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## What's new

The GRDC GrowNotes are dynamic documents that are updated according to user feedback and newly available information.

This version of the GRDC Safflower GrowNotes (updated March 2017) contains the following updates on original content published in August 2015:

#### Section A: Introduction

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- New link: Research paper: Greijdanus A, Kragt M. (2014). The grains industry: An overview of the Australian broad-acre cropping: <a href="http://ageconsearch.umn.edu/bitstream/164256/2/WP1400002.pdf">http://ageconsearch.umn.edu/bitstream/164256/2/WP1400002.pdf</a>
- New information: Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing; <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>

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#### Section 5: Nutrition and fertiliser

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- New information: Part I Achieving great aeration results and Part II Silo recirculation as an aid to fumigation: <a href="https://grdc.com.au/Research-and-achieventh">https://grdc.com.au/Research-and-achieventh</a>













 $\underline{results\text{-}and\text{-}Part\text{-}II\text{-}Silo\text{-}recirculation\text{-}as\text{-}an\text{-}aid\text{-}to\text{-}fumigation}$ 

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- New information: An analysis of frost impact plus guidelines to reduce frost risk and assess frost damage: <a href="https://grdc.com.au/Research-and-Development/grdc-com.au/Research-a

## **Section 15: Marketing**

## Page 15.1

• New text, tables and figures: Profarmer Australia













# Start here for answers to your immediate safflowers crop management issues



What varieties of Safflower are available?



What is the sowing rate for Safflower?



What herbicides options do I have in Safflower?



What are the rotational benefits of Safflower?



When can I harvest Safflower?





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# Keys to successful safflower production

Keep the market and end use in mind when selecting varieties and

consider forward contracts

if on-farm storage is not available







1.5-4.0<sub>cm</sub>

Always use quality seed and DO NOT SOW TOO DEEP





Safflower requires **MORE WATER** than canola, ensure that **9–18** Use moderate sowing rates, especially when sowing early KG/HA in drier situations

**Early sowing** 

is important to

**Harvest during cooler conditions** to improve cleanliness of seed and reduce the risk of fire

Increase

late sowing

**NORTHERN** 

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Australia, safflower can be sown

much later without significantly affecting yield

at least

fewer herbicides are available

Monitor crops regularly for pests



Supply



Harvest as soon as crops are mature and be careful to avoid seed damage, which reduces quality,

Manage pests and weeds during **ESTABLISHMENT AND EARLY GROWTH**  Consider on-farm storage of safflower to enable access to more





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## Introduction

Safflower (Carthamus tinctorius L.), a member of the Asteraceae family, is a versatile, winter-spring growing, minor oilseed crop in Australia, offering key benefits to diverse summer and winter crop systems as well as components of mixed production systems (Figure 1).

As an oilseed crop, benefits include improved productivity of subsequent crops, lifting farm income, reducing the impact of disease and weeds; and producing edible and industrial quality oil and meal. Safflower integration offers the opportunity to enhance overall environmental, production and economic sustainability.

Safflower is grown largely for the food industry in Australia. Safflower has received focused attention as an industrial oilseed and potentially represents a significant new crop industry for the northern region. Research to establish baseline data to develop agronomic management is crucial for future industry development of safflower and linseed. 12

#### Key points

- Safflower is best suited for rotation with cereal crops. Agronomic attributes include roles in integrated disease, weed and pest management programs.
- Limited market development restricts its current contribution to farming systems.
- The development of safflower crop technology for the biodiesel industry presents the potential of a significant addition to crop options in northern farming systems.
- Safflower is heat and drought resistant, adaptable to arid and semi-arid climates as well as irrigation. 3

Safflower can be used in rotations effectively to break the lifecycle of cereal root diseases such as take-all and crown rot. It has an extensive root system, which can break up hardpans and create channels in the soil profile, facilitating air and water movement. The deep roots, combined with a long growing season, also dry soil at depth, which benefits the management of soils prone to waterlogging and salinity.



A general summary of the Australian grain growing regions is available at Greijdanus A, Kragt M. (2014). The grains industry: An overview of the Australian broad-acre cropping



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FEEDBACK



Figure 1: Safflowers in CSIRO trial.

Photo: Brad Colliss, Coretext

Compared to traditional winter crops such as wheat or canola, the later sowing window of safflower increases options for the pre-sowing control of problem winter weeds and provides opportunity to generate income from fields where seasonal conditions prevent the establishment of other winter crops.

Safflower can also provide management flexibility to a cropping enterprise. The later sowing and harvest time of safflower suits some growers because peak demands on labour and machinery are spread over a longer period. Safflower fits well into cereal-based cropping systems, with no additional machinery being required.

Safflower may also be sown as an opportunity crop. In such situations, it may be sown outside the optimum window with fewer inputs and still produce economic yields. For example, safflower can be sown in spring to replace failed winter crops. <sup>4</sup>

## A.1 Safflower agronomy at a glance

Keys to successful safflower production:

- Safflower requires more water than canola to produce comparable yields;
   therefore, ensure that moisture is available to at least 1 m soil depth at sowing.
- Keep the market and end use in mind when selecting varieties and consider forward contracts if on-farm storage is not available.
- Always use quality seed and do not sow too deep (1.5–4.0 cm depth recommended).
- Main sowing window is June to August. Early sowing is important to maximise
  yields in drier situations (June or July).
- Flowering can commence in 85–140 days i.e. at the end of October and during November (depending on genotype, sowing date and environment).
- In wetter situations in southern Australia, safflower can be sown much later (to mid spring) without significantly affecting yield. Increase sowing rate for very late sowing.
- Use moderate sowing rates, especially when sowing early in drier situations (9–18 kg/ha).
- Supply adequate nutrition (fertiliser).



Safflower in Australia

Potential role of safflower in

Australia's southern farming systems





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- Minimise waterlogging when irrigating safflower, and/or fill the soil profile before sowing.
- Select paddocks carefully because fewer herbicides are available for use in safflower than in the more widely grown crops (some permits are available).
- Manage pests and weeds during establishment and early growth.
- · Monitor crops regularly for pests.
- Safflower matures in 110–170 days. Harvest period in northern New South Wales (NSW) is normally from mid-December through to the end of January, varying with location, seasonal conditions and sowing date.
- The rate of dry down of seeds and stems can vary. Harvest delays can occur
  when drying down to 8% moisture content in the seed (delivery standard) where
  stems have not dried down sufficiently. Stem dry down can be slowed when
  periods of rain and high humidity occur and when low crop populations produce
  plants with thick stems.
- Where food and birdseed markets demand clean bright white seed, timely harvest is imperative.
- Harvest as soon as crops are mature and be careful to avoid seed damage, which reduces quality, and to avoid blocking equipment.
- Harvest during cooler conditions to improve cleanliness of seed and reduce the risk of fire.
- In most seasons, average dryland yields are 1–1.2 t/ha.
- Anecdotally, the highest known commercial yield is reported to be 3.3 t/ha under irrigation in northern NSW.
- Consider on-farm storage of safflower to enable access to more lucrative markets.  $^{\rm 5\ 6}$

## A.2 Crop overview

Safflower originated in the Near East and it has been grown for centuries in China, India and North Africa. It is a multi-purpose species with many traditional uses. Preparations made from the florets are thought to benefit the circulatory system, and yellow and red dyes extracted from the florets were once used to colour food and clothing. Immature plants can be grazed or stored as hay or silage, and some forms are used in fresh or dried floral arrangements.

The use of safflower as an oilseed dates to Roman times, and it has been used in India since the 1800s. However, only since the crop was introduced into the United States in the 1930s has it developed into the oilseed crop we know today. Safflower is now grown in >20 countries, with the United States, India and Mexico accounting for  $^{\sim}70\%$  of world production.

Worldwide, safflower is a minor crop compared with other oilseeds. Average production for the 5 years to 2008 was 0.78 million tonnes, or "0.3% of world soybean production. Safflower has been grown in Australia since the 1950s, initially to extract oil from seeds for use in the paint and resin industries. Production expanded to 42,000 ha by 1968, then declined because of drought and severe outbreaks of Alternaria disease (caused by *Alternaria carthami*). Interest in oilseed production resumed when quotas on the use of vegetable oils for margarine production were abolished in1976. The area sown to safflower in Australia peaked in 1979 at 74,688 ha.

There are two types of safflower, which produce different kinds of oil, one high in monounsaturated fatty acid (oleic acid) and the other high in polyunsaturated fatty acid (linoleic acid). The predominant edible oil market is for the former, which is lower



<sup>5</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>

K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>





in saturated fatty acids than olive oil, for example. The latter has uses including in painting in place of linseed oil, particularly with white paints, because it lacks the yellow tint of linseed oil.

In 1987, CSIRO released the two cultivars Sironaria, with resistance to Alternaria carthami, and Sirothora, with resistance to Phytophthora spp. Nonetheless, the area of production has remained variable. In the 10 years to 2008, the average annual area of production was 25,781 ha, but this has ranged from 3,600 to 45,000 ha. Growers have indicated that this is historically due to many factors including unfavourable seasons, variable prices, limited cultivars, competition from other crops and a lack of information on growing safflower.

Additional cultivars with higher oil content and increased disease resistance have been imported in recent years, mainly from the USA. The main market for these cultivars is oil for human consumption, with the remaining meal suitable for ruminants. White-seeded cultivars can be valuable when sold into birdseed markets; however, prices can be volatile depending on supply and demand.

Worldwide demand for vegetable oil is increasing as consumers seek healthier diets. Inclusion of safflower in rotations can diversify cropping programs and help to spread risk. With appropriate management, safflower can produce satisfactory returns in many cereal-growing regions of Australia, especially in wetter situations.

Safflower is a versatile crop that can add considerable value to cropping systems by playing various strategic roles. 7

## A.2.1 Marketing safflower

Safflower is currently mainly grown as an oilseed crop comprising two main oil types:

Linoleic acid is a polyunsaturated (omega-6) fatty acid. The most widely grown linoleic oil cultivar is Sironaria, released by CSIRO in 1987. Linoleic genotypes contain >75% linoleic acid. Linoleic cultivars are grown for seed and oil.

Oleic acid is a monounsaturated fatty acid. Oleic varieties include S317 and S517 which are grown their oil, for use the food industry for frying and in the manufacture of pharmaceuticals, cosmetics, soap, paint additives, adhesive and sealant compounds, plastics and lubricants.

Current oleic safflower production, comprising principally S317, targets the food industry, supplying manufacturers, wholesalers and food service operators. Export in the form of oil or as seed varies with the costs of crushing and oil extraction. Recent increases in crushing costs from \$150/t to \$300/t mean that seed imports have replaced oil imports (Bill Slattery, pers comm).

Presently, India is the main market for oleic safflower oil for the food industry, looking to import around 30,000 t seed. Australia currently falls well short to meet this, struggling to supply 4000 t seed.

Safflower is grown under contract on a per hectare basis. Prices paid for oleic safflower in 2014 were \$490/t and in 2015 \$520/t. Prices are quoted ex-farm, ex-GST. Contracts are written to Australian Oilseed Federation (AOF) Standards. Payments are based on the percentage of oil in the seed and test weight at 8% moisture and 4% impurities. The baseline oil content is 38% with applied 2% discounts and premiums. In 2014, all deliveries exceeded 38% oil.

#### Seed

Safflower seed is used in birdseed and small animal feed mixes. Visual seed appearance is an important market criterion, preference given to a bright white appearance. Sironaria is the preferred variety. Other varieties like S317 (an oleic oil variety) are not desirable for this market because of inherent varietal characteristics like a creamy coloured seed coat and grey stripe on the seed.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy





Large price variations between seasons are common due to the speculative nature of production. The small market for birdseed and small animal feed mixes is easily over supplied.

#### Linoleic oil

Linoleic oil is an edible oil, used in products such as salad oils and soft margarines. It is also used in the manufacture of pharmaceuticals, cosmetics and paint in some other countries

Similarly, overseas in the USA as an example, a by-product after oil extraction is the high fibre meal. The fibre is important in stock with low fibre diets e.g. feedlots and dairy. The meal containing around 24% protein is used as a livestock protein supplement. Meal from de-hulled seed has about 40% protein with reduced fibre content. 8

## A.2.2 Potential industry growth

The unique properties of oleic acid also make it of potential use in biodiesel production. GRDC reports that market analysis indicates global demand for high-purity oleic acid oil could require more than 100,000 ha of the new safflower varieties. As an indication of potential, the size of the Australian cotton industry was estimated to be 270,000 ha in 2015–16 by Cotton Australia.

'Cotton soils' could be classified as 'safflower soils'. Depending on water availability with seasonal conditions, pricing comparisons of crop choice and water costs, and field rotations, some level of substitution may be a potential viable option for some growers.

The Northern Grains region is characterised by a variable climate where agriculture comprises diverse cropping systems. Predominantly comprising soils with high water holding capacity, it is an environment that suits safflower with its heat and drought tolerance. Oleic oil synthesis within the seed is favoured by warmer finishing conditions, promoting high oleic content.

The existing expertise with modern agricultural technology, including GM crop production, and the region's pre-existing oil crushing facilities, combine to offer opportunities for the development of an industrial safflower oil enterprise in farming systems.

Economics will determine industry growth with competition from profitable crop options. <sup>9</sup>

## A.2.3 Safflower production in Australia

In Australia, safflower has always been a minor crop and has attracted sporadic attention for research and development. Australian industry began to investigate safflower in the 1940s amid concerns about shortages of drying oil in the paint and resin industries (Smith 1996). Several cultivars were subsequently introduced from overseas, allowing small-scale commercial production to commence in the mid-1950s.

Safflower comprises cultivars that are of two oil types, high in linoleic or oleic fatty acids. Linoleic cultivars were principally marketed as a component of feed mixes for birds and small animals; and oleic cultivars used in manufacturing industries producing paints, resins, pharmaceuticals and cosmetics.

Areas sown to safflower vary widely, ranging between 6100 and 45,000 ha in the decade from 2003 (FAO 2015). Reasons for this include few available cultivars, susceptibility to Alternaria (*Alternaria carthami*) and Phytophthora (*Phytophthora cryptogea*), limited agronomic research, disappointing farmer experiences and



<sup>8</sup> K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>

K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>



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Ground Cover Radio 119:

<u>Development may herald new</u>
oilseeds industry



## **MORE INFORMATION**

http://www.australianoilseeds.com/\_data/assets/pdf\_file/0019/6742/ Final\_Jochinke\_paper.pdf adverse seasons. A history of inconsistent prices and market opportunities because of competition from both alternative oilseed crops and the continuing development of petroleum substitutes have further hampered adoption. <sup>10</sup>

Cultivar Gila was introduced in the early 1960s, and with higher seed and oil yields, the safflower industry expanded to 42,000 ha by 1968. At the time, safflower was mainly grown in Queensland. Production subsequently declined because of drought in 1968 and 1969, followed by several seasons of above-average rainfall, which favoured Alternaria disease. Production continued in Queensland and expanded into other states at varying levels, but in 1975, grower confidence was again lost by a severe outbreak of Alternaria disease in Queensland.

During the 1960s and 1970s, cotton (*Gossypium hirsutum*) and hybrid sunflower (Helianthus annuus) industries developed, creating competition to the safflower industry. The abolition of quotas on the use of vegetable oils for margarine production in 1976 led to increased interest in oilseed production, and in the following seasons record prices were paid for safflower. After the area sown in Australia peaked in 1979 at 74,688 ha, it declined, presumably due to volatile prices and competition from other oilseed crops.

CSIRO developed cvv. Sironaria and Sirothora in response to disease concerns and they were released in 1987. However, this did not revive safflower production in Queensland, with production in the last two decades shifting largely to NSW and Victoria. During this period, the Australian industry has been based largely on Sironaria, which has linoleic oil and is suitable for birdseed markets. <sup>11</sup>

Recent research and development has focused on a new end use for safflower, through a collaboration between CSIRO and GRDC to produce genetically modified safflower with increased quantities of fatty acids with industrial applications, such as biodegradable plastics. <sup>12</sup>

## A.3 End uses

The main end uses for Australian safflower seed are oil and birdseed. Safflower seed can contain over 40% oil. Two types of safflower are currently in commercial production.

Some varieties have 70 to 80% polyunsaturated fatty acid (linoleic acid) making it suitable for salad oil and margarine. It is also blended with other vegetable oils to lift polyunsaturated ratios to the level required for edible products. Because this type of oil polymerises readily when heated, it is less suitable for cooking.

Other varieties typically produce oil with 80% monounsaturated oleic acid, which is similar to olive oil. Oils with high levels of oleic acid are stable at high temperatures making them superior for frying. Other minor uses for safflower oil include; livestock rations, industrial lubricants, soaps, cut flowers, pharmaceutical products, infant formulas, cosmetics and biodiesel. Organically produced safflower may command a premium for both monounsaturated or polyunsaturated types.

Safflower seed is also used in pet food products, particularly in birdseed and mixes for small rodents like guinea pigs. Birdseed markets demand large, bright white seeds, without coloured stripes or pappus, that are also free from cracking, sprouting and staining from weather or disease. Some oilseed safflower varieties have striped seed and are not suitable for pet food markets.

Safflower seed for oil production may be either cold pressed, expeller pressed or solvent extracted. The meal remaining after oil extraction is usually high in fibre (30–



<sup>10</sup> K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>

<sup>11</sup> D Jochinke, N Wachsmann, T Potter, R Norton (2008) Growing safflower in Australia: Part 1—History, experiences and current constraints on production. Australian Oilseeds Federation, <a href="http://www.australianoilseeds.com/">http://www.australianoilseeds.com/</a> data/assets/pdf\_file/0019/6742; Final\_Jochinke\_paper.pdf

<sup>12</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>



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Development of super high oleic oil in safflower

The molecular basis of high and super-high oleic safflower seed oils 40%) with 20–22% protein and is best suited for ruminant diets, but meal properties do vary with soil extraction method.

Compared to cold or expeller pressing, the meal by-product from solvent extraction is higher in protein, but has a lower oil content ( $^{\sim}1\%$ ) resulting in a low energy content. On the other hand, cold or expeller oil extraction processes result in a meal with less protein, but a higher oil content in the range of 8 to 11%. Expeller pressed oil has the poorest shelf life.

Hulls can be removed prior to oil extraction increasing protein to 42% and reducing the fibre content to 10%. Such meal is suitable for pigs and poultry, but with no market for hulls at present this process is not economically viable and oil extraction is usually performed on whole seeds. 13



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>



# Planning/Paddock preparation

In Australia, safflower production commenced in northern NSW and Queensland, but has since shifted to include the higher rainfall (>450 mm), cereal-growing regions of southern NSW, Victoria and South Australia.

Safflower can be grown over a wide range of regions if severe frosts (<-4°C) are avoided during stem elongation and if harvest can be completed before heavy summer rainfall events that occur after the crop matures.

Safflower has a relatively high water requirement and is more reliable where stored soil water and rainfall allow total crop water use to exceed 300 mm between sowing and maturity.

Traditional production areas include the deep cracking clay soils near Moree, Warren and Griffith in NSW, the Wimmera region of Victoria, and the area from Bordertown southwards in South Australia. Safflower can also be grown successfully as an irrigated crop in most river valleys and irrigation areas, such as the Hay Plain in NSW. <sup>1</sup>

## 1.1 Paddock selection

Checklist for paddock selection for safflower:

- high water-holding capacity, deep soil with no hardpans and not prone to waterlogging
- clean paddocks with low populations of broadleaf weeds, particularly thistles
- no history of hard-to-kill broadleaf weeds such as bindweed, thorn apple (false castor oil), peach vine
- neutral to alkaline soils, good fertility (may still require phosphorus and zinc).

Particularly in the Northern Region, both winter and summer broadleaf weeds must be taken into consideration because of the late window for safflower and the likelihood of early-emerging summer weeds. There is no current registration for in-crop broadleaf control.

Safflower is adapted to a wide range of soils (Figure 1). It is best suited to neutral and alkaline soils and less tolerant of acidic soils. It is a deep-rooted crop and it should be grown on soils of  $\geq 1$  m depth and with good water-holding capacity.

Clay loams and alluvial soils are satisfactory. Shallow sandy soils and heavy, structureless soils prone to surface crusting are not suitable. Safflower is only slightly less tolerant than barley to salinity. It can be grown under irrigation, but this needs to be carefully monitored because many varieties are susceptible to Phytophthora root rot. Pre-irrigation of a paddock is usually recommended to ensure that the soil profile is full and no additional water is applied.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>





Figure 1: Safflower is adapted to a wide range of soils.

Photo: GRDC

Safflower's extensive root system can break up hard-set soils and can dry soil profiles where required. In some seasons, safflower is grown as an opportunity crop on full profiles of soil water on floodplains or normally dry lakebeds after floodwater recedes. Safflower may also provide cropping options in paddocks where herbicide-resistant weeds are present, because of the potential to use either knockdown herbicides or mechanical means of weed control, and the later sowing date of safflower. <sup>2</sup>

## 1.2 Paddock rotation and history

Safflower is a good rotation crop with winter cereals and is best sown into a no-till long fallow to ensure good subsoil moisture. As a rotation crop, it can disrupt cereal-disease cycles such as crown rot and take-all.

To avoid potential disease problems, safflower crops should not be grown in succession in the same paddock. A rotation of one season in four for safflower is recommended. A safflower crop can be followed by a summer crop; however, growers should note the minimal soil water available to the following crop due to the high water use of safflower.

It is important to select paddocks with good pre-plant weed control because safflower is a poor competitor with weeds in its early growth stages and herbicide options are limited. Safflower is susceptible to damage from various residual herbicides, so growers should consider previous herbicide use in a paddock. <sup>3</sup>

Spores of *Alternaria carthami* (the causal agent of Alternaria blight) can remain on infected stubble for >2 years. Paddocks selected should not be adjacent to the previous crop's stubble, and volunteer crop plants should be controlled, as well as alternative hosts. Spores *Phytophthora cryptogea* (causing Phytophthora root rot) will remain on many host crops. Avoid low-lying paddocks, paddocks with previous Phytophthora problems and paddocks where medics have grown. Safflower should not be sown directly into stubble of alternative hosts such as chickpeas.

In wet years, safflower can be planted following a sorghum crop provided there has been sufficient rainfall for a moist soil profile to at least 1 m depth. In drier or average seasons, safflower should be planted following a summer fallow from the previous



<sup>2</sup> R Byrne (2009) Safflower. In Summer crop production guide 2009. NSW Department of Primary Industries. (Eds L Serafin, L Jenkins, R Byrne)

<sup>3</sup> R Byrne (2009) Safflower. In Summer crop production guide 2009. NSW Department of Primary Industries. (Eds L Serafin, L Jenkins, R Byrne)



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winter cereal crop. This allows sufficient moisture to be accumulated, and the safflower is then able to provide a break from cereal crown and root diseases.

Generally, it is not advised to follow a broadleaf crop with safflower, because the broadleaf weed population is likely to have increased. However, safflower following a cereal crop allows for good control of broadleaf weeds from previous seasons, running down the seedbank, and careful fallow control can reduce populations of summer weeds.



