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GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

CANOLA

SECTION 4

PLANT GROWTH AND PHYSIOLOGY

Plant growth and physiology

4.1 Canola types

4.1.1 Conventional

The first rapeseed varieties were introduced into Australia from Europe and Canada in 1969. Under Australian conditions these varieties were late flowering (and so restricted to the higher rainfall zones) and very susceptible to blackleg.

From 1970 to 1988, conventional breeding techniques were used to improve yield, adaptation, blackleg resistance and seed quality (low erucic acid, low glucosinolates). These varieties were based on *B. rapa* (formerly known as *B. campestris*). They had earlier maturity and tolerance to pod shattering.

In 1988 the first varieties were released that combined blackleg resistance with higher yield. These varieties were based on *B. napus* material from Asia and Europe. From this time, there was a complete swing to breeding *B. napus* varieties.

Brassica napus is thought to have formed originally from natural crosses (hybridisation) of *B. rapa* and *B. oleracea*. It is distinguished from other species by the shape of the upper leaves: the lower part of the leaf blade half-grasps the stalk. [1]

4.1.2 Triazine-tolerant canola

Triazine-tolerant (TT) varieties were first commercialised in 1993, with the release of the variety Siren. Genes for tolerance to the triazine group of herbicides were bred into conventional canola varieties. This enabled the control of *Brassica* weeds, which were previously unable to be controlled in standard canola varieties.

The triazine-tolerant trait is associated with reduced conversion of sunlight into biomass (i.e. reduced radiation-use efficiency). Triazine-tolerant varieties are therefore generally less vigorous as seedlings and produce less biomass than conventional varieties. This results in 10% to 15% lower yields and 1% to 3% lower oil contents than in conventional varieties. However the effective weed control available in these varieties means actual yield is often higher then conventional varieties competing with weeds. Another effect of the triazine-tolerant trait is a delay in plant development. [2]

4.1.3 Hybrids

Hybrids were first released in 1988. Hybrid varieties are produced using controlled pollination of a female parent by a male parent (the source of pollen). The progeny (the F1 hybrid) contain the best characteristics of both parents, known as hybrid vigour. Hybrid varieties are typically associated with larger seeds, strong seedling vigour and greater biomass production. [3]

1 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

2 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

3 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

4.1.4 Specialty canola – high oleic/low linolenic (HOLL)

Specialty canolas were bred by traditional means to increase the content of the monounsaturated fat oleic acid and decrease the level of the polyunsaturated fat linolenic acid in the oil. This type of oil is more stable at higher temperatures and more suited for deep frying. This gave a high oleic/low linolenic (HOLL) canola. [4]

4.1.5 IMI-tolerant canola

IMI-tolerant varieties are tolerant to imidazolinones (IMIs), the active ingredients of herbicides such as OnDuty® and Intervix®. They are grown as part of the CLEARFIELD® production system. IMI-tolerant canola varieties were developed by selection of naturally occurring mutations from conventional canola varieties. Unlike the TT gene, the gene for IMI tolerance is not associated with a yield penalty. [5]

4.1.6 Condiment (Indian) mustard

Condiment mustards are varieties of *Brassica juncea* grown for their hot, peppery taste. Although related to juncea canola, condiment mustards have different meal and oil qualities. The level of glucosinolates in the meal after crushing is much higher in condiment mustard and is responsible for the hot and spicy taste of table mustard. The oil has a distinct 'nutty' flavour, but the erucic acid level is sufficiently low to make it suitable for human consumption. Indian mustard is the preferred oilseed in many parts of South Asia, northern and western China and eastern Russia. It has a reputation for having greater drought and shattering tolerance than canola. [6]

4.1.7 Junecea canola – *Brassica juncea*

Juncea canola is the name given to plants bred from *Brassica juncea* to have all the oil and meal quality specifications of canola. The oil has high levels of oleic acid and low levels of erucic acid, and there are low levels of glucosinolates in the meal (Table 1). The meal can be substituted for canola meal in animal diets. Juncea canola has the same market end-use as canola.

