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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

CHICKPEA

SECTION 4

PLANT GROWTH AND PHYSIOLOGY

SECTION 4

Plant growth and physiology

4.1 Key to growth stages

The chickpea growth stages key is based on counting the number of nodes on the main stem.

Uniform growth stage descriptions were developed for the chickpea plant based on visually observable vegetative (V) and reproductive (R) events.

The V stage was determined by counting the number of developed nodes on the main stem, above ground level. The last node counted must have its leaves unfolded.

The R stages begin when the plant begins to flower at any node.

Germination is hypogeal, with germination occurring when the cotyledons are below the soil surface. This enables the seedling to emerge from sowings as deep as 15 cm. In arid regions, chickpea is sown deep because surface moisture is often inadequate to assist crop establishment.

The node at which the first branch arises on the main stem above the soil is counted as node one. In chickpeas, alternate primary branches usually originate from nodes just above ground level (usually 1–8 primary branches on the main stem, depending on growing conditions).

A node is counted as developed when 6–15 leaflets have reached the stage where they are unfolded and flattened out (Figure 1).

Figure 1: Growth habit of a chickpea plant.

Chickpeas are considered very indeterminate in their growth habit (i.e. their terminal bud is always vegetative and keeps growing). Vegetative growth continues even as the plant switches to reproductive mode and flowering begins (Table 1).

Flower terminals normally develop from the axillary bud at the base of each node. Chickpea flowers are purple in the Desi type and white to cream in the Kabuli type. Flowers are borne on a jointed peduncle that arises from nodes. Flowers are primarily self-pollinated, with most reports measuring 100% self-pollination.

Table 1: Growth stages of a chickpea plant (Nolan 2001)

Vegetative growth stage (V-stage) in chickpeas		
Designation	**Growth stage**	**Description**
VG	Germination	Cotyledons remain underground inside the seed coat and provide energy for rapidly growing primary roots (radicle) and shoots
VE	Emergence	The plumule emerges and the first two leaves are scales. The first true leaf has two or three pairs of leaflets plus a terminal leaflet
V1	First node	Imparipinnate (terminal unpaired) leaves attached to the first node are fully expanded and flat while the 1st imparipinnate leaf attached to the upper node starts to unroll
V2	Second node	1st imparipinnate leaf attached to the second node is fully expanded and flat while the 2nd imparipinnate leaf on the upper node starts to unroll
V3	Third node	2nd imparipinnate leaf attached to the third node is fully expanded and flat while the 3rd imparipinnate leaf on the upper node starts to unroll. The bulk of the yield is found on the branches stemming from the first three nodes
V(n)	N-node	A node is counted when its imparipinnate leaf is unfolded and its leaflets are flat
Reproductive growth stage (R-stage) in chickpea		
R0	False flowering	In the transition from vegetative to include reproductive growth, a number of false flowers (called pseudo flowers) may develop from the axillary buds. These flower buds lack fully developed petals and typically appear if flowering is triggered before mean temperatures are high enough for true flowers to develop, especially if soil has high moisture content coinciding with flowering, which enables it develop a bigger canopy
R1	Start flowering	One flower bud at any node on the main stem (see p. 5 in 'The chickpea book', Loss et al. 1988)
R2	Calyx opening	Bud grows but is still sterile, sepals begin to form
R3	Anthesis	Pollination occurs before the bud opens
R4	Wings extend	Flower petals extend to form a flower
R5	Corolla collapses	Flower collapses and petals senesce and peduncle reflexes so that the developing pod usually hangs below its subtending leaf
R6	Pod initiation	One pod is found on any node on the main stem
R7	Full pod	One fully expanded pod is present that satisfies the dimensions characteristic of the cultivar
R8	Beginning seed	One fully expanded pod is present in which seed cotyledon growth is visible when the fruit is cut in cross-section with a razor blade. (Following the liquid endosperm stage)
R9	Full seed	One pod with cavity apparently filled by the seeds when fresh
R10	Beginning maturity	One pod on the main stem turns to a light golden-yellow in colour
R11	50% golden pod	50% of pods on the plant mature
R12	90% golden pod	90% of pods physiologically mature (golden yellow), usually about 140–200 days after planting depending on season and cultivar

For populations, vegetative stages can be averaged if desired. Reproductive stages should not be averaged.

A reproductive stage should remain unchanged until the date when 50% of the plants in the sample demonstrate the desired trait of the next reproductive (R) stage. The timing of a reproductive stage for a given plant is set by the first occurrence of the specific trait on the plant, without regard to position on the plant. [1]

More information

Australian Centre for Plant Functional Genomics Pty Ltd

[1] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

More information

[J Whish (2016), Accessing and using day degrees in field crops as a tool to assist crop management]

[QDAF (2015), Planting chickpeas, Effects of temperature and frost damage]

4.2 Crop growth and development

Chickpea, being a legume, belongs to the botanical family of *Fabaceae*, subfamily *Faboideae*. It is a semi-erect annual with a deep taproot. Worldwide, two main types of chickpea, Desi and Kabuli, are cultivated. Kabuli types, grown in temperate regions, are large-seeded and mainly consumed as a whole seed, whereas Desi types, grown in semi-arid tropical and subtropical regions, are mainly consumed as split dhal or turned into flour. Chickpea seed contains about 20% protein, 5% fat and 55% carbohydrates.

Crop duration is highly correlated with temperature, such that crops will take different times from sowing to maturity under different temperature regimes. The concept of thermal time is the mechanism used to represent a crop's evolved requirement to accumulate a minimum time for development through each essential growth stage (e.g. vegetative or reproductive growth). Consequently, crops growing under low air temperatures generally require more time to develop than crops growing under warmer temperatures. Thermal time is also referred to as heat units, day-degrees or growing degree-days (sometimes represented as °Cd).

The base temperature for calculating thermal time for chickpea is 0°C.

The phenology of most crops can be described using nine phases:

1. Sowing to germination
2. Germination to emergence
3. A period of vegetative growth after emergence, called the basic vegetative phase (BVP), during which the plant is unresponsive to photoperiod
4. A photoperiod-induced phase (PIP), which ends at floral initiation
5. A flower development phase (FDP), which ends at 50% flowering
6. A lag phase prior to commencement of grain-filling (in chickpea this period can be very long, up to 2 months in some cases, under cool temperature conditions (<15°C), which inhibit pod set and pod growth)
7. A linear phase of grain filling
8. A period between the end of grain-filling and physiological maturity
9. A harvest-ripe period prior to grain harvest

These stages of development are generally modelled as functions of temperature (phases 1–8) and photoperiod (phase 4).

Chickpeas are a medium-duration crop, usually beginning flowering within 90–110 days of planting, depending on photoperiod and temperature (Figure 2). Chickpea is a photoperiod-sensitive, long-day plant, where flowering is delayed as day length becomes shorter than a base photoperiod (17 h). [2]

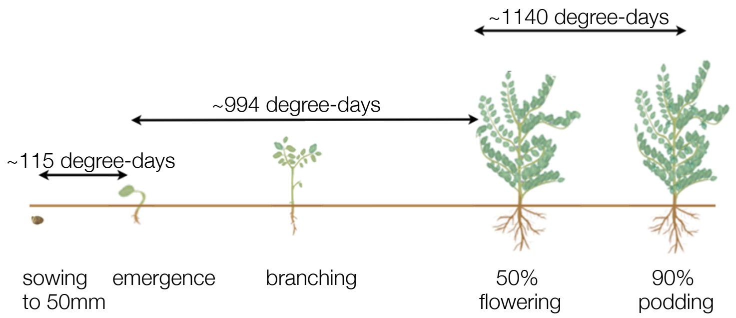

Figure 2: Key developmental stages of chickpea and their thermal time targets. (Source: J. Whish, CSIRO)

[2] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

4.2.1 Emergence

Pulses are classed as 'epigeal' if the cotyledons appear above the ground or 'hypogeal' if they remain below the ground. Chickpeas are hypogeal (Figure 3). Seedlings with hypogeal emergence are less likely to be killed by frost, wind erosion or insect attack because new stems can develop from buds at nodes, at or below ground level. By contrast, if an epigeal pulse is broken below the cotyledons, the plant will die, as there are no buds from which to shoot.

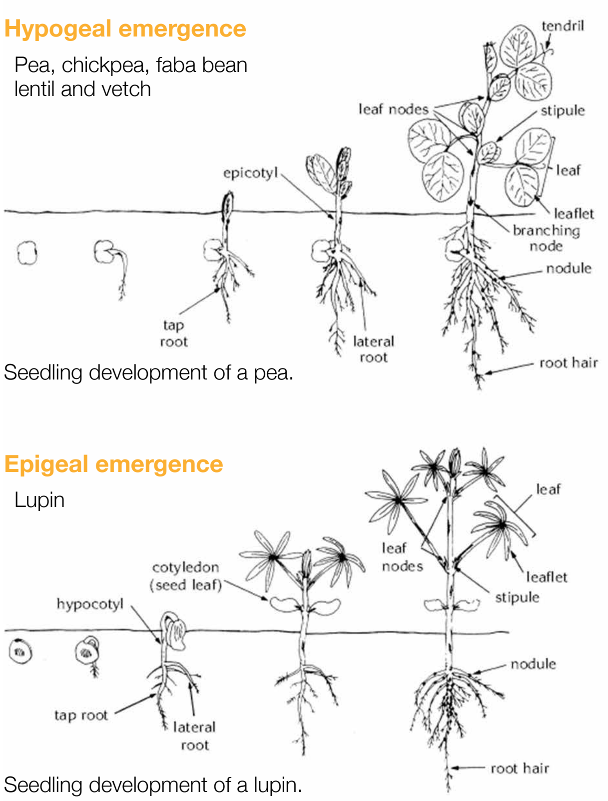

Figure 3: Hypogeal and epigeal emergence patterns in pulses.

Under optimum moisture and temperature conditions, chickpea seeds imbibe water quickly and germinate within a few days, providing temperatures are >0°C. Unlike lupins, chickpea seedlings have hypogeal emergence, that is, their cotyledons (embryonic leaves) remain underground inside the seed coat while providing energy to the rapidly growing roots and shoots.

Emergence occurs 7–30 days after sowing, depending on soil moisture and temperature conditions and depth of sowing. Growth of the shoot (plumule) produces an erect shoot and the first leaves are scales. The first true leaf has two or three pairs of leaflets plus a terminal one. Fully formed leaves with 5–8 pairs of leaflets usually develop after the sixth node (Figure 4). [3]

[3] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

Figure 4: Chickpea growth and development from germination to 2 months. Plants may vary according to variety and environment. (Photo: H. Clarke, UWA)

4.2.2 Leaves

Leaves in chickpea are alternate along the branch (Figure 5). Each leaf is composed of 10–16 serrated leaflets, which can fold slightly in dry conditions to minimise transpiration. Despite having more leaves and branches than other legume crops such as faba bean, canopy development in chickpea is slow, especially during the cool winter months.

Figure 5: Alternate leaves along the branch, with multiple leaflets on each leaf. (Photo: G. Cumming, Pulse Australia)

The entire surface of the plant shoot, except the flower, is densely covered with fine hairs known as trichomes (Figure 6). Many are glandular and secrete a highly acidic substance containing mainly malic acid but also some oxalic and citric acid. Secretions of acid increase with temperature throughout the day; they are diluted when the hairs are washed by dew overnight, and by wind shaking the acid droplets from the hairs.

Figure 6: A green pod covered in glandular hairs excreting acid. (Photo: H. Clarke, UWA)

The acid seems to play a role in protecting the plant against pests such as redlegged earth mite, lucerne flea, aphids and pod borers. The acid is also secreted through the root system and it can solubilise soil-bound phosphate and other nutrients. The acid also corrodes leather boots. [4]

4.2.3 Roots

Chickpea root systems are usually deep and strong, and contribute to the ability to withstand dry conditions (Figure 7). The plant has a taproot with few lateral roots. Root growth is most rapid before flowering but will continue until maturity under favourable conditions. Although rare, in deep well-structured soils, roots can penetrate more than 1 m deep; however, subsoil constraints such as soil chloride >800 mg/kg soil in the top 60 cm will restrict root growth and water availability.

