com.au/bysp/surveyinfo.aspx?sid=4

1.6 Seedbed requirements

Poor crop establishment of sunflower can cause major yield losses. High soil-surface temperatures may kill germinating seeds or inhibit elongation of the hypocotyl of young seedlings. High temperature also causes rapid drying of soils, reducing the window of opportunity for planting, and leading to high water demand during the summer growing period.

Tillage is the conventional method of seedbed preparation but makes the soil prone to slaking and dispersion of aggregates. Infiltration of rainwater into the soil is often limited by surface sealing of cracking clay soils.

Heavy rain soon after planting leads to dispersion of clay aggregates, crusting of the soil surface and increased soil strength, preventing proper emergence of seedlings. This process is exacerbated by high evaporation.

Disturbance of the soil can be minimised by using conservation or no tillage techniques. Suitable seedbed conditions are needed only in the planting furrow where the seed is actually placed. No tillage is the most common method of planting sunflowers, as no tillage stores addition moisture in the fallow and retains seedbed moisture longer, widening the potential planting window than conventional tillage.

The use of press-wheels is recommended to improve contact between soil and seed and to improve the transfer of moisture to the seed. Press-wheel pressure and shape can be varied to suit the soil type and seasonal conditions. Too much press-wheel pressure can damage the seed and create a hard band in some soil types. The addition of a chain to drag loose soil back into the row can aid in reducing drying out of the trench and limit a ‘Kinze crack’ forming.

Pre-soaking of seed and injection of water into the planting furrow have been ineffective in improving establishment. [15]

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12 Australian Sunflower Association (2004) The New Big Black Sunflower Pack.

13 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

14 Australian Sunflower Association (2004) Weed management. The New Big Black Sunflower Pack. Australian Oilseeds Federation

15 B Winter, L Wade, P Blamey, A Douglas (1994) Sunflower crop establishment and yield compensation. Australian Oilseeds Federation. Northern Focus Aug.–Sept. 1994, http://www.australianoilseeds.com/__data/assets/pdf_file/0007/7792/1994_Aust_Grain_Sunflower_Crop_Establishment_and_Yield_Compensation.pdf

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http://www.apsim.info/Portals/0/APSoil/SoilMatters/Mod4/2_04.htm

http://www.grdc.com.au/uploads/documents/GRDC_Water%20Use%20Efficiency%20.North%20version%20231009.pdf

1.7 Soil moisture

Sunflower yields are highly influenced by the amount of water available during the growing season. This can be supplied in three ways:

1. Starting soil water
2. In crop rainfall
3. Irrigation

Sunflowers should not be sown unless the soil profile is wet to a depth of 80 cm (>150 mm plant-available water, PAW) to minimise the risk of crop failure or uneconomic yields. Agronomists suggest an absolute minimum of 150 mm PAW to make the crop commercially successful.

Starting soil water should be assessed by using a push probe or by soil-coring and calculating starting PAW. To calculate PAW, refer to 'Soil Matters' (Dalgliesh and Foale)· [16],[17] If soil-coring is used, crop lower limits; where available; (the water content of a soil after a crop has extracted all of the water available to it) can be applied to determine the exact amount of PAW. Final sunflower yield will still be a reflection of the starting soil water and the in-crop rainfall received as well as seasonal conditions and crop agronomy. Starting with a full profile of moisture minimises the risk of crop failure. [18]

From the project 'Sunflowers in Northern NSW and Southern Qld—Tools for Success', crop lower limits were established for a selection of soils in northern NSW (see Table 2). [19]

The amount of starting PAW also has an impact on management decisions such as row configuration, with skip-row or wide-row configurations sometimes used when starting soil water is less than ideal. [20]

Sunflowers have a deep taproot, which can extract moisture from up to 2 m depth in ideal soil conditions, and have higher soil water extraction ability than many other crops, including sorghum and maize. This means that more water can be extracted by sunflowers than by other crops from the same soil. [21]

16 NP Dalgliesh, MA Foale (1998) Soil matters. Monitoring soil water and nutrients in dryland farming. Agricultural Production Systems Unit, CSIRO, http://www.apsim.info/Portals/0/APSoil/SoilMatters/pdf/front_matter.pdf