## 1.3 Benefits of safflower as a rotation crop

Safflower can be a valuable addition to cropping systems, providing a number of strategic, agronomic and financial benefits as well as cash return.

#### Rotation benefits include:

- late winter crop option if there is a late break or failed establishment of the winter crop
- potential to double crop out of sorghum
- heat and drought tolerant oilseed crop suited to lower rainfall areas where canola and sunflower are not adapted
- broadleaf crop option—break crop for cereal diseases including Crown rot (Fusarium pseudograminearum), Common root rot (Bipolaris sorokiniana), Yellow leaf spot (Pyrenophora tritici-repentis) and Spot form of net blotch (Pyrenophora teres f. maculata)
- resistant to both *P. thornei* and *P. neglectus* root lesion nematodes
- good host to arbuscular mycorrhizae fungi (AMF), promoting the increase of AMF in the soil
- different weed spectrum to most other crops—it offers the opportunity to control late germinating weeds and/or herbicide resistant winter weeds and to incorporate additional IWM strategies
- greater crop enterprise diversity to spread economic and production risk
- used in a soil ameliorant role to improve soil structure; strategically as a first crop in the rotation after cotton to break up subsoil to remove compacted layers, improve aeration and water infiltration; and root development to subsequent crops (anecdotal reports of rooting depths of 2.2 m). 4

#### Other advantages include:

- alternative crop suited to both dryland and irrigation
- · low input, low maintenance and easy to grow
- crop inputs and machinery requirements similar to wheat production
- sowing and harvest windows effectively spread peak workloads and machinery use over a longer period, increasing efficiencies and harvest timeliness of different crops
- widely adapted to various soil types, but best suited soils with high water holding capacities
- · competitive crop against weeds after the mid to late spring period
- tolerant of hot summer conditions during crop maturation due to deep roots, providing sufficient water is available
- utilises soil water deep in the soil profile. Lowers the water table with dissolved salts, reduces water logging in following crops and improves N efficiency by utilising leached N at depth



<sup>4</sup> K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>









Root and crown diseases of wheat and barley

Crown rot—Queensland



 increasing climate variability presents opportunities for safflower as an oilseed as it can grow on less rainfall than other major oilseed crops such as canola, sunflower and soybeans. Potential to be grown across a wide geographic area.

## 1.3.1 Break crop

Safflower is not a host for the major root and crown diseases of cereals. Diseases such as crown rot that infect cereals such as wheat and barley are carried over from one cereal crop to the next on stubble, volunteer crop plants and certain grass weeds. Because these diseases are not hosted by safflower, with good grass-weed control, the populations of these organisms are significantly reduced in safflower crops, resulting in higher cereal yields in the following season. Safflower does not suffer from blackleg, making it a suitable break crop for canola, and it is one of a few crops resistant to both species of root-lesion nematodes, meaning that it will not allow build-up of either *Pratylenchus thornei* or *P. neglectus*.

The number of successive break crops required to reduce crown rot levels sufficiently will vary depending on rainfall in the break year(s). In dry years, when residue breakdown is slower, a 2-year break crop may be required to reduce crown rot to acceptable levels. With wetter seasons, a 1-year break may be sufficient.

## 1.3.2 Enterprise diversification

In a cereal-based enterprise, safflower can provide a hedge against unpredictable weather. Because safflower can be planted later than cereals, it can be substituted for part of the cereal crop if planting rains begin too late for cereals, or if too much rain prevents their establishment. A large amount of rain during cereal sowing and harvest can be detrimental to these crops, but may benefit safflower because its growing season is much later.

This allows for a more diversified cropping program, which has several advantages. For example, the later sowing and harvest of safflower spreads seasonal workloads and may reduce the exposure of crops to frost, and the incorporation of another crop species increases the opportunity to rotate herbicide groups. Safflower's late growing season can help to mitigate effects on the whole-farm budget of spring frost damage to cereals, thereby reducing risk.

## 1.3.3 Drought tolerance

Provided the soil profile is moderately wet at sowing, safflower can yield reasonably well with little follow-up rain, because of its deep taproot. Safflower tolerates heat and drought better than most other crops and can survive for extended periods without rain. Safflower will utilise deep soil moisture; therefore, the period of return to crop needs to be taken into account as part of the longer term rotation.

## 1.3.4 Tool for managing problem weeds

Safflower is often sown later than other winter crops, which allows more time for winter weeds to germinate before sowing. Such weeds can then be controlled using knockdown herbicides or cultivation, minimising resistance to selective herbicides. Furthermore, pre-emergent herbicides such as pendimethalin and trifluralin can be used at higher rates in safflower than in wheat, giving greater control of weeds such as annual ryegrass and wild oats. One drawback with safflower is the lack of broadleaf control options in-crop.



K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>









## 1.3.5 Entry crop and soil ameliorant

Safflower's aggressive root system penetrates further into soil than many other crops. The roots create channels in the subsoil, improving water and air movement as well as root development in subsequent crops. Safflower can be used to dry wet soil profiles, such as after irrigated cotton. This facilitates the natural shrinking and cracking of compacted layers, which can be further shattered by deep ripping.

## 1.3.6 Tool for managing salinity and waterlogging

Safflower is a long-season crop with a deep taproot, so it has the ability to use surplus water from deep in the soil profile, lowering water tables with dissolved salts and reducing the expansion of saline seeps. Similarly, some growers use safflower to dry soil profiles to reduce waterlogging in subsequent crops.

### 1.3.7 Pest deterrence

The prickly nature of safflower later in its growing season means that it is occasionally grown in situations where other crops may fail under high kangaroo, bird or feral pig pressure. Safflower is relatively unpalatable to these animals and growers can achieve an economic return with minimal maintenance of the crop. <sup>6</sup> Safflower can also be grown as a barrier crop around other cereals and pulses to decrease the pest burden in those crops.

## 1.4 Disadvantages of safflower as a rotation crop

Despite the benefits of safflower in a range of farming systems, several factors tend to result in lower yields, making it a less popular crop. These include:

- Late maturity, which exposes safflower to heat and moisture stress at the end of the season (Figure 2). Sowing significantly earlier brings maturity forward by only a small amount and increases the risk of frost damage during stem elongation.
- The upright seed heads are like a cup and easily saturated by rain. Summer rain
  can therefore cause staining of seed, reducing its value, and/or sprouting, where
  ripe seeds germinate in the head.
- In-crop herbicide options are limited, especially for the control of broadleaf weeds.
- The depletion of water from the soil profile by safflower can result in less water being available for the subsequent crop(s).
- Because most cultivars develop spines, care is needed to prevent blockages and header fires during harvest.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>7</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>



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**Figure 2:** Wheat and safflower in the Victorian Wimmera. Safflower matures 4–6 weeks after wheat (photo taken 31 December). In this example, both crops were sown on 24 July.

Photo: Nick Wachsmann

## 1.5 Fallow weed control

Many herbicides have restrictive safe re-cropping intervals prior to planting safflower. When considering knockdown herbicides prior to planting, the rate and re-cropping interval should be checked for all Group I phenoxy herbicides (i.e. 2,4-D) and planned accordingly. For instance, in Queensland, application of <a href="Ministrate">Amicide</a> Advance 700 restricts plant-back for at least 14 days following at least 15 mm of rain.

Herbicide applications undertaken in the previous 12 months need to be considered. Particularly restrictive plant-backs apply to most residual broadleaf herbicides, such as picloram, a component of Tordon\*, as well as commonly applied herbicides such as the Group B herbicide metsulfuron-methyl (e.g. <a href="Metsulfuron 600 WG">Metsulfuron 600 WG</a>). These herbicides can have restrictions of >9 months in some pH ranges, so planning for safflower paddocks and their management must begin early. Talk to your agronomist regarding likely herbicide restrictions and check current labels.

## 1.6 Seedbed requirements

Paddock preparation for safflower is similar to that for other oilseeds, with emphasis on weed control and good moisture profile. Safflower can be sown into cultivated seedbeds or direct-drilled into stubble from previous crops. If cultivating, avoid overworking, which may damage soil structure and consequently reduce establishment, especially where soils are prone to crusting.

Safflower can also be grown on raised beds, which will improve drainage, thereby reducing the risk of waterlogging and root diseases. Ideally, the topsoil should be moist enough for seeds to germinate, and crop reliability is improved where the profile contains water to a depth of at least 1 m at sowing. This can be checked by taking cores, pushing a steel probe into the soil, using capacitance probes or utilising tools such as 'HowWet?' (a program that uses farm rainfall records to estimate plantavailable water and nitrate in the soil at planting and throughout the fallow season).

To prevent injury, ensure that plant-back periods for safflower are observed for herbicides used in the previous crop, summer or pre-sowing knockdown sprays (e.g. 7–21 days for some 2,4-D products, >9 months for some residual herbicides).



Weed control in winter crops 2016

<u>Australian Pesticides and Veterinary</u> <u>Medicines Authority</u>



Estimating plant available water capacity





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## **MORE INFORMATION**

SoilWaterApp — a new tool to measure and monitor soil water



## **MORE INFORMATION**

Comparative growth, yield and water use of safflower, Linola™, mustard, canola and wheat in southern

Australia

Comparative growth, water use and yield of chickpea, safflower and wheat in south-eastern Queensland

Estimating plant available water capacity

<u>A 'how to' for getting soil water from</u> your EM38 field measurements

Broadacre field crops. Managing water resources

Several pre-emergent herbicides containing trifluralin, pendimethalin, triallate and EPTC are registered to control a range of grass and broadleaf weeds in safflower. At present, no seed-applied fungicides are registered for use in safflower in Australia.

## 1.7 Soil moisture

Although safflower can be grown on a range of soil types, it prefers deep neutral to alkaline soils that are well drained, but still have a high water-holding capacity (e.g. deep clay loams).

Fertile, deep black or grey, self-mulching or cracking clays that allow full development of the root system are ideal. Loams and alluvial soils are also satisfactory but should be deep and free from hardpans, compacted layers, and hostile chemicals or elements so that the root system can reach as deep into the profile as possible to extract water.

No-till farming systems with full stubble retention can increase the amount of water stored in soil profiles and therefore the reliability of safflower, provided weeds can be controlled.

Soils that are prone to extended periods of waterlogging are generally not suitable because they predispose crops to Phytophthora root rot, which is often fatal in safflower. Soils that are prone to crusting will reduce plant establishment, and unless in high-rainfall areas, sandy soils may limit safflower production by having waterholding capacity that is too low.

Paddocks with subsoil constraints such as boron that will impair root development should be avoided.

The salinity tolerance of safflower is moderate to high, similar to barley or cotton. It is more tolerant of sodium than calcium or magnesium salts and less tolerant as a seedling than at later growth stages, where yield is affected by salinity levels >14 dS/m. Tolerance to salinity does differ between varieties, but little information is available on the cultivars grown in Australia.

With its deep taproot, safflower is often used in a tactical role on problem soils to break up hardpans and to improve water and air infiltration into the subsoil through the creation of pores. 8

Safflower is usually sown in late winter or spring in southern Australia. Because of its deep taproot and extended growing season, enabling it to use water longer into the season compared with other winter crops, safflower has been proposed as a crop that can be used to 'dewater' wet soils and utilise subsoil moisture that may be beyond the reach of other winter crops. This may have positive implications for the whole farming system where waterlogging or rising saline water tables threaten production. However, the same features can lead to poor or variable yields in dry environments.

#### 1.7.1 Soil moisture use

Safflower uses more water than other winter crops, attributed to its deeper rooting depth and longer growing season. The deep rooting habit dries the soil profile. This has implications for subsequent crops, limiting crop potential where soil water reserves are not replenished by sufficient rainfall in dryland situations. When conditions remain dry, planned crop sequences may be disrupted.

Adequate stored soil moisture at sowing is crucial. Safflower production is a greater risk crop in low rainfall areas when there is low stored soil water at sowing. Limited starting soil moisture and lack of timely in-crop rainfall will produce poor or variable safflower yields.



<sup>8</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>



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More recently, GRDC funded research conducted in western Victoria in 2000 and 2001 (Waschmann et al 2003) reported safflower used 100 mm of additional water compared to wheat in wetter seasons. Whilst all crop species measured similar daily water use, safflower's longer growing season (34–40 days more than wheat) meant it used additional soil water. To achieve similar yields to canola, safflower used an additional 120 mm. Safflower yielded 3.71 t/ha and canola 3.44 t/ha. <sup>9</sup>

## 1.7.2 Dryland

Safflower is a very adaptable crop that can be winter- or spring-sown in dryland conditions. It has good drought and heat tolerance and its deep taproot enables it to use nutrients below the root-zone of cereal crops. Given safflower's high water use, it is important to ensure sufficient water in the profile to achieve an economic yield. Safflower has a role as a niche crop on drying flood plains and lakebeds, particularly around far-western NSW.

Safflower is suitable for dryland production in deep soils with high water-holding capacity, where a good soil moisture status below 1 m depth is recorded. Climatic forecasts should be used to ascertain spring conditions and the likelihood of rainfall when estimating yield.

## 1.7.3 Irrigation

Safflower can be grown successfully on well-drained soils under irrigation, with yields >4 t/ha possible. Both overhead and flood irrigation can be used, but care is needed to prevent extended periods of waterlogging. The submersion of roots in water for >48 hours may kill crops by starving roots of oxygen and creating conditions suitable for root diseases like Phytophthora root rot.

The effect of waterlogging on safflower crops appears to be worse during warming temperatures later in the season. Experience suggests that irrigation should stop after flowering to allow water demands during seedfill to be met from soil reserves. Care is also needed with overhead irrigation to minimise the duration of humid conditions in the canopy, which favour the development of leaf and head diseases. Irrigated safflower does best on raised beds with good drainage.

For best results, the soil profile should be filled to at least 1.5 m depth prior to sowing, with small subsequent irrigations between stem elongation and flowering. Fully irrigated crops require  $^{\prime\prime}500-750$  mm of water, and Californian experience suggests that it is best to apply at least 60% of this prior to sowing. Sowing dry and watering up is not generally recommended because rain after irrigation on cold soils may reduce crop establishment.  $^{10}$ 

The economics of irrigating safflower should be compared with other crop choices in the rotations.

## 1.8 Yield and targets

The yield of oilseeds is generally lower than of cereals owing to the higher energy content of the seed. When sown as a winter crop, safflower can produce similar yields to canola but it requires additional water.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>



Safflower potential in southern Australia





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For example, in an experiment in the Victorian Wimmera, canola used 387 mm of water to produce a yield of 3.4 t/ha, whereas safflower used 507 mm of water to produce 3.7 t/ha of seed. In other words, the Water Use Efficiency of safflower is often less than that of canola.

Where stored soil water and rainfall limit crop water use to <300 mm, canola, mustard or linseed are likely to be higher yielding winter oilseed options. However, in wetter situations, safflower can be competitive with these crops. Safflower generally requires fewer inputs and does not need to be windrowed. <sup>11</sup>

Safflower generally has lower input costs in terms of insecticide and fungicide treatments, although the fertiliser requirement is generally the same as comparable oilseeds. Harvest costs for safflower can be generally lower than for canola (when comparing with windrowing); however, they are generally higher than a standard cereal crop.

#### 1.8.1 Seasonal outlook

Safflower provides flexibility for growers to adapt to seasonal conditions because it has a wide sowing window that can adapt to the availability of rainfall during the season. Growers need to consider the markets within each season; they can be quite volatile. Growers should secure contracts before sowing.

#### 1.8.2 Fallow moisture

Soil moisture is one of the integral requirements for viable safflower production, and as such, water conservation prior to sowing is crucial. Stubble retention may improve water conservation, together with good control of fallow weeds.

## 1.8.3 Water Use Efficiency

Although safflower is often regarded as drought-tolerant, it does have a high water requirement. It survives dry conditions by developing an extensive taproot and scavenging for deep soil water rather than relying on growing season rainfall. This assumes that deep soil water is present and that adverse soil conditions do not restrict root growth. Safflower's high water requirement is often ascribed to its relatively long growing season, and some water must be available to crops during flowering and seedfill. Safflower performs best in regions that receive >450 mm of rainfall annually, but yields exceeding 1 t/ha can be expected on clay soils that are wet to 1 m depth at sowing, provided at least 50 mm of post-sowing rainfall is received.

The higher water use of safflower was demonstrated in trials mentioned above in the Victorian Wimmera and near the South Australian border when it was compared with wheat, canola, mustard and linseed. Safflower produced similar yields to canola in two wetter site-years, but used an additional ~120 mm.

Over the four site-years in which these trials were conducted, safflower yields varied 9-fold (0.4–3.7 t/ha), whereas the yields of canola (1.2–3.4 t/ha) and wheat (2.1–6.0 t/ha) varied only 3-fold. Where conditions limited the water use of safflower to <290 mm, canola, mustard and linseed were more productive winter oilseed options.

Water use data from these and other experiments over a range of sowing times indicate that safflower can produce yields of  $^{\sim}1$  t/ha where conditions (stored soil water + rainfall) allow total water use to be 275 mm, but yield reliability increases where more water is available (Figure 3). Situations allowing safflower to use 500 mm of water have resulted in yields approaching 4 t/ha in trials, provided waterlogging is avoided  $^{12}$ 



<sup>11</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy

<sup>12</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy









## **MORE INFORMATION**

Growing safflower in Australia:
agronomic research and suggestions
to increase yields and production

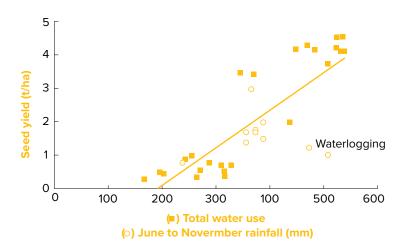
The search for alternative safflower cultivars adapted to southeastern
Australia with improved marketability

<u>The performance of imported</u> <u>sunflower hybrids in south-eastern</u> Australia



## **MORE INFORMATION**

Nitrogen use efficiency of safflower as compared to sunflower



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Figure 3: Relationship between safflower yield and total water use (a) for June–November rainfall.

(c) across a range of experiments in the Victorian Wimmera and the south east of South Australia.

In summary, winter-sown safflower has a higher water requirement than other crops grown in the cereal-growing regions of southern Australia. Nevertheless, yields in excess of 4 t/ha when sown in winter and 3 t/ha when sown in spring are possible with high soil-water availability.

For safflower to compete with canola as a cash crop in the 350-550 mm annual average rainfall, broadacre cropping zones, it will need to return a profitability similar to canola.  $^{13}$ 

## 1.8.4 Nitrogen-use efficiency

Safflower has nitrogen requirements similar to cereals. International research has found that, in terms of nitrogen utilisation, safflower is a low-input crop and outperforms sunflower with respect to seed yield on soils low in available nitrogen.

## 1.8.5 Double-crop options

Double-crop options may be limited when growing safflower, owing to its high water demand.

Safflower is often considered an opportunity crop. Because it requires a relatively full profile for planting, it may be suitable for double cropping out of a summer crop when autumn rainfall is particularly favourable. The comparatively late sowing window allows more time for moisture recharge then early-plant cereals, pulses and canola. In terms of double cropping following safflower, the late harvest period compared with cereals makes it unlikely that the summer planting window would still be open, and instead, fallowing to a winter cereal is more appropriate.

## 1.9 Disease status of paddock

Seasonal conditions largely determine the incidence and severity of disease in safflower. Management includes preventative strategies and variety resistance. The main issues of concern in the Northern region are Alternaria and Phytophthora.



<sup>13</sup> N Wachsmann, D Jochinke, T Potter, R Norton (2008) Growing safflower in Australia: Part 2—Agronomic research and suggestions to increase yields and production. Australian Oilseeds Federation, <a href="http://www.australianoilseeds.com/">http://www.australianoilseeds.com/</a> data/assets/pdf\_file/0003/6744; Final\_Wachsmann\_paper.pdf



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Alternaria leaf spot (*Alternaria carthami*) when present at high infection levels can result in significant yield loss of up to 50%. Oil (and protein) content can be reduced. Sironaria is resistant.  $^{14}$ 

Phytophthora root rot (*P. cryptogea*) (and Pythium root rot) is the most significant soilborne disease of safflower. This is often an unpredictable fungal disease and usually occurs in wet soils, especially when temperatures are high. it is present in all growing areas but is most prevalent in irrigated crops where yield can be significantly reduced depending on the timing and extent of the infection. Growers are recommended to avoid producing safflower in soils suspected of having Phytophthora infection, avoid poorly drained soils, and use sound irrigation practices to minimise the incidence of waterlogging. <sup>15</sup> Sironaria is resistant to phytophthora. <sup>16</sup>

Rust ( $Puccinia\ carthami$ ) may cause significant yield loss where infection occurs early in the season. Inoculum survives in crop residues and alternative host Carthamus species like safflower. <sup>17</sup>

## 1.9.1 Cropping history effects

*Phytophthora cryptogea* is hosted on a wide range of crops and harboured in the soil and has the ability to survive for long periods in the absence of preferred hosts. It can infect the fine roots of many weeds without causing obvious symptoms. <sup>18</sup>

Safflower is a potential host to sclerotinia (*Sclerotinia sclerotiorum*). Other alternate host crops include sunflower, mustard, canola and chickpea. <sup>19</sup>



<sup>14</sup> K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>

<sup>15</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>16</sup> K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/ Tactical-agronomy-of-safflower-and-linseed

<sup>17</sup> K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/</a>. Tactical agreenomy of safflower and linseed:

<sup>18</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy

<sup>9</sup> K Hertel (2016) Tactical agronomy of safflower and linseed: place in the rotation, yield potential, time of sowing, plant growth and marketing. GRDC Update Papers 1 March 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/03/Tactical-agronomy-of-safflower-and-linseed</a>



# **Pre-planting**

## 2.1 Safflower varieties

The first commercial oilseed safflower variety in Australia was Gila, introduced from Arizona in the 1950s. In the 1970s and 1980s, Gila suffered severe losses from Alternaria disease (caused by *Alternaria carthami*), leading the CSIRO to develop and release the varieties Sironaria and Sirothora in 1987. Sironaria is resistant to *A. carthami* and moderately resistant to *Phytophthora* spp., whereas Sirothora is susceptible to *A. carthami* but resistant to *Phytophthora* spp. and recommended for irrigation. A few other varieties were introduced from the United States, including the oleic oil variety Saffola 517 and the linoleic oil variety Saffola 555. Sironaria is still widely grown, but as a dual-purpose birdseed and linoleic oil type; its oil content is lower than newer safflower varieties from other parts of the world. Australia's safflower-breeding program ceased in 1987 and, with the exception of recent introductions by private companies, little work on variety development has since been conducted in Australia.

