20 TIPS FOR PROFITABLE CANOLA

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

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CSIRO

NSW GOVERNMENT | Department of Primary Industries

OPTIMISED CANOLA PROFITABILITY

grdc.com.au

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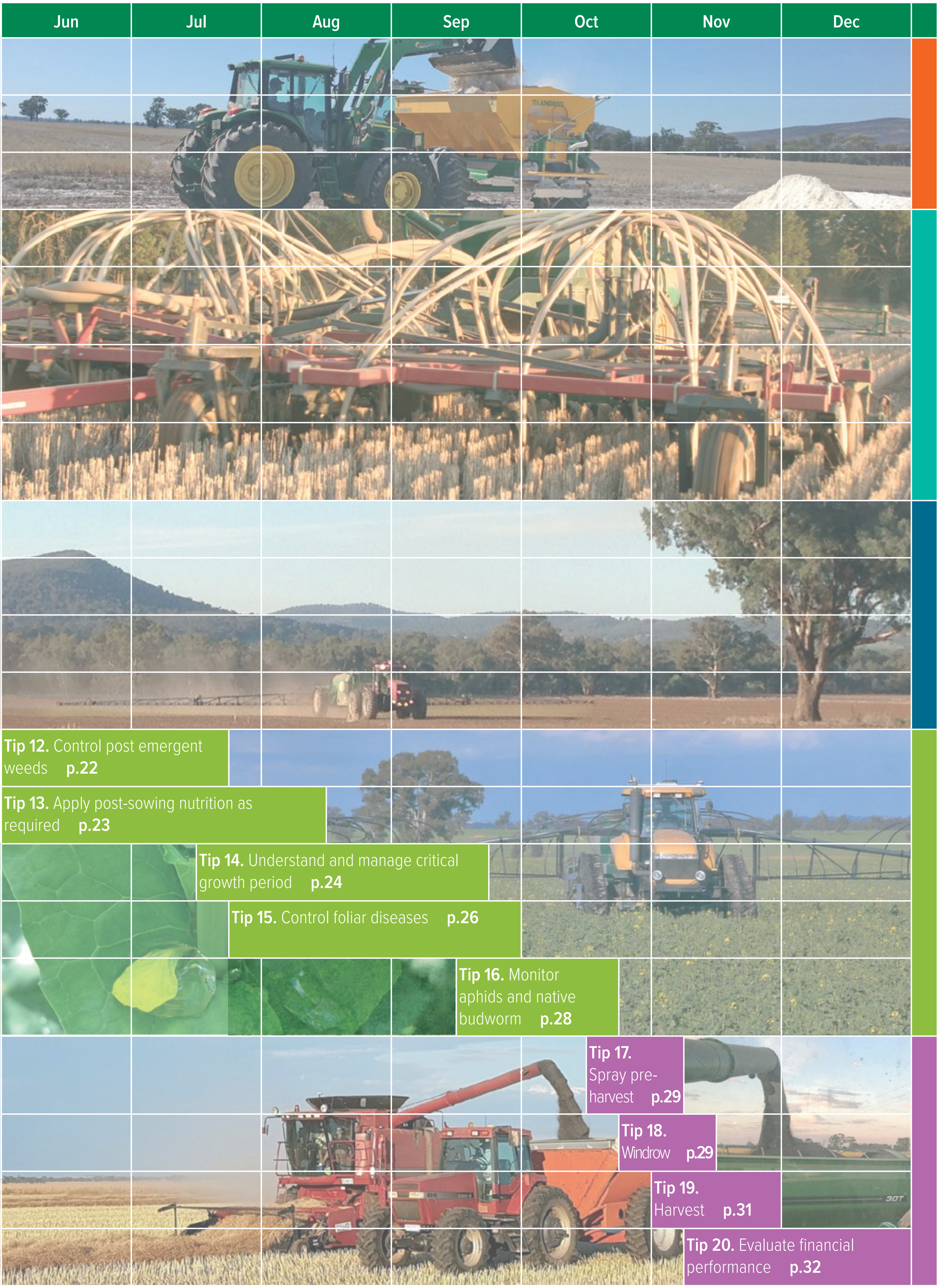
Calendar of decisions (contents)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SECTION 1: CROP PLANNING AND PREPARATION

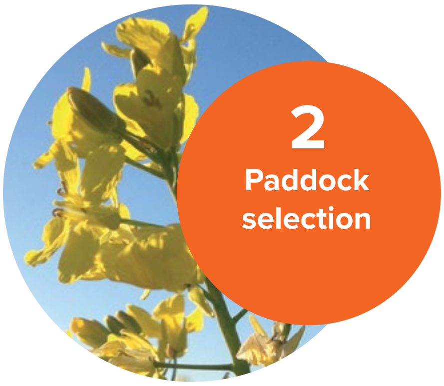
Rainfall that falls during the fallow period often contributes more than half the water requirement of the canola crop in northern NSW. Soils can hold more than 200mm plant available water (PAW) which with sound agronomy, should be converted to 2t/ha grain. To get the best from fallow rainfall, it is important to:

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

Further information

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

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



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

In northern NSW it is risky to sow canola when either water or nitrogen (N) levels in the soil are low at sowing, and extremely risky when both are low.

Canola should be sown following a wet summer when PAW is high or after a pulse crop to maximise N and water availability. Canola can extract slightly more subsoil water than wheat and to a similar depth.

Research has shown that very high nitrogen (N) application rates (over 200 kg 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.

Water use efficiency (WUE) can be highly variable depending largely on timing and amount of available water. Growers should target a minimum WUE >11kg/ha.mm, with very well grown crops able to achieve 15kg/ha.mm.

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.

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

Sowing canola after chickpeas or faba beans is a very successful strategy in northern NSW to improve canola production and break weed and crop disease cycles.

There are three key decision areas with variety selection:

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

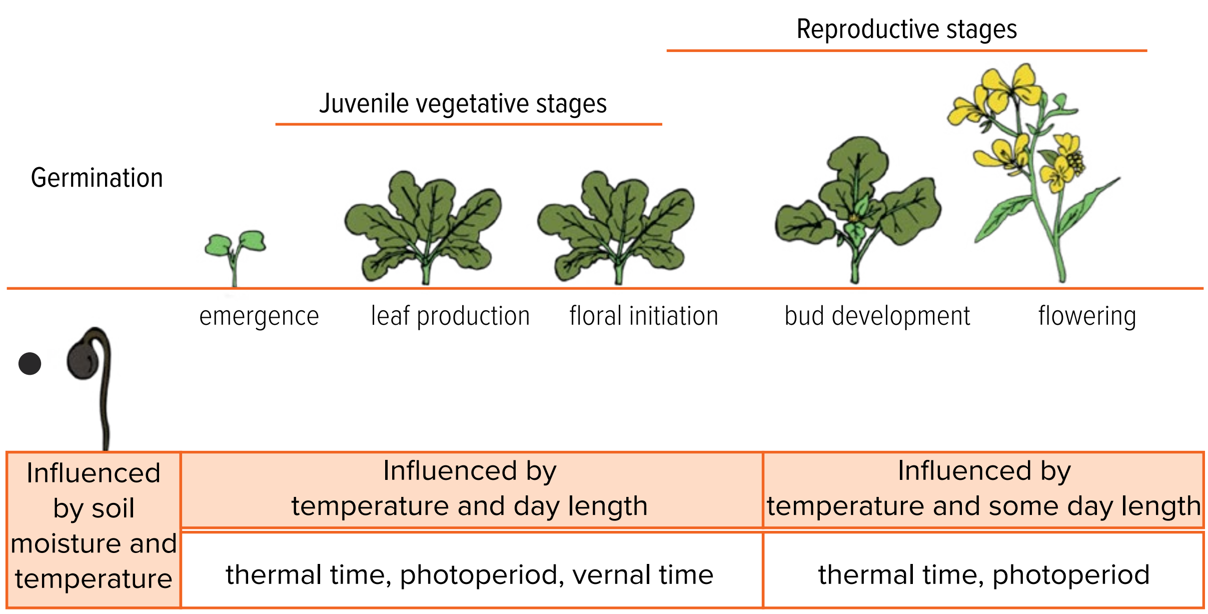
Varietal phenology

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.

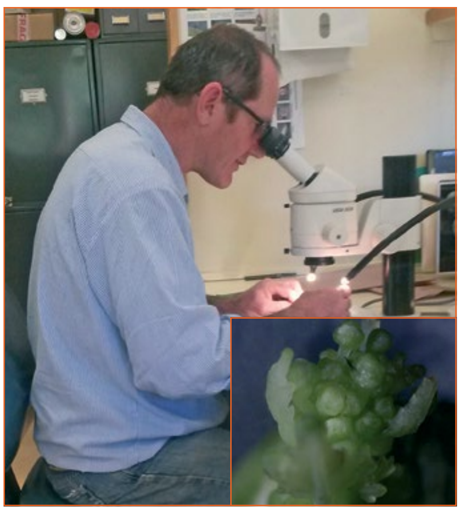
Plants respond to temperatures, to determine when they move from one growth stage to another. A simple way to think of this is as a biological clock that accumulates average daily temperatures (day degrees) until a specific target (thermal time target) is met.

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



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.

Same varieties

Sown first week of May

Photos last week in June

Different environments

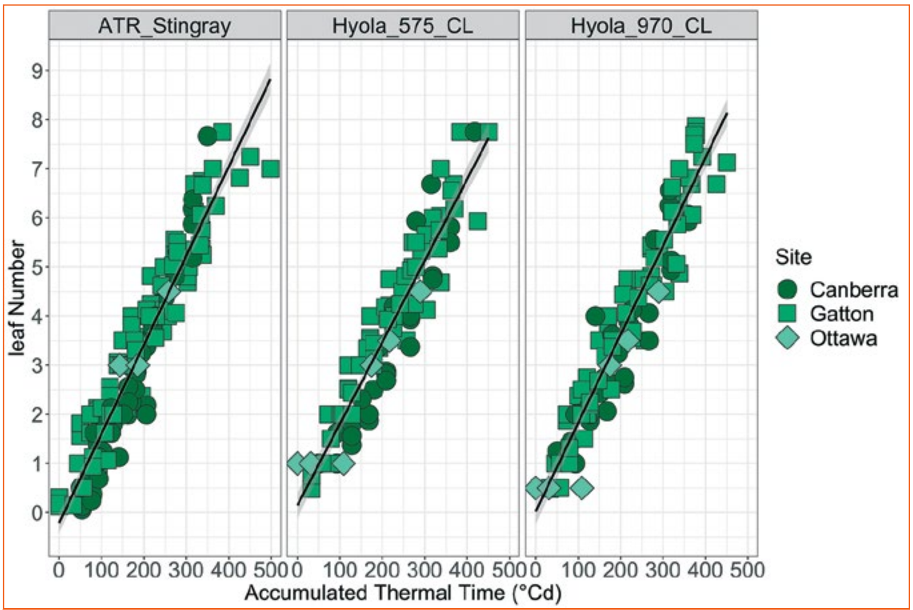
Canberra ACT

Gatton QLD

Ottawa CANADA

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).



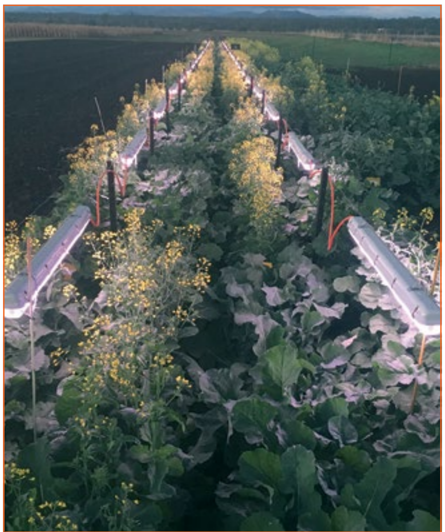
Leaf appearance rates at three different environments (Canberra ACT, Gatton QLD and Ottawa Canada).

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.



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

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

Example 1: grain yield potential 2.5t/ha and grain price $500/t, equates to an additional $200/ha income, easily paying for the additional seed cost.

Example 2: lower yield potential 1t/ha and grain price $500/t, additional income is $80/ha, similar to the cost of hybrid seed.

Breeding type

Open-pollinated

Open-pollinated (OP) canola is not widely grown in northern NSW. OP varieties generally have lower yield potential than hybrids and there is little diversity in the breeding background for blackleg disease resistance. OP canola significantly reduces the cost risk of growing canola as farmer retained seed costs approximately 10% of hybrid seed.

Hybrid

Hybrid canola is dominant in northern NSW and has consistently achieved higher grain yields than OP canola. Seed orders need to be made early to ensure supply of the desired variety.

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.

Further information

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

Winter Crop Variety Sowing Guide ttp://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.

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.

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.

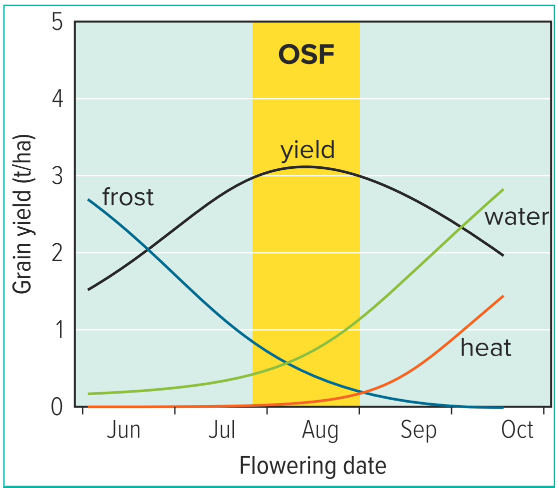
The OSF at a location depends on timing and frequency of extreme temperatures and the pattern of water stress.

- 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 northern NSW and southern Queensland 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 Moree canola should start flowering between 10 July and 8 August (from 15 days before 24 July to 15 days afterwards).