17 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

18 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

19 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

20 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

21 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

Table 1: *Soil-water crop lower limits for sunflower in northern NSW.* [22]

Depth of soil	Pine Ridge	Tambar Springs	Breeza	Moree	Biniguy	Ashley
10–30 cm	0.29	0.30	0.26	0.24	0.18	0.24
30–60 cm	0.35	0.35	0.34	0.33	0.20	0.25
60–90 cm	0.38	0.36	0.34	0.31	0.20	0.25
90–120 cm	0.41	0.27	0.30	0.26	0.24	0.30
120–150 cm	0.37	0.34	0.36	0.26	0.25	0.32
150–180 cm	–	–	–	0.26	0.25	0.32
Soil Type	Black Vertosol	Black Vertosol	Black Vertosol	Grey Vertosol	Red Chromosol	Grey Vertosol

Values are proportion volumetric water content of the soil when the crop has extracted as much water as it can.

1.7.1 Irrigation

Sunflowers can be successfully grown under irrigation. Irrigation through pivots or by surface irrigation on raised beds is suitable. Care should be taken when using irrigation systems not to create an environment favourable for diseases such as powdery mildew. [23]

Sunflower yields will be reduced by waterlogging; therefore, quick, even and efficient irrigation is important.

The maximum depth of water extraction is thought to be reached at 50% flowering. Root growth occurs at a rate of 3.2–3.5 cm/day, with the extraction front proceeding at around 3.8 cm/day. Studies by the Department of Employment, Economic Development and Innovation (DEEDI Qld) showed that daily water uptake peaks at ~40 days after sowing, or close to budding.

The amount of irrigation water required varies depending on whether the crop is planted in spring or summer. Spring-planted crops require more water. In northern NSW, the total crop water use is 4.5–7.5 ML/ha. This demand is normally met by a combination of stored soil moisture, rainfall and irrigation. If 250 mm of in-crop rainfall is assumed, then 2.0–5.0 ML/ha may be required as irrigation.

Water stress between flowering and maturity has the biggest impact on grain yield. As a rule of thumb, in self-mulching soils, a water depletion of 75–90 mm can be used to schedule irrigations; however, this depends on soil type. Do not leave the irrigation application too late as water and nutrient access will be limited if roots are broken from deep soil cracking. This can also lead to infection from pathogens such as *Sclerotinia*.

Sunflowers have a relatively low demand for water until about 10 days after bud-visible. The demand for water then increases dramatically until ~26 days after 50% flowering.

The recommended times for surface irrigations are:

1. Prior to sowing—pre-water fields
2. Budding—first irrigation
3. Start of flowering—second irrigation
4. Early seed fill—third irrigation

Caution should be exercised if using overhead irrigation to avoid irrigating during flowering, to ensure that seed-set is not affected. In addition, irrigating too late

22 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

23 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

into seed-fill will increase the risk of paddocks remaining wet at harvest, reducing trafficability and potentially causing compaction. [24]

1.8 Yield and targets

Sunflower average yield and oil content varies between seasons; however, the project 'Sunflowers in Northern NSW and Southern Qld—Tools for Success' showed that higher yields are generally achieved in the Gunnedah district than in Moree and southern Queensland (Table 3). As a result nitrogen and gross margin budgeting should be carried out using data for the relevant growing region and incorporate the starting soil water and anticipated in-crop rainfall. [25]

Table 2: *Average dryland yields and oil contents for sunflower crops grown in regions of northern NSW and in southern Queensland.*

Region	Average Yield (t/ha)	Yield Range (t/ha)	Average Oil %	Oil % Range
Moree	1.42	0.50–3.00	39.4	30.7–45.8
Gunnedah	1.78	0.58–2.96	39.0	34.5–45.0
Sthn Qld	1.29	0.30–3.33	41.2*	40.0–43.0

* Only includes data from 8 crops

1.8.1 Seasonal outlook

Queensland Alliance for Agriculture and Food Innovation (QAAFI) produces regular, seasonal outlooks for summer crop producers. These high-value reports are written in an easy-to-read style and are free. For more information, visit https://qaafi.uq.edu.au/article/2016/10/sorghum-crop-outlook-march-2016.