As well as their role in water and nutrient uptake, chickpea roots develop symbiotic nodules with the *Rhizobium* bacteria, capable of fixing atmospheric nitrogen (N2). The plant provides carbohydrates for the bacteria in return for nitrogen fixed inside the nodules.

These nodules are visible within about 1 month after plant emergence, and eventually form slightly flattened, fan-like lobes (Figure 8). Almost all nodules are confined to the top 30 cm of soil and 90% are within 15 cm of the surface. When cut open, nodules actively fixing nitrogen have a pink centre (Figure 9). Nitrogen fixation is highly sensitive to waterlogging, and hence, chickpea needs well-aerated soils. [5]

4 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013, Pulse Australia Limited.

5 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013, Pulse Australia Limited.

Figure 7: Chickpea usually has a deep tap root system. (Photo: P. Maloney, DAFWA)

Figure 8: Nodulated chickpea roots. (Photo: G. Cumming, Pulse Australia)

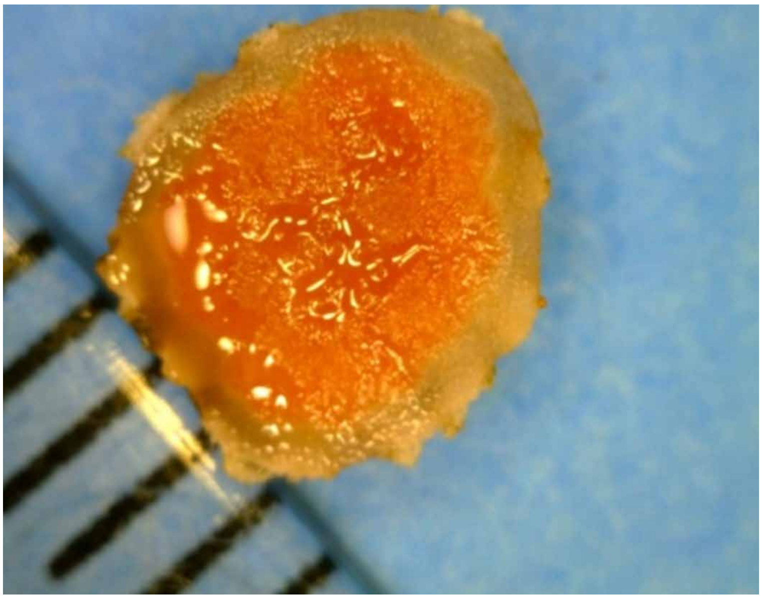

Figure 9: Active nodules have a pink centre. (Photo: G. Cumming, Pulse Australia)

4.2.4 Branches

Primary branches, starting from ground level, grow from buds at the lowest nodes of the plumular shoot as well as the lateral branches of the seedling. These branches are thick, strong and woody, and they determine the general appearance of the plant (Figure 10). The main stem and branches can attain a height of about 40–100 cm. Kabuli varieties are generally taller than Desi varieties.

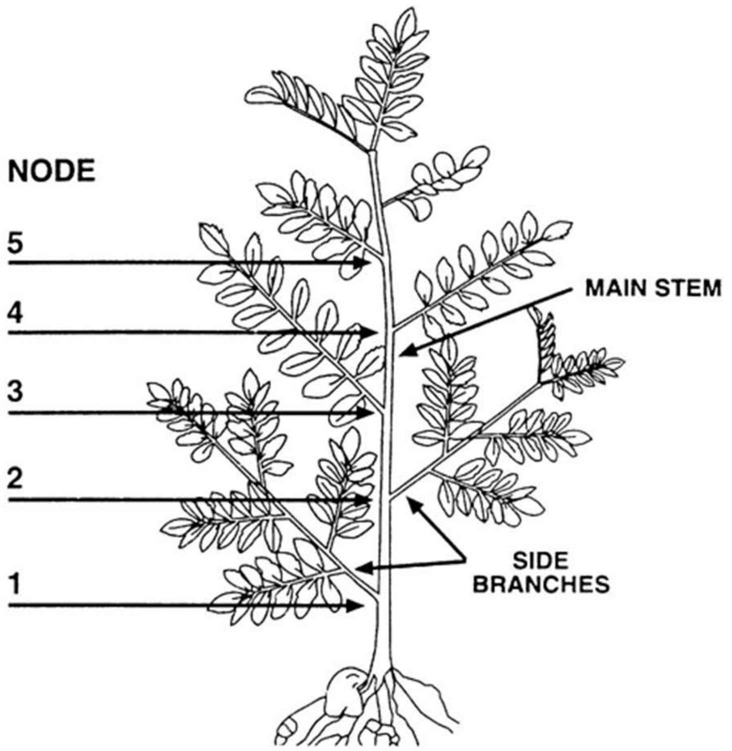

Figure 10: Chickpea at the 5–7-node stage of development.

Secondary branches are produced by buds on the primary branches. They are less vigorous but contribute to a major proportion of the plant yield. Tertiary branches growing from buds on secondary branches are more leafy and carry fewer pods.

The number of primary branches can vary from one to eight depending upon the variety and growing conditions. In chickpea, five branching habits based on angle of branches from the vertical are classified: erect, semi-erect, semi-spreading, spreading and prostate.

Most modern varieties are erect or semi-erect, to enable mechanical harvesting. The final height of the plant is highly dependent on environmental conditions and the variety being grown, but in general, can range from 50 to 100 cm. [6]

4.2.5 Flowering, podding and seed development

Growth in chickpea is often described as 'indeterminate'. This means that branch and leaf (or vegetative) growth continues as the plant switches to a reproductive mode and initiates flowering. Hence, there is often a sequence of leaf, flower bud, flower and pod development along each branch (Figure 11).

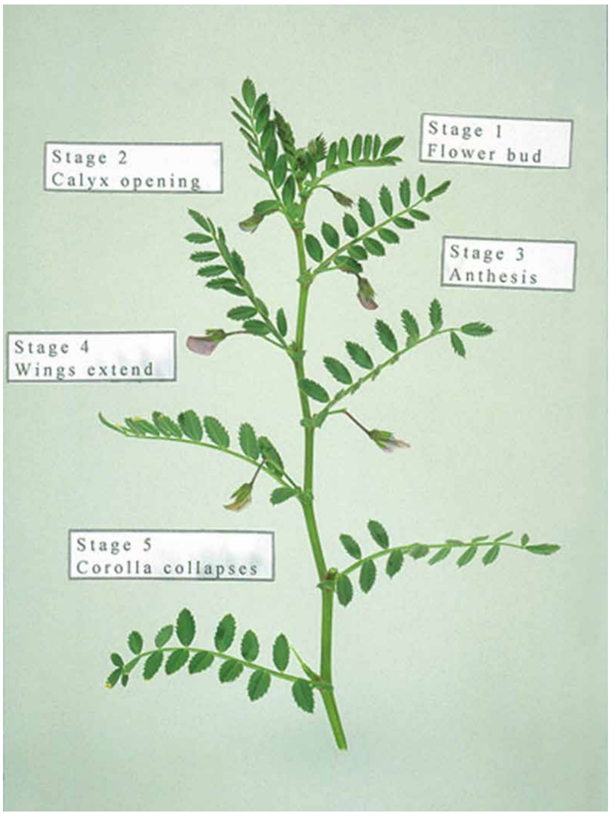

Figure 11: Different stages of flower development on the same chickpea branch. (Photo: K. Siddique, DAFWA)

The duration of vegetative growth before flowering depends on many factors. Chickpea is peculiar among pulses in that a number of pseudo-flowers or false flower buds develop during the changeover from leaf buds to flower buds on the stem.

Therefore, there could be a period of ineffective flowering when pod set does not occur. In warmer tropical and subtropical environments, this period is minimal but in cooler temperate–subtropical environments, it can be as long as 50 days.

Flowering commences on the main stem and lower branches and proceeds acropetally at intervals averaging 1.5–2 days between successive nodes along each branch. The bulk of the yield is found on the branches stemming from the first three nodes.

6 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

The fruit develops in an inflated pod containing 2–4 ovules, of which one or two usually develop into seeds.

At any location, seasonal variations in temperature can bring about a significant shift in flowering times (i.e. ±10 days from the figures quoted below). In general, warmer temperatures hasten development.

Petals are generally purple in the Desi type (Figure 12) and white to cream in the Kabuli type. Purple-flowered Desi types generally contain high amounts of the red pigment anthocyanin, and their leaves, stems and seed coats are generally dark.

Figure 12: Desi chickpea purple flowers. (Photo: G. Cumming, Pulse Australia)

By contrast, the white-flowered Kabuli types lack anthocyanin, have light green leaves and stems, and pale seeds (Figure 13). Increased pigmentation is evident following environmental stresses such as low temperature, salinity, waterlogging, drought, and virus infection, especially in Desi types.

Pollination takes place before the flower bud opens in chickpea, when the pollen and the receptive female organ are still enclosed within a fused petal, called the keel. Natural cross-pollination has been reported; however, most studies indicate 100% self-pollination.

Figure 13: Kabuli chickpea lack anthocyanin, hence their white flowers. (Photo: G. Cumming, Pulse Australia)

Chickpea plants generally produce many flowers. However, about 30% do not develop into pods, depending upon the variety, sowing date and other environmental conditions.

Under favourable temperature and soil moisture conditions, the time taken from fertilisation of the ovule (egg) to the first appearance of a pod (pod set) is about 6 days. The seed then fills over the next 3–4 weeks (Figure 14). Once a pod has set, the jointed peduncle of the senescing petals reflexes, so that the developing pod hangs beneath its subtending leaf.

After pod set, the pod wall grows rapidly for the first 10–15 days, and seed growth mainly occurs later.

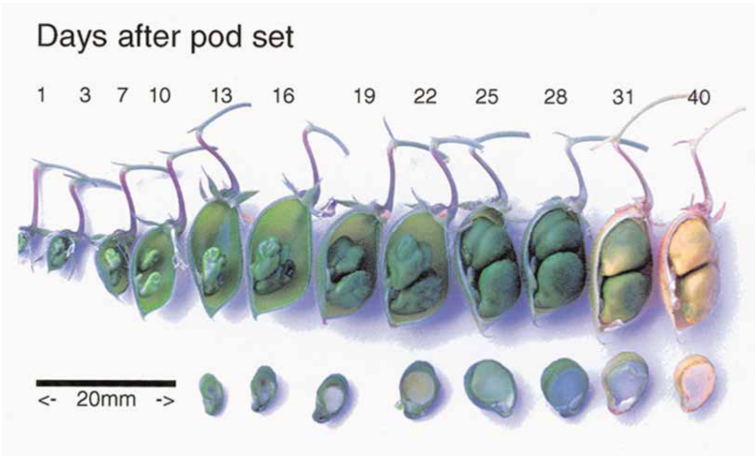

Figure 14: Development of pods and seeds from pod to maturity. (Photo: L. Leport)

Chickpea pods vary greatly in size between varieties. Pod size is largely unaffected by the environment. By contrast, seed filling and subsequent seed size are highly dependent on variety and weather conditions.

Seeds are characteristically 'beaked', sometimes angular, with a ridged or smooth seed coat. Seed colour varies between varieties from chalky white to burgundy and brown, to black, and is determined by the colour and thickness of the seed coat and the colour of the cotyledons inside. Seeds vary from one to three per pod. [7]

[7] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

4.2.6 Climatic requirements for flowering

The timing of flowering is an important trait affecting the adaptation of crops to low-rainfall, Mediterranean-type environments (such as the south-west of Western Australia), and seed yields of many crops in these areas have been increased by early sowing and the development of early-flowering varieties.

Temperature, daylength, and drought are the three major factors affecting flowering in chickpea. Temperature is generally more important than daylength. Flowering is invariably delayed under low temperatures but more branching occurs.

Progress towards flowering is rapid during long days, whereas under short days (>17 h daylight), flowering is delayed but never prevented.

