SOUTHERN

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GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

FABA BEAN

SECTION 5

PLANT GROWTH AND PHYSIOLOGY

KEY POINTS | DEVELOPMENTAL STAGES | FACTORS AFFECTING DEVELOPMENT | NODULATION | POLLINATION | EFFECT OF ENVIRONMENT ON YIELD COMPONENTS | GENETIC VARIATION

Plant growth and physiology

Key points

- Faba bean and broad bean development is divided into five phases and secondary growth stages.
- Faba bean has hypogeal emergence, which can be an advantage.
- Faba bean development is mostly influenced by daily average temperature, longer days and, to a lesser extent, a cold requirement.
- Rhizobia bacteria in nodulated faba bean roots 'fix' nitrogen into a plant-available form.
- Honey bees can increase pollination and, therefore, the yield of faba bean crops.
- Low temperatures can cause flower and pod abortion. Low light can also reduce podset. Breeders aim to overcome these issues in the future with new varieties.
- Faba bean have poor tolerance to drought and high temperatures.
- High humidity and chocolate spot can reduce podset.
- Pod height is affected by agronomic practices.
- Breeders are developing more determinate varieties to reduce excess biomass.
- Breeders are developing lines with improved herbicide tolerance (Group B and Group C).

5.1 Developmental stages

Faba bean developmental stages are divided into five principal phases, with each phase sub-divided into secondary stages (Table 1 and Figure 1). The stages of development allow for better understanding of farm chemical labels for correct timing of applications. While the secondary stages are classed as 'growth stages', they are technically developmental stages.

Table 1: Developmental phases and 'growth stages' of faba bean.

Developmental phase	Growth stage (GS)	Description
00 Germination and emergence	GS000	Dry seed
	GS001	Imbibed seed
	GS002	Radicle apparent
	GS003	Plumule and radicle apparent
	GS004	Emergence
	GS005	First leaf unfolding
	GS006	First leaf unfolded
10 Vegetative	GS101	First node (i.e. first leaf fully unfolded with one pair of leaflets)
	GS10(x)	x = node x leaf fully unfolded with more than one pair of leaflets
	GS1(n)	n = last recorded node n – any number of nodes on main stem with fully unfolded leaves, according to variety
20 Reproductive	GS201	Flower buds visible and still green
	GS203	First open flowers on first flower cluster (raceme)
	GS204	First pod visible at first fertile node
	GS205	Green pods fully formed, small immature seeds within.
	GS207	Pod-fill, pods green
	GS209	Seeds rubbery, pods still pliable, turning black
	GS210	Pods dry and black, seeds dry
30 Pod senescence	GS301	10% of pods dry and black
	GS305	50% of pods dry and black
	GS308	80% of pods dry and black
	GS309	90% of pods dry and black
	GS310	All pods dry and black
40 Stem senescence	GS401	10% stem brown/black or most stem green
	GS405	50% stem brown/black or 50% stem green
	GS410	All stems brown/black, all pods dry and black, seed hard

Note: The vegetative and reproductive phases can run concurrently.
Source: *Faba beans: The Ute Guide* (2009)

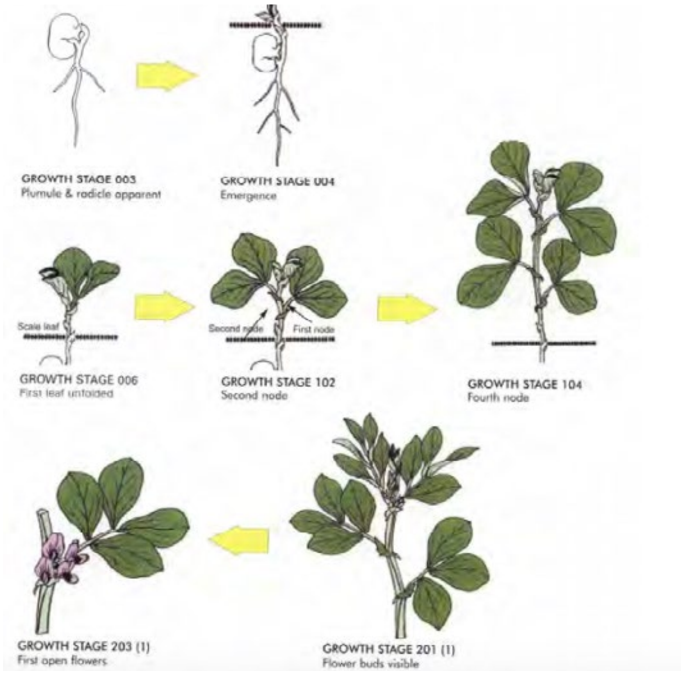

Figure 1: *Faba bean stages of development.*

Source: PGRO, UK

If a crop has uneven development, the average should be taken for the vegetative stage. Reproductive stages should not be averaged.

Once the crop reaches the reproductive phase, the timing of the growth stage should stay the same until 50% of plants demonstrate the characteristic of the next reproductive growth stage.

For an individual plant, the timing of a reproductive growth stage is based on the first occurrence of the specific trait on the plant. [1] [2]

5.1.1 Germination and emergence

Faba bean germination is 'hypogeal', meaning the cotyledons stay beneath the surface. This allows plants to emerge from sowing as deep as 25 cm (Figure 2).

Under optimum conditions faba bean seeds imbibe water and germinate within a few days, provided temperatures are above 0°C. Depending on soil moisture, temperature and sowing depth, the plant should emerge 7–10 days after sowing. The first true leaves have a pair of leaflets.

After sowing, water uptake into the embryo is very fast, depending on soil moisture content. Seeds that are sown into marginal moisture and have imbibed some water may have either dried down or not taken up enough moisture to germinate. These 'primed' seeds will germinate quickly when the soil becomes wet again.

If the seed coat is cracked, water may be taken up too quickly or microorganisms may access the starch and protein in the seed's endosperm.

Seed that has undergone some pre-harvest sprouting from the year it was harvested will have lower germination percentage, seedling vigour and seed viability in storage.

Seedlings with hypogeal emergence, such as faba bean, are less likely to be killed by frost, wind erosion or insect attack as new stems can develop from buds at nodes, at/

1 CM Knott (1990) A key for stages of development of the faba bean (Vicia faba). Annals of Applied Biology 116. pp 391–404. Reprinted in: T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba beans: The Ute Guide. Primary Industries and Resources South Australia, http://onlinelibrary.wiley.com/doi/10.1111/j.1744-7348.1990.tb06621.x/abstract

2 Pulse Australia (2016) Plant physiology. Southern Faba Bean – Best Management Practices Training Course manual. Pulse Australia.

or below ground level. In contrast, if an epigeal pulse (e.g. lupin) is broken below the cotyledons, the plant will die as there are no buds from which to shoot.[3 4]

