Producing pulses in the northern agricultural region

Peter White
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Mark Seymour
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Producing Pulses in the 
Northern Agricultural Region

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Producing Pulses
in the
Northern Agricultural Region

Editors: Peter White, Martin Harries, Mark Seymour and Pam Burgess
Department of Agriculture, Western Australia. GRDC Project DAW712

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The information contained in this book is based on research conducted by the scientists, extension officers and plant breeders working in the Department of Agriculture, Western Australia. None of the work would have been possible however, without the contribution of the Department’s valued partners. The following are gratefully acknowledged: Grains Research and Development Corporation (GRDC), Pulse Association of the South East, The Midwest Pulse Growers Association, The Ninghan Farm Focus Group (formerly The Central Wheatbelt Pulse Growers Association), The Great Southern Pulse Growers Association, The Centre for Legumes in Mediterranean Areas (CLIMA), The South Australian Research and Development Institute, The Department of Primary Industries, Victoria and The New South Wales Department of Primary Industries.

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The harsh climate, and the ancient, nutritionally deficient soils that dominate most of Western Australia’s cropping region have resulted in farming systems where pasture legumes, and more recently grain legume crops, play an important role. For a century, sheep were grazed on subterranean clover or medic pastures, which were rotated with cereal crops and used to raise soil fertility and break disease cycles. In the last 20 years grain legumes (lupins and pulses) and oilseeds have entered rotations in response to economic pressures and technical innovation and now share a more diversified farming system with animal enterprise. As a result of this diversification, Western Australia’s farming systems are potentially more ecologically and economically stable than at any time in their history. Yet challenges remain. The development of pulses in Western Australia has undergone tremendous advances over the past 12 years. From a tiny industry in the early 1990’s where the knowledge of both scientists and farmers was very limited, we now have a robust industry with production packages and improved varieties for all the grain legumes species that are well suited to our environment.

The rapid growth of pulses in the mid 1990’s has stalled as problems have emerged. The industries began in a relatively disease free environment, but as the area has increased, diseases (especially in chickpea and faba bean) have emerged that severely constrained production. Fortunately, a number of new, improved varieties have recently been developed. The use of these varieties with suitable production packages will enhance the adoption of number pulse crops in Western Australia’s farming system.

This book, which is both comprehensive and practical, collates much of the information gathered through pulse research and commercial experience over the past 10 years and will be valuable to all pulse growers, agronomists, students and industry advisors alike. The knowledge presented in this book has resulted from the dedicated efforts of scientists and industry specialists in Western Australia, working hand-in-hand with leading farmers, together with generous funding from the State Government and the Grains Research and Development Corporation (GRDC). This cooperation has been vital in establishing the industry and will continue to be essential as the industry further expands and evolves. All contributors to this book are to be congratulated for their insight, dedication and hard work.
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Pulses have a long and important history in world agriculture. Field pea, chickpea and lentil were cultivated along with cereals as early as the seventh century BC. Today, they are of economic importance because of their contribution to the diets of millions of people worldwide, and their inclusion as major feed ingredients in intensive animal production. Importantly, pulses are also a significant component of robust farming systems, helping to manage weed, disease and insect pests and contributing to soil fertility and animal feeding on-farm.

In Western Australia the term pulses generally refers to any legume species other than lupin (principally narrow leafed lupin) that is cultivated for its grain which is used for either human food or animal feed. Lupin is not included as pulses because it is a much larger and more mature industry in Western Australia compared with field pea, chickpea or other pulses and because the composition of lupin grain often suits it to different end uses. The word pulse is derived from the Latin *puls*, meaning pottage or a vegetable boiled to make a thick soup or porridge. The starch contained in pulse grain allows the thick porridge to form on cooking. Lupin grain lacks this starch.

In Western Australia, field pea has been cultivated for more than a century and there are early records of field pea and faba bean research in the Western Australian scientific literature. In more recent times a concerted breeding and agronomic research program beginning in the 1980’s has produced new, improved varieties and robust production packages for all the major pulse species suited to the Western Australian environment. These developments offer substantial benefits to Western Australian cropping systems that will underpin further productivity improvements in our vital grains industry. Together with lupin, pulses now allow a profitable grain legume cropping option that can be included in rotations on nearly all soil types and environment where cereals are grown in Western Australia. This provides the crucial flexibility and strength on which highly profitable cropping systems are built.

**Peter White**

Faba beans (called horse beans here) grown at the Merredin Research Station in the 1930’s.
Soil and environmental factors affecting pulse adaptation in Western Australia

Bob French and Peter White

Chapter 1

Introduction

Pulses, like most other temperate crops, are ideally suited to environments with mild temperatures, adequate rainfall and free draining soils that have a deep uniform profile, a medium to fine texture and slightly acid to neutral pH (6.5-7.5). Pulses when grown on these soils and in these environments produce reliable yields, are relatively easy to manage and achieve good returns on investment.

Pulses can be grown very successfully in less ideal situations, but must then be managed carefully to ensure reliable yields. The different pulse species, and even different varieties of the same species, vary in how tolerant they are of less than ideal conditions. Understanding how pulses respond to soil and environment will make it easier to successfully manage crops in the range of situations occurring in the northern agricultural region.

Differences between species

Field pea is adapted to a wider range of soils and environments than most other pulse crops grown in Western Australia. Lentil has the narrowest adaptation. With reasonable care, it is possible to produce a profitable field pea crop on most soil types present in Western Australia. Producing lentil yields that are consistently profitable, on the other hand, is difficult on most soils other than those ideally suited to the crop. As a general

Percentage land area suitable for at least one pulse crop (field pea, chickpea, faba bean and lentil) in the agricultural area of Western Australia.
Maps generated by D. van Gool and P. White using the Department of Agriculture’s Map Unit database, July 2004.
What discriminates grain legume performance in Western Australia?

Pulse species comparison trials conducted in Western Australia during the 1990s found the environmental factors having most effect on grain yields were soil pH (CaCl₂), clay content, soil water holding capacity, soil electrical conductivity (a measure of salinity), rainfall, and the presence or absence of frost. The soil properties mentioned are highly correlated with one another in Western Australia, so it is impossible to unequivocally separate the effects of each, but there are good reasons to believe that soil pH has profound effects in its own right. Grain legume species respond to soil pH differently. Field pea can grow well with soil pH as low as 4.5, and faba bean, chickpea and vetch with soil pH between 5 and 6, but care must be taken in this pH range to ensure good nodulation. Lentil will not grow well with soil pH below 6.

Rainfall, or perhaps more correctly growing season length, also affects species differently. This is shown most clearly when we compare species at sites with different yield potential (Figure 1). Averaging yields across a large number of sites separates pulse species into three groups. The first high yield potential group consists of field pea, faba bean, narrow-leaved lupin, common vetch and narbon bean. The second medium yield potential group, consists of desi chickpea, albus lupin and lathyrus. The third group, with lowest yield potential, consists of lentil, bitter vetch and kabuli chickpea. Faba bean, despite belonging to the high yield potential group, yields no better than desi chickpea or lentil in low yielding situations (which could result from low rainfall or late sowing), and is therefore considered to have poor yield stability. Field pea has good yield stability, and in low yielding situations is usually higher yielding than other pulses. The yield of field pea, however, does not increase as much as that of other species in high yielding environments. In these situations faba bean often yields considerably more than other species. As a result, faba bean can be a good choice of crop in medium and high rainfall areas or when early sowing is possible, but field pea is a better choice in low rainfall areas or when early sowing is not possible. Common vetch and narbon bean, like faba bean, are also more responsive than chickpea, lentil or field pea to good growing conditions. Chickpea, lentil and lathyrus have average yield stability.

Figure 1. How grain yield of different grain legume species varies across sites with different yield potential. From K. Siddique et al. (1999) Australian Journal of Agricultural Research 50, 375-387.
rule the range of adaptation of pulse crops to soils occurs in the following order (widest to narrowest): common vetch ≥ field pea ≥ lathyrus ≥ narbon bean ≥ chickpea ≥ faba bean ≥ lentil.

The suitability of soils for pulses also varies with rainfall environment. Pulses can grow on sandier and more acid soils where rainfall is higher and more reliable. This is particularly relevant for faba bean because it is the least drought tolerant of all the pulse species. Sandy soils quickly become unsuitable for faba bean production as the crop is moved to medium and low rainfall environments.

A common complaint about some pulse crops, particularly faba bean and lentil is that the yield is unreliable. Part of the reason for this is that new growers have tried to push these crops into soils and environments not well suited to their production without changing their management appropriately. Growers unfamiliar with pulse production, particularly faba bean and lentil, should first gain experience with the crops in the soils and environments best suited to their production. With experience it may then be possible to move to more marginal soils. Experienced growers, however, should be aware that in different seasons pulse crops grown on marginal soils are more likely to have unreliable yields.

The main factors influencing pulse crop adaptation include: water and nutrient availability, temperature, and environmental toxins (mainly salinity). Plant disease also has a profound effect on the performance of pulses in different environments but is not discussed in this section.

Water use and water-use efficiency

Pulses vary in the amount of water they use to produce grain, and how efficiently they use it. The amount and efficiency of water use depends on a number of factors including soil type, rainfall, root growth, how quickly the crop canopy covers the ground, air temperature and humidity, and how efficiently the crop converts biomass into grain. There are also more subtle influences, which need not concern us here.

In Western Australia's grain belt, most water used by pulse crops falls as rain while the crop is growing. In some years extra water from pre-season rain may be stored in the soil at sowing, especially on fine-textured soils with high water holding capacity and on deep soils. In order to benefit from stored water in the soil the crop must have sufficiently deep roots to reach it. Root depth depends both on crop species and soil type. Field pea, faba bean and lentil have shallower roots than lupin or wheat. Chickpea usually has deeper roots than other pulses.

Subsoil constraints such as hardpans, waterlogging, toxic levels of salt or nutrients (aluminium in some acid soils and boron in many alkaline soils) can restrict the root growth of many crop species. In shallow rooted crops, water may be lost through drainage below the roots. This happens most often in wet winters or on coarse-textured soils (sands) with limited water holding capacity. The different sensitivities of pulse species to aluminium and boron is discussed under the Nutrients section.

Water-use efficiency (WUE), usually defined as the amount of grain produced per mm of water used, varies considerably between pulse species. Under ideal conditions for each crop in Western Australia, field pea and faba bean (WUE about 10 kg/ha/mm) are more efficient users of water than lentil or chickpea (WUE about 4-6 kg/ha/mm). Cereals have a WUE of 15-20 kg/ha/mm.

When a crop uses water it passes through the plant and evaporates from the leaves. Very little is retained by the plant itself. Water also evaporates directly from the soil surface. Only water passing through the plant (the process is called transpiration) contributes to crop growth. Minimising the amount of water lost by soil evaporation is one means to improve water use efficiency because more of the water is then available for use by the plant. Rapid canopy development, as in field pea and faba bean, helps by maximising soil surface shading (hence reducing soil evaporation). The slow canopy development of chickpea contributes to its poor water use efficiency because it allows more soil evaporation. As well, water does not evaporate from dry soil surfaces, so water use efficiency is sometimes higher in dry seasons and dry locations than in wet ones.

Transpiration is an inevitable consequence of the way plants grow. They absorb carbon dioxide (CO₂), from which the bulk of plant biomass is built, through pores in their leaves called stomata. The insides of the leaves are wet (and must be, since most of the necessary chemical reactions only occur in solution) so water vapour escapes to the dry external atmosphere at the same time the stomata are open to let CO₂ in. If the stomata close to restrict transpiration, CO₂ assimilation, and hence crop growth, is reduced. If the stomata open up to allow faster CO₂ assimilation, the crop grows faster but more water is lost.

The efficiency with which water is used as it passes through the plant varies. The hotter and drier the air, the faster transpiration will be for a given stomatal opening. When the surrounding air is at 100 percent relative humidity, there will be no transpiration irrespective of stomatal opening, but CO₂ will continue to be assimilated. Crops therefore use transpired water more efficiently during winter and early spring, and in the early morning, when the air is cool and humid, than in late spring and summer, or in the late afternoon. This is a further reason why early maturing pulses that complete most of their life cycle during cool, humid weather, like field pea and faba bean, have higher water use efficiency than crops like chickpea which continue to grow as the weather becomes hotter and drier.

The chemical composition of the grain also affects water use efficiency. Protein and oil are more expensive to make than carbohydrate; that is, it takes more of the plant’s
energy to make them. Grain legumes, with high protein, and sometimes high oil, in their grain, therefore typically have lower water use efficiency than cereals, with high levels of carbohydrate in their grain. Acquisition of nitrogen from the atmosphere also requires more energy than taking it up from the soil, and this also contributes to the lower water use efficiency of pulses compared with cereals.

Adaptation to drought

Plants use three main strategies to cope with drought: drought escape, drought avoidance, and drought tolerance.

Drought escape involves the plant completing as much of its life cycle as possible while water is still plentiful; escaping the drought that will inevitably follow. This strategy is especially suitable for environments with well-defined wet and dry seasons. The early maturity of field pea and faba bean is an example of drought escape. Selecting early maturing cultivars, and planting crops early so that they flower and mature early, also enhance the ability of crops to escape drought. However, this strategy can be carried too far.

If a crop matures while there is still water available in the soil, or before the last spring rains, total water use will be reduced, and so will crop productivity.

Drought avoidance entails increasing water acquisition and reducing water loss, thereby avoiding the drought that would otherwise occur. Shedding leaves and closing stomata in response to dry conditions are examples of drought avoidance; these responses reduce productivity if they begin too early. A more positive example of drought avoidance is root system proliferation, which some plants exhibit in response to a receding soil water supply. Lupin and chickpea, for example, can grow very deep roots on the right soils, gaining access to large amounts of water. This strategy, however, is obviously pointless if there is no water stored in the subsoil.

Plants that are able to maintain productivity even when their tissues become stressed, show drought tolerance. Levels of water stress in plants are often measured in terms of leaf water potential, which measures how tightly the plant holds water in its tissues. In a well-watered environment leaf water potential is close to zero; it falls, as water becomes scarcer. The leaf water potential of
process that enables leaves to remain healthy at low water potentials, which enhances the ability of plants to extract water from drying soil. This is most useful on clay and loam soils, which hold water more tightly than sands. One process that enables leaves to remain healthy at low water potential is osmotic adjustment. It involves accumulating solutes, such as sugars, in tissues to enhance their ability to attract water by osmosis. This, however, diverts energy from growth. Chickpea and lentil have a greater capacity for osmotic adjustment than other grain legume crops grown in Western Australia and faba bean and lupin have almost none.

Waterlogging
Too much water also reduces crop growth. In the case of waterlogging, though, it is a shortage of oxygen that is the main culprit. Oxygen is not very soluble in water, and diffuses through it very slowly, so roots in saturated soil soon become oxygen deficient. Toxic substances produced by changes in soil chemistry may also accumulate in waterlogged soils; these further impair root function. The damage and tolerance of plants to waterlogging depends on the degree and duration of saturation, the soil temperature (oxygen is depleted more quickly in warm than cool soils), the stage of the crop (germinating and seedling crops are generally more susceptible than established crops), and the crop species.

Pulses are generally not well suited to waterlogged soils. Lentil and chickpea are the least tolerant, with particular sensitivity during early seedling growth and at flowering. Field pea and vetch are more tolerant than lentil or chickpea but are still sensitive. Emergence to the six-node stage is the most sensitive period of field pea growth, and plants growing in saturated soil for more than six days at this stage of their development will have reduced growth and up to 50 percent less yield. After the six-node stage extended periods of saturated soil can be tolerated, but growth will be reduced and the plants will be more prone to disease. Some anecdotal reports state that field pea and vetch show a similar response to waterlogging as narrow-leaved lupin. However, in the northern region, narrow leaved lupins are placed in situations where waterlogging occurs less frequently.

Low temperatures may sometimes cause purpling in field pea during early vegetative growth. Photo P. White.
often because they are grown on deep, course, sandy soils. Faba bean is the most tolerant pulse to waterlogging and exhibits some adaptation in new roots when the soil has been saturated for more than two weeks. Faba bean is able to produce good yields under waterlogged conditions that can cause failure of chickpea or lentil crops. The variety Fiesta appears slightly more tolerant of waterlogging than Fiord or Ascot. Importantly, however, the growth of faba bean will still be reduced when subject to extended periods of waterlogging (longer than 2 weeks) and chocolate spot disease is likely to be more severe.

Temperature
Normal plant growth processes only occur if the temperature is within a certain narrow range. For temperate crop plants this is roughly from 0° to 35°C. Within this range processes generally accelerate as the temperature rises, but there is often an optimum temperature above which growth rates flatten out or even begin to decline.

Outside this temperature range growth ceases and the plant may even be killed. Of the cool season pulses grown in Western Australia, chickpea is the least sensitive to high temperatures and the most sensitive to low temperatures. This is one reason why chickpea is more widely adapted to the Northern Agricultural Region than to the southern agricultural regions.

Chickpea pollen formed at low temperature is usually sterile, and most current cultivars will not set pods if average daily temperature is below 15°C. The two most recent varieties released from the Western Node of the National Chickpea Breeding Program (Rupali and Sonali) have improved chilling tolerance and will set pods at temperatures as low as 10 or 12°C. Faba bean is the least sensitive pulse to low temperatures, including frost.

If severe enough, frost will kill flowers, flower buds and developing seeds of all pulses. The most sensitive stage to frost differs with pulse species. Chickpea is very sensitive throughout flowering and early podding. Field pea, faba bean and lentil are more sensitive during early podding than at flowering. Cereals, on the other hand, are most sensitive in the few days either side of flowering. Cereals that are flowering are more sensitive to frost than pulses that are flowering or at early podding. Flowering and early podding of pulses, however, occurs over a longer period than flowering in cereals. Pulses therefore remain vulnerable to frost for weeks rather than days, which accounts for their reputation as being very susceptible to frost.

Separating the effects of very high temperature from those of water stress is difficult since, in rainfed agriculture, they nearly always occur together. There is, however, no doubt that high temperature has deleterious effects of its own. In lupin, short bursts of temperature in the mid to high 30’s can reduce the size of individual seeds and, if they occur early in seed filling, cause seed abortion. It is likely that similar effects occur in other grain legume species. In all pulses, high temperature will cause premature cessation of flowering, and shedding of flowers and young pods. The early maturity of field pea, faba bean and lentil is an effective strategy to escape high temperature.

Soil texture
Pulses are regarded in Western Australia as only being suited to fine-textured soils (sandy loams to clays). But, pulses can grow well on sandy soils depending on soil pH and water and nutrient supply. For example:

- chickpea is grown on the coarse-textured (usually alkaline) sands of Pakistan;
- faba bean is grown as a horticultural crop on the deep sands of the Western Australian coastal plain when well supplied with irrigation water and nutrients;
- Department of Agriculture trials have shown that all pulses grow well on the deep brown sands of the Avon Valley;

In most broadacre situations in Western Australia, only field pea and vetch can be reliably grown on sandy soils provided they do not waterlog. Research has shown that field pea produces consistently higher yields than lupin when grown on a wide range of soils from relatively deep sands to sandy clays and shallow duplex soils.

Soil erosion after harvest is the primary constraint to field pea production on the sandier soils. Field pea should not be grown on fragile, sandy surfaced soils unless the stubble and grazing is managed carefully (see stubble management in the field pea section). Vetch produces less fragile stubble than field pea and allows easier management of soil erosion.

Soil pH
The ideal soil pH for growing pulses is between 6.5 and 7.5, but successful crops are routinely grown on soils with pH outside this range. In Western Australia problems are more likely to arise on soils with pH below this range rather than above it. Pulse species differ in their sensitivity to deviations from this ideal range: field pea and common vetch are least

Frosted faba bean seeds. Photo M. Seymour.
sensitive, faba bean and chickpea are moderately sensitive, and lentil is most sensitive (see Table 1).

The main way low soil pH seems to affect pulse crops is by restricting root growth. On very acid soils (pH < 4.5) in the central and northern wheatbelt aluminium becomes increasingly soluble in the soil solution. High levels of aluminium will suppress or completely stop root growth of many plant species. In the pH range 5.0 to 6.0, where soluble aluminium is no longer a problem, the root growth of some pulse species can still be slow.

The pH trend is also important. For example, a soil with surface pH of 5.0 can be very suitable for faba bean if the pH increases to 6.0 at 10 cm depth, but clearly unsuitable if it decreases to 4.5. The type of root system can also be important. Species with deep roots, such as chickpea, are less sensitive to low pH at the surface than species with shallow roots, like lentil.

Low soil pH also has less effect on crop yield in high rainfall environments and on otherwise fertile soils with high water holding capacity. This is because a smaller soil volume needs to be explored to satisfy the crop’s demand for water and nutrients than in drier environments. Slow root growth on fertile soils in well-watered environments therefore has fewer consequences for crop yield.

Soil pH also influences nodulation, nitrogen fixation and rhizobium survival. Current rhizobium strains are able to nodulate plant roots and fix nitrogen at low pH levels (although not where aluminium levels are toxic) so the plant is usually the most sensitive partner in the symbiosis. Nodulation and nodule function should not be affected on acid soils as long as the seed has been well inoculated and the plant itself is growing well.

After a legume crop matures its nodules disintegrate and release the bacteria they contain into the soil. These bacteria become a source of infection for subsequent legume crops, but the population declines gradually in the absence of suitable roots to nodulate and multiply on. The rhizobium species that infect field pea, faba bean, lentil and chickpea do not survive well on acid soils. Furthermore, the strains that do survive well in acid soils may not fix nitrogen very efficiently if they do not nodulate even the plant. This, coupled with less vigorous root growth by these species on acid soils, is why on most soils in Western Australia, fresh inoculation of pulses is recommended each time they are grown. Achieving good nodulation of pulses on acid soils is generally much harder than with lupin.

Soil pH will also have important effects on the availability of plant nutrients.

**Nutrients**

Nitrogen (N), phosphorus (P), zinc (Zn) and iron (Fe) are the important nutrients affecting adaptation of grain legumes in Western Australia. Boron (B) and sodium (Na) are more commonly present at toxic levels in Western Australian soils.

**Nitrogen**

All pulses are legumes and can assimilate nitrogen directly from the atmosphere by nitrogen fixation or can take up mineral nitrogen from the soil. Nitrogen fixation involves collaboration between the plant and rhizobium bacteria living in nodules on the plant’s roots.

The amount of nitrogen that pulses in Western Australia acquire via fixation varies depending on the amount of mineral nitrogen in the soil, the health of the nodules, and the crop species. Well-nodulated crops can fix as little as 50 percent of their nitrogen requirement or as much as 99 percent.

The formation of effective nodules requires active root growth and the presence of appropriate rhizobium bacteria. Some species of rhizobium will form root nodules with a range of pulse species: *R. leguminosarum* will infect field pea, faba bean, lentil and vetch. Within a rhizobium species there are some strains that will fix nitrogen more efficiently with particular pulse species than others. Hence field pea has a different inoculum group (Group E) than faba bean and lentil (Group F) even though the rhizobium species is the same. Chickpea requires its own specific rhizobium species (*R. ciceri*) and will not form nodules with *R. leguminosarum*. It is important to match the correct strain of inoculum with the correct pulse species.

High levels of nitrogen in the soil will inhibit nodulation and nitrogen fixation. Spreading nitrogen fertiliser may therefore reduce the amount of nitrogen fixed by the plant. Nevertheless, application of small amounts of nitrogen fertiliser at seeding is often recommended for pulse crops, particularly on acid soils (sometimes termed ‘starter N’ and applied at 5 to 10 kg N/ha). This amount of nitrogen fertiliser is too low to inhibit nodulation, but is sufficient to stimulate early seedling growth and crop establishment in situations where nodulation is delayed by soil acidity or low temperature. Research in Western Australia so far has not shown consistent beneficial effects of starter nitrogen on crop yields.
Phosphorus

Almost all Western Australia soils are phosphorus deficient and large quantities of phosphorus have been added to our agricultural soils since we began farming. Plants absorb phosphorus from the soil solution, but many Western Australian soils rapidly immobilize phosphorus into insoluble forms. This happens in both acid and alkaline soils, although different chemical reactions are responsible in each case. This explains why phosphorus can gradually accumulate in soils over a long period of time. Some plants have evolved mechanisms that allow them to extract these forms of soil phosphorus more effectively than other plants. Chickpea exudes malic acid from its roots, and albus lupin exudes citric acid from special structures called proteoid roots. Both of these exudates help dissolve phosphorus in insoluble soil forms and make it available for uptake by the plant. These species generally require less phosphorus fertiliser than other grain legumes, and on some soils none at all.

Faba bean and field pea sometimes show larger responses than wheat to phosphorus fertiliser applications, but this is not universal and on some soils (often those with a higher pH and lower nitrogen content) field pea has been shown to use phosphorus fertiliser more effectively than wheat.

Zinc

Transient symptoms that look like zinc deficiency are sometimes observed in pulses in Western Australia. Zinc becomes less available as the soil pH rises and increased phosphorus availability may reduce zinc uptake. Adding moderately high rates of phosphorus fertiliser to neutral and alkaline soils may therefore induce a zinc deficiency. Limited studies have shown that faba bean uses zinc in the soil more effectively than chickpea, which in turn uses it more effectively than wheat and lentil.

Iron

Iron deficiency is commonly observed in pulses when grown on calcareous soils around the world. Legumes facilitate iron uptake by acidifying the soil immediately around their roots, making the iron more soluble. The lime present in calcareous soils buffers against this acidification. In Western Australia, chlorotic symptoms, which are indicative of iron deficiency, are often seen in pulses grown on neutral and alkaline soils that are waterlogged for short periods of time. This often occurs in some coastal areas of the northern region, such as Dongara. The plants, however, usually grow out of these symptoms without apparent effects on yield once the soil drains.
High sodium and boron levels often occur together and are frequently associated with soil salinity. High levels of these nutrients are toxic to the plant. In addition, high sodium adversely affects soil structure by dispersing clay particles which then clog pores and make root penetration, and therefore water and nutrient acquisition, difficult. Salinity also makes water harder to absorb from the soil through the osmotic effects of salts dissolved in the water.

Boron toxicity causes reduced plant growth, marginal necrosis and in extreme cases, plant death. It is most common on soils derived from marine sediments. In low rainfall environments and on clay soils, boron is leached more slowly than salt, so boron toxicity does not always occur in conjunction with salinity. High levels of boron can occur in quite narrow bands in the subsoil, so potentially toxic soils are not easily identified by soil testing. Boron toxicity is not common in the Northern Agricultural Region.

Critical levels at which boron begins to reduce the growth of pulses have not yet been determined. Some cultivars of field pea, faba bean, vetch and narbon bean appear to tolerate boron toxicity well, whereas lentil and chickpea are considerably more sensitive (Figure 2). As a general rule, pulses are more sensitive to boron toxicity than cereals.

Pulses grown in areas with high salt levels will show necrosis around the margins of the middle and lower leaves and yellowing of the older leaves, and will grow slowly and produce low yields. Reddening of the leaves and stems can also occur, particularly in desi chickpea. In severe cases, symptoms progress to younger leaves and older leaves shrivel and die. Symptoms of salt toxicity in pulses can easily be confused with symptoms of other nutrient disorders, disease, herbicide damage or drought.

Some pulse species tolerate salinity better than others and there is considerable variation amongst genotypes within a species (Figure 2). Lentil, in particular shows large variation. Some lentil genotypes exhibit reasonable tolerance while others are very sensitive. (most current varieties are very sensitive). In general, pulses are more sensitive to salinity than wheat or canola. Field pea, lupin and faba bean all show similar sensitivities to salinity. Chickpea and lentil are more sensitive to salinity than these species.

**Surface crusting**

Pulse crops grown in Western Australia have a hypogeal pattern of emergence. The cotyledons remain below the soil surface and the plant pushes its relatively small diameter plumule through the soil. This enables pulses to emerge from deeper in the soil than plants with an epigeal emergence pattern (lupin). It also makes it easier to emerge through surface crusts. A strong surface crust, however, will still reduce the emergence of a pulse crop. The force that a seedling is able to generate to push through a surface crust is related to seed size. Lentil and vetch have smaller seeds than most other pulses.

Consequently, lentil and vetch are less able to push through surface crusts. However, lentil and vetch emerge sooner than other species with larger seeds, and therefore may be able to emerge before the crust is fully formed.

**Herbicides**

Cereals commonly precede grain legumes in the cropping sequence in Western Australia, and many of the herbicides used for selective weed control in cereals are toxic to pulses. Any traces of herbicides remaining after the preceding cereal crop can severely restrict grain legume productivity. The most troublesome herbicides in this respect are sulfonylureas (e.g. Glean®, Logran®, Ally®).

Herbicides that remain active after being applied to soil gradually lose their effectiveness over time. This mainly results from chemical and biological degradation, and leaching. Sulfonylureas are subject to each of these processes. Chemical degradation is by acid hydrolysis, and is much slower in neutral and alkaline soils than in acid soils. How tightly the herbicide is bound to soil particles, and how much water drains through the soil affect leaching. Biological degradation depends on microbial activity in the soil. This is greatest when the soil is warm and moist.

Sulfonylurea residues are therefore most likely to be a problem on neutral to alkaline soils, and on fine-textured soils after dry seasons and dry summers. Duplex soils that have sand over an alkaline clay can present a particular problem. The sulfonylurea herbicide can leach down into the clay where it will be more persistent at the higher pH.
Effect of simazine on faba bean when applied to sandy soil. The boundary between the sand and loam area is marked by the death of faba bean plants. Peter White can be seen kneeling next to a lupin plant growing well in the sandy soil. Photo K. Siddique.

| Table 1. Summary of determinants of pulse crop adaptation in Western Australia |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                                  | Field pea       | Chickpea        | Faba bean       | Lentil          | Narbon bean     | Common vetch    |
| Soil pH requirement             | 5.0 – 9.0       | 5.5 – 9.0       | 6.0 – 9.0       | 6.5 – 9.0       | 5.0 – 9.0       | 5.0 – 9.0       |
| Texture                         | Loamy sand - clay | Sandy loam - clay | Loam - clay | Loam - clay | Sandy loam - clay | Loamy sand - clay |
| Average yield potential         | High            | Medium          | High            | Low             | High            | High            |
| Yield stability                 | Good            | Average         | Poor            | Average         | Average         | Poor            |
| Drought adaptation strategies   | Drought escape  | Drought         | Drought escape  | Drought escape  | Drought escape  | Drought escape  |
| Waterlogging                    | Sensitive       | Very sensitive  | Moderately tolerant | Very sensitive | Moderately sensitive | Sensitive |
| Boron toxicity/sodicity         | Moderately tolerant | Very sensitive | Moderately tolerant | Very sensitive | Moderately tolerant | Moderately tolerant |
| Salinity                        | Moderately sensitive | Very sensitive | Moderately sensitive | Moderately sensitive | Sensitive | Moderately sensitive |
| Surface crusting                | Moderately sensitive | Moderately sensitive | Moderately sensitive | Moderately sensitive | Sensitive | Sensitive |
| Other considerations            | Adapted to late sowing | Adapted to mid–late sowing | Requires early sowing or high yield potential environment | Good yield potential on suitable soils | Moderately tolerant | Moderately tolerant |
|                                 |                 |                 |                 |                 |                 |                 |
Roots growing into this zone will be pruned but the plant may appear apparently unaffacted until Spring arrives. Without deep roots the plants can’t access water stored in the clay and may hay-off very early without filling pods. Pulse species also differ in their sensitivity to sulfonylurea residues (Figure 3).

Herbicide rates applied to pulse crops also need to be modified depending on soil type. Rates of herbicide that, from experience, are tolerated on fine-textured soils can often be toxic when applied to crops sown into sandy soils. In addition, some herbicides are more mobile in sandy soils, so chemicals applied as a pre-emergent spray may move deeper into the soil and come in contact with the seed or the seedling roots. For example, simazine applied at the recommended rate of 2 L/ha is well tolerated by faba bean and chickpea when grown on fine-textured soils but, damage has occurred at this rate on coarse-textured soils. Both the establishment and the growth of the crop can be affected, resulting in a thin, stunted crop.

Adverse effects of herbicide (both those carried over from cereal crops and those applied to the pulse crop) can be subtle so the crop generally appears unthrifty and produces a disappointing yield without a clear indication of the cause of the problem. Herbicide toxicities can be a major and unrecognised cause of low yields in pulse crops if appropriate care is not applied.

Further reading


Thomson, B.D. and Perry, M.W. A guide to selecting grain legumes for your soil. CLIMA, University of Western Australia, Nedlands, WA. 6009.


Crop management
Growing chickpea

Martin Harries, Kerry Regan and Peter White

Introduction
Chickpea (Cicer arietinum) is one of the most important pulse crops in the world. Production was at 7.5 million metric tonnes world wide in 2003 with India producing the majority of this (4.5 million tonnes). It is an important source of protein in human diets for people of the Indian subcontinent.

There are two types of chickpea: desi and kabuli. The desi-type shows greater adaptation to the lower rainfall areas (<450 mm rainfall), while the kabuli-type are best produced where annual rainfall is greater than 450 mm. In Australia, approximately 70-80 percent of the production is desi-type. Production in Australia was at 200,000 metric tonnes in 2003.

Chickpea has been grown as a commercial crop in Australia since the early 1980’s. It is suited to a wide range of environments from the Mediterranean-type climates of southern Australia to the tropical Ord River Irrigation Area of Western Australia, as well as sub-tropical southern Queensland and northern New South Wales.

Chickpea is grown as a high value pulse, largely for export as human food. Prices for chickpea grain have been variable and have ranged from less than $300 to about $600 per tonne. Major world chickpea producers are India, Pakistan, Turkey, Canada, Mexico and Australia. Queensland and New South Wales are the states that currently dominate chickpea production in Australia.

In Western Australia, chickpea is mainly grown in the northern and eastern parts of the cropping region, although a small industry also exists for specialty large seeded kabuli chickpea grown under irrigation in the Ord River Irrigation Area. Large scale cropping of chickpea started in the mid-west and northern region in the early 1980’s. The area expanded rapidly to 70,000 hectares before the arrival of ascochytta blight in WA which caused a substantial contraction of the area. Current chickpea varieties are well adapted to the mild conditions of the northern and central wheat belt regions.

Select the right paddock!

- No more than one chickpea crop in the past four years.
- At least 500 m away from last years chickpea, lentil, vetch, narbon bean or faba bean stubble.
- Free from sulphonylurea residues.
- Low broad-leaved weed.
- Medium to heavy textured soils.

Paddock selection
Soil type
Choose a soil with a loamy sand texture or heavier. Also ensure it is free draining and has a pH of at least 5.5 (CaCl₂). Chickpea has been grown on soils with a surface pH of 5.0 if sub-soil pH rises to above 5.5 within 10 to 15 cm of the surface. Paddocks should also be relatively free of large stones, stumps and other debris. Chickpea pods can be set close to the ground if sown in deep furrows in low rainfall zones, particularly in dry years.

Table 8. Suitability of soils for chickpea

<table>
<thead>
<tr>
<th>Suitable</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy deep clays</td>
<td>Must be well drained, waterlogging causes yield loss.</td>
</tr>
<tr>
<td>Heavy loam</td>
<td>Can crust over if conditions dry rapidly after sowing.</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>Chickpea perform well on grey or red loams.</td>
</tr>
<tr>
<td>Salmon Gum</td>
<td>Soils with pH of at least 5.5 (CaCl₂).</td>
</tr>
<tr>
<td>Low pH soils</td>
<td>Surface soil pH of 5.0 reasonable if sub surface higher than pH 5.5. Soils pH 5.5 or higher throughout the profile are more suitable.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Not Suitable</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saline soils</td>
<td>Chickpea has low salt tolerance.</td>
</tr>
<tr>
<td>High boron soils</td>
<td>Chickpea has low boron tolerance.</td>
</tr>
<tr>
<td>Sandy soils</td>
<td>With less than 10% clay unless in high rainfall environment.</td>
</tr>
<tr>
<td>Wodjil soils</td>
<td>Acid sands and aluminium toxicity.</td>
</tr>
</tbody>
</table>
There are many loamy sands and clays well suited to chickpea production in the northern and central agricultural regions. The red loams, loamy earths and duplex soils of the north eastern wheatbelt running through Mullewa, Mingeneew, Three Springs, Dalwallinu through to Coorow and parts of Mungkinbin and Merredin are particularly well suited to chickpea. Local names for these soils include morrel soil, salmon gum-gimlet, merredin sandy loam, yorke gum soil and red-brown earth. These soils have characteristics that require subtle differences in management. For example red loams in the Northampton area have free stones at the surface while, in the Mingeneew area, some of the red loams can crust over if warm conditions occur after seeding. The pH of the red loams can vary substantially. The soil in two similar paddocks may have the same texture and colour, but differ widely in pH. It is essential to check the pH of these red loams at the surface and at depth, even if you think you know the soil type.

Other brown, grey, and red loamy duplex and loamy earth soils found throughout the region, particularly in the Chapman and Avon Valleys and the Moora regions are also well suited provided the subsoil pH is above 6.0. The deep brown sands and calcareous deep sands in high rainfall areas, particularly in the Avon Valley and the northern coastal strip may also be suitable. Deep yellow, grey and white sands and acid duplex soils are unsuitable for chickpea production.

**Paddock history**

Chickpea should not be grown on the same paddock more than once in four years. The paddock chosen should also be at least 500 m away from stubble of last year’s lentil, vetch, narbon bean, faba bean or chickpea crop. Finally, ensure that at least two years have passed since sulphonylurea herbicides (Glean®, Ally®, Logran® or Lontrel®) were applied in the paddock.

Fungal spores can be carried over in the soil and on stubble from one crop to the next. Even if disease was not obvious in last year’s crop, it could still have harboured some disease that will infect this year’s crop.

Chickpea is sensitive to sulphonylurea herbicides and will be damaged if residues of these herbicides remain in the soil. These herbicides will break down within one to two years of application depending on soil pH, organic matter content, soil structure and rainfall. Minimum plant back periods must be observed.

Finally, it is important to choose a paddock with low numbers of broad-leaved weeds. Currently few herbicides are registered for control of broad leaf weeds in chickpea crops.

**Varieties**

There are two major types of chickpea: kabuli which is best suited to high rainfall areas with long growing seasons where large seed size can be consistently produced and; desi which has smaller grain and is better suited to the low and medium rainfall zones.
Sonali, Rupali or Genesis 836 are the suggested desi variety for the northern regions. These varieties have better resistance to ascochyta than superseded varieties Sona or Heera and have higher yield potential. In the next few years lines with substantially improved resistance to ascochyta will be released to farmers.

Kaniva is the only kabuli line readily available to growers in Western Australia. It is susceptible to ascochyta and farmers will need a very good disease management program to successfully grow Kaniva. Kabuli varieties with excellent resistance to ascochyta will be released to growers in 2006.

**Sowing**

Don’t sow chickpeas into dry soil. This is because weeds become more difficult to control, crop and weed emergence is usually patchy and staggered and rhizobium applied onto seed dressed with fungicide will die.

The ideal time to sow chickpea is between early May to mid June, depending on the growing environment. Chickpea does not respond to very early sowing, particularly in southern regions, because temperatures at flowering must average above 15°C before flowers will set pods. Flowers that form during cold days on early sown plants will abort, giving no yield advantage. Early sowing will also expose the plants to greater risk from ascochyta blight.

In situations where the risk of ascochyta blight is high, it is better to sow chickpea in the latter half of the sowing window. High risk from ascochyta occurs in the high rainfall and wetter part of the medium rainfall zones, or where isolation from other inoculum sources (previous crop’s stubble) has not been adequately achieved. Desi chickpea is currently not recommended for the high rainfall regions (> 450 mm annual rainfall) because the risk from ascochyta blight is too high.

Sowing after mid June will result in yield penalties. Reductions in yield caused by late sowing will be highest in the drier, shorter season areas. Ascochyta blight, however, can be controlled more easily in these areas. If you are thinking about late seeding, consider the level of sub-soil moisture. Later sowing is much more likely to be successful if stored soil moisture is available provided the roots grow in the subsoil and are not impeded by hardpans or salinity.

New varieties of kabuli chickpea have higher levels of resistance to ascochyta and the higher value grain affords more opportunity to manage the disease through fungicide application.

**Seed depth**

Aim for a depth of about 5 cm. Chickpea will emerge from up to 8 cm in the soil without a reduction in establishment if conditions are good at the time of sowing. Placing seeds at 5 cm or deeper in the soil minimises the chances that the seed or the emerging roots will come into contact with surface applied herbicide. There is also some evidence that seeds infected with ascochyta blight are weak and will not emerge from this depth, thus reducing the potential for disease establishment in the crop.

**Sowing rate**

Aim to establish 40-45 plants per m² for desi and 30-35 plants per m² for kabuli chickpea. This corresponds to sowing rates of 90-100 kg/ha or 130-150 kg/ha respectively. The plant density that gives highest yields will change depending on the site and season. In general, the higher rates within these ranges are beneficial for lower rainfall and shorter season environments. Higher seed rates promote the rapid crop growth and development that is required in short seasons.

In the medium and high rainfall zones high plant densities result in a dense, humid canopy that is conducive to the development of botrytis grey mould. The longer seasons in the higher rainfall environments, also allow individual plants a greater time to reach their yield potential before the season finishes. Hence, plant densities within the lower part of the recommended range are appropriate.
### Table 9. Chickpea varieties.

<table>
<thead>
<tr>
<th>Plant type</th>
<th>Variety</th>
<th>Yield (% of control)</th>
<th>Description</th>
<th>Ascochyta blight</th>
<th>Botrytis grey mould</th>
<th>Flowering time</th>
<th>Seed size (mg)</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desi</td>
<td>Howzat</td>
<td>118</td>
<td>MS</td>
<td>I</td>
<td>Medium</td>
<td>210-230</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sona</td>
<td>100</td>
<td>MS</td>
<td>MS</td>
<td>Early</td>
<td>170-220</td>
<td>Medium</td>
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<td></td>
<td>Heera</td>
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<td>Tyson</td>
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<td>Rupali</td>
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<td>Sonali</td>
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<td>Flip 94-508c</td>
<td>98</td>
<td>MR</td>
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<td>Genesis-836</td>
<td>123</td>
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<td>Medium</td>
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<td>Medium-Tall</td>
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<td>Kabuli</td>
<td>Kaniva</td>
<td>100</td>
<td>HS</td>
<td>HS</td>
<td>Medium to Late</td>
<td>280-400</td>
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<td>FLIP 97-530</td>
<td>131</td>
<td>MR to HR</td>
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<td>FLIP 97-537D</td>
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<td>MR to HR</td>
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<td>FLIP 97-503</td>
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Desi yield as a % of control variety (Sona, Heera or Tyson). Trials had a complete fungicide management package, with a minimum of 2 foliar sprays. Kabuli chickpea lines tested in separate trials and are expressed as a % of Kaniva; results are in absence of ascochyta.

HS = Highly Susceptible; MS = Moderately susceptible; I = Intermediate; MR = Moderately resistant; HR = Highly resistant.