Chickpeas, unlike other cool season legumes, are very susceptible to cold conditions especially at flowering, and any advantage derived from early flowering is often negated by increased flower and pod abortion. Experiments have shown that the average day/night temperature is critical for flowering and pod set, rather than any specific effects of maximum or minimum temperatures (Singh 1996). The critical mean or average daily temperature for abortion of flowers in most current varieties is <15°C (Siddique 1998). Abortion occurs below this temperature because the pollen becomes sterile and reproductive structures do not develop. Flowers may develop below this temperature but they contain infertile pollen.

Once true flowers are produced, a period of cool weather can cause some flower or pod abortion. Figure 15 provides an example of when effective seed set commenced at Trangie, NSW, in 2008. If flowering starts before average daily temperatures reach 15°C, then flowers will continue to abort until temperatures increase beyond this critical level.

Selection of sowing date is a trade-off between sowing early with high yield potential in those years with a warmer spring and lower yield potentials with delayed sowing to ensure that flowering occurs with temperatures closer to 15°C in cooler springs.

In many chickpea crops, it is not until temperatures rise in late August and September that pod set and seed-filling commence. When temperatures rise, true flowers develop within 3–4 days. Even after the production of true flowers, periods of low temperature may result in further flower and pod abortion at intermittent nodes on the stems.

Note that the impacts of low air temperatures will be moderated by topography and altitude (i.e. there will be warmer and cooler areas in undulating country).

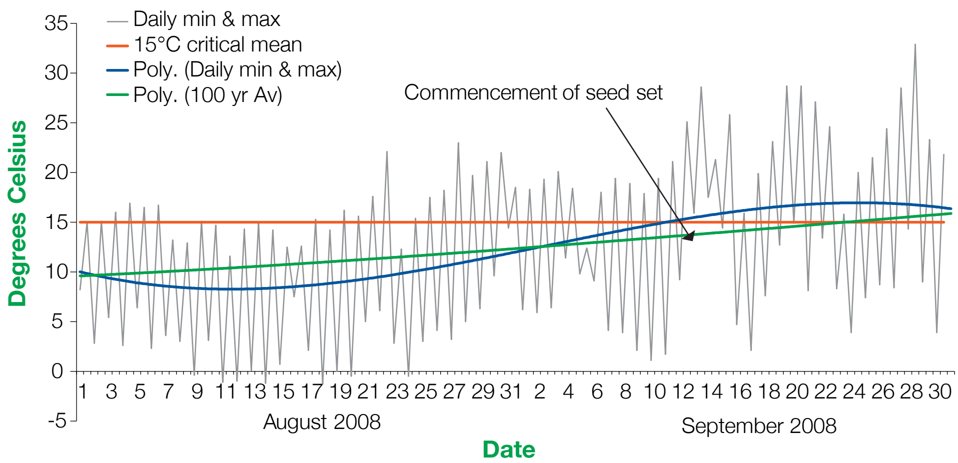

Figure 15: Commencement of effective seed set, showing minimum, maximum and average daily temperatures at Trangie NSW, 2008.

In addition to the effects of cold described above, sub-zero temperatures in winter and spring can damage leaves and stems of the plant. Frosts can cause bleaching of leaves, especially on the margins, and a characteristic 'hockey-stick' bend in the stem (Figure

16). However, chickpea has an excellent ability to recover from this superficial damage and is able to regenerate new branches in severe cases.

Figure 16: Frost can cause bends like a hockey stick in chickpea stems. (Photo: S. Loss, DAFWA)

Late frosts also cause flower, pod and seed abortion (Figure 17). Pods at a later stage of development are generally more resistant to frost than flowers and small pods, but may suffer some mottled darkening of the seed coat.

Frost will normally affect the earliest formed pods low on the primary and secondary branches. By contrast, pod abortion induced by moisture stress is normally noted on the last-formed pods at the tips of the branches. Minimum temperatures <5°C during the reproductive stage will kill the crop, but new regrowth can occur from the base of the killed plants if moisture conditions are favourable.

Figure 17: Frost can cause pod abortion (usually low on the stem) but the plant may set many pods late in the season if conditions are favourable. (Photo: T. Knights, NSW DPI)

More information

Paper in the journal *Crop & Pasture Science*: High temperature tolerance in chickpea and its implications for plant improvement

Temperatures >35°C in spring may also reduce yield in chickpea, causing flower abortion and a reduction in the time available for seed filling. Chickpea, however, is considered more heat-tolerant than many other cool-season grain legumes.

In Australia, drought stress often accompanies high temperatures in spring, causing the abortion of flowers, immature pods and developing seeds. On the other hand, high levels of humidity and low light also prevent pod set. [8]

4.2.7 Tolerance to low temperature

Research overseas and within Australia has demonstrated a range of cold tolerance among chickpea varieties. In parts of the world where chickpeas are grown as a spring crop because of the very cold winter, varieties have been developed that tolerate freezing conditions during vegetative growth. These varieties can be sown in autumn, survive over winter, and are ready to flower and set pods when temperatures rise in summer.

However, chickpea varieties resistant to low temperatures during flowering have not yet been found. Some genotypes from India are less sensitive than those currently grown in Australia, and these are being utilised in chickpea-breeding programs at Department of Agriculture and Food Western Australia (DAFWA) and the University of Western Australia.

Controlled environment studies at University of Western Australia have identified two stages of sensitivity to low temperature in chickpea. The first occurs during pollen development in the flower bud, resulting in infertile pollen even in open flowers. The second stage of sensitivity occurs at pollination when pollen sticks to the female style, and produces a tube that grows from the pollen down the style to the egg (Figure 18).

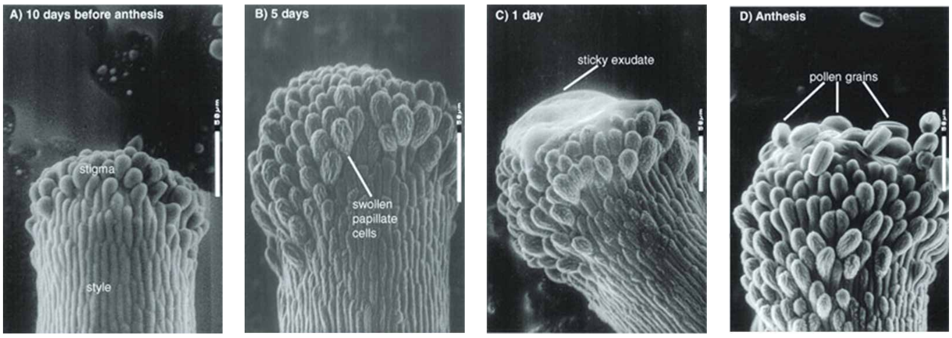

Figure 18: Development of the style and stigma of chickpea flowers taken with an electron microscope. (Photo: H. Clarke, UWA)

At low temperatures pollen tubes grow slowly, fertilisation is less likely and the flower often aborts. The rate of pollen tube growth at low temperature is closely related to the cold tolerance of the whole plant. This trait can therefore be used to select more tolerant varieties (Figures 19 and 20).

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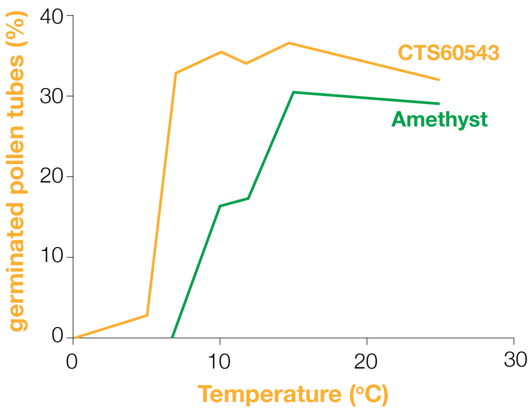

Figure 19: Proportion of pollen germination at various temperatures in cold-sensitive (Amethyst) and cold-tolerant (CTS60543) varieties.

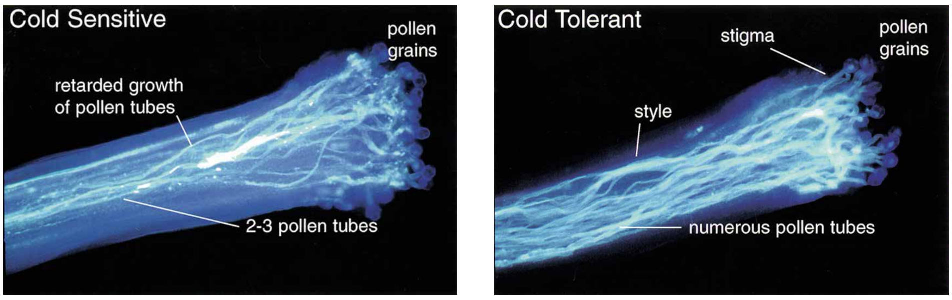

Figure 20: Pollen tube growth (stained with a fluorescent dye) in the stigma of cold-tolerant and cold-susceptible chickpea varieties. (Photo: H. Clarke, UWA)

The critical average daily temperature for abortion of flowers in most varieties currently grown in Australia is about 15°C. New hybrids that set pods at about 13°C are being developed.

In the field, cold-tolerant varieties set pods about 1–2 weeks earlier than most current varieties. As well as conventional methods for plant improvement, DNA-based techniques are also being investigated. [9]

4.2.8 Maturity

Soon after the development of pods and seed-filling, senescence of subtending leaves begins. If there is plenty of soil moisture and maximum temperatures are favourable for chickpea growth, flowering and podding will continue on the upper nodes. However, as soil moisture is depleted, flowering ceases and eventually the whole plant matures (Figure 21). This is typical of grain legumes and annual plants in general.

Chickpea can tolerate high temperature if there is adequate soil moisture, and it is usually one of the last grain legume crops to mature in Mediterranean-type environments.

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Figure 21: Chickpea may be forced to mature early on soils with poor moisture holding capacity. (Photo: K. Siddique, DAFWA)

As leaves begin to senesce, there is a rapid re-translocation of dry matter from leaves and stems into the seeds.

Recent research has indicated that unlike other winter pulses under mild moisture stress, chickpeas are capable of accumulating solutes (sugar, proteins and other compounds) in their cells, thereby maintaining stomatal conductance and low levels of photosynthesis. This process is known as osmoregulation.

In southern Australia, chickpea crops can reach maturity 140–200 days after sowing, depending on the sowing date, variety, and a range of environmental factors including temperature. Chickpeas become ready to harvest when 90% of the stems and pods lose their green colour and become light golden yellow. At this point, the seeds are usually hard and rattle when the plant is shaken (Figure 22). [10]

Figure 22: Physiologically mature grains 'rattle pod'. (Photo: G. Cumming, Pulse Australia)

[10] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

4.3 Flowering and maturity date in chickpea

Table 2 shows the average date for flowering to commence on 50% of plants and for maturity (pods brown) to occur on 95% of plants in a paddock for a range of sowing dates and locations in the northern region. Planting date has a major impact on actual crop yields, because the flowering date will determine whether fertile flowers are produced and pods will form. [11]

Table 2: Average flowering and maturity dates (cv. Amethyst) in relation to planting across a range of areas

Sowing date	Dalby	Goondiwindi	Roma	Emerald	Walgett	Narrabri	Dubbo
Flowering date (50% flower)							
1 May	18 July	18 July	17 July	30 June	6 Aug.	7 Aug.	7 Aug.
15 May	5 Aug.	5 Aug.	4 Aug.	18 July	12 Aug.	13 Aug.	24 Aug.
1 June	23 Aug.	22 Aug.	20 Aug.	5 Aug.	25 Aug.	27 Aug.	8 Sept.
15 June	3 Sept.	3 Sept.	31 Aug.	19 Aug.	8 Sept.	7 Sept.	18 Sept.
1 July	14 Sept.	14 Sept.	11 Sept.	31 Aug.	17 Sept.	18 Sept.	27 Sept.
15 July	22 Sept.	22 Sept.	20 Sept.	10 Sept.	26 Sept.	26 Sept.	4 Oct.
Maturity date (90% brown pods)							
1 May	9 Oct.	9 Oct.	5 Oct.	12 Sept.	14 Oct.	14 Oct.	29 Oct.
15 May	20 Oct.	19 Oct.	15 Oct.	25 Sept.	25 Oct.	24 Oct.	7 Nov.
1 June	31 Oct.	30 Oct.	26 Oct.	8 Oct.	4 Nov.	4 Nov.	16 Nov.
15 June	8 Nov.	6 Nov.	2 Nov.	17 Oct.	10 Nov.	10 Nov.	22 Nov.
1 July	15 Nov.	14 Nov.	10 Nov.	26 Oct.	17 Nov.	17 Nov.	29 Nov.
15 July	21 Nov.	20 Nov.	16 Nov.	3 Nov.	22 Nov.	22 Nov.	4 Dec.

