CRC for Australian Weed Management

Technical Series

#9

Weeds in winter pulses – integrated solutions

Well-managed pulse crops can be used as a key component of a whole farm weed management program. The information in this publication provides integrated pulse-based solutions to weed management in annual cropping systems across Australia. It includes recent research and 'on farm solution' case studies.

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NSW DEPARTMENT OF PRIMARY INDUSTRIES

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Well-managed pulses can be used as a key component of a whole farm weed management program. This national publication was written with the intent that it will provide pulse-based solutions to weed management in annual cropping systems. It has also consolidated the diverse range of research that has been conducted on pulses across Australia and made this information accessible to grain growers and agronomists.

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Photo by: Eric Armstrong

Front cover: Faba bean grower Wendy Muffet (left) and one of the authors, Di Holding (right), inspect a faba bean crop near Forbes in central NSW. Well grown, competitive faba beans are a useful inclusion in Wendy's crop rotation, allowing use of alternate herbicide groups and the reduction of grass weeds in the seedbank.

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Introduction

Cool season pulse crops in southern Australian farming systems

The word 'pulse' refers to the seed of leguminous plants consumed by humans, and includes peas, beans and lentils. In southern Australia cool season pulses are grown in rotation with cereals and include field peas, chickpeas, lentils, faba beans, narrow-leafed lupin and albus lupin. It is well known that the inclusion of a pulse in the cropping system significantly improves the yield and quality of subsequent wheat crops by:

- reducing the incidence of diseases such as take-all and crown rot; and
- adding to the mineral nitrogen pool.

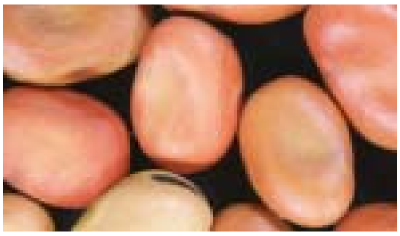
This positive effect on wheat yield and quality however only occurs when the pulse crop is grown either weed free, or with very low populations of weeds. Grass weeds such as *Vulpia* spp. (silver grass) can act as an effective host to cereal root diseases dramatically reducing the effect of the break crop. All non-leguminous weeds draw on the nitrogen pool, again reducing the beneficial effects of a pulse crop in the rotation.

It is often forgotten that the inclusion of a pulse crop allows for a wider range of weed control measures to be adopted in any one paddock, which is an essential component of effective weed management and the prevention or management of herbicide resistance.

Many farmers are now successfully utilising pulses and alternative weed management techniques in their farming system to reduce weed numbers. Pulses are often blamed for 'blowouts' in weed numbers. However, this increase in weed burdens is often due to poor planning and management rather than the pulse *per se*.

This publication aims to assist those involved in the Australian pulse industry to improve whole farm weed management and the quality and yield of the pulses produced.

Lentil–red (*Lens culinaris*)



Faba bean (*Vicia faba*)

Field pea–dun (*Pisum sativum*)

Chickpea–kabuli (*Cicer arietinum*)

Chickpea–desi (*Cicer arietinum*)

Field pea–white (*Pisum sativum*)

Lupin–albus (*Lupinus albus*)

Lupin–narrow-leafed (*L. angustifolius*)

Field pea–blue (*Pisum sativum*)

Choosing a pulse species

Factors to consider

Individual pulse species are characterised by specific adaptations. For example narrow-leafed lupins are suited to well drained acid soils, while faba beans can tolerate some waterlogging during winter and require neutral to alkaline soil. The various species and varieties are suited to different environments (rainfall, soil type) and management systems (see Table 1).

Soil type

Soil type is probably the most important environmental factor to look at when planning to grow and choosing a pulse. In the planning phase of a crop rotation you should think of 'a pulse' being included in a certain year and then decide on which specific one is to be grown on a paddock-by-paddock basis. Table 1 highlights soil and other characteristics that need to be considered when choosing which pulse to grow. Drainage and soil pH are key soil characteristics which should be checked. For example, in poorly drained paddocks where there is likely to be short periods of waterlogging, faba beans should be grown. On light, sandy, acid soils narrow-leafed lupins are the best option.

