20 TIPS FOR PROFITABLE CANOLA

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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CSIRO

NSW GOVERNMENT | Department of Primary Industries

OPTIMISED CANOLA PROFITABILITY

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THE OPTIMISED CANOLA PROFITABILITY PROJECT 2014–19

Canola is Australia's third largest grain crop and is known for its value as a break crop for weed and disease management, and for its profitability when managed well. Despite these accepted benefits, growers and advisers across the country were rightly concerned about managing the risks and high relative costs of growing canola, especially in the face of more variable seasonal conditions.

In 2014, the GRDC co-invested in a five year program of research across eastern Australia that aimed to equip growers with tactical agronomy strategies for canola, underpinned by world-leading crop physiology research. The collaborative research team comprised CSIRO, NSW DPI and collaborators in four eastern mainland states using 60 field experiments and detailed physiological studies across nine regions. The team focused on gaining a thorough understanding of factors driving crop growth, development, flowering time, yield formation and response to stress to provide tips and tactics to improve canola profit and reduce risk. Issues resolved by the research include:

- What drives different flowering times in canola varieties in different regions?
- How do I know what varieties I can sow early with success?
- What's the most cost-effective way to increase profit – sowing date, variety, N, seeding rate?
- Does canola have a "critical period" when it is most sensitive to stress?
- When is the best time for canola to flower on my farm?
- When is the best time to windrow for highest yield and oil?

Our research team has provided answers to these questions and more, as the pathway to improved and more reliable canola profit.
We present them here as *20 Tips for Profitable Canola* organised in a calendar of seasonal decisions that confront growers during the canola-growing year. For those interested in more detail, links are provided for further reading on individual topics.


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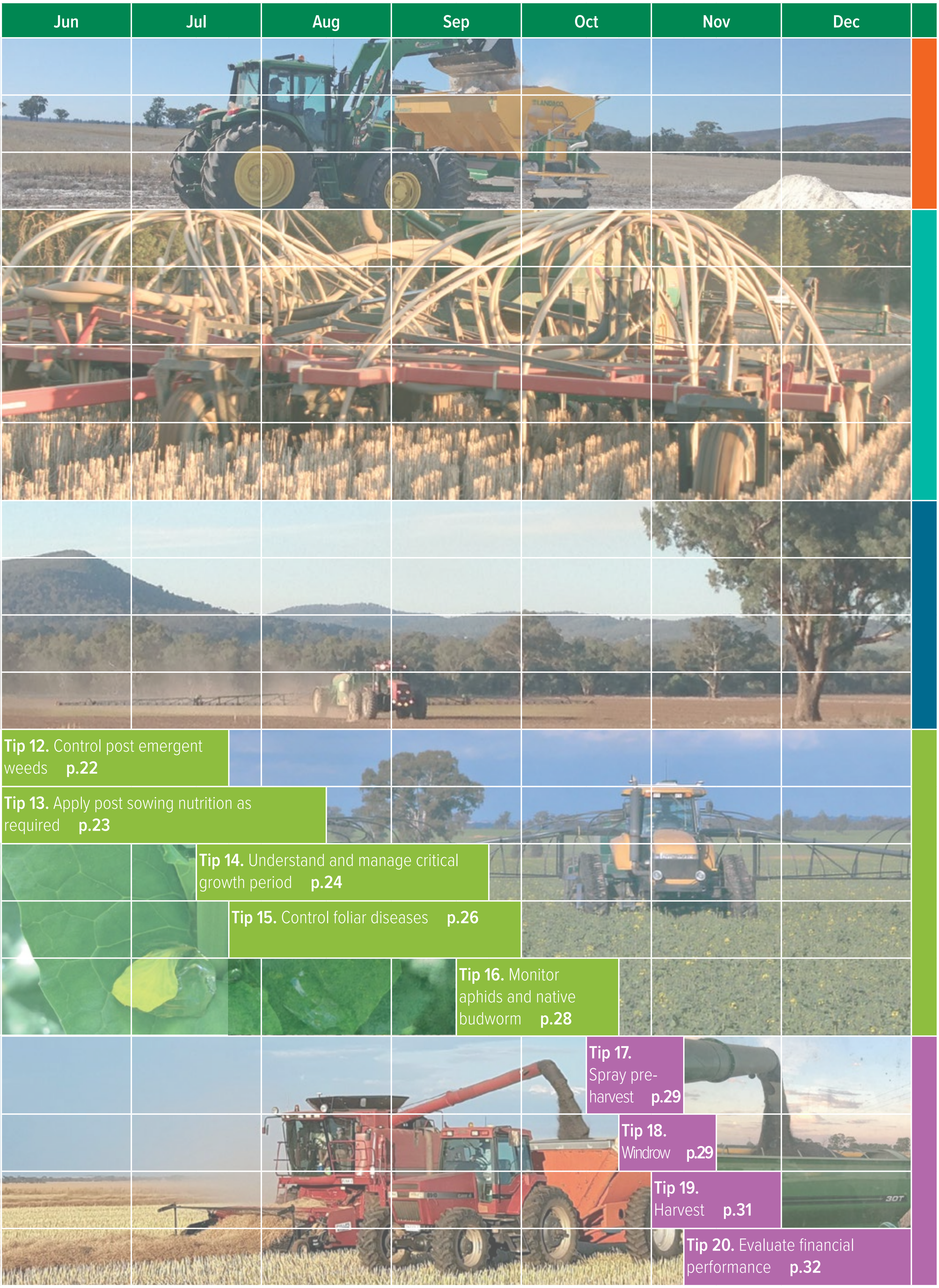
Calendar of decisions (contents)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SECTION 1: CROP PLANNING AND PREPARATION

1 Fallow management

Since the Millennium Drought, there has been increased recognition of the value of out-of-season rainfall to the following grain crop.

Conserving moisture from summer rain contributes an average 25mm plant available water (PAW) on clay soils at Hart and close to 33mm PAW at Minnipa and 35mm on sand at Waikerie. There is also a 0.6kg N/ha benefit for each extra millimetre of PAW conserved from summer weed control. To get the best out of summer rain, it is important to:

1. Spread crop residue evenly at harvest to avoid bare soil or heavy clumps.
2. Control summer weeds when they are small, before they start to use soil moisture.
3. If grazing, ensure that at least 2t/ha stubble biomass (70% cover) is maintained at all times.

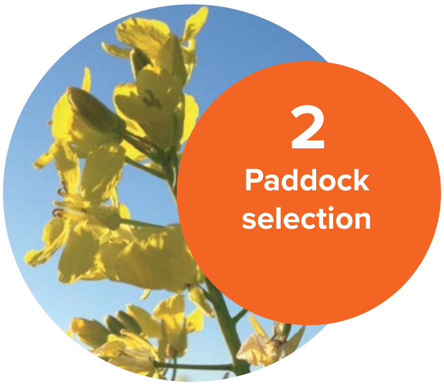
Further information

Contribution of summer fallow rain to crop yield in southern Australia http://bit.ly/fallow-rain

Graze and retain stubble for profit http://bit.ly/stubble-profit

Sheep impacts on stubble http://bit.ly/stubble-sheep

2 Paddock selection



The two most important factors to consider when selecting paddocks for canola are nitrogen and stored soil water.

Growing canola after a pulse crop or long fallow will ensure relatively high nitrogen and plant available water (PAW) levels.

In the low rainfall zones of South Australia (Upper Eyre Peninsula, Upper North and Mallee), it is risky to sow canola when either water or nitrogen levels are low, and especially when both are low.

In South Australian areas with reliable winter and spring rainfall, selecting paddocks with high starting N will increase crop yield potential, especially for hybrids.

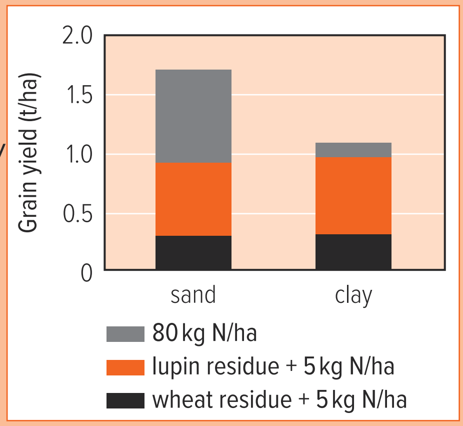
Sowing canola after legumes minimises problems with high cereal stubble loads and boosts crop N fertility.

Research has shown that very high nitrogen (N) application rates (over 150kg N/ha) are required to achieve high yield when soil N reserves are low. Selecting paddocks with high starting N levels reduces costs associated with reliance on fertiliser N.

Lentils and faba beans are a profitable crop in many regions of South Australia and planting canola after lentils will improve canola profitability.

Karoonda 2017

In low rainfall environments, the cost of production is a key consideration given the variability in yields achieved. One option explored to reduce input costs, was to grow canola on legume stubbles in order to reduce N fertiliser costs. Experiments showed that legumes offered a significant yield benefit to subsequent canola (0.6t/ha on average at two Mallee sites) compared to canola following wheat. They also showed that on the lower fertility sands there was still a benefit of adding fertiliser N to canola grown on the legume stubble (canola yielding 0.8t/ha more with 80kg N/ha).



Other important factors to consider when selecting paddocks for canola include:

- **Weeds** – select a paddock with a low broadleaf weed burden to reduce the reliance on herbicides for control.
- **Stubble cover** – select paddocks with even stubble residue cover, which will help retain moisture in the soil surface and maximise success with autumn sowing opportunities.
- **Herbicide residues** – be mindful of herbicide residues from previous crops and from the fallow phase, especially Group B (except where a tolerant variety will be grown) and Group I products.

Further information

Water and N accumulation effects on winter crop yield
http://bit.ly/WaterNitrogen

There are three key decision areas with variety selection:

1. varietal phenology.
2. breeding type (hybrid or open-pollinated).
3. herbicide tolerance.

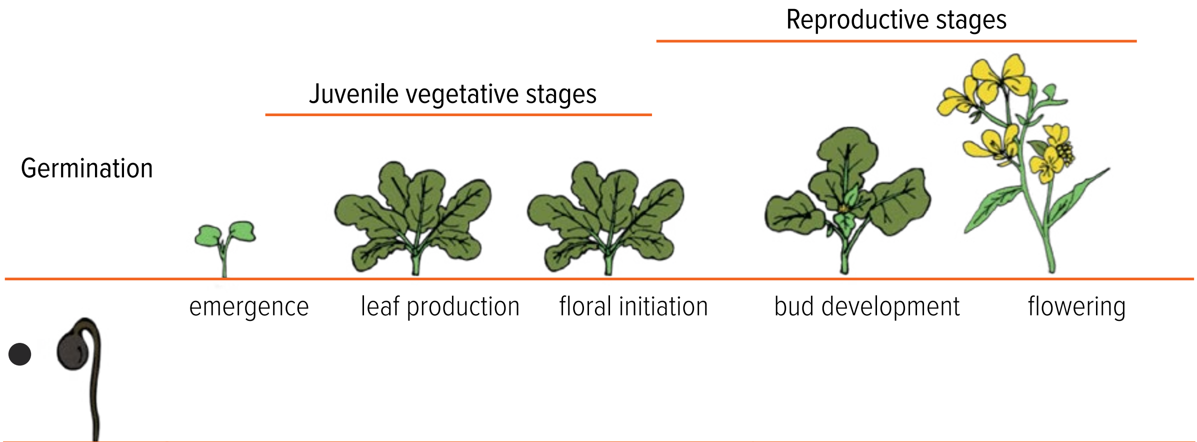
Varietal phenology

What is phenology?