Varietal selection of safflower should be based on growing location, disease resistance, maturity, yield potential (both seed and oil content), and suitability for the target market. Growers should be aware of the risk of cross-pollination between varieties. Oleic and linoleic varieties should not be grown in close proximity because of the potential for cross-pollination, which can alter fatty acid composition, decrease oil purity and reduce the value of seed. They should be separated by at least 400 m. <sup>1</sup>

Some newer introductions are becoming available to growers, but many are only obtainable on a closed-loop selling arrangement. This means that seed is provided by a company and the grower agrees to grow the crop and sell it back to the same company or its agent. Other new varieties have been going through testing and seed multiplication. The characteristics of safflower varieties currently commercially available in Australia are provided in Table 1.

Safflower hybrids have been developed overseas, but none are commercially available in Australia. Growers should check with local agronomists and seed companies to determine the most appropriate variety for their situation. Markets should also be considered, because different varieties are better suited to different markets. <sup>2</sup>



<sup>1</sup> R Byrne (2009) Safflower. In Summer crop production guide 2009. (Eds L Serafin, L Jenkins, R Byrne) NSW Department of Primary Industries.

<sup>2</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>









**Table 1:** Summary of safflower varieties in Australia.

Variety	Maturity	Morphology	Oil content	Alternaria resistance	Phytophthora root rot resistance	
Oleic oil ty	pes					
CW88- OL	_	Tall, yellow– orange	_	-	-	
CW99- OL	-	Medium, yellow- yellow	-	-	-	
S317	Late	Tall, yellow– orange	42%	MS	-	
S517	Medium	Medium, yellow– orange	42%	-	MS	
Linoleic a	Linoleic acid types					
CW1221	Medium	Medium, yellow- yellow				
CW2889	Very early	Short, yellow- yellow				
Gila	Early	Medium	35%	S	S	
Sironaria	Medium	Tall, yellow– orange	34%	MR	MS	
Sirothora	Early	Short,	33%	MS	MR	
S501	Early	Short, yellow– orange	42%	-	-	
S555	Medium	Medium, yellow- yellow	42%	-	-	

MS, Moderately susceptible; MR, moderately resistant; S, susceptible

## 2.1.1 High-oleic safflower

The development of unique safflower varieties with unprecedented levels of industrially useful oleic oil has the potential to usher in a new oilseeds industry. The safflower variety and its 'super-high oleic safflower oil' (dubbed SHOSO) is the culmination of 11 years of investment and research within the GRDC and CSIRO Crop Biofactories Initiative (CBI). The development is now taking the first steps towards commercialisation with the appointment of an industry partner, GO Resources. <sup>3</sup>

#### Key points

- Safflower engineered by CSIRO produces levels of oleic acid that can replace some petrochemicals in the manufacture of plastics, paints, resins and many other industrial oils.
- Commercialisation of the new safflower oil is underway by Australian company GO Resources, the licensee of the technology.
- Final testing of crop performance under field conditions and deregulation activities (associated with the Office of the Gene Technology Regulator) are in progress.
- The ability to use plants as 'biofactories' is a cornerstone of the bioeconomy, a 'green' production system essential to future environmental stability and economic growth. <sup>4</sup>



<sup>3</sup> G Braidotti (2015) Development may herald new oilseeds industry. Ground Cover Issue 119, Nov–Dec 2015, <a href="https://grdc.com.au/Media-centre/Ground-Cover/Ground-Cover-Issue-119-Nov-Dec-2015">https://grdc.com.au/Media-centre/Ground-Cover-Issue-119-Nov-Dec-2015</a>

<sup>4</sup> G Braidotti (2015) Grain could drive new Australian oil trade. Ground Cover Issue 119, Nov-Dec 2015, <a href="https://grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-119-Nov-Dec-2015/Grain-could-drive-new-Australian-oil-trade">https://grdc.com.au/Media-Centre/Ground-Cover-Issue-119-Nov-Dec-2015/Grain-could-drive-new-Australian-oil-trade</a>









## 2.2 Planting seed quality

Safflower seeds (Figure 1) are contained in a thick hull, which, in botanical terms, is actually a type of fruit known as an achene. However, as with sunflower, most people refer to the whole unit as a seed, and that convention will be used here. Depending on variety, hulls may be smooth or ridged, pure white or white with a grey or brown tinge, and/or may possess purple, grey or black stripes. Hulls generally lack a pappus, and where present, pappus hairs are usually short.

NORTHERN



Figure 1: Safflower seed.

Photo: Nick Wachsmann

As for all crops, planting seed should be genetically pure, free from seed-borne diseases, have a high germination percentage (>80%), and be free from weeds and other crop seeds. Many suppliers can provide a copy of the quality certificate on request; otherwise, samples can be sent to an accredited laboratory for testing.

The longevity of oilseeds under normal silo conditions is limited, so fresh seed should be used where possible. Planting seed from crops that have experienced an extended period of warm, wet weather prior to harvest should be avoided. These conditions favour the development of *Alternaria carthami*, which can infect seed and transmit Alternaria disease to the next crop, causing newly planted seed to rot in the soil, or the damping off of seedlings.

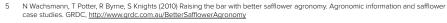
The germination percentage of seed can also be markedly reduced by rain on mature crops, which causes sprouting in the head.  $^{5}$ 

#### 2.2.1 Seed size

The size of safflower seeds varies between varieties and with growing conditions, but they are shaped like small sunflower seeds. Typically, seeds average 6–7 mm in length and weigh about 4 g/100 seeds, making 25,000 seeds/kg. The recognised test weight is  $52.5 \, \text{kg/hL}$ , which is similar to oats.  $^6$ 

## 2.2.2 Seed germination and vigour

A germination percentage of 80% is assumed for safflower, with a germination percentage as high as >90%; however, growers should always check the bag and conduct germination tests.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>



Breeding improvements in safflower (Carthamus tinctorius L.)











## 2.2.3 Seed storage

When storing safflower seed, grain moisture should be <8% to prevent mould production and deterioration due to heat.

## 2.2.4 Safe rates of fertiliser sown with the seed

Safflower has nutritional requirements similar to wheat with respect to nitrogen, phosphorus and sulfur. However, surface-applied fertilisers have variable response in safflower because the plants obtain moisture and nutrients down to 3 m in the soil profile, with their extensive taproot system. Hence, fertilisers should either be drilled in prior to sowing or topdressed before bud formation in damp soil conditions, to allow the nutrients to move down the soil profile.

In order to avoid toxicity, which will reduce crop establishment, no more than 20 kg/ ha of nitrogen should be drilled with seed.  $^{7}$ 

Fertiliser should preferentially be sown in a band 2.5 cm below and beside the seed, particularly when fertiliser rates of nitrogen are high. It is assumed that the relative seed size of safflower means that it should be treated as per sunflower, rather than canola, in terms of seed safe requirements. Consult your nutritional advisor or fertiliser supplier for more specific information.



<sup>7</sup> R Byrne (2009) Safflower. In Summer crop production guide 2009. (Eds L Serafin, L Jenkins, R Byrne) NSW Department of Primary Industries.



# **Planting**

## 3.1 Seed treatments

The fungicide thiram is commonly applied to safflower seed (Figure 1) to provide protection against seed-borne fungi that cause seed rot and seedling damping off. However, infections contained within the seed, such as *Alternaria carthami*, may still occur, even with a fungicidal dressing.



Figure 1: Safflower seed.

Photo: AM Photography

# 3.2 Time of sowing: yield losses due to delay, frost-risk timing

Safflower development is controlled by a combination of temperature and daylength. Large delays in the time of sowing therefore have a much smaller effect on the timing of flowering and provide for a flexible sowing window. This is because crops progress through the vegetative fill stages much more rapidly, with only a small effect on the period between flowering and maturity (Figure 2).





**FEEDBACK** 

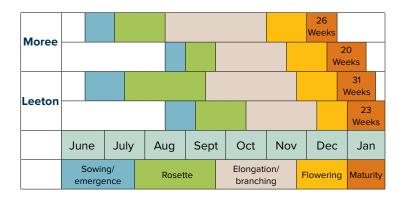
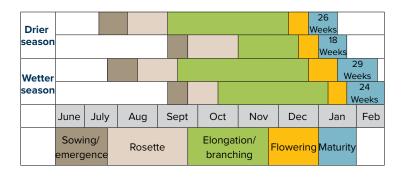


Figure 2: Effect of sowing in mid-June and mid-August on safflower development at Moree and Leeton in NSW.

Source: adapted from Colton 1988

The development of safflower is also hastened in seasons that are warm and dry; this is due to higher temperatures in the crop canopy (Figure 3).



**Figure 3:** Effect of sowing in mid-July and mid-September on safflower development in a wetter and drier season at the same location in the Victorian Wimmera.

Sowing too early can result in frost damage during stem elongation, branching and even budding. Risk is greatest in northern areas because the generally warmer climate causes plants to begin stem elongation in winter.

Very early sowing followed by good early-season growing conditions may cause excessive vegetative growth, increasing crop water use, which may restrict seedfill if soil-water reserves are depleted.

Sowing too late reduces yield potential by shortening the duration of vegetative fill and pushing flowering and seedfill into late spring and summer, which often coincides with higher temperatures and the decreasing chance of rainfall. Late-sown crops may also be at greater risk of seed staining and sprouting in regions prone to significant summer rainfall events.

Generally, safflower should be sown in June or early July in central and northern NSW and during July in the southern regions of NSW, Victoria and South Australia (Figure 4). In the southern regions, sowing can be extended to mid-August, but this should be considered only if earlier sowing is not possible or if there are other reasons for growing safflower, such as the pre-sowing control of problem winter weeds. Spring sowing is possible in parts of Victoria and South Australia where, in cooler conditions

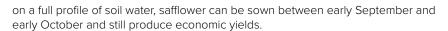




#### **SECTION 3 SAFFLOWERS**







The sowing time for safflower is quite flexible under favourable conditions in southern regions, or if it is included in cropping rotations as a strategic or opportunity crop. When safflower is grown as a cash crop, however, it should be sown at the optimum time to maximise yields, which is generally earlier in northern regions than southern regions (Figure 4).

Safflower yields are related to sowing time, and the yield of dryland and irrigated crops is most reliable when crops are sown in late June or early July. Each week of delayed sowing after mid-July usually results in a yield penalty of 5%, although under relatively cool growing conditions with adequate water supply, sowing can be delayed until mid-September without substantial yield reduction. <sup>1</sup>

	Ma	ıy			Jur	ne			Jul	y			Au	gust			Se	ptem	ber		Oc	tobe	r	
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Northern NSW			V	V	$\odot$	$\odot$	☺	$\odot$	☺	☺	$\odot$	W	W											
Central NSW					٧	V	☺	☺	☺	☺	☺	W	W											
Southern NSW								V	V	☺	☺	☺	☺	☺	W	W								
Victoria								٧	٧	☺	☺	☺	☺	☺	W	W	W	W	W	W				
South Australia								V	V	☺	©	©	©	©	W	W	W	W	W	W	W	W		

## (i) MORE INFORMATION

Optimum sowing time for rainfed safflower in southern Australia is affected by soil water availability

Effect of sowing time on the growth, yield and water use of safflower—some preliminary results

**Figure 4:** Recommended optimum (©) and extended sowing window (v or w) for safflower in different regions.

Two field experiments were undertaken in the Victorian Wimmera to assess the effect of sowing time on the development, growth and yield of safflower. Delayed sowing of safflower resulted in yield penalties similar to those of other winter crops (~5% per week), but the rate of decline is less where more soil water is available at sowing.

For low-rainfall areas, early sowing appears important to achieve good safflower yields, but where the soil profile is reasonably wet at sowing and/or where follow-up rains are likely, safflower can produce economic yields (>1 t/ha) when sown as late as mid-October in southern Australia. The common practice of sowing safflower in spring can lead to yield loss and growers should consider earlier sowing to achieve yields that are more reliable in drier environments. <sup>2</sup>

#### 3.3 Targeted plant population

It is important to establish a consistent stand of safflower at a plant population suited to the expected growing conditions, as it is for all crops. Safflower compensates for low plant densities by producing additional branches, so the yield of early-sown crops in good growing conditions does not vary greatly over a wide range of sowing rates. However, very low sowing rates offer little competition to weeds and can produce very large individual plants with thick, woody stems. These plants are difficult to harvest and the volume of material passing through machinery may make it hard to obtain a clean sample.

Under drier conditions, sowing at too high a rate will create a dense crop canopy early in the season, increasing water use. If water in the soil profile is depleted too early in the season, there may be insufficient reserves for flowering and seedfill, resulting in reduced yield and quality.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

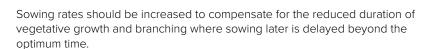
<sup>2</sup> N Wachsmann, R Norton, D Jochinke, S Knights (2004) Optimum sowing time for rainfed safflower in southern Australia is affected by soil water availability. The Regional Institute, <a href="http://www.regional.org.au/au/asa/2004/poster/1/4/1196\_wachsmannn.htm">http://www.regional.org.au/au/asa/2004/poster/1/4/1196\_wachsmannn.htm</a>



#### **SECTION 3 SAFFLOWERS**







Target plant populations for safflower over a range of environments are provided in Table 1. Sowing is recommended at the lower end of the range provided when sowing early in June or July or where stored soil water or expected rainfall is less than ideal. Sowing rates should be increased for late sowing, after mid-July, or if subsoil moisture or seasonal rainfall is more assured.

Higher rates should also be used for irrigated crops, or where poor emergence is expected because of issues such as seed quality, cold temperatures, depth of sowing to reach moisture, or soil-surface crusting. In drier environments, such as lakebeds in the far west, lower seeding rates than normal may be justified. Consider 6–8 kg/ha in the northern regions and 10–12 kg/ha in the southern regions.



**Table 1:** Target plant populations (no. of plants/m²) and sowing rates (kg/ha) assuming 90% germination and 25% establishment losses.

Nutrient	Favourable conditions	Drier conditions	Irrigated crops
Northern and central NSW	20–25 plants/m²	15 plants/m²	40–50 plants/ m²
	(12–15 kg/ha)	(9 kg/ha)	(25–31 kg/ha)
Southern NSW	30–35 plants/m² (18–22 kg/ha)	25 plants/m² (15 kg/ha)	
Victoria and South	30–40 plants/m²	20–30 plants/m²	
Australia	(18–24 kg/ha)	(12–18 kg/ha)	

#### 3.4 Calculating seed requirements

Sowing rates can be calculated by using the following formula and assuming  $^{\sim}25,000$  safflower seeds per kg:

Sowing rate (kg/ha) =  $\frac{\text{(Target plant population/m}^2) \times 10,000 \times 10,000}{\text{(seeds/kg)} \times \text{germination}\% \times (100\text{-establishment loss)}}$ 

For example, sowing rate (kg/ha) =  $\frac{(20/\text{m}^2) \times 10,000 \times 10,000}{25,000 \times 90 \times (100-25)}$ 

#### 3.5 Sowing depth

Depth of sowing will vary according to soil characteristics, planting machinery and moisture levels. Unlike wheat, safflower has a hull and needs to be placed into good moisture to assist the seed in imbibing sufficient moisture to enable germination. For this reason, safflower is ideally sown into moist soil with equipment such as presswheels to provide good seed—soil contact.

Sowing depth will vary with soil type and conditions but is normally between 2 and 5 cm. Sowing deeper can delay emergence and reduce early vigour (Figure 5), leaving crops more susceptible to pests, diseases and competition from weeds. Some growers extend sowing depth to 7 cm to place seed into moisture; however, this should be avoided if possible, especially where soils are prone to crusting.



FEEDBACK



**Figure 5:** Seven-week-old safflower plants sown at depths of 1, 5 and 10 cm in clay soil.

Photo: Nick Wachsmann

#### 3.5.1 Row spacing

Safflower is normally planted with standard cereal-sowing equipment in rows 18–36 cm apart. Narrower rows allow greater suppression of weeds, whereas wider rows may facilitate better airflow for disease control.

Wider rows are also more suited to inter-row sowing, cultivation for weed control or band spraying. Low sowing rates and very wide rows to 50 cm may be preferable in very dry situations, but row spacings >36 cm have resulted in lower yields in more favourable growing conditions. Wider rows can also be used with row-crop equipment for planting irrigated safflower crops. Californian experience indicates that planting single rows on hills 75 cm apart, twin rows on 1 m raised beds, or several rows on raised beds 1.5–2 m can all be satisfactory.  $^3$ 

#### 3.6 Sowing equipment

Generally, safflower is sown with standard wheat equipment. Press-wheels should be used to ensure good seed—soil contact, and the wheel width and pressure adjusted to sowing conditions. In dry soils or if soil-dwelling pests may be present, heavier pressure is usually required to achieve reasonable establishment. <sup>4</sup>



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>4</sup> R Byrne (2009) Safflower. In Summer crop production guide 2009. (Eds L Serafin, L Jenkins, R Byrne) NSW Department of Primary Industries.



# Plant growth and physiology

Safflower is an erect, winter/spring-growing annual herb that resembles a thistle. Along with sunflower, it belongs to the daisy plant family (Asteraceae). Despite being related to saffron thistle, safflower will not become a weed because the seeds have no dormancy and plants are easily controlled by cultivation and hormone herbicides. Cross-pollination between safflower and saffron thistle produces only sterile seed. After emergence, safflower plants slowly develop a rosette of basal leaves (Figure 1).

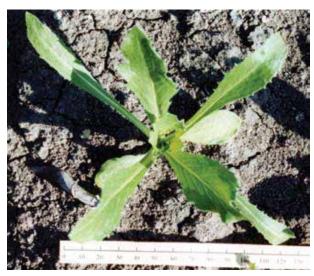


Figure 1: Rosette stage of safflower.

Photo: Nick Wachsmann

As day length and temperature increase, a fast-growing, central woody stem develops (Figure 2), reaching maximum height around the time of flowering. Depending on variety, management and growing conditions, the maximum height is reached at the start of flowering and may be 30–150 cm. A strong taproot begins to develop during the rosette stage and can penetrate deeper into the subsoil than roots of many other crops. In one comparison, safflower roots were found to a depth of 2.1 m, whereas nearby wheat roots extended to only 1.4 m.





#### **SECTION 4 SAFFLOWERS**

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Figure 2: Stem elongation stage of safflower.

Photo: Nick Wachsmann

Lateral branches develop once stems are  $^{\sim}20-40$  cm high, and these lateral branches may in turn branch to produce secondary and tertiary branches. The central main stem is often referred to as the terminal stem, with the first level of branching known as primary branches. The extent of branching is dependent on variety, sowing rate and growing conditions. Leaves are arranged on both sides of the stem, often at uneven intervals. Leaf dimensions vary greatly between varieties and with distribution on individual plants.

Typically, leaves are 2.5–5 cm wide and 10–15 cm long. The margins of lower leaves range from being almost entire to deeply serrated, and leaves terminate with acuminate tips. Upper leaves forming the bracts that surround the flowers are usually short, stiff and ovate to obovate, and they terminate in a spine. Upper leaves frequently also possess spines on the margins, and although spineless varieties do exist, they are not widely grown commercially. The spines make the crop difficult to walkthrough; however, they also act as a deterrent to animals such as pigs and kangaroos.

Buds are borne on the ends of branches (Figure 3), and each composite flower head (capitulum) contains 20–180 individual florets. Depending on variety, crop management and growing conditions, each plant can develop 3–50 or more flower heads of 1.25–4.0 cm diameter. Flowering commences with terminal flower heads (central stem), followed sequentially by primary, secondary and sometimes tertiary branch flower heads. Individual florets usually flower for 3–4 days, and the whole flowering period can range from <10 days to >4 weeks. Commercial varieties are largely self-pollinated, with <10% outcrossing.



**NORTHERN** 

**MARCH 2017** 





Figure 3: Early flowering stage of safflower.

Photo: Nick Wachsmann

The amount of outcrossing is increased by the presence of insect pollinators, but the presence of bees is unlikely to increase yield by >5%. Flowers are commonly yellow, orange or red, but white and cream forms also exist. Each flower head commonly contains 15–50 seeds; however, the number can exceed 100. <sup>1</sup>

# 4.1 Effect of temperature, photoperiod and climate effects on plant growth and physiology

Despite a relatively high water requirement, safflower is not tolerant of waterlogging, especially when air temperatures are >20°C. Older crops are more susceptible than younger crops. Waterlogging for >48 hours can starve roots of oxygen and kill crops, in addition to favouring the development of root diseases such as Phytophthora root rot. Heavy rain and high humidity during the reproductive phase can inhibit pollination, encourage diseases, discolour seed and cause seeds to sprout in the capitula. Overall, safflower is best adapted to higher rainfall, cereal-growing regions with a dry climate during late spring and early summer, where water demands can be supplied from stored subsoil reserves. Care should be taken when irrigating crops, especially after flowering, to avoid waterlogging.

#### 4.1.1 Temperature

Safflower will emerge at soil temperatures >4°C, but 15°C is considered optimal. It tolerates frosts to -7°C during the rosette stage, but frosts <-4°C can damage the growing point and can split stems during stem elongation and branching. Provided damage is not extensive, the plant can partially compensate by producing new shoots from below the damaged area. Crops sown very early are most susceptible, especially where frosts in late winter follow a period of mild weather favouring the early initiation of stem elongation. Risk can be minimised by sowing later, but many growers tend to overreact and plant far too late, which results in yield losses much greater than would likely be caused by frost. Safflower matures during December and January, when temperatures are often high in traditional cereal-growing regions. It can tolerate these temperatures if sufficient moisture is available. Experiments on irrigated crops in the Ord River region of Western Australia have demonstrated that



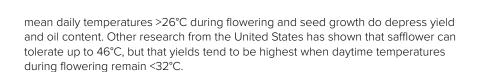
<sup>1</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>



#### **SECTION 4 SAFFLOWERS**







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#### 4.1.2 Wind and hail

Safflower has better tolerance of wind and hail than cereals. Hail can severely damage young and succulent plants, but as they become stiff and woody towards flowering, they develop more resistance. Safflower resists lodging. Although ripe plants do not shatter, they are prone to feeding damage from birds. <sup>2</sup>

#### 4.2 Plant growth stages

#### 4.2.1 Emergence and early growth

Safflower normally emerges 1–3 weeks after sowing. Emergence is slower under low temperatures, increasing the risk of insect damage and disease. Germination is epigeal, which means that, as for canola or lupins, the shoot carrying the seed emerges above the soil, where the cotyledons expand and act as the first leaves. The first true leaves then emerge, forming a rosette. During the rosette stage, safflower can tolerate frosts to  $-7^{\circ}$ C. Crops should be monitored for establishment pests such as redlegged earth mite during this period. Growth during the rosette stage is initially slow; it occurs in winter with short daylengths and cold temperatures. This stage can last for several weeks and varies with location and sowing date. For the same sowing date, the rosette stage is normally longer in southern than northern Australia.