For tips on understanding weather and climate drivers, including the SOI, visit the Climate Kelpie website. Case studies of 37 farmers across Australia who were recruited as Climate Champions as part of the Managing Climate Variability R&D Program can also be accessed at the Climate Kelpie website.

'Australian CliMate' is a suite of climate analysis tools delivered on the web, iPhone, iPad and iPod Touch devices. CliMate allows you to interrogate climate records to ask questions relating to rainfall, temperature, radiation and derived variables such as heat sums, soil water and soil nitrate, and well as El Niño Southern Oscillation status. It is designed for decision makers such as farmers whose businesses rely on the weather.

Download from the Apple iTunes store at https://itunes.apple.com/au/app/australian-climate/id582572607?mt=8 or visit http://www.australianclimate.net.au

One of the CliMate tools, '*Season's progress?*', uses long-term (1949 to present) weather records to assess progress of the current season (rainfall, temperature, heat sums and radiation) compared with the average and with all years. It explores the readily available weather data, compares the current season with the long-term average, and graphically presents the spread of experience from previous seasons.

Crop progress and expectations are influenced by rainfall, temperature and radiation since planting. *Season's progress?* provides an objective assessment based on long-term records:

- How is the crop developing compared with previous seasons, based on heat sum?
- Is there any reason why my crop is not doing as well as usual, such as because of below-average rainfall or radiation?

MORE INFORMATION

L Serafin, S Belfield. Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

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http://www.climatekelpie.com.au/ask-a-farmer/climate-champion-program

24 L Serafin, D McCaffery, S Thompson (2014) Sunflower. Summer crop production guide 2014. pp. 80–92. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/guides/summer-crop-production-guide

25 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

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http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Seasonal-climate-outlook-improvements-changes-from-historical-to-real-time-data

www.australianclimate.net.au

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- Based on the season's progress (and starting conditions from HowWet/N?), should I adjust inputs?

For inputs, *Season's progress?* asks for the weather variable to be explored (rainfall, average daily temperature, radiation, heat sum with base temperatures of 0, 5, 10, 15 and 20°C), a start month and a duration.

As outputs, text and two graphical presentations are used to show the current season in the context of the average and all years. Departures from the average are shown in a fire-risk chart as the departure from the average in units of standard deviation. [26]

The Bureau of Meteorology has recently moved from a statistics-based to a physics-based (dynamical) model for its seasonal climate outlooks. The new system has better overall skill, is reliable, allows for incremental improvements in skill over time, and provides a framework for new outlook services including multi-week/monthly outlooks and the forecasting of additional climate variables. [27]

1.8.2 Water Use Efficiency

The yield and quality of summer crops grown in the northern region depends on the amount of plant available water (PAW) and the evaporative demand at flowering and early grainfill.

Water Use Efficiency (WUE) of summer crops is of limited value unless some account is taken of 'rainfall effectiveness'.

A key strategy to reduce production risk is to maximise PAW at planting as sunflowers use soil water relatively early (compared to sorghum or cotton). This is a function of fast early growth and higher leaf area. [28]

Further work should be done to monitor water-use patterns and WUE for sunflowers on wider row configurations. [29]

The WUE is the measure of a cropping system's capacity to convert water into plant biomass or grain. It includes the use of water stored in the soil and use of rainfall during the growing season.

WUE relies on:

- the soil's ability to capture and store water;
- the crop's ability to access water stored in the soil and rainfall during the season;
- the crop's ability to convert water into biomass; and
- the crop's ability to convert biomass into grain (harvest index). [30]

1.8.3 Nutrient efficiency

Nitrogen and sulfur (S) are two of the critical nutrients for sunflower production. Sunflower nutritional requirements are often considered moderate compared with other crops. However, adequate crop nutrition is critical to targeting high yields and oil contents.

Nitrogen is a major nutrient affecting seedling vigour, crop growth and development, and grain yield and quality (seed size and oil content). Many of these factors are influenced by interactions with other nutrients, such as sulfur. Nitrogen is also a major cost to sunflower growers when applied as fertiliser N, in turn affecting crop profitability.

