Spring vs winter canola phenology across Australia: Insights for northern NSW growers

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GRDC code

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Key messages

- Day degrees describe the biological clock within crops
- Several factors affect canola development, so simple day-degree calculations do not describe all development processes
- Published days to flowering may not be relevant beyond the site where they are measured
- Knowing the flowering mechanisms allows prediction of flowering without an on-site trial
- Using site variability across Australia improves knowledge at specific sites.

Background

Canola's diverse genetics allows it to be grown as a short-season spring crop or a long-season winter crop. In Australian cropping regions, avoiding damaging frosts or high temperatures during flowering and pod fill are key to maximising yield and oil quality (Kirkegaard et al 2018). Having confidence that a cultivar will flower when expected, ensures timely management and that crops will flower at the optimal time (Lilley et al 2019). Recent climatic changes and the logistics of planting large areas have resulted in canola being sown earlier. This has seen some cultivars behave unpredictably with flowering occurring earlier or later than expected. Phenology is the term used to describe the development or lifecycle of a plant. Understanding the phenological mechanisms within each canola cultivar allows us to predict when it will flower in different environments (Whish et al 2020), allowing growers to choose better adapted cultivars and management strategies for different environments.

Identifying cultivar phenology

Plants have distinct stages of development and these describe the phenology of the plant. The most common and easily recognised canola stages are emergence, green bud, flowering, podding and maturity (Figure 1).