Northern NSW and southern QLD				
Location	Optimal start of flowering date	Acceptable range (days)	Soil type	PAWC (mm)
Nyngan	5 July	33	Sandy clay loam	108
Mungindi	10 July	28	Brown chromosol	170
Goondlwindl	19 July	28	Grey vertosol	188
North Star	24 July	27	Grey vertosol	239
Walgett	24 July	26	Grey vertosol	198
Moree	24 July	30	Black vertosol	238
Trangie	29 July	28	Sandy clay loam	141
Condamine	30 July	27	Grey vertosol	285
Narrabri	1 August	29	Vertosol	218
Breeza	3 August	28	Grey-black vertosol	264
Gunnedah	5 August	23	Grey-black vertosol	264
Warwick	14 August	24	Brown vertosol	216

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 northern NSW locations for three phenology types.

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

	Month and week	March				April				May			
Region	Phenology	1	2	3	4	1	2	3	4	1	2	3	4
North-east/Liverpool Plains Gunnedah, Bellata, North Star	Slow					Early	On time	On time	Late				
	Mid						Early	On time	On time	On time	Late		
	Fast								Early	On time	On time	Late	
North West Coonamble, Burren Junction, Garah	Slow						Early	On time	On time	Late			
	Mid							Early	On time	On time	Late		
	Fast								Early	On time	On time	Late	

Early – risk of frost, disease infection and lower potential yield
On time
Late – risk of moisture 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.

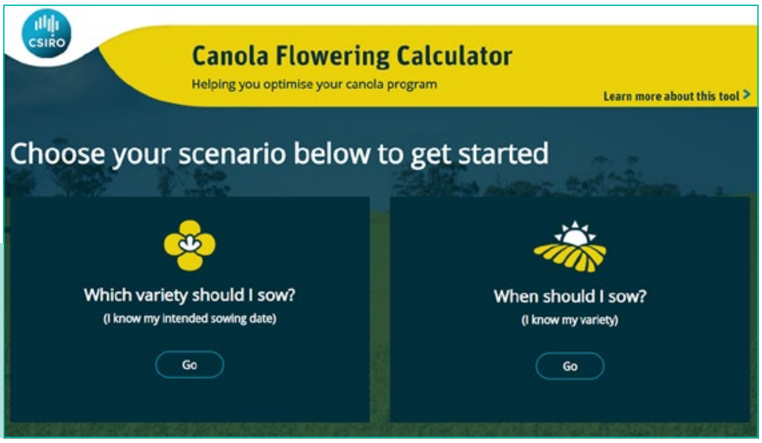
How does it differ from other models like YieldProphet® or APSIM

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

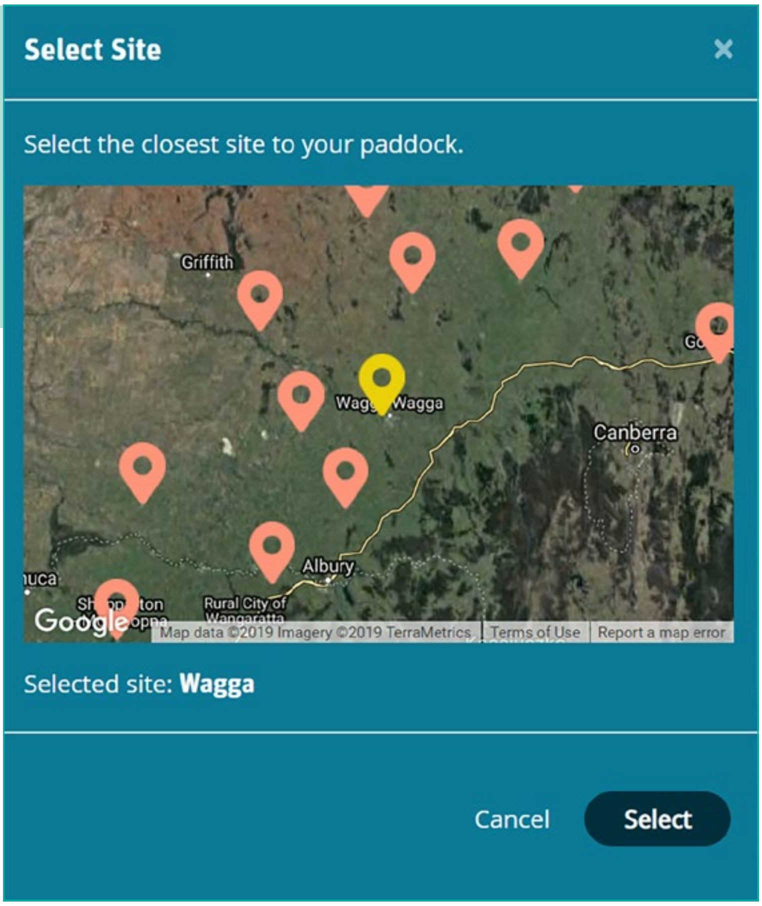
Are you trying to decide:

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.



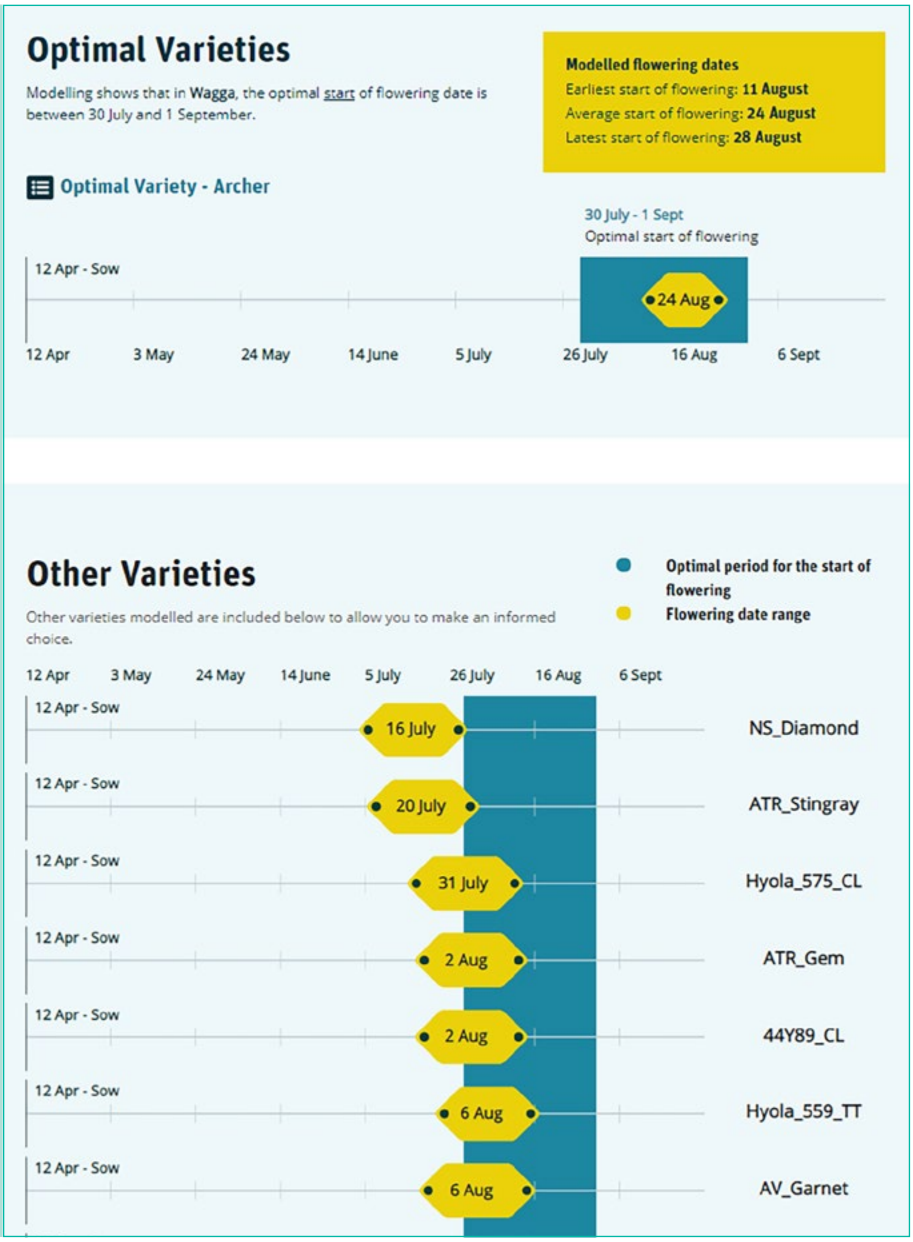
Which variety should I sow?