26 Australian CliMate—Climate tools for decision makers, www.australianclimate.net.au

27 J Sabburg, G Allen (2013) Seasonal climate outlook improvements changes from historical to real time data. GRDC Update Papers 18 July 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Seasonal-climate-outlook-improvements-changes-from-historical-to-real-time-data

28 R Long. Water Use Efficiency in sunflowers—an on farm perspective. How do sunflowers compare with other summer crops. B & W Rural Pty Ltd. Australian Oilseed Federation, http://www.australianoilseeds.com/__data/assets/pdf_file/0016/907/Long_Read-Only.pdf

29 R Long. Water Use Efficiency in sunflowers—an on farm perspective. How do sunflowers compare with other summer crops. B & W Rural Pty Ltd. Australian Oilseed Federation, http://www.australianoilseeds.com/__data/assets/pdf_file/0016/907/Long_Read-Only.pdf

30 GRDC (2009) Converting rainfall to grain. Northern Region. GRDC Water Use Efficiency Fact Sheet, http://www.grdc.com.au/uploads/documents/GRDC_Water%20Use%20Efficiency%20North%20version%20231009.pdf

The industry standard for the oil content of sunflower grain is 40%, with a premium and discount system applied to the measured oil content above and below the standard. Commercially, sunflower oil contents are variable and may be largely related to crop nutrition. A benchmarking study by Serafin and Belfield (2008—Sunflower production guidelines for the northern grains region—northern NSW and southern Qld) of 32 commercial paddocks of sunflower in northern NSW and southern Queensland indicated large variations in nitrogen management of the crops, resulting in large variations in N supply. Of concern was the fact that 20% of paddocks had starting soil nitrate-N levels >200 kg/ha.

Four nitrogen rate experiments were conducted in northern NSW in the 2005–06 summer on farms near Tamarang and Pine Ridge on the Liverpool Plains and Gurley and Mallawa in the Moree district.

The major outcome of these replicated trials was the negligible effects of applied fertiliser N on grain yields (until the point of excess) and the negative effect on oil content. This prompted further interrogation of the data, because it appeared that the relationship between N nutrition, starting soil water, target yield and oil content was crucial.

The ratios of soil water to nitrate have been used successfully to target specific grain proteins, in the study of wheat and barley production in southern Queensland (Dalal et al. 2007). Since protein and oil contents of grains are inversely related, it seemed possible to use a similar approach to target oil contents sunflower of >40%.

Starting soil water and N rates were converted to a nitrate: water ratio and the measured oil contents were then subjected to regression analysis.

As N supply increased and the soil nitrate: water ratio increased from 0.35 to 1.80, grain oil contents declined from 45% to ~38%. Grain yields also showed a slight decline through the range of nitrate: water ratios. Matching nitrate to water at ratios of 0.5–1.0 optimised oil contents above the required industry standard of 40% as well as grain yield. Oil contents were, on average, <40% when the nitrate: water ratio was >1.0.

On one hand, there is an important need to supply sufficient N to optimise yield, while on the other not compromising grain quality. In the case of sunflower, high N supply may result in low oil contents and a price penalty.

Data from the four replicated N-rate trials suggest that the concept of targeting oil content through matching of soil nitrate and water at ratios of 0.5–1.0 has merit. Clearly, additional data are required to confirm the relationship. An incomplete data set from a benchmarking study of commercial sunflower crops in northern NSW and southern Queensland (L Serafin and S Belfield, unpublished data) has indicated a similar negative relationship between the nitrate : water ratio and oil content, with 26% of the crops sown into soils with the ratio >1.0. Further investigation to clarify the relationship is planned.

Sulfur is also a major nutrient of sunflowers, but to date little research has been done in the northern grains region to determine potential benefits and specific requirements of S. Sulfur and N interact to determine leaf area, which provides photosynthetic capacity for developing florets and seeds. A deficiency of N and S leads to reduced seed weight and number of seeds, as well as affecting seed quality.

Sunflowers remove 5 kg of S in the seed of a 1-tonne crop; hence, including sunflowers as a regular crop in the rotation has the capacity to remove significant amounts of S over time.

Preliminary trial work has been conducted to investigate the effects of the major nutrients, N, S and K, alone and in combination. Results from a trial conducted in the 2008 season at Pine Ridge showed a yield advantage of applying 5 kg S/ha, broadcast at sowing as gypsum. However, there was no significant difference between applying 10 kg S/ha and the nil treatment. No effects on oil content were recorded.