Albus lupins can not tolerate waterlogging at any stage during the season. Even though this paddock has a reasonable slope a soak area has killed the lupins in a below-average rainfall season.
Photo: Mark Richards

Take note

Wild radish and lentils

Growers considering growing lentils in paddocks with a known radish problem should do so with caution.

Lentils do not compete well with weeds and will allow rapid multiplication of weed seed in infested paddocks.

Herbicide options are limited with many options giving suppression only.

Growers should only consider lentils in paddocks where radish numbers are low enough to be hand rogued.

Weeds

It is important to consider the broadleaf weed species present in a paddock and their likely population as many, such as wild radish, can be very difficult to control in a pulse crop. Wire weed is one weed often overlooked as it is controlled so reliably

Table 1 Characteristic requirements of each cool season pulse species.

Species	Soil texture	Soil drainage	Soil pH ($CaCl_2$)	Herbicide options	Sowing time	Markets	Comments
Narrow-leafed lupin	Sandy loam to clay loam	Very well drained	Tolerant of low pH	Many	Early, before wheat	On-farm feed, stock feed	Stores easily; tolerates high soil aluminium levels
Albus lupin	Sandy loam to clay loam	Very well drained	> 5.0	Many	Early, before wheat	Human food, stock feed	Stores easily
Field pea	Sandy loam to clay	Well drained	> 4.5	Many	Late, after wheat	Human food, stock feed	Opportunities to apply knockdown herbicide prior to sowing
Faba bean	Loam to heavy clay	Tolerates limited waterlogging	> 5.0	Some	Mid	Human food, stock feed	Disease management program essential; large seeded - sowing machinery problems
Chickpea	Loam to heavy clay	Very well drained	> 5.2	Some	Mid to late	Human food	Disease management program essential
Lentil	Loam to clay	Very well drained	> 5.2	Limited	Late, after wheat	Human food	Very low growing - not in stony paddocks

Research highlight

Soil factors influence field pea and narrow-leafed lupin yield

Trials arranged in clusters of two or three in close proximity, but on contrasting soil types were used to compare narrow-leafed lupin and field pea growth and yield across the Western Australian wheat belt. Soil pH (surface and 50 cm), depth of topsoil, clay content at 50 cm and other soil properties varied across a wide range. Electrical conductivity, pH, soil water holding capacity and topsoil depth were all closely related.

Lupin yield was 2.6 times more variable between trials within locations than the field pea. This highlights the specific adaptation of narrow-leafed lupin to well-drained and deeper soils, while the field peas have much broader adaptation. Soil pH and correlated soil properties could largely explain the variability of the lupin yield but none of the variability of the field pea yield. The effect on grain yield was largely due to the effect on dry matter production.

French (2002)

in cereals by herbicides. When no herbicide control measure is in place wireweed returns as a significant problem, especially late in the pulse growing season. The nature of its growth and seed set over summer ensure that it always maintains a seed bank in problem paddocks. In these cases effective control using herbicides and stubble burning should be used to reduce the addition to the soil of seed.

Weeds such as hard seeded vetch can be a significant problem in pulse production. For example, it is impossible to control vetch in field peas with herbicides, and very difficult and costly to remove it from the grain sample. Growers should check delivery standards for weed seed contamination thresholds, especially when targeting human food markets, and ensure all likely weeds can be controlled.

The National Agricultural Commodities Marketing Association Ltd. (NACMA) / Pulse Australia delivery standards (2002) set the maximum limit at two vetch seeds (including tare and commercial) per 200 g sample in all pulses. Numerous other weed species have contamination limits specified.