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.

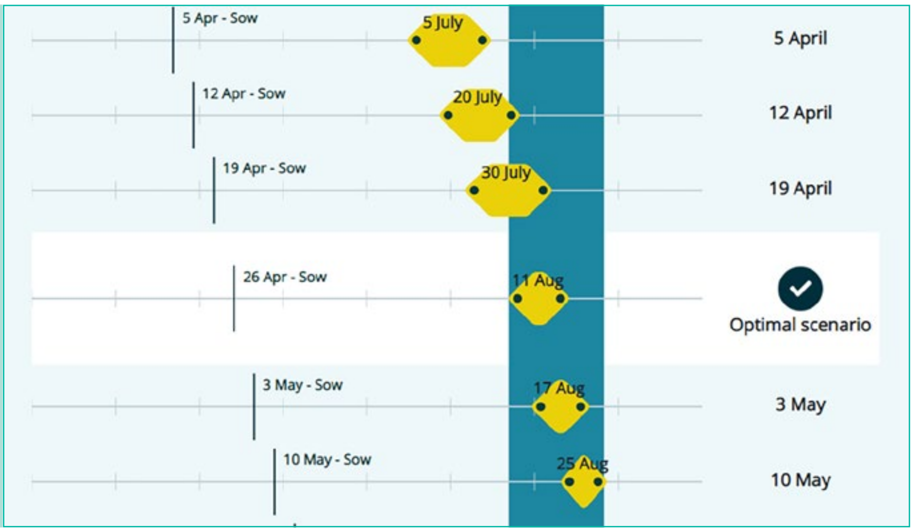
If you know your paddock is frost prone you may want to ensure you flower at the middle or end of the optimal flowering period for your region rather than at the beginning.



When should I sow?

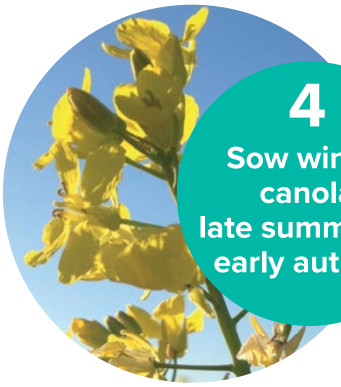
This option looks at a specific variety and the best time to sow to achieve the start of flowering during the optimal period.

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 early, so it is most suited to eastern tablelands environments of northern NSW. As a grain-only crop, early-sown *winter* canola generally does not yield more than *spring* canola sown later, 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.

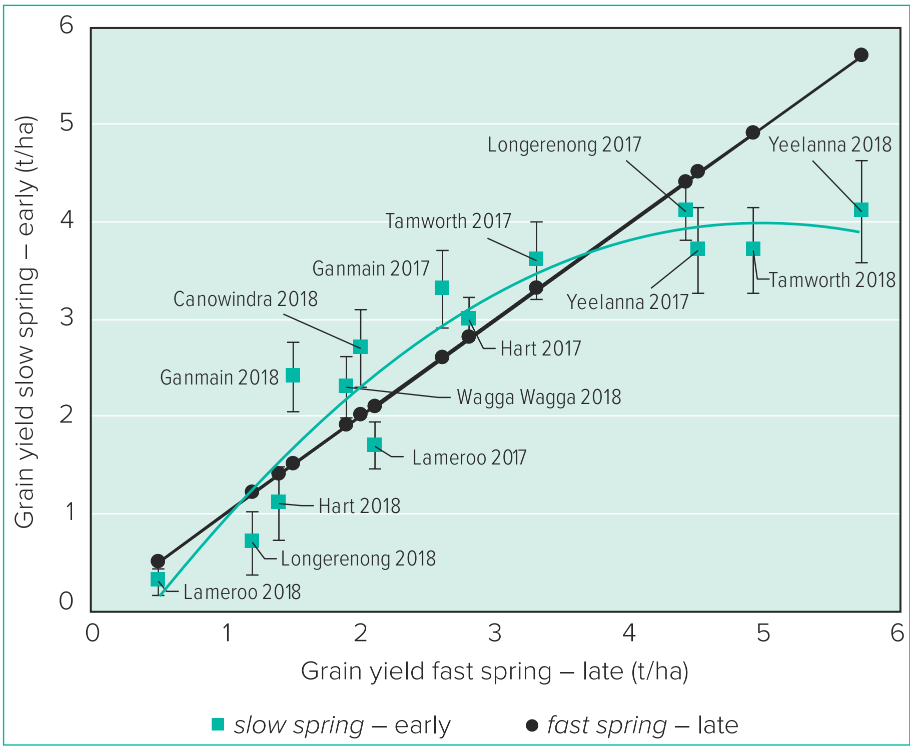
If sowing in February or March it is important there is good stored water and nutrients to capitalise on early forage production.

5 Sow slow spring canola late March to mid April

Slow developing spring canola can be sown from mid to late 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 northern NSW but grain yield has generally been less than the best *fast spring* and *mid-fast* hybrids. There are currently both hybrid and OP varieties available to sow in this window (see page 8).

There are generally only occasional opportunities to sow early in northern NSW. For growers planning to sow early, attention to detail in the fallow period will increase the likelihood of canola establishing well from a March/early April sowing.