Don’t double sow headlands. This will create the dense, humid canopy that will allow botrytis grey mould to gain a foothold in the crop.

**Inoculating seed**

Always inoculate chickpea seed with Group N inoculum. This applies regardless of the cropping history of the paddock.

![Figure 3. Relationship between yield (in absence of disease) of chickpea and sowing date in the low rainfall northern region.](image-url)
All chickpea seed should receive a fungicide seed dressing to reduce ascochyta blight; however, fungicide seed dressings are toxic to rhizobia. The pickle and inoculation procedures must be done separately with the pickle applied first (may be applied months in advance) and allowed to dry before inoculum is applied. Ideally, apply the inoculum just before the seed is sown and double the rate of inoculum to compensate for some death of the rhizobium. Make sure the seed is sown into moist soil within 6 hours of applying the inoculum. Fungicide coated onto seed and placed into dry soil will kill all the rhizobia inoculated with the seed.

The method of inoculation will affect the success of nodulation. Peat sprinkled out of the bag onto seed as it is being augered into the seeder is quick but not effective. Slurry inoculation is the best way to ensure a well nodulated crop.

To apply a slurry, measure the time taken to transfer 100 kg of seed. For each 100 kg of seed you will need to make a slurry of 250 g of peat inoculum mixed with 1 litre of water. As you transfer seed to the seeder box add the 1 litre of the slurry to the hopper in the time taken to auger the 100 kg of seed. Granular inoculum will make it easier to inoculate seed that is dressed with fungicide, if it becomes available in future (see page 47).

**Spacing**

A row spacing for chickpea of about 25 cm is most common. Trials continue to look at spacings out to 100 cm in the northern and central eastern wheatbelt with desi chickpea. Results have been variable but in most cases going out to 50 or even 75 cm has not reduced yields.

**Levelling the paddock**

The paddock does not need to be rolled after seeding because plants are generally tall enough to be harvested easily. The only time when there may be harvest problems is if deep furrows are left after seeding. The furrows will need to be levelled to reduce the risk of post-sowing, pre-emergent herbicide wash into the furrow and this will also make it easier to harvest the lower pods of short crops in low rainfall areas.

**Fertiliser**

Chickpea, like all legumes, does not require nitrogen fertiliser if well nodulated. In some circumstances, small amounts of nitrogen fertiliser (5 to 10 kg nitrogen/ha) are recommended to stimulate the early growth of plants if they are grown on sandy soils with a pH below 5.5. This level of nitrogen is low, so it won’t inhibit nodulation, but there is also no clear evidence that it will increase crop yield.

About 3.5 kg of phosphorus are exported in one tonne of grain. This is equivalent to about 40 kg/ha of plain superphosphate. Traditionally superphosphate has been used along with compound fertilisers with ammonium and phosphate that add a small amount of nitrogen. A wide range of new fertiliser options are also available which include phosphorus and other elements without nitrogen, these are generally

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*Chickpea sown at wide row spacing between rows of cereal stubble. Photo P. White*
Rob stresses that sub-soil moisture or a very good break is needed to grow chickpeas to ensure that they remain profitable with the current fungicide management requirements: “I won’t be scratching chickpea in on 10-15 mm with current varieties”.

Managing weeds with balance

Rob McTaggart from Mingenew has grown both desi and kabuli chickpea with the area sown reaching 25% of cropped land in 1996 and 1997. Rob has cut back in area since the occurrence of ascochyta blight but in 2003 he sowed a 26 hectare trial paddock of Howzat desi chickpea.

The paddock was seeded with a shallow full cut and lightly harrowed to level the surface. After seeding, 100 g/ha of Lexone® and 85 g/ha Balance® were applied. Lexone® was used instead of simazine to target doublege. Excellent residual control of broadleaf weeds meant that Broadstrike® was not used. From experience this herbicide generally sets crops back about two weeks: not using it was a great result.

Disease control was good. Seed was picked with P-Pickle-T and the crop given three sprays of fungicide. Each application was of about 1.0 litre of chlorothalonil. Late in the season ascochyta did infect a few small patches of the crop.

Yield was 1.0 t/ha which was good considering that the crop was planted with no sub-soil moisture into drying soil and that rains did not come again for four weeks after emergence. Rob commented: “Given the rainfall of 210 mm and the very dry three weeks after seeding, which reduced vigour, I think we grew the crop well”.

Rob stresses that sub-soil moisture or a very good break is needed to grow chickpeas to ensure that they remain profitable with the current fungicide management requirements: “I won’t be scratching chickpea in on 10-15 mm with current varieties”.

Case Study

Seed can be inoculated by running a slurry into the flight of the auger. This auger has a bung that can be removed to do this. Photo M. Harries. Included in the legume/pasture fertiliser range of suppliers.

Chickpea is effective at extracting phosphorous due to the secretion of acids which dissolve soil phosphorous making it more available. The latest research on phosphorus requirements of chickpea suggests that at very low levels of available soil phosphorus (10 mg/kg Colwell test) chickpea responds well to added phosphorus. At moderate soil levels (20 mg/kg Colwell test) the response to phosphorus fertiliser is similar to that of wheat and at levels above 20 mg/kg there is no benefit in adding extra phosphorus fertiliser.

Deep banding fertiliser one or two centimetres below the seed is now common and easily achieved on most of the loams into which chickpea can be sown. This allows roots to grow into nutrients and is the best method of applying nutrients that are not mobile in the soil; for example zinc. It is also the best method to apply the usual fertilisers if using wide rows. Fertiliser should not be placed with the seed at wide row spacings because toxicity problems can occur and should be either deep or side banded. This is because more fertiliser is being concentrated around the seed at wide spacing, if using the same rate per hectare.

Deficiencies of zinc, manganese, or boron have not been
widely observed in chickpea grown in Western Australia. Transient iron deficiency is seen in some years in the calcareous soils when they become saturated with water. Plants usually grow out of the deficiency, particularly when the soil surface dries. Zinc deficiency has been observed in northern New South Wales and Southern Queensland and may have gone unnoticed in Western Australia. The requirements of chickpea for zinc are higher than wheat. Zinc deficiency is difficult to detect. If severe the plants will be stunted and the tips of plants may die back. In less acute cases, general yellowing of the new growth is the major symptom.

**Weed management**

Choose a paddock with a low broad-leaved weed burden and do not sow chickpea into a pasture paddock.

A double knockdown is always a good option if the season breaks early enough. This is achieved by applying glyphosate at full label rate followed by Sprayseed® at full label rate two or more days later. If the paddock is expected to have grasses, use Trifluralin prior to seeding. Simazine can be used pre-sowing in combination with Trifluralin. It is best to use knife-points and leave furrows rather than full cut points or harrows to level the seed bed. This is because levelling the soil after the herbicide is applied will result in herbicide placed directly above the seed. However, when using herbicides like simazine pre-sowing, there is always the potential that the herbicides can wash into the furrows. This is why soil mobile herbicides are best applied post sowing pre-emergent on a flat seed bed.

<table>
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<th>Table 10. Herbicides for chickpea</th>
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<tr>
<td><strong>Time</strong></td>
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<td>Pre-sowing</td>
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<td>Incorporate at sowing</td>
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<td>Post sowing pre emergent</td>
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| Post emergent | Flumetsulam (Broadstrike®, Select® Verdict®, Correct® Fusilade®, Fusion®) | 25 g/ha | Suppression of radish and doublegee. Radish larger than 10 cm diameter will not be controlled adequately. Can cause yellowing and reduce crop growth for a week or two after application.  
A range of grass selective herbicides are available refer to label for use. |
A safer method is to level the paddock by harrowing then use the range of post-sowing pre-emergent options available: simazine, Balance®, Bladex® and metribuzin. The new group F herbicide Balance® gives very good control of brassica weeds, Wild Radish, Turnip Weed and Indian Hedge Mustard. Balance® is not volatile and will remain on the soil surface until rain activates it to be taken up by weed roots. Balance® is compatible with simazine. Adding simazine at 1 L/ha to Balance® applied post-sowing pre-emergent to a levelled paddock is recommended to control grass weeds and add to the effect of Balance® on broad-leaved weeds.

Grasses can be effectively controlled post emergent with a range of group A herbicides however post emergent broad-leaved weed control options are limited. Broadstrike® is registered at the 4-6 node stage of the chickpea. It is not effective on large radish, more than 10 cm wide, so weeds should be targeted when small. Always read product labels.

Desiccation and swathing of the crop is a weed control strategy used for some grain legumes. This is not effective in chickpea because the crop matures later than most weeds. Yield losses are high and weed control is poor. Swathing or desiccation are salvage operations only.

Fungicides such as Bravo® (chlorothalonil) should not be mixed with herbicides or insecticides. Plants can be damaged, making them more susceptible to disease. The tips of the leaves burn and if severe, leaves and small branches will fall off the plant. This has been observed when mixing grass selectives and Broadstrike® with Bravo®.

Later in the year other fungicide products which cause less foliar damage may be used. For example, mancozeb which is compatible with a range of chemicals including Targa®, Select®, Verdict®, Fusilade, Correct®, Lemat®, Fastac®, Dominex®, Decis® and Hallmark® may be used, and the mixes are safe on the crop. While mancozeb is compatible with these pesticides it has been shown to provide poorer ascochyta blight control compared with chlorothalonil products.

**Insect management**

Seedling pests are rarely a problem on chickpea because of the organic acids excreted onto the leaves by the plants. Nevertheless crops should still be monitored because occasional sporadic damage may occur with red legged earth mite or lucerne flea or where trash harbours brown pasture looper or cutworm.

**Native budworm**

Starting at flowering, monitor the crop for native budworm, which is the most serious insect pest of chickpea.

The timing of insecticide sprays for native budworm is critical in order to protect early pods from attack. Don’t wait for the caterpillars to grow; spray immediately.

Native budworm damage will be seen on the plant as spindly small branches with very small leaves. These branches have been stripped by native budworm. This can occur in late winter or early spring. Damage to pods is of more concern than damage to the plant. If the pod wall is punctured when the pods are forming, the growing seed will abort even if the seed is not touched by the caterpillar. The caterpillars will also chew developed seeds, reducing both the quality and yield of grain.

Monitoring should occur at regular intervals throughout pod development. At least 5 lots of 10 sweeps should be made at several locations in the crop. Spray thresholds will depend on grain prices (see Chapter 5). A good rule

**Research Update**

**Ascochyta**

Work by Jean Galloway on the biology of ascochyta rabiei showed that:

“The ascochyta fungus will survive on above-ground stubble for up to 24 months and on buried stubble for up to four months. Both the asexual and sexual stage of the ascochyta fungus occur in Western Australia. Spores released by the sexual stage can be blown over very long distances. This highlights the need for good crop rotation and paddock selection to ensure that the current season’s crop is not grown in too close proximity to the previous season’s chickpea stubble.”
Managing ascochyta blight

Cameron Tubby’s family in Canna, started cropping chickpea in the early 90’s and were one of the first to take up chickpeas in the area, settling on the desi types due to higher yields.

Cameron generally uses DAP type fertiliser to give a small nitrogen boost to the crop because the soil pH of his paddocks are at the low end for chickpeas (around 5.0). In 2003 he used 50 kg/ha triple super and believes the plants did not seem to get away as well as previous seasons so will use DAP in the future.

After 10 years of trying Cameron believes he has found a post sowing pre-emergent combination of herbicides in 750 mL/ha simazine, 100 g/ha Balance® and 500 mL/ha diuron which gives good residual weed control and little crop damage. He found that Broadstrike® set the crop back a few weeks, which reduced yield in his short season environment. The crop is sown with a Morris airseeder and a DBS bar and lightly harrowed to increase the safety of the herbicides.

Cameron is convinced that with ascochyta management the early sprays are critical.

“Even if the disease can not be seen in the crop, it must be sprayed,” he says. In 2003 he tested his theory by doing a test strip where the earliest application was missed. The result was the disease came in quickly and was very severe. Even though the crop only received 230 mm of rain for the season it required four fungicide sprays to manage the disease.

Yield was a bit lower than the anticipated 1.0 t/ha. “The problem is that you need the rain for yield but then ascochyta is difficult to control with current varieties,” Cameron said. “Basically we have a fair bit of experience with chickpea and are happy with the general agronomy and the excellent break it gives for cereals. We are really keen on the new varieties with improved ascochyta resistance.”

of thumb is to spray insecticide if the number of caterpillars average more than 1 grub per 10 sweeps for desi crops or more than 1 grub per 20 sweeps for kabuli crops. Synthetic pyrethroids are best and will prevent re-infestation for up to 6 weeks after application. Usually one well-timed spray is sufficient to control native budworm in most chickpea crops. It is nevertheless important to always maintain a monitoring schedule, even after spraying.

Further information on insect pests of pulses can be found in Chapter 5.

Fungus disease management

Following a good rotation and isolating the crop from infection sources is fundamental to good disease management in chickpea.

Make sure that no more than one chickpea crop in four years occurs in any paddock and that new crops are located at least 500 m away from last year’s chickpea, lentil, vetch, narbon bean or faba bean stubble.

Fungal spores remain viable on seed for up to 5 years so test all seed for the ascochyta fungus. Tests will detect a critical seed infection level of 0.1 percent (1 infected seed in 1000) but are unable to categorically determine if the entire seed lot is free of ascochyta. All seed should be coated with a fungicide to kill spores and provide some early protection to the seedling.
A healthy growing plant is also a key. Waterlogging, herbicide damage, poor nutrition, nodulation failure or drought, stress a plant making it easier for diseases to gain a foothold in the crop. A common way in which disease is spread is by spray rigs and other vehicles driving through the crop. Often the easiest place to find disease is close to wheel tracks, where plants are damaged and disease may have been introduced while spraying. This is a good place to monitor for disease. Use the same spray lines throughout the season to minimise disease spread and development.

Sowing up and back is a good option to reduce disease spread. By sowing this way double sown headlands are reduced. This is another area where disease, particularly botrytis grey mould, can develop because of the dense, humid canopy created.

Post emergent fungicide should be applied to all chickpea crops about four weeks after emergence to control ascochyta blight. Products containing chlorothalonil are the most effective fungicides currently available for this application. A second spray should be applied before a rain front, about 3 weeks later. Crops should be monitored after fungicide sprays and further sprays applied as required. Fungicides only prevent new disease infection and do not control existing fungal infection. If chlorothalonil products are not available then use full rates of a mancozeb product. New varieties with improved ascochyta resistance are likely to require fewer fungicide sprays.

**Virus disease management**

For chickpea, the main virus diseases are cucumber mosaic virus (CMV), alfalfa mosaic virus (AMV) and beet western yellow virus (BWYV).

Key control measures are:

- sow seed from a virus-tested seed stock with <0.1% virus infection;
- promote early canopy development by sowing at recommended seeding rates and narrow row spacing. This will shade over early infected plants and deny aphids access to them. It also reduces aphid landing rates.
- If sowing at wide rows, maintain stubble cover between the rows. This will reduce aphid landings in a similar way to that of a narrow spaced crop because aphid landings are reduced if there is less contrast between the green crop and bare earth.
- Isolation from other grain legume crops and legume pastures that are potential virus sources will help avoid spread of infection into the crop from external sources.
- Control weeds well, especially wild radish, which is a major reservoir of BWYV.

Further information on the management of diseases can be found in Chapter 4.

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**Harvesting**

Chickpea is relatively easy to harvest compared to field pea and lentil because it is taller and rarely lodges. If sown in a deep furrow using narrow points there may be a height problem in drier areas. In these cases the soil should be harrowed to flatten out ridges. This will make harvesting easier and application of post-sowing, pre-emergent herbicides safer. Air reels or tine pick-up reels are generally gentler than batt reels, causing less shedding from the front.

Remove every second concave wire or fit a wide wire concave and remove filler plates, to give about a 15 to 17 mm clearance between wires in the concave. Start with the closest concave and slowest drum speed. Increase concave clearance if seed is being cracked. Increase drum speed if seed is left in the pods. Use standard lip sieves.

Measure harvest losses so the efficiency of the header can be improved. Seed on the ground should be counted at the following stages:

- before harvest, to assess the shedding that has already occurred;
- below the knife to see if you are loosing grain before it enters the header and;
- behind the machine after the trash has come through, to see what is coming over the sieves.

For desi chickpea 4 seeds in a 30 x 30 cm quadrant equals 100 kg/ha of grain. Only 2 kabuli seeds per 30 x 30 cm quadrant equals a 100 kg/ha loss.

**Handling and storage**

Minimise the handling of chickpea to avoid damaging the seed particularly if the seed is dry and brittle. Belt conveyors (either flat belt or tube) are better than augers because the seed can be damaged by auger flights. If an auger is used then run it full and at a slower speed than for cereals. Augers with a large gap between the flight and the barrel are less likely to jam. If an auger has been used for fertiliser or is very rusty inside, run the first chickpeas with the auger not full (close the choke at the bottom) until the rust is removed.

Growers should plan to store the grain on farm and deliver to Perth. It is important to provide cool dark storage conditions to maximise seed quality.

The minimum receival standard for Export Grade Farmer Dressed desi chickpea usually requires a minimum of 97% pure chickpea by weight with a maximum moisture content of 14% and maximum 8% by weight of defective seed. The tolerance for poor colour is 2% by weight and the sample must have no more than 1% of seed with visible ascochyta lesions.

The minimum receival standard for Farmer Dressed kabuli chickpea requires a minimum of 97% pure chickpea by weight with a maximum moisture content of 14% and a maximum 3% by weight of defective seed including poor colour. The sample must have no more than 1% of seed with visible ascochyta lesions.
Specific up to date standards for chickpea receival and export are available on the Pulse Australia web site www.pulseaus.com.au.

**Further reading**


Growing field pea
Bob French, Ian Pritchard, Mark Seymour and Glen Riethmuller

Introduction
Field pea (*Pisum sativum* L.) has been an important grain legume crop for millennia, seeds showing domesticated characteristics dating from at least 7000 years ago have been found in archaeological sites in Turkey. The seed is used both as animal feed and for human consumption. It is closely related to the garden pea, whose immature pods and seeds are used throughout the world as green vegetables.

There are several types of field pea grown in Australia. Dun types are the most common; they usually have purple or faintly pink flowers and seeds that have yellow cotyledons and mixture of either green or brown seed coats. Some dun varieties, though, have almost uniformly green (Helena) or brown (Kaspa) seed coats. Round-white peas (called yellow peas in North America and Europe) are also grown in significant quantities, particularly in eastern Australia. These types generally have white flowers, yellow cotyledons, and a white-creamy seed coat. Other field pea types include blue (called green peas in North America), marrowfat and maple peas. These are specialist type peas and are not grown widely in Australia.

Canada and France dominate world export markets and produce mainly white peas. Australia is the major exporter of d Un type peas. Victoria and South Australia have historically been the largest Australian field pea producers, but production has recently expanded considerably in Western Australia as a result of better varieties and improved production technology. More than ninety percent of the field pea grown in Western Australia is the dun type, with the majority of the grain exported to the Indian sub-continent for food.

Field pea is the most widely adapted pulse crop in Western Australia, being suited to a wide range of fine and medium textured soils, and to both medium and low rainfall environments. Field pea has unique farming system advantages because it can be sown later than most other annual crops. This allows weeds to germinate; with adequate time left for control by either mechanical means, or with non-selective herbicides, before sowing. The reduced reliance on selective herbicides provides a very useful tool in the battle against herbicide resistant weeds. Field pea also matures early, so can often be harvested before other crops are ready. The late sowing and early harvest means the planting and harvest windows of the cropping program as a whole can be widened, thus allowing more efficient labour and machinery use.
Case Studies

Managing weeds
According to Gerard O’Brien (from the Avon Valley) there are only three phases of his rotations that give a net decrease in ryegrass numbers, these being:

• Several years of well manipulated pasture.
• Hay, which is cut prior to soft dough stage of weed seeds.
• Field pea, which is sown late and then manipulated with spray-topping.

By incorporating into the rotation a hay crop, which is then followed by a field pea crop, even high problem ryegrass paddocks become very easy to manage and the level of ryegrass falls to a point where the successive wheat crops don’t need to have any grass selective herbicide applied.

Neil Wandel (from the Esperance Region) considers the inclusion of field pea in his rotations has increased his average wheat yields by more than 1 tonne per hectare. The ability to control weeds in field pea crops has contributed to this yield increase. Neil says “the key factors of weed control in field pea are the delayed seeding of field pea, being the last crop sown in my program, plus the ability to crop-top without sacrificing much yield”.

Paddock selection
When selecting a paddock in which to grow field pea you need to consider the following points:

Soil type
Field pea can be successfully grown on a wide range of soil types, but prefers sandy loams or heavier, and pH above 5.0. Duplex soils with neutral to alkaline subsoils are suitable if they don’t become waterlogged, although erosion of the sandy surface after harvest may be difficult to manage. Field pea does not tolerate salinity or waterlogging well, so avoid soils where these are likely.

Blackspot risk
Blackspot risk is largely determined by the rotational history of the paddock, and of surrounding paddocks. Choose paddocks that have not grown field pea for at least 3 years, and go no closer than 500 m to paddocks that grew field pea in the previous year. It is preferable to be at least 50 m downwind of 2 and 3 year old stubbles, but no separation is necessary upwind.

Surface condition
Surface condition has important implications for ease of harvest and soil erosion after harvest. Avoid paddocks with a rough or uneven surface that will not allow the header front to follow the ground closely. Also avoid paddocks with stones or stumps that could be picked up by the header. These can cause considerable damage if they pass through the threshing drum. Some obstacles are acceptable if they are buried by rolling post-sowing. Avoid paddocks with loose surface soil if it will be exposed to strong winds after harvest.

Herbicide residues
Field pea is sensitive to residues of sulfonylurea herbicides that may have been applied to a preceding cereal crop, so avoid paddocks where this will be a problem. Residues are more likely on alkaline soils, and after a dry growing season and a dry summer. Different sulfonylureas have different breakdown rates. Information on persistence and safe withholding periods is given on the herbicide label, and should be consulted.

Large sticks and rocks may potentially cause damage during harvest. Photo P White.

Weed population
Field pea is not a strong competitor with weeds, so the most suitable paddock will have a low weed burden, especially of broad-leaved weeds. However, remember that the ability to plant late means that some cultural weed control is usually possible, and that there is a greater range of post-emergent herbicides available for use in field pea than in other pulse crops.

Frost risk
Frost during early pod-filling can cause devastating yield losses in field pea. Fortunately in the northern region, temperatures are usually mild during early podding and frosts are rare. Nevertheless, avoid paddocks if there is a possibility of frost during the first three weeks after the beginning of flowering.

Varieties
The most important criteria in choosing a cultivar are marketability, harvestability and yield potential.
At present there is good demand for Australian dun peas in South Asian countries, and these are the most readily marketed. Australian white peas compete in bulk markets with product from Canada and Europe, which are usually
of better quality (mainly larger seed) than Western Australian white peas. Nevertheless, there may be niche marketing opportunities for good quality white peas produced in Western Australia. Exploiting these opportunities will require some extra work and will usually require delivery of grain to specialist traders in Perth. Seed appearance can differ between dun cultivars, especially with respect to seed colour, and marketers are reluctant to mix them. If you intend to deliver your peas to CBH find out what cultivars your local receival point will accept, otherwise you may have to deliver to Perth. Table 2 describes the commonly available field pea cultivars.

The architecture of the plant is an important determinant of how easy it is to harvest. Semi-leafless types are more erect at maturity and easier to harvest than conventional trailing types, although under some conditions semi-leafless types may also lie reasonably flat at maturity. Semi-leafless peas have some leaflets replaced by tendrils so plants grab on to each other to form a self-supporting canopy. They also usually have stiffer stems. The most recent semi-leafless variety, Kaspa, also has reduced pod shattering. The semi-leafless character is present in both white and dun type varieties.

There is little difference among varieties (white or dun; semi-leafless or conventional) in other agronomic traits or management required in Western Australia. Semi-leafless varieties are likely to lose more yield than trailing types if plant density is below 40-50 plants/m². The only disease resistance among Australian field pea cultivars is to downy mildew, which is of little significance in Western Australia.

Sowing

Choosing when to sow field pea requires a compromise between sowing early enough to avoid end of season drought, and late enough to avoid bad blackspot infection. Other crops, such as wheat, lupin and canola, benefit much more from early sowing than field pea, so these crops should be sown first.

Data from Department of Agriculture trials suggest that the best compromise is to sow around the beginning of June, or slightly earlier in low rainfall areas. Delaying sowing until the end of June is safe in the central wheatbelt and risky in the medium rainfall areas of the northern wheatbelt. It is too late for the low rainfall northern wheatbelt. As a general rule, if there is less than 100 mm of water stored in the soil then don’t sow later than June 1st in low rainfall areas north of a line between Moora and Bencubbin. If more than 100mm of water is stored in the soil then crops can be safely sown until June 15th.

Seed quality

It is important to use good quality seed to ensure that a vigorous, healthy, crop that will compete well with weeds is established and has the best chance of overcoming environmental stresses. Don’t use seed from crops badly

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Table 2. Characteristics of field pea cultivars in Western Australia

<table>
<thead>
<tr>
<th>Flower colour</th>
<th>Seed type</th>
<th>Plant type</th>
<th>Seed size (g per thousand)</th>
<th>Days to flowering†</th>
<th>Grain yield* (% Dundale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helena</td>
<td>Purple</td>
<td>Dun, dimpled</td>
<td>Conventional</td>
<td>170</td>
<td>89</td>
</tr>
<tr>
<td>Dunwa</td>
<td>Purple</td>
<td>Dun, dimpled</td>
<td>Conventional</td>
<td>220</td>
<td>91</td>
</tr>
<tr>
<td>Parafield</td>
<td>Purple</td>
<td>Dun, dimpled</td>
<td>Conventional</td>
<td>220</td>
<td>87</td>
</tr>
<tr>
<td>Kaspa</td>
<td>Pink</td>
<td>Dun, round</td>
<td>Semi-leafless</td>
<td>200††</td>
<td>95</td>
</tr>
<tr>
<td>Snowpeak</td>
<td>White</td>
<td>White, round</td>
<td>Semi-leafless</td>
<td>202</td>
<td>81</td>
</tr>
<tr>
<td>Cooke</td>
<td>White</td>
<td>White, round</td>
<td>Conventional</td>
<td>164</td>
<td>89</td>
</tr>
<tr>
<td>Dundale</td>
<td>Purple</td>
<td>Dun, dimpled</td>
<td>Conventional</td>
<td>190</td>
<td>84</td>
</tr>
</tbody>
</table>

* These figures are the best estimate derived from all crop variety testing trials conducted in Western Australia from 2000 to 2003. The number of trials each cultivar was tested in is given in parenthesis.
†† These figures are derived from 10 trials conducted across the state from 1999 to 2003. Dundale flowering time varied from 74 to 97 days after sowing, depending on location and time of sowing. Environment has little effect on differences between most cultivars however it does seem that Kaspa performs better in long season length environments such as areas that receive greater than 400 mm annual rainfall.
†† Only limited figures available for Kaspa. They suggest a similar size to Snowpeak and Dundale.
infected with blackspot, especially if there were pod lesions. Also avoid small seed or seed batches with less than 80% germination. Test seed for bacterial blight if it is sourced from eastern Australia and reject if any level of infection is detected. Seed tests for blackspot are available but this is not usually helpful in Western Australia. Tests for seed vigour, used in Europe and Canada, have not been calibrated for Western Australian conditions.

**Inoculation**

Field pea should be inoculated with Group E inoculum before sowing, irrespective of whether the paddock has grown field pea before. This is because the best rhizobium for field pea may not survive well in Western Australian soils so an ineffective bacteria may nodulate the crop if inoculum is not applied. Field pea will nodulate with Group F inoculum, but this group is not recommended for field pea. Achieving good nodulation is crucial to growing a good crop, so take care to inoculate properly. Slurry inoculation is the best way to ensure a well nodulated crop. Refer to page 23 in the chickpea section of this manual for more details on slurry inoculation.

Inoculate seed as close to the time of sowing as possible because the inoculum has only a limited life span on dry seed. If more than 24 hours lapses, then reinoculate seed at the same rate. Don’t apply fungicide seed dressings to the inoculated seed because they will reduce the life span of the rhizobium. Fungicide seed dressings have not been shown to increase yields of field pea in Western Australia. It is likely that inoculum will be made available for field pea in Western Australia in granular form from 2005 onwards (see page 47). Granular inoculum will not need to be stuck to the seed in the same way as peat inoculum, but applied to the soil separately in much the same way as fertiliser. This will give more flexibility at sowing time because it will remove the need to inoculate before sowing, and will make achieving good nodulation compatible with fungicide seed dressings if they are ever used.

**Sowing depth**

Field pea should be sown 5 cm deep. This minimises the effects of soil applied herbicides on the crop, and reduces the risk that the roots of young seedlings dry out during the establishment phase. It also increases the survival of rhizobium because the soil is usually cooler and more moist at this depth.

**Sowing rate and row spacing**

Sow sufficient seed to establish 45 plants/m² for conventional-leaved varieties, and 55 plants/m² for semi-leafless varieties. The necessary seed rate will depend on germination percentage and seed size, which should always be taken into account.

Typically, seed rates of 100 kg/ha are adequate for a small seeded variety such as Helena, 110 kg/ha is adequate for a medium seeded variety such as Dundale and 120 kg/ha is required for the larger seeded varieties such as Parafiel and Dunwa and the medium seeded semi-leafless variety Kaspa. Details of how to calculate the necessary seed rate, and typical seed rates, are given in Appendix 2.

The yield of field pea is usually fairly unresponsive to changes in density around these seed rates. However, dense crops compete better with weeds and feed into the harvester better, so resist the temptation to reduce seed rates. Early indications are that semi-leafless varieties will lose yield more rapidly than conventional varieties at plant densities below 45-55 plant/m².

**Table 3. Sowing time recommendations for field peas in the Northern Agricultural Region of Western Australia**

<table>
<thead>
<tr>
<th>Start date</th>
<th>Finish date</th>
<th>Comment</th>
<th>Target date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low rainfall</td>
<td>7 May</td>
<td>1 June</td>
<td>If less than 100 mm stored soil water</td>
</tr>
<tr>
<td>Low rainfall</td>
<td>7 May</td>
<td>15 June</td>
<td>If more than 100 mm stored soil water</td>
</tr>
<tr>
<td>Medium and high rainfall</td>
<td>15 May</td>
<td>30 June</td>
<td>Blackspot risk reduced if delayed to June</td>
</tr>
</tbody>
</table>

Field pea grows well in conventionally spaced rows (18 to 25 cm). Limited research in the 1990’s showed that yields were not reduced by planting in rows as wide as 36 cm. However the crop was less able to stand (with a conventional-leaved prostrate cultivar) and consequently was more difficult to harvest. Wider rows are therefore, not recommended for field pea. The standing ability of semi-leafless cultivars is also likely to be impaired by wide rows because the tendrils will be less able to latch onto wider-row-neighbours for support.

**Fertiliser**

Phosphorus is the main fertiliser required by field pea in Western Australia. There has been some recent research done in Western Australia on the response of field pea to phosphorus fertiliser, but results have been inconsistent. In some cases field pea is more responsive than wheat,
and in others less, and there are no apparent patterns according to soil type or other factors. It is recommended to apply as much phosphorus fertiliser as you would for wheat grown on the same paddock, and the most economic rate will depend on soil phosphorus levels and fertiliser price. Field pea removes about 4 kg phosphorus per tonne of grain. This means that a 2 t/ha crop removes about 8 kg/ha of phosphorus, equivalent to the amount contained in 90 kg/ha plain superphosphate.

Some Western Australian soils are becoming increasingly deficient in potassium, and responses are commonly seen in wheat and canola. Research on the responsiveness of field pea to potassium has not yet been undertaken in Western Australia because the finer textured soils on which most field pea are grown usually have adequate potassium levels. Field pea crops may be responsive to potassium fertiliser on sandier soils where responses in wheat have been observed. In most situations applying adequate potassium fertiliser to the wheat phase of the rotation will be the most economic means of ensuring field pea has enough potassium. Soil sampling at depth is recommended.

The most likely trace elements to be deficient in field pea are zinc, copper and manganese. These need to be applied infrequently, and where the levels are adequate for cereals they should be suitable for field pea. Trace element deficiencies are best diagnosed by tissue testing.

Small doses of nitrogen fertiliser (5 - 10 kg N/ha) are sometimes recommended on acid soils to boost early growth before root nodules form. This level of nitrogen is low, so it will not inhibit nodulation, but there is also no clear evidence that it will increase crop yields.

**Levelling the paddock**

Trouble-free harvesting requires an even soil surface, and this is best achieved by rolling. This is most important for prostrate, conventional-leafed cultivars, but applies also to semi-leafless, erect cultivars that may lodge under some circumstances.

Use either a steel or rubber-tyred roller. Heavy steel rollers do a better job levelling fine textured soil, especially the large ridges left by no-till seeding equipment. They also push small stones and sticks into the ground. Steel rollers have a greater tendency than rubber-tyred rollers to smear and seal the soil surface if it is moist, and it may be necessary to wait for the soil surface to dry after seeding before rolling with a steel roller. Rubber-tyred rollers can usually be used directly behind the seeder. Rubber-tyred and steel rollers are equally effective on sandy soils because less pressure is required to flatten ridges and smearing is less of a problem.

Roll the soil immediately after sowing as long as the soil surface is not too moist. If rolling is delayed until after emergence wait until plants are between the 3 and 10 node stages (Figure 4 explains how to count the number of nodes on pea plants). Rolling earlier risks damaging emerging seedlings and older plants may not recover completely from being knocked down in the rolling operation. Don't roll for two weeks before or after applying post-emergent herbicides because the stress of rolling will predispose the crop to herbicide damage. It is best to roll crops in the afternoon, because plants will be more flaccid and less likely to be broken.

**Weed management**

Good weed management is crucial to growing a successful field pea crop, and to maximising the benefits of field pea to following crops. An integrated strategy attacking weeds in several different ways is most effective, and will minimise the selection for resistant weeds. A good integrated weed management strategy includes:

- Selecting paddocks with a low burden of broad-leaved weeds.
- Taking advantage of sowing field pea late by allowing weeds to germinate and then killing them with non-selective herbicides or other means. If it is compatible with other aspects of the cropping system, a shallow autumn cultivation may help by stimulating early weed germination.
- Establishing the optimum density for the crop, and providing as close to ideal growing conditions as you can to ensure that it competes with weeds as much as possible.

**Pre-emergent herbicides**

It is important to consider when the chemicals are applied in relation to the timing of the seeding and levelling operations.
Typically farmers use two herbicide strategies in field pea. The first option is to apply a mix of 1-1.5 L/ha Diuron and 1-2 L/ha Trifluralin before sowing. The Diuron gives you good control of many broad-leaved weeds, whilst the Trifluralin picks up the grasses and wireweed. The benefits of the Diuron + Trifluralin mix are that it can be applied before seeding and rolling, and it is a relatively cheap option. The downside is that you are using a useful shot of Trifluralin in field pea when it may be better to save it for a cereal crop, and the efficacy may be reduced in paddocks with a heavy load of cereal stubble. If the crop is sown with conventional full cut systems where the soil is mixed, it is best to apply the Trifluralin before sowing and the Diuron after sowing to reduce the risk of Diuron damaging the peas.

The second option for no-till sown field pea crops is to use a mix of 34 g/ha Spinnaker® and 1-1.5 L/ha Diuron, after the crop is sown and soil levelled. Spinnaker will control wireweed (particularly in heavy stubble situations), a wide spectrum of broad-leaved weeds and, to some degree, grass weeds. The Spinnaker® + Diuron mix should not be applied before the soil has been harrowed or rolled, as the efficacy of the Spinnaker® will be reduced by excessive mixing and if there is rain between spraying and rolling the Diuron may be washed into the furrow and damage the peas. The benefits of this option are the improved effect on broad-leaved weeds, efficacy is less affected by heavy stubble, the mixing of 2 chemical groups to aid resistance management, insecticide can be added to protect against mites and grubs, and the chemicals can be applied.

**Case Study**

**Rolling and harvesting**

Scaddan farmer, Neil Wandel, preaches that successful field pea harvesting is due to planning, preparation and rolling with a heavy 8 tonne steel roller - a ‘real roller’.

With Neil harvesting approximately 2,500 hectares of field peas a year, he is one person with considerable experience harvesting field pea and worth listening to.

Without doing some important preparation before and after seeding Neil, believes growers will get very frustrated at harvest time and will probably give up with field pea after the first season. In his experience the use of a good roller has been invaluable. He has used a rubber tyre roller, a light steel roller, but the best has been a heavy steel roller that pushes any object above the ground, such as stumps or stones, into the ground so that it is level. For those who are worried about drift and soil erosion or soil compaction you can safely roll peas from the 3 to 7 node stage without causing damage to the crop. Neil explains that with lighter rollers he still had unacceptable amounts of harvester damage. For example, on the first day of harvest, a brand new harvester went 300 metres and picked up a press-wheel from the seeder. This caused significant damage to the spiral.

“We minimised this type of damage with a ‘real roller’ and only empty our stone traps once or twice a day, rarely picking up anything that can cause significant damage to our harvesters”.

Big steel rollers. Photo M. Seymour.
applied once the seeding rush is over. The downside is the paddock has to be levelled before the chemical can be applied. This can be an issue for farmers sharing rollers, or in soils that seal. However both of these issues are known before seeding commences.

If the paddock is not likely to be levelled prior to the crop emerging it is possible to apply Diuron before sowing and then Spinnaker® post sowing but pre-emergent. Spinnaker® is not registered for use before sowing and it is usually not as effective applied before sowing because it is diluted by mixing with the soil. However, we are aware of some farmers with low weed burdens and seeding machinery with very limited disturbance of the soil that have used Spinnaker® before sowing.

Spinnaker® can cause issues in following summer and winter crops due to a carry over of residual chemical in the soil. This is more likely to be an issue in low rainfall areas or when applied to acid soils due to slower breakdown of the chemical. Weed burden is usually less in these instances and Spinnaker® may not be required. Diuron alone at 1.0 to 2.0 L/ha is a safe effective option. Note, the suggested rate of Spinnaker® of 34 g/ha is half the rate at which many of the residual problems, such as crop shortening in sensitive crops like wheat have been observed.

Whilst both fore mentioned herbicide strategies are usually effective in most field pea crops, for better control of volunteer medic or doublegee, replace Diuron with 150 g/ha of Metribuzin. This chemical is more effective on the weeds but can also damage the crop, particularly if it is sown shallow. Over recent years we have seen extreme damage following Metribuzin application post sowing pre-emergent (PSPE), on to furrow sown crops prior to paddock levelling. It is vital in no-till crops to have separation of the chemical and the pea seedling either by ‘spray and throw’ or ‘flatten and spray’. Metribuzin should only be applied PSPE in no-till crops once the furrows have been flattened. Simazine is not registered for use in field pea. Trial data and field experience indicates Simazine is a risky option, reducing yield and in some instances exacerbat ing blackspot damage. Simazine is most commonly used by farmers to control silver grass. Post emergent applications of Raptor WG® offer a registered method of controlling silver grass.

If in doubt seek advice from your local Western Australian Department of Agriculture pulse researcher or your agronomist.

Post emergent herbicides

There are more registered options for post emergent weed control in field pea than for any other pulse crop in Western Australia. These are mostly applied at the 3 to 6 node stage of the crop (see Figure 4). There is a wide choice of products for controlling grass weeds, all of which field pea tolerates well. Some of the more popular options for post emergent control of broad-leaved weeds are listed below. Note that not all of these herbicides are compatible with post emergent grass killers, nor with oil or wetter. Follow instructions on herbicide labels.

- Brodal® and metribuzin mixes: usually 60 mL/ha Brodal® (500 g a.i./L) and 60 mL/ha metribuzin (750 g a.i./L) is adequate for cruciferous weeds and capeweed. Higher rates of metribuzin will improve doublegee control, but are also more likely to damage the crop. At higher rates Brodal® and metribuzin can be used alone, but they are more likely to damage the crop and are less effective against weeds than when mixed together.

- Raptor WG® applied at 45g/ha + 0.2% BS1000 will control cruciferous weeds, lupin, barley grass, brome grass, and volunteer cereals. It will not control annual ryegrass and cannot be tank mixed with post emergent grass killers.

- MCPA 250 (as the sodium salt) applied at 700 - 1000 mL/ha will control late germinating cruciferous weeds

Rubber tyre rollers inspected by Tim Pope. Steel plates hold a bank of tyres together. Photo C. Veitch.
and can be applied to field pea from the 6 to 8 node stage. However, it will retard the crop, and you may see stem distortions for up to 2 weeks after application. This option should only be used when you expect good growing conditions following application so the crop can recover. It is often not a reliable option in the northern and eastern wheatbelts where the short growing season limits the plant’s opportunities to recover.

Crop topping is very effective in field pea to prevent seed set of surviving in-crop weeds, thus benefiting the next crop in the rotation. The early maturity of field pea makes it ideally suited to crop topping. Reglone can be used for crop topping, but the most economical chemical is Gramoxone at 600 mL/ha for ryegrass, or 800 mL/ha for wild radish. Glyphosate should be avoided because it can reduce seed viability of the harvested grain.

Timing is critical for the success of crop topping. Spraying too early will reduce the crop’s yield potential, and spraying too late will have little effect on the weeds. Ideal timing is when the field pea seeds have reached 30% moisture, or when the lower 75% of the pods are brown. The seeds will be firm and the pods leathery. At this stage the crop can still have green tips but yields will not be reduced. In many situations harvest efficiency is also improved by making the crop ripen more evenly.

**Blackspot management**

The only significant disease of field pea in Western Australia is blackspot - Chapter 4 discusses the other minor diseases of field pea. The best way to manage this disease is to separate the crop from potential infection sources. Fungicides do not provide effective economic control under Western Australian conditions. The two cardinal principles of blackspot management are separation from old stubbles and delayed sowing.

Choose paddocks that have not grown field pea for at least 3 years, and that are at least 500 m (further on the windward side) away from one-year old pea stubbles. It is also best to be at least 50 m away from 2 or 3 year old stubbles on the windward side. There is no need to isolate the crop if the 2 or 3 year old stubbles are downwind from the crop.

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**Research Update**

**Predicting blackspot risk**

In Western Australia, by far the most significant source of blackspot infection is spores released from old stubble. Recent research has enormously increased our understanding of what influences spore release, and we are now in a position to use this understanding to tailor our blackspot management to suit specific regions and seasonal conditions.