When studying plants, distinct stages of growth have been identified and these have been formalised into keys that are often used in both plant physiology and agronomy. The description of crop growth stages is called the phenology of the plant. The most common and easily recognised canola stages are emergence, green bud, flowering, podding, end of flowering and maturity.

Plants respond to temperatures, to determine when they move from one growth stage to another. A simple way to think of this is as a biological clock that accumulates average daily temperatures (day degrees) until a specific target (thermal time target) is met.

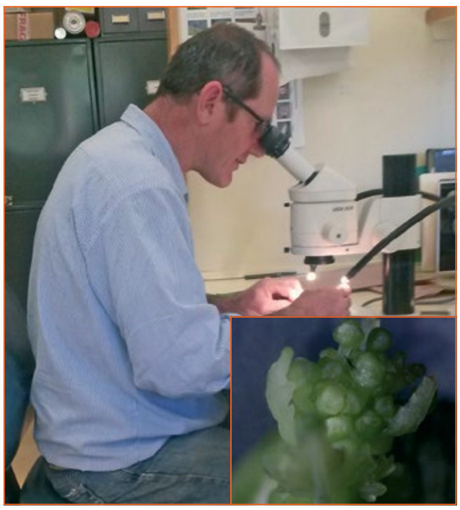
Canola growth stages highlighting the different stages and the dominant environmental signals that influence growth in that stage.



Influenced by soil moisture temperature	Influenced by temperature and day length	Influenced by temperature and some day length
	thermal time, photoperiod, vernal time	thermal time, photoperiod

Why is phenology important?

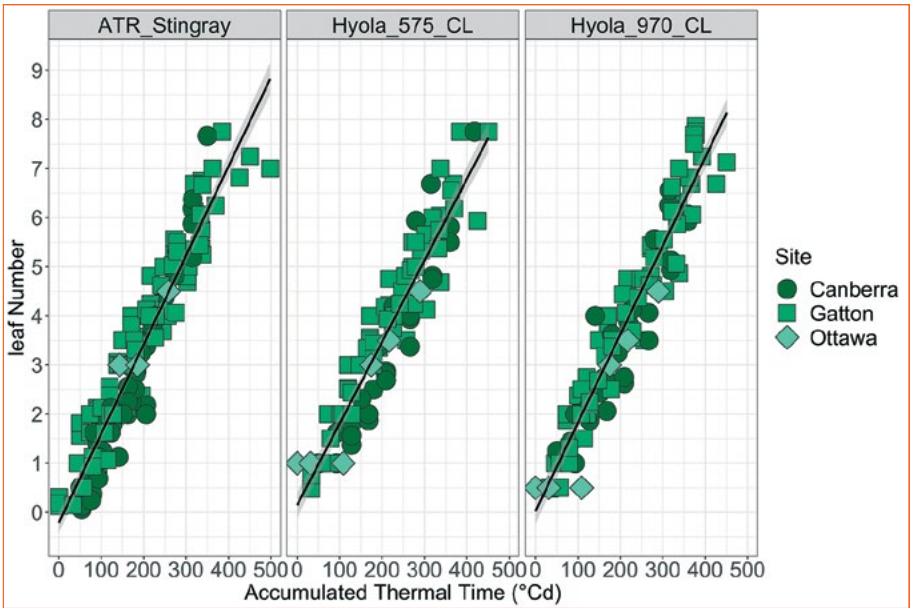
There is a range of canola phenology types distinguished by the time they start flowering. However, phenology responses change with environment. Flowering time is one of the most important drivers of canola grain yield. It is important that canola flowers within a particular window for a given environment. If a canola crop flowers too early it will be exposed to: higher frost risk; increased damage from upper canopy blackleg infection; greater risk of sclerotinia stem rot; and will accumulate limited biomass (linked to yield potential). If the crop flowers too late it will have increased risk of damage from heat and drought stress.



Each canola variety has a set of triggers that drive its development and control flowering time; thermal time (day degrees), vernalisation (cold) and photoperiod (day length). Each of the development triggers could play a different role in each variety.

To match a variety with a sowing time in a particular environment and have it flower within the optimum window requires an understanding of the phenology for each different variety. We have determined how each variety responds to thermal time and photoperiod, in contrast to calculating the number of days since sowing.

Using thermal time (day degrees) to describe leaf appearance the development (phenology) was the same at all three environments despite obvious differences in biomass and days to flowering (photos).



Leaf appearance rates at three different environments (Canberra ACT, Gatton QLD and Ottawa Canada).

Rate of leaf appearance (relative to temperature) is the same in all three environments.

How can we use phenology?

Having a range of phenology types is an advantage to a farming system, sowing slower developing varieties earlier and faster developing varieties later can help ensure all paddocks flower at the optimal time to maximise yield. Taking advantage of long season varieties for dual-purpose graze and grain allows two enterprises to benefit, provided you are in the right environment and have sufficient resources.

In recent seasons, the OCP teams have determined the phenology of new canola varieties to ensure they are sown at the optimum time in each environment. This will be updated as new varieties are released.

Same varieties

Sown first week of May

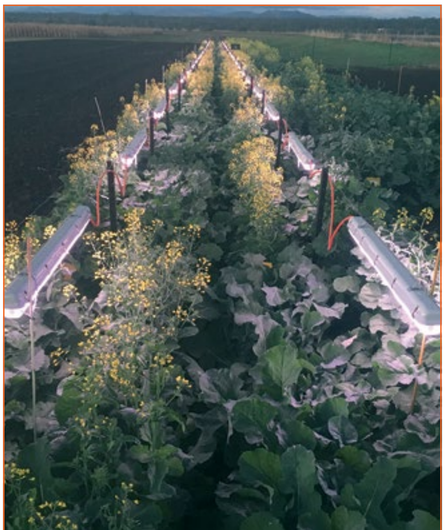
Photos last week in June

Different environments

Canberra ACT

Gatton QLD

Ottawa CANADA



Lights extend day length in canola photoperiod experiment, Gatton QLD.

Variety	Phenology*	Maturity	Herbicide tolerance	Breeding type (hybrid or OP)
Nuseed Diamond	Fast	Early	Conventional	Hybrid
ATR Stingray	Fast	Early	Triazine	OP
Hyola 350TT	Fast	Early	Triazine	Hybrid
SF Spark TT	Fast*	Early	Triazine	Hybrid
Hyola 506RR	Fast	Mid-early	Roundup Ready	Hybrid
Hyola 580CT	Fast	Mid-early	Imidazolinone/Triazine	Hybrid
HyTTec Trident	Mid-fast	Early	Triazine	Hybrid
Hyola 550TT	Mid-fast*	Mid	Triazine	Hybrid
InVigor T3510	Mid-fast*	Early to early-mid	Triazine	Hybrid
Banker CL	Mid-fast	Mid	Imidazolinone	Hybrid
InVigor T4510	Mid-fast	Early-mid	Triazine	Hybrid
Saintly CL	Mid-fast	Early-mid	Imidazolinone	Hybrid
Pioneer 44T02 (TT)	Mid-fast	Early-mid	Triazine	Hybrid
Hyola 530XT	Mid-fast*	Mid	Truflex/Triazine	Hybrid
Xseed Raptor	Mid-fast*	Mid-early	Truflex	Hybrid
Hyola 410XX	Mid-fast*	Mid-early	Truflex	Hybrid
ATR Flathead	Mid-fast*	Early	Triazine	OP
ATR Bonito	Mid-fast	Early to early-mid	Triazine	OP
InVigor R4022P	Mid-fast*	Mid-early	Truflex	Hybrid
Pioneer 43Y92 (CL)	Mid-fast	Early	Imidazolinone	Hybrid
Pioneer 43Y29 (RR)	Mid-fast*	Early	Roundup Ready	Hybrid
Pioneer 44Y27 (RR)	Mid-fast	Early-mid	Roundup Ready	Hybrid
Pioneer 44Y90 (CL)	Mid-fast	Early-mid	Imidazolinone	Hybrid
ATR Mako	Mid-fast	Mid-early	Triazine	OP
Nuseed Quartz	Mid	Mid to mid-early	Conventional	Hybrid
HyTTec Trophy	Mid	Early to early-mid	Triazine	Hybrid
Pioneer 45T03 (TT)	Mid	Mid	Triazine	Hybrid
ATR Gem	Mid	Mid-early	Triazine	OP
DG 670TT	Mid	Mid	Triazine	Hybrid
GT-53	Mid	Mid	Roundup Ready	Hybrid
Victory V75-03CL	Mid-slow*	Mid	Imidazolinone	Hybrid
Pioneer 45Y93 (CL)	Mid-slow*	Mid	Imidazolinone	Hybrid
Pioneer 45Y91 (CL)	Mid-slow	Mid	Imidazolinone	Hybrid
InVigor R5520P	Mid-slow	Mid to mid-late	Roundup Ready	Hybrid
SF Ignite TT	Mid-slow	Mid to mid-late	Triazine	Hybrid
ATR Wahoo	Mid-slow	Mid-late	Triazine	OP
Pioneer 45Y25 (RR)	Mid-slow	Mid	Roundup Ready	Hybrid
Archer	Slow	Mid-late	Imidazolinone	Hybrid
Victory 7001 (CL)	Slow	Mid-late	Imidazolinone	Hybrid
Pheonix CL	Winter	Winter	Imidazolinone	Hybrid
Edimax CL	Winter	Winter	Imidazolinone	Hybrid
Hyola 970CL	Winter	Winter	Imidazolinone	Hybrid

Phenology response to early sowing. Rankings may vary for later sowing dates. Varieties are ranked from fastest to slowest within phenology groups

* One year (2019) experiment data only

How do I know what suits my environment?

A range of tools exist to help you understand what type of canola suits your environment. The *Ten tips to early-sown canola* (https://grdc.com.au/10TipsEarlySownCanola) is a valuable resource for those considering sowing early. *Optimal flowering periods for canola in eastern Australia* explains the importance of getting flowering right and a new app has been released at canolaflowering.com

Further information

Matching canola phenology to the environment http://bit.ly/match-canola

Canola agronomy and phenology to optimise yield http://bit.ly/agron-phenology

Canola – critical agronomy for optimal canola growth http://bit.ly/critical-agron

Breeding type

Open-pollinated

Open-pollinated (OP) canola is the dominant canola type in South Australia as growers are able to retain seed from season to season. Allowing for seed grading and treatment, OP seed generally costs about 10% of hybrid seed.

OP varieties have lower yield potential than hybrids and there is little diversity in their breeding background for blackleg disease resistance. OP canola significantly reduces the financial risk of growing canola and allows growers to react to seasonal breaks, as it is more practical to have seed of several varieties with different phenology on hand.

Hybrid

Hybrid canola is increasing in popularity in South Australia, providing more herbicide options, improved disease resistance and higher yields than OP canola. Seed cost of hybrid canola is much greater than OP canola which increases the risk of growing canola in more marginal areas. Seed orders need to be made early to ensure supply of the desired variety which means that it is difficult to react to the timing of an autumn break by swapping phenology type.

Herbicide tolerance

Triazine tolerant (TT)

Generally lower biomass and lower yielding than non-TT canola but robust weed control options.