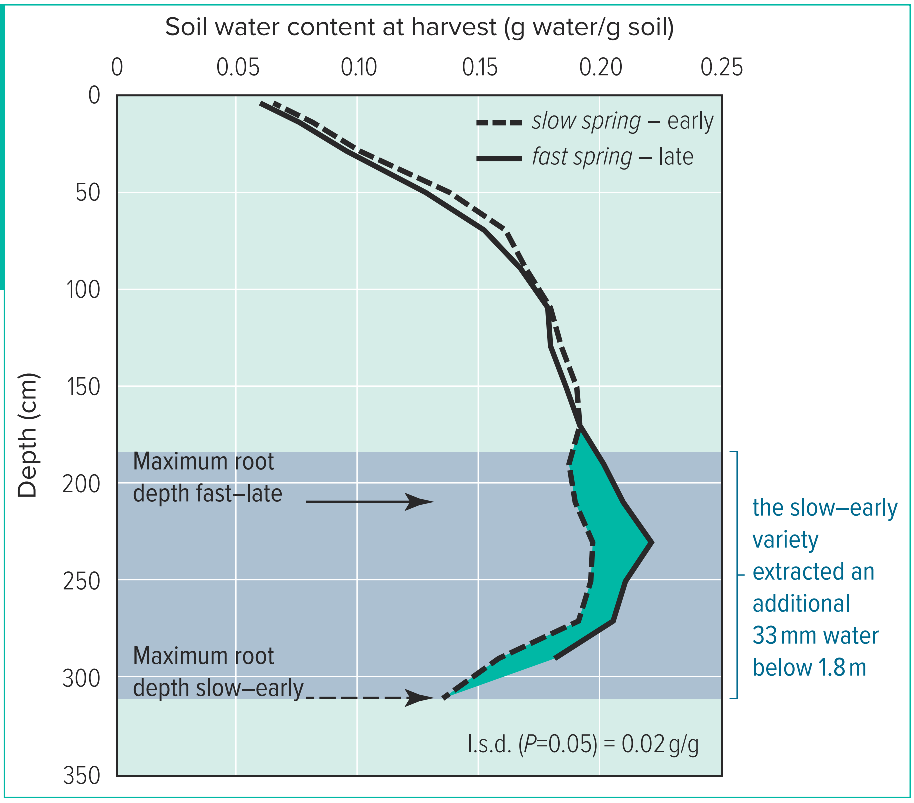
Early sowing of *slow spring* canola is a safer strategy after a wet summer, where the longer vegetative phase (compared with sowing faster varieties later) gives more time for roots to access subsoil water, resulting in higher biomass and higher grain yield. Sowing a *slow spring* variety is also a 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 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 dryland sites in NSW in 2017 and 2018.

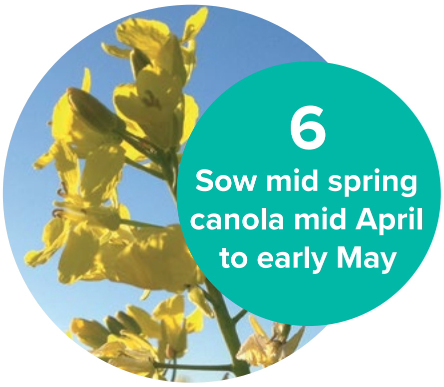
Early sowing gave the crop roots time to access water stored in the subsoil during the fallow period and the slow phenology ensured that frost was avoided. Later sowing of fast developing canola had higher yield in very high yielding trials and very low yielding trials.

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



Further information

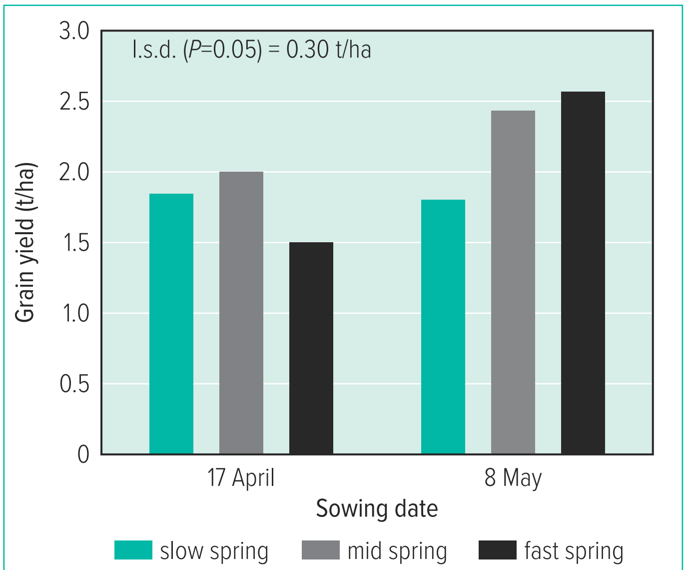
Canola Agronomy – Consistent messages on canola agronomy hold strong in a decile 1 season
http://bit.ly/Update-WW2019



Mid spring canola has universal adaptability in northern NSW, especially varieties with mid-fast phenology. Mid-fast types can be sown from mid April to mid May 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.

In an 'average' season *mid spring* canola varieties have similar yield across sowing dates (not necessarily the highest at any one date).



In OCP trials with yield from 1.5–3.0t/ha, *mid spring* canola had consistent yield across mid April and early May 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

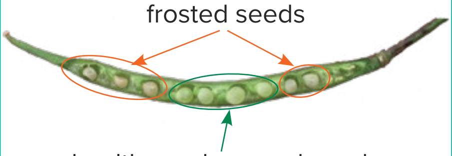
Fast developing spring canola varieties have little to no vernalisation response. These varieties are suitable for sowing in late April to mid-May. When sown earlier *fast spring* varieties develop rapidly and can be exposed to frost damage (dry frosty years) and disease (wet years) or produce low biomass. Sowing *fast spring* varieties early resulted in significant grain yield penalties from disease (2016) and frost (2014, 2017 and 2018) across OCP experiments. In contrast, at very high yielding sites (> 4t/ha) *fast spring* canola sown late often had the highest yield.

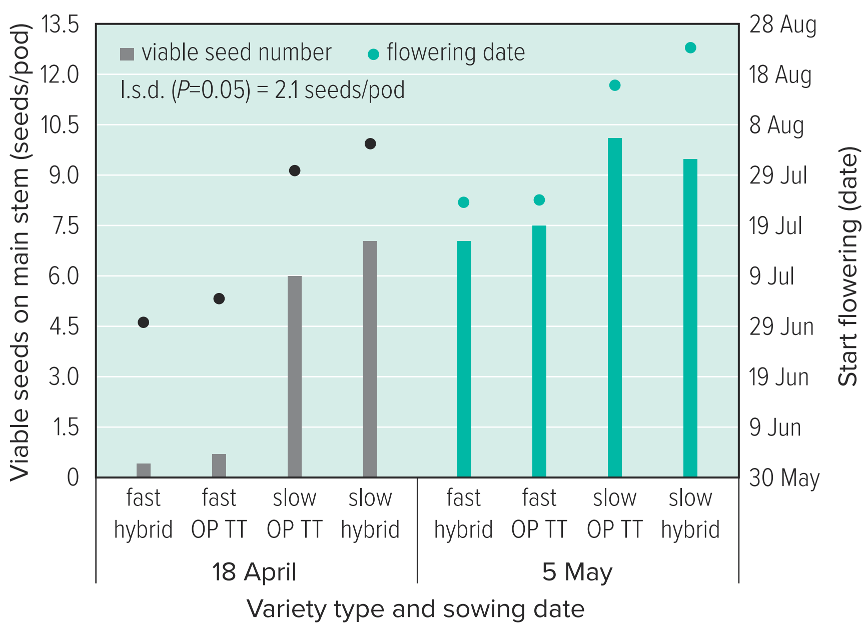
Unlike *mid spring* canola, there is little flexibility in the sowing window of *fast spring* canola. *Fast spring* canola is best suited to systems where sowing is likely to be later in the window, such as in western regions.