Further trial work is needed to provide additional data to develop our understanding of the full impacts of S nutrition.

In relation to N management, from the current data set it can be surmised that oil contents were, on average, <40% when the nitrate : water ratio was >1.0. These results suggest that sunflower oil contents may be more specifically targeted and fertiliser N inputs more accurately determined for optimum profitability. The key outcome of this study is that excessive N in relation to starting soil water reduces oil content. However, sufficient N is needed to maintain yield.

Sulfur nutrition and its interaction with N needs further investigation. A positive response to yield was obtained in one preliminary trial. [31]

1.8.4 Double-crop options

Double-cropping is an option in seasons where the soil profile refills quickly; however, it is not recommended where stored moisture is limited. [32] Surprisingly, only 14% of sunflower paddocks are sown into a double-crop situation. [33]

1.9 Nematode status of paddock

MORE INFORMATION

GRDC The current and potential costs from diseases of wheat in Australia

http://www.soilquality.org.au/factsheets/root-lesion-nematode-in-queensland

In the northern grain region, the predominant root lesion nematode (RLN), *Pratylenchus thornei*, costs the wheat industry AU$38 million annually. Including the secondary species, *P. neglectus*, RLN is found in three-quarters of fields tested. [34]

Resistance and susceptibility of crops can differ for each RLN species, and sunflowers have a role to play where nematode populations are limiting crop production, because the crop is resistant to both *P. thornei* and *P. neglectus*. [35]

As information on nematode incidence and species type becomes available, the use of sunflowers as a management tool for nematodes is likely to increase. RLN are widespread in central and northern NSW, with *P. thornei* generally having a much higher distribution (69% random paddocks) than *P. neglectus* (32% random paddocks). [36]

1.9.1 Nematode testing of soil

It is important to have paddocks diagnosed for plant parasitic nematodes so that optimal management strategies can be implemented. Testing your farm will tell you:

- whether nematodes are present in your fields and at what density
- which species are present

It is important to know which species are present because some crop-management options are species-specific. If a particular species is present in high numbers, immediate decisions must be made to avoid losses in the next crop to be grown. With low numbers, it is important to take decisions to safeguard future crops. Learning that a paddock is free of these nematodes is valuable information because steps may be taken to avoid future contamination of that field. [37]

Testing of soil samples taken either before a crop is sown or while the crop is in the ground provides valuable information.

31 L Serafin, S Belfield, D Herridge (2011) Sunflower yield performance and agronomy: Where and when do they fit best in the northern grains region? GRDC Update Papers, 13 Sept. 2011

32 L Serafin, S Belfield (2008) Sunflower production guidelines for the northern grains region—northern NSW and southern Qld. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/249779/Sunflower-production-guidelines-for-the-northern-grains-region.pdf

33 L Serafin, S Belfield, D Herridge (2011) Sunflower yield performance and agronomy: Where and when do they fit best in the northern grains region? GRDC Update Papers 13 Sept. 2011

34 GM Murray, JP Brennan (2009) The current and potential costs from diseases of wheat in Australia. GRDC Report, https://www.grdc.com.au/~/media/B4063ED6F63C4A968B3D7601E9E3FA38.pdf

35 L Serafin, S Belfield, D Herridge (2011) Sunflower yield performance and agronomy: Where and when do they fit best in the northern grains region? GRDC Update Papers 13 Sept. 2011

36 L Serafin, S Belfield, D Herridge (2011) Sunflower yield performance and agronomy: Where and when do they fit best in the northern grains region? GRDC Update Papers 13 Sept. 2011

37 QPIF (2009) Root lesion nematodes—management of root-lesion nematodes in the northern grain region. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

MORE INFORMATION

https://sites.google.com/site/crownanalyticalservices/

http://www.sardi.sa.gov.au/products__and__services/entomology/diagnostic_services/predicta_b

http://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

MORE INFORMATION

https://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Summer-crop-decisions-and-root-lesion-nematodes

1.9.2 Effects of cropping history on nematode status

Root-lesion nematode numbers build up steadily under susceptible crops and cause decreasing yields over several years. Yield losses >50% can occur in some wheat varieties, and up to 20% yield loss in some chickpea varieties. The amount of damage caused will depend on:

- the numbers of nematodes in the soil at sowing
- the tolerance of the variety of the crop being grown
- the environmental conditions

Generally, a population density of 2000 RLN/kg soil anywhere in the soil profile has the potential to reduce the grain yield of intolerant wheat varieties.