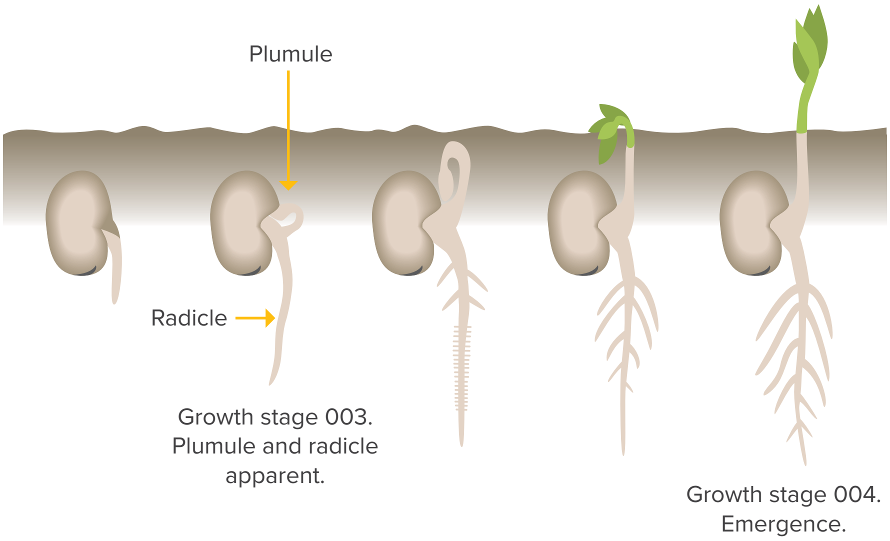

Figure 2: *Germination and hypogeal emergence of faba bean. Hypogeal emergence means cotyledons remain below the ground, while in epigeal emergence, cotyledons appear above the ground.*

Source: images based on slideplayer.com

5.1.2 Vegetative phase

Faba bean produce branches stemming from the base. Leaves from the early growth stages have only two leaflets, while leaves formed after the start of flowering have up to seven leaflets per leaf. [5]

The vegetative stage is determined by counting the number of developed nodes on the main stem, above ground level. Nodes are counted from the point at which the first true leaves are attached to the stem. The node at which the first leaflet arises from the main stem above the soil is counted as node one. A node is counted as developed when leaves are unfolded and flattened out. Scale leaves at the base of the plant and close to the ground are not counted as true nodes.

The last node counted must have its leaves unfolded (Figure 3). A node is counted as developed when leaves are unfolded and flattened out. Scale leaves at the base of the plant, close to the ground, are not counted as true nodes.

Faba bean stems do not actually have branches but produce tillers that grow from the nodes at the base of the plant, just above the main stem. Hereafter, tillers will be called branches. The leaves are alternate, up to 8 cm long, each with two to six leaflets. [6] Plants usually have one to five branches (tillers) on the main stem, depending on variety and growing conditions.

Unlike lupin and some other pulse crops, faba bean does not develop secondary or tertiary branches from the main stem of branches.

Faba bean canopies develop rapidly, especially in early-sown crops or during warm winters.[7]

3 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

4 Pulse Australia (2016) Plant physiology. Southern Faba Bean – Best Management Practices Training Course manual. Pulse Australia.

5 Pulse Australia (2016) Best management guide. Faba bean production: Southern and Western Region. Pulse Australia, 15 January 2016, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/southern-guide

6 V Heuze, G Tran, R Delagarde, M Lessire, F Lebas (2016) Faba bean (Vicia faba). Feedipedia, a programme by INRA, CIRAD, AFZ and FAO, www.feedipedia.org/node/4926

7 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

Photo 1: *The second leaf is fully unfolded in this plant at GS102 (second node stage).*

Photo: GRDC

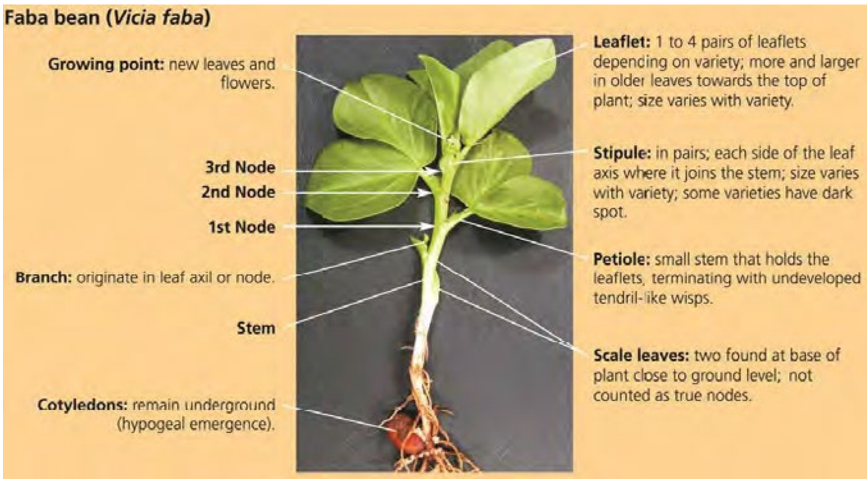

Figure 3: *Determine the vegetative stage of faba bean by counting the nodes on the main stem. The last node counted must have fully unfolded leaves.*

Source: D Holding, A Bowcher (2004) Weeds in Winter Pulses, CRC for Australian Weed Management

5.1.3 Reproductive phase

Flower development

Flowers develop from the bud at the axil of the leaf ('axillary bud') at the base of each node. Flowering usually begins at about the 6th to 10th node on the main stem and lower tillers, depending on variety, location and time of sowing (Photo 2). Flowers are borne on a stem called the peduncle that comes from the nodes.[8]

Flowers develop in clusters of 1–5, on up to 15 flowering nodes in a well-grown faba bean crop in Australia. Each flower cluster develops into 1–4 pods.

8 K Esau (1977) Anatomy of seed plants. 2nd edn. Wiley.

Photo 2: *GS203, first flowers open. Faba bean plants have alternate leaves along the branch, with multiple leaflets per leaf.*

Photo: GRDC

Flowering continues at intervals averaging 5–7 days between successive nodes on each tiller. The intervals between nodes are slow in winter during the vegetative and early reproductive phases (at least 7 days) but are fast during spring.

Most Australian faba bean varieties are 'semi-determinate'. This means vegetative growth continues once the plant switches to the reproductive phase – but can terminate before moisture becomes limiting.[9]

Other Australian varieties are indeterminate. An indeterminate variety will continue to flower if weather conditions in spring are favourable, with the potential to capitalise on the season or irrigation to produce high yields, similar to canola. In contrast, for fully determinate plants, all the flower buds open at about the same time, much like wheat.

Australian faba bean breeders are developing determinate attributes into locally adapted breeding lines[10] (see Section 5.6.2 Breeding determinate varieties for more information).

In southern Australia, flowering of faba bean continues for 6–10 weeks, depending on time of sowing, moisture and air temperature, from late July to mid-October.[11]

In cool, temperate environments, there can be a period of ineffective flowering that can be as long as 30 days. Early flowers can fail to set pods if there is a dense canopy and cold weather.

Pod and seed development

Once the flowers begin to develop and open, pollination (fertilisation) takes place. About 10–20% of flowers develop into pods. This is affected by variety and environmental factors (see Section 5.5 Effect of environment on yield components for more information).