The key advance is a computer model that predicts the release of spores from old stubble and their spread by wind. The fungal fruiting bodies, or perithecia, which release thousands of spores into the atmosphere only mature within a certain temperature range, with an optimum of about 20°C. Summer is too hot for this, and winter too cold, but there are regional differences too. In the southern agricultural areas temperature falls into the ideal range earlier in the autumn, so maturation starts earlier, and is completed sooner, than in the north. Once perithecia are mature, as little as 0.2 mm of rain is sufficient to release spores into the atmosphere, but no further spores are released until there is more rain. Thus spore release, and infection risk, starts early in seasons with cool, moist autumns, but late in seasons with warm, dry autumns. Because spores remain viable for only a few hours after their release, delaying sowing until most spores have been released can reduce the risk of infection. This is most effective in southern regions, but is by no means ineffective in the north. This is illustrated in Figure 6 which shows that in the years 1999 to 2003 the percentage of total spore release intercepted by a crop sown at the ideal time for the area, ranged from none to 64% at Scaddan. At Northam it ranged from 8% to 73%, and at Mingenew from 45% to 93%.

Coupling these predictions with information on the location of previous year’s pea stubbles (which determines potential maximum spore load) and wind direction (which determines potential spore spread) enables disease risk to be assessed in individual paddocks in individual seasons, and is the basis of the computer model “Blackspot Manager.” This can be used to compare disease risk in different paddocks sown at different times, and therefore has the potential to be a useful tool in selecting paddocks and making sowing time decisions for field pea.
Delay sow ing so the disease has a shorter time to build up to damaging levels before the crop sets pods and matures. Delayed sowing may also cause most fungal spores to fall harmlessly to the ground before the crop emerges. However, this is not as effective in the northern region as it is in the southern region (see Figure 6). The dry, warm autumn conditions in the northern region cause spores to be released late in the season so they may still be falling when seedlings emerge, even if sowing is delayed. In these situations, isolating the crop from the source of the spores (old stubbles) is the only effective way of managing blackspot disease.

**Virus disease management**

The main virus diseases of field pea are bean yellow mosaic virus (BYYMV) and pea seed-borne mosaic virus (PSbMV), but beet western yellow virus (BWYV), alfalfa mosaic virus (AMV) and cucumber mosaic virus (CMV) also occur. Key control measures are: sow seed from a virus-tested seed stock with <0.1% virus infection and promote early canopy development by sowing at recommended seeding rates and narrow row spacing. This will shade over early infected plants and deny aphids access to them. It will also reduce aphid landing rates. Adequate stubble groundcover also helps decrease aphid landing rates. Isolation from other grain legume crops and legume pastures that are potential virus sources will help avoid spread of infection into the crop from external sources. Control weeds, especially wild radish, which is a major reservoir of BWYV. Further information on diseases of pulses can be found in Chapter 4.

**Insect management**

**Early season pests**

During emergence until about two weeks after emergence check for red legged earth mite, lucerne flea, cutworm and bryobia mite. Field pea is very sensitive to red legged earth mite, which can cause considerable damage just as the crop is emerging.

Two main strategies can be used to control seedling pests in field pea. Their usefulness will depend on the relative abundance of the different pests. Note these seedling pests are potentially more of a problem coming out of a pasture phase.

1. Apply an appropriate insecticide with the knockdown herbicide spray. This will be effective in controlling lucerne flea, cutworm and bryobia mite. It may also be effective against red legged earth mite if the season has a late break.

2. If bryobia mite and red legged earth mite are the major pests then apply an appropriate insecticide as a bare earth spray, prior to emergence of the crop.

For both these strategies check the crop after emergence to ensure the production and expansion of new leaves is occurring at a faster rate than damage is occurring by the
When to monitor for insects

**Break of season to two weeks after crop emergence:**
- Monitor for mites, lucerne flea and cutworm.

**From start of flowering and into podding:**
- Monitor the crop for pea weevil and native budworm.

*Check PestFax for regular updated information on insect pests and diseases.*

remaining insects. If not, a second post emergent insecticide spray may be required.

**Pea weevil**

From early podding onwards check for pea weevil. Pea weevil is potentially the most damaging insect pest of field pea since it can not only reduce yields but also dramatically reduce grain quality to the point where it is no longer suitable for human consumption. Some parts of the state, such as the Avon Valley, have very much higher populations of pea weevil than others.

Pea weevil management begins the year before growing a crop. All field pea used for seed should be fumigated with phosphine as soon as possible after harvest. Add two phosphine-generating tablets per tonne of silo capacity (internal volume of the silo) and keep sealed for 21 days. If the seed is harvested at above 12% moisture it should be dried by aeration before sealing.

- Begin monitoring the crop with a sweep net just before the first pods begin to form (5 to 7 days after flowering begins). There is no point in monitoring on cold, overcast days because the adult pea weevil only become active when it is warmer than 18°C.
- First monitor along the edges of paddocks nearest to trees. Spray if you find more than 1 pea weevil in 100 sweeps and the crop has pods. Aim to kill the adults before they lay eggs, because the eggs and larvae once inside the pod can’t be killed by insecticide. Pea weevil have to eat field pea pollen before they become sexually mature, so you have 7 to 14 days to kill them after they first appear in the crop.
- Spray with synthetic pyrethroids using rates given on the label. It is usually only necessary to spray a 60 m border around the paddock because pea weevil gradually work their way in from the edges, and take time to reach the centre of a paddock.
- Continue to monitor the crop about 10 days after spraying, and spray again if you find more pea weevil.
- Harvest as soon as the crop is ready, and fumigate the seed promptly. This is important because pea weevils continue to develop and cause damage after the grain is mature.

Grain left on the ground after harvest can be a source of pea weevil infestation in the future, so harvest as efficiently as possible (early harvest will help). Where the soil type allows, graze the stubble early to clean up spilt grain.

**Native budworm**

Native budworm is a serious insect pest of field pea in Western Australia, check for native budworm from early podding onwards. The timing of insecticide sprays is critical in order to protect early pods from attack. Don’t wait for the caterpillars to grow; spray immediately.

Monitoring should occur at regular intervals throughout pod development. At least 5 lots of 10 sweeps should be made at several locations in the crop. Spray thresholds will depend on grain prices (see Chapter 5). A good rule of thumb is to spray insecticide if the number of caterpillars average more than 1 grub per 10 sweeps. Synthetic pyrethroids are best and will prevent re-infestation for up to 6 weeks after application. Usually one well-timed spray is sufficient to control native budworm in most field pea crops. It is, nevertheless, important to always maintain a monitoring schedule, even after spraying.
Native budworm. Photo by I. Pritchard.

Native budworm does not necessarily work its way into a crop from the edges like pea weevil and can occur simultaneously across the whole paddock rather than just along the edges. If a border spray has been applied for pea weevil, be sure to do some monitoring inside the sprayed border. Further details on insects can be found in Chapter 5.

**Harvesting**

Harvesting is easiest in a crop of uniform density on a flat soil surface, with the machine either working into or across the direction that the crop has been laid by the wind.

Even the most efficient harvesters cannot overcome poor planning. Successful field pea harvesting begins at the end of the previous season through good paddock selection and stubble handling. Decisions made at sowing and spraying of the field pea crop are also important.

Probably the most important step in reducing harvesting difficulties is to select a paddock with a low weed burden and one that is relatively even and free of stones, sticks and large soil clods. Broad-leaved weeds such as wild radish and mustard decrease yield by competition and increase harvest losses.

Rolling, which levels the paddock and pushes small rocks and sticks into the soil is the second most important step (see previous section on rolling).

The most common method of harvesting is to use crop lifters with a tine or pick-up reel. The lifters should be spaced so as to fit the shortest length of the vine to be harvested. Normally this is 300 mm. A lifter should ride on its flat section behind the tip, not on the point, to avoid damaging the lifter and soil being thrown into the front. Most harvester fronts can be tilted, so once lifters are fitted, the harvester front angle should be adjusted. The lifters should have adequate travel for the conditions. The finger tine reel or pick-up reel should be set forward and lower than the knife to reach down and gently lift the crop over the knife. The finger angle is adjustable and should be set perpendicular to the top edge of the lifters. The ideal option is to link reel speed to ground speed. Plucker fronts can also be used but may not be able to travel as fast, or start as early, as lifters in damp conditions. Crops can be swathed but the windrow must be rolled to prevent it being spread by wind.

<table>
<thead>
<tr>
<th>Component</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reel speed</td>
<td>1.1 x ground speed</td>
</tr>
<tr>
<td>Table auger clearance</td>
<td>7-12 mm (standard)</td>
</tr>
<tr>
<td>Drum speed</td>
<td>300-600 rpm</td>
</tr>
<tr>
<td>Concave clearance</td>
<td>10-25 mm (start at 10 mm)</td>
</tr>
<tr>
<td>Fan speed</td>
<td>60-75% (start at 75%)</td>
</tr>
<tr>
<td>Top sieve</td>
<td>20-25 mm (start at 25 mm)</td>
</tr>
<tr>
<td>Bottom sieve</td>
<td>10-15 mm (start at 15 mm)</td>
</tr>
</tbody>
</table>

Kaspa is sometimes difficult to feed into the broad elevator and may flow over the top of the front. Photo M. Seymour.
Safely swathing field pea

Scaddan farmer Mark Delroy has been a champion of swathing field pea over the last few years, and has been called upon by many neighbours to offer advice. Mark suggests the time to start swathing is when the crop is around 25-50% green, looking across the paddock. To reduce ryegrass and other weed seed set, Mark uses 1 L/ha of glyphosate 2-3 days before swathing as it is slower acting and therefore safer to use than Gramoxone at this time.

In 2003 he swathed 700 hectares of field pea and cites being able to obtain a good sample, no sand in the harvester and the ease of harvest day and night, as the main reasons he decided to try and then ultimately stick with swathing. Mark uses two swathers:
1. A 36’ Macdon Self Propelled (SP) swather with long plastic fingers on pickup reel - Class type lifters.
2. A 30' John Deere with Honeybee SP swather and steel fingers on pickup reel - Class type lifters.

The Esperance region is renowned for strong winds and Mark stresses it is essential the swaths are rolled with a canola roller immediately behind the swather. “Don’t even think of not rolling!” is Mark’s comment. The ends of swath runs are the areas most likely to be affected by wind. Similarly Mark noted “One paddock that was swathed too ripe had sections of swath blow, but were still able to be harvested with very little loss of time or grain.” Mark also stresses that even when swaths do move the losses are usually lower than would have occurred with direct harvesting.

Mark considers it is much easier to get a good clean sample when field pea is swathed. Interestingly, the seed coat of the Dun varieties grown, such as Parafield, are noticeably greener when the crop is swathed, but up to now Mark has had no problem with green immature seed (green cotyledons) when delivering the grain.

In 2003 Mark swathed the semi-leafless field pea variety Kaspa. He thought if anything Kaspa formed a better swath than the normal trailing types.

Semi-leafless varieties like Kaspa and Snowpeak have some leaves replaced by tendrils that latch onto adjacent plants to keep the crop canopy more erect at maturity. Pod height is therefore, generally higher and the crop easier to harvest. Kaspa also has a sugar-pod trait that reduces pod shatter and further improves harvestability. These characteristics, however, also result in slightly different harvest properties for the semi-leafless varieties compared with conventional training type varieties. For Kaspa:

- the vine (straw) requires a chopper to break it up;
- the crop is better harvested during the heat of the day;
- harvested material is sometimes difficult to feed into the broad elevator and may build-up on draper (belt) fronts.

For all field pea crops remove every second concave wire, or fit a wide wire concave and remove filler plates, to give at least 7 mm clearance between wires in the concave. Start with the closest concave and slowest drum speed. Increase concave clearance if seed is being cracked. Increase drum speed if seed is left in the pods. Use standard lip sieves. Screens on the clean grain and repeat elevators help remove soil from the grain.

Harvester settings will depend on the moisture content of the crop foliage and seed. The settings suggested here and the operator’s manual for the header may be a useful starting guide.

Drum or rotor speed should be kept to a minimum without significantly reducing the harvesting capacity.

<table>
<thead>
<tr>
<th>Make</th>
<th>Model</th>
<th>Drum or rotor diameter (mm)</th>
<th>Drum or rotor speed for 12 mps (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case IH</td>
<td>2388</td>
<td>762</td>
<td>300</td>
</tr>
<tr>
<td>Cat Lexion</td>
<td>480</td>
<td>600</td>
<td>380</td>
</tr>
<tr>
<td>Claas</td>
<td>116CS</td>
<td>450</td>
<td>510</td>
</tr>
<tr>
<td>Gleaner</td>
<td>R70/72</td>
<td>635</td>
<td>360</td>
</tr>
<tr>
<td>John Deere</td>
<td>CTS</td>
<td>660</td>
<td>350</td>
</tr>
<tr>
<td>Massey Ferguson</td>
<td>860</td>
<td>560</td>
<td>410</td>
</tr>
<tr>
<td>New Holland</td>
<td>TR98</td>
<td>432</td>
<td>530</td>
</tr>
</tbody>
</table>

As a guide, to reduce pulse seed damage the peripheral speed of the drum should not be greater than 12 metres per second (20 to 30 metres per second for cereals). The drum speed will be different for each drum diameter according to the following formula:

\[
\text{Drum speed (rpm)} = \frac{60,000 \times \text{peripheral drum speed (m/s)}}{3.14 \times \text{drum or rotor diameter (mm)}}
\]

Harvesters have a range of drum or rotor diameters so this must be checked in order to start at around the correct rotational speed.

A DVD and video that demonstrates all aspect of harvesting field pea is available from the Great Southern Pulse Growers Association. For more information, contact the Department of Agriculture.
Harvesting semi-leafless peas

Perhaps the most attractive feature of semi-leafless peas is their ease of harvest. There have been a number of opportunities to compare the new variety Kaspa with conventional varieties on a paddock scale in Western Australia in 2002 and 2003, and the following is a summary of observations made by researchers and farmers.

The main difference is that Kaspa remains more or less erect at maturity and holds its pods higher. For example, at Lake King in 2003 Kaspa pods were between 38 and 50 cm above the soil surface, while Parafield pods were between 15 and 35 cm. This means that the harvester front need not follow the ground surface so closely, with reduced risk of picking up stones or stumps, or digging into the soil. However, Kaspa can still lodge, so the normal precautions taken with conventional field pea to ensure a level soil surface should still be taken with Kaspa. Kaspa also remains more firmly attached to the ground than conventional varieties, so plucker fronts do not work as well. We recommend that lifters and a finger tine reel are used for harvesting Kaspa.

The tendrils of semi-leafless peas help the crop canopy support itself, but they also hold individual plants apart at maturity so the crop feeds into the harvester as a fluffy, airy mass rather than as a blanket like conventional field pea. This is difficult to feed into the broad elevator, and material may build up on the front, especially on belt or draper fronts, and may even flow over the top of the front. The following have been found helpful in overcoming this:

- Fitting a top auger above the belt on draper fronts.
- Fitting lupin breakers to spirals to assist movement of material.
- Adding cutting wheels to the ends of the front to prevent build-up of material.
- Ensuring that concave wire gaps are at least 7 mm and are not blocked to ensure the bulk of material from a high-yielding crop can be threshed.

If these precautions are taken, harvest losses with Kaspa should be very low. If steps are not taken to ensure ready feeding into the harvester, losses with Kaspa can actually be higher than with conventional cultivars.

Management after harvest

Grain handling and quality

Once field pea grain is harvested it should be handled as few times, and as gently, as possible. The seed of field pea is very fragile, and mechanical damage caused by augering, for example, can damage the seed and reduce viability. Belt conveyors (either flat belt or tube) are better than augers because the seeds can be damaged by the auger flights. If an auger is used, run it full and slower than for cereals. Augers with a large gap between the flight and the barrel are less likely to jam.

The minimum receival standard for No. 1. Farmer Dressed field pea requires no less than 97% pure peas by weight, and no more than 14% moisture. There is a low tolerance of doublegee, other pulses, and unmillable material, and a nil tolerance of objectionable material. Details of the most up-to-date receival standards are available on the Pulse Australia website (www.pulseaus.com.au).

Stubble management

The aim of stubble management is to minimise soil erosion. The main decision is whether or not to graze the stubble. Least erosion will occur if the stubble is ungrazed as sheep can easily loosen 40 t/ha of soil with their feet, which is then susceptible to being blown away. Cultivation after summer rain can make the soil less susceptible to erosion by roughening the surface.

There can be significant nutritional value in field pea stubbles, and in areas with high pea weevil populations, cleaning up spilt grain can be an important part of managing this pest. Maximising harvest efficiency will
Further reading

reduce the need to graze stubbles, but if you are going to graze the stubbles then choose your timing carefully.
If the aim of grazing is to reduce pea weevil numbers, then stubbles must be grazed as soon after harvest as possible. If the aim is to capture the feed value of the stubble, the best timing, chosen to minimise erosion risk, will depend on soil type. Medium and heavy soils that will form a crust after summer rain can be grazed anytime, but straight after harvest is best. Grazing sandy soils that are likely to form only a weak crust should be deferred until as close to seeding the next crop as possible to minimise exposure to erosion. It is better not to graze stubbles on sandy soils if it can be avoided.

Growing faba bean

Peter White, Mark Seymour and Martin Harries

Introduction
Faba bean (Vicia faba L.) is an ancient crop with a multitude of uses. The grain is valued as an animal feed and has a special place in the diets of people in the Middle East, Mediterranean Europe and China. The green immature seed is also favoured as a vegetable (broad bean). China is the largest producer of faba bean in the world. North Africa, Europe and Australia produce significant quantities. Australia is the World’s largest exporter. Faba bean has been regarded as a commercial crop in Australia since the early 1980’s. South Australia has dominated faba bean production since this time. Faba bean is grown primarily in Australia as a high quality grain for human consumption, with Egypt being the principal market. Prices of between $200-$350 per tonne for food grade faba bean have been received in recent years. A significant proportion of Australia’s faba bean crop is also used for animal feed and the demand is likely to continue to grow.

In Western Australia the faba bean area expanded rapidly in the early to mid 1990’s and reached a peak of about 40,000 ha in 1997. Chocolate spot epidemics in 1997 and 1998, followed by a run of dry seasons (2000-2002) has since seen the faba bean area contract.

Faba bean is a crop well suited to the Western Australian cropping system. It is particularly well adapted to heavy soils and tolerates transient waterlogging and mild frosts well. It has an erect growth habit and can be planted and harvested with standard cropping equipment. Faba bean is best grown in the medium and high rainfall areas where it has the highest yield potential of all cool season grain legumes available in Western Australia. Grower’s crop yields in the range 1.0 to 2.5 t/ha are regularly reported. In the medium term it is projected that about 100,000 ha of faba bean will be grown annually in Western Australia.

Growers successfully producing faba bean for human consumption, point to the importance of careful management that focuses on choosing the right paddock and variety, strategic use of fungicides, and attention to harvest timing.

Paddock selection
When selecting a paddock to grow faba bean, consideration must be given to the following:

• Is the land suitable to grow faba bean?
• What were the crops and herbicides in the paddock in the past three years and in the neighbouring paddocks in the previous year?

Soil type
The soil should have a sandy loam texture or heavier and a pH above 6.0 (CaCl₂). This will help ensure plants grow vigorously and are well nodulated. Best yields will be obtained on soil that is well drained, but land subject to short periods of waterlogging may also be suitable. Faba bean is moderately tolerant to waterlogging.
It is possible to grow faba bean on more acid and sandier soils than that described above (see Chapter 1) but, thought must be given to planting times and herbicide rates. Yields of crops grown on these acid and sandier soils are likely to be more variable and diseases more difficult to manage.

Faba bean is an upright crop that can set pods along the length of the stems. Some paddocks should therefore, be relatively even and free from sticks or stones. This will enable the harvester cutter bar to be set low without risk of damage.

The alkaline red shallow loamy duplex soils and the calcareous loamy earths of the north eastern wheatbelt running through Muluwa, Minginew, Three Springs, Dalwallinu through to Coorow and parts of Mukinbudin and Merredin are particularly well suited to faba beans. Local names for these soils include: morrel soil, salmon gum-gimlet, merredin sandy loam, york gum soil and red-brown earth. The self-mulching dark cracking clays of Dongara and the northern coastal flats are also very well suited to faba bean. Other brown, grey, and red loamy duplex and loamy earth soils found throughout the region, particularly in the Avon Valleys and the Moora regions are also well suited provided the subsoil pH is above 6.0 (CaCl2). Deep yellow, grey and white sands and acid duplex soils are unsuitable for faba beans.

Paddock history
Faba bean should not be grown on the same paddock more than once in three years. Also, avoid paddocks that have grown vetch or barley bean in the previous two seasons. These species harbour the same botrytis fungus that causes chocolate spot in faba bean. The paddock chosen should be also at least 500 metres away from stubble of last year’s faba bean, barley bean or vetch crop. Finally ensure that at least two years has passed since sulphonylurea herbicides (Glean®, Ally®, Logran®, Lontrel®) were applied in the paddock.

Spores can be carried-over on stubble from one crop to the next. Even if disease was not obvious in last year’s crop, it could still harbour some disease that will infect this year’s crop. Isolating the crop in the way described above will substantially reduce the chances of disease infection (see disease section for more information).

Faba bean is sensitive to sulphonylurea herbicides and will be damaged if residues of these herbicides remain in the soil. These herbicides will break down within one to two years of application depending on soil pH, organic matter content, soil structure and rainfall. Minimum plant back periods must be observed.

Other considerations
Currently few herbicides are registered for control of broad-leaved weeds in faba bean crops. Therefore, select a paddock that is relatively free of broad-leaved weeds to make weed management easier.

Faba bean produces large amounts of biomass and has a reputation as one of the best ‘break crops’ for cereal rotations. Selecting a paddock that will be used for premium wheat production after a faba bean crop should also be considered.

Varieties
Faba bean varieties vary widely in their seed size, adaptation and disease resistance (Table 5). Fiesta, Farah or Cairo are currently the varieties best suited to most parts of the northern region because they combine a degree of disease resistance with reliable yields and good quality grain. The following should be considered when choosing a variety:

- Older varieties (Fiord, Ascot and Barkool) generally have smaller grain than new varieties (Fiesta or Farah). Be aware of blockage problems with old seeding machinery when the new varieties with larger seeds are sown.

Research Update
Faba bean breeding in Australia
Faba bean breeding occurs at two nodes in Australia: Adelaide, South Australia and Narrabri, northern New South Wales. Some crosses are made specifically for Western Australia and the germplasm is tested as part of the Western Node of the Australian Faba Bean Improvement Program. Dongara and Merredin are key sites for this program in the Northern Agricultural Region. Recent releases including Cairo and Farah were screened in Western Australia.
• Ascochyta blight has not been a serious disease in the Northern Agricultural Region so varieties with lower levels of resistance to ascochyta blight (e.g., Cairo) are acceptable.

• Chocolate spot is a serious disease that can cause significant yield loss, but current varieties with improved resistance to this disease (Fiesta and Farah) currently have a slightly lower yield potential in the northern region, compared with Fiord.

• Cairo flowers earlier than Fiesta or Farah and has produced high yields, but it has lower levels of resistance to chocolate spot.

• Varieties with seed heavier than 130 g/100 seeds are classed as broad beans and can command high prices, but the premium market for broad beans is small.

Sowing
Highest yields will generally be achieved from earlier sowing. However sowing too early will increase the likelihood of severe chocolate spot disease and reduce opportunities for pre-sowing weed control. Sowing time is, therefore, a compromise between planting early to achieve high yield potential, while delaying sowing

When to sow faba bean

Low rainfall (<350 mm):
• 25th April to 15th May.

Medium rainfall (350 to 450 mm):
• 1st May to 30th May.

High rainfall (>450 mm):
• 15th May to 7th June.

Table 5. Faba bean varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>Description</th>
<th>Chocolate spot</th>
<th>Rust</th>
<th>Seed size (g/100 seeds)</th>
<th>Height</th>
<th>Yield (% of Fiord)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascot</td>
<td>Ascochyta resistant selection from Fiord. In the presence of ascochyta blight will produce 8% higher yields than Fiord but in the absence of the disease will produce 20% lower yields than Fiord.</td>
<td>VS</td>
<td>R</td>
<td>S</td>
<td>35-50</td>
<td>Short</td>
</tr>
<tr>
<td>Aquadulce</td>
<td>A broad bean that produces a range of seed sizes ranging from 120 to 160 g/100 seeds. A very large grain size &gt;140 g/100 is needed to meet premium market specifications.</td>
<td>MT</td>
<td>MS</td>
<td>MT</td>
<td>120-160</td>
<td>Tall</td>
</tr>
<tr>
<td>Barkool</td>
<td>Farmer’s selection from a crop of Fiord in New South Wales. Selected for erect branches and podding higher on the stem. In Western Australia, Barkool is very similar to Fiord.</td>
<td>S</td>
<td>MS</td>
<td>VS</td>
<td>35-50</td>
<td>Short</td>
</tr>
<tr>
<td>Cairo</td>
<td>Developed by the northern node of the national breeding program selected for rust resistance and high yield in short season environments. Not recommended for southern growing regions</td>
<td>S-MS</td>
<td>S</td>
<td>MR</td>
<td>45-65</td>
<td>Short</td>
</tr>
<tr>
<td>Fiesta</td>
<td>Developed in South Australia for high yield and chocolate spot resistance. In Western Australia Fiesta matures about a week later than Fiord and produces lower yield.</td>
<td>MS</td>
<td>MS</td>
<td>S</td>
<td>45-65</td>
<td>Medium</td>
</tr>
<tr>
<td>Farah</td>
<td>Ascochyta resistant selection from Fiesta. In the absence of ascochyta blight disease, Farah has produced a similar yield to Fiesta.</td>
<td>MS</td>
<td>MR</td>
<td>MT</td>
<td>50-65</td>
<td>Medium</td>
</tr>
<tr>
<td>Fiord</td>
<td>Oldest variety current being grown in Western Australia and consistently a high yielding variety over a range of environments in the absence of disease.</td>
<td>S</td>
<td>S</td>
<td>S</td>
<td>35-50</td>
<td>Short</td>
</tr>
</tbody>
</table>

R= resistant, MR= moderately resistant, VS= very susceptible, MS= moderately susceptible, S= susceptible, MT=moderately tolerant
to avoid disease and ensuring weeds are adequately managed.

Faba bean has the highest yield potential of all pulse crops grown in Western Australia but it is also more sensitive to drought. Delayed sowing in our environment tends to reduce yields of faba beans more severely than other pulses. Potential yield can decline by up to 56kg/ha with each day sowing is delayed. Faba bean is therefore, best suited to the medium to high rainfall areas in Western Australia. When consistent rain occurs during April in low rainfall areas, the high yield potential of faba bean also offer an excellent sowing opportunity in late April-early May to capture maximum benefit from the early break.

It is possible to sow faba bean successfully into dry soil, however, weeds become more difficult to control, emergence is generally patchy and staggered and inoculation with rhizobium is less effective because a large proportion of the inoculum dies. In most circumstances it is recommended that faba bean is not sown into dry soil, but if dry sowing is necessary, increase the sowing rate by 10%.

**Sowing depth**

Faba bean has a hypogeal pattern of emergence (it leaves its cotyledons below the soil surface) and therefore is able to emerge from deeper in the soil than plants with an epigeal emergence pattern (eg. lupin). Faba bean is also large seeded and produces a relatively strong seedling, which further enable seedlings to emerge from deeper in the soil.

Aim to sow faba bean at a depth of 5 cm, if in doubt plant a little deeper rather than shallower. If the top 5 cm of soil is dry at sowing, seed may be sown deeper at 8 to 10 cm.

Placing seeds deep in the soil minimises the chances that the seed or the emerging roots will come into contact with surface applied herbicide. This is particularly important on sandier soils where the herbicide may infiltrate into the surface few centimetres of the soil. Also at 5-10 cm deep the soil is more likely to remain moist for longer periods. Placing the seed into this layer helps survival of the seed and the rhizobium inoculum, and produces a more even emergence of the crop.

**Sowing rate**

Aim to establish 40-45 plants per m² for small-seeded varieties (Fiord, Ascot, Barkool: seed sizes < 45 g per 100 seeds) and 30-35 plants per m² for varieties with medium sized seeds (Fiesta, Farah, Cairo: seed sizes 45-60 g per 100 seeds) and 20 plants per m² for large-seeded varieties (Aquadulce). This is equivalent to 150 to 220 kg/ha depending on seed size and germination percentage: see Appendix 2. The higher densities within these ranges should be used where growing conditions are less favourable and individual plant growth is limited, such as in low rainfall and short season environments, eg. Merredin. The lower densities should be used in the more favourable growing environments where individual plants have a better chance to express their yield potential, eg. Dongara.

It is important to always check the germination percentage of the seed. Faba bean seed can be easily damaged if handled roughly particularly if it is handled when very dry. Damaged seed will have a substantially lower proportion of viable seeds.

Research in Western Australia has consistently shown profitable responses to the sowing rates recommended here. These recommendations are above the rates that many commercial crops are sown in Western Australia.

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**Research Update**

**Granular inoculum**

ALOSCA is a dry clay granule containing rhizobial inoculant embedded in a peat and clay matrix. ALOSCA is under development by BayClassic Pty Ltd and the Centre for Rhizobium Studies at Murdoch University. ALOSCA granules are being developed for both pulse and pasture legumes. They provide the opportunity to separate inoculant from the seed, such that fungicides can be seed-coated, and they also allow for legumes to be sown dry. The rhizobia will not die rapidly in the clay formulation, as they do when coated onto seed with peat. Trials in 2002 and 2003 have been highly promising. The data below refers to an experiment at the Department of Agriculture site near Nyabing in 2003. The nodule count shows that faba beans sown into drying soil in late May nodulated very adequately when drilled with ALOSCA Group F granules at 10 kg/ha.

The graph shows data on nodule number per plant achieved with normal slurry inoculant (Group F) applied immediately before sowing, the slurry applied 24 hrs prior to sowing (Group F 24 hr), the slurry applied immediately before sowing but with an 18 month old culture (Group F 18 mth), the slurry applied immediately before sowing in addition to a clay based PGPR (Group F + PGPR), ALOSCA and an uninoculated control.

The ALOSCA inoculant survived the period in the dry soil before opening rains better than the standard slurry inoculants. It is also interesting to note that the older inoculant also tolerated the dry conditions. There is some evidence that ageing toughens the cells. The PGPR treatment is a growth promoting bacteria that has previously been shown to increase nodulation, as it appears to have done here.
Inoculating seed
Always inoculate faba bean seed with Group F inoculum. This applies regardless of the cropping history of the paddock because even if rhizobia are present in the soil, they are likely to be less efficient than the inoculated strain. Inoculated seed must be sown within 24 hours of applying the inoculum. If more than 24 hours lapses, then reinoculate seed at the same rate.

The survival rate of rhizobium on inoculated seed that is sown into dry soil is lower than if it is sown into moist soil. The rate of inoculum for dry sowing, therefore, should be doubled in order to improve the chances of the rhizobium survival.

Fungicide seed dressings are toxic to rhizobium and are not usually necessary for faba bean in Western Australia. Nevertheless, if the seed has been dressed with fungicide, then double the rate of inoculum and sow seeds into moist soil as soon as possible after inoculating. Do not sow seed that is inoculated and dressed, into dry soil. It is unlikely the rhizobium will survive to nodulate the crop.

Seed inoculation is an important operation. There are many cases where poor inoculation technique has caused crop failure. Peat sprinkled out of the bag onto seed as it is being augered into the seeder is quick but not effective. Slurry inoculation is currently the best way to ensure a well nodulated crop. Refer to page 23 in the chickpea section for more details on slurry inoculation.

Faba bean growers may benefit by switching to granular inoculum as it becomes available in Western Australia over the next few years.

Levelling the paddock
Levelling furrows and rolling the paddock to create an even soil surface after sowing will make harvesting faba
bean easier. It will also reduce herbicide wash into furrows. Faba bean is an erect crop but some pods can be set close to the ground, particularly in short, late sown crops. A flat, even paddock allows a low harvest height to be set in order to capture these pods.

Paddocks must be rolled prior to crop emergence. Too much damage occurs to plants if rolling occurs after the plants have emerged. Ideally, seeding ridges should be levelled with harrows and then rolled with a rubber tyre or steel roller to flatten the soil surface and push obstacles into the soil. Post sowing, pre-emergent herbicides can then be applied. Care should be taken on soils that are prone to smearing and surface crusting. Don’t roll these soils if it is likely to cause surface crusting that will reduce seedling emergence. Rubber tyre rollers are less likely to cause smearing than steel rollers.

**Fertiliser**

Faba bean is more responsive to phosphorus than other pulse crops. It is also likely to require as much or more phosphate fertiliser than wheat grown in similar circumstances. If a phosphate fertiliser rate has not been determined from a soil test, then apply a maintenance rate. About 100 kg of single super phosphate is required to replace the phosphorus removed in two tonnes of faba bean grain.

Phosphate fertiliser may be either drilled with the seed or banded 3 cm below the seed. Banding the fertiliser below the seed is a common practice but, research has not shown that it increases yields. Conversely, drilling fertiliser with the seed can cause toxicity and reduce seed germination if too much fertiliser is placed with the seed. Blockages may also occur if a large amount of seed and fertiliser is going down the boot together. More fertiliser is needed within the row of wide-row crops in order to achieve the required rate per hectare. The amount of fertiliser that can be placed with the seed without causing fertiliser toxicity is not known for faba bean. Research in Western Australia has shown that up to 150 kg of double superphosphate per ha can be placed with the seed sown in
38 cm rows without causing problems. Topdressing phosphate fertiliser onto the finer textured soils on which faba bean is commonly grown, is about half as effective, as drilling the fertiliser with the seed.

Small amounts of nitrogen fertiliser (10 to 15 kg/ha) are sometimes recommended to stimulate the early growth of plants when grown on sandy loam soils with a pH below 6.5. This level of nitrogen is low, so it won’t inhibit nodulation, but there is also no clear evidence that it will increase crop yields.

Faba bean has a lower zinc requirement than wheat or other pulse crops. Application of other fertilisers is unlikely to produce profitable responses in faba bean when grown on its recommended soil types in Western Australia.

**Weed management**

Choose a paddock with low numbers of broad leaved weeds. In particular, avoid paddocks with high numbers of doublegee, wild radish, lupin, chickpea and field pea. These weeds will reduce faba bean yields through competition and contaminate the grain sample. Controlling these weeds in the paddock will avoid the need to grade their contaminating seeds out of the harvested grain.

Always use a pre-emergent herbicide such as simazine (1.5-2.0 L/ha) or Bladex® 2 L/ha. Rates above 1.5 L/ha of simazine have caused damage to faba bean on sandy-surfaced soils with low pH, but higher rates are safe on fine-textured, alkaline soils. If wireweed, fumitory, ryegrass or wild oats are present, it is also worth using a dinitroaniline base herbicide such as Trifluralin (1-2 L/ha) or Spinnaker® at 34 to 70 g/ha.

When using high rates of simazine or Spinnaker®, consider carryover of these herbicides into the next year, especially after a dry season.

Raptor WG®, is currently on a special use permit for faba bean, and is the only herbicide available for controlling broad-leaved weeds after the crop has emerged. Raptor WG® should be applied at 45 g/ha at the 3-6 node growth stage of the crop. Do not tank mix Raptor WG® with any other chemical or additive other than an approved wetting agent such as BS1000. In some situations the height of the crop may be reduced at this rate but yields are unlikely to be affected. Growers should note that faba bean does not offer the same amount of competition as field pea or pasture species to weeds. Therefore, experience has shown that half rates of Raptor WG® do not provide reliable control of wild radish.

**When to monitor for insects**

*Break of season to three weeks after crop emergence:*

- Monitor for mites, lucerne flea and cutworm.

*Early vegetative growth to early pod fill:*

- Monitor for aphids.

*From start of flowering:*

- Monitor for native budworm.

*Check PestFax for regular updated information on insect pests and diseases.*

Most grass weeds are easily controlled with a range of post emergent selective herbicides.

**Insect management**

**Early season pests**

From the break of the season to three weeks after crop emergence, monitor for red legged earth mite, lucerne flea, cutworm and bryobia mite.

There are two strategies to control these pests. Their usefulness will depend on the relative abundance of the different pests. Note these seedling pests are potentially more of a problem coming out of a pasture phase.
1. Apply an appropriate insecticide with the knockdown herbicide spray. This will be effective in controlling lucerne flea and bryobia mite. It may also be effective against red legged earth mite if the season has a late break.
2. If bryobia mite and red legged earth mite are the major pests then apply an appropriate insecticide as a bare earth spray, prior to emergence of the crop.

For both these strategies check the crop after emergence to ensure the production and expansion of new leaves is occurring at a faster rate than damage is occurring by the remaining insects. If not, a second post emergent insecticide spray may be required.

**Aphids**

Aphids are a more serious pest in faba bean than in some of the other pulse species. Inspect the crop from early vegetative growth until pod fill at about 10 locations in the paddock and spray insecticide if aphids are present on more than 30% of plants inspected at these locations.

Monitoring should occur at regular intervals throughout pod development. At least 5 lots of 10 sweeps should be made at several locations in the crop. Spray thresholds will depend on grain prices (see Chapter 5). A good rule of thumb is to spray insecticide if the number of caterpillars average more than 2 caterpillars per 50 sweeps.

Synthetic pyrethroids are best and will prevent re-infestation for up to 6 weeks after application. Usually one well-timed spray is sufficient to control native budworm in most faba bean crops. It is nevertheless important to always maintain a monitoring schedule, even after spraying.

Etiella web moth, weevils, false wireworm, slugs and snails are also occasional pests of faba bean that need to be checked for and controlled if populations begin to build up. Further details are provided in Chapter 5.

**Fungus disease management**

The main diseases of faba bean are chocolate spot, ascochyta blight and rust. Chocolate spot is found wherever beans are grown. Ascochyta blight is a minor disease in the Northern Agricultural Region, although it is a serious disease in the southern wheatbelt. Symptoms of ascochyta blight are sometimes seen in very susceptible lines in the central wheatbelt, but this disease has not caused yield loss in commercial crops grown north of the Great Eastern Highway. Rust has not yet been seen in faba bean crops grown in the Northern Agricultural Region but is potentially a damaging disease that can reduce yields.

Other diseases, cercospora and altenaria, often produce minor symptoms on the varieties currently grown but usually do not occur at high enough levels to significantly affect yields. Detailed information about these diseases is provided in Chapter 4.

The following steps should be used to manage these diseases in faba bean crops in the Northern Agricultural Region. The aim is to effectively manage the diseases early so they don’t build up to unmanageable levels causing yield loss and seed discolouration later:

- Avoid paddocks that have been sown to faba bean, vetch or narbon bean in either of the two previous years or that are within 500 m of last year’s faba bean, vetch or narbon bean stubble.
- Use a variety with appropriate resistance to combat the most prevalent disease. For most areas this will

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**Native budworm**

Native budworm is the most serious insect pest of faba bean in Western Australia. The timing of insecticide sprays is critical in order to protect early pods from attack. Don’t wait for caterpillars to grow; don’t delay spraying. The caterpillars will reduce yields by eating the developing grain and damaged grain may incur a price penalty if the thresholds for grub-damaged seeds are breached. The caterpillars can also introduce fungal infections while feeding.

Look closely at the growing points of the plant where aphids develop their infestations. Some aphid species, particularly cowpea aphids, colonise clumps of plants or attack weaker plants and thin patches in the crop.

Damage from aphids tends to be greater in drier regions and seasons. Aphids can also cause damage by spreading viruses or making plants more susceptible to fungal disease.

Native budworm on a faba bean pod. **Photo M. Seymour.**

Ascochyta blight in faba bean. **Photo W. MacLeod.**
mean choosing Farah or Fiesta with their moderate resistance to chocolate spot. Fiord should only be grown in low disease risk areas such as Merredin provided it is not sown too early. Avoid Barkool, which is very susceptible to rust. Cairo is more susceptible to chocolate spot than Farah or Fiesta but has produced higher yields in the northern region.

- Use clean seed.
- Sow within the recommended window for each rainfall zone. Sowing too early will encourage chocolate spot disease.
- Monitor for cercospora from emergence. Seek advice if many lesions are seen.
- Apply prophylactic fungicide spray at the start of flowering to prevent chocolate spot affecting flowers and small pods. Continue to monitor the crop for chocolate spot and rust. Further fungicide sprays may be necessary if infection from these diseases reach threshold conditions (see Table 6).
- Graze or plough-in stubble to reduce the amount of inoculum that may infect next year’s crop.

The fungicides available to manage these diseases in faba bean are only able to stop new infections of leaves, flowers and pods. They will not kill the fungus once it has already invaded part of the plant. The fungus needs moist conditions to infect and will do so a few hours after rain. Fungicides, therefore, should be applied immediately

<table>
<thead>
<tr>
<th>Table 6. Summary of disease management in faba bean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop Stage (sowing to 12 weeks)</td>
</tr>
<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Check for cercospora.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop Stage (10-17 weeks)</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply a fungicide spray at early flowering even if no disease symptoms are present.</td>
<td>This is strongly recommended for all faba bean crops as a precaution against chocolate spot.</td>
</tr>
<tr>
<td>After fungicide application, continue to monitor for disease symptoms to ensure disease is not killing flowers and preventing pod set.</td>
<td></td>
</tr>
<tr>
<td>A second spray may be required if the following thresholds are reached or if pod set is delayed, but seek advice before spraying. The efficacy and financial return from further sprays will depend on prevailing weather conditions and the yield potential of the crop.</td>
<td></td>
</tr>
<tr>
<td>Threshold for 2nd fungicide spray at flowering:</td>
<td></td>
</tr>
<tr>
<td>Rust occurs on more than 5% of the leaf area;</td>
<td></td>
</tr>
<tr>
<td>Chocolate spot symptoms still clearly evident and damage easy to find ie. damaged or dead leaves and flowers.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop Stage</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>At late podding yields can only be improved by increasing seed size. Fungal diseases are only likely to affect yields if they substantially reduce the green area of the crop so that it is unable to fill pods sufficiently. Severe pod infection may also discolour seeds and reduce seed quality.</td>
<td></td>
</tr>
<tr>
<td>A fungicide spray may be required at late podding if the following thresholds are reached, but seek advice before spraying. An economic return from further sprays is only likely if the yield potential of the crop is high.</td>
<td></td>
</tr>
<tr>
<td>Threshold for fungicide spray at late podding:</td>
<td></td>
</tr>
<tr>
<td>Rust occurs on more than 5% of the leaf area;</td>
<td></td>
</tr>
<tr>
<td>Chocolate spot symptoms still clearly evident and damage easy to find, ie. damaged or dead leaves.</td>
<td></td>
</tr>
</tbody>
</table>

Fungal disease within the canopy of a faba bean crop grown at Merredin in 2003, Photo P. White.
Pea seed borne mosaic virus can cause distinctive markings on faba bean seed. Photo P. White.

before rain, so the plant is protected from further infection once the rain occurs. New leaves, flowers and pods that develop after the fungicide has been applied, will not be protected.

When monitoring, ensure the crop canopy is parted during inspection so the lower leaves can be seen easily as they are usually where diseases develop first.

In most years one or two, well-timed sprays is all that will be needed, but also be wary of late infections that may discolour seeds.