Juncea canola is being developed as a drought- and heat-tolerant alternative to canola for the low rainfall zone. It also has excellent seedling vigour (similar to that of hybrid canola) and is more tolerant of shattering than canola. Because it is a relatively new crop, breeding, selection and agronomic research have not progressed as far as with canola. The first commercial varieties were grown in 2007.

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4 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

5 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

6 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

MORE INFORMATION

GRDC Update Paper: Optimising grain yield and grazing potential of dual-purpose crops

GRDC Update Paper: Managing dual purpose crops to optimise profit from grazing and grain yield

GRDC Fact Sheet: Dual-purpose crops

Canola in the grazing mix is food for thought

GRDC Update Paper: Dual purpose crops do they have a fit in your system and how can they be managed to optimise forage and grain production

GRDC Update Paper: The effect of grazing and burning stubbles on grain yield and quality in no till and zero till controlled traffic farming systems in SNSW

Table 1: *Typical seed quality characteristics for canola, juncea canola and condiment mustard when grown in the low rainfall zone.*

Characteristic	Canola	Juncea canola	Condiment mustard
Oil %	36–42	34–40	34–40
Oleic acid %	57–63	57–63	variable
Linoleic acid %	18–25	18–25	variable
Linolenic acid %	8–13	8–13	variable
Erucic acid %	<1	< 1	1–20
Glucosinolate in meal (µmol/g – 10% MC)	< 30	< 30	110–160
Allyl glucosinolate in meal (µmol/g – 10% MC)	0	< 1	NA

Source: NSW DPI

4.1.8 Roundup Ready®

Roundup Ready® (RR) varieties have been bred by genetic modification technology to be tolerant of the herbicide glyphosate. This allows glyphosate to be sprayed over canola in the early stages of growth without affecting the development of the crop. The first varieties were grown commercially in 2008.

4.1.9 Industrial mustard

Industrial mustard is a *B. juncea* type that is not suitable for either of the edible markets because of its high levels of erucic acid and/or glucosinolates. Industrial mustard is grown for use in a number of industrial products, including biodiesel.

4.1.10 Winter types for grazing (dual-purpose canola)

Canola is now a viable and reliable grazing option on mixed farms. Research developed 'rules of thumb' for grazing the widely grown spring canola varieties are:

- be ready
- sow early with later-maturing types with high blackleg tolerance
- graze when plants are well anchored (six-leaf stage)
- lock-up canola before buds elongate more than 10 cm. [7]

Research over 2012–15 has refined some of the accepted rules about lock-up times for canola. Until now these were based on the stage of crop development: lock-up before buds elongate 10 cm.

Trials demonstrate that the residual biomass at lock-up time also influences the yield outcome (depending on the yield potential of the season).

Achieving a higher target yield requires more biomass at flowering, which means more residual biomass at lock-up, especially if it is late. Target yield is linked to critical flowering biomass to predict the residual biomass required on different lock-up dates to avoid yield penalties.

For example, spring canola in south-eastern Australia requires 5 t/ha of biomass at flowering for 2.5 to 3 t/ha yield. A residual biomass of 1.5 t/ha at the end of July will be sufficient to reach the critical biomass, so grazing management can be directed by this.

Table 2 shows the typical sowing times, grazing periods, range of grazing days and seed yield achieved in experiments and in commercial fields as part of the dual-purpose canola projects. These varieties were used successfully in dual-purpose

7 GRDC (2016) Canola in the grazing mix is food for thought. Ground Cover Issue 117, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-117-Optimising-canola-profitability/Canola-in-the-grazing-mix-is-food-for-thought

canola experiments across different regions and are representative of others that would also be suitable in specific areas. The results are for crops where grazing had no impact on the seed yield or oil content of canola. [8]