Imidazolinone tolerant (IT, Clearfield®)

Very high grain yield potential but high upfront seed cost. Especially useful in rotations with other imi-tolerant (IT) crops.

Roundup Ready® (RR)

Very high grain yield and broad spectrum weed control. Price is generally discounted compared with non-GM canola. Truflex® with Roundup Ready® technology extends the application window to control later germinating weeds.

Dual herbicide tolerant (RR/TT, IT/TT, TruFlex® RR/TT, TruFlex® RR/IT)

Offers benefits of multiple modes of action, especially useful for managing soil herbicide residues.

Conventional canola

High grain yield but with limited herbicide options.

Hybrid non-TT canola has yielded 16% higher than OP TT canola, on average in OCP research.

Example 1: medium rainfall zone average yield 1.8t/ha and grain price $500/t, equates to an additional $135/ha income, easily paying for the additional seed cost.

Example 2: lower yield potential SA Mallee with average yield 1t/ha and grain price $500/t, equates to additional $80/ha income, a margin of $24/ha compared with a hybrid seed cost $56/ha.

Further information

Ten tips to early sown canola https://grdc.com.au/10TipsEarlySownCanola

Winter Crop Variety Sowing Guide http://bit.ly/WCVSG

National Variety Trials™ https://www.nvtonline.com.au/

SECTION 2: MATCH VARIETAL PHENOLOGY WITH SOWING DATE

Optimal Start of Flowering in Canola

- The optimal start of flowering (OSF) for canola has been identified for locations across Australia.
- Duration and timing of the OSF varies with site and season but not with variety.
- Sowing date x variety combinations that achieve OSF and maximise yield have been identified.

What is OSF?

The OSF is the period when canola should start flowering for highest average yield potential at a given location. Crops that flower too early might have insufficient biomass or frost damage, while late flowering could increase damage from heat and terminal water stress.

Knowing the OSF is especially important for crops sown prior to the traditional sowing window (late April to early May). We have defined the OSF for canola at 77 sites across Australia's winter cropping zone.

The OSF at a location depends on timing and frequency of extreme temperatures and the pattern of water stress.

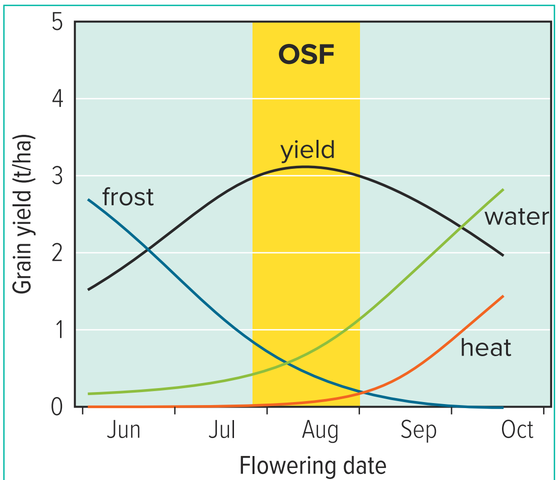
Start of flowering is defined as when 50% of plants have one open flower. The plot in the centre (below) is at the start of flowering and is flanked by plots that started flowering 10 to 15 days earlier.

- Flowering in the OSF period maximises average yield.
- Flower too early: risk of frost stress during early grain fill is high.
- Flower too late: risk of heat stress during flowering is high.
- Flowering too late increases the risk of water stress.
- Locations differ in the relative importance of frost, heat and water stress.

In mild environments the OSF is relatively long (e.g. eight weeks at Hamilton, VIC), while in low rainfall environments the OSF is quite short (e.g. 19 days at Condobolin, NSW). In warmer northern environments the OSF is earlier (e.g. 10 July to 8 August at Moree, NSW) while further south it is usually later (e.g. 30 July to 1 September at Wagga Wagga, NSW).

When defined in this way, the OSF does not account for pest or disease stresses. Growers should consider that disease risks interact with the OSF which has been defined only by long-term average conditions of temperature and water availability. See *Tip 15 Control foliar diseases*.

The OSF for locations in South Australia is shown on the next page. The OSF for eastern state locations are shown in detail on page 2 of *Ten Tips to Early Sown Canola*.



Frost, heat and water stress reduce yield

Optimal start of flowering period for local sites

- Maximise yield by flowering in the period around the optimum flowering date.
- For example, at Hart canola should start flowering between 6 July and 12 August (from 19 days before 25 July to 19 days afterwards).

South Australia				
Location	Optimal start of flowering date	Acceptable range (days)	Soil type	PAWC (mm)
Bute	18 July	42	Red sandy clay loam	139
Kadina	18 July	36	Calcic loam	102
Lamaroo	19 July	32	Loamy sand	90
Yeelanna	19 July	53	Duplex	152
Minlaton	21 July	43	Red sodosol	88
Loxton	21 July	25	Sand	118
Wudinna	22 July	20	Red sandy clay loam	139
Karoonda	22 July	33	Sandy loam	136
Hart	25 July	37	Clay calcarosol	183
Booleroo	26 July	31	Clay loam	128
Naracoorte	28 July	29	Dark grey clay	80
Spalding	29 July	38	Red chromosol	143
Tarlee	4 August	47	Duplex	225
Bordertown	11 August	34	Grey vertosol	128

How do I use this information?

Once the OSF for your site is known, appropriate varieties can be matched to specific sowing dates to ensure flowering will start during the OSF to maximise yield. The phenology of varieties is a genetic characteristic and determines how the plant will respond to sowing dates. More information about phenology can be found in *Tip 3 Variety selection*.

The *Canola Flowering Calculator* has been developed by CSIRO. It has a simple phenology model to assist growers to determine the OSF for their location and the corresponding variety and sowing date to achieve this.

Recommended sowing dates for key South Australian locations for three phenology types.

Following these sowing guidelines will ensure varieties flower within their ideal OSF window.

Region	Month and week	March				April				May			
		1	2	3	4	1	2	3	4	1	2	3	4
	Phenology												
Murray Mallee Lamaroo	Slow			Early	Early	On time	On time	Late					
	Mid				Early	Early	On time	On time	Late				
	Fast						Early	On time	On time	Late			
Adelaide Plains Hart	Slow			Early	Early	On time	On time	Late	Late				
	Mid					Early	On time	On time	On time	Late	Late		
	Fast							Early	On time	On time	Late	Late	
Lower Eyre Peninsula Yeelanna	Slow			Early	On time	On time	On time	Late					
	Mid					Early	On time	On time	On time	Late	Late		
	Fast							Early	On time	On time	On time	Late	Late

Early – risk of frost, disease infection and lower potential yield
On time
Late – risk of drought and high temperature stress

Further information

Ten tips to early sown canola https://grdc.com.au/10TipsEarlySownCanola

Optimal flowering periods for canola in eastern Australia http://bit.ly/OSF-Agron2017

Canola agronomy and phenology to optimise yield http://bit.ly/agron-phenology

Defining optimal sowing and flowering periods for canola in Australia http://bit.ly/OSF-Canola-FCR

The *Canola Flowering Calculator*

canolaflowering.com

What is it?

The canola flowering calculator is a simple phenology model that uses 60 years of local weather data to calculate a range of possible flowering dates for a specific environment.

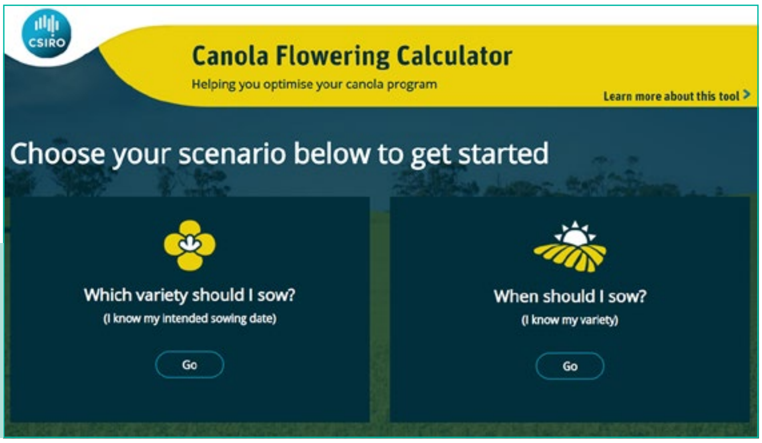
How does it differ from other models like YieldProphet® or APSIM

APSIM and *YieldProphet®* are full biological models that consider many interactions including soil, water, nutrients, light and temperature and can estimate growth and development. The *Canola Flowering Calculator* only predicts development.

It uses the same underlying phenology model as APSIM with climate files produced from *SILO*. Tests show its flowering predictions are the same as APSIM 97% of the time.

How do I use the *Canola Flowering Calculator*?

Go to the web site canolaflowering.com



Step 1

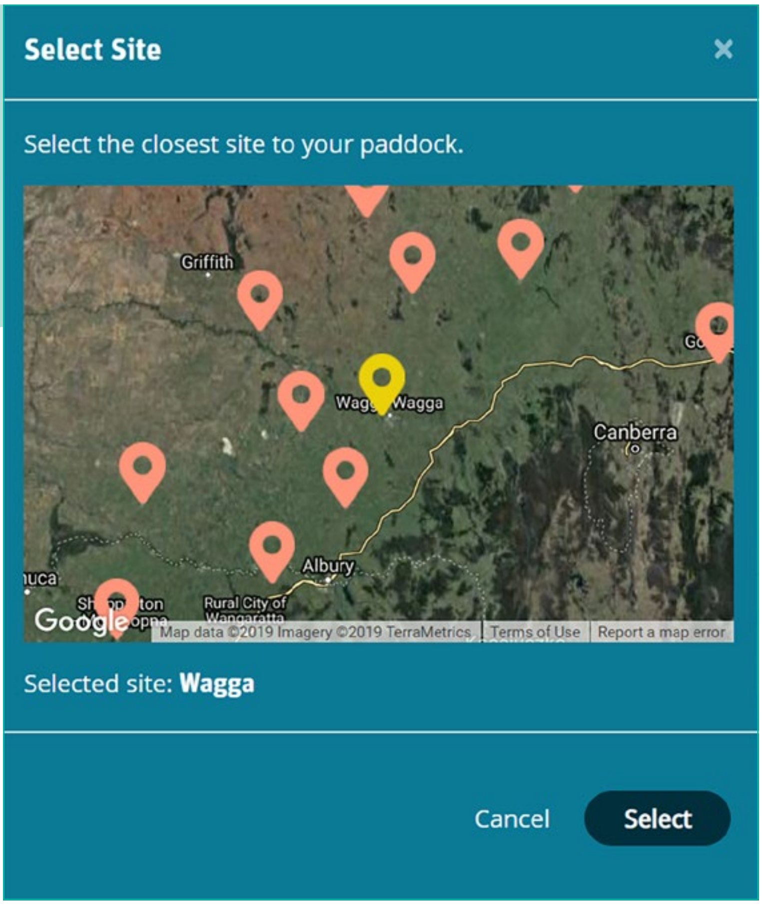
Are you trying to decide:

1. Which variety should I sow?
2. When should I sow?

Step 2 Select location

The next screen allows you to select the location where you want to sow.

There are 77 sites around Australia to pick from or you can use location services (if enabled) to choose the closest site to where you are.