#### 4.2.2 Stem elongation and branching

With increasing temperature and daylength towards the end of winter and spring, plants grow more rapidly and the central stem begins to elongate and branch. Frosts below –4°C at this growth stage can cause stem splitting and death of the growing point, and although plants often recover to some extent by producing new shoots from below the damaged areas, yield is likely to be penalised. The number of branches produced is an important determinant of yield, because each branch eventually terminates in a flower head. Early sowing allows more time for a large rosette and an extensive branch structure to develop, creating high yield potential. However, excessive vegetative growth increases crop water use early in the season and can lead to the depletion of soil moisture before maturity, decreasing yield. Delayed sowing (e.g. August) reduces the period of the rosette and branching growth stages. This results in fewer flower heads per plant, which lowers yield potential, but can be partially overcome by increasing sowing rates. A development scale for safflower is shown in Figure 4.



<sup>2</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>



#### **SECTION 4 SAFFLOWERS**







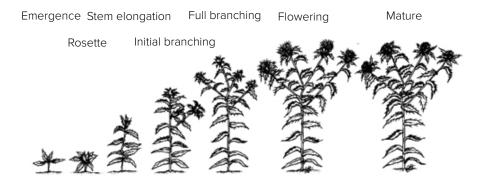


Figure 4: The development of a safflower plant.

Source: Kaffka and Kearney 1998

#### 4.2.3 Flowering to maturity

Flowering generally coincides with wheat harvest in most cereal-growing areas. It is more influenced by daylength than by time of sowing. The period from the end of flowering to maturity is usually 4 weeks, so safflower is normally ready to harvest 4–6 weeks after wheat. The need for long days before the crop will flower forces flowering and seed growth into a period of high temperatures and, often, dry conditions in late spring or early summer. Safflower can tolerate these conditions if demand for water can be supplied from soil reserves, but where these reserves are depleted, low yields can be expected. As plants mature, they become stiff and woody and therefore are reasonably tolerant of wind and hail. However, excess rain may reduce yield and oil quality by inhibiting pollination, discolouring seed, promoting disease and/or causing ripe seeds to sprout in the heads. The total period from sowing to harvest maturity varies with variety, location, sowing time and growing conditions; for June or July sowings, it may be  $^{\sim}26-31$  weeks.  $^{3}$ 



<sup>3</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>



## **Nutrition and fertiliser**

#### 5.1 Declining soil fertility

The natural fertility of cropped agricultural soils is declining over time, and so growers must continually review their management programs to ensure the long-term sustainability of high quality grain production. Paddock records, including yield and protein levels, fertiliser test strips, crop monitoring, and soil and plant tissue tests all assist in the formulation of an efficient nutrition program.

Pasture leys, legume rotations and fertilisers all play an important role in maintaining and improving the chemical, biological and physical fertility of soils, fertilisers remain the major source of nutrients to replace those removed by grain production. Fertiliser programs must supply a balance of the required nutrients in amounts needed to achieve a crop's yield potential. The higher yielding the crop, the greater the amount of nutrient removed. Increasing fertiliser costs means growers are increasing pulses within their crop rotation and even the use of ley pastures to complement their fertiliser programs and possibly boost soil organic matter. <sup>1</sup>

#### **5.1.1** Soil organic matter

Soil organic matter (SOM) is a critical component of healthy soils and sustainable agricultural production. Growers understand that crops grown in healthy soils perform better and are easier to manage. Soil organic matter is 'all of the organic materials found in soils irrespective of its origin or state of decomposition' that is anything in or on the soil of biological origin, alive or dead. It is composed mainly of carbon (approximately 60%) as well as a variety of nutrients (including nitrogen, phosphorus and sulfur). It is difficult to actually measure the SOM content of soil directly so we measure the soil organic carbon (SOC) content and estimate SOM through a conversion factor:

Soil organic matter (%) = organic carbon (%)  $\times$  1.72

It is important to understand the role of plants in the SOM cycle. Photosynthesis is the process by which plants take in carbon dioxide ( ${\rm CO_2}$ ) from the atmosphere, combine with water taken up from the soil, and utilising the energy from the sun, form carbohydrate (organic matter) and release oxygen (O2). This is the start of the SOM cycle. When the leaves and roots (carbohydrate) die they enter the soil and become SOM. These residues are decomposed by soil organisms which provides them with the energy to grow and reproduce. The SOM cycle is a continuum of different forms (or fractions) with different time frames under which decomposition takes place. Over time SOM moves through these fractions; particulate, humic and resistant fractions. As SOM decomposes carbon is released from the system along with any nutrients that are not utilised by the microorganisms. These nutrients are then available for plants to utilise. Eventually a component of these residues will become resistant to further decomposition (resistant fraction Figure 1).



QDAF (2010) Nutrition management. Overview. Department of Agriculture, Fisheries and Forestry Queensland, <a href="https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/nutrition-management/overview">https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/nutrition-management/overview</a>

<sup>2</sup> JA Baldock, JO Skjemstad (1999) Soil organic carbon/Soil organic matter. In KI Peverill, LA Sparrow, DJ Reuter (eds). Soil analysis: An interpretation manual. CSIRO Publishing, Collingwood Australia.









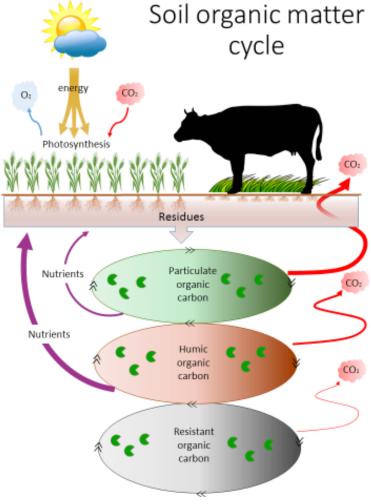


Figure 1: Organic matter cycle.

Source: J Gentry, QDAF

Organic matter is fundamental to several of the physical, chemical and biological functions of the soil. It helps to ameliorate or buffer the harmful effects of plant pathogens and chemical toxicities. It enhances surface and deeper soil structure, with positive effects on infiltration and exchange of water and gases, and for keeping the soil in place. It improves soil water-holding capacity and, through its high cation-exchange capacity, prevents the leaching of essential cations such as calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na). Most importantly, it is a major repository for the cycling of nitrogen and other nutrients and their delivery to crops and pastures.

Australian soils are generally low in SOM. Initial SOM levels are limited by dry matter production (and so climate) for each land type/location. SOM levels have declined under traditional cropping practices. On-farm measures (sampled 2012–15) from over 500 sites in Queensland and northern NSW confirm that soil organic matter, measured as soil organic carbon, declines dramatically when land is cleared and continuously cropped. This decline affects all soils and land types but is most dramatic for the brigalow–belah soils because their starting organic carbon levels are so high (Figure 2). <sup>3</sup>



<sup>3</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, <a href="http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANSTrials2015-screen.pdf">http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANSTrials2015-screen.pdf</a>

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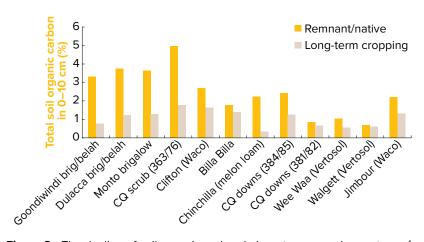
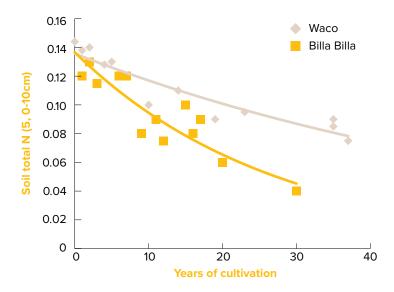


Figure 2: The decline of soil organic carbon in long-term cropping systems. <sup>4</sup>

Declining levels of SOM have implications for soil structure, soil moisture retention, nutrient delivery and microbial activity. However, probably the single most important effect is the decline in the soil's capacity to mineralise organic nitrogen (N) to plant-available N. Past research (1983) has shown that N mineralisation capacity was reduced by 39–57%, with an overall average decline of 52% (Figure 3).  $^5$  This translated into reduced wheat yields when crops were grown without fertiliser N.



**Figure 3:** Graph of decline in soil total N with years of cropping. The decline was greater for the Billa Billa soil (clay content 34%) than the Waco soil (clay content 74%). <sup>6</sup>

Source: based on Dalal & Mayer (1986a,b)



<sup>4</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland. pp. 112–117. http://www.moreprofitoerdrop.com.au/wp-content/uploads/2016/08/RANSTrials2015-screen.pdf

<sup>5</sup> RC Dalal, RJ Mayer (1986) Long term trends in fertility of soils under continuous cultivation and cereal cropping in southern Queensland. II. Total organic carbon and its rate of loss from the soil profile. Australian Journal of Soil Research 24, 281–292.

<sup>6</sup> RC Dalal, RJ Mayer (1986) Long term trends in fertility of soils under continuous cultivation and cereal cropping in southern Queensland. II. Total organic carbon and its rate of loss from the soil profile. Australian Journal of Soil Research 24, 281–292.

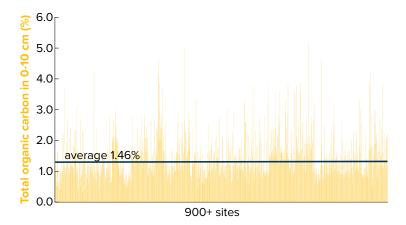


#### 5.1.2 Current situation

Soil organic carbon levels are simply a snapshot of the current balance between inputs (e.g. plant residues and other organic inputs) and losses (e.g. erosion, decomposition) constantly happening in each soil and farming system. The decline over time is overwhelmingly driven by the extent of fallowing in our farming systems. Most fallow rain in the northern region (as much as 75–80% in a summer fallow) is lost as runoff or evaporation. This wasted rain does not grow dry matter to replenish the organic matter reserves in the soil. However, increasing moisture in the fallowed soil continues to support microbial decomposition. This helps accumulate available nitrogen for the next crop, but reduces soil organic carbon. The soil organic matter and carbon levels will continue to decline until they reach a new lower level that the dry matter produced by the new farming system can sustain. Put simply,

'Crops may make more money than trees and pastures, but do not return as much dry matter to the soil.'

Total soil organic carbon levels vary within a paddock, from paddock to paddock and from region to region. Comprehensive sampling was under taken throughout the northern region, with over 900 sites sampled and analysed for total organic carbon at 0–10 cm depth. These results varied enormously across sites. The average was 1.46% however it varied from under 0.5% to over 5% (Figure 4).  $^7$  A selection of these data from representative soil types throughout the northern grains region clearly indicates how soil carbon levels can be significantly different due to soil type (Figure 5).  $^8$ 



**Figure 4:** Soil organic carbon levels on mixed farms within the GRDC Northern Region. <sup>9</sup>

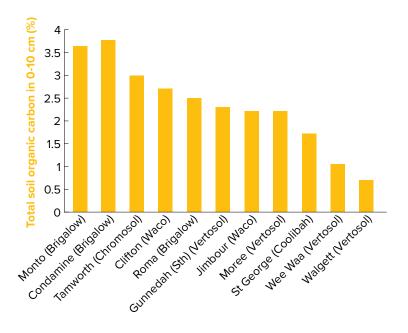


<sup>7</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112 – 117. http://www.moreprofitoerdrop.com/au/wp-content/uploads/2016/08/RANSTrials/2015-screen.pdf

<sup>8</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, <a href="http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf">http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf</a>

<sup>9</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, <a href="http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf">http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf</a>

FEEDBACK



**Figure 5:** Impact of land-type on total soil carbon levels (0-10 cm) across the northern region. <sup>10</sup>

## **5.1.3** Options for reversing the decline in soil organic matter

Soil organic matter is an under-valued capital resource that needs informed management. Levels of SOC are the result of the balance between inputs (e.g. plant residues and other organic inputs) and losses (e.g. erosion, decomposition, harvested material) in each soil and farming. <sup>11</sup> So maximising total dry matter production will encourage higher SOC levels, and clearing native vegetation for grain cropping will typically reduce SOC and SOM levels. <sup>12</sup>

Modern farming practices that maximise Water Use Efficiency for extra dry matter production are integral in protecting SOM. Greater cropping frequency, crops with higher yields and associated higher stubble loads, pasture rotations and avoiding burning or baling will all help growers in the northern region to maintain SOM.

Research in the past has shown the most direct, effective means of increasing SOM levels is through the use of pastures, however these pasture have to be productive. A grass only pasture will run out of N especially in older paddocks, which is normally the reason why these paddocks are retired from cropping. As a result, a source of nitrogen is required to maximise dry matter production, this can be supplied via a legume or N fertiliser. The rotation experiments of I. Holford and colleagues at Tamworth, NSW and R. Dalal and colleagues in southeast Queensland provide good evidence of this (Table 1).

The greatest gains in soil carbon and nitrogen, relative to the wheat monoculture, were made in the 4-year grass—legume ley, with increases of 550 kg total N/ha and 4.2 t organic C/ha. The chickpea—wheat rotation fared no better than the continuous wheat system. The shorter (1–2-year) lucerne and annual medic leys resulted in marginal increases in soil organic C and N (Table 1).



<sup>10</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, <a href="http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf">http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf</a>

<sup>11</sup> FC Hoyle, JA Baldock, DV Murphy (2011) Soil organic carbon: Role in rainfed farming systems. In PG Tow, I Cooper, I Partridge, C Birch (eds). Rainfed farming systems. Springer, pp. 339–361.

<sup>12</sup> RC Dalal, RJ Mayer (1986) Long term trends in fertility of soils under continuous cultivation and cereal cropping in southern Queensland. II. Total organic carbon and its rate of loss from the soil profile. Australian Journal of Soil Research 24, 281–292.



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Clearly, time and good sources of both carbon and nitrogen are required to build up SOM, which is exactly what the 4-year grass—legume ley provided. Nitrogen was supplied via  $\rm N_2$  fixation by the lucerne and annual medic in the pasture, with most of the carbon supplied by the grasses, purple pigeon grass and Rhodes grass. There were no inputs of fertiliser nitrogen in any of the treatments in Table 1.  $^{13}$ 

**Table 1:** Effects of different rotations on soil total N and organic C (t/ha) to 30 cm and as gain relative to continuous wheat.

	Wheat	Soil to	tal N	Organ	Organic C			
Rotation	crops	0-30 cm	Gain	0–30 cm	Gain			
Grass/ legume ley 4 years	0	2.91	0.55	26.5	4.2			
Lucerne ley (1-2 years)	2-3	2.56	0.20	23.5	1.2			
Annual medic ley (1-2 years)	2-3	2.49	0.13	23.1	0.8			
Chickpeas (2 years)	2	2.35	0.00	22.0	0.0			
Continuous wheat 4 years	4	2.36	-	22.3	-			

Further research was initiated in 2012 to identify cropping practices that have the potential to increase or maintain soil organic carbon and soil organic matter levels at the highest levels possible in a productive cropping system. Paired sampling has shown that returning cropping country to pasture will increase soil carbon levels (Figure 6). However, there were large variations in carbon level increases detected, indicating not all soil types or pastures preform the same. Soil type influences the speed by which carbon levels change, i.e. a sandy soil will lose and store carbon faster than a soil high in clay. As too does the quality and productivity of the pasture, maximising dry matter production by ensuring adequate nutrition (especially in terms of nitrogen and phosphorus) will maximise increases in soil carbon over time. Current research in Queensland being undertaken by the Department of Agriculture, Fisheries and Forestry (QDAF) is indicating that the most promising practice to date to rebuild soil carbon stocks, in the shortest time frame, is the establishment of a highly productive pasture rotation with annual applications of nitrogen fertiliser, however, adding an adapted legume is also effective. <sup>14</sup>



D Herridge (2011) Managing legume and fertiliser N for northern grains cropping. Revised 2013. GRDC, <a href="https://grdc.com.au/uploads/documents/Managing-N-for-Northern-Grains-Cropping.pdf">https://grdc.com.au/uploads/documents/Managing-N-for-Northern-Grains-Cropping.pdf</a>

<sup>14</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, <a href="http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf">http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf</a>



FEEDBACK



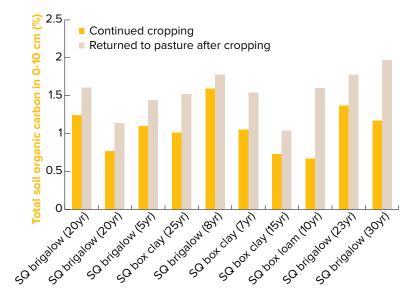


Figure 6: Total organic carbon comparisons for croplands resown to pasture. 15

#### Impact of fertiliser N inputs on soil

If the rates of fertiliser N are sufficiently high, the effects can be positive. In the Warra experiments, both soil organic C and total N increased marginally (3–4%) over an 8-year period when no-till, continuous wheat, fertilised at a rate of 75 kg N/ha, was grown. This is in contrast with decreases of 10–12% in soil organic C and N in the non-fertilised, continuous wheat and chickpea—wheat plots. The result was much the same in NSW Department of Primary Industries experiments in northern NSW. At the Warialda site, for example, SOM increased during 5 years of cropping but only where fertiliser N had been applied to the cereals.

It is clear from the above examples that building SOM requires N. It works in two ways. First, the fertiliser or legume N produces higher crop/pasture yields and creates more residues that are returned to the soil. Then, these residues are decomposed by the soil microbes, with some eventually becoming stable organic matter or humus. The humus has a C/N ratio of about 10:1, i.e. 10 atoms of C to 1 atom of N. If there are good amounts of mineral N in the soil where the residues are decomposing, the C is efficiently locked into microbial biomass and then into humus.

If, on the other hand, the soil is deficient in mineral N, then more of the C is respired by the soil microbes and less is locked into the stable organic matter.  $^{16}$ 

Safflower has nutrient requirements similar to cereals (Table 1), but requires slightly more phosphorus (P) and may require additional sulfur (S) in soils that are low in or do not have native gypsum. Responses to surface-applied fertiliser have been variable, because the topsoil is often dry later in the season and safflower can extract nutrients from deep in the soil profile. This can be useful for recovery of nitrates and other nutrients that have leached beyond the reach of most other crops. Fertiliser applications should be drilled at sowing, or topdressed onto damp soil prior to bud formation and allowed to leach to the root-zone. Foliar fertilisers are also suitable; they allow certain nutrients to be directly absorbed by leaves but may have a high relative cost. Selection of fertiliser type and rate will depend on soil type, paddock



<sup>15</sup> QDAF (2016) Queensland Grains Research – 2015. Regional Research Agronomy Network. Department of Agriculture, Fisheries and Forestry Queensland, pp. 112–117, <a href="http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf">http://www.moreprofitperdrop.com.au/wp-content/uploads/2016/08/RANsTrials2015-screen.pdf</a>

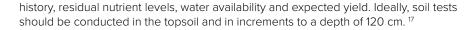
D Herridge (2011) Managing legume and fertiliser N for northern grains cropping. Revised 2013. GRDC, <a href="https://grdc.com.au/uploads/documents/Managing-N-for-Northern-Grains-Cropping.pdf">https://grdc.com.au/uploads/documents/Managing-N-for-Northern-Grains-Cropping.pdf</a>



#### **SECTION 5 SAFFLOWERS**







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#### 5.2 Crop removal rates

Safflower removes slightly more P and S than wheat; however, the lower relative yield indicates that maintenance requirements would be similar to those of wheat.

**Table 2:** Nutrient removal by safflower (kg/t seed).

Nutrient	Safflower	Wheat
Nitrogen	25	23
Phosphorus	4.3	3
Sulfur	4	2

#### 5.3 Soil testing

Standard soil testing should be carried out to determine residual levels of nutrient and match fertiliser application to the estimated yield of the safflower crop.

#### 5.4 Plant and/or tissue testing for nutrition levels

Tissue tests can be carried out on safflower. It has been reported to respond to foliar application of manganese and iron ~6 weeks after sowing.

#### 5.5 Nitrogen

At least 30 kg/ha of nitrogen (N) should be applied to most dryland crops and this can be increased to >100 kg N/ha for high-yielding crops under irrigation. To avoid toxicity, which will reduce crop establishment, no more than 20 kg N/ha should be drilled with seed. Nitrogen fertiliser rates should also reflect water availability and be moderated where moisture is limited or where high levels of N are present deep in the soil profile. Excess N can boost vegetative seedfill, increasing crop water use early in the season and resulting in poor yields if soil reserves are depleted before flowering and seedfill. Economic responses to high rates of N are most likely in fully irrigated crops, where subsoil water is favourable, and/or where soils have low N fertility. If seasonal conditions are unfavourable, consider sowing with 20 kg N/ha and topdressing or applying liquid forms later in the season if conditions are favourable. <sup>18</sup>

In the Northern Region, however, consider that topdressed N may not be available at depth unless there is sufficient rainfall for movement, and if moisture levels at depth are good, then the crop may still fall short of N later in the season.

#### 5.6 Phosphorus

An adequate supply of P is critical to high yields and the long-term sustainability of farming systems. Soil tests, test strips, local experience and expected yield are all good guides to P requirements. Each tonne of safflower seed contains 4.3 kg P, so a crop of 2.5 t/ha would remove  $2.5 \times 4.3 = 10.75$  kg P from the paddock. As a rule of thumb, 12-20 kg P/ha is recommended on deficient soils. Responses to P are unlikely on soils with Cowell-P levels >40 mg/kg, although small amounts can still be applied at sowing to improve early growth and maintain soil levels. <sup>19</sup>



<sup>18</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>



Why soil sample? Nutrient Advantage

Sampling instructions. Nutrient Advantage

Back Paddock SoilMate

CSBP Soil & Plant Analysis Laboratory



<sup>9</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>



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BSES-P tests will give an indication of pool reserves and availability of pool P through the season. Please consult a qualified nutrition adviser.

#### 5.7 Sulfur

Many soils contain adequate levels of S for safflower production. Soil S levels should be monitored with soil tests and S can be applied as gypsum or as a component of a blended fertiliser when necessary.  $^{20}$ 

#### 5.7.1 Potassium

Safflower uses moderate amounts of potassium, but most soils in the cereal-growing regions of Australia contain adequate levels. The general exception is sandy soils, which are not best suited for safflower production unless in high-rainfall regions. Potassium is not very mobile in soils, so where required it is best banded under seed. <sup>21</sup>

#### 5.8 Micronutrients

On certain soil types, such as the black soils in northern NSW or the heavy black or grey clay over limestone soils in South Australia, safflower does respond to manganese, iron and/or zinc. These are best applied as a foliar application around 6 weeks after sowing if necessary. <sup>22</sup>



<sup>20</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy

<sup>21</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>22</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>



## **Weed control**



The later sowing of safflower enables more time for the control of autumn—winter-germinating weeds with knockdown herbicides or cultivation before sowing. Good weed control is essential because safflower is a poor competitor with weeds during the rosette stage, especially when sown in winter.

No selective herbicides are currently registered for broadleaf weed control in safflower. Metsulfuron was available on permit for some time; however, the permit was not renewed because unpredictable crop damage occurred. The use of preemergent herbicides is recommended for the control of grass and for some limited broadleaf control as per labels. Selective grass herbicides such as diclofop-methyl are available for the control of grasses without resistance to Group A herbicides, as per labels.