**Virus disease management**

The main virus diseases of faba bean are Bean Yellow mosaic virus (BYMV) and beet western yellow virus (BWYV), but pea seed-borne mosaic virus (PShMV), alfalfa mosaic virus (AMV) and cucumber mosaic virus (CMV) also occur. Key control measures are: sow seed from a virus-tested seed stock with <0.1% virus infection and promote early canopy development by sowing at recommended seeding rates and narrow row spacing. This will shade over early infected plants and deny aphids access to them, it will also reduce aphid landing rates. Adequate stubble groundcover will also help decrease spread by reducing aphid landing rates.

Isolation from other grain legume crops and legume pastures that are potential virus sources will help avoid spread of infection into the crop from external sources. Control weeds well, especially wild radish, which is a major reservoir of BWYV. Perimeter sowing of cereals will help reduce BYMV spread into the crop from outside.

Further information on diseases can be found in Chapter 4.

**Harvesting**

Harvest faba bean when the pods are brown to black and the stems are brittle enough to be cut and fed through the harvester. At this stage the stems are usually slightly greenish-yellow. The seed moisture should be as close to the acceptable receival standard as possible (14%). Seed
in the lower pods will be drier than seed in upper pods.

Don’t delay harvest because the grain quality can deteriorate due to increased discolouration and the seed can become too dry. The pods don’t shatter (except for broad bean) but they may drop if harvest is delayed. Dry seed is brittle and can easily crack and break during harvest.

Set a low cutting height (<15 cm) to achieve maximum harvest yield. In dry seasons or late sown crops, faba bean plants can be short and pods are set close to the ground. Air reels or tine pick up reels are better than batt reels. Remove every second concave wire or fit a wide wire concave and remove filler plates, to give about a 15 to 17 mm clearance between wires in the concave. Start with the closest concave and slowest drum speed. Increase concave clearance if seed is being cracked. Increase drum speed if seed is left in the pods. Use standard lip sieves.

Faba bean can be swathed when the seeds are at about 50% moisture content. This is when most of the leaves have senesced and there is no further change in seed quality. Another indicator of this development stage is when the hilum (a scar-like area on the seed where it attaches to the pod) has fully changed to black, while the seed coat is still green.

Research in Western Australia has shown that yields and seed quality of a swathed crop is similar to that of a direct-harvested crop. However, if it rains on the swath then losses of between 40-60% has been known to occur, resulting in a substantially lower yield.

Swathing is useful when there are late maturing weeds in the crop. It also allows a lower cutting height and faster harvest speed. Swathing is sometimes the best way to harvest a tall crop that has lodged.

**Handling and storage**

Minimise handling to avoid damaging the seed, particularly if the seed is dry and brittle. Belt conveyors (either flat belt or tube) are better than augers because the beans can be damaged by auger flights. If an auger is used then run it full and at a slower speed than for cereals. Augers with a large gap between the flight and the barrel are less likely to jam. Dropping seed from augers onto hard surfaces will damage the seed. Bean ladders have been used in Canada to reduce damage from falling grain.

Farmer Dressed beans usually requires a minimum of 97% pure beans by weight with a maximum moisture content of 14% and a maximum 3% by weight of poor coloured or broken beans. There is a low tolerance for doublegee or other pulses. The tolerance for foreign unmillable or objectionable material is also very low or nil. Specific up to date standards for faba bean receival and export are available on the Pulse Australia website; (www.pulseaus.com.au).

**Further reading**


Growing lentil

Kerry Regan, Peter White and Glen Riethmuller

Introduction

Lentil (*Lens culinaris*) is an annual winter legume of temperate and sub-tropical regions. It is one of the oldest food crops of mankind. Lentil was first domesticated in Turkey. Major lentil producers now include: India, Turkey, Canada, Syria, Australia, United States and New Zealand.

In Australia, lentil has been grown as a commercial crop since the late 1980's. It is grown as a high value pulse, largely for export as human food. Prices of between $350 to $550 per tonne have consistently been received for lentil grain. Victoria and South Australia dominate lentil production.

In Western Australia the lentil area has expanded slowly since the first commercial crops were sown in 1994. Lentil is well suited to the central and northern agricultural region with considerable potential for the area to expand. Specialised receival and processing plants for lentil have now been established in Perth.

Lentil has particular production and harvest requirements, but if grown with attention to detail, it has proved to be a highly profitable crop.

Lentil is the most sensitive pulse to acid soils and waterlogging. Care is required during harvest because plants are short and tend to lodge at maturity. Herbicides are available for post and pre-emergent broad-leaved weed control and good levels of resistance to most diseases are present in the major lentil varieties.

In dry environments lentil matures quickly and avoids drought. In areas receiving more than 450 mm annual rainfall, lentil is prone to excessive vegetative growth, fungal disease, and damage from waterlogging.

Paddock selection

When selecting a paddock to grow lentil, consideration must be given to the following:

- the crops and herbicides in the paddock in the past three years and in the neighbouring paddocks in the past year;
- the suitability of land to grow lentil this year.

Lentil should not be grown on the same paddock more than once in three years. That means the previous two crops should not have been lentil. In addition, avoid paddocks that have grown a crop of chickpea, faba bean or vetch in the previous two seasons. The paddock chosen should be also at least 500 metres away from the stubble of last year's lentil, faba bean or vetch crop. Finally ensure that at least two years has passed since sulphonylurea herbicides (*Glean®, Ally®, Logran®, Lontrel®*) were applied in the paddock.

These precautions will minimise the risk of fungal disease and herbicide damage.

Lentil is extremely sensitive to sulphonylurea herbicides and will be damaged if residues of these herbicides remain in the soil. These herbicides will break down within one to two years of application depending on soil pH, organic matter content, soil structure, and rainfall. Minimum plant back periods must be observed.

Soil type

Lentil is best produced on free draining soils with a loamy sand texture or heavier and a pH of at least 6.5 (CaCl₂). Lentil is the most sensitive pulse species to low pH (<6) and the most tolerant of high pH (>8).

Good soil type selection is a critical step towards the production of good lentil crops. In the central agricultural regions there are many loamy sands and clays well suited to lentil production. Lentil crops can be found on heavy cracking clays in the Dongara area, the red loams throughout the Midwest and the salmon gums soils in areas such as Coorow and Mukinbudin.

Lentil has a low tolerance to salt and boron, which should also be taken into account when assessing soil suitability. Waterlogging is also an issue because lentil cannot withstand even short periods in saturated soils.

Paddocks should be free of stones, stumps and other debris and should always be rolled to ensure a smooth harvest.
Lentil can be classed as either red or green. At maturity, red lentil has reddish orange cotyledons, small seed (2.5-4.5 mm) and a reddish grey seed coat. Green lentil has yellow to light brown cotyledons, large seed (4-8 mm) and a pale green to olive green seed coat. Green lentil is also known as brown, yellow, Chilean or Continental lentil. Red lentil is better suited than green lentil to Western Australian conditions. The yield and seed size of green lentil varieties currently available are usually too low when produced in Western Australia.

Cassab is the suggested variety for the northern region. It combines adequate disease resistance with good yield potential and marketable grain. Table 13 outlines the characteristics of varieties available to growers in Western Australia.

Sowing
The ideal time to sow lentil is from early May to mid June, depending on rainfall.

Highest yields will generally be achieved from earlier sowing. Early sowing allows greater dry matter production and more bulk to the crop leading to easier and more efficient harvest. On the other hand, lentil is a poor competitor with weeds, and delaying sowing will allow better weed management before sowing.

Don’t sow lentil before May 1st in low rainfall environments or before May 15th in medium rainfall environments. In high rainfall zones lentil should only be sown if the break of season is very late and the soils have low levels of subsoil moisture. This will reduce the chances of waterlogging. Sowing dates in high rainfall zones are from June 1st to June 20th. It is important to select a free draining paddock.

In general, early sown crops are more prone to ascochyta blight and botrytis grey mould than later sown crops. These diseases have not yet caused significant yield loss in Western Australia, but as a precaution don’t sow earlier than the recommended dates, particularly in wetter environments.

Do not sow lentil into dry soil because the crop will not nodulate effectively and weeds will be too difficult to manage.

Seed depth
Sow lentil 4 to 6 cm deep.

Crops sown at these depths are less likely to be damaged by herbicides applied before or immediately after sowing. Soil temperatures and moisture at these depths also tend to be more favourable for the survival of rhizobium.

Lentil will emerge rapidly from the soil compared to other pulses, but they exert less force. Therefore, plant establishment may be reduced if seedlings need to emerge...
from deeper than 6 cm or need to penetrate a surface crust.

**Sowing rate**

Aim to establish a crop of 120-150 plants/m². The higher densities in this range should be used where growing conditions are less favourable and individual plant growth is limited, such as in low rainfall and short season environments. The lower densities should be used in the more favourable growing environments where individual plants have a better chance to reach their individual yield potential.

Sowing rate is dependent on seed size and germination percentage. Based on an 80 percent germination percentage and allowing a further 10 percent for emergence loss, a sowing rate of about 70-85 kg/ha is required for Cassab and Digger. Refer to Appendix 2 to calculate sowing rates.

**Seed dressing**

Lentil seed needs to be treated with a fungicide and inoculated prior to sowing.

Fungicide seed dressings are necessary to limit seedling disease, particularly ascochyta blight. Seed borne infection is the primary means of spread of this disease. Fungicides are toxic to rhizobia and a double rate of inoculum needs to be applied to the seed no more than six hours prior to sowing into moist soil. The rhizobium will quickly die if it is applied to seed dressed with fungicide and then sown into dry soil.

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**Table 11. Lentil varieties**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Ascochyta blight</th>
<th>Botrytis grey mould</th>
<th>Flowering time</th>
<th>Seed yield as % Digger</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Foliage</td>
<td>Seed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Digger</td>
<td>MR&lt;sup&gt;a&lt;/sup&gt;</td>
<td>MS</td>
<td>Medium (0)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>100</td>
<td>A high yielding red lentil, broad adaptation southern Australia. Well suited to low and medium rainfall regions in Western Australia.</td>
</tr>
<tr>
<td>Cassab</td>
<td>MR</td>
<td>MS</td>
<td>Early-medium (-2)</td>
<td>114</td>
<td>A high yielding and high quality red lentil for low and medium rainfall regions of southern Australia. Well suited to low and medium rainfall regions in Western Australia.</td>
</tr>
<tr>
<td>Matilda</td>
<td>MR</td>
<td>S</td>
<td>MS</td>
<td>Medium (+2)</td>
<td>Green lentil. Its seed size, under Western Australian conditions, makes it less favourable for export markets. Suitable for low and medium rainfall regions.</td>
</tr>
<tr>
<td>Nugget</td>
<td>MR</td>
<td>MS</td>
<td>MR</td>
<td>Medium (0)</td>
<td>A red lentil wide adaptation in Victoria and South Australia. Similar seed type/quality to Digger.</td>
</tr>
<tr>
<td>Northfield</td>
<td>R</td>
<td>R</td>
<td>S</td>
<td>Medium/late (+7)</td>
<td>A red lentil with small red cotyledons preferred by some markets.</td>
</tr>
<tr>
<td>Aldinga</td>
<td>MR</td>
<td>MS</td>
<td>MS</td>
<td>Medium (+4)</td>
<td>A red lentil with larger seeds compared to Digger.</td>
</tr>
<tr>
<td>Cobber</td>
<td>MR</td>
<td>S</td>
<td>MS</td>
<td>Medium (+2)</td>
<td>Red lentil yields similar to Digger in the absence of ascochyta blight.</td>
</tr>
</tbody>
</table>

<sup>a</sup> R= resistant, MR= moderately resistant, MS= moderately susceptible, S= susceptible.  
<sup>b</sup> time to 50% flowering in days compared to Digger.  
<sup>c</sup> Average 1992 – 2000
Always inoculate lentil seed with Group F inoculum. The seed should be inoculated with rhizobia regardless of the cropping history of the paddock. Even if rhizobia are present in the soil, they are likely to be less effective than the inoculated strain. Seed needs to be sown as soon as possible following inoculation because the viability of rhizobia on inoculated seed deteriorates rapidly with time.

It is important to take care when inoculating seed. There are many cases where poor inoculation technique has caused crop failure. Peat sprinkled out of the bag onto seed as it is being augered into the seeder is quick but not effective. Slurry inoculation is the best way to ensure a well nodulated crop. Refer to page 23 in the chickpea section for more details on slurry inoculation. Granular inoculants may be useful when they become available (see page 47).

**Levelling the paddock**
Always roll the paddock after sowing lentil. This is essential to ensure an even soil surface so the crop can be efficiently harvested. On most soils it is best to roll the paddock immediately after sowing. On soils that form surface crusts that may hinder emergence, it is best to roll after plants have emerged and have reached the 3-5 node stage. If rolling immediately after sowing, paddocks should be levelled with harrows and then rolled with a rubber tyre or steel roller to flatten the soil surface and push obstacles into the soil.

Rolling the paddock after emergence will weaken the plants. Therefore, as a precaution, don’t roll the paddock within two weeks before or after the application of post-emergent herbicides. Roll the crop in the afternoon when plants are naturally more limp.

**Fertiliser**
Fertiliser requirement for lentil is similar to other pulses. Apply a maintenance application of about 5 kg/ha phosphate. This can be applied most conveniently as 20-25 kg/ha diammonium phosphate (DAP). The nitrogen may stimulate the early growth of plants before nitrogen fixation begins. This level of nitrogen is low, so it won’t inhibit nodulation, but there is also no clear evidence that it will increase crop yields. Yellowing caused by iron deficiency may occur sometimes, particularly in soils with a pH above 7.0, following cold weather or where the soil is saturated. In most cases, in Western Australia however, plants will grow out of these symptoms without any apparent effect on yield.

**Weed management**
Lentil emerges quickly from the soil compared to other pulses. This needs to be considered when applying post-sowing, pre-emergent chemicals. Ideally, control most weeds one week before sowing.

To kill weeds before sowing use an effective knockdown herbicide combination such as Sprayside (2 L/ha) and Bladex® (2 L/ha). Trifluralin® (1.5 L/ha) can also be
used, but should be incorporated within four hours of application.

If weeds need to be controlled after sowing, apply pre-emergent herbicides if lentils have been sown at least 5 cm deep. Examples are Bladex® (2.0 L/ha) and Lexone® (180 g/ha of the 750 g/kg active ingredient product).

If broadleaf weeds need to be managed after the crop has emerged, Brodal (80-100 mL/ha applied after the 3 node stage) or Broadstrike (25 g/ha applied at the 4-8 leaf stage) may be used. Both of these herbicides can cause symptoms in the crop. Brodal® causes leaf flecking and necrosis of leaves and in severe cases bleaching of some plant stems while Broadstrike® can result in a general stunting of growth and slightly pale crop for a few weeks.

Grass weeds can be easily managed with a range of post-emergent selective herbicides such as Select @ 250 mL/ha + oil + wetter, Sertin, Sertin Plus, and Fusilade. Be aware that applying broadleaf weed control may cause crop damage if applied within 14 days of a grass selective herbicide.

**Insect management**

**Seedling pests**

During emergence until about two weeks after emergence check for red legged earth mite, lucerne flea, cutworm and bryobia mite. Lentil is very susceptible to attack by red legged earth mite at emergence. Two main strategies can be used to control seedling pests in lentil. Their usefulness will depend on the relative abundance of the different pests. Note these seedling pests are potentially more of a problem coming out of a pasture phase.

1. Apply an appropriate insecticide with the knockdown herbicide spray. This will be effective in controlling lucerne flea, cutworm and bryobia mite. It may also be effective against red legged earth mite if the season has a late break.

2. If bryobia mite and red legged earth mite are the major pests then apply an appropriate insecticide as a bare earth spray, prior to emergence of the crop.

For both these strategies check the crop after emergence to ensure the production and expansion of new leaves is occurring at a faster rate than damage is occurring by the remaining insects. If not, a second post emergent insecticide spray may be required.

These insects cause damage that is usually seen soon after the crop emerges. Threshold levels for their control have not been determined for lentil in Western Australia. Heavy infestations will severely retard plant growth.

**Aphids**

Aphid infestation can be rapid, so it is very important to monitor the crop regularly. Inspect the crop from early vegetative growth until pod fill at about 10 locations in the paddock and spray insecticide if aphids are present on more than 30% of plants at these locations. Look closely at the growing points of the shoot where aphids develop their infestations. Some aphid species, particularly cowpea aphids, colonise clumps of plants or attack weaker plants and thin patches in the crop.

Damage from aphids tends to be greater in drier regions and seasons. Aphids can also cause damage by spreading viruses.

**Native budworm**

Lentil is very susceptible to native budworm damage. The timing of insecticide sprays is critical in order to protect early pods from attack. Don’t wait for the caterpillars to grow; spray straight away.

Monitoring should occur at regular intervals throughout pod development. At least 5 lots of 10 sweeps should be made at several locations in the crop. Spray thresholds will depend on grain prices (see Chapter 5). A good rule of thumb is to spray insecticide if the number of caterpillars average more than 1 caterpillar per 30 sweeps. Synthetic pyrethroids will prevent re-infection for up to 6 weeks after application. Usually one well timed spray is sufficient to control native budworm in most lentil crops. It is nevertheless important to always maintain a monitoring schedule, even after spraying.

If left uncontrolled, native budworm caterpillars will reduce yield by eating the developing grain. In some cases, native budworm have been known to eat entire lentil pods. The insects will also damage grain inflicting a price penalty if the limits for the minimum level of grub damaged seeds is exceeded.

**Other pests**

Etiella web moth, weevils, false wireworm, slugs and snails are also occasional pests of lentil that need to be checked for and controlled if populations begin to build up. Etiella web moth, in particular, has caused damage to lentil crops in Victoria and South Australia resulting in downgrading of harvested grain due to poor seed quality. Further details are provided in Chapter 5.
There are several steps to managing ascocyntha blight and botrytis grey mould in lentil:

- Choose the right variety. Current lentil varieties have good leaf-resistance to ascocyntha blight, but the pods of most varieties have only moderate resistance or are susceptible. Northfield has both pod and foliage resistance to ascocyntha blight, but does not yield as well as other varieties in Western Australia, and is susceptible to botrytis grey mould. Digger, Cassab and Nugget have moderate resistance to botrytis grey mould.

- Sow lentil on the same paddock no more frequently than one year in three. Also don’t sow lentil more frequently than one year in three in rotation with chickpea, faba bean or vetch crops because the fungus that causes botrytis diseases is common amongst these species.

- Seed is a major source of ascocyntha infection in the Western Australian environment. Use seed with the lowest level of ascocyntha blight infection available, and do not sow seed with more than 5% infection.

- Ensure crop are at least 500 m away from last year’s lentil stubble and if possible up-wind.

- Always apply a permitted fungicide dressing to the seed before sowing.

- Don’t sow earlier than the recommended sowing window.

- Don’t create dense humid canopies in the crop by double sowing headlands or other areas of the crop.

- Apply a foliar fungicide at early flowering if any disease is present. This is unlikely to increase seed yields for varieties with moderate ascocyntha blight resistance, but will minimise the infection on pods and reduce seed discolouration.

Botrytis grey mould is more prevalent in warm and wet spring conditions where crop biomass is large and the crop canopy is dense.

**Fungus disease management**

In Western Australia lentil crops are at most risk from ascocyntha blight. This disease can reduce seed yields in susceptible varieties and decrease the value of the seed through discolouration. Serious yield losses from either ascocyntha or botrytis grey mould have not yet been widespread in Western Australia, nevertheless crops must be carefully managed to minimise the risks associated with these diseases.

**Virus disease management**

For lentil, the main virus diseases are seed-borne alfalfa mosaic virus (AMV), cucumber mosaic virus (CMV) and pea seed borne mosaic virus (PSbMV) but bean yellow mosaic virus (BYMV) and beet western yellow virus (BWYV) also occur. Key control measures are: sow seed from a virus-tested seed stock with <0.1% virus infection; and promote early canopy development by sowing at recommended seeding rates and narrow row spacing to shade over early infected plants. This will deny aphids access to them, and reduce aphid landing rates. Adequate stubble groundcover will also help decrease spread by reducing aphid landing rates. Isolation from other grain legume crops and legume pastures that are potential virus sources will help avoid spread of infection into the crop from external sources. Control weeds, especially wild radish which is a major reservoir of BWYV.

Further information on diseases can be found in Chapter 4.

**Harvesting**

Harvest lentil when the earliest (lowest) pods have turned light brown and rattle when shaken. Most pods will be light brown in colour with the latest (highest) pods still green. The seed moisture should be as close to the acceptable receival standard as possible (14%). As the crop dries, seed may be lost through pod shatter and pod drop after ripening. Harvest delays may increase the risk of rain damage, which increases harvest loss and affects grain quality. Very dry seed may have a low hydration capacity, and poor quality for splitting.

**Desiccation**

Lentil crops can often ripen unevenly. Chemical desiccation will even out ripening and improve harvestability. The crop can mature very rapidly in the
northern and eastern wheatbelts if conditions are warm at the end of September and beginning of October. The crop should be monitored every 3 or 4 days during this period.

The best time to desiccate the crop is when it first starts to yellow. The crop will be ready to harvest 5 to 10 days after the application of the desiccant, depending on the weather.

Timing is critical. If the crop is desiccated too early, seed size may be reduced and the sample quality impaired by the presence of green cotyledons.

Monitor the crop closely after desiccation to ensure the

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**Suggested harvesting settings**

<table>
<thead>
<tr>
<th>Component</th>
<th>Red Lentils</th>
<th>Green Lentils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reel speed</td>
<td>Slightly faster than ground speed</td>
<td>Slightly faster than ground speed</td>
</tr>
<tr>
<td>Table auger clearance</td>
<td>7-10 mm</td>
<td>8-12 mm</td>
</tr>
<tr>
<td>Drum or rotor speed</td>
<td>300-600 rpm</td>
<td>300-600 rpm</td>
</tr>
<tr>
<td>Concave clearance</td>
<td>10-12 mm (start at 10 mm)</td>
<td>13-20 mm (start at 13 mm)</td>
</tr>
<tr>
<td>Fan speed</td>
<td>60-75% (start at 75%)</td>
<td>70-85% (start at 85%)</td>
</tr>
<tr>
<td>Top Sieve</td>
<td>10-20 mm (start at 20 mm)</td>
<td>13-25 mm (start at 25 mm)</td>
</tr>
<tr>
<td>Top Sieve</td>
<td>10-20 mm (start at 20 mm)</td>
<td>13-25 mm (start at 25 mm)</td>
</tr>
<tr>
<td>Bottom Sieve</td>
<td>5-10 mm (start at 10 mm)</td>
<td>8-16 mm (start at 16 mm)</td>
</tr>
</tbody>
</table>

For further information see Farmnote 99/99 ‘Successful lentil harvesting’.  

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Uneven ripening in lentil. *Photo M. Seymour.*
crop is harvested before plants become too brittle, causing excess harvest losses.

**Swathing**

Lentil is suited to swathing, particularly in medium rainfall areas. A self-propelled swather is required to cut across the lay of the crop and a pick-up front is ideal if sufficient biomass is produced. Swathing in low rainfall areas can produce a small or thin windrow that is difficult to pick up.

**Direct heading**

Lentil crops are short and may lodge at maturity. Harvesting is easiest in a crop of uniform density on a flat soil surface, with the harvester either working into or across the direction that the crop has been laid by the wind.

Lentils are best harvested with crop lifters and finger tine reels. Most cereal crop lifters can be used, but since the lentil plant has many thin stems, a slim crop lifter will reduce the sideways movement of the plant. A lifter should ride on its flat section behind the tip, not on the point, to avoid damaging the lifter and soil being thrown into the front. Refer to harvesting field pea on page 40 for more information on using crop lifters.

A floating (flexible) cutter bar is ideal for harvesting lentils. Generally, harvest speed can be faster and there is less driver fatigue with a flexible cutter bar, because the knife will follow the ground contour and the driver does not need to concentrate as hard on maintaining correct height compared to a conventional front.

The set-up of a flexible cutter bar in relation to a tine reel is important since the extra movement of the knife can allow the knife to cut the tine reel fingers. For example, if a section of the knife floats up over undulating ground and the reel is set very low, the knife may hit the reel fingers.

Harvester settings will depend on crop foliage and seed moisture. The harvester settings suggested in the box above are a useful starting point.

**Lentil quality standards**

The minimum receive standard for Whole Red No. 1 grade lentil usually requires a 97% pure sample with a maximum of 4% defective seeds and a maximum of 14% moisture content. There is a nil tolerance for vetch seed and a low tolerance for doublegees and other pulses, including lupin. There is also a low tolerance for foreign, unmillable and objectionable material. The up-to-date details of receive standards are available on the Pulse Australia website. (www.pulseaus.com.au.)

**Further reading**


Growing common vetch

Mark Seymour

Introduction

Vetches (Vicia spp.) are winter growing annual legumes that are an excellent cropping option for the medium and heavy textured soils of Western Australia. Historically two species of vetch, common vetch (V. sativa) and purple vetch (V. benghalensis) have been grown in Western Australia on a small scale basis. Most vetch grown currently in Western Australia are the common vetch varieties Languedoc, Morava and Blanchefleur.

Common vetch has more potential as a grain crop in Western Australia than other vetch species. Common vetch is sold for use as birdseed (pigeons and specialty markets), seed for green manure, and in sheep and cattle rations. Trade out of Western Australia is usually in container lots and farmers contract to regional or Perth based traders. To maximise returns growers must be prepared to hold the grain on farm for extended periods of time (3-6 months). On farm prices fluctuate based on local demand and supply. Farm prices currently range from $180/t. Common vetch is sold more than once in three years. Also, avoid paddocks that have grown faba bean or narbon bean in the previous two years.

Select the right paddock!

- No more than one common vetch crop in the past three years.
- No more than one faba bean or narbon bean crop in the past two years.
- At least 500 m away from last vetch, faba bean, narbon bean, chickpea or lentil crop.
- Free from sulphonylurea residues.
- Medium to heavy textured soils (pH above 5.5).
- Low number of broad-leaved weeds.
- For efficient harvesting the paddock should be relatively even and free from sticks or stones.

Common vetch is difficult to control in lentil crops. Seeds are of similar size and appearance, and are very difficult to grade out. There is a nil tolerance of common vetch in lentil grain, so lentil should not be grown in close rotation with common vetch.

Vetch is increasingly being used as a green manure crop, and in some instances common vetch is manured in September prior to a summer crop being sown. Careful consideration should be given to the chemicals used in the common vetch crop to ensure they are not harmful to the summer crop (eg. Spinnaker®).

Ensure that at least two years has passed since sulphonylurea herbicides (Glean®, Ally®, Logran®) were applied in the paddock. Common vetch is sensitive to sulphonylurea herbicides and will be damaged if residues of these herbicides remain in the soil. These herbicides will break down within one to two years of application depending on soil pH, organic matter content, soil structure, and rainfall. Minimum plant back periods must be observed.

Soil type

Common vetch, like field pea, will grow well on a wide range of soils. Nodulation and plant growth will be best in neutral to alkaline soils (pH 6.0 to 8.0), but successful crops are often grown on soil with pH values ranging from 5.0-9.0 (CaCl₂). Highest yields have been obtained on well-drained clay-loam soils but common vetch can be grown very successfully on soil types ranging from shallow duplex (10 cm of sand over clay) to heavy clays.

Vetch produces sturdier stubble than field pea. Therefore wind erosion of sandy soils following a vetch crop can be more easily managed than following a field pea crop.

Common vetch does not tolerate waterlogging. Preliminary studies indicate that narrow leafed lupin tolerates a higher incidence and duration of waterlogging than vetch when grown on sandy duplex soils.
On heavier soil types reports are mixed, with many growers noting common vetch appears to recover better than field pea from a short duration (7-10 days) of waterlogging during the vegetative growth phase.

Suitable soils within the northern region include:

- Red clay loams to sandy loams such as those in the Mullewa, Morawa and Mingenew districts;

- Red brown loams over a clay subsoil such as the heavier salmon gum-gimlet and york gum-jam soils;

- Grey cracking and hard setting clay loam soils which are found in the medium and high rainfall zones from Dongara and Mingenew through to Moora.

Varieties

Languedoc is the suggested common vetch variety for the low rainfall areas of Western Australia. Medium rainfall growers should consider Morava due to its resistance to rust which is a potentially devastating disease. However, rust has not been widespread in Western Australia and the yield of the late flowering Morava has been variable, with very low yields in low rainfall seasons.

Sowing

Experiments conducted from 1997 to 1999 throughout the low and medium rainfall zones of southern Western Australia indicates that the best time to sow Languedoc vetch is May, and in most areas the second half of May produces the highest yields. Delayed sowing until June reduces yield and dry matter production by as much as 40% in low rainfall regions. In medium and high rainfall zones the effect on grain yield of delayed sowing until June will be less marked. The majority of experiments conducted in Western Australia have used the early flowering variety Languedoc. The varieties Blanchfleur and Morava are later flowering than Languedoc and may suffer greater yield loss from delayed sowing.

Optimum sowing time is a compromise between sowing early to provide adequate time for vegetative and reproductive growth, and sowing later to avoid frost and manage disease and weeds. Sowing common vetch in April has produced lower yields because of poor crop establishment and disease, and it increases the dependence on pre-emergent herbicides.

There is also the additional consideration of fitting in with other crops (cereal or canola) that may have priority in the seeding program.

Seed depth

Aim to sow common vetch at a depth of 5 to 8 cm. Sowing deeper than this can reduce emergence, particularly if the soil is susceptible to surface crusting. Placing seed less than 5 cm deep increases the risk that herbicides applied immediately after sowing will come in contact with the seed or developing roots. This risk is greater in sandy surfaced soils. There is also some evidence that shallow sowing makes plants more susceptible to insect and disease attack.

Common vetch can be dry sown if:

- the broad-leaf weed burden is low;

- the seeding rate is increased by 10 percent and the recommended rate of rhizobium is doubled;

- the seed has not been dressed with a fungicide;

- the soil is not hard setting or sodic.

Emergence of dry sown crops will be staggered and patchy, particularly on soils prone to non-wetting, and weeds are likely to be more difficult to control.

Sowing rate

The seeding rate of common vetch should be adjusted to achieve 40-60 plants/m². In general a seed rate of 50 kg/ha will provide this target density.

In areas where grain yield is expected to be above 1.5 t/ha a target density of 60 plants/m² is recommended. In all other areas 40 plants/m² is adequate, but there is no yield penalty in aiming for a higher density.

Establishing an even, healthy crop is the key to achieving consistently good seed yields of vetch. Low-density crops (25 plants/m² or less) compete poorly with weeds, are more attractive to aphids and are more difficult to harvest.

The seed rate required to achieve this density depends on seed size, germination percentage and field establishment.

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**Table 7. Recommended common vetch varieties (Vicia sativa) for the southern agricultural region**

<table>
<thead>
<tr>
<th>Variety</th>
<th>Languedoc</th>
<th>Blanchfleur</th>
<th>Morava</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended region</strong></td>
<td>Low rainfall</td>
<td>Medium to high rainfall</td>
<td>Medium to high rainfall</td>
</tr>
<tr>
<td><strong>Maturity</strong></td>
<td>Early</td>
<td>Mid-late</td>
<td>Mid-late</td>
</tr>
<tr>
<td><strong>Days to flowering</strong></td>
<td>98 (80-110)</td>
<td>116 (95-141)</td>
<td>117 (103-138)</td>
</tr>
<tr>
<td><strong>Seed size (mg)</strong></td>
<td>57</td>
<td>51</td>
<td>61</td>
</tr>
<tr>
<td><strong>Cotyledon colour</strong></td>
<td>Yellow to beige</td>
<td>Orange</td>
<td>Beige</td>
</tr>
<tr>
<td><strong>Flower colour</strong></td>
<td>Violet</td>
<td>White</td>
<td>Violet-purple</td>
</tr>
<tr>
<td><strong>Rust rating</strong></td>
<td>Susceptible</td>
<td>Susceptible</td>
<td>Resistant</td>
</tr>
<tr>
<td><strong>Protein (%)</strong></td>
<td>26</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td><strong>γ-glutamyl-β-cyanoalanine (%)</strong></td>
<td>0.95</td>
<td>0.72</td>
<td>0.80</td>
</tr>
<tr>
<td><strong>Shattering loss 12 days after maturity (%)</strong></td>
<td>14</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>
Only about 60-75 percent of the seeds sown, establishes in the field, depending on the conditions at sowing. Morava has larger seed than Languedoc or Blanchefleur and therefore normally requires a higher seeding rate.

Inoculating seed
Always inoculate common vetch seed with Group E inoculum. This applies regardless of the cropping history of the paddock. In situations favourable to the persistence of rhizobium in the soil, crops may nodulate without inoculation. Experience has shown, however, that often a less efficient rhizobial strain has nodulated the crop and nitrogen fixation is low. Therefore inoculation is recommended in all circumstances.

Inoculated seed must be sown within 24 hours of applying the inoculum. If more than 24 hours lapses, then reinoculate seed at the same rate recommended on the packet. The survival rate of rhizobium on inoculated seed that is sown into dry soil is lower than if it is sown into moist soil. The rate of inoculum for dry sowing, therefore, should also be increased in order to improve the chances of the rhizobium survival.

Fungicide seed dressings are toxic to rhizobia. If the seed has been dressed, then double the rate of inoculum and sow seeds as soon as possible after inoculating into moist soil. The rhizobium will quickly die if it is applied to fungicide-dressed seed and then sown into dry soil.

It is important to take care when inoculating seed. There are many cases where poor inoculation technique has caused crop failure. Peat sprinkled out of the bag onto seed as it is being augered into the seeder is quick but not effective. Slurry inoculation is the best way to ensure a well nodulated crop. Refer to page 23 in the chickpea section for more details on slurry inoculation.

Sowing method
Level paddocks after sowing by trailing harrows and a roller. This is important to ensure an efficient harvest. Rolling should take place immediately after seeding but on hard-setting soils, rolling may form a hard crust, which can reduce seedling emergence. In this case roll the paddock after the crop has established (2-3 leaves present or 3-4 weeks after emergence). When rolling established plants do not roll in the mornings when plants are stiff but wait until mid afternoon. Don’t roll 2-3 weeks before or after post emergence herbicide because plants will be more prone to herbicide damage. Common vetch can be rolled immediately prior to flowering without too much physical damage, but plants will be more prone to disease. Vetch is well suited to both no-tillage and conventional seeding methods. Crop growth will usually be improved if common vetch is sown into cereal stubble. In many no-tillage operations where press wheels are used, the ridges formed may need harrowing prior to rolling.

Fertiliser
Fertiliser requirement is similar to other pulses. In most situations a maintenance application of 70-150 kg/ha superphosphate is all that is required. A starter dose of 10-12 kg nitrogen/ha at seeding may stimulate the early growth of plants if soil pH is less than 6 in CaCl₂ or the soil has a low nitrogen status. This level of nitrogen is low, so it won’t inhibit nodulation, but there is also no clear evidence that it will increase crop yields.

On calcarceous, alkaline soils vetch may show extreme yellowing of new leaves in mid winter. This is thought to be iron deficiency. The symptoms usually disappear within 2-3 weeks. Other trace element deficiencies have not been reported in vetch grown in Western Australia.

Weed management
There are few post emergent herbicides registered for broad-leaved weed control in common vetch crops. Therefore, as many broad-leaved weeds as possible should be controlled, prior to crop emergence. There is also nil tolerance to cereals in many high value common vetch markets. Read labels and check with your Department of Agriculture pulse agronomist for advice on herbicide use in vetch crops.

The majority of growers use either a Diuron+Trifluralin mix or Spinnaker®. Spinnaker® is preferred when sowing into very heavy stubble where Trifluralin is less effective.

When choosing herbicides consider crops that will follow common vetch within the rotation. Canola and many summer crops may be affected by residual herbicide and the continuous use of Trifluralin in both cereal and common vetch crops increases the risk of developing herbicide resistant weeds.

Lifters used during harvest can dig into wheel ruts left by spraying vehicles so avoid spraying when the soil is very wet and use low-pressure tyres.

Croptopping
Common vetch is very well suited to croptopping to reduce ryegrass seed set. The canopy of vetches often collapses prior to the ryegrass flowering, leaving the ryegrass heads above the common vetch crop making chemical application of contact herbicides particularly effective.

Croptopping also allows for earlier harvest of the common vetch because it desiccates the crop and brings on an even maturity.

The correct timing for croptopping is when 75 percent of the lower pods are yellow-brown and the seed has started to harden. The tips of the plants and upper pods will be green. Alternatively, aim for when the top third of the ryegrass seed head is at soft to hard dough and the heads will have started to change from green to yellow. Desiccating the common vetch crop too early will result in smaller seeds, reduced yield and increased proportion of immature seeds in the sample. A common chemical used is 600-800 mL/ha of Gramoxone 250.

The common vetch crop will be ready to harvest a very short time after croptopping; in some cases 1-3 days. Consideration must be given to the 14-day harvest-withholding period of Gramoxone used in this process.
Insect management

Seedling pests
During emergence till about two weeks after emergence check for red legged earth mite, lucerne flea, cutworm and bryobia mite. Common vetch is very susceptible to attack by red legged earth mite at emergence.

Two main strategies can be used to control seedling pests in common vetch. Their usefulness will depend on the relative abundance of the different pests. Note: these seedling pests are potentially more of a problem coming out of a pasture phase.

1. Apply an appropriate insecticide with the knockdown herbicide spray. This will be effective in controlling lucerne flea, cutworm and bryobia mite. It may also be effective against red legged earth mite if the season has a late break.

2. If bryobia mite and red legged earth mite are the major pests then apply an appropriate insecticide as a bare earth spray, prior to emergence of the crop.

For both these strategies check the crop after emergence to ensure the production and expansion of new leaves is occurring at a faster rate than damage is occurring by the remaining insects. If not, a second post emergent insecticide spray may be required.

These insects cause damage that is usually seen soon after the crop emerges. Threshold levels for their control have not been determined for vetch in Western Australia. Heavy infestations will severely retard plant growth.

Aphids
Inspect the crop from early vegetative growth until pod fill at about 10 locations in the paddock and spray insecticide if aphids are present on more than 30% of plants inspected at these locations. The black cowpea aphid is the most common aphid found on vetch. Look closely at the growing points of the plant where aphids develop their infestations. Some aphid species, particularly cowpea aphids, colonise clumps of plants or attack weaker plants and thin patches in the crop.

Damage from aphids tends to be greater in drier regions and seasons. Aphids can also cause damage by spreading viruses.

Native budworm
Native budworm is an important pest of common vetch. The timing of insecticide sprays is critical in order to protect early pods from attack. Don’t wait for the caterpillars to grow; spray immediately.

Monitoring should occur at regular intervals throughout pod development. At least 5 lots of 10 sweeps should be made at several locations in the crop. Spray thresholds will depend on grain prices (see Chapter 5). A good rule of thumb is to spray insecticide if the number of caterpillars average more than 1 caterpillar per 10 sweeps. Synthetic pyrethroids are best and will prevent re-infestation for up to 6 weeks after application. Usually one well-timed spray is sufficient to control native budworm in most vetch crops. It is nevertheless important to always maintain a monitoring schedule, even after spraying.

If left uncontrolled, native budworm caterpillars will reduce yields by eating the developing grain. The insects will also damage grain, inflicting a price penalty if the limits for exceeding the minimum level of grub damaged seeds is exceeded.

Other pests
Etiella web moth, weevils, false wireworm, slugs and snails are also occasional pests of common vetch that need to

When to monitor for insects

Break of season to two weeks after crop emergence:
• Monitor for mites, lucerne flea and cutworm.

Early vegetative growth to early pod fill:
• Monitor for aphids.

From start of flowering:
• Monitor for native budworm.

Check PestFax for regular updated information on insect pests and diseases.
be checked for and controlled if populations begin to build up. Further details are provided in Chapter 5.

**Fungus disease management**

Botrytis grey mould, chocolate spot, ascochyta blight and rust are important diseases of common vetch in Western Australia. Effective and profitable management of these diseases is possible using a combination of crop rotation, paddock selection, time of sowing and ensuring good plant health. Fungicide use alone is unlikely to provide an economic return. Vetch is an alternate host for diseases of faba bean, chickpea and lentil. The following strategies should be used to minimise fungal disease:

- Isolate the crop from potential inoculum sources by avoiding paddocks that have been sown to vetch in the past three years, or faba bean or narbon bean in the two previous years. Also avoid paddocks that are within 500 m of last year’s faba bean, common vetch, narbon bean, chickpea or lentil stubble.
- Ensure volunteer common vetch has been well controlled in the previous crop.
- Use the variety Morava in high rainfall areas to reduce incidence and severity of rust infection.

Refer to Appendix 1 for fungicides.

**Virus disease management**

For vetch the main virus disease is Bean Yellow Mosaic Virus (BYMV).

The key control measures are: sow seed from a virus-tested seed stock with <0.1% virus infection, and promote early canopy development by sowing at recommended seeding rates to shade over early infected plants and deny aphids access to them. This will also reduce aphid landing rates.

Adequate stubble groundcover will help decrease spread by also reducing aphid landing rates. Isolation from other grain legume crops and legume pastures that are potential virus sources will help avoid spread of infection into the crop from external sources. Further information on diseases can be found in Chapter 4.

**Harvesting**

Common vetch is ready to harvest when the pods are light brown and the seeds rattle within the pods when shaken. Pods can be shed and shatter if harvesting is delayed. Common vetch sown in May will mature in mid-late October. Languedoc will mature at or before Dundale field peas. Blanchefluer and Morava will be ready to harvest 10-14 days after Languedoc.

Grain should be delivered with 14 percent moisture content. Crops have been successfully harvested with

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*Pam Burgess in a vetch crop at flowering. Photo M. Seymour.*

*Chocolate spot in vetch. Photo M. Seymour.*

*Grey mould in vetch. Photo by M. Seymour.*

*Aphids in Vetch. Photo M. Seymour.*
moisture contents of 13-16%. If grain at 16% moisture is left in a stack it will naturally dry out. Early harvest will reduce yield loss at harvest and may improve the seed size and colour.

Common vetch is best harvested across the lay of the crop using crop lifters and finger tine reels. The lifters should be spaced so as to fit the shortest length of the vine to be harvested. Normally this is 300 mm. A lifter should ride on its flat section behind the tip, not on the point, to avoid damaging the lifter as well as soil being thrown into the front.

Most harvester fronts can be tilted, so once lifters are fitted, the harvester front angle should be adjusted. The lifters should have adequate travel for the conditions. The finger tine reel or pick-up reel should be set forward and lower than the knife to reach down and gently lift the crop over the knife. The finger angle is adjustable and should be set perpendicular to the top edge of the lifters. The ideal option is to link reel speed to ground speed.

Floating flexible cutter bars or flexi-fronts are ideal as the knife can follow the ground contour and stay very close to the ground without extreme driver concentration as required with conventional fronts.

Pea plucker fronts can be used, but because common vetch is more firmly anchored to the soil than field pea, excessive soil may be thrown into the harvester. Screens on the clean grain and repeat elevators may help remove soil from the grain. If the crop is not harvested or swathed on time and continues to lodge, a plucker may be the only way of harvesting the crop.