9 GRDC (2016) Growth Stages for Faba Bean (unpublished). Grains Research and Development Corporation.

10 K Adhikari (2015) Faba bean. PBA Winter 15 News. Pulse Breeding Australia. pp 6–8, https://grdc.com.au/Research-and-Development/Major-Initiatives/PBA/Newsletters

11 RC Keogh, APW Robinson, IJ Mullins (2010) Faba beans. Pollination Aware. The Real Value of Pollination in Australia. Prepared by Strategen Environmental Consultants August 2010 RIRDC Publication No 10/081. Rural Industries Research and Development Corporation, https://rirdc.infoservices.com.au/items/10-081

The first pods appear about 6 days after pollination under favourable seasonal conditions. The pod wall grows rapidly for the first 10–15 days, while seed growth mainly occurs later.

The developing pods remain erect beneath the leaf canopy. Pods can contain up to eight seeds. Not every ovule (female reproductive cell) will develop into a seed. Pods may bend and point downward when seeds are near maturity in some varieties, particularly broad bean. Most of the seed yield is from the lower flowering nodes on the main stem and basal branches. Not all pods that set progress to fill seeds.

Photo 3: *Faba bean pod developing at leaf axil at base of node. Note the dead flower from which the pod arises.*

Photo: Wayne Hawthorne, formerly Pulse Australia

If moisture and temperature conditions are favourable, extra crop growth, node production, flowering and crop height occurs until flowering finishes. Hot conditions or a lack of moisture can end the flowering period and crop growth; faba bean plants stand upright and although they can grow to about 2 m, most Australian crops are shorter than 1.5 m. The height of the plant depends on soil moisture or rainfall, length of growing season and variety.

Pods in a well-grown crop (Photo 4) are produced about 20–30 cm above ground level, with each pod containing two to four seeds. Seed size varies with variety.

In a fully grown crop, the taproot will penetrate to about 60 cm with profuse fibrous roots that are less deep than cereals.[12]

Several factors can cause flowers to shed.[13] For the surviving pods, seed development goes through three stages: pre-storage, transition and storage, which have been described in detail in scientific literature.[14]

Faba bean seeds are oval and flat, sometimes with a ridged, dimpled or smooth seed coat. Seed coat colours also vary considerably.

12 Pulse Australia (2016) Best management guide. Faba bean production: Southern and Western Region. Pulse Australia, 15 January 2016, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/southern-guide

13 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

14 JW Patrick, FL Stoddard (2010) Physiology of flowering and grain filling in faba bean. Field Crops Research 115. pp 234–242, https://www.researchgate.net/publication/236875206_Physiology_of_flowering_and_grain_filling_in_faba_bean

Photo 4: *Mature, well-podded faba bean before the pods and stems dry for harvest.*

Photo: Wayne Hawthorne, formerly Pulse Australia

5.1.4 Pod and stem senescence

Soon after the pods develop and seeds fill, the plant begins to senesce (die). The lowest pods will mature first and become black, along with the lower leaves. This will continue gradually upward as the plant senesces.

As leaves senesce, biomass (or dry matter) is rapidly translocated from the leaves and stems and into the seeds.

If soil moisture is adequate and maximum temperatures are favourable for growth, flowering and podding will continue on the upper nodes. As soil moisture depletes and temperatures rise, flowering ends and eventually the whole plant matures.

Faba bean crops in southern Australia reach maturity 180–220 days after sowing, depending on sowing date, variety and a range of environmental factors including temperature.

Faba bean are ready to harvest when more than 90% of the stems and pods have become black. At this stage, seeds are usually hard but do not rattle when the plant is shaken, unlike chickpea and lentil [15] (see Section 12 Harvest for more information).

5.2 Factors affecting development

The rate at which faba bean develop is largely affected by average daily temperature. Some faba bean varieties also flower in response to longer days, while others are not affected by day length ('photoperiod'). Some faba bean varieties have a cold requirement, called 'vernalisation', although this is less important in Australian than in some European varieties, particularly the 'winter' varieties.[16]

Scientists are yet to fully understand the genetic code and physiology of faba bean that will help predict the rate of development of faba bean varieties and breeding

15 Pulse Australia (2016) Best management guide. Faba bean production: Southern and Western Region. Pulse Australia, 15 January 2016, http://pulseaus.com.au/growing-pulses/bmp/faba-and-broad-bean/southern-guide

16 GK McDonald, T Adisarwanto, R Knight (1994) Effects of time of sowing on flowering in faba bean (Vicia faba). Australian Journal of Experimental Agriculture 34(3). pp 395–400, http://www.publish.csiro.au/an/EA9940395

lines in response to the plant's environment. However, there is some understanding of the effects of thermal time and photoperiod on the time it takes for a faba bean crop to emerge and flower.[17]

5.2.1 Thermal time

The time a faba bean crop takes to develop depends mostly on the accumulation of 'thermal time', a function of time and temperature.

In general, warmer temperatures hasten development; even for the same location and same sowing date, flowering times can differ by more than 10 days due to differences in the seasonal conditions.[18]

Thermal time is the sum of the average daily temperatures above a base temperature, and measured in 'degree-days'. For faba bean, the base temperature is usually 0°C. [19] The average daily temperature is the daily maximum temperature minus the minimum temperature, divided by two. For example, 10 days with an average daily temperature of 12°C equates to 120 degree-days, when 0°C is the base temperature.

Consequently, a faba bean crop sown in early April will flower in less time than one sown in mid-June, as the April-sown crop will accumulate thermal time more rapidly during the warm autumn months.

Thermal time effect on vegetative phase

Research comparing a diverse range of faba bean genotypes (different plant types) showed they responded in a similar way to thermal time.[20]

Australian research also showed that the thermal time taken from sowing to emergence varied little among a range of breeding lines used in the experiment. On average, it took 208 degree-days from sowing to emergence (base temperature 0°C). The later the sowing date (from April to August), the longer the crop took to emerge.[21]

Similarly, New Zealand research with a single faba bean variety using a range of sowing dates found that 75% of the crop emerged after 217 degree-days, using a base temperature of 1.2°C.[22]

Thermal time effect on reproductive phase

Thermal time is the most important contributor to progress to flowering in faba bean. A faba bean crop needs about 830–1000 degree-days before it will flower.[23]

In southern Australia, the optimum temperature for faba bean growth is 15°C–20°C,[24] while the optimum temperature for progress to flowering is considered to be 20°C–23°C.[25]

Australian research showed that faba bean sown between April and August took, on average, between 43 and 73 days from emergence to the first flower, depending on

17 JW Patrick, FL Stoddard (2010) Physiology of flowering and grain filling in faba bean. Field Crops Research 115. pp 234–242, https://www.researchgate.net/publication/236875206_Physiology_of_flowering_and_grain_filling_in_faba_bean

18 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

19 JW Patrick, FL Stoddard (2010) Physiology of flowering and grain filling in faba bean. Field Crops Research 115. pp 234–242, https://www.researchgate.net/publication/236875206_Physiology_of_flowering_and_grain_filling_in_faba_bean

