Tipping the balance

Tipping the balance towards the pulse not the weeds

The numbers game!

Managing weeds in all cropping and pasture situations, including the pulse phase, is about reducing numbers. We regularly see growers spraying large populations of weeds. Densities of 2000 plants per m^2 (20 million per ha) of annual ryegrass or 10 plants per m^2 (100,000 per ha) of wild radish are common. If a herbicide does a very good job and kills 99% of the weed population, we still have 200,000 ryegrass plants per ha or 1000 radish plants. These will then have the opportunity to produce large numbers of seed for the following year.

For this reason growers should be targeting very low weed population thresholds when deciding on whether a weed should be controlled or not. There may not be an economic benefit from taking action in the pulse crop year – rather a large cost in future years if nothing is done.

An integrated system to manage weeds is essential to play this numbers game. Reliance on herbicides alone has many associated problems, including the likely development of herbicide resistance, high cost and environmental hazards. Growers need to employ a diverse range of control methods. Unfortunately many of these cost more or result in a yield reduction. However growers should look at this cost as an investment in the longevity of their herbicides and long term profitability.

See page 39 Cultural weed management.

Research highlight

Wild radish seed production in lupins

It has been demonstrated that the probability of wild radish seedlings developing to seed production decreases with later dates of emergence within an established lupin crop. Wild radish emerging later than 21 days after crop emergence have been shown to produce no seed. Early emerging wild radish seedlings produce more seed and also more dormant seeds than later emerging ones.

Panetta *et al.* (1988); Cheam (1986)

Research highlight

Annual ryegrass and crop competitive ability

In southern NSW, both narrow-leafed lupins and field peas have been shown to be poor competitors against annual ryegrass compared with cereal crops. These crops had 100% yield reduction when competing against 300 annual ryegrass plants per m^2.

Winter field crop	% Yield reduction
Oats	2-14
Triticale	5-24
Canola	9-30
Wheat	22-40
Barley	10-55
Field pea	100
Narrow-leaf lupin	100

Lemerle *et al.* (1995)

Optimising competitive ability

The effect of weeds on pulse crops can be reduced by forward planning and giving the pulse every opportunity to maximise its competitive ability. 'Best management' should consider:

- Crop type (and in some instances, variety) and canopy development.
- Sowing time, seeding rate and row spacing.
- Sowing depth and soil properties.
- Fertiliser and its placement.
- Disease & insect management.

Generally, a pulse's ability to compete with weeds can be ranked:

Field Pea > Faba Bean > Lupin=Chickpea=Lentil

However, the ranking of these species can change. Selecting the most competitive pulse will be determined by both the regional and individual paddock conditions. This includes soil type, water holding capacity, drainage and rainfall. Crop varieties that are susceptible to early insect or disease damage also become more susceptible to subsequent weed invasion and competition.

See page 2 Choosing a pulse species.

On farm solution

Monitoring weed seed banks

Farmer: Mark Branson.

Location: Stockport, South Australia.

Property size: 850 ha.

Annual rainfall: 450 mm.

Soil type: Red brown earth and dark brown cracking clay.

Main enterprises: Cropping - durum wheat, bread wheat, malt barley, canola, pulses - and some sheep grazing.

Mark employs a range of weed management strategies within his paddock rotation to reduce and maintain ryegrass at low levels. Mark is a member of a weed seed bank monitoring group which enables him to actually monitor the effectiveness of his chosen strategies in managing the ryegrass seed bank.

Using one of Mark's paddocks as an example you can see some of the strategies he employs. In this particular paddock Mark has reduced the ryegrass seedbank from a high level to a low level using a wide range of practices.

Year	**1998**	**1999**	**2000**	**2001**	**2002**
Crop	**Pasture**	**Pasture**	**Canola**	**Barley**	**Faba beans**
Weed control measure used	Nil	Targa® spray-top	3 cultivations trifluralin glyphosate Select® windrow glyphosate rows burnt	2 cultivations glyphosate trifluralin	1 cultivation glyphosate simazine trifluralin Targa® crop-top
Ryegrass in following autumn (seeds per m^2)	2684	157	17	51	39

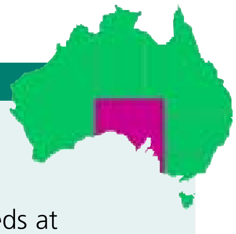
Spray topping or crop topping is practised in pastures and pulses, particularly following the application of selective grass herbicides, to prevent seed set of potentially resistant escapes.

Spray nozzles are fitted to the windrower so that glyphosate can be applied underneath the windrowed crop to prevent ryegrass plants from re-shooting and producing viable seed following windrowing. Nozzles (TeeJet® 015-80) are spaced at 50 cm on the back bar (see photograph). Just behind the knife in the opening, nozzles (TeeJet® 015-110) are spaced at 25 cm.

When harvesting canola, straw spreaders are disconnected so that residues (including ryegrass seed) can be placed in a row which can be later burnt.

See page 43 Stubble management.

Research highlight



Differences in competitive ability in field peas

		Ability to suppress weeds		
		Low	Medium	High
Tolerance to competition	Low	Bonzer Bluey Mukta	Glenroy Soupa Progreta	
	Medium	Bohatyr	Alma Dundale Parafield	
	High		Jupiter	Morgan

MacDonald (2002)

Trials using annual ryegrass and wheat as weeds at Roseworthy, SA have been used to rank a number of field pea varieties in order of:

- tolerance to competition (yield under weed competition), and
- ability to suppress weed growth and seed set.