(Source: J. Whish, CSIRO.)

[11] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

4.3.1 Effect of planting time on flowering in different areas of Queensland

The full set of values for all regions can be found in Appendix I. Figure 23 depicts the effects of three planting dates on flowering times at Dalby, Darling Downs, Queensland. Table 3 shows preferred planting times for various regions in Queensland and NSW.

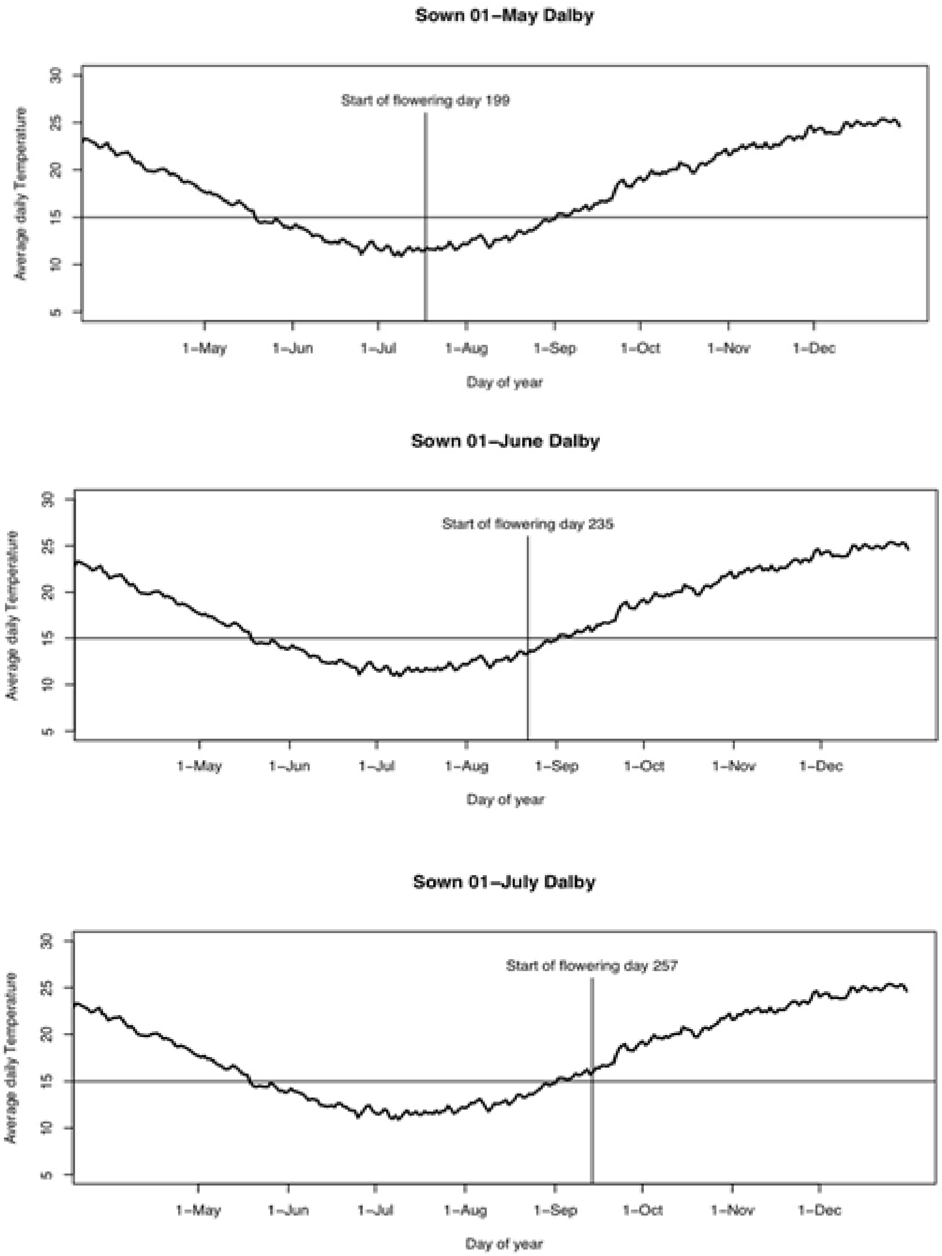
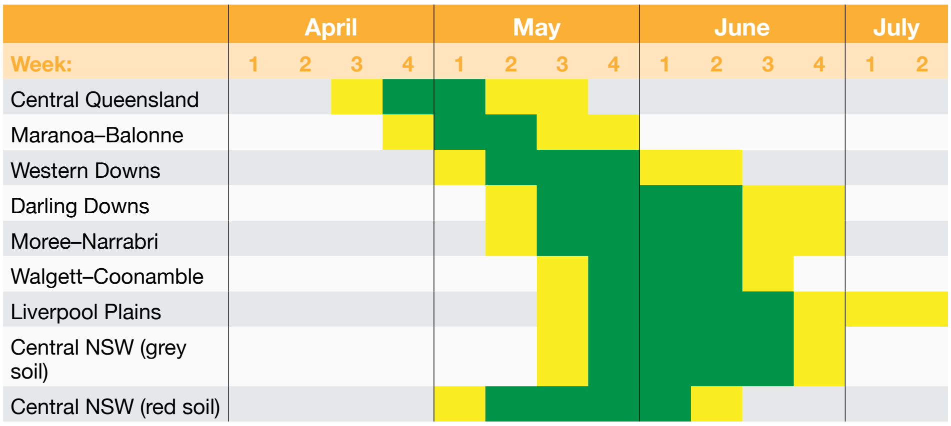


Figure 23: Effect of planting date on flowering in the Dalby Region.

Table 3: Preferred planting times for different regions



Yellow boxes indicate marginal sowing time, where increased costs and/or lower yields are likely; green boxes indicate preferred sowing window

4.4 Reliable chickpea yields: risk management

4.4.1 Soil water storage capacity

Calculation or estimation of a yield expectation for chickpeas requires knowledge of the plant-available water-holding capacity (PAWC) for a soil type and of how full this capacity is.

Table 4 shows the approximate PAWC for a range of soil types with original vegetation. The table does not consider factors within the soil such as sodic layers, compaction or salinity that may be present in some areas.

Table 4: Plant-available soil water (mm) for a range of soils

Soil type	Total plant-available soil water	0–30 cm	30–60 cm	60–90 cm	90–120 cm
Heavy alluvial (e.g. silty clay)	250	70	70	60	50
Heavy black earth (e.g. Waco)	220	70	70	50	30
Less heavy black earth	190	60	60	40	30
Heavy box	160	50	40	40	30
Uplands Brigalow	140-150	40	40	30	30
Grey clay (e.g. Coolibah)	150	40	40	30	30
Open Downs	130-150	40	40	30	20
Red earth (Western Downs)	110	40	30	30	10
Red Ferrosol (krasnozem)	100	30	30	30	10
Shallow clay (Central Highlands)	70-90	40	30	–	–

Note: Values are approximations only and individual soils will vary around the value quoted

4.4.2 Rooting depth

Chickpeas can access moisture to 90 cm depth provided there is no compaction or saline/sodic layers in the soil profile.

Dense, impermeable subsoils (high bulk density) can lead to extensive development of lateral roots in the top 30 cm of soil, with only weak development of the taproot. [12]

12 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

4.5 Yield expectation: relation to starting soil water and location

Starting soil water can have a strong influence on the yield expectation of chickpea as well as the riskiness of production. Table 5 presents the average and range of yields in good and poor years.

The values in the table are derived from the simulation model APSIM, which has been tested in the northern region over the past 10 years. Values are APSIM-simulated chickpea yields for three conditions of starting plant-available water at eight locations in the northern grains region. Simulations were conducted with 100 years of daily historical climate data at each location. The simulation setup involved cv. Amethyst sown in late May at 20 plants/m^2. The values are a conservative estimate. [13]

Table 5: Potential chickpea grain yield (kg/ha) in a range of years with different starting soil water levels

Location	Starting soil water (mm)	Driest 10%of years	Driest 25%of years	Average	Wettest 25% of years	Wettest 10% of years
Biloela	170	897	1065	1707	2318	3022
	100	355	413	853	1201	1828
	66	259	337	767	1047	1782
Emerald	170	967	1231	1742	2278	2850
	100	347	442	854	1093	1842
	66	240	354	754	922	1749
Dalby	170	1164	1609	2202	2867	3180
	100	763	1093	1819	2660	3000
	66	344	598	1260	1895	2635
Roma	170	885	1056	1587	2083	2556
	100	462	571	1062	1374	1891
	66	319	417	898	1206	1833
Moree	170	1155	1449	2026	2584	2924
	100	749	931	1686	2325	2856
	66	297	453	1142	1667	2416
Kingaroy	170	1181	1670	2354	3071	3378
	100	577	803	1449	2032	2643
	66	460	649	1288	1820	2424
Walgett	170	981	1359	1840	2399	2741
	100	627	844	1409	1920	2561
	66	242	367	814	1007	1880
Goondiwindi	170	1065	1356	1884	2446	2830
	100	641	904	1505	1934	2718
	66	282	439	975	1349	2309

(Source: M. Robertson CSIRO.)

4.6 Seasonal climate outlook and yield expectation

The Southern Oscillation Index (SOI) can be a strong predictor of the likelihood of an above- or below-average seasonal climate outlook, particularly for winter cropping in the northern grains region. Knowledge of pre-season SOI and models estimates of yield expectations can be used to provide yield probabilities.

13 Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

Table 6 shows the influence of SOI phase in May preceding the winter season on average simulated chickpea yields at three locations in the northern grains region. The simulations show that a consistently negative SOI in May will predict a significantly lower yield expectation than all other cases of SOI. The values are derived from the simulation model APSIM. [14]

Table 6: Effect of Southern Oscillation Index (SOI) on chickpea grain yield (kg/ha) with a range of starting soil water

The yields in the 'All years' column are average yields derived from Table 5

Location	Starting soil water (mm)	SOI					
		All years	Falling	Negative	Positive	Rising	Zero
Emerald	170	1742	1761	1428	1817	1836	1741
	100	854	849	600	923	929	857
	66	754	733	498	798	880	738
Dalby	170	2202	2006	1769	2262	2347	2355
	100	1819	1551	1324	1862	1982	2040
	66	1260	953	824	1265	1426	1498
Roma	170	1587	1442	1270	1659	1691	1673
	100	1062	941	774	1116	1164	1135
	66	898	755	612	963	996	977
Moree	170	2026	1910	1780	2177	2204	1924
	100	1686	1531	1350	1877	1890	1595
	66	1142	952	874	1386	1276	1047
Walgett	170	1840	1666	1539	1927	2031	1815
	100	1409	1186	1078	1536	1599	1389
	66	814	601	619	934	921	812
Goondiwindi	170	1884	1772	1521	1941	2019	1989
	100	1505	1433	1120	1549	1602	1646
	66	975	917	618	997	1042	1136

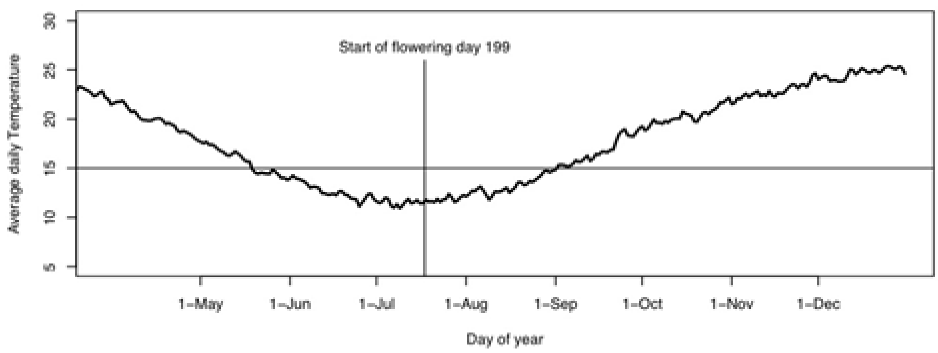
(Source: M. Robertson, CSIRO.)