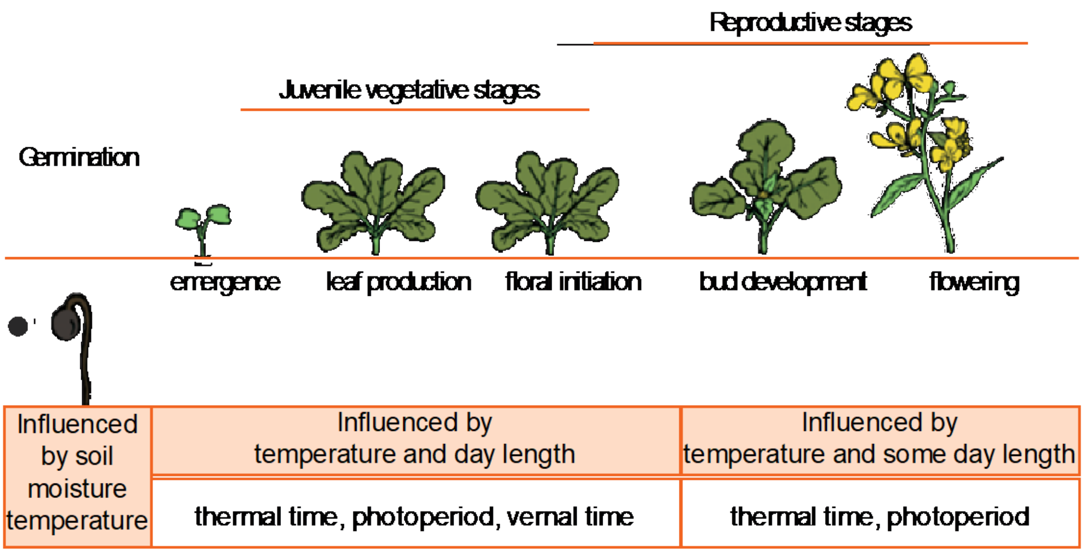


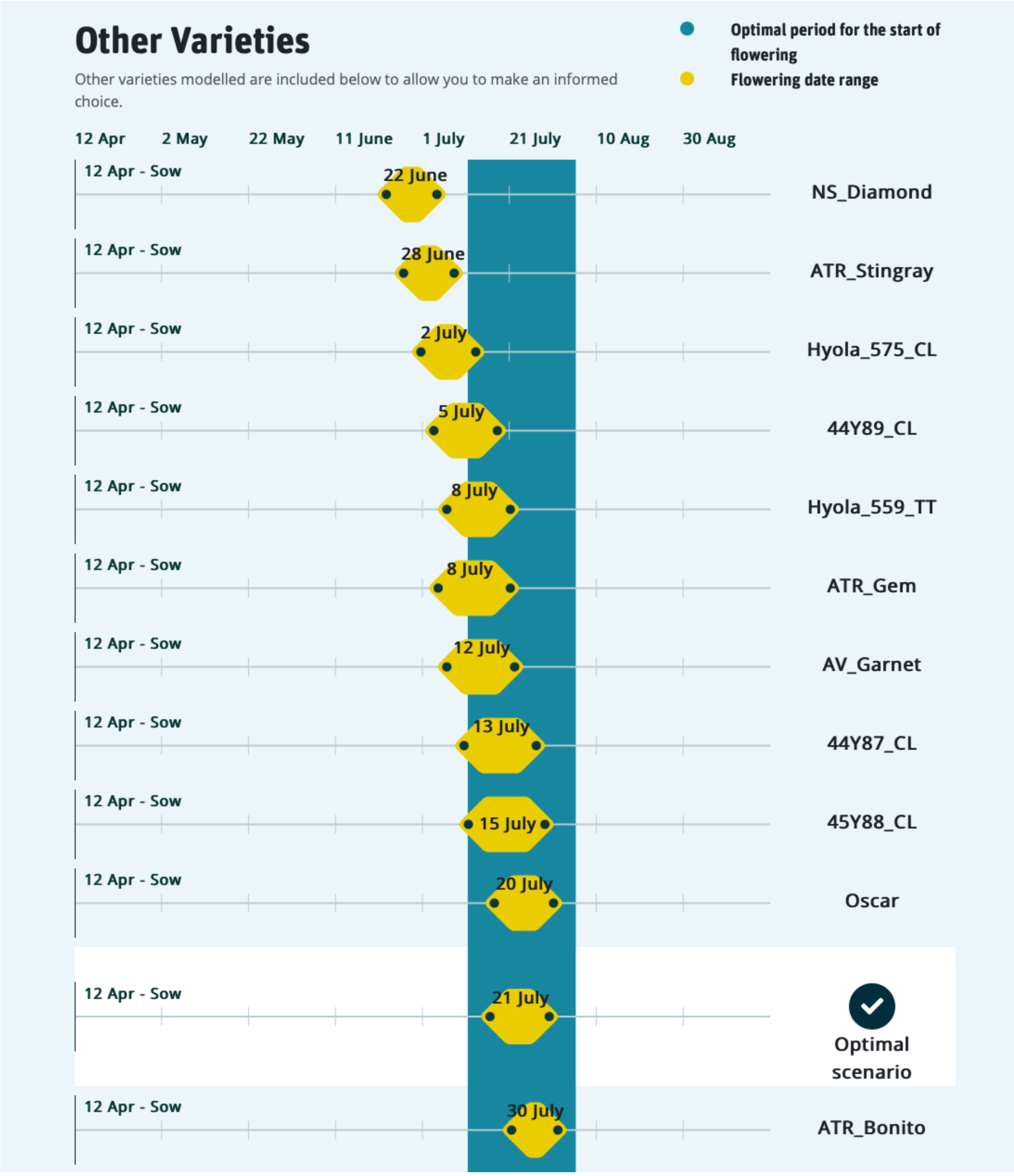
Figure 1. Growth stages for canola and the dominant environmental signals that influence growth in each stage.

Plants respond to environmental signals such as temperature to determine when they move from one developmental stage to another. At the biochemical level, this is caused by specific temperatures inducing the production of plant hormones until a critical concentration triggers the change within the plant. A simpler 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 achieved.

Why would we want to know this?

Understanding how the environment affects the growth of a plant assists in crop management. Many management decisions are time critical, that is, for optimum results the intervention (spray application, defoliation, stop grazing, add fertiliser) needs to occur before a plant reaches a particular growth stage. Identifying these stages can be difficult, for example, floral initiation can occur well before any visible sign appears in the plant. If the crops are grazed or stressed during this floral initiation period, then a yield penalty can occur (Kirkegaard et al 2008; Sprague et al 2014). Knowing the developmental stage a plant is at can often help prevent yield loss or ensure that untimely management does not occur.