Morgan was the most competitive variety of those tested.

Canopy development

The speed and amount of crop canopy development will impact on competition with weeds. The canopy development can be influenced by row spacing, seeding rate, seeding depth and environmental conditions including soil properties and nutritional status. These will all in turn affect plant density, radiation adsorption, dry matter production and yield.

Higher seeding rates can result in earlier canopy closure and greater dry matter production and thus improve the suppression of both weeds and aphids.Some pulses have slow winter growth rates and this can decrease their ability to compete with autumn weeds and also their light and water use efficiency. This includes crops such as chickpea and lentil. Faba bean and field pea have high crop growth rates early in the season. The encouragement of early canopy closure can be achieved through management.

Research highlight

Faba bean canopy development

Varying sowing rate changed the canopy development of Fiord faba bean in a study in southern WA. High sowing rates gave substantially earlier canopy closure and greater seed yields. Higher plant densities (up to 49 plants per m^2 or 270 kg per ha) produced taller crops with the lowest pods on the plant positioned higher above the ground. At 8 to 16 plants per m^2 pods were 10 cm above the ground, while at 49 plants per m^2 pod height was 18 cm, thus thus reducing harvest losses.

Dry matter production, yield and profit can be increased by using sowing rates of 270 kg per ha or even higher, however machinery capabilities and the large quantities of seed required will limit seeding rates at this stage.

Loss *et al.* (1998)

Seeding rate

The choice of seeding rate can affect a pulse crop's ability to compete against weeds. It may impact on canopy development and yield. The target plant density for each of the pulse crops will differ (seek local advice), and depend on growing conditions and economic viability.

In unfavourable conditions (eg areas of low rainfall, delayed sowing) the growth of individual pulse plants becomes limited so higher plant densities are favoured.

Take note

Maximise seeding rate

Use the highest practical seeding rate in order to maximise faba bean competitive ability. This will increase the effectiveness of herbicides used, reduce weed seed set and increase yield. High seeding rates promote early canopy closure, increase the height to the lowest pod and optimise yield.

Research highlight

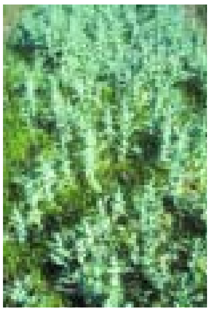
Kabuli chickpea seeding rate

Seeding rates for large seeded pulses is always an issue due to the large investment placed in seed. Trials conducted in Western Australia found a positive relationship between kabuli chickpea seeding rate and grain yield. Although there were fewer pods per plant at higher seeding rates, the higher plant population resulted in more pods per m^2. The study also found that establishment rates for kabuli chickpea were poor - only 75% of viable seeds sown actually became established plants. Taking economic considerations into account:

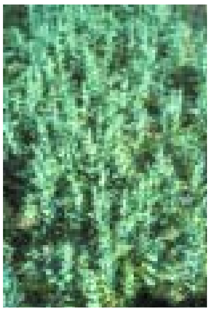
- a plant density of 25 plants per m^2 is most profitable for crops yielding approximately 1.0 t per ha
- a plant density greater than 35 plants per m^2 will be most profitable for higher-yielding situations, greater than 1.5 t per ha.

Regan *et al*. (2003)

20 plants per m^2

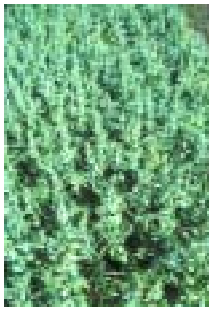


40 plants per m^2



50 plants per m^2

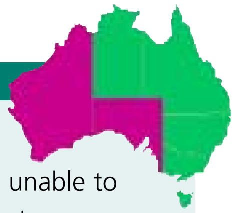
60 plants per m^2



80 plants per m^2

The rate of development of the crop canopy will impact on its competitive ability. High seeding rates of field peas, such as Excell pictured here in trials in South Australia, can suppress annual ryegrass.

Research highlight



Lentil seeding rates

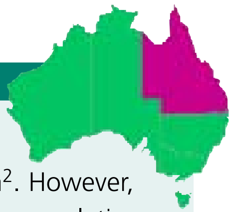
There are few herbicide options for lentils. They have slow winter growth and therefore are unable to compete strongly against autumn and winter germinating weeds. The use of high seeding rates as a viable means of improving competitiveness and yields still requires further investigation with respect to weed management. However, it is likely when conditions are less favourable, that compared to low density lentil crops, those sown at higher densities (up to 230 plants per m^2) will:

- have improved yields,
- be better able to compete with weeds,
- be less prone to aphids and viruses,
- help reduce soil water evaporation, and
- be taller and easier to harvest.

In Western Australia, a target density of 150 plants per m^2 (equivalent to seeding rate 90 to 110 kg per ha) is recommended depending upon mean seed weight and germination percentage. Harvest index, seeds per pod and seed weight all remain relatively stable with changes in seeding rate. Even higher seeding rates may be optimal where growing conditions are not favourable and plant growth is limited.