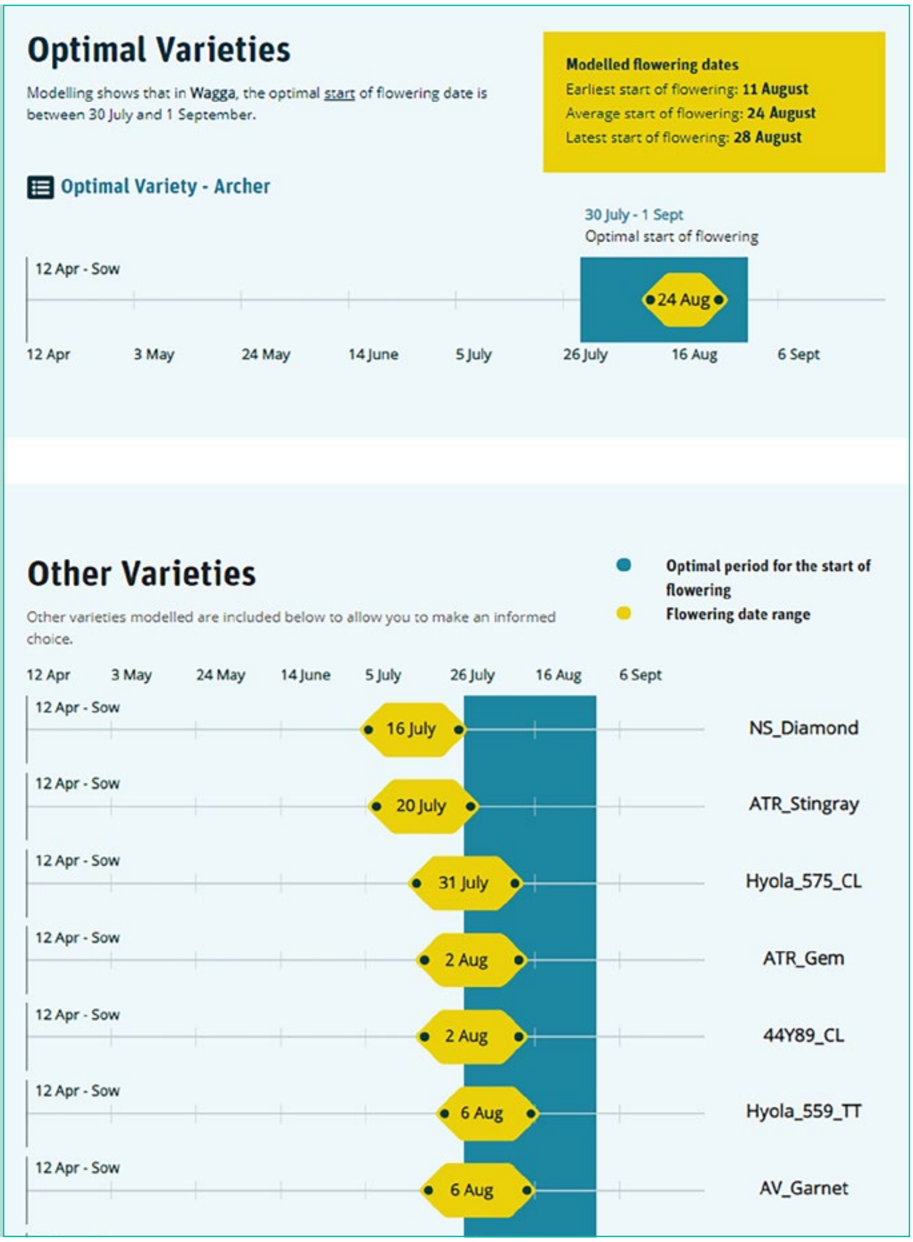
Which variety should I sow?

The results show what happens if you plant any variety on that date. The yellow box is the range of start of flowering dates generated over the 60 years of simulations. The dark blue box is the optimal period for the start of flowering (OSF) at the chosen location.

The optimal scenario is the variety that fits within the optimal start of flowering period best. It is important to note that there are many varieties within the optimal period, and the 'optimal' is just a suggestion.

It is also important to remember that this is a guide to the start of flowering. If you are a bit early you may lose some flowers to cold stress, and a bit late your crop may suffer some heat stress, but each season is different.

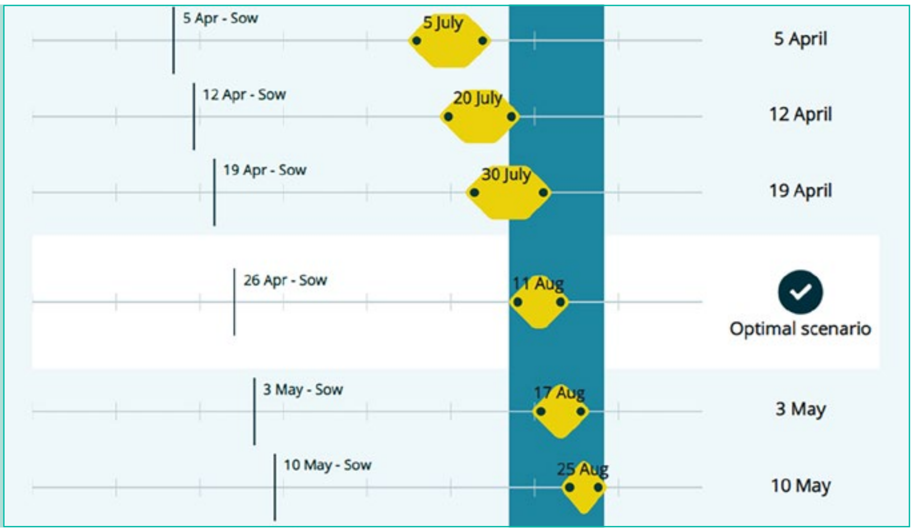
If you know your paddock is frost prone you may want to ensure you flower at the middle or end of the optimal flowering period for your region rather than at the beginning.



When should I sow?

This option looks at a specific variety and the best time to sow to achieve the start of flowering during the optimal period.

Remember the yellow box is the range of start of flowering dates for the last 60 years. If you sow between 19 April and 3 May you will have high confidence that flowering will start within the optimal period.



The *Canola Flowering Calculator* will be updated as the OSF is determined for new varieties.

If you have any comments on the *Canola Flowering Calculator* please fill out the survey through the tool or get in touch with us.

4 Sow winter canola late summer to early autumn

Winter canola is generally sown from late summer into early autumn. It is most commonly sown to provide high quality forage for grazing livestock in autumn and early winter, then locked up in July for grain harvest in November or December.

Winter canola flowers very late, even when sown very early, so in South Australia, it is most suited to the Lower South East and Kangaroo Island. As a grain-only crop, early-sown winter canola generally does not yield more than spring canola sown later (except in the High Rainfall Zone), but it can be useful to avoid frost and disease risk in high rainfall areas due to its later flowering.

In a mixed farming situation, if a dry season makes grain yield seem unlikely, the crop can be cut for hay or silage, or grazed out.

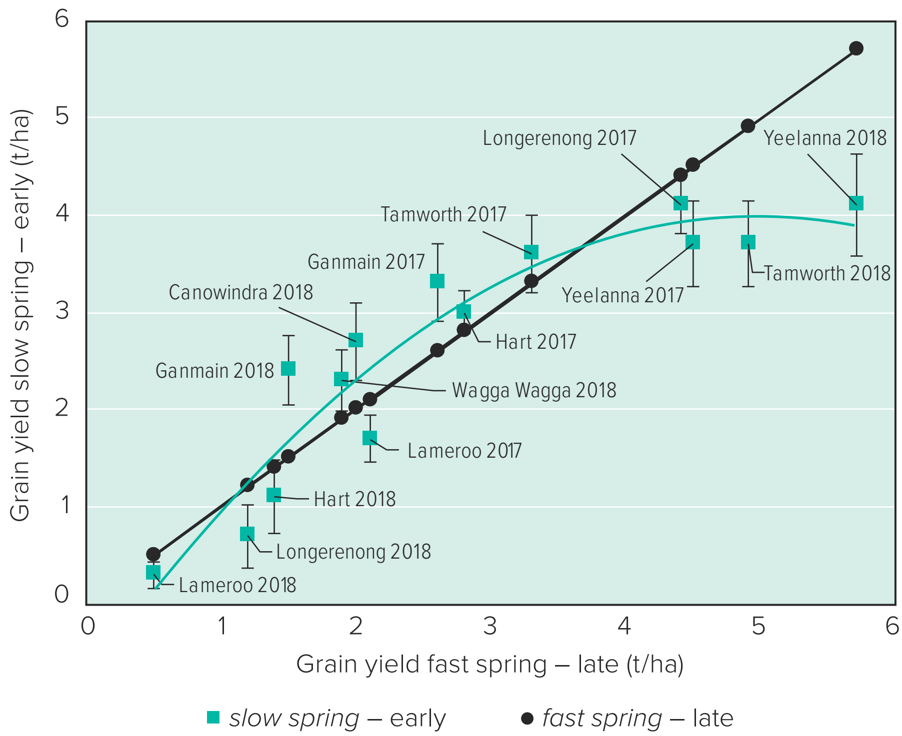
If sowing in February or March it is important there is good stored water and nutrients to capitalise on early forage production.

5 Sow slow spring canola late March to mid April

Slow developing spring canola can be sown from late March to mid April. *Slow spring* varieties respond to vernalisation (but don't require vernalisation), so they require more thermal time to flower when conditions are warm (e.g. from early sowing) than when it is cold (later sowing). *Slow spring* varieties sown in this window will still flower at the optimum time in South Australia. There are currently both hybrid and OP varieties available to sow in this window (see page 8).

Attention to detail in the fallow period (see Tip 1 *Fallow management*) will also increase the likelihood of canola establishing well from a March/early April sowing. Consider the likelihood of having enough moisture for canola to germinate in this period before selecting a slow developing variety.

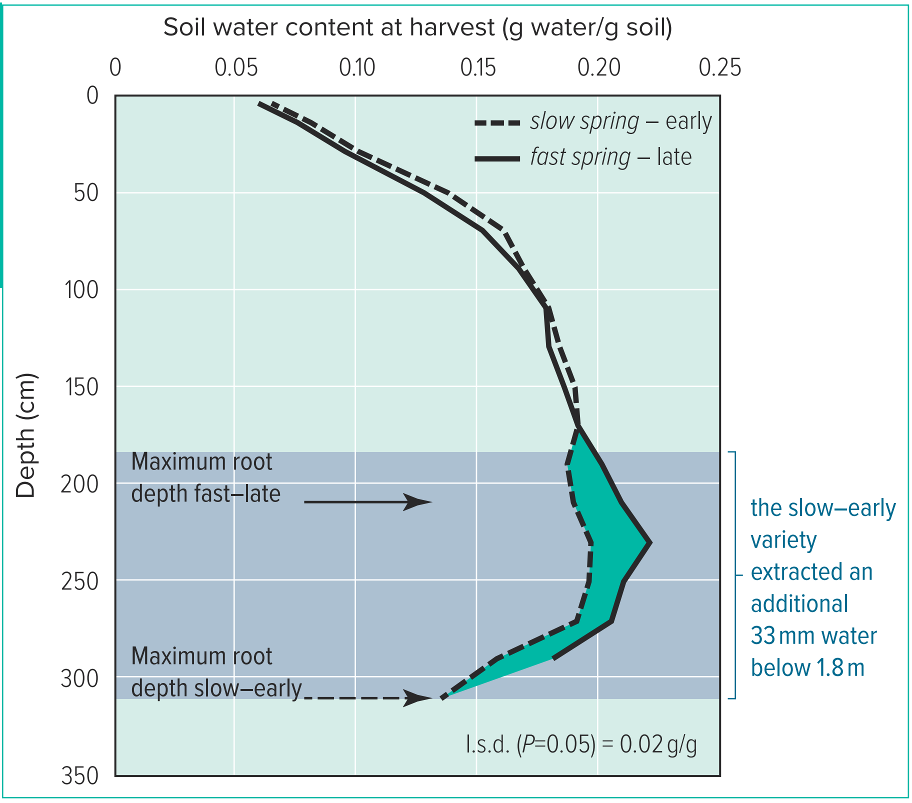
Early sowing of *slow spring* canola is a useful strategy after a wet summer, where the longer vegetative phase (compared with sowing faster varieties later) gives more time for roots to access subsoil water, resulting in higher biomass and higher grain yield. Sowing a *slow spring* variety is also a useful strategy to avoid frost as they have a very stable flowering window, meaning that they will flower in a relatively tight window in late winter/early spring regardless of sowing date.