[14] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

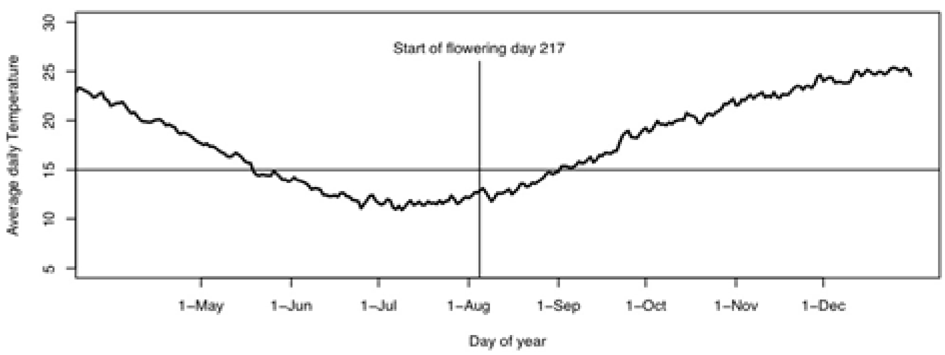
4.7 Appendix I. Effect of planting time on flowering [15]

4.7.1 Effect of planting time on flowering in the Dalby region

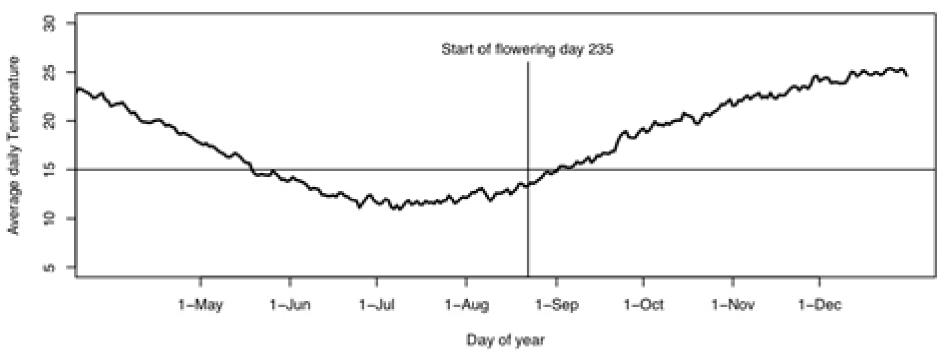
Sown 01–May Dalby



Sown 15–May Dalby

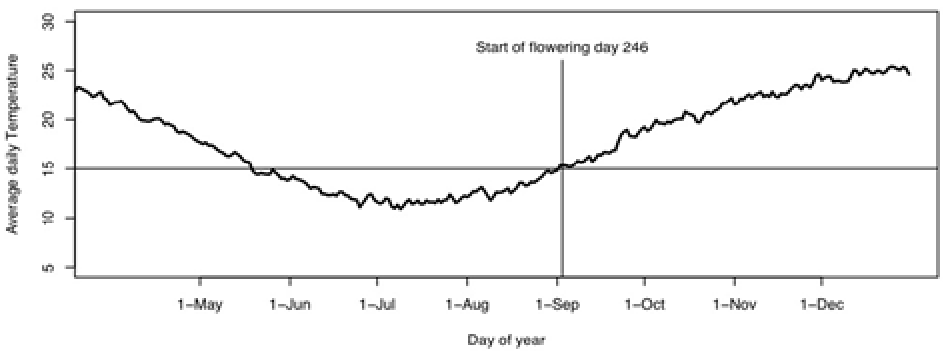


Sown 01–June Dalby

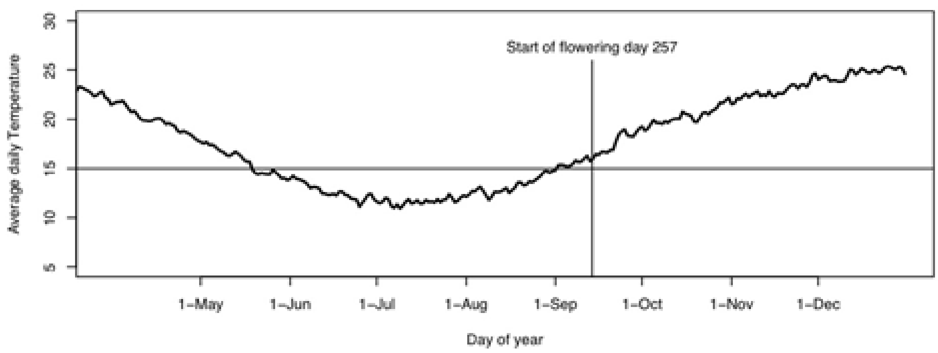


[15] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

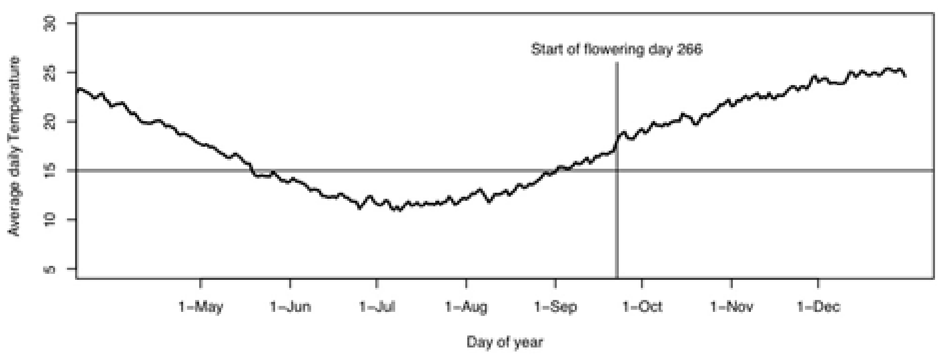
Sown 15–June Dalby



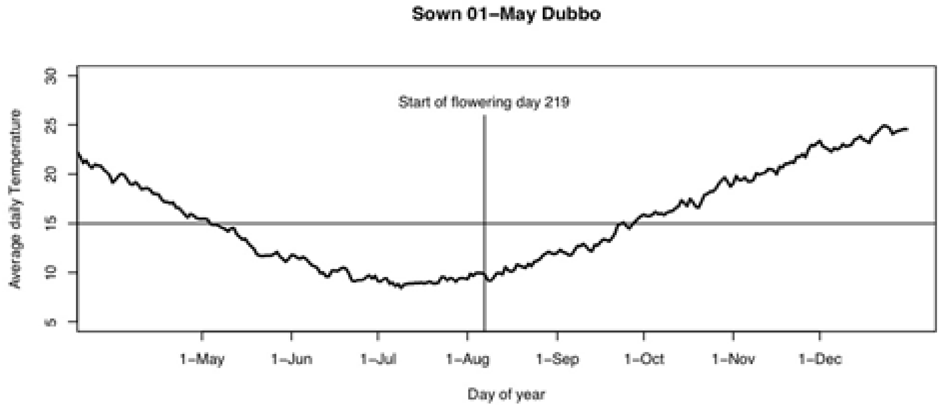
Sown 01–July Dalby

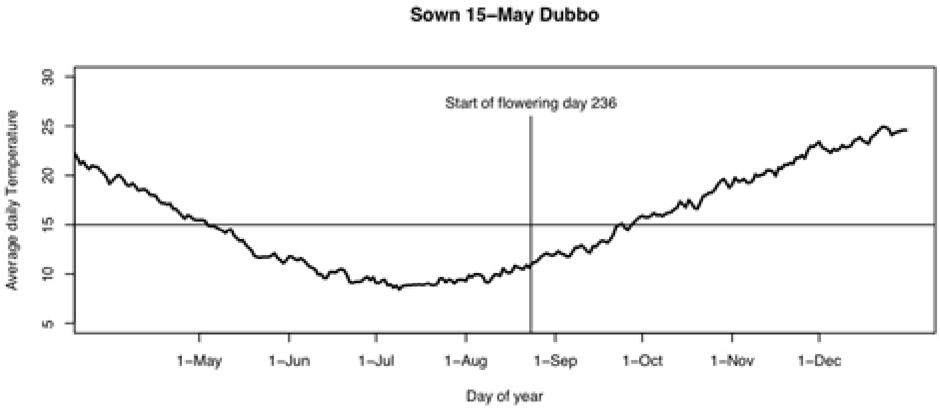


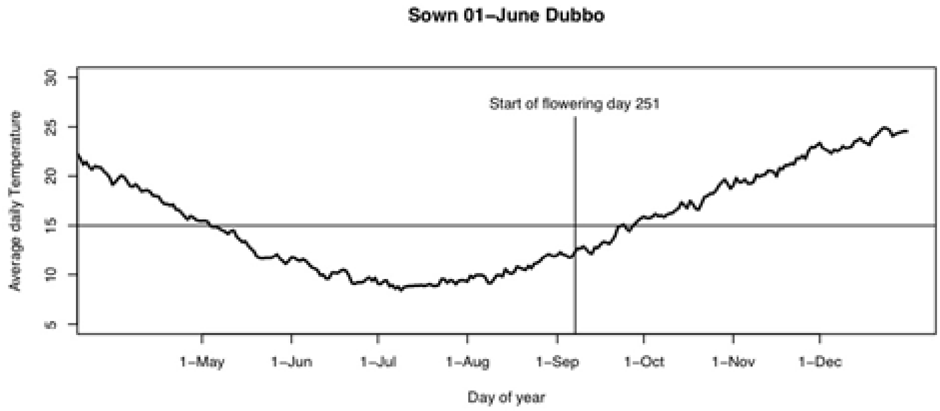
Sown 15–July Dalby

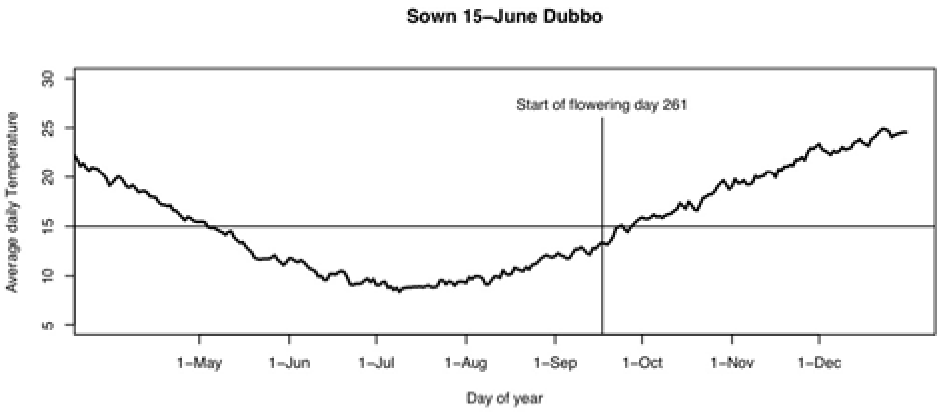


4.7.2 Effect of planting time on flowering in the Dubbo region

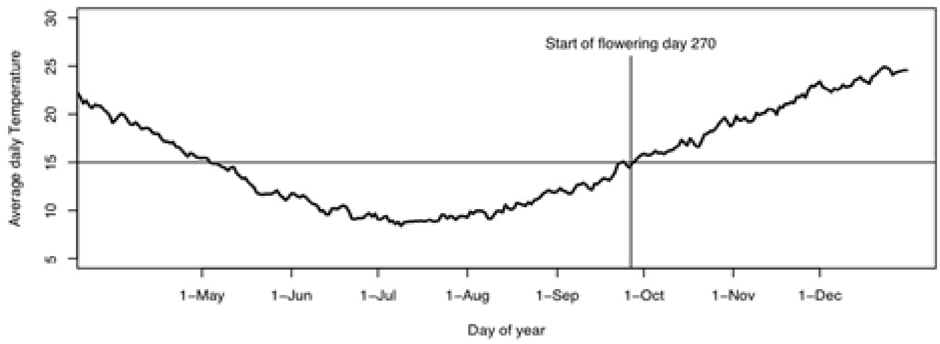