Common vetch may be swathed when the top pods are still green and the bottom 75 percent of pods are yellow-brown and the seed is just hardening. This is the same timing as for croptopping or desiccation. Grower experience since 1998 has been that the vetch windrows are quite stable in most wind conditions. To further reduce the risk of the wind moving the rows, the swath may be rolled.

**Forage and hay**

Once established, common vetch can be grazed. Depending on intended end use, it is best to let common vetch grow to a height of 10-15 cm before grazing, and then only graze to within 3-5 cm of the ground. Remove sheep at or near flowering. Common vetch produced for hay should be cut a few weeks after the start of flowering.

Historically oat-vetch mixes have been widely used to produce a good quality hay. Use 15-25 kg/ha of common vetch and 30-60 kg/ha oat seed. Horses prefer a higher proportion of oats in the mix, while ruminants prefer a greater legume component. Oat-vetch mixes will respond to nitrogen up to rates of 30 kg nitrogen/ha. Use high rates of nitrogen when the proportion of vetch is reduced.
**Green manure**
The best time to green manure vetch is often a compromise between killing weeds (most commonly resistant ryegrass) and achieving maximum biomass and nitrogen production of vetch. Most farmers aim for maximum effect on ryegrass.
Common vetch can be quite hard to kill at the late flowering-early pod set stage. Often glyphosate alone will not kill the crop. Experience has shown that Lontrel® (50-300 mL/ha) added to high rates of glyphosate (1-2 L/ha) hastens the kill. However in some situations it may still be necessary respray or graze the crop to kill regrowth.

**Handling and storage**
Common vetch seed can be easily damaged. Most visible damage is when the grain is split but less obvious damage can occur to the seed coat, which will reduce the germination rate. Seed sold for cover crops in orchards must have a germination percentage of 95 percent.
To minimise damage the following steps should be adopted:
- keep handling to a minimum;
- use grain belt conveyors rather than augers;
- augers, if used, should be run slowly and full;
- avoid handling the seeds when very dry or brittle; and
- avoid dropping seed from heights.
In Western Australia the seed of common vetch is easily stored in any rainproof enclosure, shed or silo.
The minimum receival standard for farmer dressed common vetch is 97 percent purity by weight with a maximum moisture content of 14 percent and a maximum of 5 percent defective seeds. Specific up to date standards for common vetch receival and export are available on the Pulse Australia website (www.pulseaus.com.au).

**Further reading**

<table>
<thead>
<tr>
<th>Suggested harvesting settings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Component</strong></td>
</tr>
<tr>
<td>Reel speed</td>
</tr>
<tr>
<td>Drum speed</td>
</tr>
<tr>
<td>Concave clearance</td>
</tr>
<tr>
<td>Fan speed</td>
</tr>
<tr>
<td>Top sieve</td>
</tr>
<tr>
<td>Bottom sieve</td>
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</tbody>
</table>

Harvesting vetch using a draper front. *Photo M. Seymour.*
Growing narbon bean

Mark Seymour

Introduction
Narbon bean (Vicia narbonensis) is a winter growing annual legume with a semi-erect growth habit. It has been grown for centuries in Mediterranean countries as a fodder. Only since the 1990’s has it been used as an agricultural plant in Western Australia. Breeding during the late 1980’s and 1990’s led to the release of the first Australian variety, Tanami, which is suitable for grain, fodder and green manure.

Narbon bean is well suited to low and medium rainfall parts of the Western Australian agricultural zone where it produces about 70 percent of the yield of field pea. Farmers already growing field pea may find narbon bean useful to include in the rotation as part of their blackspot reduction strategy.

Narbon bean grain may also be used for on-farm sheep and cattle feed rations. Humans, pigs, chickens and other monogastric animals however, find the grain of narbon bean unpalatable due to the presence of a sulphur compound, Y-Glutamyl-S-propenyl-cysteine (GEC).

Paddock selection
When selecting a paddock to grow narbon bean, consideration must be given to the following:

• the crops and herbicides in the paddock in the past three years and in the neighbouring paddocks in the past year;

• the suitability of the land to grow narbon bean.

To minimise the risk of fungal disease narbon bean should not be grown on the same paddock more than once in three years. Similarly avoid paddocks that have grown a crop of chickpea, faba bean, lentil or vetch in the previous two seasons.

The paddock should also be at least 500 metres away from the stubble of last year’s narbon bean, faba bean, chickpea, lentil or vetch crop.

To minimise the risk of herbicide damage ensure that at least two years has passed since sulphonylurea herbicides (Glean®, Ally®, Logran®) were applied in the paddock.

Soil type
Narbon bean will grow on a wide range of soil types from coarse-textured sandy soils to fine-textured clay soils with a pH range of 5.0 to 8.0 (CaCl_2). Loam and clay soils with good fertility are the most suitable.

Narbon bean tolerates waterlogging better than lentil, field pea and chickpea, but less than faba bean. Narbon bean appears to be well adapted to sodic and high boron soils.

Narbon bean will grow on all soils suitable for field pea production. However, it will not perform as well as field pea on sandy soils.

Suitable soils within the northern region include:

• Red clay loams to sandy loams such as those in the Mullewa, Morawa and Mingenew districts;

• Red brown loams over a clay subsoil such as the heavier salmon gum-gimlet and york gum-jam soils;

• Grey cracking and hard setting clay loam soils that are found in the medium and high rainfall zones from Dongara and Mingenew through to Moora.

Other considerations
Narbon bean can be grown in areas receiving between 250 to 650 mm annual rainfall. They are more suited to low rainfall (<350 mm) conditions than faba bean. In high rainfall regions (>400 mm) narbon bean takes less advantage of good growing conditions than faba bean, producing lower yields and is more likely to lodge.

Choose paddocks relatively clear of sticks and stones. Rolling the paddock following sowing, although not essential, will make harvesting easier.

Select a paddock that is relatively free of broad-leaved weeds.

Choosing varieties

Tanami is the first and currently the only cultivar released in Australia. It was bred and selected by researchers from Victoria at the Mallee research station in Walpeup. Tanami was released because of its good agronomic performance combined with consistently low levels of GEC in the seed.

In Western Australian trials the average yield of narbon bean (1.2 t/ha) over six years (1993-99) on multiple sites, soils and sowing times was 70 percent of...
yield of field pea (1.7 t/ha). Based on these and other studies narbon bean are included in the group of grain legumes, including field pea, common vetch and faba bean, that have wide adaptation to south-western Australia.

At flowering time (90 days after sowing) Tanami has produced 2-3 t/ha of dry matter in most years. Once flowering has commenced growth rapidly increases and narbon beans can produce 4-5 t/ha of dry matter by the end of the growing season. In most years this level of dry matter production is similar to that produced by field pea and faba bean. However, both faba bean and field pea appear to have a greater capacity to respond to favourable growing conditions than narbon bean and can produce dry matter in excess of 5 t/ha.

**Sowing**

In low rainfall areas (<350 mm) narbon bean can be sown from late April to mid June. Plants appear moderately tolerant of frost during the vegetative and reproductive stages. Sowing after mid June in low rainfall environments will limit both dry matter and seed production.

In medium and high rainfall areas (>350 mm) it is best to sow in May. Sowing in April will increase the risk of fungal disease and lodging.

Aim to sow narbon bean at 5 cm. If in doubt sow deeper rather than shallower. Seed placed at 5 cm is less likely to be damaged by herbicides applied before or immediately after sowing. Rhizobium inoculated on the seed will also survive longer and provide better nodulation, because soil temperatures and moisture are usually more favourable at this depth compared with shallow depths.

**Sowing rate**

Sowing rate experiments conducted with the narbon bean line SA26554 in Western Australia over two years indicate the optimum density is 31-33 plants/m², this is equivalent to the sowing rates of about 75 to 100 kg/ha.

**Inoculating seed**

Inoculate narbon bean with Group E inoculum, which is also used for field pea and vetch. Always inoculate seed regardless of the cropping history of the paddock to ensure the most efficient rhizobium strain nodulates the plant. Seed should be sown within 24 hours of inoculation. Seed inoculation is an important operation. There are many cases where poor inoculation technique has caused crop failure. Slurry inoculation is the best way to ensure a well nodulated crop.
See page 23 in the chickpea section for more details of inoculation procedure.
There is no need to dress narbon bean seed with a fungicide.

**Fertiliser**

Narbon bean requires similar amounts of fertiliser as other grain legumes. Maintenance applications of phosphate equivalent to 10 kg/ha of phosphorus are recommended. A starter dose of nitrogen (up to 10 kg/ha) at sowing may be useful, particularly on soils with a pH less than 6.0 (CaCl₂). This rate of nitrogen has been shown to increase early plant growth but has not yet been shown to increase grain yields. This low level of nitrogen will not impair nodulation. The required level of nitrogen and phosphorus can be applied as 50-60 kg/ha of diammonium phosphate (DAP).

**Weed management**

There are no chemicals registered for use in narbon bean grown for seed or grain. Herbicide tolerance experiments have shown narbon bean to be tolerant to a wide range of herbicides. Read labels and check with your Department of Agriculture pulse agronomist before applying herbicide. Non selective control of weeds is possible by grazing the crop once it has reached the 6-node stage.

Prior to a cereal crop being sown, a knockdown herbicide often in combination with 2,4D amine or ester provides adequate control of narbon bean. To control narbon bean within a cereal crop use a mix of 400 mL/ha of 2,4D ester and 70 mL/ha of Lontrel®.

**Insect management**

**Seeding pests**

Monitor for red legged earth mite, lucerne flea, cutworm and bryobia mite.

Two main strategies can be used to control seeding pests in narbon bean. Their usefulness will depend on the relative abundance of the different pests. Note these seeding pests are potentially more of a problem coming out of a pasture phase.

1. Apply an appropriate insecticide with the knockdown herbicide spray. This will be effective in controlling lucerne flea, cutworm and bryobia mite. It may also be effective against red legged earth mite if the season has a late break.

2. If bryobia mite and red legged earth mite are the major pests then apply an appropriate insecticide as a bare earth spray, prior to emergence of the crop.

For both these strategies check the crop after emergence to ensure the production and expansion of new leaves is occurring at a faster rate than damage is occurring by the remaining insects. If not, a second post emergent insecticide spray may be required.

These insects cause sporadic damage that is usually seen soon after the crop emerges. Threshold levels for their control have not been determined for narbon bean in Western Australia. Heavy infestations of these insects will severely retard plant growth.

**Aphids**

From early vegetative growth to early pod fill inspect the crop at about 10 locations in the paddock and spray insecticide if aphids are present on more than 30% of plants inspected at these locations. Look closely at the growing points of the plant where aphids develop their infestations. Some aphid species, particularly cowpea aphids, colonise clumps of plants or attack weaker plants and thin patches in the crop.

Damage from aphids tends to be greater in drier regions and seasons. Aphids can also cause damage by spreading viruses or making plants more susceptible to fungal disease.

**Native budworm**

Monitoring should occur at regular intervals throughout pod development. At least 5 lots of 10 sweeps should be taken at several locations in the crop. Spray thresholds will depend on grain prices (see Chapter 5). A good rule of thumb is to spray insecticide if the number of caterpillars average more than 2 per 10 sweeps. Synthetic pyrethroids are best and will prevent re-infestation for up to 6 weeks.
after application. Usually one well-timed spray is sufficient to control native budworm in most narbon bean crops. It is nevertheless important to always maintain a monitoring schedule, even after spraying.

If left uncontrolled, native budworm caterpillars will affect yields by eating the developing grain. Budworm caterpillars feeding on narbon bean can also introduce fungal infections that may cause further yield loss or damage to the grain.

**Other pests**

Etiella web moth, weevils, false wireworm, slugs and snails are also occasional pests of narbon bean that need to be checked for and controlled if populations begin to build up. Further details are provided in Chapter 5.

**Fungus disease management**

Target spot, ascochyta blight and chocolate spot have been observed on narbon bean trials or farmers crops in Western Australia. These diseases however have not limited growth or reduced yields. Fungal diseases may become more prevalent as the area of narbon bean expands. Other diseases that have been found on narbon bean elsewhere in Australia include grey mould and staphylyium blight.

Sowing crops away from potential sources of inoculum is the best way to reduce both current and future disease levels. Ensure there is at least a two year break between narbon bean and other crops that host the same diseases as narbon bean: faba bean, vetch, lentil or chickpea. In low rainfall areas a narbon bean/wheat/barley/narbon bean rotation is suitable for effective disease management. In the medium and high rainfall zones a rotation that substitutes field pea or canola for the second narbon bean in the rotation is required.

Stubble is likely to be the main source of disease infection, so locate this year’s crop at least 500 m away from the stubble of last year’s narbon bean, faba bean, vetch, lentil or chickpea crop.

**Virus disease management**

Narbon bean may become infected with four viruses commonly found in Western Australia, alfalfa mosaic virus (AMV), bean yellow mosaic virus, (BYMV), cucumber mosaic virus, (CMV) and pea seed borne mosaic virus (PShMV). It is very susceptible to BYMV and PShMV, and has lower susceptibility to CMV.

Management of viruses in narbon bean has not yet been thoroughly researched, but it is likely be similar to that already developed for other grain legumes:

- Clean seed (<0.5% CMV virus infection for low rainfall zones but a more stringent threshold of <0.1% for the riskier high rainfall zones);
- Sow at recommended seeding rates of 75 to 100 kg/ha to promote early canopy development. This will help shade out seed-infected plants thereby reducing spread by aphids from them to healthy plants;
- Retain stubble to deter aphid landings and reduce virus spread prior to canopy closure.

In high rainfall areas where BYMV is endemic to subterranean clover pastures, a perimeter sowing of cereals will help reduce BYMV spread into the crop from outside. Further information on diseases can be found in Chapter 4.

**Harvesting**

Narbon bean is easier to harvest than many other grain legumes because of their semi-erect growth habit. In most years, growers will be able to harvest narbon bean with conventional machinery. In some situations the crop may lodge and crop lifters will be required.

Narbon bean is ready to harvest when the pods are brown to black, like faba bean. Harvester settings will depend on crop foliage and seed moisture.

Tanami seed is of similar size to narrow-leafed lupin (150-160 mg). The seed coat is dark brown and has a prominent white hilum (scar on the seed coat marking the point of attachment to the pod). Removal of the seed coat will expose a bright yellow cotyledon.

There is no established domestic or export market for narbon bean. Currently narbon bean is used as a fodder, green manure or grain for livestock on farm.

**Green manure**

Narbon bean is well suited for use as a green manure. The crop should be manured prior to seed set. In most parts of Western Australia growers should aim to manure narbon bean 100-120 days after sowing.

Chemicals suitable to kill Tanami for green manuring include:

- 1.2 L/ha of Glyphosate and 70 mL/ha of Lontrel®
- 400 mL /ha of 2,4D ester and 70 mL/ha of Lontrel®

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**Suggested header settings**

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<td>Bottom sieve</td>
<td>10-15 mm (start at 15 mm)</td>
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</table>
**Fodder**

Green narbon bean samples taken prior to flowering typically have a protein content of 16-17 percent and a metabolisable energy content of 9.4 MJ/kg DM. Trials conducted in Victoria, showed lambs introduced to narbon bean crops at flowering, first selectively grazed grass and broad-leaved weeds. Eventually they became accustomed to the narbon bean crop and, over a four-week period, live weight gains of up to 331 g/day were obtained. Narbon bean can also be used as a dry feed.

**Stockfeed**

Narbon bean grain has a protein content of 23-28 percent which is similar to field pea. Narbon bean seed should only be used in ruminant diets. The presence of GEC in the seed makes it unpalatable to monogastrics. When fed to ruminants, narbon bean can be used as a substitute for field pea, vetch or lupin. It can be fed as whole grain. Weaner lamb on diets containing a narbon bean supplement (fed at 1 % and 2 % of initial body weight in combination with pasture), were similar to that of lambs fed field pea or vetch.

**Further reading**

Growing lathyrus

Kerry Regan, Colin Hanbury and Peter White

Introduction
There are two main species of lathyrus, Lathyrus sativus (grasspea) and Lathyrus cicera (dwarf chickling or vetchling). Both species have been cultivated since ancient times. Currently, lathyrus is mainly grown in India, Bangladesh and Ethiopia where the grain is harvested for human food and animal feed.

Lathyrus is still in the early stages of development as a commercial crop in Australia and is intended as a multipurpose crop for feed grain in cattle and sheep, fodder, hay and green manure. The crop grows slowly during winter, but produces leaves, flowers and pods rapidly in spring. It is well adapted to a wide range of soil types and environments and currently has few disease problems in Western Australia.

Lathyrus is relatively tolerant to waterlogging and a wide range of post-emergent herbicides. It has good resistance to red legged earth mite and does not produce hard seed. Seed yields of lathyrus have averaged about 75% to 90% of field pea in the south eastern region of Western Australia. Harvesting lathyrus is more difficult than field pea. It is recommended that farmers have experience growing and harvesting field pea before they consider producing lathyrus for seed.

Seed of lathyrus contain a toxin known as ODAP (oxalyl diamino propionic acid), which, when eaten in large quantities, and as the main part of the diet can cause lathyrism. The most obvious symptom of lathyrism is paralysis of the legs in animals and humans. ODAP was discovered in the 1960’s, and breeding has since reduced the concentration of ODAP in the seeds of modern varieties to safe levels. ODAP concentrations of 0.7 % are common in the seed of traditional varieties and land races. Modern cultivars available in Western Australia have ODAP levels below 0.1% providing an excellent grain for feed with no ill effects.

Paddock selection
When selecting a paddock to grow lathyrus, consideration must be given to the following:

• the crops and herbicides in the paddock in the past two years;
• the suitability of the land for lathyrus this year.

Lathyrus is sensitive to sulphonylurea herbicides and will be damaged if residues of these herbicides remain in the soil. These herbicides will break down within one to two years of application depending on soil pH, organic matter content, soil structure, and rainfall. Minimum plant back periods must be observed.

Lathyrus does not share the same serious foliar diseases like botrytis grey mould and ascochytia blight common in other pulse crops. Therefore, isolation from stubble of other pulses is not necessary. However, non-specific legume diseases, such as sclerotinia, will occur if legumes are grown on the same paddock for several years.

Soil type
Lathyrus is adapted to a wide range of soil types similar to field pea, but will also tolerate some waterlogging.

Ideally, the soil should have a loamy sand texture or heavier and a pH greater than 5.0 (CaCl₂). This will help ensure plants grow vigorously and are well nodulated (if inoculated).

Paddocks should also be relatively even and free from sticks or stones. This will ensure the crop can be harvested without the risk of damage to headers by passing rocks or sticks into the threshing drum.

Other considerations
Lathyrus is a poor competitor with weeds and only Broadstrike® is registered for post-emergent weed control in the crop. Selecting a paddock that is relatively free of broad-leaved weeds therefore will make weed management easier.

If the stubble is going to be used for grazing, consider the soil erosion risk.

Varieties
Lathyrus produces seeds about half the size of a field pea. The seeds are smooth, but angular (3.5-8.0 mm) with a reddish grey seed coat and pale yellow cotyledon. Two varieties of Lathyrus cicera are available to Australian growers: Chalus and Lath-BC. Chalus is preferred because of its lower ODAP levels. Chalus is more suited to warmer areas, Lath-BC to cooler areas. Both varieties have similar yields.

Ceora is the only variety of Lathyrus sativus available to Australian growers. Ceora has slightly lower levels of ODAP and higher levels of protein in the seed compared with Chalus. Forage quality is similar between the two varieties. Lathyrus sativus is more vigorous, more tolerant to waterlogging and less liable to collapse at maturity than Lathyrus cicera.

Sowing
Sow lathyrus anytime from early April through to June in all rainfall zones.

Early sowing allows greater dry matter production and more bulk to the crop leading to easier and more efficient harvest. Unlike other pulse crops, early sowing does not promote disease. On the other hand, Lathyrus is a poor
Aim to establish a crop of 50 to 80 plants per m² for grain crops and 70 to 80 plants per m² for forage crops. The higher densities should be used where growing conditions are less favourable and individual plant growth is limited, such as in low rainfall and short season environments. The lower densities should be used in more favourable growing environments where individual plants have a better chance to express their yield potential. In general, higher sowing rates will increase forage yield.

**Inoculating seed**
Always slurry inoculate seed with Group F inoculum. Lathyrus seed should be inoculated with rhizobia regardless of the cropping history of the paddock. Seed needs to be sown within 24 hours following inoculation. Re-inoculate seed if it is stored for longer than 24 hours. Seed inoculation is an important operation. There are many cases where poor inoculation technique has caused crop failure. Peat sprinkled out of the bag onto seed as it is being augered into the seeder is quick but not effective. Slurry inoculation is the best way to ensure a well nodulated crop.

**Levelling the paddock**
If the crop is to be harvested for seed then roll the paddock at sowing to provide an even soil surface. Make sure ridges have been flattened and large sticks and stones have been pushed into the soil. This will allow a low harvest height to be achieved.

On most soils it is best to roll the paddock immediately after sowing. On soils that form surface crusts that hinder emergence, roll after the plants have emerged and reached 3 - 5 node stage.

At sowing, paddocks can be levelled with harrows and then rolled with a rubber tire or steel roller. If the paddock is rolled after plants have emerged then ensure it occurs two weeks before or after the application of post emergent herbicides.

**Fertiliser**
Apply a maintenance application of 5-10 kg/ha phosphorus and 10-15 kg/ha of nitrogen. This can be applied most conveniently as 60 - 80 kg/ha diammonium phosphate (DAP).
**Weed management**

Lathyrus grows slowly during winter and does not compete well with weeds. The slow early winter growth of lathyrus means that sowing can be delayed without substantial yield penalties. This will allow a good percentage of weed seeds to germinate and then be controlled by a knockdown herbicide. A sufficient rate of knockdown must be used, as transplants will be difficult to manage.

Trials have shown that lathyrus tolerates a range of broad-leaved and grass herbicides, but few of these are registered for grain crops. Read labels and check with your Department of Agriculture pulse agronomist before applying herbicides.

**Insect management**

During emergence until about two weeks after emergence check for red legged earth mite, lucerne flea, cutworm and bryobia mite. Lathyrus is relatively tolerant to these seedling pests so infestations are unlikely, nevertheless, it is important to monitor plants as they emerge. If infestations are present and damaging the crop then apply control measures as described for early season pests of field pea (page 38).

**Native budworm**

From early podding onwards, check for native budworm. Native budworm is the most important insect pest of lathyrus in Western Australia. The timing of insecticide sprays is critical in order to protect early pods from attack. Don’t wait for the caterpillars to grow; spray straight away.

**Suggested harvesting settings**

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<td>Bottom sieve</td>
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</table>

Monitoring should occur at regular intervals throughout pod development. At least 5 lots of 10 sweeps should be made at several locations in the crop. Spray thresholds will depend on grain prices (see Chapter 5). A good rule of thumb is to spray insecticide if the number of caterpillars average more than 2 caterpillars per 10 sweeps. Synthetic pyrethroids will prevent re-infestation for up to 6 weeks after application. Usually one well-timed spray is sufficient to control native budworm in most lathyrus crops. It is nevertheless important to always maintain a monitoring schedule, even after spraying.

If left uncontrolled, native budworm caterpillars will severely reduce yields by eating the developing grain. Further details are provided in Chapter 5.

**Disease management**

No serious diseases have been recorded on lathyrus to date. Powdery mildew and downy mildew can be serious but are less likely to occur under Western Australian conditions. Field trials have shown lathyrus to be susceptible to bean yellow mosaic virus (BYMV) but this is less likely to be a serious problem in broadacre crops, especially in low rainfall areas.

**Harvesting**

Maturity is evident when pods lose their green colour and plants become brittle.

With experience, dense crops are relatively easy to harvest.

**Case Study**

**Finding a fit for lathyrus**

The 2003 season saw Chris Broun ask 14 of his clients to each trial 500 kg of lathyrus (variety Chalus). All the crops did extremely well, with one finally yielding 1.5 t/ha. Chris was wanting a crop for the duplex soil type and gravel areas, where lupin and field pea are not ideally suited and tend to die off. Chris was also looking for a crop which: could be put in early; tolerates simazine well for silver grass control; was able to be cropped; and was resistant to root lesion nematodes.

In the future Chris is looking at sowing a mixture of lathyrus and lupin together on stubble paddocks which have been burnt, and letting the season and the incidence of brown spot determine the resulting harvest mix.

Chris reckons that harvesting lathyrus is very similar to field pea. One of Chris’s clients also found that lathyrus could be successfully windrowed with a stubble rake. The pods appear very resistant to shattering and the lathyrus vine does not ball and clump together.

The harvested lathyrus seed was used on farm and has been found to produce higher lamb weight gains than lupin.
but thin and uneven crops can be a problem. Use crop lifters as described for harvesting field peas (page 40). Pick-up reels are better than batt reels. Cutting height must be close to the ground. Do not delay harvesting because pod shattering may occur after rain and the crop will collapse on the ground, making harvest difficult. Soil can also stick to the plants after rain, which will be brought into the header.

Harvester settings will depend on crop foliage and seed moisture.

**Lathyrus quality standards**

There is no trade for lathyrus grain in Australia, so no receival standards have been developed for this crop.

**Further reading**


Handling and storage

Glen Riethmuller and Chris Newman

Introduction
Handling and storage conditions will have a large impact on the quality of pulse grain and effectiveness of measures to control storage pests. Pulses are more sensitive to rough handling and poor storage conditions than cereals. Factors during handling and storage that have been found to adversely affect the quality and viability of pulse seed are:

- high impact forces;
- high temperature;
- high relative humidity;
- high seed moisture content;
- light exposure; and
- an extended storage period.

These factors may impact on the suitability of the grain for a range of end uses, and hence, affect the price received for the grain. For example, storing grain at high temperatures may lead to darkening of the grain and reduced cooking qualities. Darkened grain, especially in chickpea and faba bean, decreases market price. Reduced cooking qualities lead to increased energy requirements to cook, poor palatability and reduced protein quality. Physical damage to seed may make the grain unsuitable for splitting, canning as whole seed or for use in sprouting.

Poor handling and storage of pulses will also adversely affect grain kept for seed. Weed seeds mixed with the grain during storage, such as green wild radish pod, can severely reduce seed germination. Similarly, poor handling can damage the seed and reduce its viability. For example, the germination percentage of field pea seed can be substantially reduced if moved with a pneumatic grain conveyor, where grain is sucked or blown at high velocity, creating high impact forces.

There is a range of insects that attack pulses in storage in Western Australia. Pea weevil (Bruchus pisorum) is the most serious. It completes its life cycle inside the field pea seed while in storage, hollowing out the grain. The drugstore beetle (Stegobium paniceum) and the cow pea weevil (Callosobruchus spp) are other insects that have been detected in long term storage. These insects can cause substantial damage and can only be effectively controlled under well maintained storage conditions.

Grain handling
Pulse grain is much more susceptible to impact damage than cereal grain. Effective handling and storage of pulse grain on farms must consider the points listed below:

Seed moisture
High seed moisture reduces the likelihood of mechanical handling damage to pulses. Pulses can be delivered at 14% seed moisture so harvesting as early as possible to get close to 14% seed moisture is the easiest way to reduce mechanical damage to seed.

Soft handling
Pneumatic grain conveyors should be avoided for pulses because the impact speed of grain on grain is higher than the critical 12 metres per second. Augers smaller than 125 mm in diameter should also be avoided. Augers should be run full and preferably run slowly to reduce seed damage. It is easier to reduce the speed of augers driven by petrol engines than augers driven by electric motors. Augers should be as short as possible and used at the lowest possible angle. Typically, auger flighting all-round clearance to the tube wall is six millimetres but worn augers can be more than this, which can create churning and more seed damage.

Belt conveyors (either flat belt or tube) cause less damage than augers because the seed is carried gently along the belt without the aggressive mixing that occurs with augers. If an auger is used then run it full and at a slower

Excellent splits are produced by the nice round shape of kaspka seed that has few dimples. Photo R. Beermier.
speed than for cereals. Augers with a large gap between the flighting and the barrel are less likely to jam. If an auger has been used for fertiliser or is very rusty inside, first run the seed with the auger not full (close the choke at the bottom), until the rust is removed because, seed such as chickpea, with a rough seed coat, can jam the auger.

Dropping seed onto a hard surface or other grain from a great height can damage the seed. Bean ladders have been used in Canada to reduce damage from falling grain. They consist of a vertical tube inside the silo that cascades the grain backwards and forwards to reduce grain impact speed due to gravity.

**Loading and unloading**

Silos are designed to withstand uniform downward and significant uniform outward forces. Because of this they must only be loaded from the central top hatch. Loading from the topside hatch will unbalance the lateral forces on opposite sides of the silo. This may effectively distort the shell of the silo, placing extreme pressure on the side of the silo holding the high side of the stack. The same principles apply when out-loading. Only empty from the bottom central opening. Don’t use the bagging off chute unless the silo is designed to withstand off-centre loads. The off-centre pressures applied to the support frame also places uneven forces on the concrete pad. Failure to construct a pad to the design specifications may result in foundation failure, placing a sudden unbalanced distribution of forces on the silo. Failure or collapse of the silo could follow.

**Rounded grains**

Rounded grain, like field pea, presents a particular management problem because of their lower angle of repose and the different forces they apply. The rounded seeds exert higher than normal pressures on the walls. When transferred to the lower sections of the silo wall, these forces may cause a crimping or pleating effect. This problem has been observed in elevated and flat bottom silos. When this occurs on only one side, the silo may lean or collapse completely.

**Grain cleaning**

Grain put in silos at harvest, without aeration, will retain its heat and remain warm for many months. The temperature and moisture at which grain is stored will determine the length of time it can be stored without spoilage. For example, the CSIRO Stored Grains Research Laboratory found chickpea could be stored for nine months without spoilage from fungi if stored at a temperature of 20°C and moisture content of 13%. But if the temperature was raised to 30°C it could only be stored for 9 months if seed moisture content was reduced to 12%.

Cooler grain temperatures have several advantages:

- seed germination percentage is maintained longer;
- lower temperatures allow moist grain to be stored safely for longer periods;
- moisture migration is reduced;
- insect breeding and hot spots are prevented from developing.

Cleaning is particularly important for field pea and lentil that may have more soil in the sample than other pulses because of their low harvest height.

**Grain storage**

**Cooling grain**

Grain put in silos at harvest, without aeration, will retain its heat and remain warm for many months. The temperature and moisture at which grain is stored will determine the length of time it can be stored without spoilage. For example, the CSIRO Stored Grains Research Laboratory found chickpea could be stored for nine months without spoilage from fungi if stored at a temperature of 20°C and moisture content of 13%. But if the temperature was raised to 30°C it could only be stored for 9 months if seed moisture content was reduced to 12%.

Cooler grain temperatures have several advantages:

- seed germination percentage is maintained longer;
- lower temperatures allow moist grain to be stored safely for longer periods;
- moisture migration is reduced;
- insect breeding and hot spots are prevented from developing;

Grain cleaning is particularly important for field pea and lentil that may have more soil in the sample than other pulses because of their low harvest height.
Silo distorted when out loading lupin. Photo C. Newman.

- mould growth is slowed;
- less air and gas exchange occurs through the pressure relief valve of sealed silos as warm grain cools, and;
- darkening of the seed coat is slowed.

Painting the silo white after installation on the pad is a useful management tool. A white, painted silo can be 4°C cooler than a weathered galvanised unit. This could double the safe storage period of grain.

An aeration attachment is a valuable addition for storing pulses that should be considered when buying a new silo. Aeration allows grain to be harvested earlier and at higher moisture levels. This improves the quality of the grain. Aerated silos are fitted with fans that push air through the grain. When aerated correctly, this cools the grain and equalises the moisture and temperature throughout the silo. With an aeration system, a vent is installed on the top of the silo to allow the air that is forced in at the base of the silo to escape. This can be a waterproof perforated lid in place of the sealed lid or a venting tube that can be capped for fumigation.

Fans are run for extended periods during the first few days of storage. An average of 12 hours using the coolest and driest air of the day is common. For longer-term storage, aeration fans are run for a few hours when needed. The amount of cooling achieved during storage depends on the moisture content of the grain and the humidity and temperature of the incoming air. Western Australian trials have shown that correctly controlled aeration can reduce grain temperature to 20°C or lower throughout summer.

Before deciding to fit an aeration unit, it is important to plan the final destination of the grain. If the grain is to be fed out or used for seed on the property, aeration will keep insect damage at a low level. If the grain is to be transported off the property for sale, it must not contain live insects. Aeration alone does not guarantee insect free grain. The grain may have to be fumigated.

**Preventing moisture migration**

Grain loaded into sealed silos must be of sufficiently low moisture content to prevent moisture migration problems. If a load is rejected because of excess moisture, do not load this grain into a sealed silo unless the silo is aerated. Moisture can migrate and condense in the upper layers. This area of grain is at high risk of mould or insect colonisation.

Moisture in a silo comes from three sources:
- the stored grain itself and any weed seeds or impurities;
- respiration of insects or mites in the grain, and;
- water entering through a leak.

Grain moisture is carried upwards in a silo by convection currents of air. These air currents are created by the temperature difference between the warm grain in the centre of the silo and cool walls or vice versa. In an aerated silo the moisture migration pattern is stopped because the entire stack is normally cooled to one temperature - usually 20°C or below.

When grain is stored at less than 14% moisture and free of insects, the moisture increase in the upper layers of the grain will not be significant. If it is stored above 14% moisture content, enough moisture may be carried into the upper layers to place the grain at risk of going mouldy.

When the grain contains insects such as native budworm in large numbers, increased moisture can cause a damp mouldy layer across the top of the grain.

Discolouration of faba bean seed at differing storage temperatures. Photo N. Abbas.
Retain quality seed for sowing

Seed kept for sowing should be taken from a fertile area of the paddock where the crop grew well and was free of weeds and seed-borne diseases. The seed should be harvested at a minimum moisture content of 13% (but up to 16% is better) to reduce mechanical damage by the harvester and handling equipment. If heat drying is necessary, do not dry the seed with air temperatures above 40°C and only dry to 13% seed moisture. Clean the seed immediately to remove foreign material such as soil and small or broken seed and fumigate immediately, for pea weevil or other insect pests. Ideally aerate to reduce the seed temperature to below 20°C. Always test the viability of the seed because field weathering can lower germination percentage. Consider buying new seed if the germination test is less than 80% because the seed batch may lack vigour.

Field pea seed infested with pea weevil. Photo S. Eyres.

Insect control

Firstly maintain good hygiene to reduce the overall numbers of insects on the property. This is a fundamental requirement for protecting stored grain in all situations.

Secondly before harvest time, clean all silos then burn or bury residues. Pulse seed can become infected with cereal insects if the silo’s previous cereal seed was infected. Treat the inside of silos with a suitable insecticide to provide residual control until the grain is loaded into the store. Do not load the new crop onto old grain in the silo.

The grain temperature must be above 15°C before it can be effectively fumigated. Below 15°C insects may not be controlled by the fumigation. Be aware that, field pea may be harvested early and aerated to even out the moisture and temperature but this may also cool the grain below 15°C if an aeration controller is used.

When new grain is loaded it is essential to fumigate the silo to the recommended standard. Fumigate as soon as the grain is loaded to prevent moisture creation by any insects that are present. To control pea weevil a very high standard of sealed silo is needed. The fumigation needs to achieve 100 ppm of phosphine for 21 days. The three-minute half-life pressure test is the minimum standard required.

To test your silo, blow air into it using a compressor. Create a difference of 25 mm in the levels in the oil bath pressure relief valve. Then watch the oil levels and check the time taken to fall to 12 mm difference. This should be no less than three minutes.
A new silo from the factory will be able to reach this standard but the silo should be tested annually to make sure it can retain its pressure. The silo hatches must be checked for rubber seal damage and the pressure relief valve filled with oil to the correct level.

Fumigation of a poorly maintained silo will not control insects effectively. Gas will be lost, and insects may survive with a degree of phosphine resistance.

Grain in a well-maintained sealed silo may be protected indefinitely by adding two phosphine-generating tablets per tonne of silo capacity (internal volume of the silo). A 50 tonne silo holding only 30 tonnes of grain still needs 100 tablets to effectively fumigate the grain. This rate will create sufficient gas to achieve complete control of pea weevil. Place the tablets on the surface of the grain in trays. Observe the correct fumigation period related to the species of the insects present (of the common pulse pests, pea weevil requires the longest period at 21 days).

Even though the fumigation has been carried out to instructions and the silo remains closed, check the grain at regular intervals for insect infestation.

Phosphine leaves no detectable residue when applied correctly and treated grain may be delivered at the bin without penalty but a declaration must be made. It is illegal to deliver grain with partly decomposed tablets of phosphine. Phosphine if applied at the recommended rate will not reduce seed germination.

Malathion® is the only insecticide registered for application to grain by farmers in Western Australia. However Malathion® resistance is widespread throughout the state and you should consider other insect control methods whenever possible. Where insects are still susceptible to Malathion® it will protect grain for three to six months.

Fenitrothion is the only other chemical registered for treatment of grain handling machinery or empty storages after cleaning. Never use fenitrothion or any other insecticide for protecting grains. Fenitrothion leaves a residue in the grain, which is unacceptable in many foreign markets. If used for empty silos there is only potential for a minute amount to transfer into the grain.

Further reading


Chapter 4

Diseases of pulses

Bill MacLeod, Vivien Vanstone, Roger Jones and Jean Galloway

Introduction

Fungi, bacteria, nematodes and viruses all cause diseases in pulses. These organisms may be blown in by the wind, brought in by insects, carried by infected seed or established in the soil. The type of organism and the method of introduction of the disease determine the options available for management.

It is necessary to correctly identify a disease and have a general understanding of its characteristics in order to manage it effectively. The Crop Management sections (see chapter 2) of this manual explains strategies to manage the major diseases for each individual crop. In this Chapter, the symptoms of main diseases and their disease cycles are described. The principals behind the management of each disease are also outlined.

The diseases in this section are those that are likely to be encountered and cause yield loss in pulse crops in Western Australia, a few minor diseases, which may be confused with yield limiting diseases, are also described.

The word “management” is used here to describe the series of decisions that start from paddock selection and go through to stubble management and grain storage, that can be used to reduce the likelihood of disease infecting the crop and building to damaging levels. “Control” is used to describe practices that may be used to minimise the impact of disease on yields once it has been observed in the crop.

Fungal and bacterial diseases

The fungal diseases that affect pulses in Western Australia predominantly cause leaf and stem symptoms. Many of the root rot diseases also occur but rarely cause significant yield loss. There are a number of diseases, which appear to be common between several different hosts; the most notable of these is the disease called “ascochyta blight.” A different fungus on each crop in fact causes this disease (refer to Table 12.)

Root and crown diseases caused by Rhizoctonia and Sclerorinia fungi are pathogens common to most pulse crops. These are discussed in the section on root diseases.

Bacterial blight of field pea is the only bacterial disease of pulses that occurs in Western Australia.

Chickpea

Ascochyta blight

Ascochyta rabiei only infects chickpea and is the most serious disease of commercial chickpea crops in Western Australia. The disease has caused significant yield losses in all the chickpea growing areas, except the Ord River Irrigation Area where it has not yet been detected.

Table 12. Important diseases of chickpea, faba bean, field pea and lentil, occurring in Western Australia

<table>
<thead>
<tr>
<th>Disease</th>
<th>Host crops</th>
<th>Pathogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascochyta blight</td>
<td>Chickpea, faba bean,</td>
<td>Ascochyta rabiei</td>
</tr>
<tr>
<td></td>
<td>field pea</td>
<td></td>
</tr>
<tr>
<td>Blackspot (Ascochyta blight)</td>
<td>Chickpea, fava bean,</td>
<td>Mycosphaera pinodes, Ascochyta pisi, Phoma</td>
</tr>
<tr>
<td></td>
<td>field pea</td>
<td>medicaginus</td>
</tr>
<tr>
<td>Botrytis grey mould (BGM)</td>
<td>Chickpea, vetch, lentil,</td>
<td>Botrytis cinerea</td>
</tr>
<tr>
<td></td>
<td>(faba bean, field pea)</td>
<td></td>
</tr>
<tr>
<td>Chocolate spot</td>
<td>Faba bean, vetch (lentil?)</td>
<td>Botrytis fabae</td>
</tr>
<tr>
<td>Sclerotinia white mould</td>
<td>All broadleaf crops,</td>
<td>Sclerotinia sclerotiorum, Sclerotinia minor</td>
</tr>
<tr>
<td></td>
<td>(field pea, faba bean)</td>
<td></td>
</tr>
<tr>
<td>Rust</td>
<td>Faba bean, vetch</td>
<td>Uromyces vicia-fabae</td>
</tr>
<tr>
<td>Cercospora leaf spot</td>
<td>Faba bean</td>
<td>Cercospora zonata</td>
</tr>
<tr>
<td>Alternaria leaf spot</td>
<td>Faba bean</td>
<td>Alternaria alternata</td>
</tr>
<tr>
<td>Downy mildew</td>
<td>Field pea (vetch)</td>
<td>Perinospora vicae</td>
</tr>
<tr>
<td>Powdery mildew</td>
<td>Field pea</td>
<td>Erysiphe polygoni</td>
</tr>
<tr>
<td>Septoria</td>
<td>Field pea</td>
<td>Septoria pisi</td>
</tr>
<tr>
<td>Bacterial blight</td>
<td>Field pea</td>
<td>Pseudomonas syringae pv. pisi</td>
</tr>
<tr>
<td>Rhizoctonia root and hypocotyl rot</td>
<td>All pulses including lupin</td>
<td>Rhizoctonia solani#</td>
</tr>
</tbody>
</table>

* Crops in brackets sometimes act as alternative hosts for the pathogen but do not suffer significant yield losses from the disease.
# There are strain differences between host crops. For R. solani one strain causes root or hypocotyl disease on pulses, however different strains cause root rots in canola and other crops.
The overall appearance of ascocytta in a chickpea crop depends on susceptibility of the variety grown and the level of fungicide protection that has been applied. In susceptible and unprotected crops, patches of plants that appear stunted become evident in the crop. The stunted appearance results from branches and leaves that have broken due to ascocytta infection. New branches that have grown during periods of dry weather, and thus, have not yet been infected, may also be evident on these plants. Stem and leaf breakage is less common in varieties with moderate resistance to the disease or in crops that have received an early fungicide application. In these crops the patches of stunted looking plants do not develop. Lighter coloured areas resulting from dead leaves and leaf lesions can, however, still be seen.

Closer examination of leaf, stem and pod will reveal spots with brown margins and grey centres. It is these lesions on stems that cause them to break, wilt and die. This stem damage causes the majority of the yield loss associated with this disease. Tiny black specks (called pycnidia) will develop in the grey centre of spots (lesions) as they enlarge. The fungus is carried to new areas in infested seed batches. The seeds themselves may be infected, or small pieces of infected trash may be carried with the seed. Seed infection levels as low as 0.1 percent can cause significant disease outbreaks in new crops. Spores from pycnidia that develop in lesions formed on seedlings grown from infested seeds are moved by rain-splash to adjacent plants. The predominantly local spread from these initial infection points produces a patchy appearance from low levels of seed infection. After flowering, infection of pods can lead to infected seed.