Take note

Low rainfall seasons

In low rainfall seasons imidazolinones (Spinnaker®, OnDuty®, Midas®), sulfonylureas (Glean®, Logran® etc.), and triazines (atrazine and simazine) are all candidates for herbicide carry-over. Imidazolinones will be more persistent on acid soils and sulfonylureas on alkaline soil (with everything else equal). Seek advice after low rainfall years on the likelihood of carry-over and plan your cropping sequence with this in mind.

There is a nil acceptance of noxious weed seeds in all pulses and state laws prohibit their inclusion in stockfeed.

Take extra care when bulking up pulses for subsequent sowing seed to minimise the risk of weed spread.

See page 10 Problem weed species in winter pulses and their distribution, and page 47 Know what you sow.

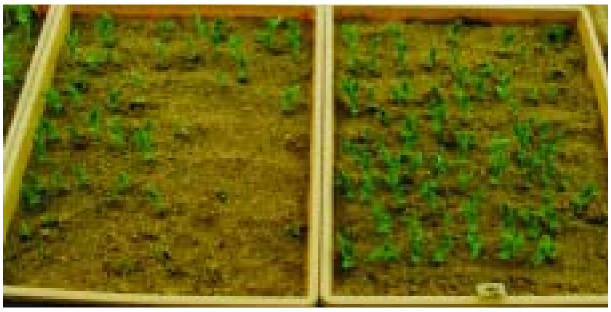
Residual herbicides

When planning your rotations think ahead when it comes to residual herbicides, in particular Group B sulfonylureas. Herbicide residues remain longer in the soil when pH is higher and rainfall is lower. Under these conditions breakdown of the herbicide is slower. In paddocks where the residual is likely to

Residual herbicides can cause significant problems with pulse crops when re-cropping intervals are not adhered to. Here, the right hand portion of the paddock was treated with clopyralid as a 'spike' to improve effectiveness of a knockdown to kill summer weeds in March. There is a nine month minimum re-cropping interval for field peas, hence the establishment failure.

cause a problem, avoid using these herbicides in years preceding the crop, especially applications late in the season. Under some conditions residual herbicides can reduce yield of sensitive pulse crops for up to three years.

Check re-cropping intervals of residual herbicides in Table 2. Little information is available for lentils, however anecdotal evidence suggests that they are extremely sensitive to residual sulfonylurea herbicides. As they are grown on higher pH soils these herbicides should be avoided for up to four years before growing lentils. Test for herbicide residuals by planting a trial strip and assessing seedlings for signs of damage.



A simple germination test is an effective tool to assess seed quality. It allows the best seed to be used, giving the crop a head start against weeds. The germination test on the left was below 50% while the sample on the right was 83%. This cheap and simple test saved a total crop failure.

Other factors

Other things to consider when choosing which pulse species to grow include:

- Markets - are there quality restrictions for various markets? Does grain need to be stored on-farm? Is there a local bulk delivery point?
- Seed availability - which varieties are available and what is the cost of seed?
- Disease management strategy – is one required? How involved will it be? What will it cost? What are the risks?

To ensure the success of the pulse phase of the rotation attention should be paid to:

- Sowing time - too early can lead to high disease risk, too late can reduce yield potential.
- Seed source - check seed is of good quality (germination test see photos this page) and has low risk of weed seed contamination.
- Fertiliser - apply sufficient phosphorous and any required micronutrients, such as zinc or molybdenum.
- Insect pest management - to ensure high quality seed.
- Weed and disease management - to obtain maximum rotational benefits, yield and quality.

Table 2 Minimum re-cropping interval for each pulse species after application of various residual herbicides.

Check labels and herbicide guides for specific details regarding soil pH and rainfall.