A summary of herbicides registered for use in safflower crops is provided in Table 1. Note that legislation on the use of herbicides varies between states, and label directions should always be followed. Contact your local agronomic adviser for further information. <sup>1</sup>



Weed control in winter crops 2016



<sup>1</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>





Table 1: Herbicides for weed control for safflower. 2

Rate per hectare	Pre-sowing						Early post-emergence				
Various trade names sometimes available under these concentrations. See specific labels for details.	Trifluralin o		Pendimethal 440 g/L Ston 440		Tri-allat 500 g/L Avadex		Diclofop- methyl 375 Rhino®	g/L	Propaquiz 100 g/L Shogun®	afop	Metsulfuron- methyl 600 g/kg Ally <sup>® 1</sup>
Incorporation/growth	PSI		PSI		PSI		_		Any time u		4–6 Leaf
stage application	IBS		IBS		IBS				weeks bet harvest	ore	
Weeds controlled	(litres)		(litres)		(litres)		(litres)		(litres)		(grams)
annual phalaris	1.2-1.7	<i>₽ ₽</i>	-	NS I	_	Ap be	-	Ad	_	an X A	_
annual ryegrass	1.2-1.7	ply t	1.5-2.25	₩ dort	_	ply a	1.0	Α	0.45	vays ickin d im	_
barley grass	_	betw .2 L/	-	In Northern NSW double incorporate at rate of NSW incorporate by sowing at rate of 1.5–2.25	_	Apply and incorporate before sowing.	_	ettir	0.2	Always add either BS1000® at 200 mL/100 L spray or Hasten™ Kwickin™ at 500 mL/100 L water. Can be mixed with Sertin® to and improve grass control. See label.	_
brome grass	-	⁄een ′ha c	_		_		_	Add wetting agent	0.3		_
capeweed	-	4 w on lig	-		-		-	gent	_	her 0 ml	_
cereals	-	Apply between 4 weeks and just before sowing Apply 1.2 L/ha on light soils and between 1.5–1.7	_		_		_		0.2 3	BS10 L/10 cor	_
common barbgrass	-		-	le ir	-	imn	1.25		_	) ) ) L\	_
deadnettle	_	d jus and	_	ncor	_	immediately prior to sowing or up to	_		_	® at wate	5.0
field pea – volunteer	_	and just before sowing ils and between 1.5–1.7	-	pora rate	-	ately	-		-	200 e lab	7.0
fumitory	1.2-1.7 (S)	fore veer	_	e of	-	pri	_		_	mL an b	5.0
Mexican poppy	-	sow 1.5	-	it rat 1.5-	-	or to	-		_	/100 e m	_
medics – volunteer	-	/ing -1.7 I	_	e of 2.25	-	SOV	-		-	L s ixed	5.0
mustards	-	and L/ha	-	f 1.9–2.5 5 L/ha. Se	-	vinc	-		-	oray wit	5.0
saffron thistle	-	incorporate on medium	-	1.9–2.5 L/ha. In L/ha. See label	-	o o	_		_	or F	_
shepherd's purse	-	ned	-	L/ha ee la	-	nb to	-		_	Hast ertin®	5.0
skeleton weed	-	rate. ium-	-	L/ha. In ee label	-	ω	-		_	to to	7.0 (S)
subterranean clover	-	incorporate. See label. on medium—heavy soils	-	Southern I.	_	weeks	-		_	broaden	5.0
wild oats	1.2–1.7 <sup>1</sup>		1.5-2.25 (S)	ıthe	1.6 <sup>2</sup>	Š	1.5-2.0		0.25	ader	_
wireweed	1.2–1.7	el. oils	1.5-2.25	'n	-		-		-		5.0–7.0
Rec water L/ha boom	70–450		50–200		40–100		50–150		30–150		50 L min
Herbicide group/ mode	D		D		J		А		А		В

<sup>1 =</sup> Tankmix with Avadex® Xtra for improved control.

#### 6.1 Registered herbicides

Several pre-emergent herbicides are registered for grass and broadleaf weed control in safflower crops. Some products containing diclofop-methyl and propaquizafop are also registered for the post-emergence control of grass weeds.

For up to date information, visit <u>Australian Pesticides and Veterinary Medicines Authority</u>.



<sup>2 =</sup> Preferred option for northern NSW only.

<sup>3 = 0.25</sup> L/ha for volunteer triticale.

<sup>4 =</sup> Sironaria, Saffola, Sirothora varieties only. (S) = Suppression only.

Incorporation

PSI = Pre-sowing incorporated.

IBS = Incorporated by sowing.

is a preferred option where NO legumes are to be undersown with the crop. READ LABEL BEFORE USE. REGISTERED CHEMICALS as at 18 April 2016.

<sup>2</sup> G Brooke, C McMaster (2016) Weed control in winter crops 2016. NSW DPI Management Guide, <a href="http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/quides/publications/weed-control-winter-crops">http://www.dpi.nsw.gov.au/agriculture/broadacre-crops/quides/publications/weed-control-winter-crops</a>



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**MORE INFORMATION** 

Raising the bar with better safflower agronomy

Safflower is not known to be tolerant to any current herbicides.

#### 6.2 Potential herbicide damage effects

Certain chemicals should be avoided for use in safflower, including metsulfuronmethyl under acidic conditions, 2,4-D, MCPA and dicamba, which can have adverse effects. Always read the label directions before using any chemical.  $^{\rm 3}$ 

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As a member of the Asteraceae family (daisies, thistles), safflower is susceptible to the herbicides used in the control of the weedy species. Herbicide damage and symptoms will be similar to those on a thistle and will depend on the mode of action of the herbicide. Prior to planting and during crop growth, read the information on herbicide labels regarding crop safety and safe re-cropping interval. Follow label directions and consult with your agronomist.



<sup>3</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>



## Insect control

Safflower is most susceptible to damage by insects during establishment and between budding and harvest. Several insect pests have been recorded on safflower, and although some are widespread, others are confined to certain regions and climates. Some of the more common insect pests are described here, and growers can consult a range of crop-insect identification and management guides for other pests or more specific details. A list of insecticides registered for use in safflower at the time of printing is provided in Table 1. Note that insecticide legislation varies between states. Label directions should always be followed; contact your local agronomic adviser for more specific recommendations. Permits may also be available to use other products (Australian Pesticides and Veterinary Medicines Authority). <sup>1</sup>

**Table 1:** Summary of insecticide active ingredients and their target pests for which one or more products are registered for use in safflower in at least one state of Australia.

	Aphids	Cutworms	Heliothis	Redlegged earth mite, blue oat mite	Rutherglen bugs	Thrips	Lucerne flea
Bacillus thuringiensis			✓				
Chlorpyrifos		$\checkmark$		$\checkmark$			
Deltamethrin		✓	✓		✓		
Dimethoate				✓			$\checkmark$
Esfenvalerate			✓				
Maldison					$\checkmark$		
Nuclear polyhedrosis virus (NPV)			✓				
Trichlorfon		<b>√</b>			<b>√</b>		

Note that the trade names provided are examples only and other products containing the same active constituents may be available

#### 7.1 Aphids (plum, green peach and leaf curl)

Aphids are usually yellow, green or brown in colour, oval, up to 3 mm long and may have wings (Figure 1). They are an intermittent pest of safflower crops, most common during budding and flowering, but may also be present at any growth stage.

#### 7.1.1 Damage caused by aphids

Aphids prefer to eat new shoots and the underside of leaves by sucking sap, causing a mottled appearance, distortion and the shrivelling of buds and capitula. High population levels can weaken plants, reducing yield, especially if crops are under moisture stress. <sup>2</sup>



<sup>1</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>2</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

FEEDBACK



Figure 1: Green peach aphids.

Photo: QDAF

#### 7.1.2 Thresholds for control

Crops should be monitored regularly, especially during establishment and between budding and flowering. Control is warranted when 20% of plants have >20 aphids per shoot, bud or capitula. The presence of beneficial predatory insects such as ladybird beetles, lacewings, hover flies and parasitic wasps should also be monitored; these can often keep aphid populations in check. <sup>3</sup>

#### 7.1.3 Management/control

Various biological control options are available for use in safflower. 4

#### 7.2 Cutworms (Agrotis spp.)

Cutworm larvae are hairless with dark heads and bodies, often with longitudinal lines and/or dark spots (Figure 2). Caterpillars grow up to 50 mm long and curl up when touched. The moths are dull brown or black in colour. Although cutworms are not common in early crop growth, crops should be monitored from establishment. Caterpillars reside in the soil during the day, so it is best to inspect crops late in the afternoon or at night for this pest when they come to the surface. <sup>5</sup>





Figure 2: Black cutworm (Agrotis ipsilon) larvae (left) and adult (right).

Photo: QDAF



<sup>3</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. http://www.grdc.com.au/BetterSafflowerAgronomy

<sup>4</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>5</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

#### **SECTION 7 SAFFLOWERS**







#### 7.2.1 Varietal resistance or tolerance

No varietal resistance or tolerance is known for safflower.

#### 7.2.2 Damage caused by cutworms

Cutworms feed near ground level, eating leaves and, more damaging, chewing through stems so that plants fall over, allowing the upper leaves to be consumed at ground level. Plants often die, leaving bare patches in crops. <sup>6</sup>

#### 7.2.3 Thresholds for control

When first observed, cutworms may already be at high population levels in crops. Treatment is therefore recommended at the first sign of damage; this is most effective late in the afternoon or at night when cutworms move from the soil to plants to feed. <sup>7</sup>

#### 7.2.4 Management/control

Spraying with chlorpyrifos or deltamethrin is the most effective method of control, although biological control agents such as brown earwigs, caterpillar parasites and some spiders may be beneficial. 8

#### 7.3 Helicoverpa spp.

Helicoverpa punctigera (native budworm) and H. armigera are major insect pests of all crops. Eggs are spherical and white at first, darkening as the larvae develop. Newly hatched larvae are generally light in colour with dark heads. Older larvae have large variations in colour including yellow, green, pink, reddish brown and almost black, often with a broad, yellowish white stripe along each side of the body and a dark-edged, whitish line down the middle of the back (Figure 3). Helicoverpa larvae of both species have four pairs of ventral prolegs at the rear of the body. Eggs are laid singly, usually on leaves and bracts surrounding the buds, the upper leaves or the stems below the buds. Fully grown native budworm larvae are ~40 mm long. 9

For more information, see GrowNotes—Chickpeas.

Weekly trap catch data for *H. punctigera* and *H. armigera* from locations across all states can now be <u>viewed online</u>. The adjustable bar below the map allows selection of a time period (1 wk, 2 wks, 1 mth, etc). <a href="https://jamesmaino.shinyapps.io/MothTrapVis/">https://jamesmaino.shinyapps.io/MothTrapVis/</a>

#### 7.3.1 Varietal resistance or tolerance

No varietal resistance or tolerance is known for safflower.

#### 7.3.2 Damage caused by Helicoverpa

Helicoverpa larvae (caterpillars) feed on leaves, but most damage is caused when they graze buds and flowers, preventing seedset. Heavy infestations between budding and seedfill can significantly reduce yield.  $^{10}$ 



<sup>6</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>

<sup>8</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>9</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>10</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

FEEDBACK



Figure 3: Helicoverpa armigera larva and moth.

Photo: QDAF

#### 7.3.3 Thresholds for control

Crops should be inspected regularly from budding and during flowering for moths, caterpillars and damage to buds or capitula. Damage to flower buds from 4-8 larvae of 5-7 mm length generally warrants control. However, well-grown crops may tolerate higher populations on buds and developing seed heads before treatment is necessary, provided adequate water is available in the soil profile. <sup>11</sup>

#### 7.3.4 Management/control

An integrated approach is most successful in controlling *Helicoverpa* populations in safflower. Control options considered should include insecticide-resistance management strategies and bio-insecticides such as *Bacillus thuringiensis* and Nuclear polyhedrosis virus, as well as conventional insecticides. Pupae busting of later summer crops to 10 cm depth may reduce the population of 'overwintering' pupae. <sup>12</sup>

#### 7.4 Rutherglen bug (Nysius vinitor)

Adults are 5 mm long and grey-brown in colour with clear, folded wings. Nymphs are reddish brown and pear-shaped (Figure 4). High population levels can substantially reduce the yield and quality of safflower crops. Infestations can be sporadic, with the pest moving in and out of crops. Infestations are most common during hot, dry weather, and where there are few other green crops growing. Activity is often greater towards evening.  $^{13}$ 



<sup>11</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010). Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, http://www.grdc.com.au/BetterSafflowerAgronomy

<sup>12</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010). Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

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FEEDBACK



**Figure 4:** Rutherglen bugs feeding on a safflower flower.

Photo: QDAF

#### 7.4.1 Varietal resistance or tolerance

No varietal resistance or tolerance is known for safflower.

#### 7.4.2 Damage caused by Rutherglen bug

Adult bugs feed on the upper stems, buds and developing capitula. Severely damaged buds and flower heads wilt and die or become grossly malformed. Adult bugs may also lay eggs in the developing seed heads, and feeding by large numbers of nymphs and adults from flowering onwards can reduce seed yields, especially where crops are deprived of moisture during seed growth. Damage may occur across whole crops or in patches. <sup>14</sup>

#### 7.4.3 Thresholds for control

Because infestations of Rutherglen bugs tend to be sporadic, check a large number of sites within a paddock to determine extent and severity. The threshold for spraying is generally  $^{\sim}15$  adults per plant, but well-growing crops may tolerate more, because healthy plants can renew up to 40% of buds if adequate water is present.  $^{15}$ 

#### 7.4.4 Management/control

Rutherglen bugs can be controlled with products containing deltamethrin, but there is a continuous risk of re-infestation from crops or weedy areas. Timing is also critical due to the transient nature of infestations. <sup>16</sup>

## 7.5 Redlegged earth mites (*Halotydeus destructor*) and blue oat mite (*Penthaleus major*)

Adults are 1 mm long and black to purplish blue in colour with eight brightly coloured legs (Figure 5). Mites are an intermittent pest of most concern during establishment. They often hide under clods of soil or on the underside of leaves during hot weather. <sup>17</sup>



<sup>4</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, http://www.grdc.com.au/BetterSafflowerAgronomy

N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>16</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>17</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

FEEDBACK





**Figure 5:** Redlegged earth mite (left) and blue oat mite (right, with distinguishing red area on back).

Photo: QDAF

#### 7.5.1 Varietal resistance or tolerance

No varietal resistance or tolerance is known for safflower.

#### 7.5.2 Damage caused by mites

Redlegged earth mites and blue oat mites have a rasping mouthpiece that damages leaves, allowing the mites to feed on plant fluids. Typically, this causes a silver discoloration, often referred to as windowing. Very high population levels can lead to the distortion of leaves and leaf tips, or whole seedlings may wither and die. Inspections for these mites are more effective in the cooler conditions of late afternoon or night. <sup>18</sup>

#### 7.5.3 Thresholds for control

Mites are usually present in large numbers, especially in dry seasons. Spraying should occur when significant damage occurs to leaves during early growth. Crops tend to grow away from this pest after stem elongation. <sup>19</sup>

#### 7.5.4 Management/control

Several insecticides are registered for use in safflower, and there are some biological control agents such as ladybird beetles. Some growers choose to spray a residual insecticide to bare soil between sowing and emergence to reduce problems during establishment. Border spraying to reduce the numbers of these pests moving into safflower paddocks is another option. <sup>20</sup>



<sup>18</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. http://www.grdc.com.au/BetterSafflowerAgronomy

<sup>19</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>20</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>



**SECTION 7 SAFFLOWERS** 







#### 7.6 Other pests

Other pests known to infest safflower crops in Australia include thrips, lucerne flea, black field crickets, grasshoppers, locusts, wireworms, false wireworms, jassids (leafhoppers) and myrids. <sup>21</sup>



<sup>21</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>



## Nematode management

Although safflower is resistant to the two common species of root-lesion nematode (RLN; *Pratylenchus thornei* and *P. neglectus*), testing of paddocks and knowledge of RLN status is useful when selecting areas suitable for safflower.

Safflower may be a better choice in soils with high RLN infestation than other, more susceptible crops (Table 1) and can be used as a break to reduce RLN populations and manage affected paddocks. <sup>1</sup>

**Table 1:** Comparison of crops for risk of Pratylenchus thornei build-up and frequency of significant variety differences within crop types.

Crop	Pt build-up risk	Variety differences
Sorghum	Low	None observed
Cotton	Low	None observed
Sunflower <sup>A</sup>	Low	None observed
Linseed <sup>A</sup>	Low	_
Canola <sup>A</sup>	Low to medium	None observed
Field peas <sup>A</sup>	Low to medium	Low
Durum wheat	Low to medium	Moderate
Barley	Low to medium	Moderate
Bread wheat	Low, medium to high	Large
Chickpeas	Medium to high	Moderate to large
Faba beans	Medium to high	Low
Mungbean <sup>A</sup>	Medium to high	Moderate to large

For crops with a range of build-up risk but a dominant category, the dominant category is in bold type; for bread wheat, varieties are in all categories but most are in the medium—high risk categories. See more at: Impact of crop varieties on RLN multiplication

A Data from only one or two field trial locations for these crops.

In the northern grain region, RLN are found throughout northern NSW and Queensland. *Pratylenchus thornei* is more widespread and generally occurs in higher population numbers than *P. neglectus*. Results from 600 samples tested in 2010–13 showed that 50% of paddocks had populations >2 nematodes/g soil.

A recent survey in Central Queensland found that 28% of paddocks had RLN, with 26% of those paddocks containing *P. thornei*. Populations were generally low, but in the Dawson–Callide region of Central Queensland, 5% of samples had populations >2 nematodes/g soil.

At planting, damaging populations of RLN can be found deep in the soil. In some soils, peak numbers occur as deep as 60 cm. This happens because the hot, dry conditions of the surface soil can cause nematode death, and RLN can migrate down the soil profile where cooler, moist conditions favour survival. Therefore, be aware that RLN populations in surface soil may not give a full picture of the population density at depth threatening crops, particularly after a long fallow. However, if RLN are detected in the surface soil, start actively managing for RLN. <sup>2</sup>



Root lesion nematodes



B Burton (2015) Impact of crop varieties on RLN multiplication. GRDC Update Papers, 1 March 2015, <a href="http://grdc.com.au/Research-and-bevelopment/GRDC-Update-Papers/2015/03/Impact-of-crop-varieties-on-RLN-multiplication">http://grdc.com.au/Research-and-bevelopment/GRDC-Update-Papers/2015/03/Impact-of-crop-varieties-on-RLN-multiplication</a>

GRDC (2015) Root lesion nematodes. GRDC Tips and Tactics, 3 March 2015, http://www.grdc.com.au/TT-RootLesionNematodes



## **Diseases**

Several diseases can infect safflower, especially in warm and humid conditions. No fungicides are registered for disease control in safflower in Australia; however, some success has been achieved with seed- and foliar-applied products in other countries, including the United States.

Control of safflower diseases in Australia relies mainly on using appropriate crop rotations, selecting resistant varieties, using clean seed, controlling volunteer and weed hosts, using sound irrigation practices and selecting appropriate soils. Many safflower diseases are hosted on stubble, volunteer plants, other *Carthamus* species (e.g. saffron thistle) and some broadleaf crops. The main diseases of safflower in Australia are described below.

#### 9.1 Alternaria blight (caused by Alternaria carthami)

Alternaria leaf blight (Figure 1) is the most serious disease of safflower, with heavy infection reducing yield by  $\geq$ 50%. Infected seed is often smaller with reduced oil content.



Figure 1: Alternaria blight infection on safflower leaves.

Photo: Hans Henning Mündel

#### 9.1.1 Varietal resistance or tolerance

The cultivar Sironaria was bred by CSIRO in 1987 with resistance to Alternaria blight.

#### 9.1.2 Damage caused by the disease

Alternaria blight is a fungal disease that attacks leaves, stems, heads and seeds. Transmission may be on infected seed or airborne spores released from crop residue for up to 2 years. <sup>1</sup>



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>





#### 9.1.3 Symptoms

Infected seeds may have typical sunken lesions on the seedcoat, but they can also appear healthy. Seedborne infection results in reduced germination, death of plants at pre-emergence stage and death or malformation of seedlings. Initial symptoms in established plants often appear as large, brown, irregular spots (lesions) on the lower leaves. With warm and humid conditions, the disease then spreads up the plant to infect the upper leaves, stems, flower head, and eventually the seeds. <sup>2</sup>

#### 9.1.4 Conditions favouring development

Rainfall and high temperatures, or humidity during and after flowering, are the conditions most favoured by Alternaria blight. It can occur in all safflower-growing regions, but it is often more prevalent in northern regions because temperatures in late spring are often warmer and the chance of summer rainfall is higher. Losses can be minimised by avoiding poorly drained soils and by using sound irrigation practices that minimise the incidence of waterlogging. <sup>3</sup>

#### 9.1.5 Management of the disease

Control of Alternaria blight is largely preventative via careful crop rotation, stubble management and control of volunteer hosts. Sowing at the correct time is also important to minimise the chance of warm, humid conditions after flowering. Seed from infected crops should not be used as planting seed, and resistant cultivars such as Sironaria are available. <sup>4</sup>

# 9.2 Phytophthora root rot (caused by *Phytophthora cryptogea*)

Phytophthora root rot (Figure 2) can be an unpredictable fungal disease and it usually occurs in wet soils, especially when temperatures are high. It is present in all growing areas, but is most prevalent in irrigated crops, where yield may be significantly reduced depending on the timing and extent of infection. Losses tend to be most serious as crops approach maturity. Spread is by spores, which can be transported by wind, rain splash, surface drainage and waterways.



Figure 2: Patches of dead plants due to Phytophthora root rot.

Photo: Bob Colton



<sup>2</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/Better/Safflower/Agronomy

N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>4</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>



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The cultivar Sirothora was bred by CSIRO in 1987 with resistance to Phytophthora root rot.

#### 9.2.2 Symptoms

This disease can infect seedlings, but more often plants are not affected until flowering. Phytophthora root rot usually becomes evident 4–5 days after rain or irrigation. Plants may dry out, appear bleached and collapse in a short time. Lower stems and roots are often discoloured and become rotted.

As the plants die, they take on a bleached appearance and the base of the stem and the roots become completely dark. Plants may die individually or in patches that often coincide with low-lying or poorly drained areas where surface water has accumulated around the plants. <sup>5</sup>

#### 9.2.3 Conditions favouring development

The disease is favoured by wet, warm soil temperatures >25°C. Plants in low-lying areas of paddocks are most susceptible. *Phytophthora cryptogea* is hosted on a wide range of crops, harboured in the soil and has the ability to survive for long periods in the absence of preferred hosts. *Phytophthora cryptogea* can infect the fine roots of mayweeds without causing obvious symptoms. <sup>6</sup>

#### 9.2.4 Management of the disease

Once infected, plants usually die. Losses can be minimised by avoiding poorly drained soils and by using sound irrigation practices that minimise the incidence of waterlogging. The risk of this disease is one of the reasons that many advisers recommend safflower not be irrigated after flowering.