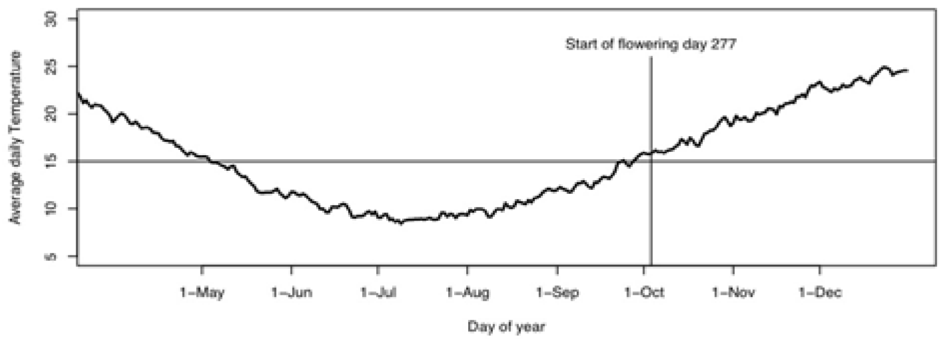




Sown 01–July Dubbo

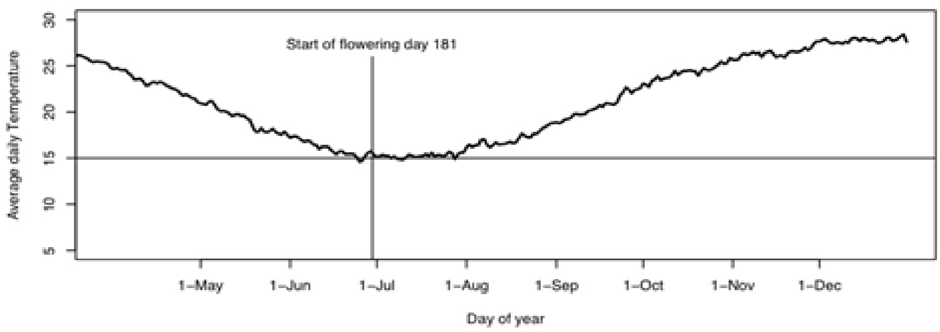


Sown 15–July Dubbo

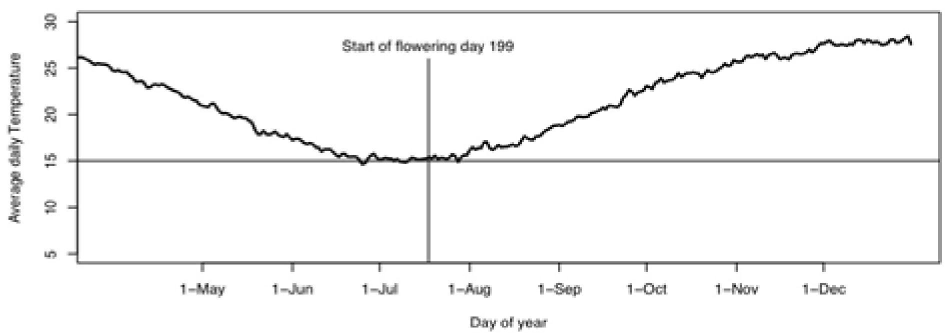


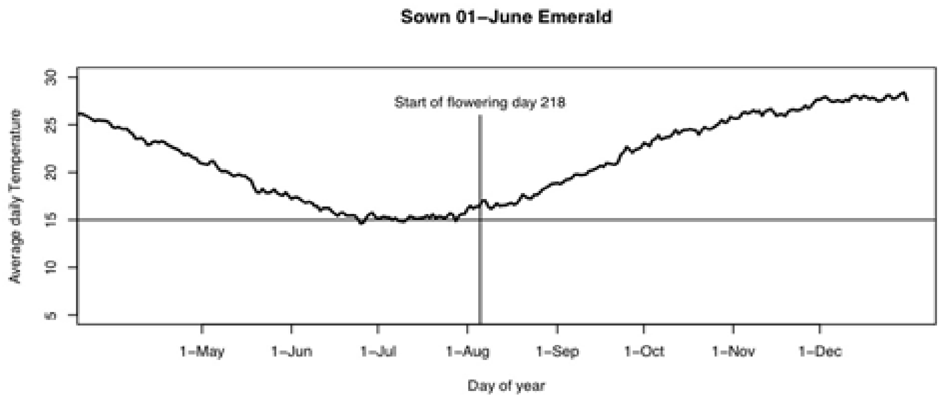
4.7.3 Effect of planting time on flowering in the Emerald region

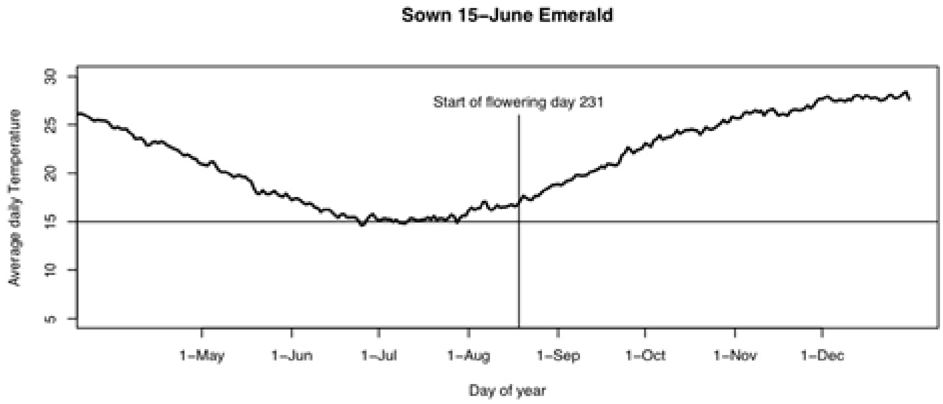
Sown 01–May Emerald

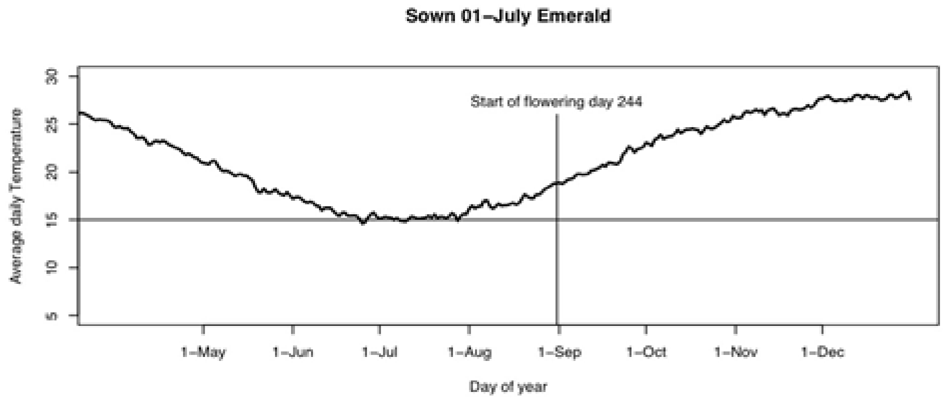


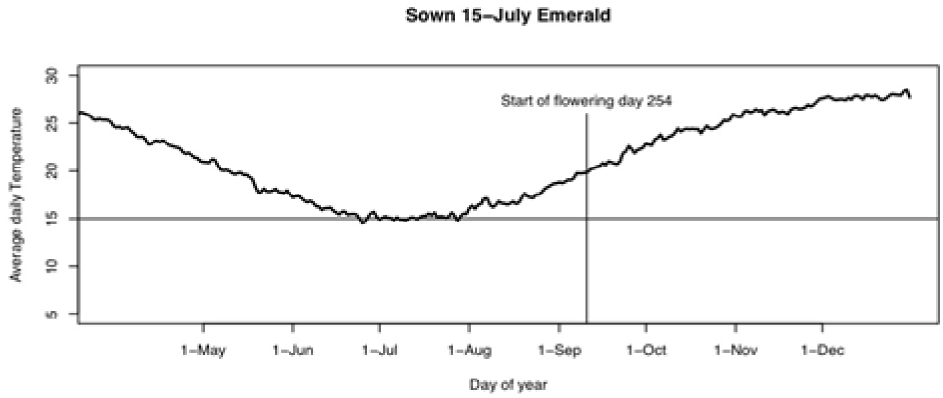
Sown 15–May Emerald



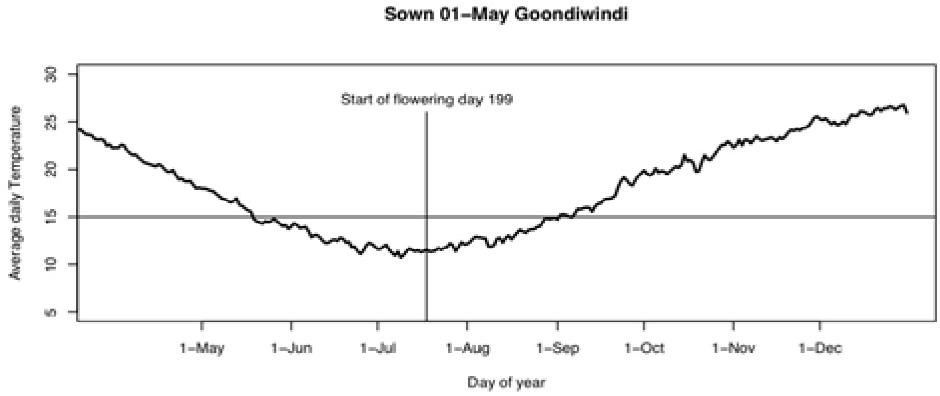

Sown 01–June Emerald
Start of flowering day 218
Average daily Temperature
5
10
15
20
25
30
1–May
1–Jun
1–Jul
1–Aug
1–Sep
1–Oct
1–Nov
1–Dec
Day of year

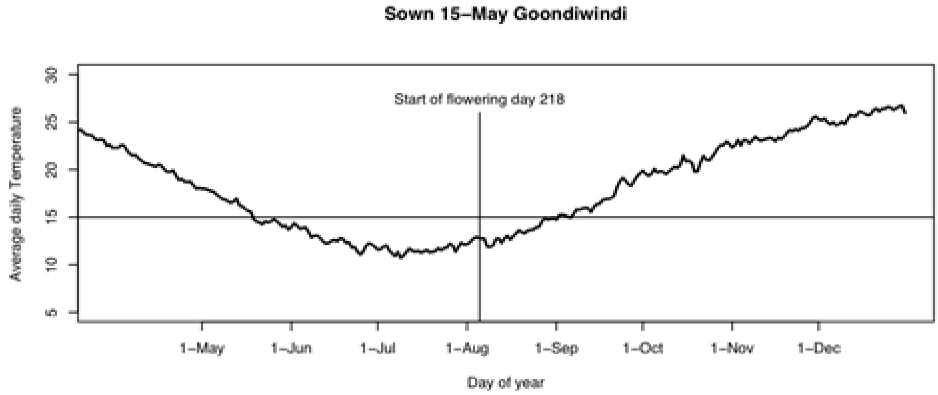

Sown 15–June Emerald
Start of flowering day 231
Average daily Temperature
5
10
15
20
25
30
1–May
1–Jun
1–Jul
1–Aug
1–Sep
1–Oct
1–Nov
1–Dec
Day of year