20 RH Ellis, RJ Summerfield, EH Roberts (1990) Flowering in faba bean: Genotypic differences in photoperiod sensitivity, similarities in temperature sensitivity, and implications for screening germplasm. Annals of Applied Botany 65. pp 129–138, www.jstor.org/stable/42758294?seq=1#page_scan_tab_contents

21 GK McDonald, T Adisarwanto, R Knight (1994) Effects of time of sowing on flowering in faba bean (Vicia faba). Australian Journal of Experimental Agriculture 34(3). pp 395–400, http://www.publish.csiro.au/an/EA9940395

22 MM Yusoff, DJ Moot, BA McKenzie, GD Hill (2013) Quantification of vegetative development of faba bean, oats, and Italian ryegrass. Crop and Pasture Science 63(12). pp 1097–1105, www.publish.csiro.au/cp/CP12305

23 RH Ellis, RJ Summerfield, EH Roberts (1990) Flowering in faba bean: Genotypic differences in photoperiod sensitivity, similarities in temperature sensitivity, and implications for screening germplasm. Annals of Applied Botany 65. pp 129–138, www.jstor.org/stable/42758294?seq=1#page_scan_tab_contents

24 B Robinson, M Raynes (2013) Growing faba bean, Agnote, AG0083. Victorian Department of Environment and Primary Industries, http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-faba-bean

25 JW Patrick, FL Stoddard (2010) Physiology of flowering and grain filling in faba bean. Field Crops Research 115. pp 234–242, https://www.researchgate.net/publication/236875206_Physiology_of_flowering_and_grain_filling_in_faba_bean

breeding line (Table 2). The thermal time to first flower varied considerably between sowing times, particularly with the later flowering accessions. The use of thermal time in isolation does not increase the accuracy of predicting flowering times in faba bean in southern Australia. Time from emergence to flowering across faba bean lines can be largely explained by the combined effects of the mean temperature and day length – and these two factors acted independently.[26]

Sowing times that resulted in flowering in winter had the greatest variation between plants, but with progressively later flowering than winter, this variation declined.[27]

At Rosedale, South Australia, Fiesta VF flowers 90 ± 3 days after sowing with a mid-May sowing. Therefore, it commences flowering in temperatures that average 11.4°C (maximum 16.5°C, minimum 6.3°C).

In many well-grown faba bean crops, podset does not occur until temperatures rise in August to September.

Table 2: Average time (days) and average thermal time (degree-days) from emergence to first flowering for cultivar Fiord and early and late-flowering accession of faba bean in southern Australia.

Accession	Time (days)			Thermal time (degree-days)		
		Range			Range	
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Fiord	53	34	68	724	534	889
ACC286	43	29	53	611	568	650
ACC863	73	50	96	972	731	1265
Average	59.50	39.0	77.8	807	620	1047

Source: Bennell *et al.* (2006)

5.2.2 Daylength

Faba bean varieties are either neutral-day or long-day plant.[28] This means that day length (or photoperiod) does not influence the time to flowering of some faba bean varieties, while for others, plants will begin to form flower buds when days are longer than their critical day length. The critical day length is between 9.5 and 12 hours for long-day faba bean varieties.

Breeders have identified improved variety breeding lines with low sensitivity to day length so that they flower early in southern Australian conditions of short days during a winter growing season.

Faba bean is a medium-duration crop, usually beginning flowering in 29–96 days of sowing, depending on photoperiod and temperature. European varieties are generally more photoperiod-sensitive; a critical day length of more than 12 hours may be required for them to flower under southern Australian conditions. In contrast, Mediterranean varieties flower with much shorter days.[29]

5.2.3 Vernalisation

Vernalisation is the process by which prolonged exposure to cold temperatures promotes flowering.[30]

26 GK McDonald, T Adisarwanto, R Knight (1994) Effects of time of sowing on flowering in faba bean (Vicia faba). Australian Journal of Experimental Agriculture 34(3). pp 395–400, http://www.publish.csiro.au/an/EA9940395

27 Pulse Australia (2016) Plant physiology. Southern Faba Bean – Best Management Practices Training Course manual. Pulse Australia.

28 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

29 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

30 R Amasino (2004) Vernalization, competence, and the epigenetic memory of winter, Plant Cell, 16(10). pp 2553–2559, http://www.plantcell.org/content/16/10/2553.full.pdf+html

In southern Australian trials, the greatest response of faba bean to vernalisation was with April sowing.[31] With late (August) sowing there was little response to vernalisation. Long and lengthening days partly overcame the vernalisation requirement of some varieties. The researchers concluded that, for normal sowing dates in dryland faba bean crops in southern Australia, there was little effect of vernalisation on the time to flowering. Instead, temperature and day length were the major controls of development.

'Winter' faba bean, which is grown in Europe (as opposed to 'spring' faba bean), will eventually flower, even without vernalisation. Mediterranean varieties of faba bean, as grown in Australia, do not have a high vernalisation requirement. Vernalisation of spring and Mediterranean varieties accelerated flowering in trials, but only in line with the accumulated thermal time.[32 33]

5.3 Nodulation

Faba bean roots develop nodules with rhizobia bacteria *Rhizobium leguminosarum* bv. *viciae*, a species capable of converting nitrogen gas from the atmosphere into forms of nitrogen that the plant can use, called 'fixation'. The plant provides carbohydrate in return.

Nodules are visible on faba bean about a month after emergence. They eventually form slightly flattened, fan-like lobes. Nearly all nodules are within the top 30 cm of soil, while 95% are in the top 15 cm. When cut open, active nodules have a 'pinkish' centre.[34]

Photo 5: *Faba bean with adequate nodulation. The inside of the nodules should be red/pink rather than grey or green.*

Source: GrowNotes™: Faba bean (northern region)

31 Pulse Australia (2016) Plant physiology. Southern Faba Bean – Best Management Practices Training Course manual. Pulse Australia.

32 GK McDonald, T Adisarwanto, R Knight (1994) Effects of time of sowing on flowering in faba bean (Vicia faba). Australian Journal of Experimental Agriculture 34(3). pp 395–400, http://www.publish.csiro.au/an/EA9940395

33 JW Patrick, FL Stoddard (2010) Physiology of flowering and grain filling in faba bean. Field Crops Research 115. pp 234–242, https://www.researchgate.net/publication/236875206_Physiology_of_flowering_and_grain_filling_in_faba_bean

34 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

5.3.1 Temperature effects on nodulation

Australian research in the 1980s showed that nodulation (and seedling growth) of the faba bean variety Fiord improves with warm temperatures at 15°C or 20°C, compared with 10°C, when grown in pots. The researchers concluded that the yield advantage of early planting of this variety may partly be due to better nodulation in warm soils.

5.3.2 Mineral nitrogen effects on nodulation

The researchers also compared two *Rhizobium* strains on Fiord faba bean and early dun field pea and found that nodulation of faba bean was remarkably slow, taking up to 50 days from sowing. Faba bean grown without mineral nitrogen showed poor early growth; however, low levels of nitrate stimulated nodule development. In contrast, doubling or tripling the level of nitrate for faba bean caused delayed nodulation, lower nodule production and poorer nodule activity.[35] This result ratifies the practice of using starter nitrogen to stimulate nodulation, but also sends the warning that it can be detrimental if soil nitrate levels are high.