In many environments it is important that canola flowers within a particular window, to avoid frost on one hand and high temperature heat stress on the other (Lilley et al 2019). If a farm is in a region that generally has sowing rain within a particular month, matching the maturity of a variety ensures it flowers inside its optimum window every year. However, in many areas sowing rainfall is unpredictable and may occur too early or too late. Understanding the phenology of different varieties allows selection of specific varieties to ensure flowering occurs at the optimum time and the risk of crop loss is reduced (Figure 2).



Other Varieties

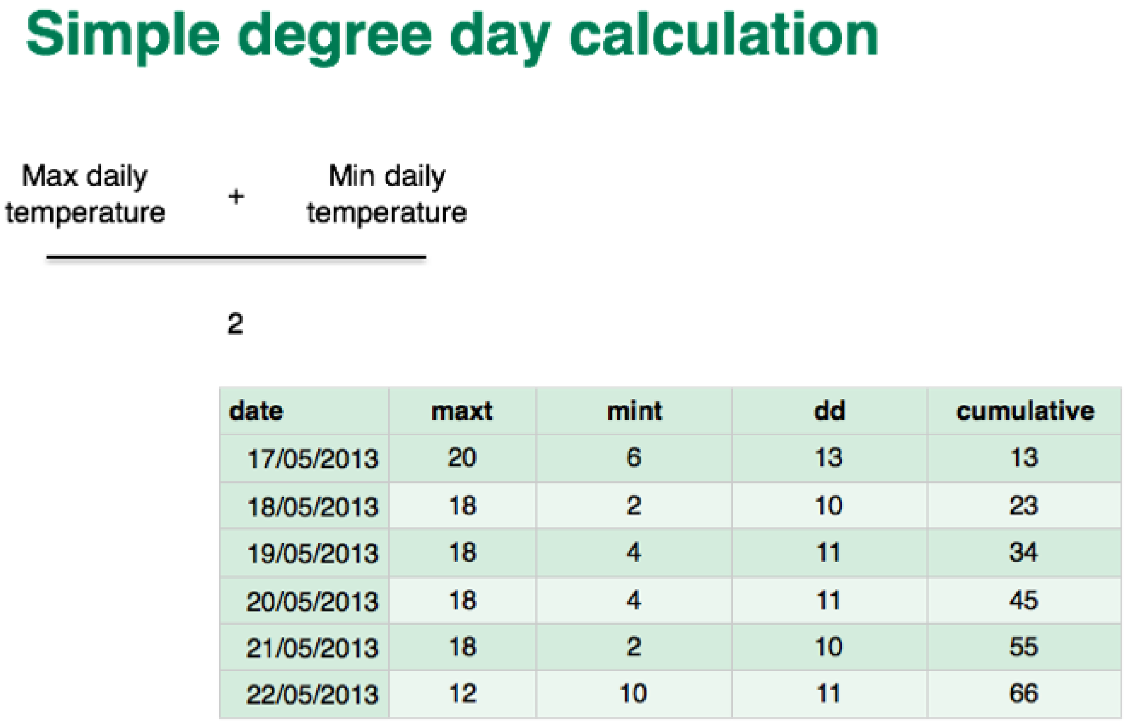
Other varieties modelled are included below to allow you to make an informed choice.

Figure 2. A screen shot from the Canola Flowering Calculator showing flowering data for several cultivars sown in Walgett, NSW on 12 April. At this sowing, short season cultivars NS Diamond, ATR Stingray ⓓ and Hyola® 575CL all start flowering before the optimal starting window while slightly longer-season cultivars like 45y86_Cl and ATR Bonitoⓓ start flowering at the optimal time.