Research from South Australia has demonstrated that yields are seldom depressed with higher seeding rates (even in dry years) and in the absence of disease, 100-200 seeds per m^2 is suitable.

Siddique *et al*. (1998); Ali and Wheeler (1996)



Research highlight

Desirable chickpea plant densities for late crops or wide rows.

Chickpea yields are reasonably stable if plant numbers are between 20 and 40 plants per m^2. However, in the northern cropping region, populations of 30 plants per m^2 will optimise yields. Higher populations benefit both yield and crop competition if planting is late. Lower populations (20 plants per m^2) are recommended for crops grown on wide row spacing (100 cm). If populations are too high when using wide rows, then main stems are often thin and there is greater risk of crop lodging.

Queensland DPI (2002)

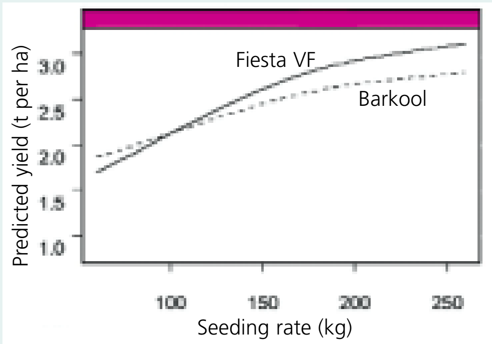
Research highlight

Faba bean seeding rate

Many trials around Australia have assessed the optimal seeding rate of current varieties of faba bean. The results of all trials indicate yield of faba bean increases with seeding rate, beyond that which can practically be sown (greater than 280 kg per ha). The graph below illustrates the predicted yield of the cultivars Barkool and Fiesta VF, both still increasing at 250 kg per ha.

A study in Western Australia found the seed number per pod and seed weight of faba beans cv. Fiord was not affected by seeding rate. Pod number per plant was reduced but the higher plant population more than compensated for this, resulting in higher yield.

Targeting faba bean seeding rates greater than the current commercial practice (15 to 25 plants per m^2) in southern Australia will give higher yield and profit. However seeding rates are a compromise between those high rates required for optimal yield, the physical limitations of seeding equipment and the cost of seed at sowing time (the largest single cost of production).



The majority of commercial seeding machinery is incapable of handling seeding rates much higher than 150 kg per ha with minimal damage to seed. Seed has an opportunity cost of $250 per tonne (very conservatively) which equates to seed costs at 270 kg per ha of $68 per ha which becomes prohibitive.

The data below from trials conducted in southern and central NSW shows how faba bean yield varies with delayed sowing (cv Barkool) and for different varieties sown on time (cv Barkool, Fiesta VF and Fiord). This is important when changing varieties. The larger seeded Fiesta VF must be sown at higher seed rates to maximise yield benefit over Barkool (see Graph above).

Seeding rate	100 kg per ha Yield (t per ha)	140 kg per ha Yield (t per ha)
Barkool	2.14	2.41
Barkool - late	1.64	2.12
Barkool - very late	1.27	1.72
Fiesta VF	2.14	2.54
Fiord	2.50	2.79

Loss *et al.* (1998); Matthews *et al.* (2001)

Row spacing

The move to conservation farming in many cropping systems has placed greater pressure on herbicides for weed control as wider row spacing and stubble retention replace cultivation and burning.

The use of wider row spacing in some pulse crops can improve stubble handling, crop fertiliser use and disease control. Improvements in crop establishment and vigour will ultimately improve crop competitive ability against weeds. Incorporating wider rows into a cropping system can also provide opportunities for inter-row weed control. Intra- and inter-row weed control may include the use of herbicide application by boom spray or less commonly used methods such as band spraying, shielded spraying, cultivation or flame weeding.

Faba beans sown at 36 cm row space. At these and wider row spacings shielded sprays or inter-row cultivation may be a useful weed management strategy. Good weed control in previous crops is essential to minimise weed seed numbers.

Take note

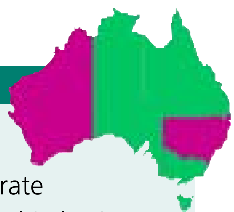
Narrow or wide rows?

Yield reductions have been observed in chickpeas sown at wide row spacings (1 m) in high yielding situations. However the advantages associated with wide row spacing far outweigh any potential yield reduction.

The selected row spacing will ultimately be determined by potential crop yield reductions. Pulse research from across Australia has shown that increasing row spacing (eg up to 76 cm in chickpeas sown in either WA or northern NSW) will not reduce crop yields. However, when deciding on row spacing, consider such things as:

- the capacity of the equipment or machinery available
- paddock conditions (eg the weed burden and stubble)
- pulse species and variety
- opportunities or limitations for pest control (eg inter-row weed control)
- fertiliser placement (eg deep banding).

Research highlight

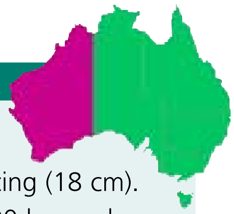


Chickpea row spacing

Sowing chickpeas (both kabuli and desi types) at row spacings up to 760 mm at a seeding rate targeting 30 plants per m^2 has little effect on yield (see Table below). Wider row spacing could also be useful for possible inter-row weed control.