Active ingredient	Chickpea	Faba bean	Field pea	Lentil	Lupin	Trade name(s)
Chlorsulfuron	⑩+	⑩+	⑩+	?	⑩+	Glean®, Lusta®, Tackle®
Sulfosulfuron	⑩+	⑩+	⑩+	⑩+	⑩+	Monza®
Triasulfuron	⑩+	⑩+	⑩+	?	⑩+	Logran®, Nugran®, Lonestar®, Trisure®
Metsulfuron methyl	⑨	⑨	⑨	?	⑨	Ally, Associate®, Lynx®
Thifensulfuron + metsulfuron methyl	⑨	⑨	⑨	?	⑨	Harmony®
Imazamox	⑩	⑩	⓪	?	⑩	Raptor®
Flumetsulam	③	⑨*	③	?	⑨*	Broadstrike®
Imazethapyr	⓪	⓪	⓪	?	⑩	Spinnaker®
Imazapic + imazapyr	⓪	⓪	⓪	?	⑧	On duty®
MCPA + imazapic + imazapyr	⓪	⓪	⓪	?	⑧	Midas®

No risk: ⓪ = 0 months
Low risk ③ = 3 months
Medium risk ⑧, ⑨, ⑩ = 8, 9 or 10 months (*on shallow soils of less than 30 cm, DO NOT plant for 2 years after application)
High risk ⑩+ = 10 to 26 months depending on soil pH - check label

Impact on production

The impact of weeds on pulse production

Impact on pulse yield

Weeds can severely impact on the yield of all crops, however pulses are poor competitors and can be affected to a greater extent than cereals. The impact of weeds can be more in pulse crops sown at wider row spacing which allows germinating weeds to establish and compete strongly.

For example, toad rush, a small insidious weed can cause severe yield reductions. Another example is wild oats in faba beans. The crop looks competitive however competition for moisture and nutrients during pod fill can see a small population of wild oats dramatically reduce the yield of a faba bean crop.

Annual ryegrass and wild oats are very competitive against lupins causing significant yield losses. Paddocks with large weed numbers or herbicide resistant populations should have a well planned program of weed management. A wide range of techniques should be used.

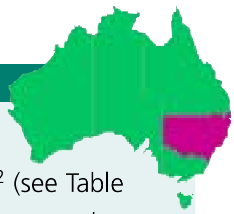
Low numbers of wild oats cause significant yield loss in faba beans. Early monitoring and control will minimise the impact on the crop.

Take note

Control weeds early

Control weeds prior to sowing and in early crop growth to minimise the impact on crop growth and yield.

Research highlight



Weeds reduce chickpea yield

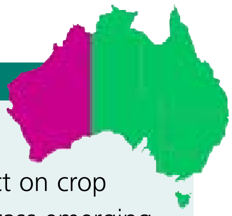
Weeds can reduce chickpea yields by up to 50% even at weed densities of 10 to 20 per m^2 (see Table below). Competition commences later than for wheat so there is more time to apply post-emergent herbicides.

Percentage yield loss compared to weed free crops

Row space	32 cm		64 cm	
Weeds per m^2	**10**	**20**	**10**	**20**
Wheat	16%	28%	27%	41%
Chickpea	44	61	56	73
Faba bean	32	46	41	58
Canola	33	51	58	73

These differences in yield were predicted as early as 35 days, and up to 100 days after sowing using reflectance technology. This could be a useful tool to predict yield loss in parts of farm paddocks.

Felton (2002)



Research highlight

Lupins and weed competition

The time of germination of a lupin crop compared to the weeds can have a dramatic impact on crop growth and yield. Research in Western Australia has shown that cape weed or annual ryegrass emerging before and with the crop can reduce the yield of narrow-leafed lupins. Time of weed control (prior to sowing and early in crop growth) is therefore essential to maximise yield. Key findings from the research included:

- Capeweed germinating six weeks prior to lupin emergence prevented lupin seed production.
- When capeweed germinated with the lupin crop the effect depended on the weed population. Ten capeweed plants per m^2 did not significantly reduce lupin yield. However 30 capeweed plants per m^2 reduced lupin yield by 20%.
- Annual ryegrass germinating 6 weeks before the crop reduced yields by 70%.
- Yield was reduced by 47% when 90 annual ryegrass plants per m^2 germinated with the lupins.
- Annual ryegrass emerging 6 weeks after the crop was not competitive and did not cause any yield reduction. Densities of 39 plants per m^2 reduced grain yields by 15%.
- Lupin biomass was unaffected by weed competition until mid spring. Lower yields appear to be due to a reduction in pod-set on both the main stem and lateral branches.