Several GRDC projects have contributed to our understanding of canola flowering in the Australian environment. More recently, this work has investigated the gene combinations that produce different flowering responses. The goal is to develop a simple PCR test to predict flowering of new cultivars in any environment. While this genetics work is progressing, companies like Pacific Seeds are using the same phenological testing procedures to ensure they recommend cultivars ideally suited to each region, sowing date and purpose. Pacific Seeds is currently evaluating winter oil seed rape & summer oil seed rape advanced germplasm across Australia in a joint three-year research project with CSIRO. This work is focused on developing a multi-platform interactive application to support management decisions around canola type (winter or spring), time to flowering, crop nitrogen management, grazing and animal health.

How do you calculate the phenological response for a cultivar?

Day degrees, growing degree days, degree days or thermal time are the terms used to describe the units of a plant's biological clock. They are a way of combining time and temperature into a single number. In their simplest form, day degrees are based on the average temperature recorded during a day (Figure 3). To calculate the thermal time target for a plant's development stage, the day degrees are accumulated until a specific target is reached, e.g., variety X accumulates 500-degree days between emergence and flowering.



Simple degree day calculation

$$\frac{\text{Max daily temperature} + \text{Min daily temperature}}{2}$$

date	maxt	mint	dd	cumulative
17/05/2013	20	6	13	13
18/05/2013	18	2	10	23
19/05/2013	18	4	11	34
20/05/2013	18	4	11	45
21/05/2013	18	2	10	55
22/05/2013	12	10	11	66

Figure 3. Simple calculation of day degrees (average daily temperature) and accumulation of day degrees over time to calculate a thermal time target for a change in plant growth stage.

This example is the simplest form and assumes that the plant has a base temperature of 0°C with no growth or development occurring below this temperature. It also assumes that growth and development will continue at high temperatures (>35°C) but this is not always the case.

The simple day degree calculation can be made more complex by identifying those temperatures where plant growth and development occurs and only calculating day degree temperatures when they are within this range. For this paper we use the average daily temperature, but more information and detail on calculating thermal time can be found at: https://www.youtube.com/watch?v=t-8bwU9ke2s

For some plants, development can be described using thermal time alone, as they will flower after accumulating the same thermal time no matter where they are planted. However, canola is more complicated than this, because in addition to accumulating thermal time, it has two other mechanisms — vernalisation and photoperiod, that influence the time to flowering. The combination and interaction of these three mechanisms complicate the process of estimating when canola crops will flower.

Photoperiod (day length)

Photoperiodism describes the response of plants to increasing or shortening day lengths. Long day plants (canola) respond to increasing day length by reducing the thermal time required to flower.

For example, if it takes an accumulated total of 800-degree days to flower during a 12-hour daylight day it would take only 700-degree days if there are 16 hours of daylight. However, in Australia, canola is generally grown with <12-hour daylengths, so daylength does not influence flowering in most commercial crops.

Vernalisation

Vernalisation is described as low temperature promotion of flowering (Salisbury and Ross 1969). It is similar to photoperiod, in that vernally sensitive cultivars require less thermal time to flower when grown in a cold environment. However, there are two types of vernalisation ‘facultative’ and ‘obligate’. Facultative vernalisation is when canola grown in cooler climates require less thermal time to flower than when grown in warmer environments. Obligate vernalisation occurs in winter canola and works like a switch with the plants remaining in a juvenile or vegetative state until about 13 days of vernal time have accumulated (this is 13 days with an average temperature of 2°C or 52 days at 12°C). Obligate vernalisation is the mechanism that keeps plants dormant during European winters, or in Australia make this type of canola good for forage or as a dual-purpose crop. Once the obligate vernalisation trigger occurs, the plant behaves similarly to a spring type - often displaying a facultative vernal response to additional cold.

How do we know this?

By studying the climate of different regions, we can build a set of key environments to test for vernal responses in canola cultivars (Figure 4).