	Condobolin (NSW)		Mullewa (WA)	
Row space (mm)	Amethyst (t per ha)	Kaniva (t per ha)	Row space (mm)	Amethyst (t per ha)
175	1.2	0.9	190	0.6
263	1.4	1.2	380	0.7
350	1.2	1.0	570	0.6
500	1.4	1.2	760	0.6
650	1.1	0.9		

Riethmuller and McLeod (2001); Fettell (1998)

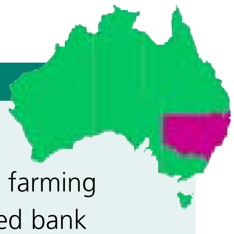


Research highlight

Row spacing of lupins

Wheat stubble or residue can cause problems at sowing when using conventional row spacing (18 cm). Lupin row spacing trials were conducted over a wide area of Western Australia, sown at 100 kg per ha and two row spacings - conventional (18 cm) and wide (36 cm). Crops had slightly higher yield (average of 3.6% increase) when sown at wide row spacing compared to conventional. Wide row spacing can provide a more efficient method of phosphorous (P) application and allow deep banding of P into heavy stubbles. This may be the only safe and effective method of P application as it can help to avoid fertiliser toxicity (and thus poor crop competitive ability). The spread of CMV may also be less in wide rows if the same seed rate per hectare is maintained. There was no difference in weed control identified between the two row spacings used in these trials.

Jarvis (1992)



Research highlight

Row spacings & stubble management in field peas

Continuing research at Wagga Wagga, southern NSW is evaluating the impact of changing farming practices such as stubble retention, row spacing, and herbicide inputs, on weed species, seed bank composition and patterns of weed emergence. Crops, including field peas cv Excell, were sown to evaluate the impact of two contrasting management systems:

- 'low-input' - non-selective pre-sowing herbicide and non-chemical methods, and
- 'best-bet' - including selective pre- and post-emergent herbicides.

Farming practice	Field pea establishment (plants per m^2)	Annual ryegrass in July (plants per m^2)	Field pea yield (t per ha)
Narrow rows, burn	64	108	2.9
Narrow rows, stubble	57	87	2.1
Wide rows, burn	59	57	2.4
Wide rows, stubble	54	58	2.2

Narrow rows = 23 cm row spacing
Wide rows = 46 cm row spacing

- 'Best-bet' field pea crops (narrow and wide row spacing) had 21.5% higher crop biomass than 'low-input'.
- 'Best-bet' field pea crops (narrow and wide row spacing) reduced weed biomass by 96.5% compared to 'low-input'.
- 'Low-input' field pea crops had the highest weed biomass at anthesis when stubble was retained.
- Crop competitive ability:

Wide rows	wheat	>	field peas	>	canola
Narrow rows	wheat	>	canola	>	field peas

- In narrow rows 'best-bet' management plus burning improved field pea yields by 8% when compared to stubble retained.
- To gain most advantage from wide rows, crops must be sown at the optimal time.

These results are the first year in each system. When changing farming system, weed management must be well planned to ensure a 'blowout' in weed seed production doesn't become a costly reminder of poor planning.

Lemerle *et al*. (2002)

Sowing time

Time of sowing has a large effect on early crop vigour, canopy development, dry matter production and final yield. All these factors have a direct impact on the competitive ability of a crop, with any reduction giving the weeds an advantage.

Delaying sowing beyond that recommended for each specific crop in a given district will reduce early vigour, extend the time taken to reach canopy closure and reduce overall dry matter production. It is therefore vital to sow within the recommended time period, not only to maximise yield, but also to make the crop competitive and reduce the pressure placed on herbicides.

Delayed sowing dramatically reduces the competitive ability of lupins. The block on the right was sown on time in late April, while those on the left were sown 3 weeks later.

Seeding depth

Seeding depth will affect crop emergence and establishment and have an impact on crop competitive ability and yield. Correct and even seeding depth will result in uniform and synchronous emergence, benefiting crop yield as well as crop competitiveness.

Pulse types react differently to seeding depth due to two types of emergence, hypogeal and epigeal. Lupin species have epigeal emergence. This means that the cotyledons are pushed up through the soil during emergence. In contrast field peas, faba beans, lentils and chickpeas have hypogeal emergence, where the cotyledons remain where the seed is sown and a shoot pushes up through the soil during emergence (see diagram next page).

Due to the epigeal emergence, the seeding depth of lupins is critical, particularly in late sowings or when soil conditions are unfavourable. Seed must not be sown too deep, no more than 5 cm deep, or the establishment population will be reduced. However in early sowings reductions in emergence can occur if the seed is sown too shallow and the seedlings run out of moisture. Recommended depth is 5 cm for early sown lupins ranging to 3 cm for later sowing.

Moisture seeking, or sowing at depth (below 5 cm) into subsoil moisture is a common practice in many regions where sowing rainfall is unreliable. This can be done with all pulse species and results in improved establishment and survival of *Rhizobium* inoculum due to more favourable soil conditions. This ensures timely establishment of the crop ahead of the germinating weeds, giving it a competitive advantage.