Early sown *slow spring* (slow spring – early) canola was consistently higher yielding than later sown *fast spring* (fast spring – late) canola at sites that had >200 mm summer rainfall.

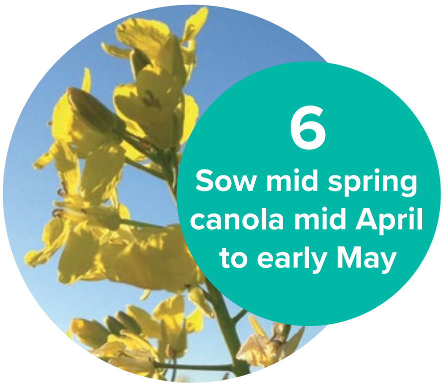
Early sowing gave the crop roots time to access water stored in the subsoil during the fallow period and the slow phenology ensured that frost was avoided. Later sowing of fast developing canola had higher yield in very high yielding trials (through improved harvest index) and very low yielding trials (through more efficient partitioning of water use).

At Greenethorpe, southern NSW in 2018, the early sown *slow spring* hybrid grew roots down to 3.1m, extracting 33 mm more water than the later sown *fast spring* hybrid, with roots down to 2.1m.



Further information

Canola Agronomy – Consistent messages on canola agronomy hold strong in a decile 1 season
http://bit.ly/Update-WW2019



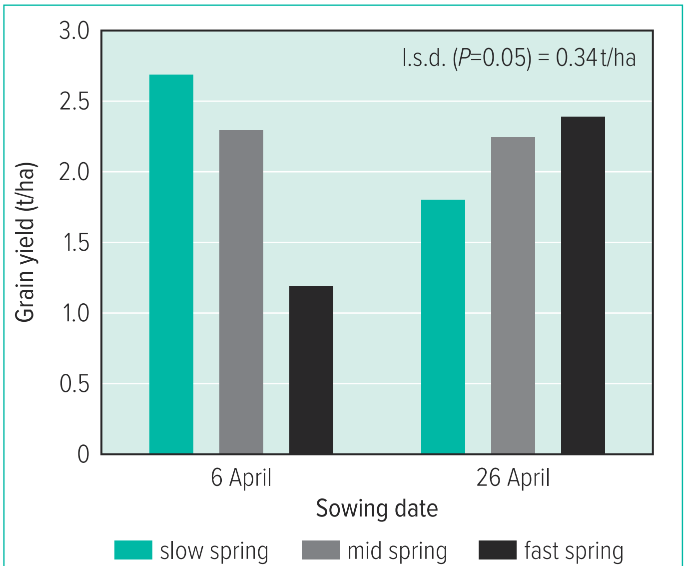
6 Sow mid spring canola mid April to early May

Mid spring canola has universal adaptability in South Australia. It can be sown from the second week of April if rainfall allows, and will also perform well when sown later, from the last week of April to early May.

These *mid spring* varieties often have a subtle vernalisation response (less than *slow spring* canola). This means they are slower in warm autumn conditions than *fast spring* varieties.

When sown later (late April to early May), this small vernalisation requirement is quickly met, so *mid spring* varieties may not be significantly slower than *fast spring* varieties from later sowing.

In an 'average' season *mid spring* canola varieties have similar yield across sowing dates (not necessarily the highest at any one date), whereas *slow spring* varieties are higher yielding from early sowing and *fast spring* varieties higher yielding from later sowing.

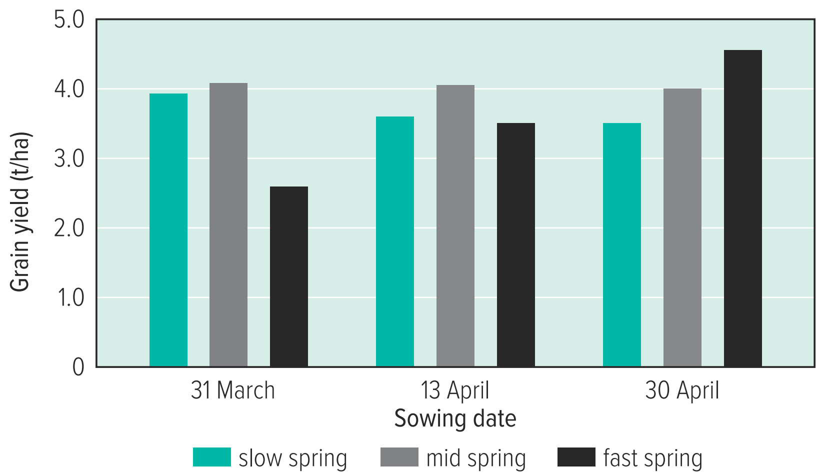


In OCP trials with yield from 1.5–3.0t/ha, *mid spring* canola had consistent yield across early April and late April sowing dates. This characteristic is useful as growers select their variety early in the year with little scope to adjust phenology in response to seasonal breaks.

7 Sow fast spring canola late April to mid May

Fast developing spring canola varieties have little to no vernalisation response. These varieties are suitable for sowing in late April to early May. When sown earlier *fast spring* varieties develop rapidly and can be exposed to frost damage (dry frosty years) and disease (wet years) or produce low biomass. Sowing *fast spring* varieties early resulted in significant grain yield penalties from disease (2016) and frost (2014 and 2018) across OCP experiments in South Australia. In contrast, at very high yielding sites (> 4t/ha) *fast spring* canola sown late often had the highest yield.

Unlike *mid spring* canola, there is little flexibility in the sowing window of *fast spring* canola. *Fast spring* canola is best suited to systems where sowing is likely to be later in the window, and in low rainfall environments. In seasons where there is a wet summer followed by dry winter, *fast spring* canola can be penalised as there is not enough time to access water stored deep in the subsoil.

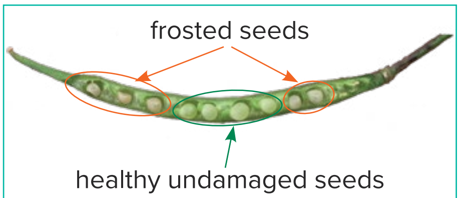


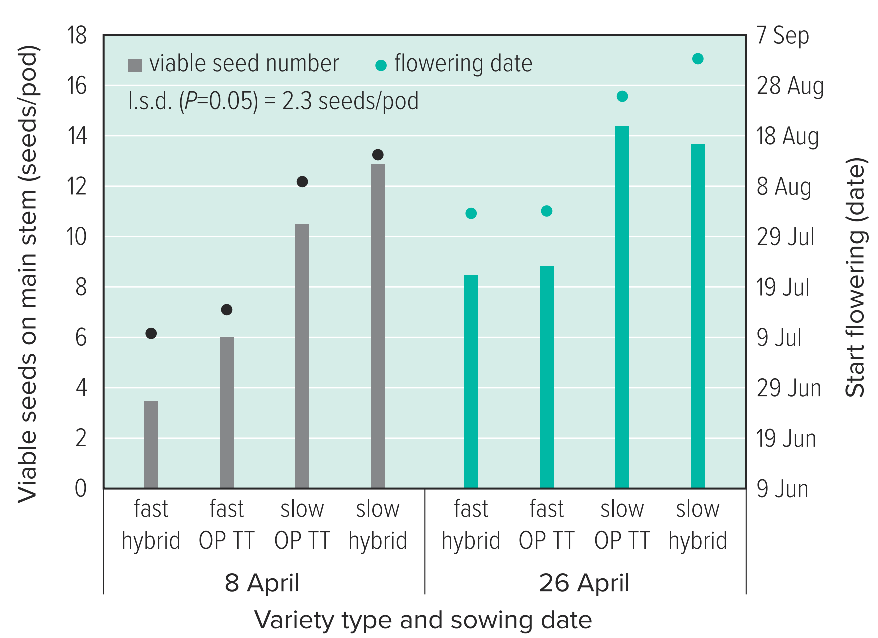
In high rainfall seasons such as 2016, early sown fast developing canola flowered in June and had low yield due to disease infection and low radiation. Yield of the fast developing varieties was very high from later sowing due to their high harvest index (0.37). At the other extreme, yield of later sown fast varieties was also higher than early sown slow varieties in low yielding (<1t/ha) environments.

There were severe frost effects in canola in many regions of eastern Australia in 2017 and 2018.

Fast varieties sown early were exposed to several major frost events during podding, which reduced seeds per pod and grain yield.

Frost damage was reduced by sowing these types late in April.





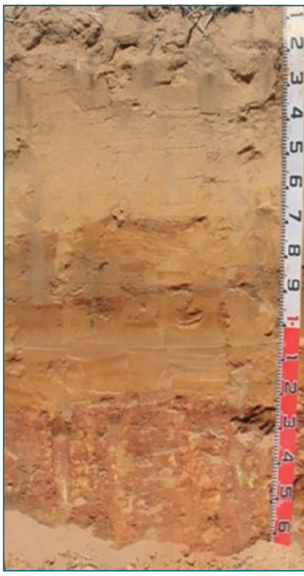
SECTION 3: PRE-EMERGENCE – PROTECT THE CROP AND MANAGE NUTRITION

8 Apply pre-sowing nutrition as required

It is rare to see canola 'hay-off' (as is often observed in other crops) from excessive early applications of nitrogen, so a significant portion of the crop nitrogen requirement can be applied at or before sowing. This can be an especially useful strategy in seasons where PAW at sowing is high (hence yield potential is good) but in-crop rainfall is low, limiting opportunities to apply N in-crop. The main negatives of applying nitrogen at sowing include loss pathways (leaching and denitrification) if wet, difficulty in assessing yield potential, and the care needed in N placement near seed (see Tip 10).

Particular care needs to be taken with nitrogen applications before sowing crops planned to be grazed. Nitrogen application will increase plant nitrate levels, potentially causing animal health issues from nitrate toxicity. However, sufficient N is required to optimise forage production.

Sulfur (S) is also an important nutrient for canola with 3.5 to 5kg per tonne of grain removed from the system. Not all paddocks will respond to S. It is important to determine S requirements to ensure money is invested in the nutrients that will provide the greatest response and return.



Soils range from sands (left) to heavy clays (right) across the major growing environments of South Australia. Sulfur concentration generally increases with depth so it is important to test the soil to the depth of the root zone to determine S requirements.