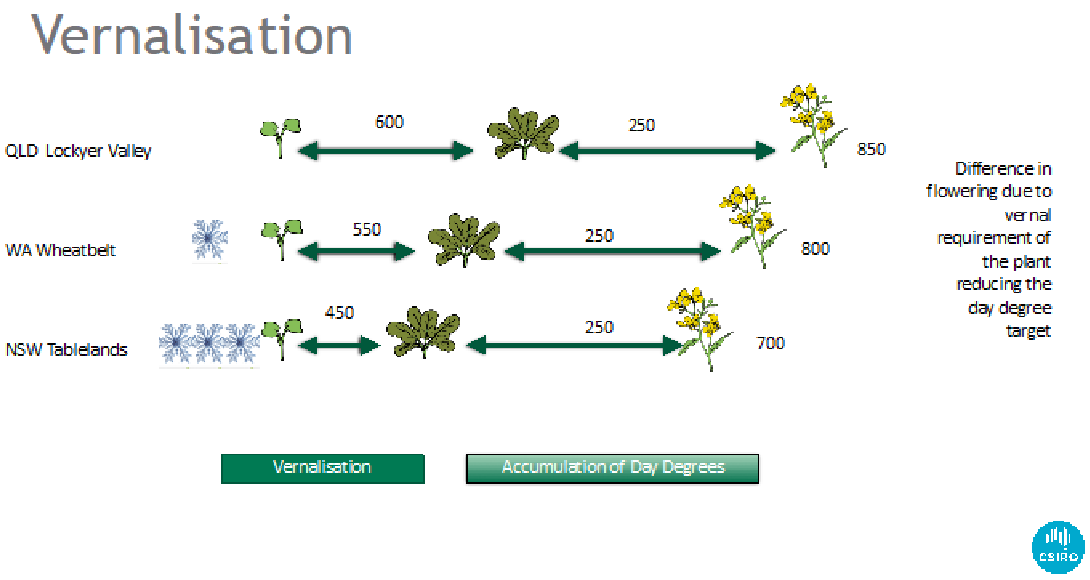


Figure 4. The influence of different rates of vernal accumulation from three sites across Australia on canola flowering time. Cooler regions require less thermal time than warmer regions to achieve flowering.

By strategically choosing sowing dates and sites that accumulate thermal and vernal time differently, we can calculate how each cultivar will behave in any environment (Figure 5). This selection of sites extends from the very cold extremes of the eastern tablelands, to areas with minimal cold, to capture all of Australia’s canola growing regions.