Shallow sown crops, especially lentil and faba bean, can be more prone to herbicide damage. It is recommended that when using post-sowing, pre-emergent herbicides, such as metribuzin, that lentils are sown 5 to 7 cm deep. Herbicides can

Research highlight

Sow on-time for competitive pulses

Dry matter and grain yield were both greater in chickpeas sown in autumn or early winter than in late winter on the Darling Downs of southern Queensland. The greater dry matter or biomass production of the early sown chickpeas also resulted in greater nitrogen (N) accumulation. The greater biomass enables the crop to better compete with weeds and improve the effectiveness of herbicides used.

Sowing time	Biomass (t per ha)	Nitrogen accumulation (kg N per ha)	Grain yield (t per ha)
Late-autumn, early-winter	4.18 - 5.95	89 - 117	1.63 - 2.25
Late-winter	3.39 - 3.86	76 - 90	0.97 - 1.22

Horn *et al.* (1996a); Horn *et al.* (1996b)

Research highlight

Seeding depth of chickpea, faba bean and lentil

The effect of three seeding depths (2.5, 5 and 10 cm) on the growth and yield of three pulses (chickpea cv. Tyson, faba bean cv. Fiord, lentil cv. Digger) was investigated at Merredin, Northam and Cunderdin, WA (soil types: reddish-brown sandy clay or clay-loam).

Target plant densities (per m^2) were: chickpea - 45, faba bean - 30, and lentil - 120.

Seeding depth had no affect on: plant density; time from sowing to 50% flowering, podding and maturity; nodulation; or dry matter production at flowering.

Pulses with hypogeal emergence tolerate sowing at 5 to 10 cm depth without yield penalty and in some situations such as sowing into stored subsoil moisture, deeper sowing can improve crop establishment and final yield. Deep sowing of faba beans improves lateral root growth and promotes better plant anchorage.

Optimum seeding depth for chickpea and faba bean was determined to be 5 to 8 cm, and field pea at a similar depth.

Due to their epigeal emergence lupins should be sown shallower in the same environment. Sowing lupins deeper than 4 to 6 cm reduces yield.

Lentils should be sown at 4 to 6 cm, especially if the soil is prone to crusting.

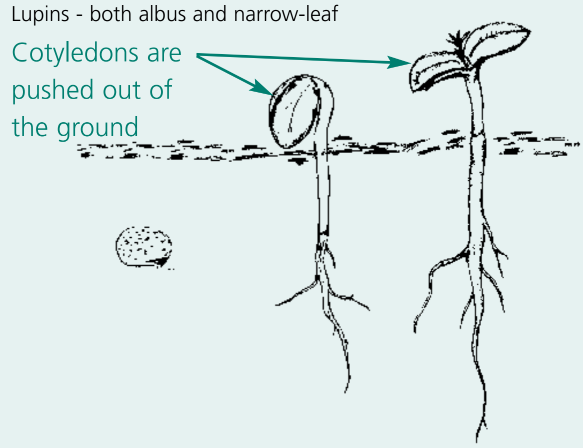
Siddique and Loss (1999)

become more mobile and active on coarse-textured soils. On these soils it is recommended to apply herbicides such as simazine before sowing, sow deeper, and incorporate them by sowing to minimise damage.

Knockdown herbicides applied before sowing to paddocks with large amounts of green plant material have been known to damage emerging field peas sown too shallow. Field peas germinate at lower temperatures than other pulses and can happily emerge from their early winter sowing at 6 cm, avoiding any risk of herbicide damage. Don't be tempted to sow them too shallow!

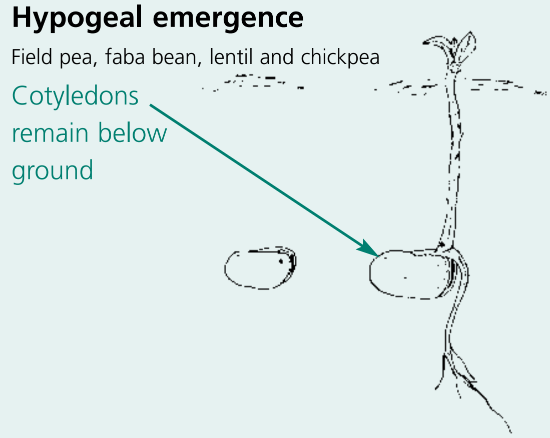
Epigeal emergence

Lupins - both albus and narrow-leaf



Hypogeal emergence

Field pea, faba bean, lentil and chickpea



Hypogeal and epigeal emergence affects the ability of pulse seedlings to establish. It is important not to sow pulses which have epigeal emergence, such as lupins, too deep.

Take note

Deep sowing

Field peas can be sown down to 6 cm without any apparent effect on emergence. Narrow-leafed lupins should not be sown deep on hard setting soils.

Research highlight

Deep planting and press wheels for late sown chickpeas

Deep planting chickpeas is an economic option when seasonal conditions do not favour conventional sowing techniques. Research in Queensland considered three planting treatments: a coulter with a narrow Keech® point; a Keech® point with a Janke® press wheel; and a combination of all three. A heavier seeding rate of 40 seeds per m^2 on 1 m row spacings was used to compensate for the late sowing. The rows under the press wheels achieved 32 plants per m^2. However emergence was reduced by 78% where press wheels were not used. Thus modifications to the sowing technique when conditions were marginal helped to achieve an acceptable plant density.