After harvest, the infected stubble also carries the infection into the next season. The fungus can survive as pycnidia and fungal growth (mycelium) on chickpea stubble for up to 20 months in Western Australia. After the break of the season, wetting of the infected stubble will cause the release of rain splashed spores (conidia) from the pycnidia. The rain-splash spores are spread, usually only a few metres, to new plants where they produce new lesions that form pycnidia in 6 to 12 days, depending on temperature. The cycle then proceeds as described for seed borne infection. Small pieces of stubble, such as pods and leaves, can be blown several hundred metres in a crop. If this stubble contains pycnidia, then new infections can start long distances away from the original source of infection.

The sexual stage (Didymella rabiei) of the ascocytta fungus was first identified in Western Australia in 2002. It develops on the previous season’s stubble after exposure to cold, wet conditions in winter and produces ascospores (dry spores) that are spread by wind in mid-to-late winter. Ascospores may infect crops at more than a kilometre from the previous season’s stubble.

The most effective ways to manage this disease are to: minimise introduction of the disease on seed; isolate the

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Chickpea Ascocytta is spread within the crop by rain splash. The patch in the plot has spread to the east (right of photo) from the initial point of infection as indicated by the white marker. *Photo W. MacLeod.*

Leaf and pod infection of chickpea showing tan lesions with concentric rings of black specks or pycnidia. The pycnidia on all parts of the plant produce spores which are splashed by rain onto other leaves, stems and pod on the same plant and nearby plants, some spores are blown by the wind several metres. *Photo W. MacLeod.*
new crop from the previous season’s stubble to minimise infection of the crop by wind-blown trash and spores and maintain a wide rotation to stop the disease carryover within a paddock. After the crop is established, fungicides are required early in the season to reduce early infection and disease spread. Additional fungicide sprays may be required depending on the resistance of the variety and the frequency of rain during the growing season.

**Botrytis grey mould**

*Botrytis cinerea* causes two diseases in chickpea: the most important of these is a stem disease known as botrytis grey mould; the other, a damping-off disease of seedlings called botrytis seed-borne root rot, has not been observed in Western Australia. Botrytis grey mould has caused serious crop losses in the northern cropping areas of Western Australia. The fungus that causes botrytis grey mould has a wide host range and can infect other pulse crops including lentil, vetch, faba bean and field pea.

Kabuli chickpea is more susceptible than desi types to both botrytis grey mould and botrytis seed-borne root rot. Chickpeas with vigorous seedling growth, early canopy closure and early flowering are more likely to develop botrytis grey mould than other varieties.

The most obvious symptom of botrytis seed-borne root rot is a reduction in plant establishment. Seedlings that develop from infected seed, sown without a fungicide seed dressing, may emerge but die within a few weeks. This disease is a major concern in southeastern Australia.

The symptoms of botrytis grey mould become apparent in late winter and spring. Dead plants or dead branches, scattered throughout the crop are the first obvious symptoms. The disease usually first appears around flowering time, when the crop canopy is fully developed and the weather is warm and humid. These conditions favour infection and disease development.

Close inspection of plants will reveal the presence of a fluffy grey or grey-brown mould on the outside of the dead branches, particularly under a closed canopy or lodged plants. Infection will spread out from the plants first infected by the disease to form patches of dead plants. Infections usually first take hold in areas of the crop that are densely sown such as headlands that have been double sown, or in areas damaged by vehicles.

A less conspicuous symptom of botrytis grey mould is a reduction in the number of pods, this results from flower infection. During favourable (humid and warm) weather flowers can become infected more easily than other plant parts. The infected flowers abort and do not set pods. Infected flowers are easily dislodged leaving no conspicuous symptom of botrytis grey mould.

The botrytis fungus can also infect pods after flowering and be carried into the next season through infected seed. Spores produced on dead seedlings can be blown onto nearby plants and produce secondary infections in warm and humid weather.

The fungus survives over summer on the previous season’s stubble as fungal growth (mycelium). It also produces sclerotia (fungal survival structures) in response to cold,
Botrytis grey mould on chickpea stems has a grey/brown downy appearance, the stems above the infection die leading to the typical scattered dead plants or patches in a crop. *Photo W. MacLeod.*

Botrytis grey mould of chickpea pods can lead to seed abortion if infection is early or seed infection, if the seed is well formed at the time of infection. *Photo W. MacLeod.*

wet winter conditions. The fungal growth and sclerotia produce spores in spring once daytime temperatures are greater than 20°C. Spores produced on stubble can be blown several hundred metres to initiate infection in new crops.

The best ways to manage this disease are to avoid the use of botrytis grey mould infected seed. Isolate this year’s crop from the previous season’s stubble of chickpea, vetch and lentil, to minimise infection by trash and spores blown into the crop by the wind. Also maintain a wide rotation both of chickpea and other potential host crops. Observe the recommended sowing times and seed rates, don’t sow too early or with seed rates that are too high. Fungicides are usually not a cost-effective means of controlling this disease, however, reduction of botrytis grey mould disease is usually a side benefit of the fungicide application for ascochyta blight control.

**Field pea**

**Blackspot**

Any one or combination of three fungi may cause blackspot in field pea. All three can occur together and symptoms caused by each may not be easily distinguished from the other. The disease is generally referred to as the ascochyta-, or blackspot-complex of field pea. The organisms involved are:

*Mycosphaerella pinodes* – leaf spot, blight

*Phoma medicaginis var. pinodella* – foot rot

*Ascochyta pisi* – leaf and pod spot

*Mycosphaerella pinodes* causes the most damage to field pea crops in Western Australia, and is the principal pathogen involved in nearly all occurrences of blackspot. *Phoma medicaginis* is occasionally found on infected stems of field pea, while *Ascochyta pisi* is not common in Western Australia.

The disease initially appears as small, dark, irregular flecks on leaves, stems and pods. Lesions enlarge in weather conditions favourable for the disease, such as when rain is frequent and humidity is high. Sometimes lesions on the leaves show concentric rings in alternating shades of tan and brown. Stem lesions enlarge to become long, wide streaks that are blue-black or purplish. These often join together to completely girdle stems, leaf stalks or tendrils. The disease damages the base of the stem and blights leaves, stems, pods and flowers.

These fungi can be seed borne. In Western Australia most seed-borne infection is by *Mycosphaerella pinodes,*
although *Phoma medicaginis* may also be found. Up to 45 percent of seeds from areas receiving over 350 mm of rain per year may carry black spot infection. Seed from areas with less than 350 mm per year are almost free from infection. Work conducted in Victoria has shown that seedlings grown from infected seed often die but there is no relationship between level of seed infection and disease development within the crop.

The black spot fungi can survive as dormant spores in the soil. In South Australia a soil test has been used to predict disease risk in paddocks. In Western Australia it does not seem that *Mycosphaerella pinodes* survives in the soil at a sufficient level to justify a soil test for blackspot fungi. *Mycosphaerella pinodes* survives on pea stubble for more than three years, and produces viable ascospores during each growing season in Western Australia. Very large numbers of ascospores are released from the first year stubble (ie 6-10 month old stubble in the growing season following the harvest of that crop). There is a substantial reduction in spore production as the stubble ages, but sufficient numbers to cause disease are still released in subsequent years. Ascospores are released from fruiting bodies (perithecia) on the stubble following rain events as low as 0.2 mm. These ascospores are airborne and can infect crops several kilometres away.

Isolating the new crop from sources of infection and not sowing too early are the best methods of managing blackspot in field pea. This will minimise the exposure of the crop to spores produced from previous seasons’ stubble and to minimise the period of favourable conditions during which the disease can develop. A sound strategy for neighbouring farmers is to group field pea paddocks into blocks starting in the south west corner of their properties and move the blocks each year towards the prevailing pre frontal winter winds (usually north westerlies). This prevents new crops from being sown next to last year’s field pea stubble on the neighbouring farm. Fungicides applied as seed dressings, in-furrow fertiliser amendments or foliar sprays do not reduce disease nor increase yield sufficiently for them to be recommended for field pea production in Western Australia. In the majority of experiments in Western Australia there has been no measurable increase in yield except where foliar fungicide has been applied at 2 or 3-week intervals throughout the growing season.

**Septoria**

*Septoria pisi*, is widespread and present in most field pea crops. However, it remains a minor disease in Western Australia, having not been known to become severe enough to cause significant yield loss. This disease causes yellow to straw coloured blotsches on older leaves. Black specks, which are the fruiting bodies of the fungus, are visible in the blotches. The fungus is a different species to those which cause septoria diseases on cereals. It survives over summer on infected field pea stubble and produces wind blown spores early in the growing season. *Septoria* is managed by the same measures, as those required that manage black spot (ie rotation, isolation and avoidance of early sowing).

**Downy mildew**

Low levels of downy mildew are sometimes noticed in field pea crops late in winter, appearing on the older, lower leaves. This disease rarely needs any specific intervention because crops grow away from it during the longer warmer spring days. The usual symptom of downy mildew is pale yellow-green blotches visible on the upper surface of leaves. When the leaf is inverted to view the underside of the blotch, it is covered with a fluffy mouse-grey spore mass.

**Powdery mildew**

Powdery mildew is rare in field pea crops in Western Australia, no specific intervention is required to management this disease. The usual symptoms of powdery mildew are off-coloured spots on the upper surface of older (lower) leaves; these spots later develop a white, powdery appearance. Small black specks, which are the fruiting bodies of the fungus, develop in older lesions.

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**Research Update**

Research by Jean Galloway revealed that the fungi that cause blackspot survives on field pea stubble for more four years under Western Australian conditions, however the bulk of the spores are released from the stubble in the first year after harvest. Spore release is triggered by rain events and spores are spread for considerable distances by wind associated with these rain events. Summer and autumn temperature and rainfall govern the timing of this spore release. Blackspot management requires separating field pea crops from the previous seasons’ field pea stubble and delayed sowing. The ‘Blackspot Manager’ is a decision support tool that predicts when spores will be released based on weather records. The outputs of this model can be used to optimise time of sowing based on local weather and selection of low risk paddocks based on proximity to previous seasons’ field pea stubbles. Information on the spore maturation process and the recommendations for sowing can be accessed from the seasonal predication site on the Department of Agriculture’s Website, or through publications such as Agmemo, On the Pulse and PestFax. The Blackspot Manager has successfully been used and ground-truthed in conjunction with the Pulse Association of the South East to plan the safest paddocks for field pea.
Bacterial blight

Bacterial Blight is rarely seen in Western Australia. The disease is seed-borne; therefore the most likely source of infection for field pea growers in Western Australia is through introduction with seed purchased from southeastern Australia. In Victoria and southern New South Wales, bacterial blight is more common, and severe outbreaks occur about once a decade. Field pea growers in Western Australia who retain their own seed, or source it from within the state, are unlikely to encounter this disease.

Bacterial blight appears as dark green, “water soaked” lesions, usually where the leaf base attaches to the stem; the lesions become browner as the leaves dry out. The infected plants tend to occur in patches around an initial infected source such as infected seed or plant debris. To spread and infect, the bacteria need a damaged area on the plant where it can enter. Hail, frost or machinery passing through the crop can cause this damage and hence create entry points for the bacteria.

The most effective way to manage this disease in Western Australia is to ensure that seed sourced from outside the State is tested and certified as disease free. If a crop becomes infected with bacterial blight it is unlikely the disease will develop to yield limiting...
Cercospora leaf spot of faba bean produces lesions that have irregular edges that may develop a ring pattern inside the spot. They can be distinguished from ascochyta blight because they do not develop black specks (pycnidia) on a grey centre. Photo W. MacLeod.

Faba bean seed infected by ascochyta blight have dark lesions which result from pod infections. Photo W. MacLeod.

severity. Do not use grain from that field for seed and harvest your seed source prior to harvesting your infected paddock.

**Faba bean**

**Ascochyta blight**

Ascochyta blight (*Ascochyta fabae*) can occur in all faba bean growing areas but the disease is only conspicuous and yield limiting in the medium and high rainfall parts of the central and southern agricultural areas. In these areas, ascochyta blight usually appears within eight weeks of sowing. Ascochyta infection will predispose crops to chocolate spot infection.

The first symptoms are grey spots that show through on both sides of the leaves. As the spots on leaves, stems and pods enlarge they develop grey centres which contain many black specks these are the fruiting bodies (pycnidia) of the fungus.

Herbicide damage (particularly simazine) can be mistaken for ascochyta blight, but lesions do not have the grey centre with black specks and are usually confined to the edges of leaves. The minor diseases alternaria leaf spot and cercospora leaf spot may also be mistaken for ascochyta blight.

Pod infection occurs during cool and moist weather at podding, and can cause seed infection and discolouration. This may lead to the grain being downgraded to a lower value category.

A faba bean crop may become infected by ascochyta blight from two major sources; firstly, the use of infected seed; secondly, spores produced on stubble from the previous year’s faba bean crops landing on this year’s crop.

Sowing infected seed is the primary way ascochyta blight is introduced into new faba bean growing areas. In areas where faba bean has been established for several years, spores produced from old faba bean stubble cause a far greater number of infections.

The fungus can survive on faba bean stubble for more than one season. Ascospores (windborne spores) are produced in fruiting bodies (pseudothecia) formed on the
previous season’s stubble after autumn rains and exposure to cold temperatures (<10°C). In areas south of the Great Eastern Highway peak ascospore release occurs from mid-June onwards. The ascospores are carried onto new crops by wind after the stubble has been wet by rain. They can be blown further than a kilometre, but most land within a few hundred metres. Ascospores are produced for the remainder of the growing season.

Once a crop has become infected, secondary spread is by conidiospores (wet rain-splashed spores) that are produced in pycnidia (the black specks in older lesions) formed on leaves and stems. Conidiospores mostly spread only short distances to adjacent leaves by rain splash. Some conidiospores may be blown several metres by the wind that accompanies rain fronts. After landing on a susceptible leaf, the spore will germinate and initiate a new infection if the leaf surface remains wet for 12 to 24 hours.

The weather is, therefore, the principal factor in translating disease risk into disease severity. Infection can occur at any stage of plant growth following either rain or heavy dew. Ascochyta blight requires cool conditions for infections to grow, and frequent rains to move spores about and provide moist conditions for their germination. The disease is particularly favoured by conditions in the high rainfall (above 450 mm) area south of Perth where the colder temperatures promote the development of ascospores and rain is more frequent and leaves remain wet for longer periods. In these conditions plant growth is also slower so ascochyta blight is more conspicuous and leads to greater yield loss.

The most effective way to manage this disease, in the central and southern agricultural areas is to use an integrated management package that includes varieties that are at least moderately resistant to the disease (such as Fiesta). More resistant varieties such as Farah or Ascot will be required in southern high rainfall areas that favour this disease. The other components of the integrated package are to isolate new crops from the previous season’s stubble to minimise the spread of infection into the crop by wind blown spores, and maintain a wide rotation to minimise the disease carryover within a paddock. Additionally, in areas where ascochyta blight occurs regularly, fungicides may be required early in the season to minimise early infection and disease spread. In regions where faba bean has not been grown, or not grown for several years, take care not to introduce the disease by sowing infected seed.

**Chocolate spot**
Chocolate spot (*Botrytis fabae*) can occur in all faba bean growing areas but is most damaging in warm humid conditions such as occur in early spring. Under favourable conditions chocolate spot can spread rapidly and cause significant yield losses within a few weeks. This disease causes yield loss mainly through flower abortion leading to reduction in numbers of pods. Once established and conspicuous within a crop, chocolate spot is very difficult to control with fungicides when weather conditions favour disease spread. Aggressive development of stem infection late in the season can cause parts of the crop to lodge.

Infection starts as small red-brown spots on leaves, stems and flowers. The spots on leaves and stems enlarge and develop a grey, dead centre with a red-brown margin. Chocolate spot kills flowers and, in severe epidemics, also kills stems.

Damage caused by red legged earth mite can be mistaken for chocolate spot. This starts as silvery patches on leaves that become red-brown, similar in colour to chocolate spot. The patches are usually irregularly shaped and do not show through to the other side of the leaf. Patches may be on both sides of the leaf but the shapes will not match through the leaf. Red legged earth mite damage mostly occurs during the seedling stage and on the lower leaves, whereas chocolate spot does not usually become obvious until the onset of flowering.

Risk of infection of a crop by chocolate spot is increased by:
- sowing near stubble from a previous year’s faba bean, or other host crop;
- early sowing;
- low plant vigour;
- insect, chemical or physical damage and
- infection by ascochyta blight.

![Chocolate spot of faba bean. Photo P. White.](image)
Chocolate spot initiated from infected seed is of minor importance except in the absence of other sources of spores, such as in districts where beans have not been grown for several years.

The chocolate spot fungus survives on faba bean crop debris over summer. Conidiospores (dry wind borne spores) produced on pieces of stubble are carried by wind onto new crops to initiate infection early in the season. Conidiospores can be carried over distances of a kilometre or more, but most will fall within a few hundred metres. More conidiospores are produced on dead leaves and flowers of plants that have become infected within a crop. Spores are splashed or blown to other leaves and plants to spread the infection throughout the crop.

Weather is the main factor that translates disease risk into infection and then to disease severity. Chocolate spot spreads most aggressively in warm and humid conditions. The optimum conditions are temperatures between 15 and 22°C with high humidity (above 90 percent). Infection will still develop but more slowly at lower temperatures. Vetch, and to a lesser extent narbon bean and lentil, can also be infected by the chocolate spot fungus and can act as an alternate host for this disease in the absence of faba bean.

The impact of chocolate spot can be minimised by isolating new crops from the previous season’s stubble, and by ensuring that faba bean crops are not grown in the same paddock more often than every fourth year. After the crop is established, prophylactic fungicide application is required to protect the early flowers. Chocolate spot can be very difficult to identify at this stage but fungicide sprays are still required because the disease can develop rapidly causing the loss of many flowers. Varieties with improved resistance to chocolate spot are being developed through the national faba bean breeding project.

Rust

Rust, caused by Uromyces vicia-fabae, is not widespread in Western Australia but moderate levels of disease have been recorded in the Esperance and Katanning regions. Individual crops in some years have suffered yield losses. Rust has not yet been identified in the central or northern agricultural areas.

Not long after infection rust produces small creamy, yellow spots on leaves. These are the spore masses of the fungus. The spots are soon replaced by the familiar orange/brown pustules (uredinia) surrounded by a pale halo (similar in appearance to rusts on cereal crops) on leaves and stems. Uredinia leave a rust-like deposit when wiped with your finger; this deposit are the spores, which can be dispersed by wind to create further infections. Later in the season, rust infections on the stem appear as black/brown masses usually surrounded by a pale halo. This is the telial, or resting stage, of the fungus which allow it to survive over summer.

Risk factors for infection of a crop with rust are:
- sowing seed contaminated with infected debris;
- spores produced on infected stubble from previous faba bean crops; and
- spores produced on volunteer bean plants in the previous year’s bean stubble.

The fungus survives on infected debris from previous faba bean crops; the spores produced from this stubble infect volunteer bean plants directly without the need for an alternate host. Rust spores from stubble and volunteers are carried to new crops by wind. Infection of volunteer beans is thought to be an important factor in the early development of rust epidemics.

Rainfall or dew is necessary for spores to infect after they land on a susceptible plant. Within 2-3 weeks new pustules form on the infected leaves and stems. Spores are blown from these to spread the disease to other plants and other crops. Severe rust infections cause reduction in the green leaf area during pod filling and also premature defoliation. This results in smaller seeds and yield losses of up to 30 percent. Yield losses can be much higher where rust occurs as a mixed infection with chocolate spot.

Management of rust through rotation and isolation from sources of infection are consistent with the management for ascochyta and chocolate spot. Fungicide application may also be required in some circumstances. Spraying is necessary when the leaf area affected by rust exceeds 5% before the end of flowering. Varieties with improved resistance to rust are being developed by the national faba bean breeding project (eg. Cairo).
**Cercospora and alternaria leaf spot**
Alternaria and cercospora are widespread but usually minor diseases throughout the agricultural area of Western Australia. But cercospora may be becoming more severe (see Research Update below). Both diseases are sometimes mistakenly identified as ascochyta or chocolate spot causing unnecessary fungicide application. Alternaria leaf spot produces lesions that have a red-brown margin which contain obvious concentric rings. Cercospora leaf spot produces lesions that are darker and have irregular edges which may develop a ring pattern. Both diseases can be distinguished from ascochyta as the spots do not produce black specks (pycnidia) on the grey centre.

**Lentil**

**Ascochyta blight**
Ascochyta blight (*Ascochyta lentis*) occurs on lentil in all areas of Western Australia, but is more likely to be conspicuous in the cool, southern high rainfall areas. Current commercial varieties are unlikely to suffer significant yield losses, but pod infection is likely to result in seed discolouration that may reduce the market value of the grain.

All above ground parts of the plant can be affected. Light brown or tan spots, surrounded by dark margins, are seen on the leaflets, pods and stems. The centre of the spot is light coloured and speckled with tiny black specks (pycnidia) that are characteristic of the disease.

Ascochyta blight is spread primarily by seed infection. Very high (>90 percent) levels of seed infection have been recorded on susceptible varieties (eg. Cumra) in Western Australia.

The fungus survives for two seasons on infected stubble. Fruiting bodies (pseudothecia) form on the previous season’s stubble in response to autumn rain and cold temperatures. Windborne ascospores are released from these fruiting bodies following rain. These ascospores can spread considerable distances, however the majority fall within the first few hundred meters.

Most recently released varieties have good foliar resistance to the disease, but only Northfield has resistance to pod infection. Fungicide spray may be needed at flowering to control the infection of pods to avoid grain discolouration. Growers should also isolate new crops from the previous season’s stubble to minimise the spread of infection into the crop by wind blown trash and spores. Wide rotations should also be maintained to minimise the disease carryover within a paddock.

**Botrytis grey mould**
Botrytis grey mould (*Botrytis cinerea* and *Botrytis fabae*) tends to occur on lentil in the cooler growing regions south of the Great Eastern Highway and in the higher rainfall coastal areas north of Perth. No serious botrytis grey mould infections have yet occurred in commercial lentil crops in Western Australia. The disease becomes

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**Research Update**

**Cercospora in Western Australia**
For the first time in Western Australia, cercospora leaf spot became a severe disease in at least two crops in the Dongara and Great Southern regions in 2003. The disease caused large lesions on leaves early in the crops life and the infection spread to the flowers and pods. Yields were reduced. Anecdotal evidence also indicate that cercospora has become more widespread and severe in faba bean crops in South Australia over the past five years. The extent to which cercospora affects yields, however is still uncertain. Severe cercospora disease also occurred in a germplasm nursery at Dongara during 2003 and large differences between lines were observed. Fiord, Fiesta and Farah all showed similar and moderate levels of tolerance to the disease (rating of 5 in a 1 to 9 scale (1= high resistance)). Cairo showed a higher level of resistance than these varieties (rating 3 to 4). Some breeding/early generation lines showed high levels of resistance.
apparent under wet, spring conditions. All above ground parts of the plant can be affected. Grey to dark brown lesions develop on stems, leaves, flowers and pods. Under humid conditions the lesions become covered with a fluffy grey mould. Pod infection results in the production of shrivelled and discoloured seed, and a reduction in yield and grain quality.

Management of botrytis grey mould in lentil requires that new crops be isolated from the stubble of the several crops that host either of the Botrytis fungi suspected to cause the disease (see Table 12). Therefore, do not locate lentil in paddocks adjacent to stubbles of lentil, chickpea, faba bean or vetch. Additionally, avoid very early sowing and very high planting density; such as may occur in double sown headlands.

**Vetch**

**Chocolate spot and botrytis grey mould**

Both chocolate spot (Botrytis fabae) and botrytis grey mould (Botrytis cinerea) infect vetch. There is no race or strain difference between the fungi that cause chocolate spot on vetch and that which causes chocolate spot on faba bean or lentil. Similarly, there is no differentiation between the B. cinerea that causes botrytis grey mould on vetch and chickpea or lentil.

Chocolate spot and botrytis grey mould can occur in all vetch growing areas. The diseases are more prolific in the warm humid conditions of early spring. Under favourable conditions these diseases can spread rapidly and cause significant yield losses within a few weeks. Chocolate spot infection starts as small red-brown spots on leaves, stems and flowers. The spots on leaves and stems enlarge and develop a grey, dead centre with a red-brown margin. The chocolate spot fungus survives on vetch, faba bean and lentil stubble over summer. Botrytis cinerea survives over summer on stubble of these hosts as well as chickpea. Both of the fungi produce conidiospores on infected stubble in warm wet autumn conditions. Sclerotia (fungal survival structures) are produced in response to cold, these may reveal hard black ‘grains’, these are the sclerotia or sclerotioum. For the purposes of this manual these diseases can be treated as one. This disease may occasionally cause reductions in plant density in well-grown crops after flowering and is mainly seen in the higher rainfall zones (>400 mm). White mould can infect all pulse crops, indeed all non-cereal crops, however, chickpea appears the most susceptible, followed by lentil. Faba bean and field pea plants are the least susceptible of the pulse crops grown in Western Australia. The fungus that causesascochyta blight in vetch is a different species from those that cause ascochyta blight on other pulses.

**Ascochyta blight**

Ascochyta blight does occur sporadically on vetch, but it is not a significant disease in cultivated varieties in Western Australia. The fungus that causes ascochyta blight in vetch is a different species from those that cause ascochyta blight on other pulses.

**Root diseases**

**Sclerotinia white mould**

There are two fungi which cause similar diseases referred to as sclerotinia white mould, they are Sclerotinia sclerotium and Sclerotinia minor. For the purposes of this manual these diseases can be treated as one. This disease may occasionally cause reductions in plant density in well-grown crops after flowering and is mainly seen in the higher rainfall zones (>400 mm). White mould can infect all pulse crops, indeed all non-cereal crops, however, chickpea appears the most susceptible, followed by lentil. Faba bean and field pea plants are the least susceptible of the pulse crops grown in Western Australia. Within well-grown crops at about flowering, single plants or small groups of plants, turn yellow and die rapidly. Lesions usually develop near the ground and have a white fluffy, cotton wool appearance. Lifting off the white fluff may reveal hard black ‘grains’, these are the sclerotia or survival structures of the fungus. The overall appearance of this disease is similar to botrytis grey mould in chickpea and lentil, however the diseases are easily distinguished by the colour of the fungal mat. White mould has a bright white cotton wool appearance while botrytis grey mould produces a grey and downy fluff.

**Sclerotinia** survives on stubble or in the soil as sclerotia (the black grains in the white mat), and may persist for several years. Spores produced in winter or spring may still require fungicide sprays to manage Botrytis.

**Rust**

Rust on vetch, caused by Uromyces vicia-fabae, is not common in Western Australia but the disease has been observed in the Esperance region. The same species of fungus that causes rust in vetch also causes rust in faba bean, however, the two diseases are caused by distinct races, which are specific to their host alone. The race that causes rust on vetch will not cause rust on faba bean. Similarly, rust on faba bean is not a threat to vetch production or rotations. The symptoms and management of rust on vetch is similar to that described for faba bean. Morava has better rust resistance than all other varieties. However, it is late flowering and grain production is reliable only in high rainfall areas (>450 mm) where it may still require fungicide sprays to manage Botrytis.
with other pulse crops, lupin, canola or pastures containing legumes or broad-leaved weeds. The disease is favoured by warm humid conditions, similar to the conditions that favour botrytis grey mould and chocolate spot. Spread of infection within the crop is limited as it only occurs through direct contact between infected plants and new hosts. The number of affected plants within a crop will usually increase through spring.

**Root and hypocotyl rots**

*Rhizoctonia solani* causes at least two distinct diseases on pulses, rhizoctonia bare patch and hypocotyl rot. Rhizoctonia bare patch is a reasonably conspicuous disease, although not common in pulses. It is caused by the same strain of *Rhizoctonia* that causes bare patch in cereal and lupin crops. As with all other crops, rhizoctonia bare patch has the greatest impact on pulse crops established using minimum, or zero-till methods. Where bare patch has been evident in a paddock during the previous year, use deep cultivation (5-10 cm) establishing your pulse crop.

Hypocotyl rot (more correctly epicotyl rot) is more cryptic than rhizoctonia bare patch and is caused by one of the strains of *Rhizoctonia solani* that causes hypocotyl rot in lupin. This strain of *Rhizoctonia* can infect all pulse crops but the disease is not common and has only been seen on chickpea in the field. Hypocotyl rot will reduce stand density by infecting scattered seedlings through the crop. Frequently, only the infected shoot is killed, a second shoot will be produced from the seed (which remain below the ground in pulses) resulting in delayed emergence of some plants.

The strain of *Rhizoctonia* that causes hypocotyl rot in pulses also infects other legumes so avoid sowing pulses after a legume based pasture or other legume crops. This disease also appears to be worse when the soil over the seed dries during crop emergence.

**Other root rots**

Other root rots caused by *Fusarium* spp, *Pythium* spp and *Phytophthora* spp are major problems in some regions of the eastern states, particularly where crops are grown on stored soil moisture, but these diseases, have not been observed in Western Australia. Similar symptoms may be caused by prolonged periods of waterlogging and, in some instances, triazine herbicides.

**Viral diseases**

Western Australian pulse crops suffer from diseases caused by seven different viruses, all of which are transmitted by aphid vectors, and some of which are seed-borne in their legume hosts. Unlike fungi, the whole plant becomes systemically invaded. The whole plant therefore is either virus-infected or healthy. Yield losses vary from year to year and from location to location and can be considerable in some circumstances. Seed quality can also be impaired. Viral symptoms in plant foliage are often confused with nutritional deficiencies, herbicide damage or water-logging, leading to underestimation of the extent of damage caused.

### Types of viruses

Viruses infecting pulses in Western Australia are either transmitted persistently by aphids or non-persistently. The persistently transmitted viruses are often called luteoviruses. These are not seed-borne and require a continuous ‘bridge’ of live plant material to survive from one growing season to the next. Non persistently transmitted viruses are seed-borne to varying extents, sometimes infecting commercial seed stocks of pulses.

**Persistent transmission**

Persistent transmission means that when an insect vector feeds on an infected plant, the virus has to pass through the body of its vector and lodge in its salivary glands before it can be transmitted to a healthy plant, a process that takes more than a day. Once the insect is infectious it remains so for the rest of its life. Very few aphid species are vectors of this kind of virus in pulses. These species of aphids tend to colonize their hosts. The pea and green peach aphids are important as vectors of luteoviruses in pulses. Because acquisition of the virus is slow insecticides that kill aphids work well in suppressing virus spread (except in the case of insecticide resistant green peach aphid). Aphids don’t often colonize chickpea because of the organic acids they excrete onto their leaves, but they will remain on the plants for long enough to transmit luteoviruses to them.

**Non-persistent transmission**

Non-persistent transmission means that the insect vector can land on a virus infected plant, make a brief probe, acquire the virus on its mouth parts within seconds and then transmit it immediately when probing on a healthy plant. The aphid loses the virus after it probes a healthy plant one or two times. After this, the insect does not infect further plants. The whole process is so quick that insecticides do not act fast enough to prevent transmission, and can make things worse by making the

<table>
<thead>
<tr>
<th>Table 13. Types of viruses infecting pulses in Western Australia</th>
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<tbody>
<tr>
<td><strong>Luteoviruses</strong></td>
</tr>
<tr>
<td>Beet Western Yellows (BWYV)</td>
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<tr>
<td>Bean Leaf Roll (BLRV)</td>
</tr>
<tr>
<td>Subterranean Clover Red Leaf (SCRLV = Soybean Mosaic Virus)</td>
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*In the case of luteoviruses BLRV is the most damaging in terms of yield losses, while BWYV is the most common, especially in field pea. BLRV has only been found recently in Western Australia but the expanding area of lucerne is likely to increase its occurrence in pulse crops.

**In the case of non-persistently aphid borne viruses AMV, CMV and BYMV sometimes cause heavy yield losses, while PSbMV generally has a lower impact on yield but has a damaging effect on seed quality, especially in faba bean. All four are common.*
aphids hyperactive, flitting from plant to plant. Many aphid species are vectors of this type of virus including ones that do not colonize legumes but just land and probe pulse crops while searching for their preferred hosts, such as oat and turnip aphids.

Viruses cause a range of different kinds of symptoms in pulses. These vary in severity from death of the plant at one extreme to symptomless or unapparent infection at the other. Intensity and type of symptoms depend, not only on the combination of virus and pulse species in question, but also, to a lesser extent, on the strain of the virus, variety of pulse, climatic conditions (especially temperature), and stage of plant growth at time of

<table>
<thead>
<tr>
<th>Table 14. Occurrence of viral diseases in selected pulses</th>
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<tbody>
<tr>
<td><strong>Chickpea</strong></td>
</tr>
<tr>
<td>Principal virus diseases</td>
</tr>
<tr>
<td>Also sometimes likely to be found</td>
</tr>
<tr>
<td>Seed stocks</td>
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</tbody>
</table>

PSbMV cause distinctive marking on faba bean seeds. Photo P. White.

infection. Plants infected via seed may be stunted and all their leaves may show symptoms rather than only the younger leaves. In contrast, with current-season infection older leaves may not show any symptoms. Typical foliage symptoms are often most clearly visible in young leaves. Normally it is difficult to tell which virus is present and causing symptoms in a particular pulse species without

AMV in faba bean. Photo R. Jones.

AMV in field pea. Photo R. Jones.

PSbMV in faba bean. Photo R. Jones.

CMV in chickpea. Photo R. Jones.
resorting to laboratory tests on leaf samples. However, sometimes foliage symptoms are sufficiently distinct to be diagnostic. For example, apical necrosis often followed by shoot death is typical of AMV infecting chickpea and field pea, while bunching and pallor of shoot tips and reddening of leaves is typical of CMV infection in desi chickpea.

Viruses affect yield by reducing the number and size of seeds. They can also cause seed shrivelling. PSbMV causes necrotic rings and line patterns in seed coats of pulses sometimes associated with cracking and wrinkling, and these symptoms are particularly severe in faba bean seeds. Virus symptoms on seeds tend to be confused with “environmental staining”, fungal disease symptoms and insect pest damage, again leading to underestimation of their occurrence.

Sources of infection
Luteoviruses are not seed-borne and require a continuous “green bridge” of host plant material, such as an infected lucerne pasture or broad-leaved weeds surviving in isolated wet spots over summer, in order to pass from one crop to the next. Non-persistently aphid-borne viruses are often seed-borne in pulse crops. They do not require a green bridge to survive over summer, but their survival, in lucerne pastures, or other hosts may increase the damage caused by these viruses by increasing the amount of inoculum available at the start of the growing season. BWYV is the most common luteovirus. It has a very wide natural host range including non-leguminous crops like canola, pasture plants such as clovers, medics and lucerne, many weeds such as paddy melons and wild radish, and certain native legumes. All of these plants act as reservoirs for BWYV spread to pulse crops. BLRV and SCRLV reservoir hosts are mainly restricted to legumes; especially lucerne pastures but also clovers, medics and native legumes.

For non-persistently aphid-borne viruses, contaminated stocks or pulse seed are the principal source of infection for crops. All four viruses currently occur in commercial pulse seeds stocks to varying extents (especially PSbMV in field pea, and AMV and CMV in lentil). Infected pastures
are also an important reservoir for spread to pulse crops particularly with AMV and BYMV which both commonly infect pastures in the Western Australian grainbelt. AMV infects medics and lucerne, and BYMV sub clover and other clovers. In addition, nearby infected crops can be important sources for spread into pulse crops. For example, PSbMV and CMV will spread readily from nearby infected field pea and lupin crops respectively.

**Epidemics**

Close proximity to a substantial virus reservoir and high summer and autumn rainfall are the two most important factors that predispose pulse crops to severe virus infection. Summer and autumn rainfall will stimulate early growth of pastures, weeds and crop volunteers upon which aphids build up before the growing season starts. This results in early aphid flights to newly emerged crops and early infection. The infected plants can then act as a reservoir for further spread of infection within the crop so the final virus incidence is high. In contrast, a dry start to the season and minimal nearby virus sources result in little virus spread and no economic losses.

**Yield and quality losses**

In general, the earlier a plant becomes infected the greater the yield loss, but there are exceptions. For example, faba bean, infected early with AMV can recover partially so that yield losses are greater in plants infected later in the season compared with recently infected plants. With PSbMV, seed quality may also be severely damaged leading to rejection or downgrading of affected samples.

**Control measures**

Viruses are best managed by using a number of control measures each acting in a different way. Each different combination of virus and pulse species may require slightly different management. Virus resistant varieties are rarely available.

The management packages for luteoviruses involves using cultural measures that suppress the virus source within the crop and decrease aphid landing rates, as well as applying insecticide early to suppress spread by killing aphid vectors. Insecticide applications are normally applied at 3 and 7 weeks after emergence, often before aphids are seen, and ‘new chemistry insecticides’ are most effective if green peach aphids with insecticide resistance are present. Insecticide application to control direct aphid feeding damage (rather than controlling virus spread) normally occurs later when large numbers of aphids are seen in pulse crops.

<table>
<thead>
<tr>
<th>Control measure</th>
<th>Mode of action</th>
</tr>
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<tbody>
<tr>
<td>Sow healthy seed stocks.</td>
<td>Minimises initial virus infection source within the crop.</td>
</tr>
<tr>
<td>Sow cultivars with low ‘intrinsic’ seed transmission rates in high virus risk regions.</td>
<td>Minimises initial virus infection source within the crop.</td>
</tr>
<tr>
<td>Sow perimeter non-host barrier crop in between a adjacent pasture and crop.</td>
<td>Decreases virus spread into crop from external pasture source.</td>
</tr>
<tr>
<td>Promote early crop canopy development.</td>
<td>Shades over infection sources within the crop and diminishes aphid landing rates.</td>
</tr>
<tr>
<td>Sow at high seeding rates to generate high plant densities.</td>
<td>Minimises infection sources and diminishes aphid landing rates. Dilutes numbers of infected plants.</td>
</tr>
<tr>
<td>Sow at narrow row spacing.</td>
<td>Narrow spacing diminishes aphid landing rates.</td>
</tr>
<tr>
<td>Maximise stubble ground cover using minimum tillage procedures that minimise soil cultivation.</td>
<td>Diminishes aphid landing rates until crop canopy develops.</td>
</tr>
<tr>
<td>Spray high value seed crops with pyrethroid insecticide.</td>
<td>Suppresses virus spread by killing or repelling aphids.</td>
</tr>
<tr>
<td>Spray adjacent pasture with pyrethroid insecticide in high virus risk regions.</td>
<td>Suppresses virus spread within external pasture infection source by killing colonising aphids.</td>
</tr>
<tr>
<td>Avoid fields with large perimeter: area ratios, adjacent to pastures in high virus risk regions.</td>
<td>Decreases ingress of virus into crop from external pasture source.</td>
</tr>
<tr>
<td>Sow early maturing cultivars.</td>
<td>Decreases final infection incidence reached, especially in prolonged growing seasons.</td>
</tr>
<tr>
<td>Isolate from neighbouring legume crops.</td>
<td>Decreases ingress of virus from any external infected crop source.</td>
</tr>
<tr>
<td>Maximise weed control.</td>
<td>Minimises potential weed virus infection sources within the crop (especially clovers for BYMV).</td>
</tr>
<tr>
<td>Crop rotation.</td>
<td>Avoids volunteer seed-borne pulse plant infection sources within the crop.</td>
</tr>
</tbody>
</table>
Management for non-persistently transmitted viruses involves sowing healthy seed and using cultural measures. Refer to Table 15.

**Nematodes**

There are two main types of plant-parasitic nematode that reduce yield of broadacre crops grown in Western Australia. These are the cereal cyst nematode (*Heterodera avenae*) and the root lesion nematode (*Pratylenchus spp.*). Pulse and lupin crops will not host cereal cyst nematode (CCN). This nematode only infects grasses (wheat, barley, oat, and some weeds, particularly wild oat), so pulse and lupin crops act as a disease break. Although CCN has been identified at some locations in the northern region around Geraldton, and in the Avon valley, it is not currently considered to be as widespread or as damaging as it is in eastern Australia.

Root lesion nematode (RLN) is estimated to occur at damaging levels in at least 40% of Western Australia’s cropping paddocks. Yield losses to wheat and barley crops from these nematodes are estimated to be at least 5-15% annually.

The predominant species of RLN in Western Australia are *P. neglectus* and *P. teres*. Both can occur together in a single paddock. In 2003, *P. neglectus* was identified in 38% of samples, *P. teres* in 8% and a combination of species occurred in 7% of the samples investigated. *P. teres* is not known to occur in eastern Australia, and worldwide there is little information available. The effect of *P. teres* on cereal, pulse and lupin crops is still under investigation. Unlike eastern Australia, *P. thornei* occurs rarely in Western Australian cropping paddocks. Other RLN species are sometimes identified in Western Australia, and these (e.g. *P. penetrans*) can also cause significant crop damage.

**Crop hosts of root lesion nematode species**

All RLN species have a wide host range, although the nematodes multiply to varying degrees on different crops (Table 16). For example, field pea and faba bean are poor hosts (i.e. resistant) to *P. neglectus*, while chickpea and wheat are good hosts (i.e. susceptible). There are also differences between cultivars within a crop species, as well as differences between nematode species (e.g. field pea is more susceptible to *P. penetrans* than it is to *P. neglectus*). Resistance to one species of RLN does not necessarily confer resistance to others. It is therefore important to diagnose accurately which RLN species is present when devising rotational strategies for management of these nematodes.

Root lesion nematode will multiply at varying rates depending on the susceptibility of the host plant. For example, *P. neglectus* will reach high levels on susceptible hosts like most wheat and chickpea cultivars, and intermediate levels on moderate hosts like barley. Poor hosts (field pea, faba bean, lupin, lentil and triticale) will restrict *P. neglectus* multiplication and reduce nematode densities in the soil.

These poor or moderate hosts can be used in rotations to reduce nematode numbers and limit yield losses in subsequent susceptible crops. For example, a susceptible wheat crop will have substantially fewer *P. neglectus* if it is planted after a field pea crop than if it were planted after a wheat crop.

In South Australian trials, wheat grown after field pea was infested...
Research Update

Resistance of field pea and faba bean to root lesion nematode (P. neglectus)

Field pea and faba bean are resistant to *P. neglectus*, and are therefore two of the crops recommended in rotations where moderate-high levels of this nematode occur. *P. neglectus* did not multiply on field pea and faba bean plants during the 2003 growing season (Table 17 and 18). Nematode multiplication rates for all cultivars were less than one, indicating resistance. Even at sites with moderate-high nematode levels at sowing (6–10 RLN/g dry soil), numbers had declined by late September.

Even though field pea is resistant to *P. neglectus*, multiplication rates for *P. penetrans* in 2003 were greater than one, indicating susceptibility (Table 19). This demonstrates the importance of diagnosing the particular RLN species present when devising rotational strategies for management of these nematodes.