Table 2: *Canola types trialled in dual-purpose canola projects.*

Region / Growing season rainfall	Canola type	Sowing window	Grazing achieved		Yield (t/ha)
			Timing	DSE days/ha	
High rainfall 300–500 mm GSR Goulburn, Delegate, Holbrook, Inverleigh	Winter CB Taurus, Pacific Seeds Hyola® 970CL, SF Senesation, SF Edimax CL	1 March to 10 April	May–August	1500–3000	3.0 to 5.0
Medium rainfall 250–350 mm GSR Young, Greenethorpe, Cootamundra	Late spring AV-Garnet®, Pacific Seeds Hyola® 575CL, 45Y88	5 April to 30 April	June–July	600–800	2.0 to 3.5
Lower rainfall 150–250 mm Temora, Wagga Wagga	Mid-spring Tawriffic, 45Y82, 43C80	15 April to 8 May	June–mid July	200–600	1.0 to 2.5

Dual-purpose use of grain crops offers the potential to improve the flexibility and resilience of mixed farming systems. Analysis of experimental data has shown that utilising winter cereals (wheat, barley and triticale) and canola for a period of grazing during their vegetative phase before allowing the crop to regrow to produce grain yield (graze + grain), can increase the net returns from that crop by 25–75%. [9]

Dual-purpose crops have become an integral part of mixed farming systems in the medium and high rainfall zones of southern Australia. Winter canola cultivars that require a period of cold (vernalisation) to initiate flowering provide a wide sowing window from early spring through to early autumn and under suitable conditions, can be grazed six to eight weeks after sowing. Although production of dual-purpose winter canola was initially adopted in the high rainfall zones, changing rainfall patterns providing good early sowing opportunities has resulted in growers planting dual-purpose crops in March. Early-sown crops provide significant periods of grazing (up to 3000 sheep grazing days/ha) and can produce good grain yield as a result of the ability to access to moisture by development of deep roots. Dual-purpose crops can also reduce risk by providing income from grazing and grain as well as broader whole-farm benefits. [10]

8 GRDC (2016) Canola in the grazing mix is food for thought. Ground Cover Issue 117, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-117-Optimising-canola-profitability/Canola-in-the-grazing-mix-is-food-for-thought

9 L Bell (2016) Role and fit for dual-purpose crops for mitigating risk and optimising profit in low rainfall western grain growing regions. GRDC Update Papers 25 February 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Role-and-fit-for-dual-purpose-crops-for-mitigating-risk-and-optimising-profit

10 A Paridaen, S Sprague, J Kirkegaard, J Lilley (2016) Winter canola for grazing and grain production. GRDC Update Papers 28 July 2016, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/07/Winter-canola-for-grazing-and-grain-production

IN FOCUS

4.2 Why know about canola development?

- Understanding the drivers behind canola development will help to improve canola management and variety selection.
- Varietal maturity ratings do not always correlate with varietal phenology.
- Early sowing opportunities may provide a means to maximise canola yield, but selection of the correct variety is important.

Despite the success of canola in Australian cropping systems, significant gaps remain in the underlying knowledge of canola physiology and agronomy, a situation exacerbated by its expansion into new areas and the release of new technologies, including vigorous hybrid varieties with herbicide tolerance.

Although growers recognise the high profit potential and the farming-system benefits of canola, a perceived risk of growing canola remains, largely due to the high level of input required (e.g. seed, nitrogen (N) fertiliser, sulfur fertiliser, herbicides, windrowing). There is a need to determine the level of investment appropriate for these inputs on a regional scale and the agronomic management practices (for example sowing date decisions) that reduce the overall risk and increase the profitability of canola.

Sound, tactical agronomic decisions require improved understanding of the physiology of yield and oil formation in canola, and of how they are affected by variety, environment and management, and the interaction (G × E × M).

Maximising canola yield and profit will be achieved through an increased understanding of canola physiology. This will occur by taking the following steps:

1. Identify the optimum flowering window to minimise heat and frost risk at specific sites.
2. Identify the variety–sowing date combinations that achieve the optimum flowering window.
3. Manage the trajectory of biomass accumulation (of specific varieties) to maximise Water Use Efficiency, optimise N-use efficiency and minimise the risk of high-input costs (e.g. seed costs, N fertiliser, herbicide types, harvest strategies).