2017 was a season with severe frost across much of NSW.

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. The majority of nitrogen required for canola crops in northern NSW should be applied before or at sowing as in-crop rain events are often unreliable. 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 5 kg per tonne of grain removed from the system. Most vertosol soils in northern NSW have high levels at sulfur at depth and do not respond to sulfur application.

It is recommended to test the soil to the full depth of the root zone as S concentration increases with soil depth.

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 northern NSW, canola is often sown into residual moisture from summer rainfall events without a true seasonal break to stimulate weed emergence. In this situation an even establishment of canola competes strongly with weeds that emerge once the seasonal break arrives.

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.

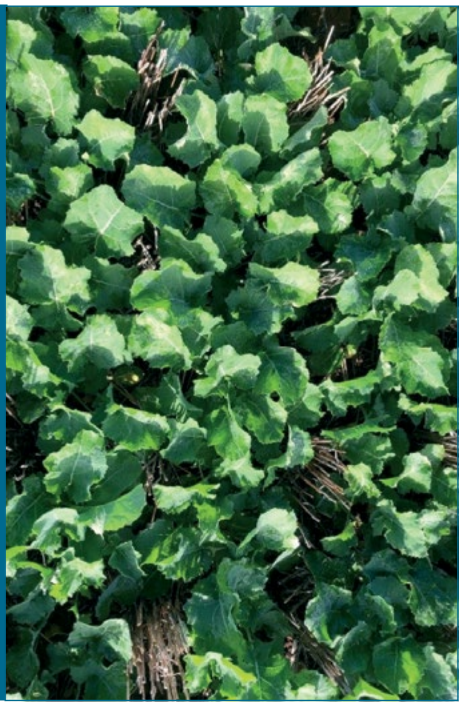


Photo: Warwick Holding

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. However there is generally a smaller impact of phosphorus fertiliser on canola establishment on vertosol soils.

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.

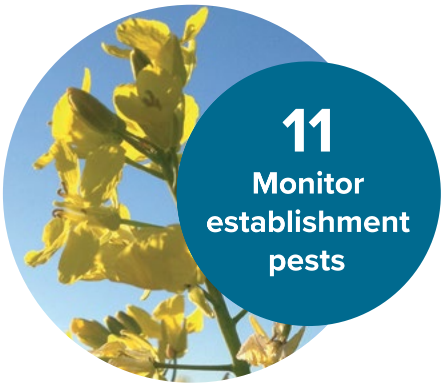
Nil P (top) and 40kg P/ha (bottom) applied to a soil with high levels of residual P.

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 in crops following pulses is higher than those following 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 36kg N/t. Assuming 50% efficiency, 72kg 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 51kg 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 72kg/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) × 72kg N/ha] − [Mineral N at sowing (kg N/ha) + estimated mineralisation (kg N/ha)]

The table (right) presents typical canola growing systems in northern NSW. Higher N application is required on soils with low mineral N at sowing and low organic carbon, these conditions being typical of intensive cropping rotations. Pulse crops can provide 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
Location	Gilgandra	Coonamble	Edgeroi	Breeza
Previous Crop	Pasture	Chickpea	Faba bean	Sorghum
Mineral N at sowing	180kg N/ha	90kg N/ha	100kg N/ha	80kg N/ha
Organic carbon	1.2%	0.7%	0.9%	1.0%
Estimated mineralisation	50kg N/ha	25kg N/ha	50kg N/ha	60kg N/ha
Target grain yield	2.2t/ha	1.7t/ha	2.6t/ha	2.8t/ha
N application required	Nil	7kg N/ha	40kg N/ha	62kg N/ha

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.

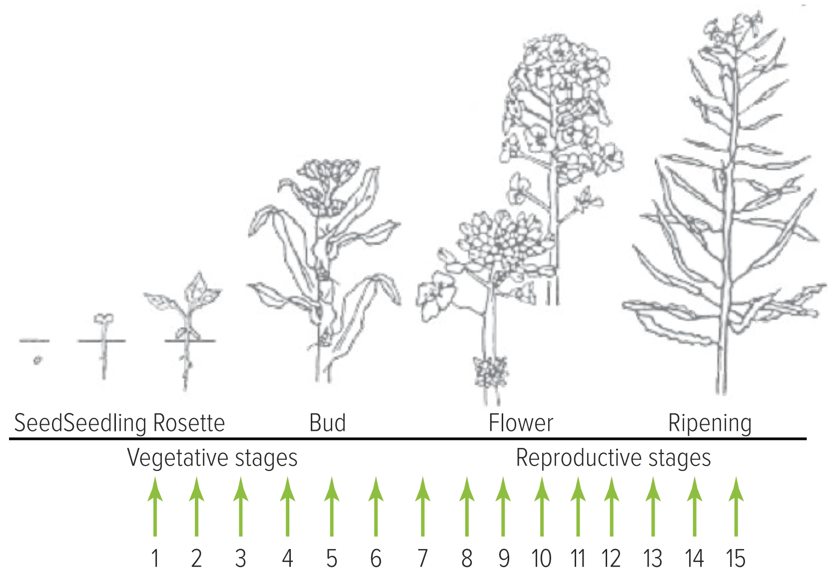
The critical period for cereals has been established as the period ~20 days before flowering, while for grain legumes it has been identified as the period ~20 days after flowering. Surprisingly the critical period for canola had never been identified.

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.

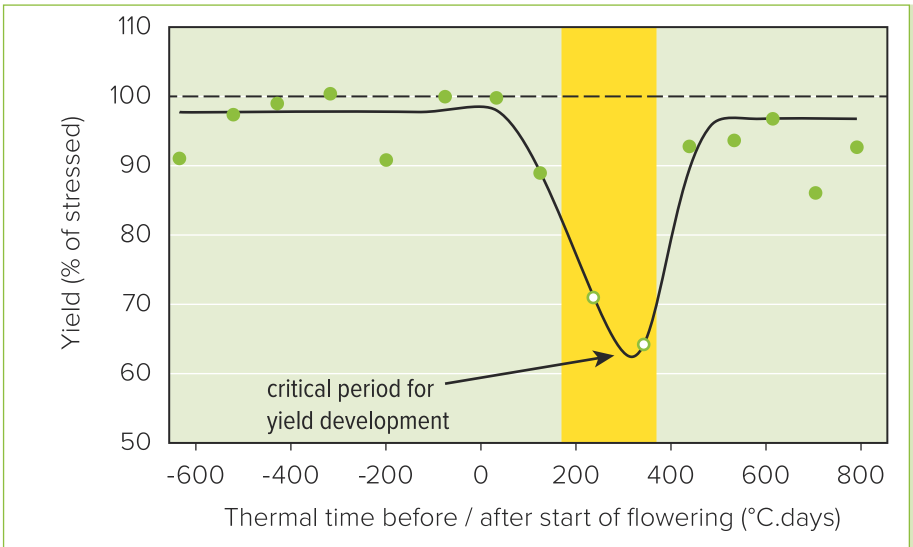
Shade shelters were made on moveable steel frames (above) so the crop could be shaded at the specific 7–13 day periods at 15 different times (right) throughout the season.