5.3.3 Waterlogging effects on nodulation

Nitrogen fixation is highly sensitive to waterlogging.

5.4 Pollination

Faba bean can be self-pollinated or cross-pollinated (open-pollinated). To maximise podset and seedset, pollen is transferred between flowers. Faba bean pollen is heavy and sticky and is not released into the air. While the wind can assist in pollen transfer, insects carrying pollen between flowers is the most effective method of cross-pollination. Several insect species will do this, including bees, lacewings, flies and ants. About 30% of plants in a population are cross-fertilised; the main insect pollinators in Australia are honey bees. When commercial faba bean crops in SA and western Victoria were surveyed for flower visitors and incidence of pollination, honey bees were the only pollen vectors.[36]

As pulse crops have a short flowering period, the number of insects required to effectively pollinate the crop is beyond what may occur in nature. Introducing honey bees is the most effective way to manage this.[37]

5.4.1 Pollination efficiency

The presence of honey bees can accelerate the rate of podsetting in faba bean[38] (Photo 6). Plants with access to bees set more pods on the lower nodes and ripen earlier, with significantly more seeds per pod.[39]

35 A Herdin, JH Silsbury (1989) Nodulation and early growth of faba bean (*Vicia faba L.*) and pea (*Pisum sativum* L.) as affected by strain of *Rhizobium*, NO3- supply, and growth temperature. Australian Journal of Agricultural Research 40(5)) pp 991–1001, http://www.publish.csiro.au/cp/AR9890991

36 FL Stoddard (1991) Pollen vectors and pollination of faba beans in southern Australia. Australian Journal of Agricultural Research 42(7). pp 1173–1178, www.publish.csiro.au/paper/AR9911173.htm

37 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

38 GK McDonald, T Adisarwanto, R Knight (1994) Effects of time of sowing on flowering in faba bean (Vicia faba). Australian Journal of Experimental Agriculture 34(3). pp 395–400, http://www.publish.csiro.au/an/EA9940395

39 D Somerville (2002)"Honeybees in faba bean pollination. Agnote DAI-128, W Smith (ed.). NSW Agriculture, www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/117110/bee-faba-bean-pollination.pdf

Photo 6: *The presence of honey bees accelerates the rate of podsetting in faba bean.*

Photo: Felicity Pritchard

It is not unusual for less than one in five faba bean flowers to set pods.[40] One of the numerous causes of this is a lack of pollination. Sometimes a faba bean flower will not pollinate, either due to a lack of bees for cross-pollination or a physical problem with the flower that prevents self-pollination. An unpollinated flower will not set a pod or produce seeds.

Faba bean plants naturally produce an excess of flowers. This is an ecological survival strategy to enhance the plant's ability to compete for pollinating insects; it is inevitable that many flowers are lost.[41]

Large pods set very low on faba bean plants are common when bees are active. These additional and larger pods are a major contributor to the increased yield.[42]

In the past, Australian growers believed that introduced managed honey bees in flowering faba bean crops were not necessary due to sufficient feral bee activity. This was originally backed by trials in SA and western Victoria, which found the incidence of pollination was never less than 50% and averaged 80%. Only 40–50% of flowers need pollinating to provide an excess of pods for the plant.[43]

In contrast, newer research in New South Wales found that honey bee pollination significantly improved the number of pods and grain yield of faba bean (Table 3). Seed yield in cages with honey bees was 25% higher than in those without honey bees. The pollen harvested by honey bees from the faba bean met their nutritional requirements for protein and amino acids but there was no detectable nectar crop gathered from the faba bean. The researcher argued there is a strong case for using managed honey bees to improve pollination and yields of Australian faba bean where feral bee populations may be insufficient.[44]

More recently, researchers studied 17 faba bean paddocks in SA and showed an average yield benefit of 17%, 90% of which is attained within 767 m of hives. The effect was most noticeable when far from timbered areas. The researchers observed that bee activity, pods per stem and average yields were higher when closer to hives. Yield maps showed the presence of this 'distance gradient', which was consistent across all paddocks, across 2 years, two faba bean varieties and two different bee-

40 Pulse Australia (2014) Northern faba bean best management practices training course – 2014. Pulse Australia.

41 GK McDonald, T Adisarwanto, R Knight (1994) Effects of time of sowing on flowering in faba bean (Vicia faba). Australian Journal of Experimental Agriculture 34(3). pp 395–400, http://www.publish.csiro.au/an/EA9940395

42 W Hawthorne (2013) Maximising yield potential in irrigated faba beans. IREC Farmers' Newsletter – Large Area 189: Spring 2013. Irrigation Research and Extension Committee, http://irec.org.au/farmers-newsletter/

43 D Somerville (2002)"Honeybees in faba bean pollination. Agnote DAI-128, W Smith (ed.). NSW Agriculture, www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/117110/bee-faba-bean-pollination.pdf

44 DC Somerville (1999) Honeybees (*Apis mellifera L.*) increase yields of faba beans (*Vicia faba L.*) in New South Wales while maintaining adequate protein requirements from faba bean pollen. Australian Journal of Experimental Agriculture 39(8). pp 1001–1005, www.publish.csiro.au/paper/EA99023.htm

hive management methods. An economic analysis found hives are profitable for faba bean crops.[45]

Reliance of feral bees for pollination may become a 'luxury of the past', due to the prevalence of several pests and disease likely to affect bee populations in the future. The potential incursion of the parasitic mite *Varroa* poses considerable threat. The success of feral bee populations in pollinating faba bean depends on crop size, population of feral bees and the health of colonies closest to the crop.[46] All these factors can vary between locations and seasons.[47]

Table 3: Honey bees significantly increased yield of faba bean by up to 25% in southern New South Wales trials. Yield of plants in cages increased by 24% when honey bees were included in the cages.

Treatment	Yield (t/ha)
Uncaged, open to bees (control)	1.86
Shaded but open to bees	1.73
Caged with bees	1.51
Caged with no bees	1.22

Source: Somerville (1999), Sommerville (2002)

5.4.2 Bee activity

Bees transfer pollen between flowers, thereby pollinating the crop while collecting pollen and, to a lesser extent, nectar.[48] Pollen collecting by bees peaks between 1 p.m. and 4 p.m. in the southern region. Each faba bean flower has up to 18 hours in which it can be pollinated, as flowers remain viable for 6 days when unpollinated.[49]

Honey bee activity is highest at temperatures above 19°C and almost stops when temperatures fall below 13°C. Bees can fly up to 150 m between rain showers but stop flying when it is raining. Strong winds will also reduce the number of flights taken by bees.

A bee colony with strong numbers will enable honey bees to leave the hive at lower temperatures, while surplus bees can remain in the brood nest to keep it at a constant temperature of 37°C.

The number of honey bees visiting the blossom is correlated with the amount and concentration of nectar produced, which is highest in old flowers.[50]

5.4.3 Hive management

Faba bean provides very little, if any, nectar to honey bees, due to the shape of its flower. Only some hives are suitable for pollinating faba bean.