Having optimised these steps, further investigation may reveal specific varietal adaptations that provide yield advantage under specific stress (heat, drought, frost) or provide further G × E × M synergies.

As a first step to improve the understanding of G × E × M interactions in current varieties, CSIRO conducted pre-field-experiment modeling by using the best available information on variety development prior to 2014 trials, and the APSIM model. This modeling explored the potential for planting canola early at locations across Australia and the potential yields to be achieved by planting cultivars with differing maturity at a range of sowing times. The results show that potential exists for longer season varieties to be planted in locations such as Cummins, South Australia, and to have improved yield potential. However, the opportunity for successful sowing of these varieties occurs in only 15% of years (when sufficient summer rainfall occurs).

MORE INFORMATION

[Canola growth and development—impact of time of sowing (TOS) and seasonal conditions]

[Improved understanding of thresholds of armyworm in barley and aphids in canola]

MORE INFORMATION

[Revisiting canola management can lift returns]

[Canola growth and development—impact of time of sowing (TOS) and seasonal conditions]

> The manner in which each canola variety develops can have a large influence on yield, when planted at different times and in different environments. The challenge for researchers is to develop and deliver information on new varieties in a way that is timely and relevant to growers and advisers. Growers and advisers will be able to use this information when selecting a set of varieties suited to the sowing opportunities that most often occur in their district and to capitalise on early or delayed sowing opportunities as the seasons dictate. [11]

4.3 Plant physiology and the stages of plant growth

All canola grown commercially in Australia is the Swede rape type *Brassica napus*. *Brassica juncea* (brown or Indian mustard), which has the same quality as canola, is also grown but in much smaller quantities.

The 10 oilseed rape types grown throughout the world are mainly annual and biennial forms of *B. napus* and *B. campestris*. In Canada, both species are important; in Europe and the Indian subcontinent, *B. napus* is the dominant species. Each species has an optimum set of environmental and growing conditions.

The life-cycle of the canola plant is divided into seven principal stages. By recognising the beginning of each stage, growers can make more accurate management decisions on timing of weed-control operations, introduction and removal of grazing livestock in crops managed as dual-purpose, timing of fertiliser applications, timing of irrigation, and timing of pest-control measures.

Each growth stage covers a developmental phase of the plant. However, the beginning of each stage is not dependent on the preceding stage being finished, which means growth stages can overlap.

The beginning of each growth stage from budding is determined by looking at the main (terminal) stem. In the literature, it is referred to as a decimal code, similar to the Zadoks code for wheat growth stages. (Figure 1). [12]

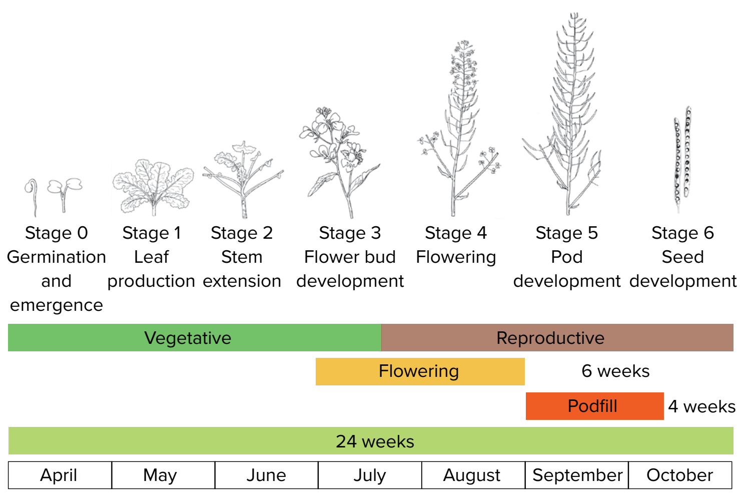

Figure 1: *Canola growth stages.*

11 A Ware *et al.* (2015) Canola growth and development—impact of time of sowing (TOS) and seasonal conditions. GRDC Update Papers, 10 February 2015, http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Canola-growth-and-development-impact-of-time-of-sowing-TOS-and-seasonal-conditions