Further information

Nitrogen and biomass in canola http://bit.ly/N-Biomass

Canola nutrition and sulfur http://bit.ly/sulfur-tips

Canola response to N in central and southern NSW http://bit.ly/CanolaNitrogen

9 Pre-emergent weed control

In South Australia, canola is often sown dry before the autumn break. An even, vigorous establishment of canola is required once rains arrive as this will compete strongly with weeds.

Combined with a pre-emergent herbicide, early sowing can reduce the reliance on in-crop herbicides for weed control as weeds are weakened from the competition of the dense canopy and the effects of the pre-emergent herbicide. Similarly, hybrids have greater vigour than OP TT canola so compete strongly with weeds, reducing the reliance on herbicides for weed control.

One of the best weed control tactics when growing canola is canola itself, especially in combination with a robust pre-emergent package.

The canola in these photos was sown on the same date with the same nutrition. The difference was seed: old seed with low vigour (left), compared with fresh seed (right).

The added crop competition provided by the new seed canola crop (right) meant there were fewer weeds left to control in-crop compared to the low vigour old seed.

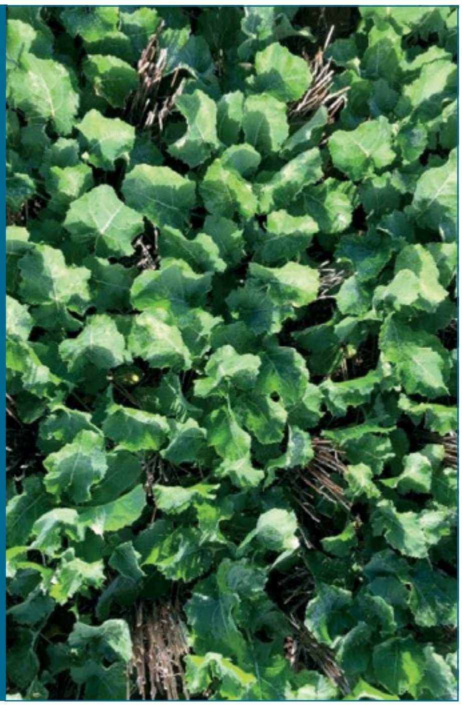


Photo: Warwick Holding

Further information

Weed control in winter crops http://bit.ly/winter-weed

10 Manage seed and fertiliser placement

Phosphorus (P) and nitrogen (N) are both essential nutrients to help canola achieve its yield potential, but recent trials have shown the importance of avoiding fertiliser damage to the germinating seed.

At Wagga Wagga on red loam soil in 2017 and 2018, applying phosphorus in the same furrow as the seed reduced canola establishment, but where seed and fertiliser were separated by 2.5cm there was no effect on establishment. These negative effects of P fertiliser have not been observed to the same extent on heavier soil types.

It is important to maintain paddock fertility (N and P) so that the crop does not require high applications of fertiliser at sowing. If high rates are required, ensure separation of up to 2.5cm between P and seed, and greater than 2.5cm between N and seed.

On red loam soils in southern NSW, placing canola seed directly with phosphorus fertiliser on a 25cm row spacing reduced establishment by approximately 1.5% for each kg P/ha.

Nil P (top) and 40kg P/ha (bottom) applied to a soil with high levels of residual P.

Further information

Managing fertiliser application with the seed http://bit.ly/seed-fertiliser

Canola establishment in central and northern NSW http://bit.ly/canola-estab

Canola establishment survey http://bit.ly/CanolaSurvey

11 Monitor establishment pests

Canola is especially sensitive to pests around establishment. Developing a plan for pest management and closely monitoring crops is important to minimise the impact of establishment pests. There are agronomic tactics that may help with pest management, including:

- **Selecting a vigorous variety** – hybrids generally grow faster early so can avoid damage from establishment pests.
- **Sow large seed** – for growers retaining seed from year to year, grade seed above 2mm to improve early vigour.
- **Adjusting sowing date** – early sowing can help avoid pests associated with wet soil, especially slugs. However, early sowing may expose the crop to more aphids, especially green peach aphids.

A canola trial with high residue levels in a no-till system at Wagga Wagga in 2016 had a significant infestation of slaters, millipedes and earwigs. Hybrid varieties generally escaped major damage due to their more vigorous growth, particularly compared with open-pollinated TT varieties.

Further information

Insect pests of establishing canola in southern NSW http://bit.ly/canola-insect

CESAR Australia www.cesaraustralia.com

SECTION 4: PROTECT THE CROP AND MANAGE NUTRITION

12 Control post emergent weeds

It is important to be aware of label restrictions for post emergent herbicide applications. For example, haloxyfop is a widely used herbicide in canola that has recently come under scrutiny for residues in canola grain. Haloxyfop must be applied before the 8-leaf crop stage, which could be reached by early-mid May in early sown crops. Similarly, Intervix® should be applied to IT canola between the two and six leaf stage and clethodim must be applied to canola before buds are visible. Adherence to label directions is important as crop damage and residue breaches could occur if they are not followed. Growers and agronomists need to be especially mindful of the rapid development of canola when sown early.

Photo: Di Holding

Clethodim is applied to the majority of canola crops in Australia to control annual ryegrass. Early sowing can lead to rapid crop development, resulting in a very narrow safe window for application.

Care should be taken to adhere to crop development recommendations to avoid crop damage and keep below the established Maximum Residue Limit (MRL).

Further information

Clethodim tolerance in canola
http://bit.ly/ClethodimTolerance

Canola clethodim damage research
http://bit.ly/cleth-dam

13 Apply post sowing nutrition as required

Nitrogen use efficiency is higher in crops following a pulse than those following a cereal. Allow for extra nitrogen when sowing canola into cereal residue as immobilisation rates will be high.

Once the crop has established well and growers and agronomists have a better gauge of the season, further nitrogen decisions need to be made.

The average seed protein content across all OCP experiments was 22.6%. On average N removal in grain was 36 kg N/t. Assuming 50% efficiency, 72 kg N/ha is required for each t/ha expected yield.

Protein ranged from 17% (low N, high rainfall sites) to 32% (low rainfall, high N sites), meaning that N removal ranged from 27 to 51 kg N per tonne of grain. Seed protein concentration was always negatively correlated with oil concentration, so as protein increased, oil declined. On average, oil and protein comprised 64% of the canola seed. Nitrogen use efficiency was highly variable across trials, but a rule of thumb is to use a figure of 50%, meaning that 50% of the N available to the crop (mineral N at sowing + mineralisation in-crop + fertiliser inputs) will be converted into grain (in an average season). Therefore growers should budget on 72 kg/ha N (through a combination of mineral N at sowing + mineralisation in-crop + fertiliser inputs) per tonne of targeted grain yield.

N requirement = [Target yield (t/ha) × 72 kg N/ha] − [Mineral N at sowing (kg N/ha) + estimated mineralisation (kg N/ha)]

The table (right) presents typical canola growing systems in South Australia. Higher N application is required on soils with low mineral N at sowing and low organic carbon, these conditions being typical of intensive canola/wheat rotations. Brown manure provides a boost to stored N for canola while a pasture phase boosts nitrogen and organic matter levels.

Nitrogen decisions should be made based on a whole rotation, not a single year, therefore input rates should be increased above the basic calculations in the table. Aim to fertilise to maintain N levels in a paddock, not mine them.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
Location	Lameroo	Hart	Spalding	Cummins	Karoonda
Previous Crop	Vetch pasture	Lentil	Lupins	Wheat	Lupins
Mineral N at sowing (kg N/ha)	60	65	70	60	40
Organic carbon (%)	0.8	1.3	1.3	1.4	0.6
Estimated mineralisation (kg N/ha)	40	50	60	60	15
Target grain yield (t/ha)	0.8	1.5	2.5	3.0	1.7
N application required (kg N/ha)	Nil	Nil	50	96	80

Despite being one of the most widely researched aspects of grain production, there have been few major advances in nitrogen nutrition management over the time canola has been widely cultivated. Applying N by mid-row banding may be a useful option as a method of using available inputs in a different way. Recently some research has been conducted on mid-row banding N in cereals in southern NSW. Further experiments are now being conducted in canola with the possibility of improving nitrogen use efficiency.

Further information

Mid-row banding in wheat http://bit.ly/mid-row-wheat

Canola N and S nutrition http://bit.ly/canola-N-S

Nitrogen management to optimise canola production in Australia http://bit.ly/canola-N

14 Understand and manage critical growth period

What is the "critical growth period" and why is it important?

All grain crops have a "critical period" for yield determination during their growth when the number of grains, and hence the yield potential is determined. During the critical period, yield is very sensitive to any kind of stress (e.g. water, nutrition, temperature and radiation) and so in any environment it is important to sow and manage crops to minimise the risk of stress and ensure adequate water and nutrients are available to the crop at this time.

The critical period for cereals has been established as the period ~20 days before flowering, while for grain legumes it has been identified as the period ~20 days after flowering. Surprisingly the critical period for canola had never been identified.

Understanding the timing of the critical growth period enables growers to select a sowing date and variety combination which ensures the critical growth period occurs when the growing environment is likely to be the most favourable (balancing risks of water, heat and frost stress).

Experiments to define the critical period

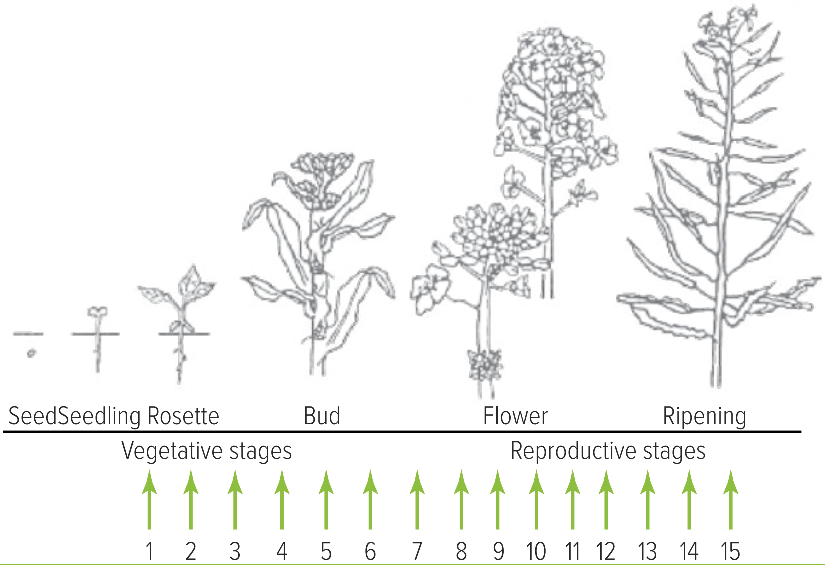
Managing the timing of environmental stresses is difficult in the field, but shade mimics these stresses by reducing photosynthesis and the sugar available for growth in the same way. The advantage of shade (i.e. radiation stress) as an experimental treatment is that it can be easily controlled to define the period of stress precisely.

We shaded crops in the field at 15 different growth stages to determine the stage at which the crop was most sensitive to stress. The critical period identified with our shade stress experiment has recently been confirmed in field-based heat stress experiments, providing confidence in the timing.

Timing of shading periods in relation to crop growth stage in an experiment to determine critical growth periods of canola.

Shade shelters were made on movable steel frames (above) so the crop could be shaded at the specific 7–13 day periods at 15 different times (right) throughout the season.