It had been thought that hives needed to be managed by providing sugar syrup early in the flowering period or ensuring there was stored honey in the hive before the bees go into the crop so they collect pollen rather than seeking nectar. These artificial nectar sources were thought to stimulate the colony to breed, thereby increasing demand for pollen. There is now a changed attitude to faba bean pollination.

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45 S Cunningham, D Le Feuvre (2013) Significant yield benefits from honeybee pollination of faba bean (Vicia faba) assessed at field scale. Field Crops Research 149. pp 269–275, www.researchgate.net/publication/257214174_Significant_yield_benefits_from_honeybee_pollination_of_faba_bean_Vicia_faba_assessed_at_field_scale

46 D Somerville (2002) Honeybees in faba bean pollination. Agnote DAI-128, W Smith (ed.). NSW Agriculture, www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/117110/bee-faba-bean-pollination.pdf

47 RC Keogh, APW Robinson, IJ Mullins (2010) Faba beans. Pollination Aware. The Real Value of Pollination in Australia. Prepared by Strategen Environmental Consultants August 2010 RIRDC Publication No 10/081. Rural Industries Research and Development Corporation, https://rirdc.infoservices.com.au/items/10-081

48 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

49 DC Somerville (1999) Honeybees (Apis mellifera L.) increase yields of faba beans (Vicia faba L.) in New South Wales while maintaining adequate protein requirements from faba bean pollen. Australian Journal of Experimental Agriculture 39(8). pp 1001–1005, www.publish.csiro.au/paper/EA99023.htm

50 D Somerville (2002) Honeybees in faba bean pollination. Agnote DAI-128, W Smith (ed.). NSW Agriculture, www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/117110/bee-faba-bean-pollination.pdf

It has now also been established that hives need constant management to adequately pollinate a faba bean crop. Bees should generally be introduced when about 5% of the crop has started to blossom, for them to start working immediately. Hive placement and management is critical. Moving hives into a crop at night is less stressful for the bees.[51]

Growers should agree on the number of combs of brood or bees before agreeing to hire bees.[52]

The new-to-Australia method of hive management markedly increases the number of forager bees collecting pollen from faba bean. This involves keeping significantly less stored honey in the hives to maintain the demand for pollen and nectar.[53] The overwhelming demand for pollen means that the bees travel to the closest source of pollen, which reduces the distance they travel from the hive. They visit every flower in the crop, including older flowers and those lower in the canopy. This method requires fortnightly servicing of hives.

Trials conducted indicate that the flight of the bees is restricted to about 200–300 m from the hive placed in the faba bean crop. This means, in order to achieve effective pollination, precise placement and density of hives is crucial for uniform pollination.

In the past, apiarists supplied hives that contained a significantly higher amount of stored honey and pollen. As a result there was not a significant immediate demand in the hive for pollen and nectar, as they had sufficient stores to sustain the hive. With a reduced demand in the hive for pollen and nectar, the bees travelled further from the hive to find more preferable areas to graze. (e.g. warm gullies, areas protected from winds or alternative native vegetation). Bees can travel up to 5 km to find alternative flora.

Trials conducted in 2007 and 2008 across SA have indicated that yield increases of up to 50% may be easily achievable with the addition of the managed hives to pulse crops.

Historically, the ideal pollination unit had been considered to be approximately six frames of brood and bees. With an expanding brood nest, the bees need more pollen to feed their larvae. This was thought to encourage them to fly more often, even when conditions were not ideal.

It had also been thought that generally, the minimum requirement was a very strong single hive or a colony expanding into a double hive. Pollen-gathering honey bees are said to fly shorter distances than nectar gatherers. Most faba bean seeds are set within a 100 m radius of a colony. If bees need to fly more than 500 m, they should be split up and placed in appropriately spaced intervals.

It is now established that for faba bean crops, apiarists must manage hives as ‘pollinators’ rather than honey producers, placing and managing hives differently than simply leaving them in the paddock corner.

The more pollen-gathering insects visiting a crop, the greater the chance of maximum pollination. The number of bees and other insects pollinating faba bean flowers is more important than hive density.

A hive density of one hive/ha is practical and profitable; grouping 30 hives together every 300 m, or using larger groups further apart, will achieve a yield response. Yields have been found to increase by 30–100% by introducing two hives/ha in a grid. In the past, one colony/10 ha of faba bean was proposed as sufficient.

Precise placement and density of hives is crucial for uniform and effective pollination (Photos 7 and 8).

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51 RC Keogh, APW Robinson, IJ Mullins (2010) Faba beans. Pollination Aware. The Real Value of Pollination in Australia. Prepared by Strategen Environmental Consultants August 2010 RIRDC Publication No 10/081. Rural Industries Research and Development Corporation, https://rirdc.infoservices.com.au/items/10-081

52 D Somerville (2002) Honeybees in faba bean pollination. Agnote DAI-128, W Smith (ed.). NSW Agriculture, www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/117110/bee-faba-bean-pollination.pdf

53 K Esau (1977) Anatomy of seed plants. 2nd edn. Wiley.

It had been thought that, where possible, hives should be placed in a warm, sunny, elevated position, protected from prevailing winds. This is no longer considered the case with faba bean.

Growers are now recommended to introduce managed honey bee colonies into a faba bean crop where it is more than 500 m from stands of mature trees that are likely to harbour feral bees or if the crop is too large to be adequately pollinated by feral bees. Hive placement should also be considered in relation to other crops such as canola that bees will preferentially visit.

Hives should not be placed within 100 m of gates, lanes, stock troughs or sheds. They should also not be placed in long rows; an irregular layout is best, with hives spaced apart and facing different directions. Ideally, beekeepers should have all-weather truck access, as limited access can increase the workload and lead to uneven placement of hives, causing inefficient pollination.[54]

Photo 7: *Bee hives need to be strategically placed within the faba bean crop and managed well to ensure adequate pollination.*

Photo: Wayne Hawthorne, formerly Pulse Australia

Photo 8: *Bee hives need to be strategically placed within the faba bean crop and managed well to ensure adequate pollination.*

Photo: Wayne Hawthorne, formerly Pulse Australia

54 RC Keogh, APW Robinson, IJ Mullins (2010) Faba beans. Pollination Aware. The Real Value of Pollination in Australia. Prepared by Strategen Environmental Consultants August 2010 RIRDC Publication No 10/081. Rural Industries Research and Development Corporation, https://rirdc.infoservices.com.au/items/10-081

5.4.4 Pesticide sprays

If bee hives are placed in the faba bean crop, talk with your apiarist about fungicide and insecticide use.[55] Pesticides are one of the biggest dangers to bee colonies or feral bees.

Some products, if applied at the right time of day, can be used without needing to shift hives.[56] Otherwise, remove or house bees before fungicide or insecticide is sprayed.[57]

When spraying, the further the beehives are placed away from the crop, the better.[58]

Pesticides should be kept to a minimum while hives remain on your property. Most poisoning occurs when pesticides are applied to flowering crops, pastures and weeds.