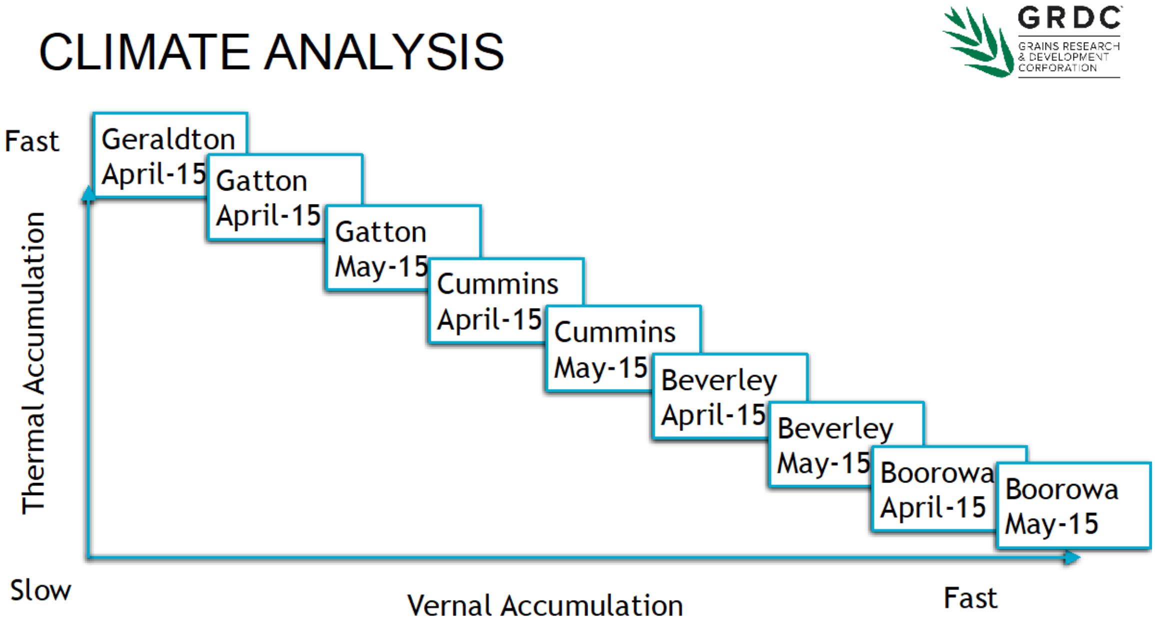


Figure 5. A selection of sowing dates and sites used to characterise the vernal to thermal ratio for Australian canola cultivars.

CSIRO's GRDC funded canola genetics project (Optimising Canola Production in Diverse Australian Growing Environments: CSP1901-002RTX) has used this approach to examine more than 300 different cultivars from around the world. The results demonstrate it is possible to identify different vernal responses (Figure 6).

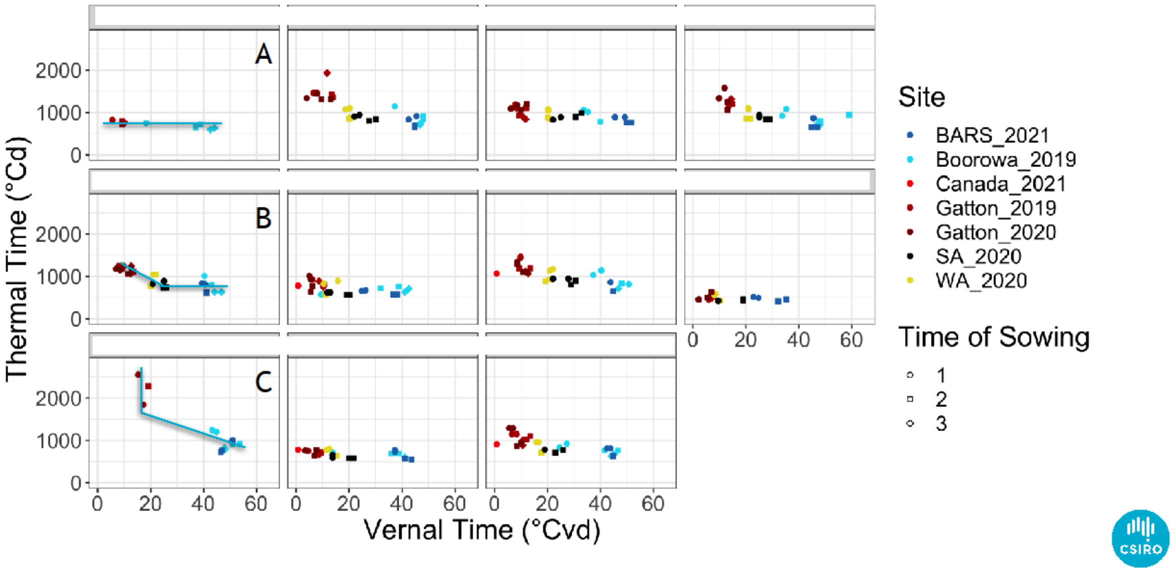


Figure 6. Data from the canola genetics project CSP1901-002RTX detailing three different vernal responses: A. no vernal response, B. facultative vernal response C. obligate vernal response.

How is this being used?

Pacific Seeds is working closely with CSIRO to assess the performance of pre-released canola material (Figure 7). The information collected will improve canola recommendations and ensure obligate winter types are not being recommended for early sowing in areas that receive insufficient vernal temperature. The data from the first year shows the pre-release lines CL210042, CL200026, CT210046 and CL90009 have contrasting vernal response patterns compared to the established cultivars of Hyola 970CL and Hyola 575CL. Such differences can be exploited to match agronomic practices to different environments.