Losses can also be minimised by controlling weeds during fallow to reduce the amount of inoculum present and by growing resistant varieties, especially where crops are irrigated. <sup>7</sup>

#### 9.3 Rust (caused by Puccinia carthami)

Safflower rust (Figure 3) is often seen on older leaves late in the season, but significant yield losses usually require warm and humid conditions earlier in the growing season.

The fungus is borne on seed or soil, and spores from infected plants or crop residues are the main method of spread both within and between crops. Spores can survive on infected stubble from one season to the next and can be spread long distances by wind. 8



Sunflower disease management.



NORTHERN

N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>6</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>

N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>8</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

FEEDBACK



Figure 3: Rust pustules on a safflower leaf.

Photo: Bob Colton

### MORE INFORMATION

Sources of *Alternaria carthami* inoculum in safflower

<u>Phytophthora drechsleri Tucker</u> and <u>Pythium spp. as pathogens of</u> safflower in NSW

Environmental factors influencing safflower screening for resistance to Phytophthora cryptogea

<u>Survival of Alternaria carthami on</u> safflower residue

<u>Fungi associated with root rot of irrigated safflower in the Namoi</u>
Valley, NSW

#### 9.3.1 Symptoms

Rust pustules can appear at the base of seedlings, which can collapse and die. In mature plants, rust first appears on the upper leaf surface as small yellow pustules, and on the lower leaf surface or stems at ground level as white pustules. As the disease progresses, the pustules enlarge to form reddish brown pustules up to 3 mm in diameter, which may be bordered by a yellow rim. The spores feel like talcum powder when rubbed between the fingers. Severe infection results in premature leaf drop. <sup>9</sup>

#### 9.3.2 Conditions favouring development

As with most fungal diseases, safflower rust favours warm, humid conditions where cycles of spore development may occur every 10-14 days.  $^{10}$ 

#### 9.3.3 Management of the disease

The main ways to manage rust in Australia are sound crop rotations, control of volunteer safflower plants and use of clean seed.  $^{\rm 11}$ 

#### 9.4 Other diseases

Other, less prevalent diseases of safflower include seedling damping off, grey mould, charcoal rot, leaf spot and Sclerotinia head rot. Most are favoured by warm, humid conditions or waterlogging and can be managed by paddock selection, sound crop rotations and use of clean seed.

Further advice on managing diseases in safflower can be obtained from plant pathologists or your local agronomic adviser. <sup>12</sup>



NORTHERN

N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>11</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>12</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="https://www.grdc.com.au/BetterSafflowerAgronomy">https://www.grdc.com.au/BetterSafflowerAgronomy</a>



# Plant growth regulators and canopy management

Research work in Brazil aimed to determine the effect of the plant growth regulators kinetin, chlorocholine chloride (CCC) and salicylic acid (SA) on achene yield and oil quality of safflower cv. Thori in relation to biodiesel production.

Researchers found that application of these plant growth regulators as foliar spray  $(10^{-5} \text{ m})$  during flowering in safflower can improve oil yield and quality, and can be utilised in a sustainable manner in commercial-scale production of good-quality biodiesel. Moreover, the kinetin treatment enhances the conversion of oil to methyl esters.

See the results at: Effect of plant growth regulators on oil yield and biodiesel production of safflower (Carthamus tinctorius L.).





# Crop desiccation/spray out

Not applicable for this crop





## **Harvest**



Safflower sown in winter is normally ready for harvest 4–6 weeks after wheat and about 4 weeks after flowering has finished. Harvest usually begins in late December in northern NSW and continues into March in south-eastern South Australia. Harvest can commence when most of the bracts surrounding heads are dry and yellow or brown and the stem is dry.

Terminal heads are the first to mature, and this can be up 2 weeks before heads on secondary branches. It is therefore important to sample whole plants to get a reliable idea of seed moisture content and maturity. Occasional late heads that are still green will contain immature seeds, but they can be ignored.

When mature, seeds should be white and can be easily squeezed out of heads by using gloved hands. Seed samples can also be extracted by cutting the heads from plants and placing them in a tray and pressing gently down on them with a soft plastic implement such as a dustpan.

Very hot and dry conditions during harvest will result in very brittle plants, which shatter easily into small pieces, making it difficult to maintain a clean seed sample. Safflower resists shattering from wind while crops are standing, but plants are easily shattered at the cutter bar of harvesting machinery if very dry. These issues can be overcome by harvesting very dry crops during cooler conditions, such as at night.

Seed moisture should be <8% and most processors will not accept seed above this level because it is prone to overheating and mould formation.

Safflower should be harvested as soon as possible to reduce the risk of yield and quality losses from rain, which can stain seed, reducing its value. Rain can also cause seed to germinate in the erect, cup-like flower heads, which can hold water for some time. The risk is greater in northern regions.

Safflower does not lodge readily, but seed can be lost in very strong wind. Furthermore, small birds such as sparrows may feed on seed while it is still in the head awaiting harvest, and cockatoos can chew plants off at the base, and then remove the seed from the flower heads when the plant is on the ground (Figure 1).





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Figure 1: Safflower damaged by cockatoos.

Photo: Nick Wachsmann

Safflower will thresh at >8% seed moisture, but harvested seed must be dried quickly in a grain drier to prevent the development of a musty odour. This may also help to preserve the preferred whiteness of the seed coat for birdseed markets. <sup>1</sup>

#### 12.1 Header settings

Safflower can be harvested with the same machinery used for cereals. Groundspeed is generally 25% slower than for cereals. This is mainly to reduce grain losses, but also to reduce the chance of blockages, which can be time consuming and uncomfortable to rectify because of the crop's spines. Header settings will vary with conditions, crop yield and the type of machinery used.

Reels should be set to push the crop gently over the cutter bar without dislodging seed from the capitula. Drum speeds are generally slower ( $^{\circ}500$  rpm) and concave openings usually wider ( $^{\circ}16$  mm at front,  $^{\circ}13$  mm at back) than used for cereals. This is to prevent the cracking of seed, which will deteriorate oil quality and reduce the value of the crop. Special care should be taken when harvesting planting seed, using as low a drum speed as possible.  $^{2}$ 

#### **12.2 Windrowing**

Wind settings are typically about two-thirds of those required for wheat. Large populations of green weeds can make harvesting difficult, and no desiccants are currently registered or recommended for use in safflower. Windrowing or swathing is an alternative, but some losses from shattering should be expected, and on current data, windrowing is not recommended. Typical grain losses during harvesting are  $^{3}$ 4%, made up of 2–3% at the back of the header and  $^{1}$ 8 at the cutter bar.



<sup>1</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC. http://www.grdc.com.au/Better/Safflower/Agronomy

<sup>2</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

<sup>3</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>









## **MORE INFORMATION**

Farm FireWise. Checklist and action plan

NSW Rural Fire Service. Fire danger ratings and total fire bans

Harvester fire: reducing the risks



## 12.3 Wet harvest issues and management

It is important to harvest safflower as soon as maturity is reached, because delayed harvest increases the risk of damage from storm weather during summer, particularly in northern areas.

The erect heads of safflower catch rainwater, which will cause the seed to discolour or sprout in the head. Strong winds may cause shatter loss. Seed may also be stained a dark brown colour, which will make it unsuitable for the birdseed market.

## 12.4 Dry harvest issues and management

In dry weather conditions, safflower may be left standing for up to 1 month before harvesting because it will withstand lodging, insect and bird attack when it is mature.

## 12.5 Fire prevention

The bristles contained in safflower heads are light, fluffy and highly flammable. Harvesting machinery should therefore be periodically cleaned when harvesting safflower to reduce the risk of fire, especially around the engine, radiator, air intakes and exhaust.

Many growers choose to drag a chain from the travelling harvester to dissipate static buildup and mitigate the possibility of header fires. <sup>4</sup>



<sup>4</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>





Stored Grain Information Hub

Storing oilseeds

# **Storage**

Safflower is lighter than wheat and more easily lost from the tops of trucks or bulk bins travelling at speed. Loads should be covered securely to minimise losses. Transport costs can also be higher because of the lower bulk density, which means that a truck can carry a greater weight of cereal than of safflower seed in a given volume. Safflower can be sold directly to crushing plants or to other markets or stored on-farm. <sup>1</sup>

## 13.1 How to store product on-farm

Safflower should be stored with a grain moisture <8% to prevent mould production and deterioration with heat.

There are four key best practice strategies that provide good results for on farm storage. When combined, they form the foundation for successful storage and importantly, a grower can build a reputation as a reliable supplier of quality grain.

Aeration: correctly designed and managed, will provide cool grain temperatures and uniform grain moisture conditions. The result is reduced problems with grain moulds and insect pests in storage, plus the ability to maintain grain quality attributes such as germination, pulse seed colour, oil quality and flour quality.

Hygiene: a good standard of storage facility hygiene is crucial in keeping storage pest numbers to a minimum and reducing the risk of grain contamination.

Monitoring: monthly checking of grain in storage for insect pests (sieving / trapping) and at the same time inspect grain quality and temperature. Keep a monthly storage record to record these details, including any grain treatments you applied.

Fumigation: in Australia we now only have gases (fumigation) to deal with insect pest infestations in stored grain. To achieve effective fumigations the storage/silo must be sealable — gas-tight (AS2628) to hold the gas concentration for the required time.  $^2$ 

#### 13.2 Pests of stored grain

Stored seed is vulnerable to common insect pests of stored grain, and harvest preparations should include cleaning and disinfesting harvesters, storage facilities and other equipment used to handle seed.<sup>3</sup>

Grain Storage Information Hotline: 1800 WEEVIL (1800 933 845) will put you in contact with your nearest grain storage specialist.

For more information on storing oilseeds, see **GrowNotes**: Sunflowers.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy

<sup>2</sup> P Burrill (2016) Part I Achieving great aeration results and Part II Silo recirculation as an aid to fumigation. GRDC Update Papers 20 July 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/Part-I-Achieving-great-aeration-results-and-Part-II-Silo-recirculation-as-an-aid-to-fumigation

<sup>3</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>



## **Environmental issues**

#### 14.1 Frost issues for safflower

Sowing too early can result in frost damage during stem elongation, branching and even budding. Risk is greatest in northern areas, where the generally warmer climate causes plants to begin stem elongation in winter.

Very early sowing followed by good early-season growing conditions may cause excessive vegetative growth, increasing crop water use, which may restrict seedfill if soil water reserves are depleted.

Sowing too late reduces yield potential by shortening the duration of vegetative fill and pushing flowering and seedfill into late spring and summer, often coinciding with higher temperatures and decreasing chance of rainfall. Late-sown crops may also be at greater risk of seed staining and sprouting in regions prone to significant summer rainfall events. <sup>1</sup>

## 14.1.1 Risk management for frost

The variability in the incidence and severity of frost means that growers need to adopt a number of strategies as part of their farm management plan. These include pre-season, in-season, and post-frost strategies. <sup>2</sup>

See GRDC Tips and Tactics <u>Managing frost risk</u> for general principles of establishing a frost management plan.

Growers need to consider carefully whether earlier sowing is justified in seasons where warmer temperatures are predicted. Warmer temperatures may reduce the frequency of frost events but also increase the rate of crop development bringing crops to the susceptible, post heading stages earlier. <sup>3</sup>

## 14.1.2 The changing nature of frost in Australia

The length of the frost season has increased across much of the Australian grainbelt by between 10 and 55 days between 1960 and 2011. In some parts of eastern Australia, the number of frost events has increased.

CSIRO analysis of climate data over this period suggests the increasing frost incidence is due to the southerly displacement and intensification of high pressure systems (subtropical ridges) and to heightened dry atmospheric conditions associated with more frequent El Niño conditions during this period.

The southern shifting highs bring air masses from further south than in the past. This air is very cold and contributes to frost conditions.

In the eastern Australian grainbelt the window of frost occurrence has broadened, so frosts are occurring both earlier and much later in the season. In the Western Australian grainbelt there are fewer earlier frosts and a shift to frosts later into the season.



N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.grdc.com.au/BetterSafflowerAgronomy">http://www.grdc.com.au/BetterSafflowerAgronomy</a>

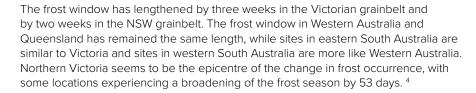
<sup>2</sup> GRDC (2016) Managing frost risk. Northern, Southern and Western Regions. GRDC Tips and Tactics, <a href="http://www.grdc.com.au/ManagingFrostRisk">http://www.grdc.com.au/ManagingFrostRisk</a>

<sup>3</sup> J Christopher, B Zheng, S Chapman, A Borrell, T Frederiks, K Chenu (2016) An analysis of frost impact plus guidelines to reduce frost risk and assess frost damage. GRDC Update Papers 20 July 2016, <a href="https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/An-analysis-of-frost-impact-plus-quidelines-to-reduce-frost-risk-and-assess-frost-damage">https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/An-analysis-of-frost-impact-plus-quidelines-to-reduce-frost-risk-and-assess-frost-damage</a>









NORTHERN

## 14.2 Waterlogging and flooding issues

Safflower does not tolerate waterlogging; it can predispose the crop to diseases such as Phytophthora root rot.

The effect of waterlogging on safflower crops appears to be worse under warming temperatures later in the season. Experience suggests that irrigation should stop after flowering, allowing water demands during seedfill to be met from soil reserves. Care needs to be taken with overhead irrigation to minimise the duration of humid conditions in the canopy, which favour the development of leaf and head diseases. Irrigated safflower does best on raised beds with good drainage.

#### 14.3 Other environmental issues

The aggressive root system of safflower penetrates further into soil than roots of many other crops. The roots create channels in the subsoil, improving water and air movement as well as root development in subsequent crops. For this reason, some growers use safflower as an entry crop in rotations.

Safflower can also be used to dry wet soil profiles, such as after irrigated cotton. This facilitates the natural shrinking and cracking of compacted layers, which can be further shattered by deep ripping.

Because safflower is a long season crop with a deep taproot, it has the ability to use surplus water from deep in the soil profile, lowering water tables with dissolved salts and reducing the expansion of saline seeps. Similarly, some growers use safflower to dry soil profiles to reduce waterlogging in subsequent crops.

The prickly nature of safflower later in its growing season means that it is occasionally grown in situations where other crops may fail under high kangaroo, bird or feral pig pressure. It is relatively unpalatable to these animals and growers can achieve an economic return with minimal maintenance of the crop. <sup>5</sup>



<u>Crop canopy temperature as an</u> <u>explanation for early flowering of</u> safflower in response to water stress



<sup>4</sup> GRDC (2016) Managing frost risk. Northern, Southern and Western Regions. GRDC Tips and Tactics, <a href="http://www.grdc.com.au/ManagingFrostRisk">http://www.grdc.com.au/ManagingFrostRisk</a>

<sup>5</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>



## Marketing

The final step in generating farm income is converting the tonnes produced into dollars at the farm gate. This section provides best-in-class marketing guidelines for managing price variability to protect income and cash flow.

Figure 1 shows a grain selling flow chart that summarises:

- · the decisions to be made
- the drivers behind the decisions
- the guiding principles for each decision point.

The grower will run through a decision-making process each season, because growing and harvesting conditions, and prices for grains, change all the time. For example, in the six years to and including 2014, Newcastle APWI wheat prices varied A\$70–\$150/t, a variability of 25–60% (Figure 2). For a property producing 1,000 tonnes of wheat this means \$70,000–\$150,000 difference income, depending on timing of sales.

The reference column refers to the section of the GrowNote where you will find the details to help in making decisions. <sup>1</sup>

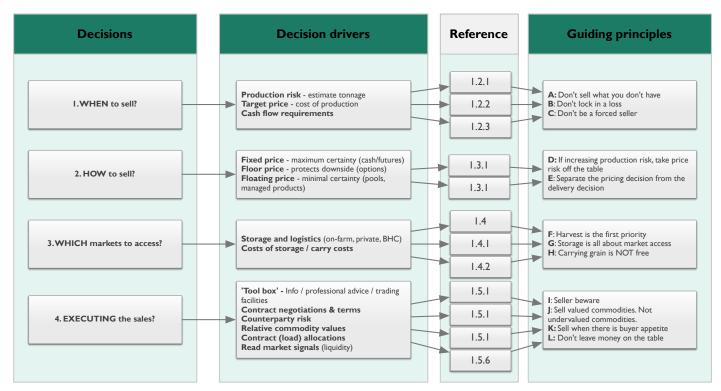


Figure 1: Grain-selling flowchart.

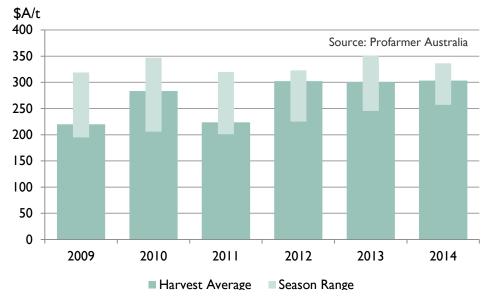


<sup>1</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote



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## Note to figure:

Newcastle APWI wheat prices have varied A\$70-\$150/t over the past 6 years (25-60% variability). For a property producing I,000 tonne of wheat this means \$70,000-\$150,000 difference in income depending on price management skill.

Figure 2: Newcastle APWI price variation, 2009-14.

Source: Profarmer Australia

## 15.1 Selling principles

The aim of a selling program is to achieve a profitable average price (the target price) across the entire business. This requires managing several unknowns to establish a target price and then work towards achieving the target price.

Unknowns include the amount of grain available to sell (production variability), the final cost of producing the grain, and the future prices that may result. Australian farm gate prices are subject to volatility caused by a range of global factors that are beyond our control and are difficult to predict.

The skills growers have developed to manage production unknowns can also be used to manage pricing unknowns. This guide will help growers manage and overcome price uncertainty.  $^{2}$ 

#### 15.1.1 Be prepared

Being prepared by having a selling plan is essential for managing uncertainty. The steps involved are forming a selling strategy, and forming a plan for effectively executing sales. The selling strategy consists of when and how to sell.

#### When to sell

Knowing when to sell requires an understanding of the farm's internal business factors, including:

- production risk
- a target price based on the cost of production and the desired profit margin
- business cashflow requirements.

#### How to sell

Working out how to sell your grain is more dependent on external market factors, including:

the time of year—determines the pricing method



<sup>2</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote

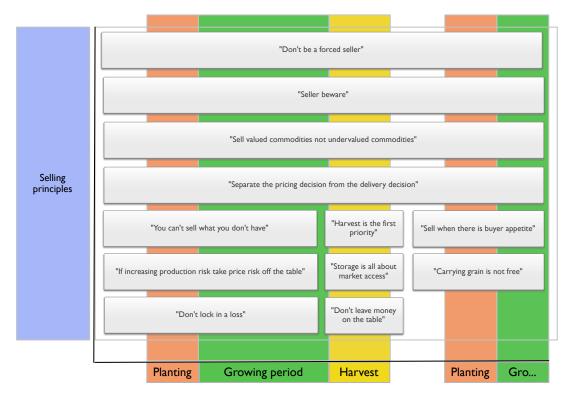






- market access—determines where to sell
- relative value—determines what to sell.

The following diagram (Figure 3) lists the key principles to employ when considering sales during the growing season. Exactly when each principle comes into play is indicated in the discussion of marketing, planning and timing in the rest of section 15.  $^3$ 



### Note to figure:

The illustration demonstrates the key selling principles throughout the production cycle of a crop.



Figure 3: Timeline of grower commodity selling principles.

Source: Profarmer Australia

## 15.1.2 Establish the business risk profile

Establishing your business risk profile helps you determine when to sell: it allows you to develop target price ranges for each commodity, and provides confidence to sell when the opportunity arises. Typical business circumstances and how to quantify the risks during the production cycle are described below (Figure 4).

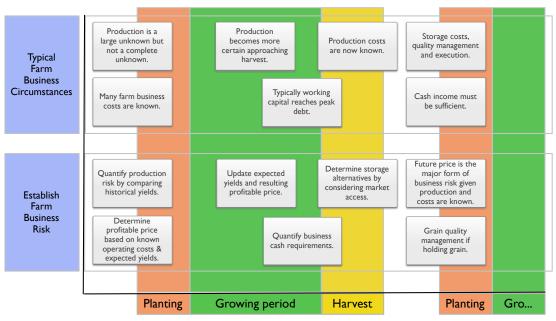


<sup>3</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote



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#### Note to figure:

When does a grower sell their grain? This decision making is dependent on:
a) Does production risk allow sales? And what portion of production?
b) Is the price profitable?
c) Are business cash requirements being met?



Figure 4: Typical farm business circumstances and risk.

Source: Profarmer Australia

## Production risk profile of the farm

Production risk is the level of certainty around producing a crop and is influenced by location (climate, season and soil type), crop type, crop management, and the time of the year.

**Principle:** You can't sell what you don't have.

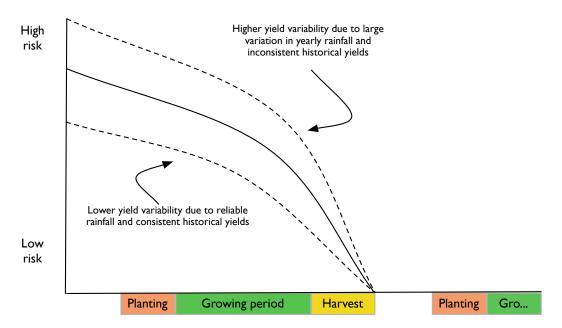
Therefore, don't increase business risk by over committing production. Establish a production risk profile (Figure 5) by:

- 1. Collating historical average yields for each crop type and a below-average and above-average range.
- Assessing the likelihood of achieving the average, based on recent seasonal conditions and the seasonal outlook.
- 3. Revising production outlooks as the season progresses.









#### Note to figure:

The quantity of crop grown is a large unknown early in the year however not a complete unknown. 'You can't sell what you don't have' but it is important to compare historical yields to get a true indication of production risk. This risk reduces as the season progresses and yield becomes more certain. Businesses will face varying production risk levels at any given point in time with consideration to rainfall, yield potential, soil type, commodity etc.



Figure 5: Typical risk profile of a farm operation.

Source: Profarmer Australia

## Establishing a target price

A profitable commodity target price is the cost of production per tonne plus a desired profit margin. It is essential to know the cost of production per tonne for the farm business, which means knowing all farming costs, both variable and fixed.

Principle: Don't lock in a loss.

If committing production ahead of harvest, ensure the price will be profitable. The steps needed to calculate an estimated profitable price is based on the total cost of production and a range of yield scenarios, as provided below (Figure 6).