White and McCosker (2001)

Soil properties

Soil properties will influence the pulse crops ability to compete strongly against weeds. Unfavourable soil conditions can have negative impacts on seedling emergence and subsequent crop vigour, growth and yield.

Winter pulses have reduced production in acid soils and high levels of manganese can be one factor that causes this. Crops such as chickpeas are very sensitive to manganese. Increasing the pH ($CaCl_2$) to above 5.5 using lime can reduce available manganese to acceptable levels. The available manganese level becomes higher when soil conditions are warm and dry. Delaying sowing of sensitive crops under marginal soil manganese levels until the second autumn rain may result in improved crop establishment and early vigour.

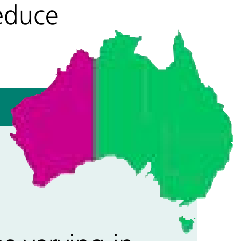
Conversely aluminium levels are highest when soil conditions are cool and wet. It is therefore essential to test levels during late winter to identify maximum likely levels during the growing season. Deeper soil (10 to 20 cm) should be tested for sensitive crops such as faba beans. If they are grown on paddocks where pH is low (less than 4.8 $CaCl_2$) and aluminium is high (above 5% total cation exchange) at 10 to 20 cm, growth will be dramatically reduced from late winter on. The crop will be highly susceptible to disease, nodulation will be poor, and it will be less competitive, allowing weeds to seed profusely.

As the density and rate of seedling emergence will impact on crop competitiveness and yield, it is important to minimise any negative soil effects on crop emergence eg soil crusting. Pulses that have an epigeal pattern of emergence (see previous page) will be most affected by crusting. This problem is compounded if the seeds are sown too deep. Hypogeal emergent pulses (eg peas) have been shown to be unaffected by crust formation. Larger seeds produce seedlings that can push through harder crusts. Small seeds produce seedlings that may be able to germinate quickly and push through the soil before the maximum crusting occurs. However, successful emergence through a crust will also depend upon sowing depth and seed orientation. Damage or removal of cotyledons as the seedling emerges through the soil crust can increase the incidence of disease and thus reduce crop vigour and yield.

Take note

Mo on acid soils

Molybdenum should be applied to acidic soils (low pH) to improve nodulation.



Research highlight

Seeding depth and lupin seedling emergence

Seedling emergence of lupin species varying in seed size was affected by seeding depth and water potential or soil moisture content.

- All seeds germinated rapidly in moist sand. However, when soil moisture was reduced germination of small seeded lupin species, including narrow-leafed, was much higher than large seeded species, including albus.
- Increasing seeding depth from 4 to 8 cm retarded seedling emergence to a greater extent than a decrease in soil moisture.
- Narrow-leafed lupin seedling emergence was less affected by seeding depth and soil moisture than other lupin species.

It is very important to pay attention to seeding depth and sowing moisture conditions to ensure seedling emergence is adequate for early crop growth, competition against weeds and yield.

White and Robson (1989)

Research highlight

Seed pressing for ryegrass suppression

'Press the seed, not the soil' is a new seeding technique which has been shown to improve lupin yield and suppress ryegrass populations in a range of soil-moisture environments in Western Australian. The lupin seed is pressed into the soil with the soil above the seed left relatively loose. This compares to firming the seed and soil together using press wheels. When only the seed is pressed the ryegrass seed soil contact is reduced.

Establishment, early plant vigour and crop growth were all improved. Yield was increased on average by 10% and ryegrass suppressed by 58%. Conversion to seed pressing has been an inexpensive and effective conversion for many farmers in WA.

The seed tube is attached in front of the press wheel. Fertiliser is placed below the seed on a leading 40 mm wide tine opener drilling into wheat stubble.

The press wheel presses the lupin seed into the soil before it is covered with loose soil.

Modified depth controlled rotary harrows cover the seed behind the press wheel. Photos: Glen Riethmuller.

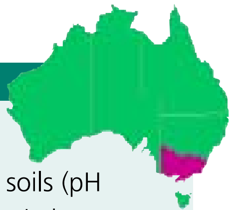
Amjad and Riethmuller (1999; 2001).

Lentils need to be grown on soils with pH greater than 5.2 ($CaCl_2$). Application of lime to increase pH of acid soils, results in a significant increase in dry matter production, ability to compete with weeds and yield.

Take note

Cations and liming

It is essential to test aluminium (Al) and manganese (Mn) levels to determine if a lime application is necessary. Low Al and Mn levels result in better nodulation, which gives improved plant vigour, impacting positively on the crop's ability to combat insects and disease, and compete with weeds.



Research highlight

Faba beans in acid soils

Faba bean crops sown in the acidic soils (pH range 4.8 to 5.9) of southwest Victoria have commonly failed when inoculated with commercial inoculant (strain SU391). Research was conducted to assess the affect on nodulation, plant development and yield of other inoculum strains. In summary:

- Improved growth and yield of faba beans was obtained using specific Rhizobium strains.
- Higher levels of soil aluminium and manganese reduced the effectiveness of the Rhizobium strains (particularly SU391).
- Applying lime can improve the effectiveness of some strains (eg NA533).