12 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

Plants don't work by calendar days but by 'day degrees'. Simply described, this means that if the average temperature in a day is 20°C then a plant accumulates 20 day degrees in one calendar day. On a coarse scale this temperature clock is how trees know to drop their leaves in winter and why herbs bolt to seed in spring. Day degrees are a way of measuring the physiological development of a plant by combining time and temperature into a single number.

All plants receive signals from the environment that influence their rate of development. When studying the physiology of 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 well know key is the Zadocks key for wheat. Similar keys exist for canola, cotton and the pulses and describe each plant development stage. The most common and easily recognised stages are emergence, flowering, grain fill and maturity. Temperature, day length and available water are the key environmental triggers that influence plant development. [13]

4.3.1 Vernalisation

Vernalisation is the need for a plant to accumulate cold days before the day degree calculation can begin. Winter wheats and winter canola are extreme examples of this, but many spring wheats and canola varieties have some vernalisation requirement. Varieties grown in Victoria can be short season, but when moved to Queensland become long season as vernalisation is not satisfied. It is not uncommon for varying degrees of vernalisation, thermal time and day length sensitivity to occur within different varieties of a crop so every variety is different and needs to be measured.

The complexity of winter crops is one of the reasons that the use of day degree calculations is not standard practice. However, the development of crop simulation models has shown that we can understand the complexity, and predict it. The use of tools such as Yield Prophet® provides a platform to accurately assess crop phenology (the measurement of plant growth incorporating vernalisation, degree days and day length) and allow specific growth stage management to be improved. [14]

Key points

- Day degrees are a 'temperature clock' that are a valuable tool in crop management.
- Crops that are only temperature responsive are easier to work with.
- Crop growth can be described by accumulating day degrees to a known target.
- Day length can modify the day degree targets in some crop varieties.
- Tools such as Yield Prophet® are a simple way to get accurate day degree information. [15]

13 J Whish (2016) Accessing and using day degrees in field crops as a tool to assist crop management. GRDC Update Papers, 23 February 2016 https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Accessing-and-using-day-degrees-in-field-crops-as-a-tool-to-assist-crop-management

14 J Whish (2016) Accessing and using day degrees in field crops as a tool to assist crop management. GRDC Update Papers, 23 February 2016 https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Accessing-and-using-day-degrees-in-field-crops-as-a-tool-to-assist-crop-management

15 J Whish (2016) Accessing and using day degrees in field crops as a tool to assist crop management. GRDC Update Papers, 23 February 2016 https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2016/02/Accessing-and-using-day-degrees-in-field-crops-as-a-tool-to-assist-crop-management

4.4 Plant growth stages

4.4.1 Germination and emergence (stage 0 [0.0–0.8])

Emergence occurs after the seed absorbs moisture and the root (radicle) splits the seed coat and the shoot (hypocotyl) pushes through the soil, pulling the cotyledon leaves upward and in the process shedding the seed coat (Figure 2). When exposed to light, the cotyledons part and become green. [16]

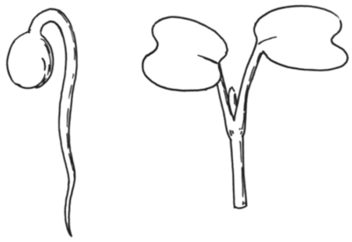

Figure 2: *Canola germination and emergence, stage 0–0.8.*

4.4.2 Leaf production (stage 1 [1.00–1.20])

A well-grown canola plant normally produces 10–15 leaves. Each leaf is counted when most of its surface is exposed to light (Figure 3). Early leaves may drop from the base of the stem before leaf production is complete. [17]