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Estimating cost of production - V	Vheat	Step 1: Estimate your production
Planted area	1,200 ha	potential. The more uncertain your production is, the more
Estimate yield	2.85 t/ha	conservative the yield estimate
Estimated production	3,420 t	should be. As yield falls, your cost
Fixed costs		of production per tonne will rise.
Insurance and general expenses	\$100,000	Stop 2: Attribute your fixed form
Finance	\$80,000	Step 2: Attribute your fixed farm business costs. In this instance if
Depreciation/Capital replacement	\$70,000	1,200 ha reflects 1/3 of the farm enterprise, we have attributed 1/3
Drawings	\$60,000	fixed costs. There are a number
Other	\$30,000	of methods for doing this (see M Krause "Farming your Business")
Variable costs		but the most important thing
Seed and sowing	\$48,000	is that in the end all costs are
Fertiliser and application	\$156,000	accounted for.
Herbicide and application	\$78,000	Stop 2: Calculate all the variable
Insect/fungicide and application	\$36,000	Step 3: Calculate all the variable costs attributed to producing that
Harvest costs	\$48,000	crop. This can also be expressed
Crop insurance	\$18,000	as \$ per ha x planted area.
Total fixed and variable costs	\$724,000	
Per tonne equivalent (total costs + estimated production)	\$212 /t	Step 4: Add together fixed and variable costs and divide by
Per tonne costs		estimated production
Levies	\$3 /t	Step 5: Add on the 'Per tonne'
Cartage	\$12 /t	costs like levies and freight.
Receival fee	\$11 /t	
Freight to port	\$22 /t	Step 6: Add the 'Per tonne' costs to the fixed and variable per tonne
Total per tonne costs	\$48 /t	costs calculated at step 4.
Cost of production port FIS equiv	\$259.20	
Target profit (ie 20%)	\$52.00	Step 7: Add a desired profit margin to arrive at the port
Target price (port FIS equiv)	\$311.20	equivalent target profitable price.

**Figure 6:** An example of how to estimate the costs of production.

Source: Profarmer Australia

GRDC's manual  $\underline{\text{Farming the Business}}$  also provides a cost-of-production template and tips on grain selling v. grain marketing.

## Income requirements

Understanding farm business cash flow requirements and peak cash debt enables growers to time grain sales so that cash is available when required. This prevents having to sell grain below the target price to satisfy a need for cash.

**Principle:** Don't be a forced seller.

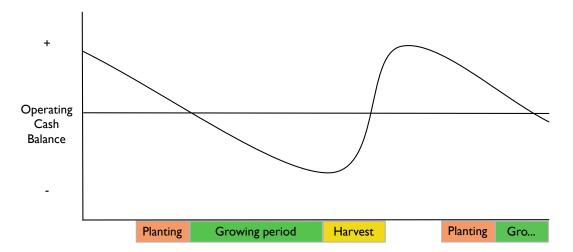
Be ahead of cash requirements to avoid selling in unfavourable markets.

Typical cash flow to grow a crop are illustrated below (Figures 7 and 8). Costs are incurred up front and during the growing season, with peak working capital debt incurred at or before harvest. Patterns will vary depending on circumstance and enterprise mix. Figure 8 demonstrates how managing sales can change the farm's cash balance.









## Note to figure:

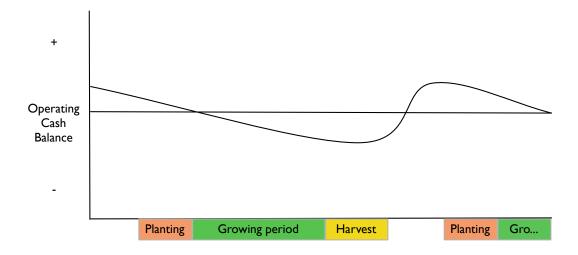
The chart illustrates the operating cash flow of a typical farm assuming a heavy reliance on cash sales at harvest. Costs are incurred during the season to grow the crop, resulting in peak operating debt levels at or near harvest. Hence at harvest there is often a cash injection required for the business. An effective marketing plan will ensure a grower is 'not a forced seller' in order to generate cash flow.



In this scenario peak cash surplus starts higher and peak cash debt is lower

Figure 7: Typical operating cash balance when relying on cash sales at harvest.

Source: Profarmer Australia



#### Note to figure:

By spreading sales throughout the year a grower may not be as reliant on executing sales at harvest time in order to generate required cash flow for the business. This provides a greater ability to capture pricing opportunities in contrast to executing sales in order to fulfil cash requirements.



In this scenario peak cash surplus starts lower and peak cash debt is higher

**Figure 8:** Typical operating cash balance when crop sales are spread over the year.

Source: Profarmer Australia

The 'when to sell' steps above result in an estimated production tonnage and the risk associated with producing that tonnage, a target price range for each commodity, and the time of year when cash is most needed.  $^4$ 



<sup>4</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote







## 15.1.3 Managing your price

The first part of the selling strategy answers the question about when to sell and establishes comfort around selling a portion of the harvest.

The second part of the strategy, managing your price, addresses how to sell your crop.

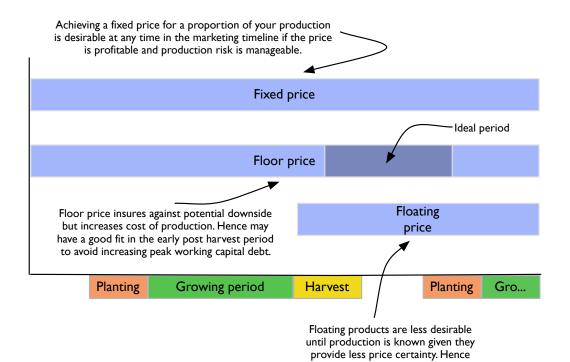
#### Methods of price management

Pricing products provide varying levels of price risk coverage, but not all products are available for all crops (Table 1).

**Table 1:** Pricing methods and how they are used for different crops.

	Description	Wheat	Barley	Canola	Oats	Lupins	Field peas	Chick peas
Fixed price products	Provides the most price certainty	Cash, futures, bank swaps	Cash, futures, bank swaps	Cash, futures, bank swaps	Cash	Cash	Cash	Cash
Floor price products	Limits price downside but provides exposure to future price upside	Options on futures, floor price pools	Options on futures	Options on futures	none	none	none	none
Floating price products	Subject to both price upside and downside	Pools	Pools	Pools	Pools	Pools	Pools	Pools

Figure 9 summarises how the different methods of price management are suited to the majority of farm businesses.



#### Note to figure:

Different price strategies are more applicable through varying periods of the growing season. If selling in the forward market growers are selling something not yet grown hence the inherent production risk of the business increases. This means growers should achieve price certainty if committing tonnage ahead of harvest. Hence fixed or floor products are favourable. Comparatively a floating price strategy may be effective in the harvest and post harvest period.



harvest selling strategies.

Figure 9: Price strategy timeline, summarising the suitability for most farm businesses of different methods of price management for different phases of production.

Source: Profarmer Australia

they are useful as harvest and post

**Principle:** If increasing production risk, take price risk off the table.





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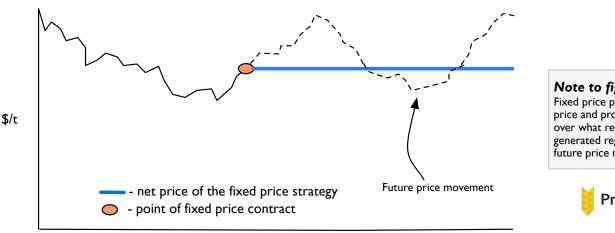
When committing to unknown production, price certainty should be achieved to avoid increasing overall business risk.

**Principle:** Separate the pricing decision from the delivery decision.

Most commodities can be sold at any time with delivery timeframes being negotiable, hence price management is not determined by delivery.

#### 1. Fixed price

A fixed price is achieved via cash sales and/or selling a futures position (swaps) (Figure 10). It provides some certainty around expected revenue from a sale as the price is largely a known factor, except when there is a floating component in the price, e.g. a multi-grade cash contract with floating spreads or a floating-basis component on futures positions.



#### Note to figure:

Fixed price product locks in price and provides certainty over what revenue will be generated regardless of future price movement.



Figure 10: Fixed price strategy.

Source: Profarmer Australia

#### 2. Floor price

Floor price strategies (Figure 11) can be achieved by utilising options on a relevant futures exchange (if one exists), or via a managed-sales program (i.e. a pool with a defined floor price strategy) offered by a third party. This pricing method protects against potential future price decrease while capturing any price increase. The disadvantage is that this kind of price 'insurance' has a cost, which adds to the farm's cost of production.

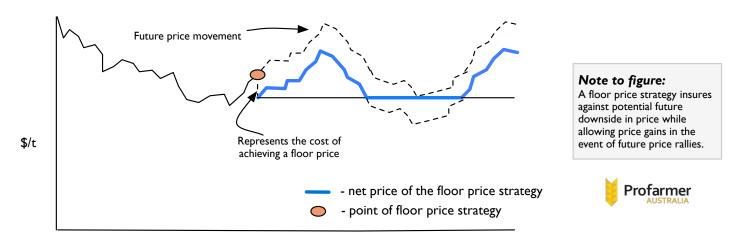


Figure 11: Floor price strategy.

Source: Profarmer Australia



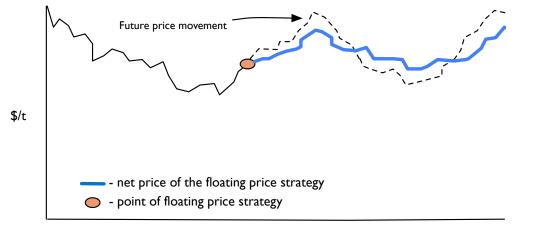






#### 3. Floating price

Many of the pools or managed-sales programs are a floating price, where the net price received will move up and down with the future movement in price (Figure 12). Floating price products provide the least price certainty and are best suited for use at or after harvest rather than before harvest.



#### Note to figure:

A floating price will move to some extent with future price movements.



Figure 12: Floating price strategy.

Source: Profarmer Australia

Having considered the variables of production for the crop to be sold, and how these fit against the different pricing mechanisms, the farmer may revise their selling strategy, taking the risks associated with each mechanism into account.

Fixed price strategies include physical cash sales or futures products, and provide the most price certainty, but production risk must be considered.

Floor price strategies include options or floor price pools. They provide a minimum price with upside potential and rely less on production certainty, but cost more.

Floating price strategies provide minimal price certainty, and so are best used after harvest. <sup>5</sup>

## 15.1.4 Ensuring access to markets

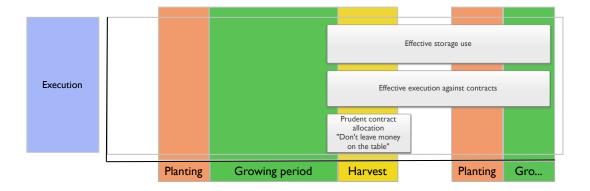
Once the questions of when and how to sell are sorted out, planning moves to the storage and delivery of commodities to ensure timely access to markets and execution of sales. Planning where to store the commodity is an important component of ensuring the type of access to the market that is likely to yield the highest return (Figure 13).







FEEDBACK



#### Note to figure:

Once a grower has made the decision to sell the question becomes how they achieve this? The decision on how to sell is dependent on:

a) Time of the year determines the pricing method
b) Market Access determines where to sell.
c) Relative value determines what to sell.



**Figure 13:** Storage decisions are influenced by selling decisions and the timing of all farming activities.

Source: Profarmer Australia

### Storage and logistics

The return on investment from grain handling and storage expenses is optimised when storage is considered in light of market access so as to maximise returns as well as harvest logistics.

Storage alternatives include variations of bulk handling, private off-farm storage, and on-farm storage. Delivery and quality management are key considerations in deciding where to store your commodity (Figure 14).

Principle: Harvest is the first priority.

During harvest, getting the crop into the bin is the most critical aspect of business success; hence storage, sale and delivery of grain should be planned well ahead of harvest to allow the grower to focus on the harvest itself.

Bulk export commodities requiring significant quality management are best suited to the bulk-handling system. Commodities destined for the domestic end user market, (e.g. feedlot, processor, or container packer), may be more suited to on-farm or private storage to increase delivery flexibility.

Storing commodities on the farm requires prudent quality management to ensure that the grain is delivered to the agreed specifications. If not well planned and carried out, it can expose the business to high risk. Penalties for out-of-specification grain arriving at a buyer's weighbridge can be expensive, as the buyer has no obligation to accept it. This means the grower may have to incur the cost of taking the load elsewhere, and may also have to find a new buyer.

On-farm storage also requires that delivery is managed to ensure that the buyer receives the commodities on time and with appropriate weighbridge and sampling tickets.

**Principle:** Storage is all about market access.

Storage decisions depend on quality management and expected markets.

For more information on on-farm storage alternatives and economics, see <u>Section 13:</u> <u>Grain Storage</u>.





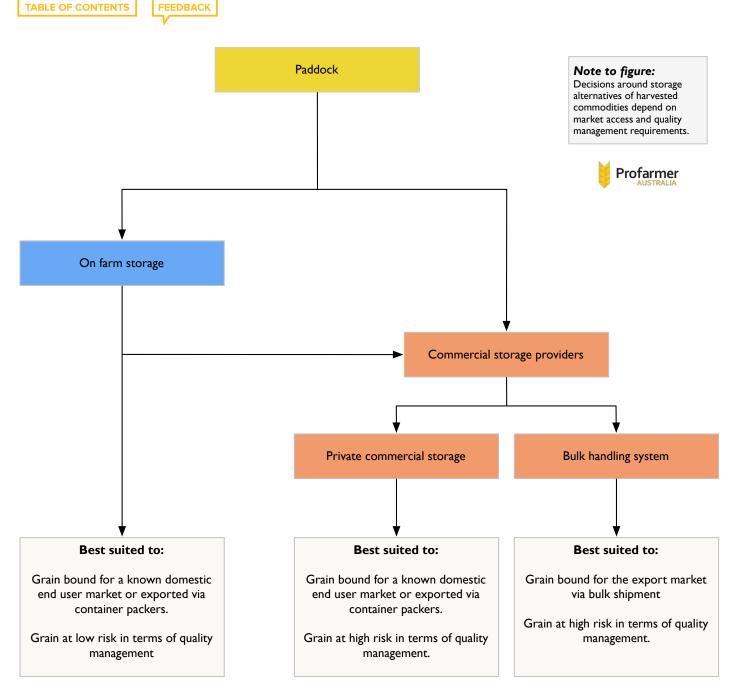


Figure 14: Grain storage decision-making.

Source: Profarmer Australia

#### Cost of holding grain

Storing grain to access sales opportunities post-harvest invokes a cost to 'carry', or hold, the grain. Price targets for carried grain need to account for the cost of carrying it. Carrying costs are typically \$3–4/t per month and consist of:

- monthly storage fee charged by a commercial provider (typically ~\$1.50-2.00/t)
- monthly interest associated with having wealth tied up in grain rather than available as cash or for paying off debt (~\$1.50-\$2.00/t, depending on the price of the commodity and interest rates).

The price of carried grain therefore needs to be \$3–4/t per month higher than the price offered at harvest (Figure 15).





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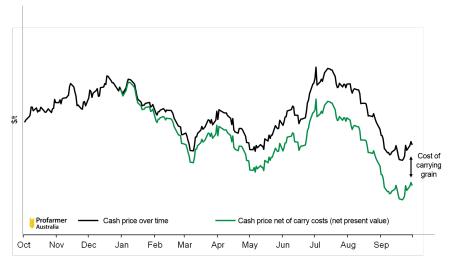




The cost of carrying also applies to grain stored on the farm, as there is the cost of the capital invested in the farm storage plus the interest component. A reasonable assumption is a cost of 3-4/t per month for on-farm storage.

Principle: Carrying grain is not free.

The cost of carrying grain needs to be accounted for if holding it for sale after harvest is part of the selling strategy. The usual way of doing this is to include it in the sale contract. For example, a crop sold in March for delivery in March—June on the buyer's call at \$300/t + \$3/t per month carrying would generate an income of \$309/t if delivered in June (Figure 15).



**Figure 15:** Cash values compared with cash values adjusted for the cost of carrying.

Source: Profarmer Australia

Optimising farm-gate returns involves planning the appropriate storage strategy for each commodity so as to improve market access and ensure that carrying costs are covered in the price received. <sup>6</sup>

## 15.1.5 Converting tonnes into cash

This section provides guidelines for converting the selling and storage strategy into cash by effective execution of sales.

#### Set up the toolbox

Selling opportunities can be captured when they arise by assembling the necessary tools in advance. The toolbox for converting tonnes of grain into cash includes the following.

- 1. Timely information—this is critical for awareness of selling opportunities and includes:
- market information provided by independent parties
- effective price discovery including indicative bids, firm bids and trade prices
- · other market information pertinent to the particular commodity.
- 2. Professional services—grain-selling professional services and cost structures vary considerably. An effective grain-selling professional will put their clients' best interests first by not having conflicts of interest and by investing time in the relationship. A better return on investment for the farm business is achieved through higher farm gate prices, which are obtained by accessing timely information, and being able to exploit the seller's greater market knowledge and greater market access.



<sup>6</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote









## **MORE INFORMATION**

Access to buyers, brokers, agents, products and banks through <u>Grain</u>
Trade Australia

Commodity futures brokers

ASX, Find a futures broker

 Futures account and a bank-swap facility—these accounts provide access to global futures markets. Hedging futures markets is not for everyone; however, strategies which utilise exchanges such as the Chicago Board of Trade (CBOT) can add significant value.

**NORTHERN** 

**MARCH 2017** 

### How to sell for cash

Like any market transaction, a cash—grain transaction occurs when a bid by the buyer is matched by an offer from the seller. Cash contracts are made up of the following components, with each component requiring a level of risk management (Figure 16):

- Price—future price is largely unpredictable, so devising a selling plan
  to put current prices into the context of the farm business is critical to
  managing price risk.
- Quantity and quality—when entering a cash contract, you are committing to deliver the nominated amount of grain at the quality specified, so production and quality risks must be managed.
- Delivery terms—the timing of the title transfer from the grower to the buyer is agreed at time of contracting. If this requires delivery direct to end users, it relies on prudent execution management to ensure delivery within the contracted period.
- Payment terms—in Australia, the traditional method of contracting requires title on the grain to be transferred ahead of payment, so counterparty risk must be managed.





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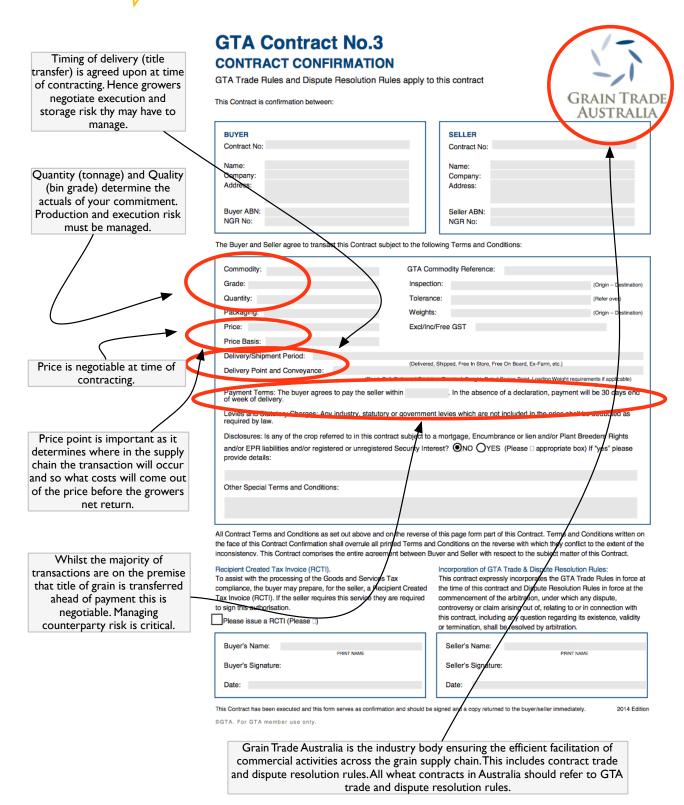


Figure 16: Typical terms of a cash contract.

Source: Grain Trade Australia

The price point within a cash contract will depend on where the transfer of grain title will occur along the supply chain. Figure 17 depicts the terminology used to describe these points and the associated costs to come out of each price before growers receive their net return.









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At weighbridge									
			Cartage	Cartage	Cartage	Cartage	Cartage	Cartage	Cartage
Farm gate		Levies & EPRs	Levies & EPRs	Levies & EPRs	Levies & EPRs	Levies & EPRs	Levies & EPRs	Levies & EPRs	Levies & EPRs
	Farm gate returns	Farm gate returns	Farm gate returns	Farm gate returns	Farm gate returns	Farm gate returns	Farm gate returns	Farm gate returns	Farm gate returns
	Net farm gate return	Ex-farm price	Up country delivered silo price. Delivered domestic to end user price. Delivered container packer price.	Free in store. Price at commercial storage.	Free on truck price	Post truck price	Port FIS price	Free on board price.	Carry and freight price.

**Figure 17:** Cost and pricing points throughout the supply chains.

Source: Profarmer Australia











## **MORE INFORMATION**

Grain Trade Australia, A guide to taking out grain contracts

<u>Grain Trade Australia, Trading</u> <u>standards</u>

GrainTransact Resource Centre

GrainFlow

**Emerald Grain** 

Clear Grain Exchange, Getting started

<u>Clear Grain Exchange, Terms and</u> conditions



## **MORE INFORMATION**

GTA, Managing counterparty risk

<u>Clear Grain Exchange's title transfer</u> <u>model</u>

GrainGrowers, <u>Managing risk in grain</u> contracts

Leo Delahunty, Counterparty risk: A producer's perspective

Cash sales generally occur through three methods:

- Negotiation via personal contact—traditionally prices are posted as a public
  indicative bid. The bid is then accepted or negotiated by a grower with the
  merchant or via an intermediary. This method is the most common and is
  available for all commodities.
- Accepting a public firm bid—cash prices in the form of public firm bids are posted
  during harvest and for warehoused grain by merchants on a site basis. Growers
  can sell their parcel of grain immediately by accepting the price on offer via an
  online facility and then transfer the grain online to the buyer. The availability of
  this option depends on location and commodity.

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• Placing an anonymous firm offer—growers can place a firm offer price on a parcel of grain anonymously and expose it to the entire market of buyers, who then bid on it anonymously using the Clear Grain Exchange, which is an independent online exchange. If the offer and bid match, the particulars of the transaction are sent to a secure settlement facility, although the title on the grain does not transfer from the grower until they receive funds from the buyer. The availability of this option depends on location and commodity. Anonymous firm offers can also be placed to buyers by an intermediary acting on behalf of the grower. If the grain sells, the buyer and seller are disclosed to each counterparty.

#### Counterparty risk

Most sales involve transferring the title on the grain prior to being paid. The risk of a counterparty defaulting when selling grain is very real and must be managed. Conducting business in a commercial and professional manner minimises this risk.

Principle: Seller beware.

There is not much point selling for an extra \$5/t if you don't get paid.