Carter *et al.* (1994)

Research highlight

Faba beans in WA: tillage history and soil structure

Faba bean yields were assessed on four tillage treatments of a long term trial running since 1977 near Merredin, WA. Tillage practices used were:

- No-till: sown with a triple-disc drill from 1977 until 1986, then narrow points after 1986 (5 t per ha gypsum was applied in 1983)
- Direct drill: sown with a standard combine with 10 cm points from 1977
- Cultivation/combine: scarify once (5 cm deep), sown with a triple-disc drill from 1977 until 1986, then a standard combine after 1986
- 'District practice': scarify once 10 cm deep, scarify once 5 cm deep, sown with a standard combine until 1986, then converted to 'Direct drill' after 1986.

In 1994 the faba beans grown under 'district practice' conditions with no gypsum, yielded 0.7 t per ha (9.2 kg per mm rainfall). The highest yields was obtained where the soil structure was the best (ie the 'no-till' + gypsum treatment) and yielded 1.2 t per ha (14.8 kg per mm rainfall).

Jarvis (1994)

Research highlight

Emergence of lupins and peas from hard setting soil

Emergence of lupin and field pea was assessed on a sandy, clay loam (26% clay, 11% silt, 61% sand) with pH 7.0 ($CaCl_2$) at Merriden, WA.

- Hard crust formation reduced the emergence of field pea, narrow-leaf lupin and albus lupin.
- Narrow-leaf lupins were more affected than albus lupins or field peas. Damage to emerging seedlings was up to 15% greater.
- The larger seeded albus lupins would appear to be able to emerge through soil with greater force than the smaller seeded narrow-leaf lupin.
- The hypogeal emergence of the field pea allowed it to overcome the soil crusting. The smaller diameter of the emerging leaves encountered less resistance than cotyledons, or were able to emerge through cracks.

White and Robson (1989)

Tine and sowing boot combinations are used to place fertiliser below the seed, maximising crop competitive ability.

Fertiliser use and placement

Pulses require adequate fertiliser applications for both vegetative growth and yield. If nutrient levels are not sufficient crop plant growth will be poor, reducing it's ability to compete against any weeds present. The amount of fertiliser required will be affected by the pulse type, soil type, paddock history and target yield. A soil test will help determine the nutrient status of the soil and the fertiliser composition most beneficial to the crop. Local advice should be sort. Fertiliser placement, such as broad cast or banded under the seed, will also have an impact on crop competitive ability.

Phosphorus (P) responses by pulses are varied. Research has shown that albus lupin, faba bean and chickpeas respond more to P than lentils, narrow-leafed lupin and field pea. Faba beans appear to suffer the most from a P deficiency. P can be applied by drilling or placing it with the seed at sowing, by banding it below the seed, or by spreading over the soil surface or top dressing and incorporating by sowing. Top dressing P in low rainfall areas of southern Australia is less effective than drilling with or below the seed. As P is relatively immobile in soil it is more efficient to place it where the roots of plants will proliferate, which will be in moist soil.

Grain legumes will generally remove more nutrients per tonne of grain than cereal crops (see Table 5, page 25). Ensure that the supply of nutrients is at least the minimum level that is adequate for the target grain yield.

Research highlight

Fertiliser placement and chickpeas

Wide row spacing provides an opportunity for fertiliser to be placed to benefit the crop rather than the weeds. Enhancing crop development can reduce weed growth and increase crop yield. In trials in northern NSW chickpeas cv. Amethyst were sown at 40 cm row spacing with weeds sown half way between the crop rows at 10 per m^2. Fertiliser (11:16.5:4.5:2 N:P:S:Zn) was applied at nil or 65 kg per ha at sowing and placed in the crop row, in the weed row, or half with the crop and half with the weeds. Crop yield was less affected by the presence of weeds when the fertiliser was placed in the crop row, giving the crop an advantage over the weeds.

Influence of weeds and fertiliser placement on chickpea yield (t per ha)

	Nil fertiliser	Fertiliser sown with		
Treatment		**crop**	**weeds**	**crop and weeds**
Nil weeds	1.9	2.4	2.1	2.5
Grass weeds	1.3	1.7	1.2	1.5
Broadleaf weeds	1.8	1.9	1.3	1.5

Felton (2002)

Research highlight

Phosphorus application

Research in Western Australia has shown that faba bean yield (cv. Fiord) increased with applications of fertiliser phosphorus (P) up to 40 kg P per ha. The yield was unaffected by the method of P application (drilled with the seed or banded 3 to 4 cm below the seed) or row spacing (conventional 19 cm and 38 cm to sow into stubble residues). It was concluded that up to 45 kg P per ha can be drilled with or banded below the seed while sowing, and that wider 38 cm row spacing can be used to minimise the problems of sowing into previous crop stubbles.

In WA, narrow-leafed lupins grown on acidic to neutral sandy soils are sown with banded P. Lupin production can be improved on soils with greater than 2% clay in regions with less than 400 mm annual rainfall by banding P fertiliser 8 cm below the seed (sowing depth 4 to 5 cm). For sandy soils with less than 2% clay, in warm areas or in cooler areas where greater than 250 kg total P per ha had been applied in previous years, top dressing or banding provides similar results.