Growers should take the following steps to minimise bee losses:

- always warn nearby growers and beekeepers of your intention to spray, with at least 2 days' notice;
- follow warnings on pesticide labels;
- select the least harmful pesticide for bees and spray late in the afternoon or night (but be aware of the risk of inversion layers);
- do not spray in conditions where the spray may drift into neighbouring paddocks, supporting foraging bees; and
- dispose of waste chemicals correctly.[59]

55 Pulse Australia (2014) Northern faba bean best management practices training course – 2014. Pulse Australia.

56 W Hawthorne (2013) Maximising yield potential in irrigated faba beans. IREC Farmers' Newsletter – Large Area 189: Spring 2013. Irrigation Research and Extension Committee, http://irec.org.au/farmers-newsletter/

57 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

58 RC Keogh, APW Robinson, IJ Mullins (2010) Faba beans. Pollination Aware. The Real Value of Pollination in Australia. Prepared by Strategen Environmental Consultants August 2010 RIRDC Publication No 10/081. Rural Industries Research and Development Corporation, https://rirdc.infoservices.com.au/items/10-081

59 D Somerville (2002) Honeybees in faba bean pollination. Agnote DAI-128, W Smith (ed.). NSW Agriculture, www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/117110/bee-faba-bean-pollination.pdf

FEEDBACK

VIDEO

GroundCover™ TV: Extreme Temperature Analysis to Better Understand Frost Events https://youtu.be/Zw637FiX5PU

5.5 Effect of environment on yield components

Stresses to the plant can affect its ability to *produce* grain. Flower and pod retention is sensitive to transient stress. Faba bean podset is reduced by a number of factors, including extremes of temperature, wind, drought, poor pollination, low light and an excess of flowers.

Photo 9: *Faba bean podset is reduced by a number of factors, including extremes of temperature, wind, drought, poor pollination, low light and an excess of flowers. Here, flowers are lost at each node near a single pod.*

Source: Wayne Hawthorne, formerly Pulse Australia

MORE INFORMATION

GroundCover™ TV: Legume Nodulation – field sampling www.grdc.com.au/ManagingFrostRisk

Frost: Frequently Asked Questions, https://grdc.com.au/frost-faq

Frost Management Tips and Tactics fact sheet

GRDC (2014) *Inoculating legumes: a practical guide*, https://grdc.com.au/Resources/Bookshop/2015/07

5.5.1 Low temperature

The optimal temperature for cool-season pulses is between 10°C and 25°C–30°C.

Low average daily temperature may cause faba bean to abort flowers and pods (while low levels of daylight will also cause flower abortion). A daily average temperature between 0°C and 10°C is considered a threshold for cold or chilling stress in cool-season pulses. Flower buds and flowers are the most sensitive parts. Faba bean and lentil are more tolerant of cold than chickpea and field pea. Unlike chickpea, low temperatures are not known to cause pollen sterility in faba bean.

Temperatures below 10°C are not necessarily an impediment to flowering in faba bean in southern Australia, unless frosts occur. Further, faba bean in southern Australia is less likely to experience damage from temperatures below 5°C during the reproductive phase, compared with northern Australia.

When temperatures rise in August to September, pods can develop quickly, within 3–6 days. Even after flowers develop into pods, periods of low temperature and poor conditions can cause seed and pod abortion before seedfilling begins. Poor conditions can include less sunlight, as well as windy or rainy weather, which affect pollinator activity.

Early-flowering varieties can be an advantage in some situations, despite the increase in flower and pod abortion with low temperatures.[60] [61]

60 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

61 K Siddique (2000) Abiotic stresses of cool season pulses in Australia. Birchip Cropping Group Trials Results Book 1999. Birchip Cropping Group, www.farmtrials.com.au/trial/13486

5.5.2 Frost

Temperatures below 0°C can damage leaves and stems and can cause a characteristic 'hockey stick' bend in the stem (Photo 10). Faba bean can recover from damage in the vegetative phase by generating new tillers in severe cases, if soil moisture is favourable. Severe frosts can cause distortion of vegetative parts, total defoliation and even plant death.

Photo 10: *Severe frost during the vegetative phase can cause characteristic 'hockey stick' bends; faba bean plants have some ability to recover if conditions are favourable.*

Photo: Gordon Cumming, formerly Pulse Australia

In the reproductive phase, temperatures below 0°C can cause faba bean flower, pod and seed abortion. Small pods are more susceptible to frost damage than larger pods (Photo 11); however, larger pods may develop mottled darkening of the seed coat (Photos 12 and 13).

If seasonal conditions are favourable, later-forming pods can compensate for the effects of frost during early flowering on early podset.

Photo 11: *Flowers and smaller pods are more likely to be aborted by frost than larger pods. The extent of damage also depends on the severity of the frost.*

Photo: Wayne Hawthorne, formerly Pulse Australia

Photo 12: *Frost can cause 'staining' of the seed coat next to the pod wall.*

Photo: Wayne Hawthorne, formerly Pulse Australia

Photo 13: *Normal (top) and frosted faba bean seeds.*

Photo: Grain Legume Handbook (2008)

Cold temperatures are moderated by topography and altitude, so there will be warmer and cooler areas in undulating paddocks.

Podset often occurs in August to September, once temperatures rise (and as there is more sunlight and pollinator activity).[62]

5.5.3 High temperature and wind

Faba bean is considered one of the least tolerant winter pulses to drought stress and high temperatures (Photo 14).

Temperatures above 27°C can cause faba bean flowers to abort,[63] while temperatures above 30°C (or a lack of moisture) can stop flowering completely, after which only a few leaf-bearing nodes are produced.

62 GRDC (2014) GrowNotes™: Faba bean (northern region). Grains Research and Development Corporation, https://grdc.com.au/Resources/GrowNotes™

63 T Yeatman, W Hawthorne, J Paull, J Bellati, J Egan, K Henry, R Kimber, M Seymour, J van Leur, K Lindbeck, P Matthews, I Rose (2009) Faba bean: The Ute Guide. Primary Industries and Resources South Australia, https://grdc.com.au/resources-and-publications/all-publications/publications/2009/11/faba-beans-the-ute-guide/

Photo 14: *Faba bean are relatively intolerant of high temperatures and drought.*

Photo: Felicity Pritchard

Faba bean flowers are particularly sensitive to hot, dry winds in their early stages of development. As flowers develop, they become less sensitive and once a pod has set and grown longer than the withered petals, it stops being vulnerable to wind and has a good chance of fully developing – if there is adequate soil moisture. If hot, windy days persist and moisture is limiting, more flowers will abort. Researchers suggest planting windbreaks to reduce wind speed on crops.

Faba bean are also particularly sensitive to hot, dry conditions during podding; prolonged cool weather in spring is ideal for pod development. Maximum temperatures above 30°C can reduce the time available for seed-filling.

Faba bean are also prone to lodging and 'necking' – or both, which are two different processes. Lodging and necking both create a crop that is no longer upright and can be difficult to harvest.