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

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 (70–80 kg N/t expected seed yield).
- Split N fertiliser application or mid/side row banding to ensure N is available at flowering.

Further information

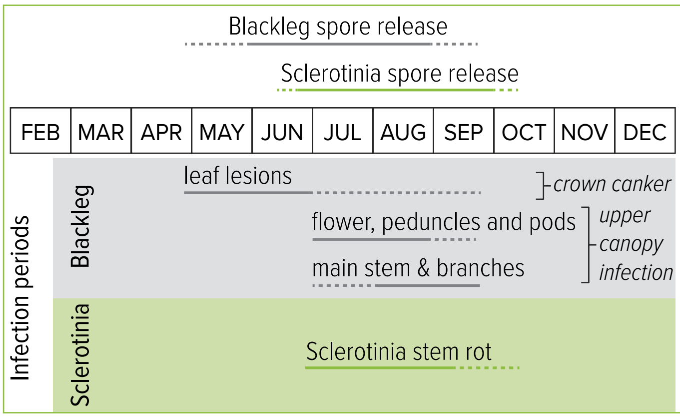
The critical period for yield and quality determination in canola.
http://bit.ly/canola-critical

15 Control foliar diseases

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.



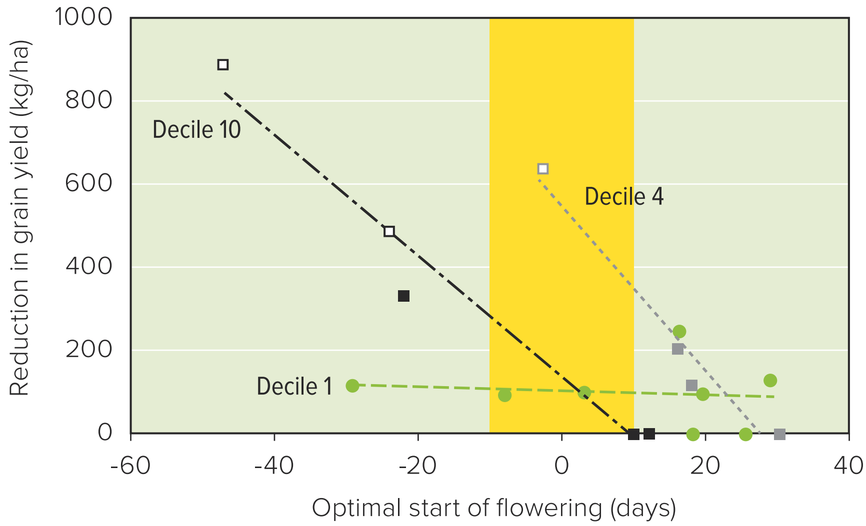
Periods of infection by blackleg and sclerotinia for different parts of the canola plant in relation to the period of spore release in medium and high rainfall zones. Solid lines indicate main periods of infection, dashed lines indicate periods of reduced risk from infection. Earlier-sown crops generally 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

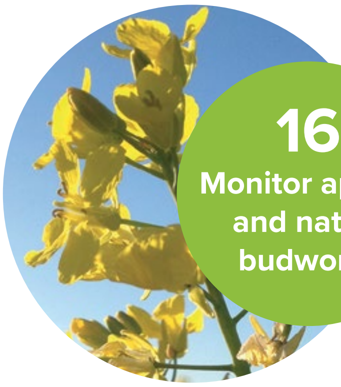
Canola yield loss from upper canopy blackleg infection can be reduced
http://bit.ly/GroundCover-blackleg

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

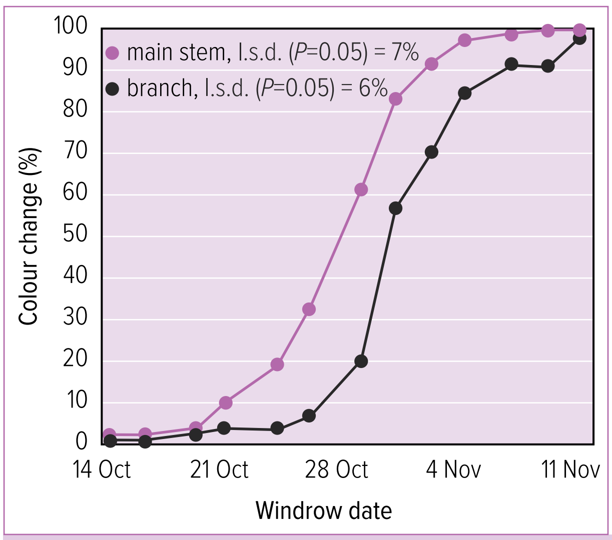
SECTION 5: HARVEST MANAGEMENT

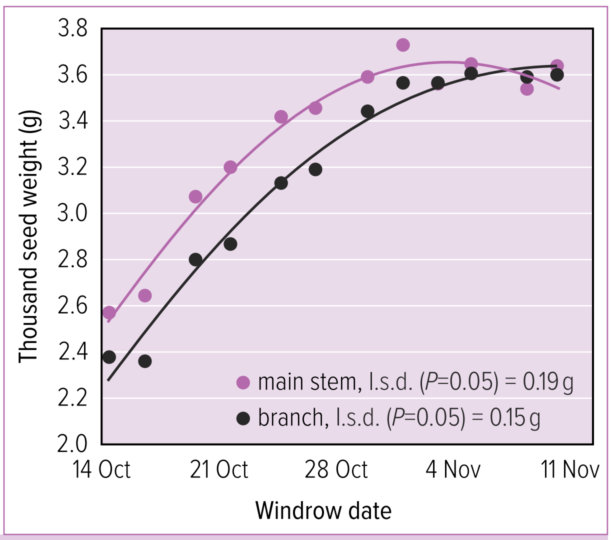
Some glyphosate products are registered for application on canola at 20% seed colour change. This can be useful to limit seed set of weeds such as annual ryegrass but also to stop the growth of non-glyphosate tolerant canola.

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.