*P. penetrans* is detected infrequently in cropping areas, but severe root damage, typical of RLN infestation, was observed in one cereal trial in 2003.

### Table 16. Crop hosts of Root lesion nematode (*P. neglectus*)

<table>
<thead>
<tr>
<th>Good hosts</th>
<th>Moderate hosts</th>
<th>Poor hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chickpea</td>
<td>Barley</td>
<td>Field pea</td>
</tr>
<tr>
<td>Wheat</td>
<td>Oat</td>
<td>Faba bean</td>
</tr>
<tr>
<td>Canola</td>
<td>Durum wheat</td>
<td>Lupin</td>
</tr>
<tr>
<td>Mustard</td>
<td>Medic</td>
<td>Lentil</td>
</tr>
<tr>
<td></td>
<td>Common vetch</td>
<td>Triticale</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Safflower</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lathyrus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bitter vetch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rye</td>
</tr>
</tbody>
</table>

### Table 17. *P. neglectus* multiplication rates for faba bean cultivars at Borden over the 2003 season

<table>
<thead>
<tr>
<th>Cultivar</th>
<th><em>P. neglectus</em> multiplication rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiesta</td>
<td>0.13</td>
</tr>
<tr>
<td>Manafest</td>
<td>0.16</td>
</tr>
<tr>
<td>SP95054</td>
<td>0.20</td>
</tr>
<tr>
<td>Ascot</td>
<td>0.21</td>
</tr>
<tr>
<td>Fiord</td>
<td>0.24</td>
</tr>
<tr>
<td>483 / 3</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>0.21</strong></td>
</tr>
<tr>
<td>RLN/g dry soil (at sowing)</td>
<td>9.92</td>
</tr>
<tr>
<td>RLN/g dry soil (late Sept)</td>
<td>2.13</td>
</tr>
</tbody>
</table>

### Table 18. *P. neglectus* multiplication rates for field pea cultivars during 2003 growing season

<table>
<thead>
<tr>
<th>Cultivar</th>
<th><em>P. neglectus</em> multiplication rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaspa</td>
<td>0.61 0.81 0.08 0.28</td>
</tr>
<tr>
<td>Dundale</td>
<td>0.74 0.30 0.12 0.55</td>
</tr>
<tr>
<td>Dunwa</td>
<td>0.58 0.34 0.05 0.15</td>
</tr>
<tr>
<td>Parafield</td>
<td>0.30 0.11 0.09 0.13</td>
</tr>
<tr>
<td>Helena</td>
<td>0.44 - 0.05 0.49</td>
</tr>
<tr>
<td>Sturt</td>
<td>- - - 0.07</td>
</tr>
<tr>
<td>Cooke</td>
<td>- - - 0.32</td>
</tr>
<tr>
<td>Snowpeak</td>
<td>- - - 1.02</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>0.58</strong> <strong>0.34</strong> <strong>0.08</strong> <strong>0.38</strong></td>
</tr>
<tr>
<td>RLN/g dry soil (at sowing)</td>
<td>10.0 0.71 6.40 6.14</td>
</tr>
<tr>
<td>RLN/g dry soil (late Sept)</td>
<td>3.61 0.26 0.53 2.05</td>
</tr>
</tbody>
</table>

### Table 19. *P. penetrans* multiplication rates for field pea cultivars at Mt Barker over the 2003 season

<table>
<thead>
<tr>
<th>Cultivar</th>
<th><em>P. penetrans</em> multiplication rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooke</td>
<td>1.43</td>
</tr>
<tr>
<td>Parafield</td>
<td>1.55</td>
</tr>
<tr>
<td>Dunwa</td>
<td>2.01</td>
</tr>
<tr>
<td>Kaspa</td>
<td>2.37</td>
</tr>
<tr>
<td>Snowpeak</td>
<td>2.54</td>
</tr>
<tr>
<td>Helena</td>
<td>2.37</td>
</tr>
<tr>
<td>Dundale</td>
<td>4.10</td>
</tr>
<tr>
<td>Sturt</td>
<td>7.01</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>3.06</strong></td>
</tr>
<tr>
<td>RLN/g dry soil (at sowing)</td>
<td>1.74</td>
</tr>
<tr>
<td>RLN/g dry soil (late Sept)</td>
<td>5.01</td>
</tr>
</tbody>
</table>
with 72% fewer \textit{P. neglectus} than wheat after oat or canola. This corresponded with a 32% greater wheat yield after the rotation with field pea. From Western Australian trials, nematode numbers in wheat following field pea were up to 20 times lower than in wheat after wheat. Similarly, wheat after wheat had significantly higher root infestations of RLN than wheat grown after faba bean.

**Symptoms of root lesion nematode infection**

Since many of the pulses are resistant to \textit{P. neglectus}, there are few observations of RLN symptoms for these crops. Chickpea, however, is susceptible and can show distinctive root symptoms. Chickpea roots exhibit dark brown-orange lesions, and the lateral roots will be severely stunted and reduced in number. Above-ground symptoms are indistinct. Plants may show a combination of symptoms, all of which can be confused with, or exacerbated by, nutrient deficiencies. These include uneven growth and stunting. Affected plants are often more prone to wilting under water stress.

Once root symptoms have been diagnosed, laboratory testing of plants or soil is still necessary for identification of the RLN species and levels. This requires extraction of nematodes from roots or soil, followed by microscopic examination of the nematodes present. Testing services are available from Agwest Plant Laboratories. Nematode levels can be determined when soil is moist, and plants can be examined and tested during the growing season.

The Bayer CropScience PreDicta-B™ test relies on identification of DNA from the soil. Currently, this test can only detect two species of RLN (\textit{P. neglectus} and \textit{P. thornei}). \textit{P. teres} and the other RLN species that occur in Western Australia will not be detected by this method. Results must be interpreted with caution, and matched with paddock observations. Agronomists and consultants can provide test kits and sampling instructions, as well as advice on management options. This test is performed on dry soil; it provides an indication of the risk of root disease that is useful for planning paddock management and rotations. PreDicta-B™ will also indicate risk from take-all, rhizoctonia, crown rot and CCN.

**Recommendations for managing root lesion nematode**

High numbers of RLN in the soil can significantly reduce the yield potential of intolerant crops. It is therefore important to monitor and manage nematode numbers as effectively as possible. Populations can rapidly multiply on a good host, but it may take two or more successive years of a poor host for numbers to decline below damaging levels, especially if they were initially high.

There are no chemical treatments available for broadacre nematode control. Eradication of RLN is not possible. At best, RLN can only be managed within the cropping
system by use of crop rotation and other cultural practices (e.g. good nutrition, weed control, early sowing).

The first step is to determine the levels and identity of RLN species:

- inspect crops for uneven growth, and symptoms resembling nitrogen deficiency;
- examine roots for distinguishing symptoms, and;
- take soil and plant samples from unthrifty patches of the crop to submit for laboratory tests to identify RLN species and levels present.

Rotation with poor host (i.e. resistant) crops and cultivars, combined with crop resistance, is the key to management of RLN:

- use resistant crops and cultivars in rotations to reduce nematode levels and yield loss;
- avoid susceptible hosts such as chickpea if nematode levels are high;
- control susceptible weeds (particularly wild oat, barley grass, brome grass and wild radish) and susceptible volunteers (especially cereals and chickpea) to reduce RLN build-up and carry-over and
- ensure adequate nutrition (especially nitrogen, phosphorus and zinc).

It is essential to consider the effect that nematodes can have on not only the current, but also on subsequent, crops in the rotation.

**Stem nematode**

Stem nematode (*Ditylenchus dipsaci*) occurs in eastern Australia, and the potential exists for its establishment in Western Australia. Growers should be vigilant and aware of the symptoms caused by, and the plants affected by, this nematode.

Symptoms include: poor plant emergence and establishment, stunting, stem swelling, leaf and stem twisting or distortion, yellowing, and production of extra tillers at the stem base of oat. Plants may also suffer premature death, lodging and production of fewer seed heads. Stem nematode occurs in patches, but the entire crop can be affected in severe cases.

Field pea, oat, canola, lentil, chickpea, lucerne, clover and faba bean can host stem nematode. Poor emergence and establishment of field pea, canola, lentil and chickpea seedlings has been observed in South Australia. Faba bean is very susceptible, but plants will not show symptoms unless nematode levels are very high. Oat is particularly sensitive to stem nematode, and intolerant cultivars will suffer a heavy yield penalty, and in severe cases crop failure.

Field pea infected with stem nematode. *Photo S. Taylor.*

Stem nematode is extremely resilient to desiccation and, once present, remains in the soil for many years. The nematode can be introduced as a contaminant with seed, straw, hay, machinery and stock. Survival and host
infection are favoured by moist conditions, clay soils and cool temperatures (< 20°C).

Resistant oat and faba bean cultivars have been bred in South Australia. The nematode can be controlled by rotation with non-hosts (e.g. wheat, barley, triticale) and the use of resistant cultivars where available. For infested areas, susceptible crops should not be grown in close rotation. Suspected cases of stem nematode should be reported immediately to the Department of Agriculture.

**Further reading**


Introduction

Insect numbers can build up quickly in pulse crops and, if left uncontrolled, will substantially reduce both the yield and quality of the grain. It is important to monitor insect numbers carefully because the large size and high value of most pulse grain makes crops vulnerable to relatively low numbers of insects. Control strategies must be applied as soon as problems become apparent.

Crop establishment and, flowering through to podding, are the two key stages of crop development where insects are likely to be a problem and when careful monitoring is required. Sweeping crops with an insect net is the best way to monitor most insects after the crop is established. Use a standard net size (380 mm diameter) and take two metre long sweeping arcs. At least five lots of ten sweeps should be taken in several parts of the crop.

Additional, updated information on insect pests and diseases can be obtained during the growing season from PestFax, a service provided by the Department of Agriculture. PestFax is available via email (pestfax@agric.wa.gov.au), the Department of Agriculture’s website (www.agric.wa.gov.au – search for PestFax) or via the AgFax service (Dial 1902 990 506, Doc 24001).

Crop establishment

Red legged earth mite

Red legged earth mite (Halotydeus destructor) is an establishment pest of most pulse crops. It is only active during winter months and spends the summer in the form of diapause eggs in the dead bodies of the females. During autumn, mites hatch once the temperature drops below 20°C for six days and adequate moisture (about 15 mm) is available. They grow into adults within 4-6 weeks. Heavy infestations can rapidly kill emerging seedlings.

Different crops vary in their susceptibility to RLEM. Screening has been conducted to compare the relative susceptibility of cool season pulses to RLEM. The results indicate that field pea is highly susceptible, together with common vetch. Faba bean, narbon bean and lentil are moderately susceptible to RLEM, while chickpea is resistant. Priority for controlling RLEM should be based on a crop’s relative susceptibility to the pest. The more susceptible it is, the higher priority should be given to mite control.

Field situations most prone to mite attack include crop established on last year’s pasture paddocks or near this year’s pasture. Plant debris or weeds (especially capeweed) also encourage mite infestations.

Table 20. Key to main insect pests of pulse crops

<table>
<thead>
<tr>
<th>Seedling damaged</th>
<th>Damage to flowering and podding plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seedlings chewed above ground</td>
<td>Go to 2</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>No chewing evident</td>
<td>Go to 2</td>
</tr>
<tr>
<td>2. Whole parts of plants or parts of leaves eaten or cut off</td>
<td>Go to 3</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Areas of green tissue removed from leaves with surface tissue remaining like windows; presence of dumpy, green, wingless insect like creatures which spring in all directions when disturbed</td>
<td>Lucerne flea</td>
</tr>
<tr>
<td>3. Some plants cut off at ground level; leaves chewed, fat, smooth caterpillars up to 40 mm long under soil surface near plants</td>
<td>Cutworm</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Leaves chewed but mostly at edges of crop; 30 mm long caterpillars with dark stripes surrounded by lighter areas down the back</td>
<td>Brown pasture looper</td>
</tr>
<tr>
<td>4. Surface tissues of leaves with silver or white patches; presence of small black creatures with orange-red legs</td>
<td>Red legged earth mite</td>
</tr>
<tr>
<td>5. Flowering stalks distorted and withered, covered with many dumpy black or green insects up to 3 mm long with or without wings</td>
<td>Aphids</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Some leaves and flowers chewed; holes in pods, especially the older ones; caterpillars up to 40 mm long, sparsely covered with bumps and hairs, often brightly covered in greens, browns and shades of orange. Usually with black stripes along dorsal surface</td>
<td>Native budworm</td>
</tr>
<tr>
<td>OR</td>
<td></td>
</tr>
<tr>
<td>Adult is 5 mm long, brownish and flecked with white, black and grey patches. Found on field peas</td>
<td>Pea weevil</td>
</tr>
</tbody>
</table>
Identification
- RLEM has a black, oval-shaped body with eight red-orange legs and is approximately 1 mm in size.
- RLEM rupture cells on the surface of leaves and feed on the exuding sap fluids. Typical feeding signs are a silvery patch in the damaged area. Although RLEM attacks adult plants, the major damage is to young seedlings.
- RLEM tend to feed in clusters.

Monitoring and control
Pulse crops are prone to attack by RLEM in the first couple of weeks after crop emergence. Most pulse crops can tolerate some mite attack when they have passed the seedling stage.

To monitor for RLEM ensure that the crop is inspected during the first two weeks of seedling emergence. Regularly inspect seedlings for damage and the ground for RLEM. The best time to monitor is when RLEM are active; early morning or late afternoon in hot weather or during the middle of the day in cold weather.

Signs of feeding damage on the leaves provide a guide for control and pest numbers can give an estimate of damage potential. Threshold levels have not been established for pulses. Thresholds are 50 RLEM per 100 cm² for wheat and barley and 10 RLEM per 100 cm² for canola. For most pulse species 20 RLEM per 100 cm² is an approximate threshold level. Estimate the number of mites per 10 cm by 10 cm quadrat. Repeat count at 5-10 sites within the crop. Implement control if there is an average of 20 or more RLEM per quadrat (100 cm²).

In high-risk situations, such as sites prone to mite attack and where susceptible crops are planted, preventative spraying is recommended. This could include insecticide sprays incorporated with knock-down herbicides pre-planting, bare ground spraying before emergence, seed dressing, or barrier spraying around crops. After insecticide application, close monitoring of mite attack is still required and prompt action taken if mite numbers reach damaging levels. Sporadic weather conditions leading to the ‘break’, may result in uneven RLEM hatchings and this may necessitate a second spray to control the newly hatched mites before they cause damage.

Besides spraying at crop establishment, other methods have also proven effective in reducing mite populations. Reducing the diapause (or over-summering) egg production through timely spraying in the spring of the year before cropping, heavy spring grazing of pastures by livestock and reducing weed problems are all useful methods to suppress potential mite populations. Controlling mites in surrounding pastures will also reduce the potential for RLEM to migrate into crops.

Lucerne flea
Lucerne flea (*Sminthurus viridis*) is an establishment pest in lentil, faba, vetch, narbon bean and field pea and is commonly found in Western Australia on heavy soils. It is rarely found in mallee soils or sandy soils. The eggs of lucerne flea hatch following soaking autumn rains. They develop from the small nymphal (miniature adult) stage until fully grown, about three to four weeks later.

A number of generations can occur through the growing season causing damage with large populations. The later generation produce over-summering eggs.

Identification
- The lucerne flea is a dumpy looking wingless creature of varied colour, but the larger specimens of 2-4 mm are predominantly green or yellow.
- Lucerne flea usually spring from the plants when approached.
- Lucerne flea causes distinctive ‘window-pane’ holes in the leaves.
- Seeding damage is often the first indication of their presence.

Monitoring and control
Inspect pulse crops at emergence for signs of seedling thinning, bare patches and seedling damage. Hot spots may occur along fence lines and around trees or rocky outcrops. These are good places to monitor. The damage to pulses is the main factor to consider not the number of fleas. There is no threshold established for spraying lucerne flea in pulse crops.

If it is likely lucerne flea will be present, preventative spraying is recommended. In severe cases a follow-up spray may be needed about two weeks after the first spray to kill insects from a subsequent hatch.

RLEM and lucerne flea often coexist but not all chemicals registered for one pest will be effective on both. Some bare earth treatments are not effective on lucerne flea.

*Bryobia mite*
Bryobia mites damage emerging pulse crops in autumn. The mites feed on the tops of leaves by stabbing into the surface cells with their sharp mouthparts, and sucking out sap. Whitish grey spots result and plants have a wilted look.

Adult bryobia are active in late spring, summer and autumn. Eggs are present over winter, and hatch as conditions dry and warm up in spring and early summer.

Identification
- The adult mites are slightly smaller than a pin head with a dark grey body and pale red-orange legs.
- They are easily confused with RLEM and are difficult to separate without the use of a hand lens. The front pair of legs on bryobia mite are very long and held out in front of the body like a pair of feelers. The body of bryobia mite is rounded and plump. Red legged earth mites are not usually present in early autumn as they have a cold temperature requirement before hatching, whereas bryobia do not.
**Monitoring and control**

Summer rains followed by warm mild autumns give bryobia mites the best conditions for survival and increase. They don’t tolerate cold wet weather but can persist into June if warm autumn conditions persist. Early control of summer weeds in paddocks that are to be cropped will prevent the build up of mite populations. Weeds present in paddocks prior to cropping should be checked to determine the numbers of bryobia mites present. If they are found in large numbers then the incorporation of insecticide with herbicide prior to sowing is a more effective control strategy than spraying when the crop is emerging and has little cover of green material. Rates of insecticides commonly used to control red legged earth mite and lucerne flea are not effective against bryobia mites.

**Cutworm**

Cutworms are plump, smooth caterpillars of several moth species in Western Australia. They feed on all pulse crops, damaging them near the ground. They tend to infest pulse crops sporadically; serious infestations can cause yield losses.

The larvae of many cutworm species (but not all) feed at night and hide below ground by day, and so can be difficult to find. Young larvae feeding on leaves cause abrasions to the leaf surface, chew marks and holes but older larvae are especially noticeable when they sever seedling stems at ground level. Pulse seedlings may recover from cutworm damage by sprouting a new shoot, however this effectively delays establishment and reduces yield potential.

Often the grubs can be located by digging the soil surface near damaged plants where they can be seen curled up in a defensive position.

**Identification**

- The larvae of cutworm are smooth-bodied with a greasy appearance up to 40 mm long without distinctive hairs.
- The common species can be distinguished in the caterpillar stage. Caterpillars with a pink tinge belong to the pink cutworm, *Agotis munda*, which has caused widespread damage in agricultural areas north of Perth. The dark grey caterpillars of the bogong moth, *Agotis infusa*, have been extremely damaging in most parts of the agricultural areas from time to time. Large numbers of patterned caterpillars belonging to different genera, *Riconis* and *Omphaletis*, have also been found attacking crops.
- Seedlings with chewed leaves or shoots cut through at ground level may be the first sign of cutworm.

**Monitoring and control**

Inspect crops after emergence in the late afternoon or evening. Look for patches of crop with seedlings cut off.

Scratch the soil at the base of damaged plants to locate caterpillars. There is no threshold level established to determine when to spray for cutworm in pulse crops. About 2 large caterpillars per 500 mm row is considered a threshold in cereals and canola. It is likely that cutworm will cause more yield loss at wide row spacings because they work their way along a cultivated row, which can leave a large bare patch in the crop.
Biological control agents, including fly and wasp parasites, disease organisms and predatory beetles, continually reduce cutworm numbers but cannot be relied on to give adequate control.

Spot spraying may be all that is necessary. A buffer of 20 m around the infestation should also be sprayed. Boom spraying in the late evening is likely to be more effective than spraying in the middle of the day.

**Brown pasture looper**

Pasture loopers (*Ciampa arietaria*) are early-season pests of all pulse crops. They often attack plants on the edge of crops where they move into the crop from adjacent pasture. Most damage is caused through chewing leaves.

Brown pasture loopers have only one generation per year. Moths fly from March to June and eggs are laid at this time. These eggs hatch and caterpillars grow to full size in about two months, pupate and remain in the pupal stage over spring and summer, until they emerge as moths in the next season.

**Identification**
- Caterpillars are grey or brown, with black and cream stripes.
- Young caterpillars walk with a characteristic looping motion but can remain motionless, appearing to be part of the plant.
- When caterpillars reach full size at 40 mm long they cease to walk with a looping motion.

**Monitoring and control**

Brown pasture loopers are early season pests. The loopers infest a crop at time of establishment. Routine chemical applications with synthetic pyrethroids pre-sowing limit the impact of this pest. There is no threshold level established to determine when to spray for pasture loopers.

The eggs may be heavily parasitised and the timing of autumn rains is critical for the survival of young caterpillars.

**Snails and slugs**

In localised areas of Western Australia, snails and slugs may damage pulse seedlings causing death of the plant and yield loss. Snails in their inactive state over summer may also contaminate grain at harvest.

Minimum tillage, straw-retention and restricted grazing help snails and slugs survive. These practices increase the organic matter content and covering of the soil helping increase its moisture levels. This makes it more favourable to slugs and snails and also provides more food because they eat organic matter in the soil.

**Identification**

There are several snail species that are pests and are found in the agricultural region of Western Australia. The most common is the white italian snail (*Theba pisana*) which thrive on areas of alkaline sandy soils with high calcium content, mainly near the coast. This species prefers open grassland but can survive in areas of native bush. In late spring, White italian snails climb up plants, posts and fences to get away from the hot ground surface. Other species include: small pointed snail, (*Cochlicella barbara*) and pointed snails, (*Cochlicella acuta*). In summer the snails are inactive until they are re-activated by rain in autumn.

There are at least two species of slugs that are involved with crop damage in Western Australia: the black keeled slug (*Milax gagates*) and the reticulated slug (*Deroceras reticulatum*). These slugs favour heavier soils, surviving over summer in cracks in the soil and under clods.
Monitoring and control

Effective control of snails and slugs involves a combination of measures, including cultural, biological and chemical methods.

Cultural control methods involve good hygiene, weed control and removal of harboursages. Abundant ground cover and vegetation provides good moisture levels and shelter for snails and slugs to thrive. For control of white snails grazing or burning vegetation reduces numbers. Grass control along fence lines is also very important.

Biological control methods are limited because all of our pest snails and slugs are introduced species. Some predatory beetles and lizards feed on them, while birds and rats can provide useful control.

Chemical baits can be an effective method of control. Chemicals registered are lethal to snails and slugs if applied when they are active. This is best achieved very early in the morning when the day is predicted to be fine; so that affected animals dehydrate before they can recover. This can be especially effective when snails or slugs are active on dewy mornings.

There are a number of chemicals registered in Australia for controlling snails and slugs. The major formulation of these chemicals is as baits.

Trying to control pest snails and slugs when they are in high numbers, usually in spring, is the least effective method. The best time to bait is in autumn, late March to April, before the break of the season, or as soon after as possible, for the following reasons:

- Adult snails and slugs are killed before they get a chance to lay their eggs (eggs are laid in soil, which is damp enough to germinate grasses).
- Snails and slugs are hungry after spending the summer period inactive and there is little alternative feed to compete with the baits.
- The ground is comparatively bare so the chance of a snail contacting bait is increased.
- Rain is infrequent, so the field life of baits is extended.

There are several species of aphid which settle and reproduce on pulses: bluegreen, cowpea and pea aphids are the main pests. Other aphid species may also populate pulse crops but these species are unlikely to reach damaging levels.

Bluegreen aphids are the largest of the common aphid species 15 to 30 mm long and have a bluish-green colour. Cowpea aphids are shiny black (adults) or grey (immature) and often form very dense colonies on a single plant, but infested plants are often isolated within a crop.

Identification

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Monitoring and control

Inspect crops from late autumn through to spring. Infestations are usually in patches across the paddock. Look closely at the growing points of the shoot where aphids develop their infestations. Bluegreen aphids are camouflaged amongst the foliage, and may be sampled by using a sweep net or knocking plants against a white background to dislodge the aphids.

The number of plants infested rather than the number of
individual aphids is important when considering control.
Pulse crops should be sprayed if aphids are observed on
the growing tips of 30% of plants from flowering through
to podding.
Before deciding to spray, assess the environmental
conditions because aphid populations can be prone to
rapid decline. Heavy rains can decrease aphid activity.
Warm, humid conditions can sometimes induce fungal
disease in aphids, causing a reduced infestation. Also check
for predators of aphids such as ladybirds, hover flies and
lacewings.

**Pea weevil**

Pea weevil (*Bruchus pisorum*) is only a pest of field pea.

The adults primarily survive over summer and winter in
field pea storage sites, but also in the field under the bark
of trees, fence posts, and sheds. Adult weevils emerge from
these hibernation sites about the time the peas are
flowering. They enter a field pea crop to feed on pollen.

Pea weevil are often only found around the perimeter of a
crop. The insects usually fly to the first flowering field
pea plant they find on the edge of crops. It is only when
population pressures are high that the adults are forced
to move deeper into the crop.

Pea weevil may fly up to 5km in search of field pea flowers.
Crops are invaded over a 3-5 week period and egg laying
starts within 7-14 days. The elongated, yellow eggs are
laid on the outside of field pea pods. The larvae hatch and
bore directly into pods, then into the seeds.

There is only one generation of weevils per year and only
green, growing peas are attacked. The pea weevil cannot
reproduce in stored grain, but the adults can remain
concealed in grain for many months.

**Identification**

- The insect is a beetle not a weevil, because it does not
  have the typical weevil snout.
- The pea weevil is a short (5-6 mm long), chunky,
  brownish beetle flecked with white, grey, and black;
- The white tip of the abdomen is marked with two black,
  oval spots.
- The white larvae have a brown head capsule and
  mouthparts.

**Monitoring and control**

Start looking for adult pea weevil at flowering, before first
pod set. Use a sweep net to sample for pea weevil at several
locations around a crop and at least 60 metres into the
crop. In many cases, pea weevil will only be found on the
edges of a crop, particularly in areas where pea weevil
populations are low. Large populations are only generally
found in regions with a history of several years of cropping
field pea. Don’t monitor on cold overcast days because
the adult pea weevil only becomes active when it is warm
(above 18°C).

Spraying is economical when there is more than one
weevil in 10 sweeps (feed grade) or one weevil in 100
sweeps (milling grade). Spray insecticide to kill adults
before they can lay eggs on young pods. Sprays will only
kill adult weevils, not the eggs or the larvae in the pods.
Recommence monitoring of the crop about 7-10 days after
spraying, if you find more pea weevil at the threshold level
spray the perimeter again or if necessary the entire crop.

Pea weevil continue to damage infested seed after maturity
and during storage, so early harvest and prompt
fumigation of all seed to be kept on farm after harvest
will prevent further pea weevil damage of infested seeds.
It will also limit the escape of adults from the seed to the
surrounding area.

To prevent pea weevil developing in field pea grown for
hay, the crop should be cut at flowering before the first
pods have developed large seeds. Good control of pea
weevil will mean fewer weevils to infest next year’s crop.

**Native budworm**

Native budworm (*Helicoverpa punctigera*) attacks all
pulse species and is a major pest in south-western
Australia causing yield loss and down-grading of seed.
The young caterpillars feed on leaf or pod material for
around two weeks before they become large enough (5 mm long) to be noticed in the crop. It takes a further four weeks until they are fully grown (40 mm) which is around seven weeks from the time of egg laying. These development times are based on average spring temperatures when caterpillars are active in central cropping areas of Western Australia. In warmer conditions the developmental rates for caterpillars will be faster. New moth flights and egg laying will result in caterpillars of varying sizes in a crop.

When fully mature, the caterpillars crawl to the ground, burrow into the soil and pupate. The length of the pupal stage depends on several environmental factors and varies from two weeks to several months.

**Identification**

- The adult form of the native budworm is a moth that may be recognised by its rapid, low-level flight that takes a zigzag path and ends with a dive into the crop.
- The moths have light brown, patterned forewings and mostly pale hind wings with a black patch at the tail end.
- White spherical eggs (0.5 mm) are laid singly, mostly near the top of the plant. The eggs darken as they mature and tiny caterpillars hatch after about seven days.
- The caterpillars vary greatly in colour from green through orange to dark brown. They usually have dark stripes along the body and are sparsely covered with fine bristles.

**Moth flights**

Male moths are easily captured in pheromone (female sex scent) traps. These traps are maintained by Department of Agriculture staff and farmers and provide an early warning of moth arrival and abundance. Results from native budworm traps are published weekly throughout the growing season in *PestFax*.

**Crop susceptibility and risk periods**

Crops vary in their attractiveness to the moths as sites for egg-laying. The crop density and growth stage (flowering and podding) will affect the number of eggs laid. Moths generally prefer crops in the following order: lentil > field pea > faba bean > chickpea > lupin > canola. The preference for narbon bean and vetch are unknown but are likely to be similar to faba bean or field pea. The feeding behaviour of caterpillars also change according to the type of crop.

Field pea, chickpea, lentil and faba bean crops are very susceptible to all sizes of caterpillar during the formation and development of pods. Tiny caterpillars can enter young pods and damage developing seed or over time devour the entire contents of the pod. In chickpea, if the pod wall is punctured, the growing seed will abort, even if the seed is not touched by the caterpillar.

Fungal infections may be introduced by caterpillar feeding, especially in faba bean. Losses attributed to native budworm come from seed abortion (chickpea), direct weight loss through seeds being wholly or partly eaten and from grain quality being downgraded through unacceptable levels of chewed grain. The percentage of broken, chewed and defective seed found in a sample will downgrade the price of pulse crops marketed for human consumption. Damage to large seeded crops such as faba
bean, kabuli chickpea and field pea can lead to particularly heavy losses.

**Monitoring and control**

Sampling of crops with a sweep net to determine the abundance of caterpillars is essential.

The decision of whether to spray a crop needs to be considered from the time of first podding. If caterpillar numbers are below the threshold limits, the decision to spray should be delayed and periodic sampling continued (see threshold table below). Natural mortality of budworm populations is sometimes sufficient to prevent economic damage.

One well-timed spray to control native budworm caterpillars should be sufficient in most situations. The application of registered rates of synthetic pyrethroid chemicals by boomspray, aircraft or, under ideal conditions, mister will kill the caterpillars present. Effectively applied synthetic pyrethroids can prevent re-infestation for up to six weeks after spraying. Subsequent caterpillar hatchings will usually be too late to cause significant damage.

**Economics of spraying**

The number of caterpillars present in a crop is the major factor determining whether economic damage will occur. Results from many trials conducted by the Department of Agriculture have been used to generate Table 21 below.

Growers should substitute their own costs and expected grain price. The economic threshold indicates the number of caterpillars that will cause more financial loss than the cost of spraying. For example, if the on-farm value of field pea is $210 per tonne and the cost of control is $12 per hectare, the calculation would be:

\[ \text{Economic threshold} = \frac{12}{50 \times 210 + 1000} \]

= 1.1 grubs/10 sweeps or 5.7 grubs in 5 lots of 10 sweeps.

### Table 21. Economic threshold (ET) for native budworm on various crops

<table>
<thead>
<tr>
<th>Crop</th>
<th>P (Grain price per tonne)</th>
<th>C (Control costs (chemical + application))</th>
<th>K (Loss for each grub in 10 sweeps (kg/ha/grub))</th>
<th>ET (Grubs in 10 sweeps)</th>
<th>ET Grubs in 5 lots of 10 sweeps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Pea</td>
<td>210</td>
<td>12</td>
<td>50</td>
<td>1.1</td>
<td>5.7</td>
</tr>
<tr>
<td>Chickpea (desi type)</td>
<td>380</td>
<td>12</td>
<td>30</td>
<td>1.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Faba bean</td>
<td>250</td>
<td>12</td>
<td>90</td>
<td>0.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Lentil</td>
<td>450</td>
<td>12</td>
<td>60</td>
<td>0.4</td>
<td>2.2</td>
</tr>
</tbody>
</table>

**Etiella moth**

Etiella moth (also called seed web moth (*Etiella behrili*)) lays eggs on the surface of legume pods in spring. Larva hatch and burrow into the pod seed, and reduce seed yield and quality. Lentils are the most sensitive pulse to attack from Etiella. Fortunately it only causes significant damage to crops in Western Australia about every five or so years.

**Identification**

- Moths grow up to 12 mm long and are greenish with a white stripe along the forewing;
- Eggs are approximately 0.5 mm long clear at first then turn orange or yellow;
- Mid-stage and older larvae are pale green with a pink tinge;
- Webbing is seen in pods.

**Monitoring and control**

Monitoring for the moths is important because it is very difficult to kill the larvae once they are inside the pod. The best strategy is to control the moths before they produce eggs.

Start checking for the moths in spring, from the start of flowering and continue until the pods harden. Monitoring is best done by looking for moths around a light at night. If monitoring in the paddock during the day moths can be found by gently brushing plants to disturb them. Eggs larvae and seed damage should also be monitored.

Very few chemicals are registered for control of etiella however it is probable that insecticides used for control of other pests at flowering or podding will may reduce etiella numbers.

**Further reading**

Financial benefits of pulse crops

Ian Pritchard, Peter White and Martin Harries

Introduction
The integration of animals, legume pastures and crops into dryland cereal farming has produced a robust agricultural system in Western Australia. The average farm business today is more efficient and more sophisticated than at any time in the past, and involves a range of complex technical and financial decisions. Many questions arise about which crop or pasture species to grow in what areas, what management to use, and what kind of livestock to produce. The answers to most of these questions are determined by a range of factors including potential profit, management ability, technical requirements and resource availability.

Crop rotations on good sandplain soils typically involve wheat and lupin and on loamy soils canola, field pea, chickpea or other pulse crops. Other factors such as unfolding seasonal conditions, herbicide resistance in weeds or disease problems can also force alteration in rotation sequences.

Profitable farming involves responding to opportunities created by weather and price, while avoiding problems and managing systems for stability over the long term.

The financial benefits of pulse crops need to be considered at two levels: firstly, the profitability of the individual crop in the year that it is grown, and secondly, the contribution of the crop to the profitability of farming systems or rotational sequences on the farm.

Pulse crops are important components of rotations because:
- Technically pulse crops are not hard to grow. There is now considerable grower experience, particularly through local grower associations.
- Pulse crops provide many rotational benefits, which increase wheat yields and quality.
- Well-grown pulse crops are profitable in their own right.
- There are a range of species available so options exist for most soils and environments.

The cost of growing pulse crops
Comparing the gross margins of individual crops in a rotation sequence provides only part of the financial picture when comparing the profitability of crops. Gross margin analysis does not include the capital infrastructure
(extra machinery, silos, etc.) that might be required to grow each crop. Expanding a cropping program by increasing the area sown to pulse crops generally does not create a need for extra seeding equipment, because pulse crops are sown either right at the start (e.g. faba bean) or at the end (e.g. field pea) of the seeding program. Nor is there a special requirement for spray equipment, apart from the realisation that the cropping program is larger and the spray equipment may need decontamination between crops (a time cost).

Additional costs associated with pulse crops may be in the areas of:

**Harrowing:** many of the best herbicide options for pulse crops involve application of chemicals post sowing, but pre-emergent. To do this safely the seedbed must be levelled by harrowing or rolling.

**Rolling:** the shorter pulse crops such as lentil, field pea and vetch should be rolled with a rubber tyred or steel roller. This provides an even level surface for harvest.

**Harvesting:** pulse crops are relatively expensive to harvest because:
- pulses can be two or three times slower than cereals to harvest;
- wear and tear on the harvester is greater with some pulse crops because the amount of soil, rock and wood entering the harvester is larger;
- additional equipment, such as crop lifters, pick-up fronts, and flexi fronts, need to be purchased to make harvesting of some pulse crops quicker and more efficient. Flexi fronts are the most expensive and efficient and should be used for lentil, the most difficult crop to harvest.

**Storage:** due to the seasonal fluctuations in price, storing harvested grain on farm to capitalise on price rises during the following growing season may be profitable for some pulses such as lentil or chickpea.

**Handling:** belt augers are softer on pulse grains than spiral augers resulting in less split and damaged grain.

**Transport:** receival points for most pulse grains are not the local cereal receival point and will therefore require relatively longer haulage.

### Should all cost be attributed to pulse crops?

Costs of croptopping reduce the gross margins for field pea and vetch crops but, the biggest benefit of croptopping is the reduction of ryegrass seed set for the following cereal crops.

The gross margins for pulse crops in Table 22 have been derived from average yields, long term price forecasts and growers actual variable costs. When comparing the variable costs of the pulse crops we can see that lentil ($245/ha) and chickpea ($261/ha) have the highest variable costs, entirely due to their requirement for fungicide sprays during the growing season. Lentil is also the highest priced commodity ($450/t) making it potentially the most profitable pulse crop with a gross margin of $205/ha for a 1.0 t/ha yield. Lentil ($84) closely followed by field pea ($79) give the greatest return
Factors such as species, soil type, season and crop vigour that leaves the paddock once the pulse crop is harvested. The net effect of pulse crops on the soil nitrogen balance ranges widely and depends upon factors that affect the total amount of nitrogen fixed and the amount of nitrogen returned to the soil largely depends on the efficiency of removal in grain and straw (hay).

More than 50 kg N/ha needs to be applied before wheat yields grown after wheat are matched by wheat grown after pulses in the absence of nitrogen fertiliser. Research with field pea over a wide range of sites and soil types has also shown that wheat following field pea produce about 0.4 t/ha extra grain (1.3 t/ha compared with 1.7 t/ha) and 1.9% extra protein (8.7% compared with 10.6%) compared to wheat following wheat. In some cases no amount of fertiliser nitrogen applied to wheat after wheat has been able to raise grain protein to the level achieved from wheat after a pulse. This indicates that pulses provide other benefits such as more even supply of nitrogen over the season, as well as simply extra nitrogen.

As a good rule of thumb, the benefits of field pea for a following wheat crop can be calculated as providing an extra two bags (approx. 400 kg) of grain and/or 2% higher protein in cereals. In practical terms this leads growers using pulse stubbles to manage protein levels within varieties. High protein grain from a pulse paddock is mixed with lower protein grain of the same variety to raise the protein levels in the low protein crop.

**Pulse crop rotational benefits**

Rotations may be defined as: “the growing of crops or pastures in a fixed sequence with the aim of maximising the long term productivity and profitability of the farm.” Pulse crops provide substantial rotational benefits to subsequent cereal and oilseed crops, thereby increasing the overall gross margin of the cropping rotation. The three main areas of benefit are through nitrogen addition to the soil, weed management and disease break.

**Soil nitrogen**

The net effect of pulse crops on the soil nitrogen balance ranges widely and depends upon factors that affect the total amount of nitrogen fixed and made available to subsequent crops. As a rule of thumb, the more biomass that is produced by a well nodulated crop, then the more nitrogen is fixed. The amount of nitrogen returned to the soil largely depends on the efficiency of removal in grain and straw (hay).

<table>
<thead>
<tr>
<th>Table 22. Gross margin budgets for pulses</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<td><strong>Variable costs ($/ha)</strong></td>
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<tr>
<td></td>
</tr>
<tr>
<td>SEED and inoculum</td>
</tr>
<tr>
<td>31.20</td>
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<tr>
<td>40.50</td>
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<tr>
<td>58.00</td>
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<tr>
<td>15.00</td>
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<tr>
<td>43.00</td>
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<td>35.10</td>
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<td>35.10</td>
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<tr>
<td>35.10</td>
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<td>28.08</td>
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<td>42.74</td>
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<td>43.05</td>
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<td>37.15</td>
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<td>44.38</td>
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<td>40.50</td>
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<tr>
<td>36.18</td>
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<tr>
<td>INSECTICIDE</td>
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<tr>
<td>5.12</td>
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<tr>
<td>3.30</td>
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<td>6.15</td>
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<td>9.71</td>
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<tr>
<td>2.64</td>
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<td>FUNGICIDE</td>
</tr>
<tr>
<td>64.00</td>
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<td>19.00</td>
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<td>MACHINERY</td>
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<td>6.30</td>
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<tr>
<td>Rolling</td>
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<td>Spraying</td>
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<td>16.00</td>
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<td>28.00</td>
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<td>24.00</td>
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<td>16.00</td>
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<td>12.00</td>
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<td>Harvest</td>
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<td>21.00</td>
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<td>12.00</td>
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<td>21.00</td>
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<tr>
<td>21.00</td>
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<tr>
<td>21.00</td>
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<tr>
<td>INTEREST 7.75% (6 mths)</td>
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<tr>
<td>4.44</td>
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<tr>
<td>7.19</td>
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<tr>
<td>6.19</td>
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<tr>
<td>3.62</td>
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<tr>
<td>5.69</td>
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<tr>
<td>FREIGHT</td>
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<td>18.00</td>
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<td>18.00</td>
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<td>18.00</td>
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<td>18.00</td>
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<tr>
<td>CROP INSURANCE</td>
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<tr>
<td>3.62</td>
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<tr>
<td>3.68</td>
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<tr>
<td>4.73</td>
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<tr>
<td>2.31</td>
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<tr>
<td>3.78</td>
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<tr>
<td>Total variable cost</td>
</tr>
<tr>
<td>192.42</td>
</tr>
<tr>
<td>260.61</td>
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<tr>
<td>244.84</td>
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<td>172.52</td>
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<tr>
<td>213.71</td>
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<tr>
<td>Gross margin</td>
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<tr>
<td>152.58</td>
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<tr>
<td>89.39</td>
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<tr>
<td>205.16</td>
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<tr>
<td>47.48</td>
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<tr>
<td>146.29</td>
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<tr>
<td>GM/$100 invested</td>
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<tr>
<td>79.29</td>
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<tr>
<td>34.30</td>
</tr>
<tr>
<td>83.80</td>
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<tr>
<td>27.52</td>
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<tr>
<td>68.45</td>
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<tr>
<td>Break even yield</td>
</tr>
<tr>
<td>@230=t/0.8t/ha</td>
</tr>
<tr>
<td>@350/t=0.7/ha</td>
</tr>
<tr>
<td>@450/t=0.5t/ha</td>
</tr>
<tr>
<td>@220/t=0.8t/ha</td>
</tr>
<tr>
<td>@240/t=0.9t/ha</td>
</tr>
<tr>
<td>Break even price</td>
</tr>
<tr>
<td>@1.5/t=$128/t</td>
</tr>
<tr>
<td>@1.0/ha=$261/t</td>
</tr>
<tr>
<td>@1.0/ha=$245/t</td>
</tr>
<tr>
<td>@1.0/ha=$173/t</td>
</tr>
<tr>
<td>@1.5/ha=$142/t</td>
</tr>
</tbody>
</table>

on dollars invested and common vetch the least ($27). Lentil and field pea have break even yields of about 50% of the average crop yield compared to 70%, 80% and 90% respectively for chickpea, common vetch and faba bean.