Yield of each shade timing was compared with unshaded control. The shade mimics other stresses such as temperature, water and nutrient stress.



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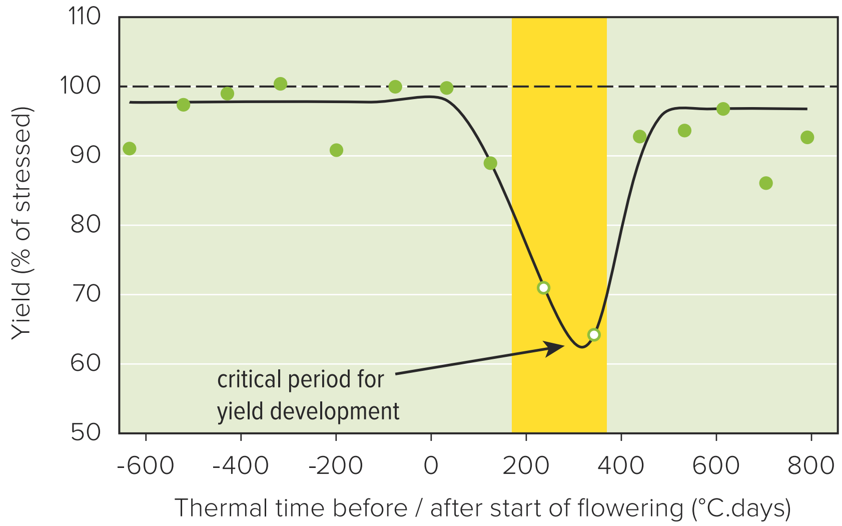
Critical period for canola

We found that the critical period for canola occurred around 350°C.days after the start of flowering. The crop at this stage has the largest number of very sensitive organs – recently opened flowers, flower buds and small pods. Any significant stress at this time causes the abortion of flowers and pods, and those pods that remain will be smaller and develop fewer and smaller seeds due to the impacts of stress on the developing ovaries during the critical period.

Yield was significantly reduced by 40% when stress was applied during this period but was less affected before or after that period (see below). Oil% was also reduced by stress during this period.



- Experiments were conducted with shade and heat for three years
- The *critical period* is when the crop yield is most sensitive to stress
- The period for canola is from two to four weeks after the start of flowering (around 350°C.days, a measure of the cumulative average daily temperature).

Managing canola to avoid stress in the critical period

There are two main ways in which farmers and consultants can use this information:

1. Careful sowing date and variety selection:

Sowing suitable varieties at the correct time to ensure that flowering commences at the optimum time (optimal start of flowering; OSF) will minimise the exposure of the crop to the combined risks of temperature, water and radiation stress (see *page 10*).

2. Managing water and N supply

Managing the crop to ensure there is adequate water and N available during the critical period is important. Rainfall may be uncertain, but agronomic strategies can include:

- Good fallow weed and stubble management to conserve summer rain and mineralise N. If there is no fallow rain, it may be better to abandon plans of growing canola in low rainfall environments.
- Sowing canola after grain legumes, hay, pasture or fallow.
- Ensure sufficient N (soil and fertiliser) for yield potential (70–80kg N/t expected seed yield).
- Split N fertiliser application or mid/side row banding to ensure N is available at flowering.

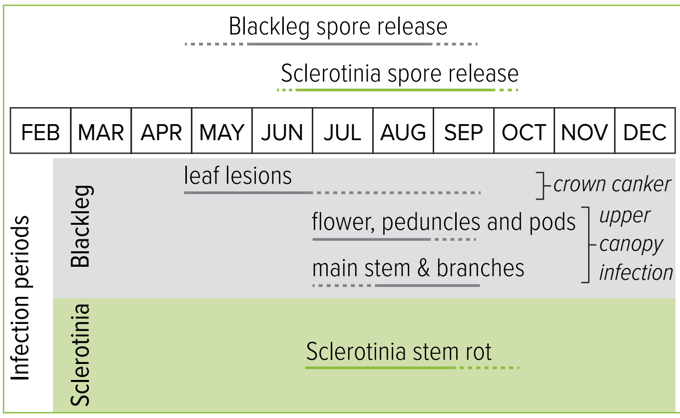
Further information

The critical period for yield and quality determination in canola
http://bit.ly/canola-critical

Disease management – blackleg and sclerotinia stem rot

Sowing date and varietal phenology have a major impact on exposure of canola to diseases, particularly the fungal pathogens that cause blackleg and sclerotinia stem rot. Yield loss is most severe when the exposure of crops at vulnerable growth stages coincides with conditions most conducive for infection (see below).

Blackleg infects all plant parts resulting in a variety of ways to cause yield loss. Conditions between May and August are generally most conducive for blackleg infection as rainfall triggers release of airborne spores from crop residues and provides ideal conditions for infection.



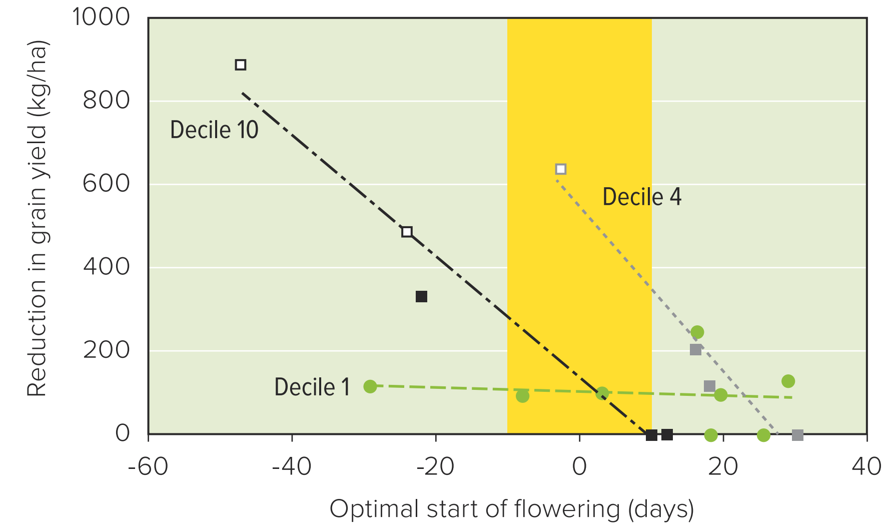
Periods of infection by blackleg and sclerotinia for different parts of the canola plant in relation to the period of spore release in medium and high rainfall zones. Solid lines indicate main periods of infection, dashed lines indicate periods of reduced risk from infection. Earlier-sown crops generally avoid blackleg leaf infections that cause severe crown canker. Crops starting to flower earlier are at greater risk of blackleg upper canopy infection and sclerotinia stem rot.

Seedling: Leaf infection during early seedling growth produces severe crown canker epidemics. Early-sown crops generally have reduced risk of seedling blackleg infection. Plants are growing rapidly, and as there is usually fewer rainfall events, crops avoid onset of spore showers and wet weather that drives infection. If sowing early, select a slow developing variety so that crop disease risk (upper canopy blackleg and sclerotinia) is not increased. Use the BlacklegCM App for tablets to assess early seedling risk and identify management options.

Flowering: After stem elongation, upper canopy blackleg infection can also result in yield loss. Flowers, pods, main stems and branches can all be affected. Crops that flower earlier are more likely to be exposed to wetter conditions, increasing the risk of blackleg infection. In very dry years where disease is limited, upper canopy blackleg is unlikely to result in yield loss. In wet years, although disease levels are high, the effects of the disease are limited as water availability is greater. However, in average seasons blackleg significantly reduces the ability of the crop to take up water and nutrients depending on the timing of rainfall and onset of stress. Under these conditions, yield reductions of up 20 kg/ha per day earlier flowering has resulted in up to 30% yield loss (next page). In high disease situations, avoid early flowering and sow varieties with lower disease risk (see *Further information*).

Upper canopy blackleg can affect stems, flowers and pods of canola. This can reduce yield by cutting off assimilate supply to flowers, pods and seeds. It is important not to confuse upper canopy blackleg with sclerotinia stem rot.

Earlier flowering crops are at greater risk of yield loss to upper canopy blackleg, even when flowering within the optimal period (yellow box). Yield reductions are highest in average seasons in which plants are maturing under high stress. Treatments compare a completely bare unsprayed control with a treatment that received multiple fungicide applications.



Sclerotinia stem rot risk is greater in earlier flowering crops. Winter rains soften sclerotia in the soil to produce airborne spores with crop infection requiring a continuous 48 hour period of leaf wetness. Susceptibility of crops increases significantly once flowering commences. Therefore, canola crops flowering in June or July are at increased risk of exposure to multiple infection events and greater yield loss, compared to those crops flowering in late winter or early spring.

In high disease risk situations where flowering in the main winter period offers significant yield benefits, growers are urged to consider strategic application of fungicides during the early stages of flowering to protect higher yield potentials.

Use the SclerotiniaCM app available for tablets to assist in identifying weather conditions conducive to sclerotinia and the likely economic response to fungicide application.

Early flowering can expose crops to a higher risk of sclerotinia stem rot infection. At Wagga Wagga in 2016, the fastest variety started flowering in early June from a late March sowing date. Fungicides were applied to control sclerotinia but there was still very high levels of disease infection.

Further information

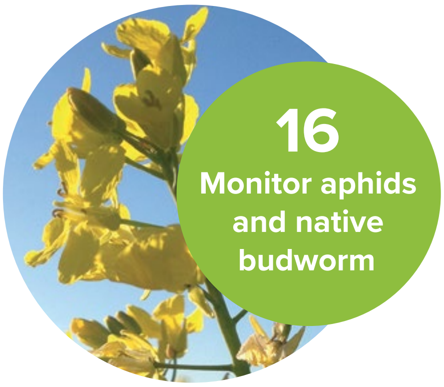
Canola yield loss from upper canopy blackleg infection can be reduced
http://bit.ly/GroundCover-blackleg

Canola – What disease is that and should I apply a fungicide? http://bit.ly/canola-fungicide

Blackleg in canola: an update on resistance, upper canopy infection and a new management app
http://bit.ly/canola-blackleg

Blackleg Management App http://bit.ly/BlacklegCMapp

Sclerotinia Management App http://bit.ly/SclerotiniaCMapp



16 Monitor aphids and native budworm

Agronomic management can have an impact on exposure to late season insects such as aphids and native budworm. Establishing a uniform plant population can limit aphid infection as aphids colonise plants from bare soil. Also sowing canola in large blocks can be useful as aphids colonise from outside the crop and often don't progress far into a crop.

Manage the fallow period to maximise moisture conservation and ensure crops don't flower too late to avoid stress on the crop as stressed crops are more prone to aphid infestation. Late flowering can also expose crops to greater pressure from native budworm. In recent seasons greatest native budworm pressure came in 2013 and 2018 when most crops flowered two to three weeks after the optimum start of flowering.