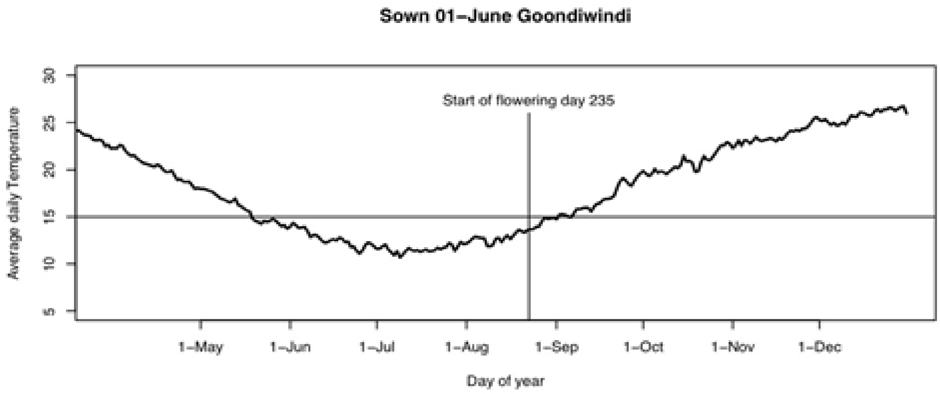

Sown 01–July Emerald
Start of flowering day 244
Average daily Temperature
5
10
15
20
25
30
1–May
1–Jun
1–Jul
1–Aug
1–Sep
1–Oct
1–Nov
1–Dec
Day of year

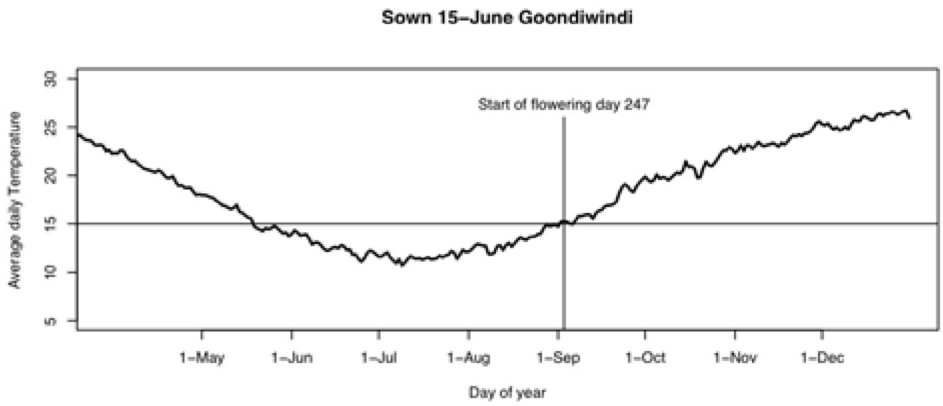

Sown 15–July Emerald
Start of flowering day 254
Average daily Temperature
5
10
15
20
25
30
1–May
1–Jun
1–Jul
1–Aug
1–Sep
1–Oct
1–Nov
1–Dec
Day of year