Allen (1977); Arnold *et al*. (1985)

Take note

Summer grasses in pulse stubbles

Control grasses over summer for effective rotations. If they are not controlled soil N, available water, and cereal disease break will all be at risk! Don't blame the pulse crop!

Impact on next year's wheat

The success of a pulse crop in breaking the disease cycle in cereals is dependent on effective control of grass weeds, in particular *Vulpia* species. Small populations of vulpia can result in carry over of cereal diseases, such as Take-all, into the following wheat crop. In addition, all non-leguminous weeds growing in the pulse phase of a rotation utilise nutrients, in particular nitrogen, reducing the benefit of having a pulse in the system.

Controlling all grass weeds in pulses will reduce the risk of carry-over wheat diseases such as crown rot and take-all, which can significantly reduce the yield of the following wheat crop. Even low numbers of grass weeds pose a threat to a successful rotation so thresholds for control must be very low.
Photo: Gordon Murray.

Take note

Inoculant

Commercial inoculant uses improved *Rhizobium* strains tested to give better nodulation, growth and yield across more soil types and environments.

Research highlight

Nitrogen from pulses ~ facts and figures

The nitrogen benefit from a pulse crop and the pulse crop yield depend on effective nodulation by a suitable strain of *Rhizobium*. Rhizobial inoculations resulted in faba bean yield increases up to 1.2 t per ha in north east Victoria and 2.5 t per ha in northern Tasmania, compared to uninoculated.

The overall effect, or the nitrogen (N) balance following a pulse crop can range from a deficit to a substantial addition, but is generally higher than after a cereal crop. This is because the pulse crop utilises atmospheric N and spares soil N, where cereals and canola rely on soil N alone. The contribution of N to the soil by a pulse crop is strongly linked to biomass production (although large amounts are removed in the seed) and the soil nitrate levels in the soil.

Many trials have been conducted to assess the net N balance after a pulse crop. Three projects are summarised below.

Chickpea and faba bean in northern NSW

A survey of 51 rain-fed chickpea and faba bean crops across northern NSW found the percentage of crop N derived from N fixation ranged from 0 to 81% for chickpea and 19 to 70% for faba bean. Net N balance ranged from -47 to +46 kg N per ha for chickpea crops, and -12 to +94 kg N per ha for faba bean crops.

Field pea in central west NSW

At Condobolin in central west NSW, the mineral N (0 to 30 cm) under a field pea crop in spring was 23 kg N per ha higher than under a barley crop. This contributed to greater post-harvest soil mineral N and higher wheat yields after field pea compared to after barley.

Lupin in WA

Six commercial lupin crops grown near Geraldton, WA, accumulated from 199 to 372 kg N per ha of which, on average, 86% (222 kg N per ha) was fixed from the atmosphere. These crops returned a predicted average 65 kg N per ha to the soil, with a range of 32 to 96 kg N per ha after harvest - quite a variable sized pool of mineral N for use by subsequent cereal crops.

Unkovich *et al.* (1994); Evans *et al.* (1996); Schwenke *et al.* (1998); McCallum *et al.* (2000); Slattery *et al.* (2003)

Excell field peas (left) at Greenthorpe in 2001. The same paddock in the drought year of 2002 (right) sown to wheat yielded significantly above the whole farm average.

Research highlight

Yield of wheat after pulse crops

In trials at Condobolin, central west NSW (N. Fettell personal communication) wheat was sown after barley, chickpea, field pea and faba bean. It took 50 kg N per ha (applied at sowing) to elevate the yield of wheat following barley to wheat following pulses with no applied N (see Table below).