A tolerant crop yields well when high populations of RLN are present (the opposite is intolerance). A resistant crop does not allow RLN to reproduce and increase in number (the opposite is susceptibility).

Growing resistant crops is the main tool for managing nematodes. In the case of crops such as wheat or chickpea, choose the most tolerant variety available and rotate with resistant crops to keep nematode numbers at low levels. Information on the responses of crop varieties to RLN is regularly updated in grower and relevant state government agencies planting guides. Note that crops and varieties have different levels of tolerance and resistance to *Pratylenchus thornei* and *P. neglectus*.

For more information, download *Management of root-lesion nematodes in the northern grain region* http://www.daf.qld.gov.au/__data/assets/pdf_file/0010/58870/Root-Lesion-Nematode-Brochure.pdf

Summer crops have an important role in management of RLN. Research shows than when *P. thornei* is present in high populations, two or more resistant crops in sequence are needed to reduce populations to low enough levels to avoid yield loss in the following intolerant, susceptible wheat crops. [38]

For more information on nematode management, see GrowNotes Sunflowers Section 8: Nematodes.

1.10 Insect status of paddock

1.10.1 Insect sampling of soil

Several species of soil-dwelling insects attack seeds and seedlings of sunflowers, causing thinning or complete destruction of plant stands. Sunflowers are more susceptible to seedling damage than are other field crops because damaged sunflower seedlings lack the capacity to regrow or tiller.

Seedlings are most vulnerable to damage:

- before they develop three to four ´true´ leaves
- during periods of moisture stress
- when other factors such as low soil temperature or soil compaction limit plant growth [39]

Soil-dwelling insect pests can seriously reduce plant establishment and populations, and subsequent yield potential.

Soil insects include:

- cockroaches
- crickets

38 K Owen, T Clewett, J Thompson (2013) Summer crop decisions and root lesion nematodes. GRDC Update Papers Bellata, 16 July 2013, http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2013/07/Summer-crop-decisions-and-root-lesion-nematodes

39 QDAF (2011) Insect pest management in sunflowers. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/sunflowers

- earwigs
- black scarab beetles
- cutworms
- false wireworm
- true wireworm

Soil insect control measures are normally applied at sowing. Since different insects require different control measures, the species of soil insects must be identified before planting. [40]

Soil sampling by spade

1. Take a number of spade samples from random locations across the field.
2. Check that all spade samples are deep enough to take in the moist soil layer (this is essential).
3. Hand-sort samples to determine type and number of soil insects.
4. Spade sampling is laborious, time-consuming and difficult in heavy clay or wet soils. [41]

Germinating-seed bait technique

Immediately following planting rain:

1. Soak insecticide-free crop seed in water for at least 2 hours? to initiate germination.
2. Bury a dessertspoon of the seed under 1 cm of soil at each corner of a square 5 by 5 m at five widely spaced sites per 100 ha.
3. Mark the position of the seed baits, as large populations of soil insects can destroy the baits.
4. One day after seedling emergence, dig up the plants and count the insects.

Trials have shown no difference in the type of seed used for attracting soil-dwelling insects. However, use of the type of seed to be sown as a crop is likely to indicate the species of pests that could damage that crop.

The major disadvantage of the germinating-grain bait method is the delay between the seed placement and assessment. [42]

Detecting soil-dwelling insects

Soil insects are often difficult to detect because they hide under trash or in the soil. Immature insects such as false wireworm larvae are usually found at the moist–dry soil interface.

For current chemical control options see the websites of Pest Genie Australia or APVMA. [43]

40 QDAF (2011) How to recognise and monitor soil insects. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/recognising-and-monitoring-soil-insects

41 QDAF (2011) How to recognise and monitor soil insects. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/recognising-and-monitoring-soil-insects

42 QDAF (2011) How to recognise and monitor soil insects. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/recognising-and-monitoring-soil-insects

43 QDAF (2011) How to recognise and monitor soil insects. Department of Agriculture, Fisheries and Forestry Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/recognising-and-monitoring-soil-insects