Bolland *et al.* (2001); Bolland *et al.* (2000); Bolland and Jarvis (1996)

Research highlight

Phosphorus placement and lupins on red-brown earth

Research in Western Australia and South Australia has shown that banding phosphorus (P) below the seed of narrow-leafed lupin at sowing can improve yield. However, in southern NSW, trials on red earth and red brown earths have shown that banding P at 7 to 10 cm depth below the seed sown at 3 cm depth rather than drilling it with the seed provides only a small advantage to grain yield.

Grain yield increased by between 30 and 60 kg per ha when 15 kg P per ha was banded under the seed compared to drilled with the seed at conventional 18 cm row spacing.

In farming systems where double row spacing and higher P application rates are used, the separation of seed and fertiliser could reduce problems such as poor germination.

Scott *et al.* (2003)

Table 5 Nutrients removed by 1 tonne of grain from various grain crops. (Adapted from Grain Legume Handbook).

	Kilograms							Grams		
Crop	**N**	**P**	**K**	**S**	**Ca**	**Mg**		**Cu**	**Zn**	**Mn**
Chickpeas (desi)	33	3.2	9	2.0	1.6	1.4		7	34	34
Chickpeas (kabuli)	36	3.4	9	2.0	1.0	1.2		8	33	22
Faba beans	41	4.0	10	1.5	1.3	1.2		10	28	30
Field peas	38	3.4	9	1.8	9.0	1.3		5	35	14
Lentils	40	3.9	8	1.8	0.7	0.9		7	28	14
Lupins (narrow-leafed)	53	3.0	8	2.3	2.2	1.6		5	35	18
Lupins (albus)	60	3.6	10	2.4	2.0	1.4		5	30	60
Wheat	23	3.0	4	1.5	0.4	1.2		5	20	40
Canola	40	7.0	9	10.0	40.0	3.8		4	40	40

Disease, mite and insect management

Disease, mite and insect damage can reduce the competitiveness of a pulse crop. It is important to take adequate precautions against these threats. Thorough monitoring and a strategic control program can manage them all economically.

Seedlings of some pulses have been found to be more susceptible to insect damage than other pulses. The feeding of insects on seedlings can reduce the crops competitive ability against weeds and final yield. If a pulse is grown after a pasture phase, then insects such as red legged earth mite (RLEM) can be a problem. In this case control in the final year of the pasture phase can dramatically reduce the risk of damage in the pulse crop.

Other insect pests that can impact on crop establishment and early crop vigour include cutworms, blue oat mite and lucerne flea. Prior to sowing, check the paddock, headlands and surrounding vegetation for potential insect populations. Inspect emerging crops in the late afternoon or evening for insects such as cutworms.

Diseases (fungal, bacterial or viral) will impact on crop vigour and competitive ability. Cold, wet conditions and soils prone to waterlogging will contribute to the incidence of many pulse diseases. In most instances, the loss of large numbers of pulse plants within a defined area makes an ideal haven for weeds. These areas need to be managed to prevent weed seed 'blowouts' from occurring. Sacrificing the low crop yield of a high weed density area will greatly reduce the numbers of weed seeds entering the soil.

A break of at least 4 years between host pulse crops should be part of every disease management program. The source of a pulse disease can be infected seed, crop trash (including pulse stubbles from neighbouring paddocks), volunteer pulse

Lucerne flea can cause significant damage in lupins and other pulses. Monitor crops during early growth for both lucerne flea and red legged earth mite. Control of insects is essential to ensure early canopy closure, reducing weed growth. Manage weeds on fence lines to reduce insect pressure.

Research highlight

Watch for red legged earth mites

Field research in Western Australia has demonstrated that the effect of red legged earth mite (RLEM) on pulse seedlings and subsequent growth and yield differs for various pulse species. Field pea and yellow lupin were most susceptible at seedling and flowering but only yellow lupin had a significant yield penalty (30%).

Pulse seedling	RLEM damage at seedling stage
Yellow lupin	Severe - 30% yield reduction
Field pea	Severe
Narrow-leafed lupin	Moderate
Faba bean	Slight
Chickpea	Little or none
Lentil	Little or none

Liu and Ridsdill-Smith (2000)

plants or soil. In order to manage disease it is essential to understand the disease threat for each crop, it's means of introduction, risk and method of spread, likelihood of infection, severity, and likely impact on yield. Paddock selection and planning are therefore extremely important when considering where a pulse crop will fit into a farming system.

See page 2 Factors to consider when choosing a pulse.

Plan ahead & mix it up

To give the pulse crop every opportunity against weeds, it is important to plan ahead and consider all of the aspects that will maximise competitive ability.

- Choose the pulse that best suits the paddock conditions. Farm plans must be flexible and will be influenced by seasonal conditions.
- Keep good paddock records and know the weed history of the paddock.
- Mix up the weed management strategies. A simple cropping system may be easy for growers but it is also easy for weeds. Try to 'confuse' the weeds and stop them adapting. Change tillage practices, seeding dates and herbicide groups and rotate crops and pastures. Investigate the various weed management options available and determine which are the most appropriate.
- Create a weed management plan that has a range of strategies, is flexible and has regular review and revision.

See page 27 Weed management using herbicides and page 39 Cultural weed management.

Applying fungicide in faba beans is essential to reduce disease risk and maximise crop competitive ability, growth and yield. Monitor regularly and apply fungicide before you see disease symptoms.