Necking is where the faba bean plant remains erect but a proportion of the stem 'necks' over between 90 and 180 degrees (Photo 15). Strong wind conditions can cause faba bean to 'neck', and this seems to be more pronounced during times of moisture stress during the reproductive phase. The stems bend over sharply, virtually snapping, at about pod height. The upper part of the plant either dies or is less able to fill pods.

Sometimes, plants recover from necking and the growing points turn to grow upright again, at times forming an 'S' shape.

Faba bean varieties differ in their susceptibility and resistance to necking but its effect on yield and seed size is largely unknown (Table 4). 'Harvestability' is often reduced. Results from trials in 2014 show the variety Nura$^{\phi}$ is most susceptible. The results for necking were different to lodging; generally, Nura$^{\phi}$ and PB$^{\phi}$ Samira$^{\phi}$ showed improved results over Farah$^{\phi}$. Apart from the Maitland site, lodging was generally low in 2014.

Table 4: Standing ability and necking scores of faba bean varieties from Pulse Breeding Australia trials and National Variety Trials, southern Australia, 2014.

Variety	Standing ability (1–9 = all plants fully upright)					Necking (1–9 = no plants with necking)				
	Freeling, SA	Saddleworth, SA	Bool Lagoon, SA	Maitland, SA	Tarlee, SA	Pinery, SA	Wonwondah, Victoria	Kalkee, Victoria	Maitland, SA	Tarlee, SA
Farah⫚	6.9	8.3	7.3	5.7	7.0	6.7	4.7	6.3	8.3	7.3
Fiesta VF	6.5	7.7	8.0	5.0	7.3	7.3	5.7	no result	8.7	6.7
Nura⫚	7.8	9.0	9.0	4.7	7.7	2.0	2.7	5.0	8.3	7.3
PBA Rana⫚	7.9	7.7	8.3	4.0	8.3	5.0	6.3	5.0	9.0	9.0
PBA Samira⫚	7.8	9.0	8.0	6.7	8.3	3.3	4.7	5.7	7.3	7.3

Source: PBA and NVT trials

Photo 15: *Faba bean can be subject to 'necking' when the stems bend sharply, almost snapping off. Hot winds and moisture stress make the crop more prone to necking.*

Photo: Wayne Hawthorne, formerly Pulse Australia

Lodging can also be caused by strong winds and rain, as well as other factors such as variety, disease, tall crops due to early sowing and dense crops (Photo 16) (see Section 12 Harvest for more information).

Photo 16: *Faba bean crops can lodge, often severely, when stems bend gently. Dense, tall crops, wind and disease increase the chance of the crop lodging.*

Photo: Wayne Hawthorne, formerly Pulse Australia

5.5.4 Drought

The ability of faba bean to retain its flowers is affected by several factors, including drought. Moderate drought and other physiological stressors can reduce the number of pods on faba bean, rather than the number of seeds per pod or the size of the seed.

Faba bean is not deep-rooted, limiting its ability to withstand dry conditions. Although the roots are robust, they can struggle to penetrate hardpans or other subsoil constraints and the crop can leave moisture at depth late in the season. While root growth is rapid before flowering, it can continue until maturity if conditions are favourable.

In a 2008 study, wheat and barley were more effective at extracting soil water than faba bean. In contrast to the cereals, faba bean used 50 mm less water, which was related to its inability to extract water below 85 cm depth and its failure in dry soil below 20% volumetric water content. This additional soil water could be of benefit to the following wheat crop in dry seasons if it could be stored in the profile until the next growing season. Faba bean roots do not produce as much biomass as chickpea or wheat roots.

Under mild moisture stress, faba bean is incapable of accumulating solutes (sugar, protein and other compounds) in its cells; photosynthesis and movement of water and carbon dioxide through the stomata (pores) stop.

5.5.5 Low light

Low light can reduce flower retention and podset in faba bean. If leaves near flowers are shaded or daylight levels are low, there may be insufficient sugars to feed the flowers as photosynthesis is affected.

Intervals of heavy, overcast weather causing low levels of light can reduce flower retention in the critical 4-day window after flowering, even with adequate pollination.

Early-sown faba bean crops in high-rainfall areas may have poor early podset; low light in dense canopies, causing low photosynthesis, is likely to be the major cause, in conjunction with low pollinator activity and possibly chocolate spot.

5.5.6 Humidity

High humidity can reduce podset in faba bean.

5.5.7 Waterlogging

While faba bean is relatively tolerant of waterlogging, the crop is most sensitive to waterlogging at flowering (Photo 17), causing flowers to die and leading to a reduction in yield. For example, at Kerang in north-west Victoria, irrigated faba bean grown on drained soils using tile drains yielded 4.2 t/ha. Faba bean on raised beds yielded 2.7 t/ha and 1.9 t/ha where sown into a conventionally laser-levelled bay.

Photo 17: *Faba bean is particularly sensitive to waterlogging at flowering.*

Photo: Felicity Pritchard

5.5.8 Disease

Chocolate spot in flowers is sometimes thought to cause poor podset. The faba bean strategic disease management plan places strong emphasis on protecting early flowers with fungicide before canopy closure occurs (see Section 9 Diseases for more information).

5.5.9 Agronomic factors

Research at the Waite Research Institute in SA found that sowing rate and time of sowing influence the distribution of faba bean pods along the stem. This may be partly due to poor light penetration into the canopy with a higher sowing rate and early sowing.

More pods set on the lower nodes with a low sowing rate. Pods are more evenly distributed along the stem with a high sowing rate.

Fewer pods per node are set when early sowing, compared with late sowing. However, the individual seed weight is more uniform along the stem for early-sown faba bean. Seed size is reduced significantly towards the top of the plant in late-sown crops. Seed size is affected by weather conditions as well as the number of seeds set and variety.

5.6 Genetic variation

5.6.1 Varietal differences

Varieties differ in the time it takes from first flowering to producing the first pod (early podset). For example, the old variety Barkool sets a pod soon after flowering, whereas Fiesta VF has a delay of several days.

While there is potential for breeders to select for varieties with better early pod retention, some management practices can reduce the amount of inter-plant competition.

Pod size is more affected by variety than environment. Faba bean pods vary considerably between varieties. Seed size is also highly affected by variety, as well as the number of seeds set and environmental conditions.

5.6.2 Breeding determinate varieties

Plant breeders are developing determinate varieties into locally adapted breeding lines. Determinate faba bean plants are much shorter than conventional plant types and may be useful in situations where excessive biomass causes problems. Australian faba bean crops (Photo 18) are prone to excessive biomass and lodging with poor podset when irrigated or grown with high rainfall.

While several determinate faba bean varieties (Photo 19) have been released in Europe, they have not been widely grown as they generally have lower yield than conventional types.

Australian faba bean breeders have attempted to introduce the trait to elite Australian lines that have been in trials in southern Australia. The trials results should give a much clearer indication of whether determinate varieties might overcome some of the problems associated with faba bean in conditions that are conducive to high biomass production.

Photo 18: *An Australian semi-determinate faba bean that is typical of our varieties.*

Photo: Wayne Hawthorne, formerly Pulse Australia

Photo 19: *A breeding line that is determinate: no new growth appears above the pods.*

Photo: Wayne Hawthorne, formerly Pulse Australia