Wheat yield following various crops (t per ha)

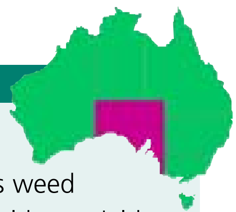
Previous Crop	N fertiliser (kg N per ha)		
	0	25	50
Barley	2.2	2.8	3.5
Chickpea	3.4	4.0	4.6
Field pea	3.5	4.1	4.4
Faba bean	4.0	4.3	4.5

Similar trials were conducted at Wagga Wagga in southern NSW, looking at the effect of sowing time of pulses and barley on subsequent wheat yield (see Table below). Growth of both lupin species was reduced by delayed sowing, and the yield of following wheat was significantly reduced. The same effect was not seen in chickpeas and field peas which are generally sown later than lupins. the best wheat crop was grown after the best pulse crop.

Wheat yield following various crops (t per ha)

Previous Crop	Sowing time (previous crop)		
	1 May	29 May	26 June
Barley	1.8	2.1	2.0
Narrow-leaf lupin	6.8	6.7	6.2
Albus lupin	6.4	5.4	5.4
Field pea	-	4.7	5.0
Chickpea	-	5.2	4.8

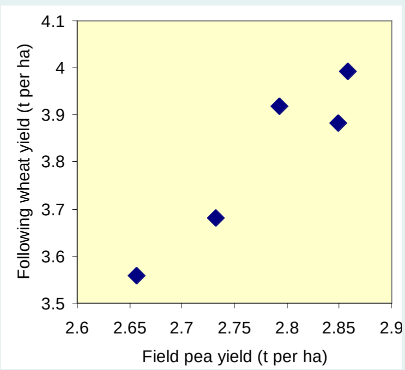
Armstrong *et al.* (1997)

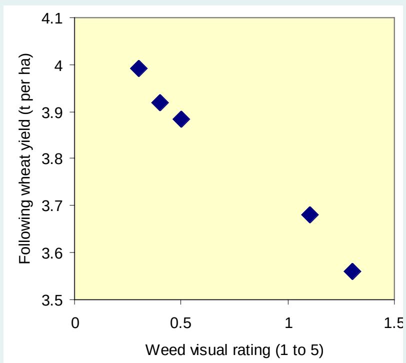


Research highlight

Weeds in field peas affect the following wheat yield

Field peas were treated with various herbicides and visual scores used in the crops to assess weed numbers and weed dry matter. Yield of the following wheat crop was directly related to field pea yield and inversely related to weed visual score. Hence the higher wheat yields were associated with high field pea yields and low weed scores. See graphs below.





McDonald (2002)

Impact on pulse quality

Producing high quality pulses is essential, especially when targeting human food markets. Weeds cause a problem with quality when they mature later than the crop species and high moisture-content, green material ends up in with the grain. This can be a particular problem with early maturing crops such as field peas, in which case desiccation should be considered. Staining due to contamination by green material can cause mould in stored grain, which will significantly downgrade quality. This is likely to result in reduced price and problems with market access.

See page 31 Herbicides for harvest management.

Research highlight

Green wild radish pods in stored pulses

Research in Western Australia has shown that green wild radish pods give off substances that kill stored seeds. The toxins inhibit germination and metabolism. Affected seeds either die or emerge with abnormal roots and shoots. Lupins and field peas were both found to be sensitive to the toxins. The degree of sensitivity depended on storage temperature, level of radish contamination, the storage period, and the crop species or cultivar involved.

Damage to lupin seed began at 5% level of contamination by weight and a storage period of 3 days. All lupin seed was killed at 8% contamination over a 5 day period of storage.

Cheam (1996)

Problem weed species

Problem weed species in winter pulses and their distribution

It is important to control broadleaf weeds well in the seasons before sowing a cool season pulse – plan paddock rotations early. Weeds that are difficult to control in a pulse crop and can substantially reduce harvest speed, grain quality and yields are listed in Table 3. Many of these weeds germinate over a long period of time. They become extremely difficult to manage if present in a pulse crop, as there are few post-emergent herbicides that are cost effective or registered. In some pulse species weeds can not be managed using herbicides, eg wild radish in lentils. However, there may be an alternative pulse for paddocks that contain a problem weed species.