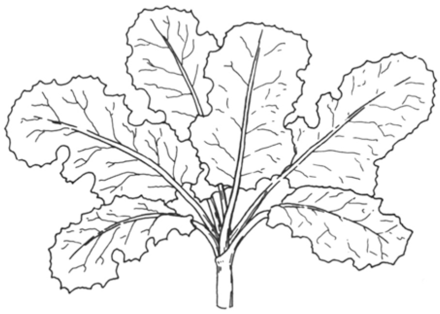

Figure 3: *Canola leaf production, stage 1.*

4.4.3 Stem elongation (stage 2 [2.00–2.20])

Stages of stem elongation are defined according to how many detectable internodes (minimum length 5–10 mm) are found on the stem (Figure 4). A leaf is attached to the stem at each node. Each internode is counted. A well-grown canola plant normally produces about 15 internodes. [18]

16 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

17 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

18 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

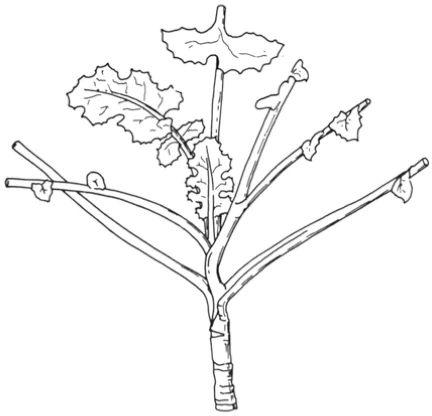

Figure 4: *Stem elongation, stage 2.*

4.4.4 Flower bud development (stage 3 [3.0–3.9])

Initially, flower buds remain enclosed during early stem elongation and they can only be seen by peeling back young leaves. As the stem emerges, they can be easily seen from above but are still not free of the leaves; this is described as the green bud stage (Figure 5). As the stem grows, the buds become free of leaves and the lowest flower stalks extend so that the buds assume a flattened shape. The lower flower buds are the first to become yellow, signaling the yellowing bud stage. [19]

Figure 5: *Canola flower bud development, stage 3.*

4.4.5 Flowering (stage 4 [4.1–4.9])

Flowering starts when one flower has opened on the main stem and finishes when no viable buds are left to flower (Figure 6). [20]

19 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

20 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

Figure 6: *Flowering, stage 4.*

4.4.6 Pod development (stage 5 [5.1–5.9])

Podding development starts on the lowest one-third of the branches on the main stem and is defined by the proportion of potential pods that have extended to >2 cm long (Figure 7). [21]

Figure 7: *Pod development, stage 5.*

4.4.7 Seed development (stage 6 [6.1–6.9])

Seed development is also seen on the lowest one-third of branches on the main stem (Figures 8, 9). The stages are assessed by seed colour as follows:

21 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

- 6.1, seeds present
- 6.2, most seeds translucent but full size
- 6.3, most seeds green
- 6.4, most seeds green–brown mottled
- 6.5, most seeds brown
- 6.6, most seeds dark brown
- 6.7, most seeds black but soft
- 6.8, most seeds black but hard
- 6.9, all seeds black and hard

Seed oil concentration in Australian crops increases through seed development following an 'S'-curve pattern, which starts 20 days after flowering and reaches a plateau ~60 days after flowering, the time when seed dry weight is ~70% of its final value (Figure 10). Final seed oil concentrations usually vary between 30% and 50% (as received). In general, high temperatures during grain filling, terminal water stress, and high N supply depress final seed oil concentration. Variety has a significant impact, with triazine-tolerant (TT) varieties typically having lower oil concentrations than conventional varieties because of their less efficient photosynthetic system. The growth stage when the crop is physiologically mature is important and one that growers should learn to recognise. It occurs when the seeds have reached their maximum dry weight and the crop can be windrowed. At this time, 50–70% of seeds have started to change from green to their mature colour (growth stage 6.4–6.5). Seed moisture content is 35–40% and most seeds are firm enough to roll between the thumb and forefinger without being squashed. It is a period of rapid change, when all seeds can develop from translucent to black over a 12-day period. It is important not to windrow too early; windrowing before physiological maturity will reduce yields by 3–4% for each day too early, because of incomplete seed development. Oil content will also be reduced. Canola can be harvested when the moisture content of mature seed is 8%. [22]