On the tablelands of eastern Australia, the use of long-season varieties for dual-purpose cropping has become popular, but using these same cultivars without grazing has not generated the same profits. The obligate vernal response of winter type canola enables long grazing, but this is limited to areas with long periods of cold temperature. Reducing the size of this obligate response could expand the areas where dual-purpose cropping could be practised and move it away from the cold of the south-eastern tablelands and towards the cool of the slopes and plains.

Dry sowing is a valuable logistics tool especially in areas like WA, but if the season breaks early, sowing a short-season crop may result in early flowering, and if the break comes late, a mid-season cultivar may flower too late. By understanding the vernal response of different cultivars, the so-called 'goldilocks' cultivars can be found, with enough vernalisation to hold them back if sown early, but also able to flower more quickly when sown late. This is less of an issue in the northern NSW as the narrow optimal flowering window restricts the choice of cultivars and sowing date.

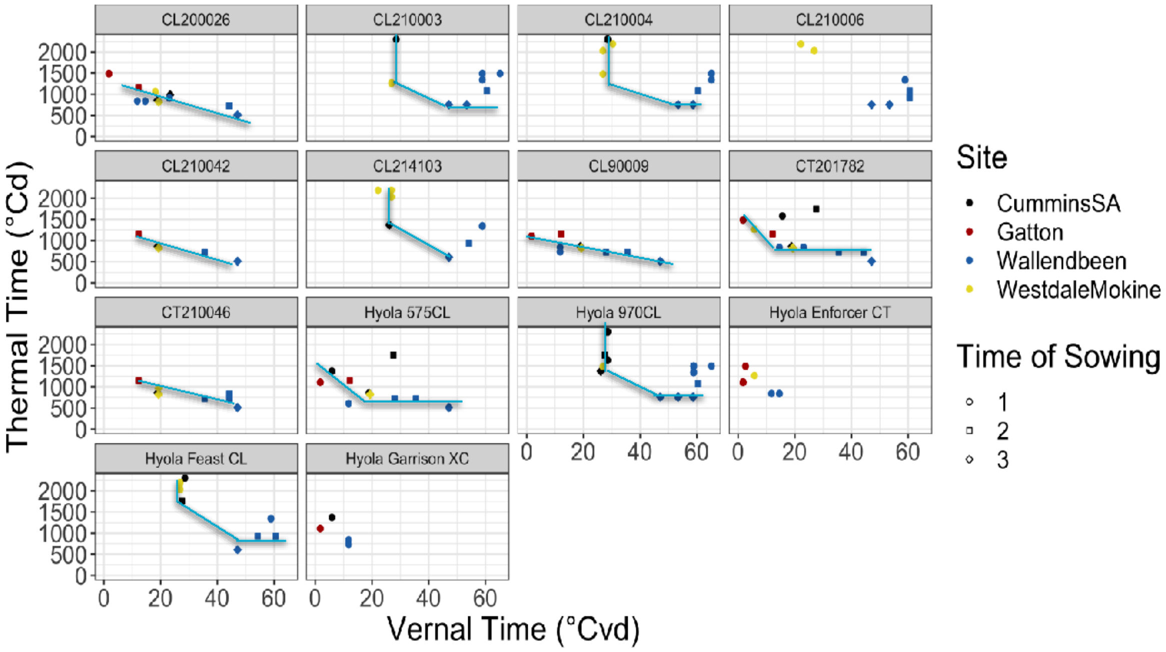


Figure 7. Pacific Seeds pre-released lines showing similar vernal responses to some established hybrids Hyola 575CL and Hyola 970CL along with a more linear response seen in CL210042, CL200026, CT210046, CL90009.

Conclusion

Understanding crop phenology enables the behaviour of crops in different environments to be better predicted and flowering patterns to be more easily calculated (as with the canola flowering calculator). It is hoped that the research described here will reduce the time needed to determine the flowering response of new cultivars. This will enable models like APSIM to use historic climate records to describe variety-by-sowing-date combinations that maximise yield production in different regions. In addition, agronomic practices that are crop-stage dependent, such as spraying or grazing, can be modelled for each area in real time to help improve management and overall grain returns.

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