Further information

Aphid management in canola crops http://bit.ly/canola-aphid

Native budworm http://bit.ly/native-budworm

17 Spray pre-harvest aid if required

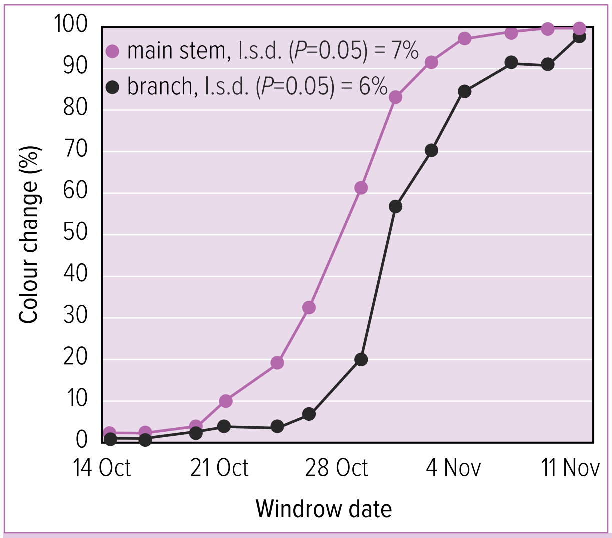
Some glyphosate products are registered for application on canola at 20% seed colour change. This can be useful to limit seed set of weeds such as annual ryegrass but also to stop the growth of non-glyphosate tolerant canola.

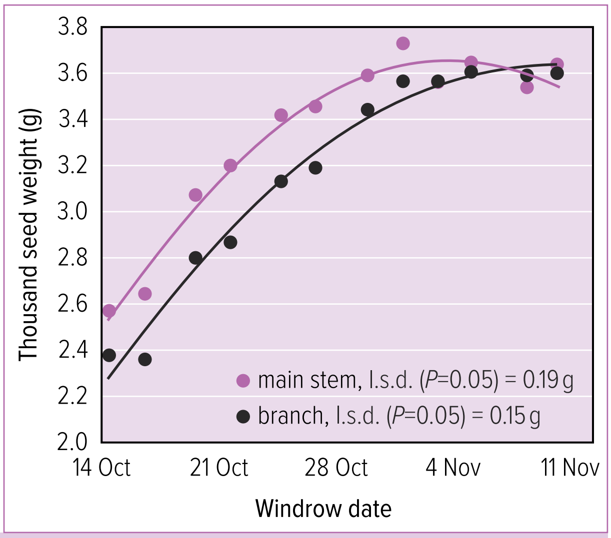
OCP experiments in northern NSW in 2015 showed that there was no effect on grain yield or grain quality when crops were sprayed with a registered glyphosate product at 25% seed colour change, while the application of the desiccant diquat and windrowing both reduced yield by 25% at this timing.

18 Windrow on time

Windrowing canola is a useful tool to even and hasten the crop ripening process, and to reduce shattering losses at harvest. Industry recommendations in the past state that canola should be windrowed when 40–60% of seeds on the main stem have changed colour from green to red or brown or black. Research conducted in northern NSW over four seasons showed that branches contributed up to 80% of grain yield. Seed colour change (SCC) starts later on the branches than the main stem, so relying solely on the main stem for windrowing decisions will underestimate seed colour change across the whole plant. Windrowing early will lead to smaller seed at harvest, lower yield and lower oil concentration.

It is recommended that windrowing is carried out when 60% of seed sampled from the middle third of main stem and branches across the whole plant has changed colour from green to red, brown or black.





At Tamworth in 2016, seed size plateaued on the 31 October. On this date, seed colour change on the main stem was 80% and 55% on the branches. As 80% of the seed was on the branches, this equated to just over 60% seed colour change when assessed across the whole plant.

Progression from 30 to 60% colour change took only 3–4 days in northern NSW and in this time seed size increased by 5–15%.

It is worth the effort to get seed colour change assessment right.

There can also be significant decreases in oil concentration as a result of windrowing at early stages of SCC. At Tamworth, there was a 6.3 percentage point reduction in oil concentration (38.9% vs. 45.2%) when windrowing at the start of SCC compared with windrowing at ~60% SCC (averaged across the plant).

Findings from this study highlight the potential for significant yield and quality penalties due to early windrow timings with yield losses of up to 55% and decreases in oil concentration of up to 7.7 percentage points. Seed should be sampled from across the whole plant to accurately assess seed colour change. Furthermore, results demonstrated the potential benefit of delaying windrow timings with yields optimised at the upper end of traditional industry guidelines of 60% or greater SCC.

Photo: Warwick Holding

Further information

Pod maturity on main stem and branches http://bit.ly/pod-check

Harvest management and seed colour change http://bit.ly/colour-change

Implications seed colour change and windrow timing http://bit.ly/windrow-timing

19 Harvest on time minimising seed loss

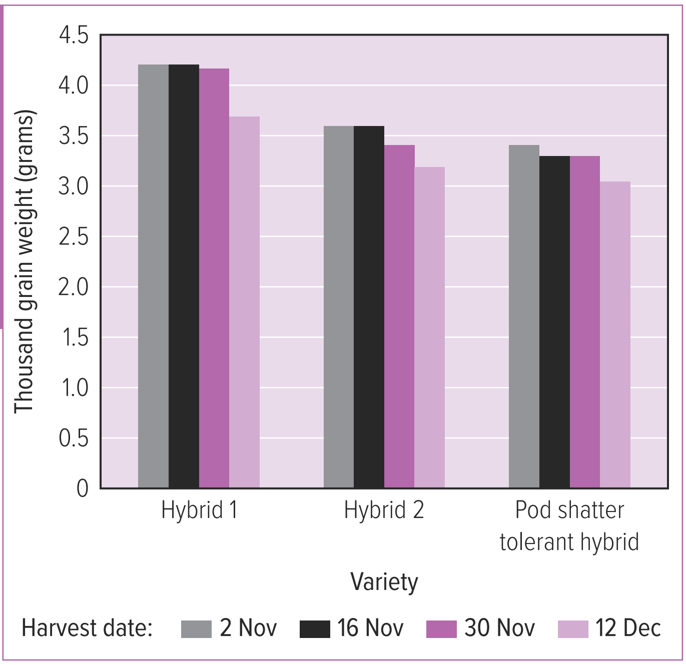
With all the hard work done growing a crop, it is important to ensure it all gets into the bin.

In OCP experiments at Tamworth and Trangie, NSW pod-shatter tolerant varieties had less seed loss from pod shattering leading up to and at harvest, but there were several other avenues for seed loss.

Where harvest was delayed and there was rain on ripe crops, seed size declined resulting in reduced yield. Also whole pods broke away from where they attached to the stem. Harvest as soon as the crop is harvest ripe, even when growing a pod shatter tolerant variety.

A third avenue for grain yield loss at harvest is through losses out the back of the header. This area of investigation was beyond the scope of research of the OCP project but growers and agronomists are urged to check their losses using information provided by a separate project on canola seed loss (http://bit.ly/harvest-loss-calc).

At Tamworth in 2015, delaying harvest from the earliest possible opportunity (2 November) to mid December caused a 10% reduction in seed size for three hybrid canola varieties. Seed size declined the most between the third and fourth harvest dates following 40mm of rain. Harvest canola as soon as it is harvest ripe to minimise losses from shattering and loss of seed weight.



Further information

GRDC Harvest resources https://grdc.com.au/resources-and-publications/resources/harvest-resources


Photo: Warwick Holding

20 Evaluate financial performance

Crop yield and cost of production must be considered when determining the profitability of a canola crop. There is a trade-off between gross income and the expense of producing that crop.

Matching variety to the sowing date in order to achieve flowering in the optimal window is critical to maximising canola annual gross margin ($/ha). Modelling, using data from OCP field trials, showed sowing hybrid canola with adequate N between 16 and 30 April at Yeelanna produced an average gross margin of $1,010/ha (ranging from $309 to $1,153/ha). If sowing was delayed to 1–15 May, average gross margin was $942/ha ($-39 to $1,161/ha), with losses in low rainfall years.

> Hybrid non-TT canola often has a yield advantage (average 16% in OCP experiments) over open pollinated TT (OP TT) canola. An impressive grain yield of 1.2 t/ha for hybrid canola (Pioneer43Y92CL®) was measured at Karoonda in a decile 1 rainfall season compared with 0.8 t/ha for an OP TT (ATR Stingray).

Given the seed cost of hybrid canola, the calculated persistent yield advantage required over a range of season types (growing season rainfall deciles) for the hybrid to be more profitable than OP-TT is:

- 20% or greater in decile 3 and above seasons in the Mallee environment.
- 15% in the Lower Eyre Peninsula environment.

Canola grown at Karoonda in the 2018 decile 1 season (133mm growing season rainfall). Top and bottom OP TT (left) compared with hybrid CL (right) with 90kg N/ha input.

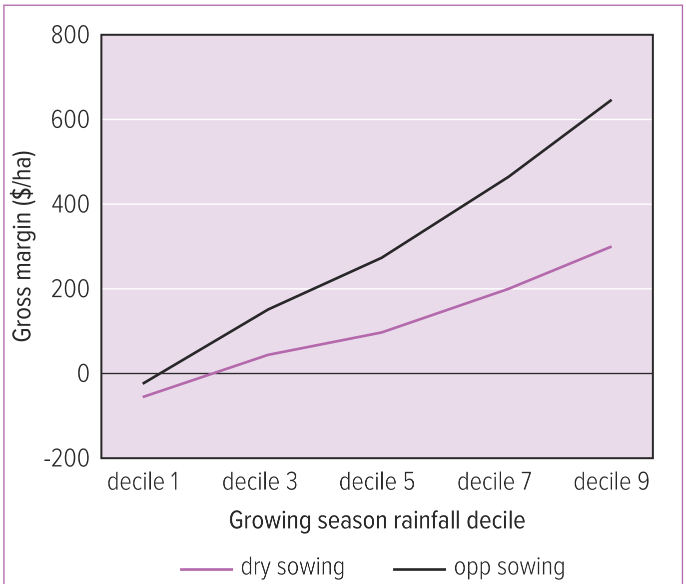
Canola gross margins ($/ha) in response to the use of an open pollinated TT variety with farm retained seed, compared with a hybrid variety commercial seed at a yield advantage of 10, 15, 20 and 25% above the open pollinated TT variety.

Growing season rainfall decile	Gross margin ($/ha) with				
	Farm retained seed	Yield advantage with hybrid seed			
		10%	15%	20%	25%
SA Mallee					
Decile 1	-15	-80	-76	-71	-66
Decile 3	173	127	140	154	168
Decile 5	267	235	256	277	298
Decile 7	469	458	492	522	554
Decile 9	622	629	669	709	749
Lower EP					
Decile 1	193	155	173	209	193
Decile 3	313	289	320	365	313
Decile 5	444	440	476	546	444
Decile 7	543	550	588	674	543
Decile 9	673	693	740	835	673

hybrid less than OP TT | hybrid equal to OP TT | hybrid greater than OP TT

Further farm level considerations that are not included in this analysis are: the cost of purchasing hybrid seed if there is no sowing opportunity and the inability to re-establish a crop if there are establishment difficulties.

A key consideration when growing canola in low rainfall environments is the ability to make the decision to not sow when conditions are not conducive to a positive gross margin. We tested the scenario where we used the rule of not sowing canola (OP-TT) if there has not been 10 mm rainfall on sand or 15 mm rainfall on loam and clay loam soils within a one week period before the second week of May. We found that this approach significantly increased the canola gross margin at all deciles above decile 1. However, there are flow on effects (such as the farm profit when deciding to grow an alternative to canola and the cost of seed not sown) that have not been considered in this analysis.



Canola gross margin for the upper Eyre Peninsula (20% sand, 40% loam, 40% clay loam).

Further information

Profitable management packages for canola http://bit.ly/manage-profit

OPTIMISED
CANOLA
PROFITABILITY

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