Control weeds on firebreaks and fence lines before they become a significant whole paddock problem.

Table 3 Problem weeds in each State (✓) that need to be controlled before choosing that paddock for growing cool season pulses. The 💣 indicates herbicide resistant populations of that weed have been detected in that State.

Common name	Scientific name	WA	SA	Vic	Sth & C NSW	Nth NSW & Qld
Broadleaf weeds						
Bifora	*Bifora testiculata*		✓			
Capeweed	*Arctotheca calendula*	✓		💣		
Doublegee	*Emex australis*	✓			✓	
Fumitory	*Fumaria spp.*		💣		✓💣	
Milk thistle	*Sonchus oleraceus*					✓
Mignonette	*Resida spp.*		✓			
Musk weed	*Myagrum perfoliatum*			✓		
Saffron thistle	*Carthamus lanatus*				✓	
Three horned bedstraw or cleavers	*Galium tricornutum*		✓	✓	✓	
Turnip weed	*Rapistrum rugosum*					✓💣
Variegated thistle	*Silybum marianum*				✓	
Vetch	*Vicia spp.*		✓	✓	✓	
Wild radish	*Raphanus raphanistrum*	✓💣	✓💣	✓	✓	✓
Wild mustard	*Sisymbrium spp.*	✓💣	💣		✓	💣
Wild turnip	*Brassica tournefortii*	✓💣		✓	✓	
Wire weed	*Polygonum aviculare*	✓	✓		✓	
Grasses						
Annual ryegrass	*Lolium rigidum*	✓💣	✓💣	✓💣	✓💣	💣
Brome grass	*Bromus spp.*	✓		💣		
Silver grass	*Vulpia spp.*	✓		💣	✓	
Wild oats	*Avena spp.*	💣	💣	✓	✓💣	✓💣

Table 4 Availability of herbicide options for winter pulses. 'Pre' refers to application pre-emergent or post-sowing/pre-emergent, 'Post' refers to application post-emergent.

Always check herbicide labels for registrations on each target in each situation and for your State before selecting a herbicide option.

	Chickpea		Faba bean		Field pea		Lentil		Lupin	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Broadleaf weeds										
Bifora	×	×	SA only	×	SA only	×	×	×	×	×
Capeweed	✓	✓	✓	×	✓	✓	✓	S	✓	S
Doublegee	✓	×	✓	×	✓	✓	✓	×	WA only	×
Fumitory	✓	✓	✓	×	✓	✓	✓	×	✓	×
Milk thistle	✓	✓	✓	×	✓	✓	✓	×	×	×
Mignonette	×	×	×	×	×	×	×	×	×	×
Musk weed	×	×	×	×	×	×	K	×	×	×
Saffron thistle	K	×	K	×	K	×	K	×	K	×
Three horned bedstraw or cleavers	×	×	×	×	×	S	×	×	×	×
Turnip weed	✓	✓	✓	×	✓	✓	✓	✓	✓	✓
Variegated thistle	K	×	K	×	K	×	K	×	K	×
Vetch	K	×	K	×	K	×	K	×	K	×
Wild radish	✓	S	✓	×	✓	✓	✓	✓	✓	✓
Wild mustard	✓	×	✓	×	✓	✓	✓	✓	✓	✓
Wild turnip	✓	✓	✓	×	✓	✓	✓	✓	✓	✓
Wire weed	✓	×	✓	×	✓	✓	✓	S	✓	S
Grasses										
Annual ryegrass	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Brome grass	S	✓	✓	✓	×	✓	S	✓	S	✓
Silver grass	S	S	S	S	S	S	K	×	K	S
Wild oats	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓ one or more herbicides registered for use in most states
× no herbicide registered for use
S one or more herbicides registered for weed suppression only in most states
K one or more pre-sowing non-selective knockdowns registered in most states