It should be noted that some of the inputs in the gross margin calculation are included because they are species ideally suited to this operation. The biggest benefit of croptopping is reducing ryegrass seed set for the following crops.
**Growing field pea in Avon Valley**

Field pea are a vital component in the most profitable rotation within the Avon Valley according to farmer, Gerard O’Brien, having analysed 37 paddocks over 6 years. The most profitable crops in the rotation are wheat and hay. However, there is a finite limit to the amount of hay most farms can manage due to the intensity of work and the critical timing to manage hay, let alone the high level of risk. Further, it is very difficult to grow cereals continuously due to weed management issues, disease and the lower returns compared to cereal legume rotations. Put simply, a legume must be part of the rotation; it is only a matter of determining which one.

Field pea analysed solely on a gross margin basis reflects a relatively low level of profit ($95/ha) compared to hay ($361/ha), wheat ($305/ha) and barley ($164/ha). However, when field pea is analysed as part of a rotational gross margin, it is an important component of the most profitable rotation – hay / field pea / wheat / wheat / hay: $311/ha average gross margin per year (see Table 23).

Field pea in Gerard’s rotation increase wheat yields by 0.4 t/ha and in conjunction with hay has allowed problem ryegrass paddocks to become very easy to manage. After two years of complete weed control, through hay and field pea production, the level of ryegrass falls to a point where the successive wheat crops don’t require any grass selective herbicides.

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Average gross margin per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preferred Rotation - Hay, Field Pea Wheat, Wheat, Hay</td>
<td>$311</td>
</tr>
<tr>
<td>All Wheat No Legumes - Wheat, Wheat, Wheat, Wheat</td>
<td>$235</td>
</tr>
<tr>
<td>Traditional Rotation - Wheat, Pasture, Wheat, Pasture, Wheat</td>
<td>$234</td>
</tr>
<tr>
<td>Common Rotation - Wheat, Lupin, Wheat, Canola, Wheat</td>
<td>$226</td>
</tr>
</tbody>
</table>

Field pea and vetch are well suited to crop topping which is very effective for controlling weed seed-set.

Pulse crops may also be used as a green manure option to manage a weed control failure.

**Crop pests**

If grasses are removed from the pulse crop, the incidence and severity of webworm, desiantha and cereal cyst nematode in following cereal crops will be reduced. Some pulses are also very useful for managing the numbers of root lesion nematode (RLN: *Pratylenchus neglectus*, *Pratylenchus teres*). Field pea, faba bean, and lentil are resistant to *P. neglectus* and cause a substantial drop in nematode numbers after only one cropping phase of these species. Chickpea, however, is a good host for *P. neglectus* and won’t reduce nematode numbers.

**Relative value of pulse species in rotations**

The relative benefits of one pulse species compared with another will depend on soil nitrogen balance and the effect the pulse crop has on weed, disease and pest pressures for the following cereal crops.

As a rule of thumb the crops producing the highest biomass such as faba bean and field pea also produce the largest amounts of nitrogen and hence, the highest yielding cereal crops. Experienced pulse growers often comment on the substantial benefits a well grown faba bean crop can have on cereal yields. Field pea is generally better than the other pulse crops in providing the other...
The benefits of pulse rotations versus continuous cereal cropping (or fallow/crop) are due to:

- Improvements in soil fertility: a beneficial feature of pulse crops is their ability to make or "fix" their own nitrogen from the air, when effectively nodulated. This nitrogen is then made available to subsequent crops as residues slowly break down. The accumulation, depletion and subsequent cycling of soil nitrogen is the most important interaction in the pulse cereal rotation.

- Improvement in soil structure: plants with deep roots such as chickpeas have been shown to improve water infiltration and root growth of subsequent crops in clay soils.

- Complementary soil water use, as one phase of the rotation may leave water stored for use by a subsequent crop.

- Reduced depletion of soil organic matter and degradation of soil structure.

- Integrated weed management: improved options for controlling weeds through the use of herbicides of a different group, crop topping and grazing.

- Disease management through breaking of disease cycles; for example foliar and root diseases of cereals and blackleg in canola.

- Pest management: insect pests such as webworm, desiantha, cereal cyst nematode and root lesion nematode can be managed in rotations.

- Better use of capital equipment and labour may be possible if the components of the rotation are not competitive in their requirements.

- Diversification of sources of income, particularly where pastures and livestock production form an important part of the farm system.

Non-nitrogen benefits in rotations, such as weed, disease and pest breaks. Field pea is also suited to a wide range of soils, and allow better utilisation of capital and, are therefore, a more flexible option.

Lentil and chickpea do not provide as great a rotational benefit as faba bean and field pea. Both crops usually provide a lower nitrogen input, and offer less flexibility for weed management. The numbers of root lesion nematode in the soil, may also increase during a chickpea crop. Chickpea or lentil therefore, should be grown less for their rotational benefits, and more for the profitability of the crop in its own right.

The rotational benefits of a green manured pulse crop are higher than a harvested pulse crop. A pulse crop that is green-manured will return more nitrogen and organic matter to the soil and offer better opportunities for weed control, than a crop grown for grain. This however, must be weighed against the lost income from not harvesting grain and the increased risk and reduced cash-flow from making early investments in paddock preparation.

**The value of pulse stubbles for livestock**

Grain left after harvesting a pulse crop are more valuable than stubble and grain left after harvesting a cereal or canola crop. This is because of the high energy value and protein of the pulse grain and the greater digestibility of the straw. However, consideration must be given to the substantially higher risks from wind erosion when grazing field pea stubble.

**Pulse market overview**

Pulse markets fall into two broad categories: food (human consumption) or feed (animals). There are local and international markets for both. In general, prices paid by the food market are higher, because the quality requirements are also higher. The countries of the Indian Sub-Continental dominate the international pulse market for human consumption. Pulse production, pulse
Table 25. The feed value of various grain

<table>
<thead>
<tr>
<th>Grain</th>
<th>Dry matter (%)</th>
<th>Metabolisable energy (MJ/kg)</th>
<th>Crude protein (%)</th>
<th>Acid detergent fibre (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>91</td>
<td>12.4-13.3</td>
<td>7.5-15.0</td>
<td>2.5-4.5</td>
</tr>
<tr>
<td>Barley</td>
<td>91</td>
<td>11.6-12.2</td>
<td>7.0-13.0</td>
<td>7.0-9.5</td>
</tr>
<tr>
<td>Oat</td>
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<td>Vetch</td>
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<td>12.4-13.2</td>
<td>22.0-30.0</td>
<td>7.5-9.5</td>
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</table>


consumption, currency value, political interference in the market and economic policy all affect world pulse prices. Pulses are often harvested earlier in Western Australia than in the eastern states and are generally the first Australian pulses into the market.

Field pea has the largest and most varied markets locally and internationally for both stockfeed and human consumption. They are also a commodity renowned for price stability (prices range of $200 to $250 per tonne). Field pea is a preferred ingredient for many stockfeed rations. Field pea prices will generally be below chickpea and lentil prices but above lupin prices.

Faba bean is used for both the human consumption and stockfeed markets. Locally, faba bean is sold into the domestic stockfeed market at a discount to the export human consumption market. Western Australian beans are now mostly exported to Saudi Arabia and Egypt. Faba bean destined for export must attain exacting quality standards of colour, size, admixture and insect damage. Prices for stockfeed are $180 to $200 per tonne and $200 to $280 per tonne for faba bean sold for human consumption.

Chickpea and lentil are marketed solely for human consumption, although downgraded chickpea and lentil can be used as stockfeed. Both crops have a relatively small domestic market but a very large export market, primarily to the Indian Sub-Continent. This market is historically very volatile. Chickpea prices fluctuate from $190 to $500 per tonne for desi types. Lentil is the pulse of first choice in the Indian Sub-Continent and range from $350 to $550 per tonne.

Common vetch is sold for birdseed, as seed for green manure and cover crops, and in sheep and cattle rations. Grain intended for use as seed for green manure and cover crops must attain exacting quality requirements (nil or very low tolerance of other grains) if it is to be exported. Trade is containerised with growers having to be prepared to store grain on farm. Prices obtained in Western Australia fluctuate with supply from within the state and Australia. In recent years vetch prices have fluctuated from $30/t lower to $30/t higher than field pea.

Narbon bean and lathyrus grain markets have yet to be developed. Their main use is on farm as stock feed for sheep and cattle. Feeding trials on the value of lathyrus in pig and poultry rations has shown that the variety Chalus, at inclusion rates up to 30% of the diet, produced equal or better growth rates to standard soybean or field pea rations.

Further reading


Herbicide options for broad-leaved weeds in lupin and pulse crops

| Herbicide group | C+C | C | C | B | F | C | C | D | C | D | C | F | F/B | C+F | B | A | B | B | C | C | C |
|-----------------|-----|---|---|---|---|---|---|---|---|---|---|---|---|-----|-----|---|---|---|---|---|---|---|
| After crop emergence |
| Capeweed        | R   | R | R | NRW | R | R | R | R | R | RS | RS | RS | NRW | NRW | RS | R | R | R | R | R | R | R |
| Clover          | R   | R | R | RS | R | R | R | R | R | R | R | R | R | NRW | R | R | R | R | R | R | R | R |
| Doublegea (Spiny Eyed) | R | R | RS | R | R | R | R | R | R | RS | RS | RS | NRW | NRW | NRW | R | R | R | R | R | R | R | R |
| Erodium (Storksbill) | NRW | NRW | R | R | NRW | NRW | NRW | NRW | R | NRW | R | NRW | R | NRW | R | R | R | R | R | R | R | R |
| Fumitory: Well  | RS  | R | R | R | RS | R | R | R | R | RS | RS | RS | NRW | R | R | R | R | R | R | R | R | R |
| Mallow          | RS  | R | R | R | RS | R | R | R | R | RS | RS | RS | NRW | NRW | NRW | NRW | R | R | R | R | R | R | R | R |
| Mustard         | R   | R | R | R | R | R | R | R | R | R | R | R | R | NRW | NRW | NRW | R | R | R | R | R | R | R | R |
| Wild Radish     | RS  | RS | RS | RS | RS | RS | RS | RS | RS | RS | RS | RS | NRW | NRW | NRW | R | R | R | R | R | R | R | R | R |
| Wild (Mediterranean) Turnip | R | R | R | NRW | R | R | R | R | R | NRW | R | R | NRW | NRW | NRW | NRW | R | R | R | R | R | R | R | R |
| Wildweed        | RS  | RS | RS | RS | RS | RS | RS | RS | RS | RS | RS | RS | RS | NRW | NRW | NRW | NRW | R | R | R | R | R | R | R | R |
| Lupin (Narrow-leaved) | Pre S | NRC | Pre S | PSPE | NRC | NRC | NRC | NRC | NRC | NRC | IBS | Pre S | IBS | IBS | NRC | 2-4 if | 4-8 if | 3-10 if | NRC | 2+ if | NRC | 8 if to 10 if | IBS | 3+ if | 5 if | NRC |
| Field Peas      | NRC | Pre S | Pre S | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | NRC | NRC | NRC | 2-4 if | 4-8 if | 3-10 if | NRC | 2+ if | NRC | 8 if to 10 if | IBS | 3+ if | 5 if | NRC |
| Chickpeas       | NRC | Pre S | NRC | NRWA | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | NRC | NRC | NRC | 2-4 if | 4-8 if | 3-10 if | NRC | 2+ if | NRC | 8 if to 10 if | IBS | 3+ if | 5 if | NRC |
| Faba Beans      | NRC | Pre S | NRC | NRWA | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | PSPE | NRC | NRC | NRC | 2-4 if | 4-8 if | 3-10 if | NRC | 2+ if | NRC | 8 if to 10 if | IBS | 3+ if | 5 if | NRC |
| Lentil          | NRC | Pre S | NRC | NRC | PSPE | PSPE | PSPE | NRC | NRC | NRC | NRC | NRC | NRC | NRC | NRWA | NRC | 3 node< if | 4-8 if | 2+ if | NRC | NRC | NRC | NRC | NRC | PO |
| Vetch           | NRC | NRWA | NRC | NRC | PSPE | PSPE | NRC | NRC | NRC | NRC | NRC | NRC | NRC | NRWA | NRC | NRC | NRC | NRC | NRC | NRC | NRC | NRC | NRC | NRC |
| Weed stage      | PE | PE-3 cm | PE-4 if | PE | PE | PE | PE | PE | PE-3 cm | 1-4 if | PO-4 if | <25 cm | PO-4 if | PO-5 cm | PO-3 if | to 8 if to 20 cm | PE-3 cm | 2-4 if | to 5 if |

| Wetting agent and oil | NN | NR | NN | NN | NR | NN | NN | NN | NN | NR | NR | WA | NR | NR | NR | NR | NR | NR | NR | NR | NR | NR |

**Notes:**
- Herbicide resistance to this mode of action sub group has been confirmed in Australian populations of this weed species. Check for resistance by in-paddock testing or using herbicide resistance testing services.
- Herbicide resistance is expected based on other data.

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# Herbicide options for grass weeds in lupin and pulse crops

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<thead>
<tr>
<th>Herbicide group</th>
<th>C+C</th>
<th>C</th>
<th>C</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>C</th>
<th>E</th>
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</table>

## Codes

- **B**: Barley
- **E**: Early tillering
- **I**: Incorporate by sowing
- **F**: Flowering
- **L**: Late
- **M**: Mid tillering
- **N**: Not necessary, optional
- **N**: Not recommended
- **R**: Not registered for this crop
- **R**: Not registered for this weed
- **NW**: Not recommended for this use in WA
- **O**: Oats
- **O**: Spray oil
- **Olv**: Vegetable based spray oil
- **P**: Post-emergence
- **P**: Pre-emergence
- **PE**: Pre-emergence
- **R**: Registered to suppress weed
- **S**: Seed stage
- **W**: Wheat
- **T**: Tillering or tillers
- **W**: Wetting agent

Note: The use of brand, trade and proprietary names has been done solely for the purpose of assisting users in the identification of products and does not imply a preferred recommendation.

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## Insecticide guide

Compiled by Department of Agriculture. Refer to PESTFAK for updates. Rates are given for EC formulation. Check labels to ensure compliance with the specific product being used.

### Registered or permit in WA for following pulse crops

<table>
<thead>
<tr>
<th>Insect/Crop</th>
<th>Rate</th>
<th>Application</th>
<th>Product Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alpha-Cypermethrin 100 g/L</strong></td>
<td>50-100</td>
<td>160-240</td>
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<tr>
<td><strong>Beta-Cyfluthrin 25 g/L</strong></td>
<td>20-40</td>
<td>96</td>
<td>64-80</td>
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<td><strong>Bifenthrin 100 g/L</strong></td>
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<td>400</td>
<td>400-500</td>
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<tr>
<td><strong>Btk (grams)</strong></td>
<td>1000-4000</td>
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<tr>
<td><strong>Chlorpyrifos 500 g/L</strong></td>
<td>140-300</td>
<td>700</td>
<td>200-500</td>
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<tr>
<td><strong>Cypermethrin 200 g/L</strong></td>
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<td><strong>Cypermethrin 250 g/L</strong></td>
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<td><strong>Deltamethrin 25 g/L</strong></td>
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<td><strong>Dimethoate 400 g/L</strong></td>
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<td><strong>Endosulfan 350 g/L</strong></td>
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<td><strong>Esfenvalerate 50 g/L</strong></td>
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<td><strong>Gamma-Cyhalothrin</strong></td>
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<td><strong>Methidathion 500 g/L</strong></td>
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<td><strong>Methidathion 400 g/L</strong></td>
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<td><strong>Methomyl 225 g/L</strong></td>
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<td>500-2000</td>
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<td><strong>Omepramox 800 g/L</strong></td>
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<td><strong>Pirimicarb 500 g/kg</strong></td>
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</table>

*Check aphid species for rates of chemical. Usually higher rates for green peach aphid. Check label withholding periods for grazing or hay/silage/fodder production before application.*

<table>
<thead>
<tr>
<th>Insect/Crop</th>
<th>Rate</th>
<th>Application</th>
<th>Product Description</th>
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</thead>
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* Check aphid species for rates of chemical. Usually higher rates for green peach aphid. Check label withholding periods for grazing or hay/silage/fodder production before application.
Common fungicides used on pulse crops

Note: fungicides are not registered for use on all pulse species. Check labels to ensure compliance with the specific product being used.

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<th>Seed treatment</th>
<th>Foliar treatment</th>
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<tr>
<td></td>
<td>Thiraflo® <strong>P-Pickel Tsc.</strong> Apron® XL 350ES</td>
<td>Carbendazim (various) Barrack® 720 Bravo® 720 Elect® 720 Kocide® (various) Mancozeb (various) Penncozeb 420SC Fortress® 500 Sumisclex® Broadacre, Spiral® Folicur 430SC Accord® Triadimefon</td>
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<tr>
<td></td>
<td>(L/t) (L/l) (mL/l) 600 g/L thiram 200 g/L thiabendazole + 360 g/L thiram 350 g/L metaxyl M</td>
<td>(mL/ha) (L/ha) (kg/ha) (kg/ha) (L/ha) (mL/ha) (mL/ha) (mL/ha) (mL/ha)</td>
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<tr>
<td>Grey mould</td>
<td>2 2 -</td>
<td>500 1.0-2.3 1.0-2.2 1.8-3.9 - - -</td>
</tr>
<tr>
<td>Damping-off</td>
<td>2 2 -</td>
<td>- - -</td>
</tr>
</tbody>
</table>

Mix 2 L with 3 L water. Add wetting agent. Use lower rate if crop is less than 20 cm high or before flowering. Do not spray crops affected by frost, in hot weather, or if poor drying conditions persist. Apply in 30 L water/ha by aircraft. Add wetting agent. Apply in at least 50 L of water. Repeat 14 days later if by ground, disease pressure high.
Calculating sowing rates for pulses

Sowing rate = \( \frac{\text{weight 1000 seeds (mg)} \times \text{optimum density} \times 100}{\text{germination percentage} \times \text{field establishment}} \)

For example: Languedoc = \( \frac{60 \times 60 \times 100}{95 \times 75} = 50 \text{ kg/ha} \)

### Example seed sizes and seed rates of pulses – assuming 95% germination and 85% field establishment

<table>
<thead>
<tr>
<th>Species</th>
<th>Variety</th>
<th>Seed size (mg)</th>
<th>Target density (plants/m²)</th>
<th>Seed rate (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field pea</td>
<td>Dundale</td>
<td>180</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Parafield</td>
<td>220</td>
<td>45</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Kaspa</td>
<td>200</td>
<td>50</td>
<td>124</td>
</tr>
<tr>
<td></td>
<td>Helena</td>
<td>170</td>
<td>45</td>
<td>95</td>
</tr>
<tr>
<td>Faba bean</td>
<td>Fiesta</td>
<td>500</td>
<td>35</td>
<td>223</td>
</tr>
<tr>
<td></td>
<td>Fiord</td>
<td>400</td>
<td>40</td>
<td>198</td>
</tr>
<tr>
<td></td>
<td>Farah</td>
<td>500</td>
<td>35</td>
<td>217</td>
</tr>
<tr>
<td></td>
<td>Ascot</td>
<td>350</td>
<td>45</td>
<td>195</td>
</tr>
<tr>
<td>Common vetch</td>
<td>Languedoc</td>
<td>50</td>
<td>60</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Blanchefluer</td>
<td>50</td>
<td>60</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>Morava</td>
<td>60</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>Chickpea</td>
<td>Sona</td>
<td>190</td>
<td>45</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>Kaniva</td>
<td>400</td>
<td>35</td>
<td>173</td>
</tr>
<tr>
<td>Red Lentil</td>
<td></td>
<td>40</td>
<td>120</td>
<td>59</td>
</tr>
<tr>
<td>Tanami narbon bean</td>
<td></td>
<td>180</td>
<td>45</td>
<td>100</td>
</tr>
<tr>
<td>Chalus lathyrus</td>
<td></td>
<td>70</td>
<td>70</td>
<td>61</td>
</tr>
</tbody>
</table>

### Ready reckoner for seed rate (kg/ha) at a range of seed size (mg) and target plant density (plants/m²) assuming 100% germination seed and field establishment

<table>
<thead>
<tr>
<th>Target density (plants/m²)</th>
<th>Seed size (mg)</th>
<th>40</th>
<th>50</th>
<th>75</th>
<th>100</th>
<th>125</th>
<th>150</th>
<th>200</th>
<th>400</th>
<th>450</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td>4</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>13</td>
<td>15</td>
<td>20</td>
<td>40</td>
<td>45</td>
<td>60</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>8</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>40</td>
<td>80</td>
<td>90</td>
<td>120</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>12</td>
<td>15</td>
<td>23</td>
<td>30</td>
<td>38</td>
<td>45</td>
<td>60</td>
<td>120</td>
<td>135</td>
<td>180</td>
</tr>
<tr>
<td>40</td>
<td></td>
<td>16</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>60</td>
<td>80</td>
<td>160</td>
<td>180</td>
<td>240</td>
</tr>
<tr>
<td>45</td>
<td></td>
<td>18</td>
<td>23</td>
<td>34</td>
<td>45</td>
<td>56</td>
<td>68</td>
<td>90</td>
<td>180</td>
<td>203</td>
<td>270</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td>20</td>
<td>25</td>
<td>38</td>
<td>50</td>
<td>63</td>
<td>75</td>
<td>100</td>
<td>200</td>
<td>225</td>
<td>300</td>
</tr>
<tr>
<td>60</td>
<td></td>
<td>24</td>
<td>30</td>
<td>45</td>
<td>60</td>
<td>75</td>
<td>90</td>
<td>120</td>
<td>240</td>
<td>270</td>
<td>360</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>40</td>
<td>50</td>
<td>75</td>
<td>100</td>
<td>125</td>
<td>150</td>
<td>200</td>
<td>400</td>
<td>450</td>
<td>600</td>
</tr>
<tr>
<td>120</td>
<td></td>
<td>48</td>
<td>60</td>
<td>90</td>
<td>120</td>
<td>150</td>
<td>180</td>
<td>240</td>
<td>480</td>
<td>540</td>
<td>720</td>
</tr>
</tbody>
</table>
Quicktips for field pea production

### Special comments
Roll the paddock immediately after sowing as long as the soil surface is not too moist. If rolling is delayed until after emergence wait until plants are between the 3 and 10 node stages and roll in the afternoon.

Well suited to croptopping to reduce ryegrass seed set - 1 to 2 weeks before harvest.

### Paddock selection
- Well drained loamy sands to clay loams with a pH above 5.0 (CaCl₂).
- A soil structure and slope that allows good drainage.
- Relatively flat with few rocks or large sticks.
- No sulfonylurea herbicide residues.
- A low broadleaf weed burden.
- A low frost risk.

### Rotation
Choose paddocks that have not grown field pea for at least 3 years, and go no closer than 500 m to paddocks that grew field pea in the previous year. It is preferable to be at least 50 m downwind of 2 and 3 year old stubbles, but no separation is necessary upwind.

### Sowing window

<table>
<thead>
<tr>
<th>Rainfall</th>
<th>North</th>
<th>Target</th>
<th>South</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low: May 7th to June 1st, 15th</td>
<td>May 25th</td>
<td>June 1st</td>
<td>Low: May 7th to June 30th</td>
<td>June 4th</td>
</tr>
<tr>
<td>Medium: May 15th to June 30th</td>
<td>June 1st</td>
<td>June 1st</td>
<td>Medium: May 15th to June 30th</td>
<td>June 4th</td>
</tr>
<tr>
<td>High: May 15th to June 30th</td>
<td>June 1st</td>
<td>June 1st</td>
<td>High: May 30th to June 30th</td>
<td>June 10th</td>
</tr>
</tbody>
</table>

### Sowing depth
5 cm.

### Seed dressing
Group E inoculum – no fungicide.

### Fertiliser
No special requirements. e.g. 50-100 kg DAP/ha or equivalent. Fungicide treated fertilisers provide unreliable results.

### Target density
- Trailing types 45 plants/m².
- Semileafless types 55 plants/m².

### Suggested varieties and their nominal seeding rate
- Kaspa, Parafield and Dunwa 120 kg/ha.
- Dundale and Snowpeak 110 kg/ha.
- Helena 100 kg/ha.

Calculate your own seeding rate as seed size and germination varies considerably.

### Row spacing
Less than 36 cm to enable efficient harvest.

### Herbicide options
- Pre-emergent herbicides. Trifluralin 1.0-2.0 L/ha, Diuron 50% flow 2.0 L/ha, Spinnaker® 35-70 g/ha, Bladex® 2.0 L/ha, Metribuzin 75% 100 – 180 g/ha.
- Post -emergent herbicides. Brodal® 100-200 mL/ha, Brodal® 60 mL + Metribuzin 60 g/ha, RaptorWG® 45 g/ha, MCPA Na 25% 0.7 – 1.0 L/ha.
- Various grass selectives.

### Pea Weevil
1 pea weevil per 100 sweeps and the crop has pods.

### Native Budworm
1 caterpillar per 10 sweeps.

### Harvesting
Crop lifters or pea pluckers are needed. Concave clearances should be opened and the drum speed low. Alternate wires and blanking plates on the concave may need to be removed.

Reel speed 1.1 x ground speed. Table auger clearance 7 - 12 mm. Drum speed 300-600 rpm (standard). Concave clearance 10-25 mm (start at 10 mm). Fan speed 60-75% (start at 75%). Top sieve 20-25 mm (start at 25 mm). Bottom sieve 10-15 mm (start at 15 mm).
### Quicktips for faba bean production

| Special comments | Fungicide must be applied to manage disease and ensure pod set.  
Sowing to 6 weeks – apply fungicide spray if more than one ascochyta lesion per metre row is seen (southern growing regions only).  
Flowering (10-17 weeks) - Apply a fungicide spray at early flowering even if no disease symptoms are present.  
A 2nd fungicide spray may be required if:  
• More than 5 ascochyta lesions per plant (south only);  
• Rust occurs on more than 5% of the leaf area;  
• Chocolate spot symptoms still clearly evident and damage easy to find ie. damaged or dead leaves and flowers. |
| --- | --- |
| Paddock selection | • Well drained loamy sands to clay loams with a pH above 6.0 (CaCl₂).  
• No sulfonylurea herbicide residues.  
• A low broad-leaved weed burden  
• Relatively flat paddock with few rocks or large sticks. |
| Rotation | One in three years. Avoid faba bean, vetch or narbon bean stubble. Plant at least 500 metres away from last year’s stubble. |
| Sowing window | Low rainfall – 25th April to 15th May.  
Medium rainfall – 1st May to 30th May.  
High rainfall – 15th May to 7th June.  
Disease management becomes more important if the crop is sown early |
| Sowing depth | At least 5 cm. |
| Seed dressing | Group F inoculum – no fungicide.  
Consider the use of granular inoculum – particularly if dry sowing. |
| Fertiliser | Faba bean is more responsive to phosphate than other pulse crops.  
Apply at least 9 kg P/ha. May be applied with compounds containing N (MAP, DAP, Agras etc) or as single superphosphate. |
| Target density | Fiord, Ascot, Barkool - Small sized seeds - 40-45 plants/m².  
Fiesta, Farah, Cairo - Medium sized seeds - 30-35 plants/m². |
| Row spacing | Up to 50 cm appears to have little effect on yield.  
Wider than 50 cm will require specialist equipment. |
| Herbicide options | • Pre-emergent herbicides. Trifluralin 1.0-2.0 L/ha, Simazine 1.5 L/ha, Spinnaker® 35-70 g/ha, Bladex® 2.0 L/ha, Metribuzin 75% 100 – 180 g/ha.  
• Post emergent herbicides Raptor WG® 45 g/ha – wetter only - no oils or other chemical.  
• Various grass selectives. |
| Aphid threshold | 30% of plants infested |
| Budworm threshold | 4 caterpillar per 100 sweeps – very low! |
| Harvesting | Reel speed 1.0 x ground speed. Table auger clearance 10-20 mm Drum or rotor speed 300-600 rpm Concave clearance 15-25 mm (start at 15 mm). Fan speed 75-100% (start at 100%). Top sieve 25-32 mm (start at 32 mm) Bottom sieve 16-20 mm (start at 20 mm). |
Quicktips for vetch production

| Special comments | Roll the paddock immediately after sowing as long as the soil surface is not too moist. If rolling is delayed until after emergence wait until plants are between the 3 and 10 node stages and roll in the afternoon.  
Well suited to croptopping to reduce ryegrass seed set - 1 to 2 weeks before harvest.  
There is a nil tolerance of common vetch in lentil grain, so lentil should not be grown in close rotation with common vetch.  
Contact markets in Perth. Prepare to hold grain on farm and sell throughout the year. |
| --- | --- |
| Paddock selection | • Well drained loamy sands to clay loams with a pH above 5.0 (CaCl₂).  
• No sulfonylurea herbicide residues.  
• A low broad-leaved weed burden.  
• Relatively flat paddock with few rocks or large sticks. |
| Rotation | Common vetch should not be grown on the same paddock more than once in three years. Also, avoid paddocks that have grown faba bean or narbon bean in the previous two seasons. These species harbour the same botrytis fungus that causes chocolate spot in vetch. The paddock chosen should be also be at least 500 metres away from stubble of last year’s vetch, faba bean, narbon bean, chickpea or lentil crop. |
| Sowing time | May. |
| Sowing depth | At least 5 cm. |
| Seed dressing | Group E inoculum.  
Consider the use of Granular inoculum – particularly if dry sowing. |
| Fertiliser | Maintenance application of 70-150 kg /ha superphosphate. A starter dose of 10-12 kg N/ha at seeding (e.g. 50-60 kg/ha of DAP) may stimulate the early growth of plants if soil pH is less than 6.0 in CaCl₂. |
| Nominal seeding rate | 50 kg/ha.  
Aim to establish a plant density of 40-60 plants/m². |
| Herbicide options | Vetch is tolerant to a range of pre and post emergent broad-leaved herbicides, but few of these are registered. Read labels and check with your Department of Agriculture agronomist before applying herbicides. |
| Aphid threshold | 30% of plants infested. |
| Budworm threshold | 1 caterpillar per 10 sweeps. |
| Harvesting | Common vetch is best harvested with crop lifters and finger tine reels, across the lay of the crop.  
Reel speed 1.1 x ground speed. Table auger clearance 7-12 mm (standard). Drum speed 300-600 rpm. Concave clearance 10-25 mm (start at 10 mm). Fan speed 60-75% (start at 75%). Top sieve 20-25 mm (start at 25 mm). Bottom sieve 10-15 mm (start at 15 mm). |
## Quicktips for lentil production

<table>
<thead>
<tr>
<th>Special comments</th>
<th>Select a paddock that is free of sticks and stones to enable efficient harvest. Roll the paddock immediately after sowing as long as the soil surface is not too moist. If rolling is delayed until after emergence wait until plants are between 3 and 5 node stages and roll in the afternoon. Croptopping is an option that can be used to ripen the crop evenly and harvest early, in order to avoid pod drop and shattering. Contact markets in Perth. Prepare to hold grain on farm and sell throughout the year.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddock selection</td>
<td>• Relatively flat without rocks or large stones. • Well drained loamy sands to clay loams with a pH above 6.5 (CaCl₂). • No sulfonylurea herbicide residues. • A low broad-leaved weed burden.</td>
</tr>
<tr>
<td>Rotation</td>
<td>One in three years. Avoid lentil, chickpea, vetch, or faba bean stubble - at least 500 metres away from last year’s stubble.</td>
</tr>
<tr>
<td>Sowing window</td>
<td>Low rainfall – May 1ˢᵗ to May 20ᵗʰ. Medium rainfall – May 15ᵗʰ to June 15ᵗʰ. High rainfall – only when the start to the season is late June 1ˢᵗ to June 20ᵗʰ.</td>
</tr>
<tr>
<td>Sowing depth</td>
<td>4 cm to 6 cm.</td>
</tr>
<tr>
<td>Seed dressing</td>
<td>P-Pickle-T, let dry then apply Group F inoculum.</td>
</tr>
<tr>
<td>Fertiliser</td>
<td>Maintenance of 5-10 units of phosphorous. May be applied with compounds containing nitrogen (MAP, DAP, Agras etc) or as single superphosphate.</td>
</tr>
<tr>
<td>Target density</td>
<td>120 – 150 plants/m². High plant density is essential for efficient harvest.</td>
</tr>
<tr>
<td>Row spacing</td>
<td>Narrow row spacings to form a dense crop, the same as wheat.</td>
</tr>
<tr>
<td>Herbicide options</td>
<td>• Pre-emergent herbicides e.g. Trifluralin 1-2 L/ha, Bladex® 2.0 L/ha, Metribuzin 75% 100 - 180 g/ha. • Post emergent herbicides Brodal® 100 mL/ha, Broadstrike® 25 g/ha. • Various grass selectives.</td>
</tr>
<tr>
<td>Aphid threshold</td>
<td>More than 30% of plants colonised.</td>
</tr>
<tr>
<td>Fungicide</td>
<td>Apply foliar fungicide at flowering if disease is observed.</td>
</tr>
<tr>
<td>Budworm threshold</td>
<td>1 caterpillar per 30 sweeps - very low!</td>
</tr>
<tr>
<td>Harvesting</td>
<td>Harvesting reel speed slightly faster than ground speed. Table auger 7-10 mm. Drum or rotor speed 300-600 rpm. Concave clearance 10-12 mm (start at clearance 10 mm). Fan speed 75-85% (start at 85%). Top sieve 10-20 mm (start at 20 mm). Bottom sieve 5-10 mm (start at 10 mm).</td>
</tr>
</tbody>
</table>
## Quicktips for chickpea production

<table>
<thead>
<tr>
<th>Special comments</th>
<th>Fungicide must be applied both to the seed and as post emergent sprays for ascochyta control. Before sowing – apply a seed dressing P-Pickle-T. Post emergence - apply chlorothalonil fungicides at four and seven weeks after emergence, then monitor regularly for disease. If disease is detected apply fungicide before rain fronts. Chlorothalonil (1-2 L/ha). NOTE: Don’t mix chlorothalonil with herbicides.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddock selection</td>
<td>• Well drained loamy sands to clay loams with a pH above 5.5 (CaCl₂). • No sulfonyl urea herbicide residues. • A low broad-leaved weed burden. • Relatively flat paddock with few rocks or large sticks. • Low salt and boron content.</td>
</tr>
<tr>
<td>Rotation</td>
<td>One in three years. Avoid chickpea, faba bean, vetch, lentil or nboron bean stubble - at least 500 metres away from last years stubble.</td>
</tr>
</tbody>
</table>
| Sowing window | **North**

<table>
<thead>
<tr>
<th>Desi</th>
<th>North</th>
<th>Kabuli</th>
<th>North</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low rainfall: April 20th to May 25th</td>
<td>Low rainfall: Not recommended</td>
<td>Low rainfall: April 20th to May 25th</td>
<td>Low rainfall: Not recommended</td>
</tr>
<tr>
<td>High rainfall: Not recommended</td>
<td>High rainfall: April 25th to May 30th</td>
<td>High rainfall: April 25th to May 30th</td>
<td></td>
</tr>
</tbody>
</table>

**South**

<table>
<thead>
<tr>
<th>Desi</th>
<th>South</th>
<th>Kabuli</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low rainfall: May 10th to June 10th</td>
<td>Low rainfall: Not recommended</td>
<td>Low rainfall: May 10th to June 10th</td>
<td>Low rainfall: Not recommended</td>
</tr>
<tr>
<td>Medium rainfall: May 15th to June 15th</td>
<td>Medium rainfall: May 5th to May 25th</td>
<td>Medium rainfall: May 15th to June 15th</td>
<td>Medium rainfall: May 10th to May 30th</td>
</tr>
<tr>
<td>High rainfall: Not recommended</td>
<td>High rainfall: May 10th to May 30th</td>
<td>High rainfall: Not recommended</td>
<td></td>
</tr>
</tbody>
</table>

| Sowing depth | At least 5 cm. |
| Seed dressing | P-Pickle-T, let dry then apply Group N inoculum. |
| Fertiliser | It takes approximately 8 units of phosphorous to grow a chickpea crop that yields 1t/ha. If soil P levels are between 10 mg/kg and 20 mg/kg add at least 8 kg P/ha. May be applied with compounds containing nitrogen (MAP, DAP, Agras etc) or as single superphosphate. |
| Target density | Desi - 40-45 plants/m². Kabuli - 30-35 plants/m². |
| Row spacing | Up to 50 cm appears to have little effect on yield. Wider than 50 cm will require specialist equipment. |
| Herbicide options | • Pre-emergent herbicides e.g. Trifluralin 1 - 2 L/ha, Simazine® 1.5 L/ha, Balance®100 g/ha, Bladex® 2 L/ha, Metribuzin 75% 100 – 180 g/ha. • Post emergent herbicides Broadstrike® 25 g/ha- don’t mix with Bravo® • Various grass selectives – don’t mix with Bravo®. |
| Budworm threshold | Desi 1 caterpillar per 10 sweeps - very low! Kabuli 1 caterpillar per 20 sweeps - very low! |
| Harvesting | Reel speed 1.0 x ground speed. Table auger 10-20 mm. Drum or rotor speed 300-600 rpm. Concave clearance 10-25 mm (start at clearance 10 mm). Fan speed 75-100% (start at 100%). Top sieve 16-25 mm (start at 25 mm). Bottom sieve 8-16 mm (start at 16 mm). |
### Quicktips for narbon bean production

<table>
<thead>
<tr>
<th><strong>Special comments</strong></th>
<th>No market developed. Use on farm for sheep feed (grain and fodder) or as green manure.</th>
</tr>
</thead>
</table>
| **Rotation**         | - Chemicals suitable to kill off narbon bean for green manuring at 100-120 days after sowing include:  
|                      |   • 1-2 L/ha of Glyphosate and 70 mL/ha of Lontrel® (clopyralid 300 g/L).  
|                      |   • 400 mL/ha of 2,4D ester and 70 mL/ha of Lontrel®. |
| **Sowing depth**     | At least 5 cm. |
| **Seed dressing**    | Group E inoculum  
|                      | Consider the use of granular inoculum - particularly if dry sowing. |
| **Fertiliser**       | At least 10 kg P/ha. e.g. 50 kg/ha DAP or equivalent. |
| **Nominal seeding rate** | Between 75-100 kg/ha.  
|                      | Calculate your own seeding rate as seed size and germination varies. |
| **Herbicide options** | Narbon bean is tolerant to a range of pre and post emergent broad-leaved herbicides, but few are registered. Read labels and check with your Department of Agriculture pulse agronomist before applying herbicides. |
| **Aphid threshold**  | 30% of plants infested. |
| **Budworm threshold** | 2 caterpillars per 10 sweeps. |
| **Paddock selection**| Well drained loamy sands to clay loams with a pH above 5.0(CaCl₂)  
|                      | - No sulfonyl urea herbicide residues.  
|                      | - A low broad-leaved weed burden.  
|                      | - Few rocks and roots and can be left relatively flat and even after sowing. |
| **Sowing time**      | Low rainfall - April 25<sup>th</sup> to June 15<sup>th</sup>  
|                      | Medium rainfall - May 15<sup>th</sup> to June 30  
|                      | High rainfall - June 1<sup>st</sup> to June 30<sup>th</sup>.  
|                      | Green manure crops particularly well suited to April sowings. |
| **Sowing depth**     | At least 5 cm.  
| **Fertiliser**       | At least 10 kg P/ha. e.g. 50 kg/ha DAP or equivalent. |
| **Nominal seeding rate** | Between 75-100 kg/ha.  
|                      | Calculate your own seeding rate as seed size and germination varies. |
| **Herbicide options** | Narbon bean is tolerant to a range of pre and post emergent broad-leaved herbicides, but few are registered. Read labels and check with your Department of Agriculture pulse agronomist before applying herbicides. |
| **Aphid threshold**  | 30% of plants infested. |
| **Budworm threshold** | 2 caterpillars per 10 sweeps. |

| **Green Manure** | No more than one narbon bean, chickpea or vetch crop in the past three years. At least 500 m away from last narbon bean, chickpea, faba bean, lentil or vetch stubble. |
| **Paddock selection** | Well drained loamy sands to clay loams with a pH above 5.0(CaCl₂)  
|                      | - No sulfonyl urea herbicide residues.  
|                      | - A low broad-leaved weed burden.  
|                      | - Few rocks and roots and can be left relatively flat and even after sowing. |
| **Rotation**       | No more than one narbon bean, chickpea or vetch crop in the past three years. At least 500 m away from last narbon bean, chickpea, faba bean, lentil or vetch stubble. |
| **Sowing depth**   | At least 5 cm.  
| **Seed dressing**  | Group E inoculum  
|                      | Consider the use of granular inoculum - particularly if dry sowing. |
| **Fertiliser**     | At least 10 kg P/ha. e.g. 50 kg/ha DAP or equivalent. |
| **Nominal seeding rate** | Between 75-100 kg/ha.  
|                      | Calculate your own seeding rate as seed size and germination varies. |
| **Herbicide options** | Narbon bean is tolerant to a range of pre and post emergent broad-leaved herbicides, but few are registered. Read labels and check with your Department of Agriculture pulse agronomist before applying herbicides. |
| **Aphid threshold** | 30% of plants infested. |
| **Budworm threshold** | 2 caterpillars per 10 sweeps. |

- Harvesting reel speed 1.1 x ground speed. Table auger clearance 7-12 mm (standard)  
  Drum speed 300-600 rpm. Concave clearance 10-25 mm (start at 10 mm). Fan speed 60-75% (start at 75%). Top sieve 20-25 mm (start at 25 mm). Bottom sleeve 10-15 mm (start at 15 mm).
### Quicktips for lathyrus production

<table>
<thead>
<tr>
<th>Special comments</th>
<th>More difficult to harvest than field pea. Roll the paddock after sowing to ensure an even soil surface. No market developed. Use for sheep feed (grain and fodder) or as green manure.</th>
</tr>
</thead>
</table>
| Paddock selection | - Loamy sands to clay loams with a pH above 5.0 ($\text{CaCl}_2$).  
- Relatively flat with few sticks or rocks.  
- No sulfonylurea herbicide residues.  
- A low broadleaf weed burden. |
| Rotation         | Lathyrus does not share the same botrytis or ascochya diseases as other pulse crops so isolation from their stubbles is not required. |
| Sowing window    | Any time from April to June in all rainfall zones. |
| Sowing depth     | 5 cm. |
| Seed dressing    | Group F inoculum – no fungicide. |
| Fertiliser       | No special requirements.  
60-80 kg DAP/ha or equivalent. |
| Target density   | Grain crops – 50–80 plants/m².  
Forage crops – 70–80 plants/m². |
| Herbicide options | Lathyrus is tolerant to a range of pre and post emergent herbicides for broad-leaved weeds but few of these are registered. Read labels and check with your Department of Agriculture agronomist before applying herbicides. |
| Budworm threshold| 2 caterpillars per 10 sweeps. |
| Harvesting       | Don’t delay harvest. Use crop lifters.  
Reel speed slightly faster than ground. Table auger clearance 7-10 mm.  
Drum or rotor speed 300-600 rpm. Concave clearance 8-20 mm (start at 8 mm).  
Fan speed 60-75% (start at 75%). Top sieve 8-15 mm (start at 15 mm). Bottom sieve 4-8 mm (start at 8 mm). |