4.7.4 Effect of planting time on flowering in the Goondiwindi region

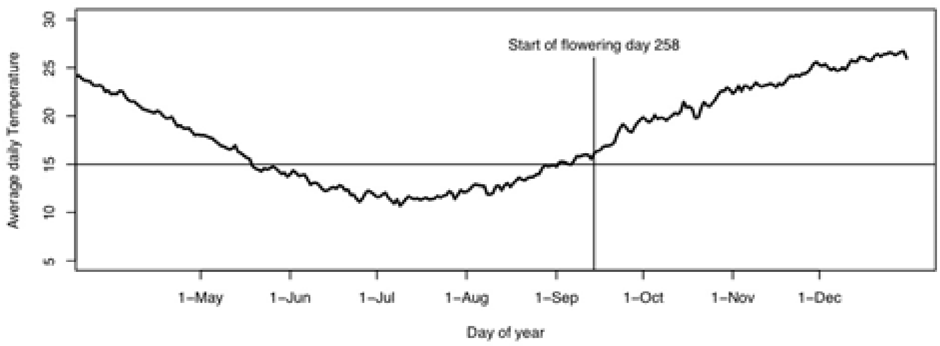




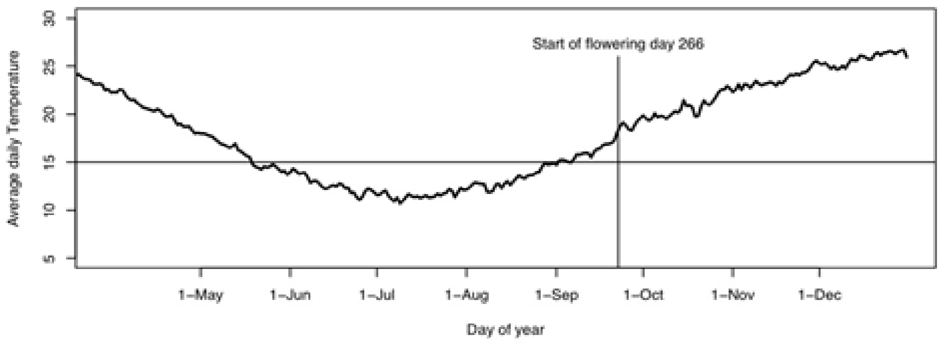




Sown 01–July Goondiwindi

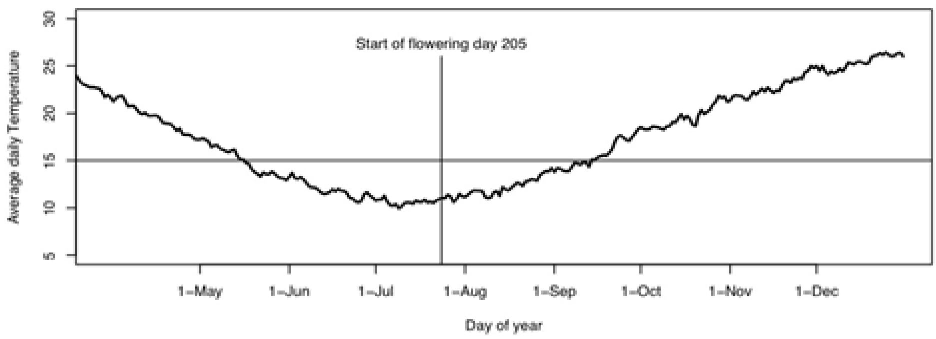


Sown 15–July Goondiwindi

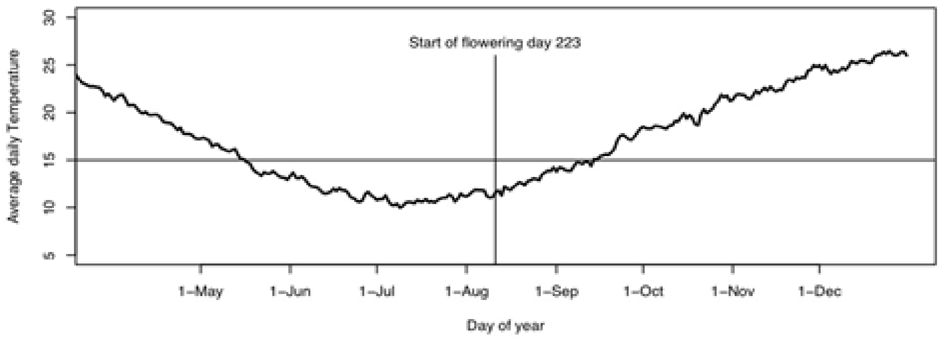


4.7.5 Effect of planting time on flowering in the Narrabri region

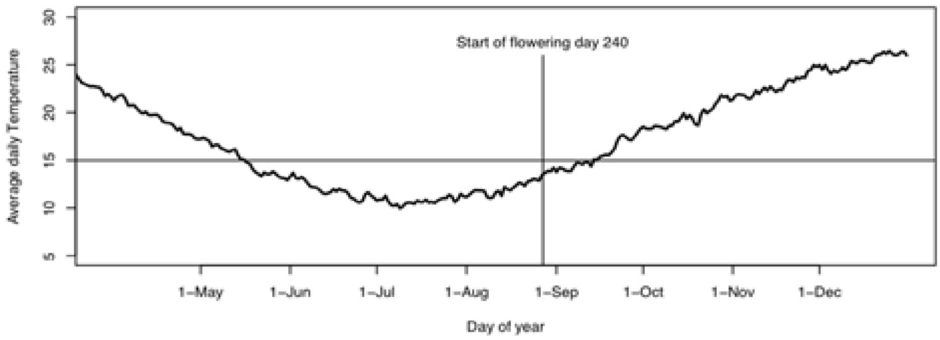
Sown 01–May Narrabri



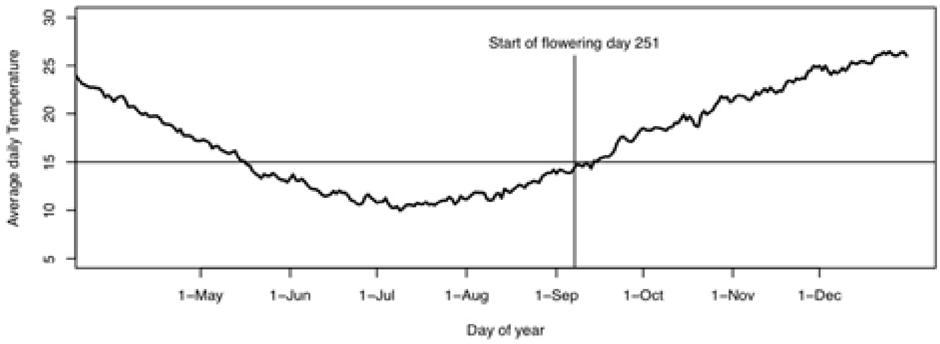
Sown 15–May Narrabri



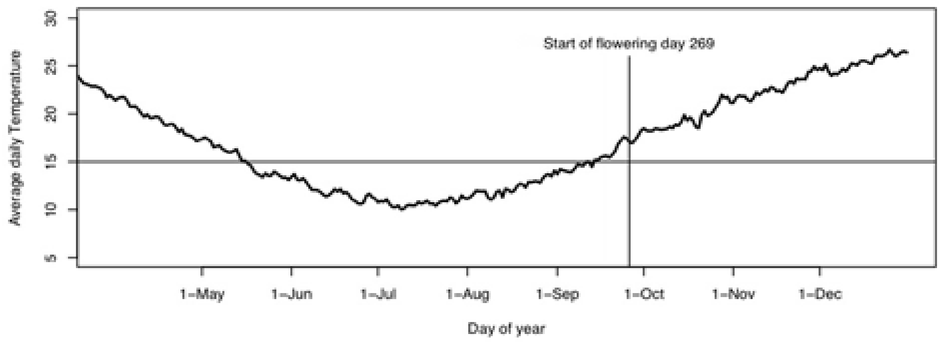
Sown 01–June Narrabri



Sown 15–June Narrabri

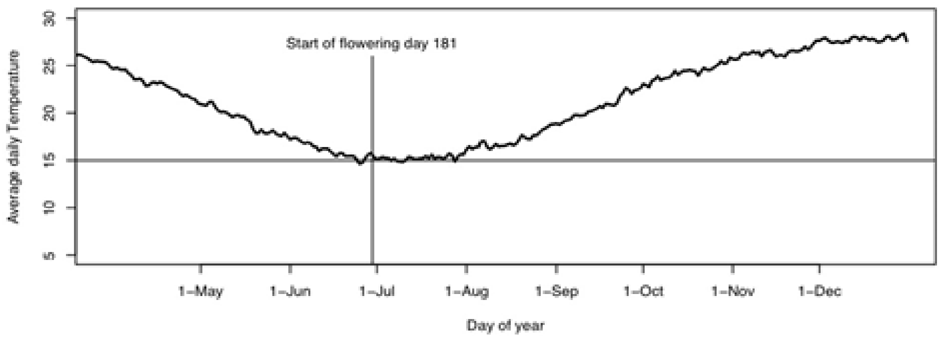


Sown 15–July Narrabri

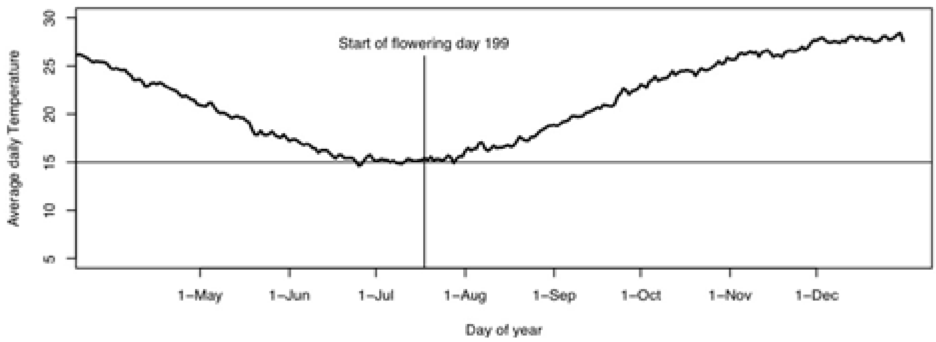


4.7.6 Effect of planting time on flowering in the Roma region

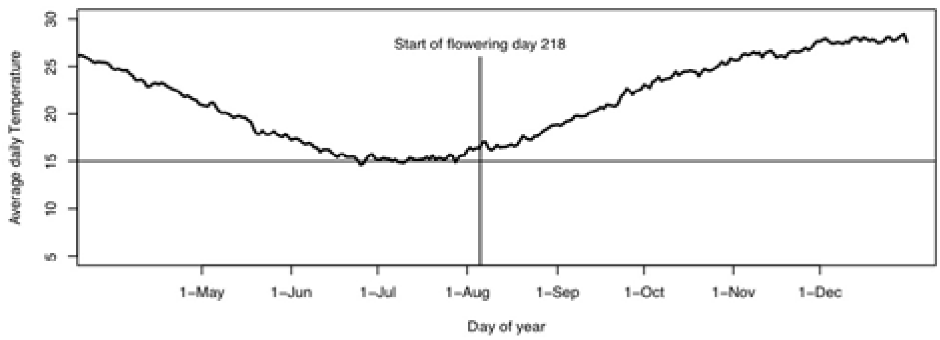
Sown 01–May Roma



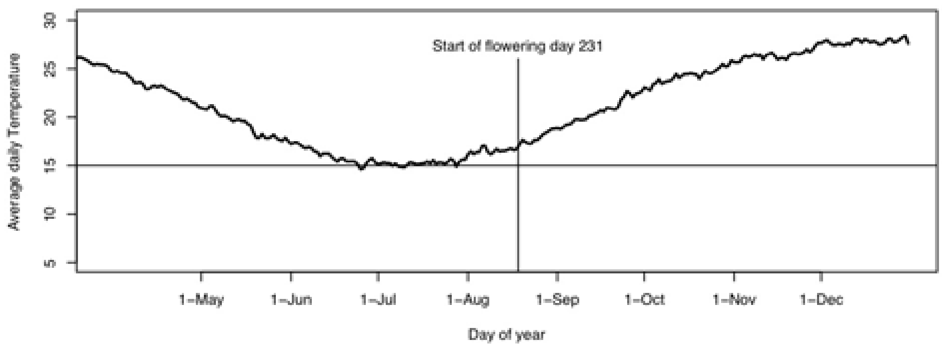
Sown 15–May Roma



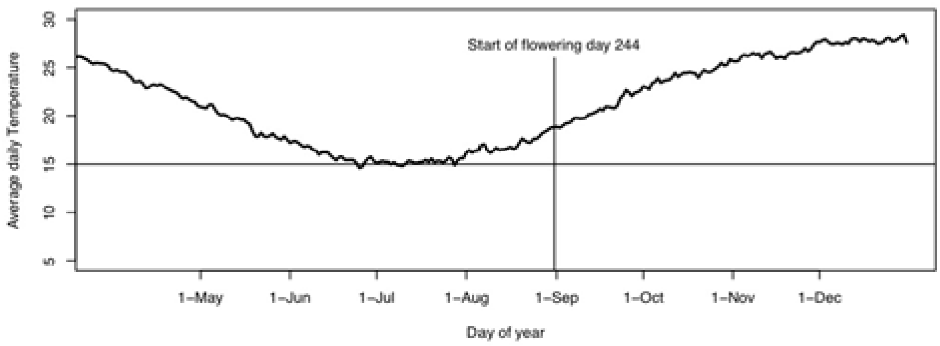
Sown 01–June Roma



Sown 15–June Roma



Sown 01–July Roma



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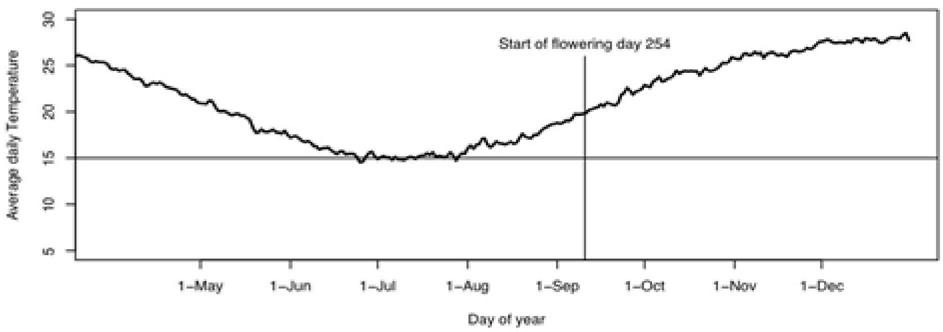
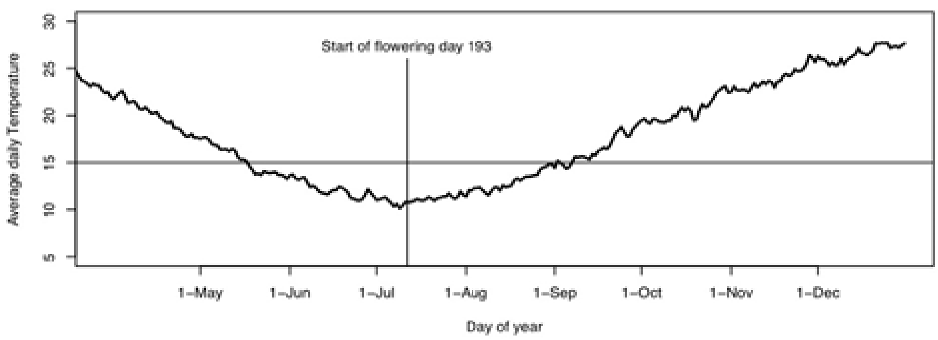
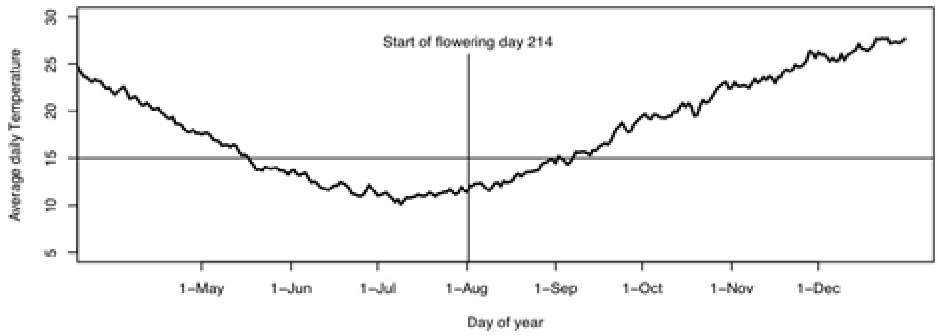


4.7.7 Effect of planting time on flowering in the Walgett region

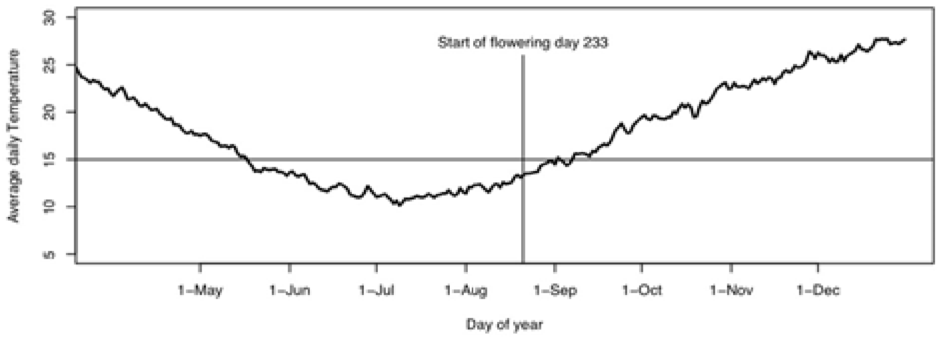
Sown 01–May Walgett



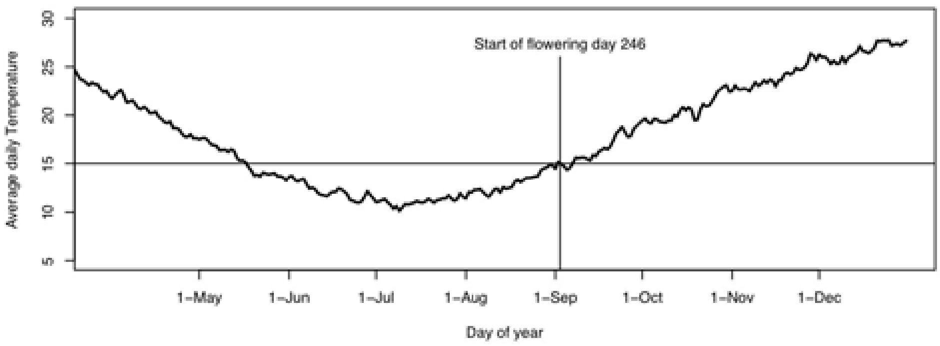
Sown 15–May Walgett



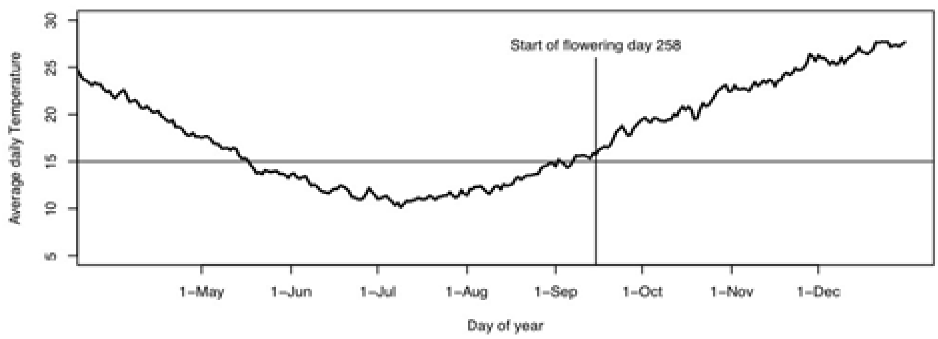
Sown 01–June Walgett

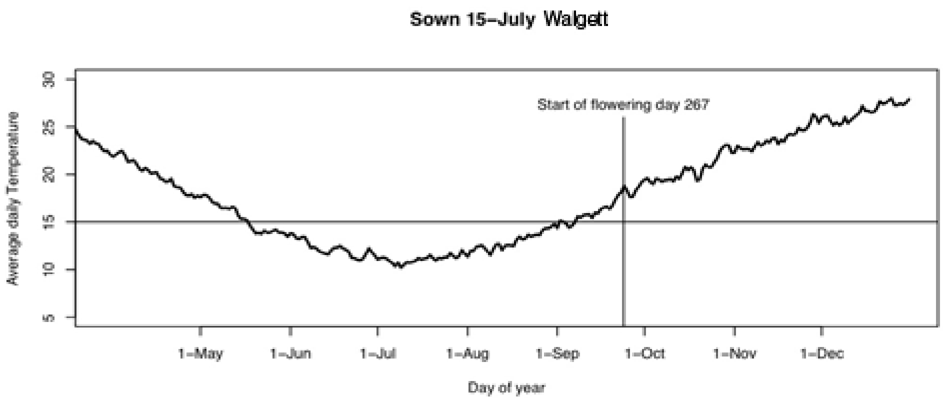


Sown 15–June Walgett



Sown 01–July Walgett





4.8 References and further reading

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