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 branches and main stem 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 mainstem 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

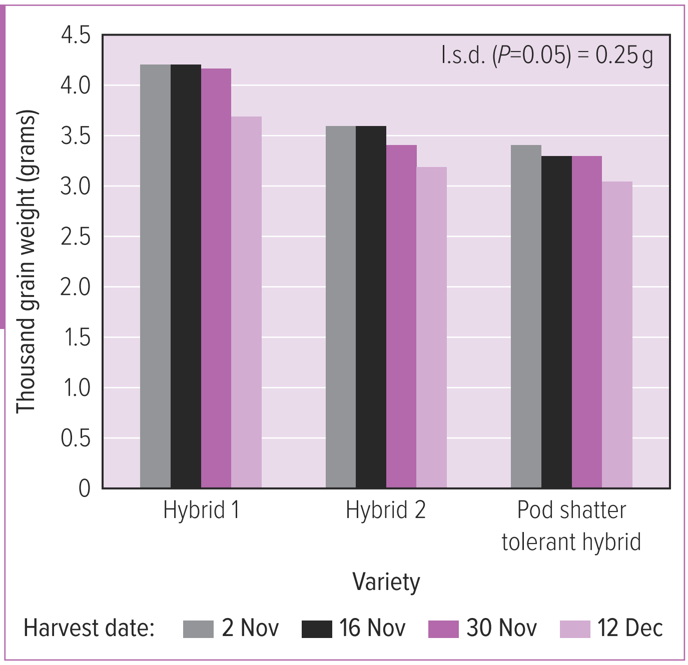
With all the hard work done growing a crop, it is important to ensure it all gets into the bin.

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

The profitability of canola must consider both crop yield and the costs of production because there is a trade-off between revenue from yield and the cost outlaid to produce that yield. We estimated the profitability (gross margins) for canola grown with different combinations of management practices (time of sowing, variety, rate of development, nitrogen (N) fertiliser rate and planting density) using the last 50 years of weather for Breeza. These were compared with the usual best practice. All simulated crop yields were not affected by weeds, disease, soil limitations or low fertility other than N.

Key finding: Using a hybrid with higher N inputs increases gross margins compared to usual practice

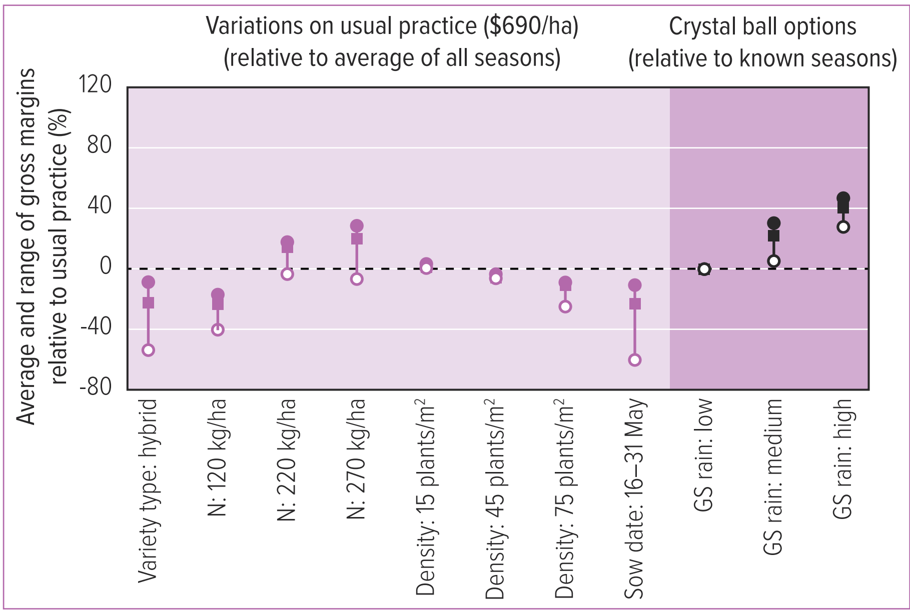
Breeza Question: What might usual practice look like?	Gross margin average and range ($/ha)
Breeza receives high rainfall with a summer dominant distribution. Hybrid canola is often sown at the beginning of May on stored water of at least 150mm to reduce production risk. We assumed that: enough rainfall (e.g. 20mm) occurred at sowing to ensure germination in the 1–15 May window, and N inputs were 50kg N/ha as soil mineral at sowing, plus in-crop fertiliser as urea valued at $1/kg applied.	
Sowing window: 1–15 May Type of variety: hybrid Clearfield® Rate of variety development: medium Density: 25plants/m² N inputs from soil and fertiliser: 220kg N/ha	690 (−1 to 873)
Question: Would a different variety be more profitable? (all else unchanged)	
Type of variety: TT OP	533 (−189 to 862)
Answer: *No – the Triazine-tolerant open-pollinated cultivar had lower minimum, average and maximum gross margin values than the hybrid, based on in-crop costing (not rotations).*	
Question: Is there a more profitable amount of N to use? (all else unchanged)	
N inputs from soil and fertiliser: 170kg N/ha	527 (163 to 685)
N inputs from soil and fertiliser: 270kg N/ha	794 (−151 to 1,058)
N inputs from soil and fertiliser: 320kg N/ha	830 (−272 to 1,207)
Answer: *Maybe – increase in N rate increases average and maximum gross margins but increases the risk of loss in low rainfall seasons.*	
Question: Would a change in planting density be more profitable? (all else unchanged)	
Plant density: 15plants/m²	712 (119 to 873)
Plant density: 45plants/m²	668 (−1 to 834)
Plant density: 75plants/m²	615 (−122 to 811)
Answer: *Yes – a lower plant density would be more profitable. Crops can compensate for lower planting density and gross margins increase due to savings in seed costs. Note that herbicide costs did not change with planting density, and crops are assumed to be free of weeds.*	
Q. Would profitability change much if I planted later? (all else unchanged)	
Sowing window: 16–31 May	535 (−357 to 828)
Answer: *Yes – on average later sowings yield less so are less profitable with an increased risk of losses in low rainfall seasons.*	

Crystal ball question: What could we expect from the most profitable management package for a 16–30 April sowing if we could tailor practices to seasonal conditions?

We simulated approximately 200,000 different combinations of sowing window, variety, planting density and N fertiliser rate over 50 years. We grouped the most profitable combination of practices assuming the growing season rainfall was known.

Low growing season rainfall (deciles 1–3)	Medium growing season rainfall (deciles 4–7)	High growing season rainfall (deciles 8–10)
Usual practice:	Usual practice:	Usual practice:
Gross margin ($/ha): 602 (–1 to 826)	Gross margin ($/ha): 711 (291 to 852)	Gross margin ($/ha): 748 (528 to 873)
Alternative practice: Variety: hybrid Development: medium Density: 25plants/m² N inputs from soil and fertiliser: 220kg N/ha Average yield: 2.6t/ha Gross margin ($/ha): 602 (–2 to 826)	**Alternative practice:** Variety: hybrid Development: medium Density: 25plants/m² N inputs from soil and fertiliser: 320kg N/ha Average yield: 3.4t/ha Gross margin ($/ha): 874 (266 to 1,207)	**Alternative practice:** Variety: hybrid Development: medium Density: 25plants/m² N inputs from soil and fertiliser: 370kg N/ha Average yield: 3.9t/ha Gross margin ($/ha): 1,054 (721 to 1,243)

Answer: *The most profitable practices for low growing season rainfall were consistent with current usual practice. With knowledge of medium to high growing season rainfall then higher N fertiliser inputs could be profitably made. These N inputs supplied between 70 and 80 kg N/t of grain yield.*



Average change in gross margins from changing management practices compared to usual practice. Points for each practice show the average and range.

The most profitable option overall was also the most profitable option across all season types.

Further information

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

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