Counterparty risk management includes:

- Dealing only with known and trusted counterparties.
- Conducting a credit check (banks will do this) before dealing with a buyer they
  are unsure of.
- Selling only a small amount of grain to unknown counterparties.
- Considering credit insurance or a letter of credit from the buyer.
- Never delivering a second load of grain if payment has not been received for the first.
- Not parting with the title before payment, or requesting and receiving a cash
  deposit of part of the value ahead of delivery. Payment terms are negotiated
  at time of contracting. Alternatively, the Clear Grain Exchange provides secure
  settlement whereby the grower maintains title on the grain until they receive
  payment, and then title and payment are settled simultaneously.

Above all, act commercially to ensure the time invested in implementing a selling strategy is not wasted by poor management of counterparty risk.

#### Relative values

Grain sales revenue is optimised when selling decisions are made in the context of the whole farming business. The aim is to sell each commodity when it is priced well, and to hold commodities that are not well priced at any given time. That is, give preference to the commodities with the highest relative value. This achieves price protection for the overall revenue of the farm business and enables more flexibility to a grower's selling program while achieving the business goal of reducing overall risk.

Principle: Sell valued commodities, not undervalued commodities.

If one commodity is priced strongly relative to another, focus sales there. Don't sell the cheaper commodity for a discount.

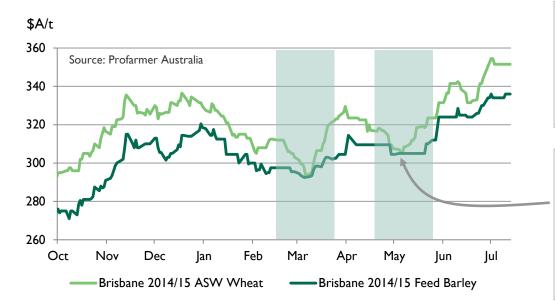
For example, a farmer with wheat and barley to sell would sell the one that is getting good prices relative to the other, and hold the other for the meantime (Figure 18).





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## Note to figure:

Price relativities between commodities is one method of assessing which grain types 'hold the greatest value' in the current market.

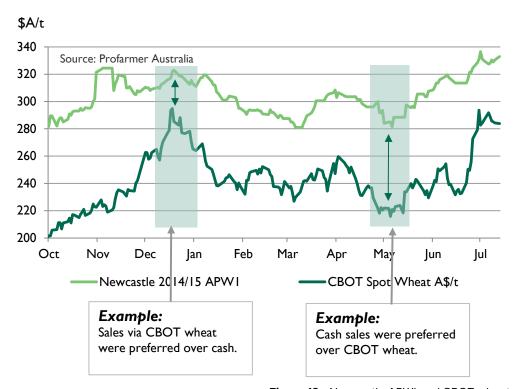
## Example:

Feed barley prices were performing strongly relative to ASW wheat values (normally ~15% discount) hence selling feed barley was more favourable than ASW wheat during this period.

**Figure 18:** Prices for Brisbane ASW wheat and feed barley are compared, and the barley held until it is favourable to sell it.

Source: Profarmer Australia

If the decision has been made to sell wheat, CBOT wheat may be the better alternative if the futures market is showing better value than the cash market (Figure 19).



## Note to figure:

Once the decision to take price protection has been made, choosing which pricing method to use is determined by which selling methods 'hold the greatest value' in the current market.

**Figure 19:** Newcastle APWI and CBOT wheat prices (A\$/t), showing when it is best to sell into each market.

Source: Profarmer Australia









#### Contract allocation

Contract allocation means choosing which contracts to allocate your grain against come delivery time. Different contracts will have different characteristics (e.g. price, premiums-discounts, oil bonuses), and optimising your allocation reflects immediately on your bottom line.

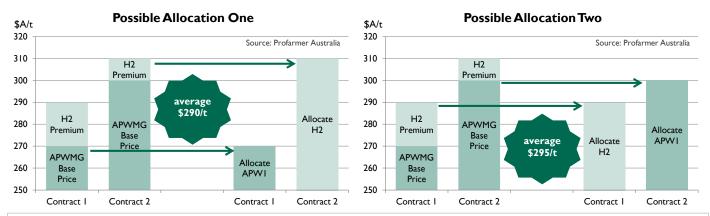
**Principle:** Don't leave money on the table.

Contract allocation decisions don't take long, and can be worth thousands of dollars to your bottom line.

To achieve the best average price for their crop growers should:

- allocate lower grades of grain to contracts with the lowest discounts.
- allocate higher grades of grain to contracts with the highest premiums (Figure 20).

The grower may have several options. For example, Figure 20 shows that the only difference between achieving an average price of \$290/t and \$295/t is which contract each parcel is allocated to. Over an amount of 400 t, the difference in average price equates to nearly \$2,000, which could be lost just in how parcels are allocated to contracts.



#### Note to figure:

In these two examples the only difference between acheiving an average price of \$290/t and \$295/t is which contracts each parcel was allocated to. Over 400/t that equates to \$2,000 which could be lost just in how parcels are allocated to contracts.

**Figure 20:** How parcels of the crop are allocated across contracts can make a substantial difference in income.

Source: Profarmer Australia

#### Read market signals

The appetite of buyers to buy a particular commodity will differ over time depending on market circumstances. Ideally growers should aim to sell their commodity when buyer appetite is strong, and stand aside from the market when buyers are not very interested.

Principle: Sell when there is buyer appetite.

When buyers are chasing grain, growers have more market power to demand the price they want.

Buyer appetite can be monitored by:

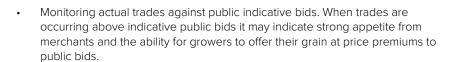
The number of buyers at or near the best bid in a public bid line-up. If there are
many buyers, it could indicate that buyer appetite is strong. However, if one
buyer is offering \$5/t above the next best bid, it may mean that cash prices are
susceptible to falling \$5/t as soon as that buyer satisfies their appetite.











The selling strategy is converted to maximum business revenue by:

- ensuring timely access to information, advice and trading facilities
- · using different cash-market mechanisms when appropriate
- minimising counterparty risk by conducting effective due diligence
- understanding relative value and selling commodities when they are priced well
- · thoughtful contract allocation
- reading market signals to extract value from the market or to prevent selling at a discount.  $^{7}$

## 15.2 Northern safflower: market dynamics and execution

#### 15.2.1 Price determinants for northern safflower

The main end uses of Australian safflower seed are oil and birdseed. The safflower market is small and volatile. Less than 1 million hectares per annum are grown globally, and production is around 500,000 mt. India produces around half the world's production. The US is the next largest producer, with California being the main source in the US. The other key players are China, Canada, Australia, Turkey, Russia, Argentina and Mexico.

The main markets for Australian safflower oil types are Japan, USA, Europe and India. Australian safflower for birdseed is sold domestically and also to Europe and Taiwan. There is a small domestic oil market.

Factors influencing price include production in competitor and destination countries, and the cost of competitors' oils. For this reason, it is important for Australian growers to understand the global safflower cropping calendar (Figure 21). <sup>8</sup>

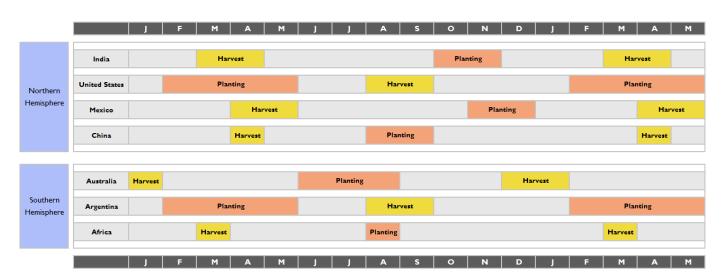


Figure 21: Global safflower crop calendar.



<sup>7</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote

<sup>8</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote



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## **MORE INFORMATION**

<u>International safflower production: An overview</u>

Raising the bar with better safflower agronomy

Australian Oilseeds Federation



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Most safflower grown in Australia is sold to Devexco or Adams Australia, and crushed by subcontractors. The remainder is for export to be crushed overseas, or for the domestic birdseed market. There are various Australian traders of safflower for birdseed, and they tend to be specialists in their field. Markets are variety-specific, so executing tonnes to cash starts when the grower selects the variety they will plant. Birdseed and oil seed types must be segregated carefully.

Closed-loop marketing may be available for some specialty oil varieties.

If marketing arrangements are not in place before harvest, it is essential to have available on-farm storage that is capable of holding safflower for an extended period of time. Safflower is a low-density seed. This make storage per tonne expensive, as it takes a greater volume to store or freight the seed than with other grains.

Stored seed is subject to the common insect pests of stored grain, and appropriate measures must be taken to ensure seed viability.  $^9$ 

## 15.3 Delivery standards

The standard oil content is 38%, with a 2% price premium or reduction for each percentage point above or below this level. Seed can be rejected if it contains >4% of impurities, and there is a one-for-one penalty >4% if the seed is accepted. Impurities consist of weed seeds, pieces of stem and seed, and other very small material that will pass through a screen with holes of 2 mm diameter.

Crops can be rejected if >7% of the seed is broken, and there is a price penalty of 0.5% for each percentage point of broken seed above this level. Broken seed normally results from mechanical damage, and consists of hulls, kernels and seed pieces.

Up to 3% of seed may be damaged without penalty, and seed will be rejected only if >40% is damaged. There is a half-for-one penalty >3%. Seed is regarded as 'damaged' if it is affected by heat, frost, sprouting or other weather damage. Current receival standards for polyunsaturated and monounsaturated safflower are shown in Tables 2 and 3.  $^{10}$ 



<sup>9</sup> Profarmer Australia (2016), Marketing Field Peas, GRDC Northern Field Pea GrowNote

<sup>10</sup> N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, <a href="http://www.qrdc.com.au/BetterSafflowerAgronomy">http://www.qrdc.com.au/BetterSafflowerAgronomy</a>







**Table 2:** Delivery standard for polyunsaturated (linoleic) safflower, as at 1 August 1 2009.

Parameter	Specification	Comment/price adjustment				
Physical and chemical parameters						
General		Safflower intended for delivery shall be free from any uncharacteristic odours, live stored product insect infestation and any nominated commercially unacceptable contaminant				
Oil	38% base level	2% premium or deduction for each 1% above or below 38%				
Linoleic acid	75% minimum	Rejectable under this limit				
Moisture	8% maximum	Immediate processing: if accepted over the maximum, 2% deduction for each 1% over maximum  For storage: if accepted over the maximum, 1.5% deduction for each 1% over maximum plus a drying charge				
Test weight	n/a					
Protein	n/a					
Seed retention	n/a					
Germination	n/a					
Defective safflower (max	x. % wt/wt based on	cleaned 0.5-L sample retained above 2.0-mm round-hole sieve)				
Broken or split	7% maximum	0.5% deduction for each 1% over the maximum				
Total defective including:	10% maximum	0.5% deduction for each 1% over the maximum				
Damaged	3% maximum	0.5% deduction for each 1% over the maximum, rejectable >10%				
Sprouted	5% maximum	0.5% deduction for each 1% over the maximum				
Contaminants (max. per 0	0.5 L unless otherwis	se stated, rejectable over unless deductions are stated as applying)				
Impurities	4% maximum					
Snails, stones	Nil above screen	Nil tolerance per 2.5-L sample for any snails or stones remaining above a 3.0-mm round-hole screen. If one snail or stone is found above the screen in the sample, th a further four 0.5-L samples should be taken. If a snail/stone is found in any of the subsequent samples, the load is to be rejected				
	1 stone or snail per 0.5 L below screen	Tolerance of 1 stone or snail per 0.5-L sample, passing through a 3.0-mm round-hole screen				
Field insects	10 large per 0.5 L	Includes Rutherglen bugs, ladybirds, grasshoppers and wood bugs				
	100 small per 0.5 L	Includes all species of aphid and all species of mites				
Ryegrass ergot	0.5 cm maximum	Maximum of all pieces aligned end on end				
Objectionable material	Nil	Harmful substances include live or dead stored-grain-product insects; live or dead pea weevil; glass; metal; specified weed seeds in excess of the limit prescribed in any of the State Stockfeed Regulations lists of permitted weed seeds; the presence of pre- or post-harvest chemicals not registered for use, used in excess of permitted levels or with residues in excess of their permitted levels; smut; material imparting an odour to the grain; sand; earth; sticks and pickled grain. Includes degraded seed such as smutty seed, hot seed, musty seed, sour seed, mouldy seed				
Seed contaminants (max. tolerance per 0.5 L to apply to individual seeds, rejectable over)						
Туре А	Nil	Alligator weed, Cape tulips, castor oil plant, coriander, creeping knapweed, Darling pea, dodder, giant sensitive plant, opium poppy, Parthenium weed, ragweed, rattlepod, saffron thistle, star burr, stinkwort, St. Johns wort				
Type B	1	Burrs (Xanthium spp.): all except where otherwise stated; wild mignonette				
Type C	2	Crow garlic, skeleton weed, thornapple				
Type D	3	Common heliotrope, darnel, Hexham scent, jute, Mexican poppy, mintweed, nightshade				
Type E	65	Sesbanian pea				









**Table 3:** Delivery standards for monounsaturated (oleic) safflower, as at 1 August 1 2009.

Parameter	Specification	Comment/price adjustment				
Physical and chemical parameters						
General		Safflower tended for delivery shall be free from any uncharacteristic odours, live stored product insect infestation and any nominated commercially unacceptable contaminant				
Oil	38% base level	2% premium or deduction for each 1% above or below 38%				
Linoleic acid	75% minimum	Rejectable under this limit				
Moisture	8% maximum	Immediate processing: if accepted over the maximum, 2% deduction for each 1% over maximum  For storage: if accepted over the maximum, 1.5% deduction for each 1% over maximum plus a drying charge				
Test weight	n/a					
Protein	n/a					
Seed retention	n/a					
Germination	n/a					
Defective safflower (ma	ax. % wt/wt based on c	leaned 0.5-L sample retained above 2.0-mm round-hole sieve)				
Broken or split	7% maximum	0.5% deduction for each 1% over the maximum				
Total defective, including:	10% maximum	0.5% deduction for each 1% over the maximum				
Damaged	3% maximum	0.5% deduction for each 1% over the maximum, rejectable >10%				
Sprouted	5% maximum	0.5% deduction for each 1% over the maximum				
Contaminants (max. pe	er 0.5 L unless otherwis	se stated, rejectable over unless deductions are stated as applying)				
Impurities	4% maximum	1% deduction for each 1% of impurities up to 4%, 2% deduction for each 1% of impurities over 4% $$				
Snails or stones	Nil above screen	Nil tolerance per 2.5-L sample for any snails or stones remaining above a 3.0-mm round-hole screen. If one snail or stone is found above the screen in the sample, then a further four 0.5-L samples should be taken. If a snail or stone is found in any of the subsequent samples, the load is to be rejected				
	1 stone/snail per ½ litre below screen	Tolerance of 1 stone or snail per 0.5-L sample, passing through a 3.0-mm round-hole screen				
Field insects	10 large per ½ litre	Includes Rutherglen bugs, ladybirds, grasshoppers and wood bugs				
	100 small per ½ litre	Includes all species of aphid and all species of mites				
Ryegrass ergot	0.5 cm maximum	Maximum of all pieces aligned end on end				
Objectionable material	Nil	Harmful substances include live or dead stored grain product insects; live or dead pea weevil; glass; metal; specified weed seeds in excess of the limit prescribed in any of the State Stockfeed Regulations lists of permitted weed seeds; the presence of pre or post-harvest chemicals not registered for use, used in excess of permitted levels or with residues in excess of their permitted levels; smut; material imparting an odour to the grain; sand; earth; sticks and pickled grain. Includes degraded seed such as smutty seed, hot seed, musty seed, sour seed, mouldy seed				
Seed contaminants (max. tolerance per 0.5 L to apply to individual seeds, rejectable over)						
Туре А	Nil	Alligator weed, Cape tulips, castor oil plant, coriander, creeping knapweed, Darling pea, dodder, giant sensitive plant, opium poppy, Parthenium weed, ragweed, rattlepod, saffron thistle, star burr, stinkwort, St. Johns wort				
Туре В	1	Burrs (Xanthium spp.): all except where otherwise stated; wild mignonette				
Туре С	2	Crow garlic, skeleton weed, thornapple				
Type D	3	Common heliotrope, darnel, Hexham scent, jute, Mexican poppy, mintweed, nightshade				
Type E	65	Sesbanian pea				





## **Current and past research**

# Project Summaries www.grdc.com.au/ProjectSummaries

As part of a continuous investment cycle each year the Grains Research and Development Corporation (GRDC) invests in several hundred research, development and extension and capacity building projects. To raise awareness of these investments the GRDC has made available summaries of these projects.

These project summaries have been compiled by GRDC's research partners with the aim of raising awareness of the research activities each project investment.

The GRDC's project summaries portfolio is dynamic: presenting information on current projects, projects that have concluded and new projects which have commenced. It is updated on a regular basis.

The search function allows project summaries to be searched by keywords, project title, project number, theme or by GRDC region (i.e. Northern, Southern or Western Region).

Where a project has been completed and a final report has been submitted and approved a link to a summary of the project's final report appears at the top of the page.

The link to Project Summaries is <a href="www.grdc.com.au/ProjectSummaries">www.grdc.com.au/ProjectSummaries</a>

# Final Report Summaries http://finalreports.grdc.com.au/final\_reports

In the interests of raising awareness of GRDC's investments among growers, advisers and other stakeholders, the GRDC has available final reports summaries of projects.

These reports are written by GRDC research partners and are intended to communicate a useful summary as well as present findings of the research activities from each project investment.

The GRDC's project portfolio is dynamic with projects concluding on a regular basis.

In the final report summaries there is a search function that allows the summaries to be searched by keywords, project title, project number, theme or GRDC Regions. The advanced options also enables a report to be searched by recently added, most popular, map or just browse by agro-ecological zones.

The link to the Final Report Summaries is <a href="http://finalreports.grdc.com.au/final\_reports">http://finalreports.grdc.com.au/final\_reports</a>

# Online Farm Trials http://www.farmtrials.com.au/

The Online Farm Trials project brings national grains research data and information directly to the grower, agronomist, researcher and grain industry community through innovative online technology. Online Farm Trials is designed to provide growers with the information they need to improve the productivity and sustainability of their farming enterprises.

Using specifically developed research applications, users are able to search the Online Farm Trials database to find a wide range of individual trial reports, project











summary reports and other relevant trial research documents produced and supplied by Online Farm Trials contributors.

The Online Farm Trials website collaborates closely with grower groups, regional farming networks, research organisations and industry to bring a wide range of crop research datasets and literature into a fully accessible and open online digital repository.

Individual trial reports can also be accessed in the trial project information via the Trial Explorer.

The link to the Online Farm Trials is <a href="http://www.farmtrials.com.au/">http://www.farmtrials.com.au/</a>





# **Key contacts**

## **GRDC Panel**

## John Minogue, Chair

John Minogue runs a mixed broadacre farming business and an agricultural consultancy, Agriculture and General Consulting, at Barmedman in south-west NSW. John is chair of the local branch of the NSW Farmers' Association, has formerly sat on the grains committee of the NSW Farmers' Association and is a winner of the Central West Conservation Farmer of the Year award. John has also been involved in the biodiversity area as a board member of the Lachlan Catchment Management Authority. His vast agricultural experience in central west NSW has given him a valuable insight into the long-term grains industry challenges.



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## Penny Heuston, Deputy Chair

Penny Heuston is an agronomist based in Warren, NSW. She is passionate about the survival of the family farm and its role in the health of local economies. Penny is dedicated to ensuring research is practical, farm-ready and based on sound science and rigour. She sees 'two-way communication' as one of the panellists' primary roles and is committed to bringing issues from the paddock to 'the lab' and conversely, the science to the paddock.



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#### **Loretta Serafin**

Loretta Serafin has extensive experience as an agronomist in north-west NSW and works with the NSW Department of Primary Industries in Tamworth. As the leader northern dryland cropping systems, she provides expertise and support to growers, industry and agronomists in the production of summer crops. Loretta is a member of numerous industry bodies and has a passion for helping growers improve farm efficiency. She sees her role as a conduit between advisers,



growers and the GRDC to ensure growers' research needs are being met.

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## **Jules Dixon**

Jules Dixon has an extensive background in agronomy and an established network spanning eastern Australia and WA including researchers, leading growers and agronomy consultants through to the multinational private sector. Based in Sydney, Jules operates a private consultancy specialising in agronomy, strategy development and business review.





## **Dr Neil Fettell**

Neil Fettell is a part-time senior research adviser with Central West Farming Systems and runs a small irrigation farm near Condobolin, NSW. Neil has a research agronomy background, conducting field research in variety improvement, crop physiology and nutrition, Water Use Efficiency and farming systems. He is a passionate supporter of research that delivers productivity gains to growers, and of grower participation in setting research goals.



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## **Andrew McFadyen**

Andrew McFadyen is an agronomist and manager with Paspaley Pastoral Company near Coolah, NSW, with more than 15 years' agronomy and practical farm management experience. He is an active member of the grains industry with former roles on the Central East Research Advisory Committee, NSW Farmers Coolah branch and planning committees for GRDC Updates. He is also a board member and the chair of Grain Orana Alliance.



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#### Jack Williamson

Jack Williamson is a private agricultural consultant and helps run a family broadacre farm near Goondiwindi, Queensland. Six years of retail agronomy and three years of chemical sales management have given Jack extensive farming systems knowledge, and diverse crop management and field work experience. He is a member of the Northern Grower Alliance local consultative committee and Crop Consultants Australia.



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#### **Arthur Gearon**

Arthur Gearon is a grain, cotton and beef producer located near Chinchilla, Queensland. He has a business degree from the Queensland University of Technology in international business and management and has completed the Australian Institute of Company Directors course. He is vice-president of AgForce Grains and has an extensive industry network throughout Queensland. Arthur believes technology and the ability to apply it across industry will be the key driver for economic growth in the grains industry.



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## **Dr Tony Hamilton**

Tony Hamilton is a grower from Forbes, NSW, and managing director of an integrated cropping and livestock business. He is a director of the Rural Industries Research and Development Corporation. He has worked as an agricultural consultant in WA and southern NSW. With a Bachelor of Agricultural Science and a PhD in agronomy, Tony advocates agricultural RD&E and evidence-based agriculture.



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#### **Brondwen MacLean**

Brondwen MacLean was appointed to the Northern Panel in August 2015 and is the GRDC executive manager for research programs. She has primary accountability for managing all aspects of the GRDC's nationally coordinated R&D investment portfolio and aims to ensure that these investments generate the best possible return for Australian grain growers. Prior to her current appointment, Brondwen was senior manager, breeding programs, and theme coordinator for Theme 6, Building Skills and Capacity.



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#### **David Lord, Panel Support**

David Lord operates Lord Ag Consulting, an agricultural consultancy service. Previously, David worked as a project officer for Independent Consultants Australia Network, which gave him a good understanding of the issues growers are facing in the northern grains region. David is the Northern Panel and Regional Grower Services support officer.



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## References

## **Section A: Introduction**

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