22 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

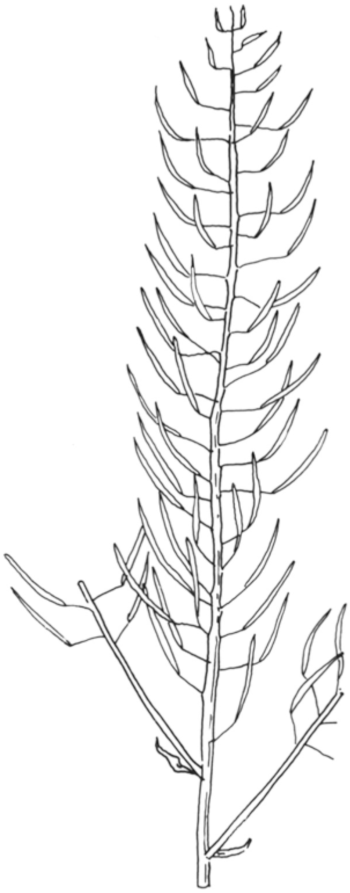

Figure 8: *Seed development, stage 6.*

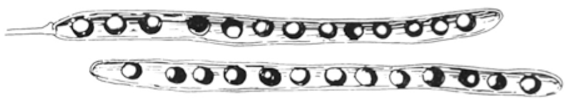

Figure 9: *Seed pods.*

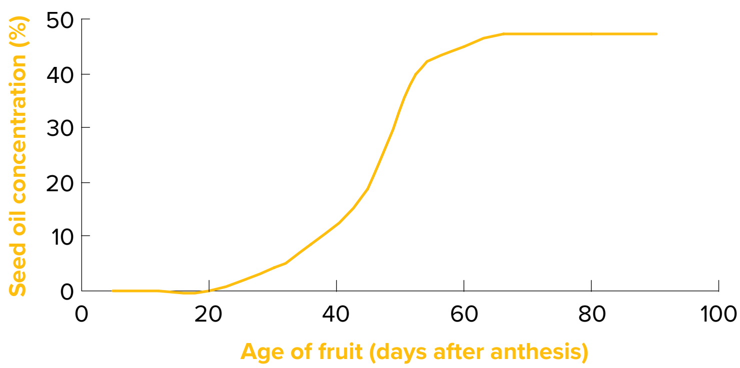

Figure 10: *Seed oil concentration in Australian crops increases throughout seed development and reaches a plateau at ~60 days after flowering.*

Source: P. Hocking and L. Mason

4.4.8 Environmental stresses impacting yield and oil content

Frost, moisture stress and heat stress can all have an impact on grain yield, oil content and oil quality. Frost can occur at any time during the growth of the canola plant, but frosts are most damaging when pods are small. Pods affected at this time have a green to yellowish discoloration, then shrivel and eventually drop off. Pods affected later may appear blistered on the outside of the pod and usually have missing seeds (Figure 11).

Figure 11: *Frost damage before the watery seed stage results in either missing seeds or very shrivelled seeds. Frost damage at this time may or may not affect oil content.*

Photo: T. Potter, SARDI

Moisture and heat stress are linked, in that the plant will suffer heat stress at a lower temperature if it is also under moisture stress. Flower abortion, shorter flowering period, fewer pods, fewer seeds per pod and lighter seed weight are the main effects, occurring either independently or in combination (Figure 12). [23] Hail damage to pods can also affect seed development (Figure 13).

23 T Potter (2009) The canola plant and how it grows. Ch. 3. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, http://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

Figure 12: *Severe moisture stress during pod filling results in seeds being underdeveloped and small.*

Photo: D. McCaffery, NSW DPI

Figure 13: *Hail damage may penetrate through the pod wall and affect seed development.*

Photo: D. McCaffery, NSW DPI