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FIELD PEA SECTION 7 WEED CONTROL

Key Points | Introduction | Integrated weed management | Key Points For Managing weeds in Field Pea | Using Herbicides | Mode of Action (Moa) | Herbicide Performance | Herbicide Types | Herbicide Residues | Herbicide Damage | Herbicide Resistance | Spraying Issues | Selective Sprayer Technology



Weed control

Key points

- Growing field pea provides the opportunity to use different herbicide groups and to target grass weeds, including herbicide-resistant weeds. Preventing weed seedset is a priority for this pulse phase of the rotation.
- There are limited options for broadleaf weed control in field pea. They need to be targeted in the preceding crop or fallow. Pre-emergent herbicides will be required.
- Use pre-emergent herbicides carefully to prevent damage to emerging plants. Be wary of herbicide damage from herbicide residues in the soil, drift from outside the crop or spray tank contamination.
- Cutting weedy crops for hay, silage, or green or brown manuring can be a useful alternative for weed control.
- Crop-topping and desiccation can be used as part of an integrated weed management strategy with techniques such as seed capture at harvest to maximise the effectiveness.
- Crop-topping can be effective in early-maturing field pea varieties, with very low risk to damage to grain quality from the herbicide application.





FEEDBACK

7.1 Introduction

7.1.1 Impact and cost of weeds

Weeds cost Australian grain growers \$3.3 billion each year. That is, \$2.6 billion in control costs and another \$745 million in reduced yield. The cost to southern growers ranges from \$105 per hectare in the low-rainfall zones to up to \$184/ha in the medium to high-rainfall zones.

Reducing the cost of weed management is one of the grains industry's largest challenges as good weed control is vital for successful and profitable crop production.

Weed management is a challenge because weed situations are constantly evolving, with changes in weed types and their characteristics, such as herbicide resistance. The use of management techniques such as crop-topping, double-knockdown and narrow-windrow burning to reduce weed seedbanks have increased.

Grasses are the most costly weeds in the southern region (Table 1). Brome grass has increased in importance since the previous rankings were determined in 2000. Planting a pulse crop as a break crop between cereals provides an ideal opportunity to target grass weeds.

 Table 1: Weeds in the southern region ranked by area, yield loss and revenue loss.

Rank	Weed	Area (ha)	Weed	Yield loss (t)	Weed	Revenue loss
1	Ryegrass	3,419,170	Ryegrass	155,332	Ryegrass	\$38.9m
2	Wild oats	1,252,299	Wild oats	87,855	Wild oats	\$21.7m
3	Brome grass	1,122,207	Brome grass	86,683	Brome grass	\$21.0m
4	Wild mustard	822,497	Wild radish	37,169	Wild radish	\$10.4m
5	Wild radish	739,339	Wild mustard	15,711	Vetches	\$4.9m
6	Wild turnip	586,488	Vetches	11,517	Wild mustard	\$3.8m
7	Fleabane	189,422	Amsinkia / yellow burr weed	8253	Amsinkia / yellow burr weed	\$2.0m
8	Vetches	174,789	Wireweed	5555	Wireweed	\$1.4m
9	Barley grass	152,483	Barley grass	3661	Barley grass	\$1.0m
10	Cape weed	138,380	Skeleton weed	3302	Skeleton weed	\$866.7k
11	Cutleaf mignonette	137,131	Prickly lettuce / whip thistle	2979	Sow thistle / milk thistle	\$730.7k
12	Paterson's curse / salvation Jane	90,088	Doublegee	2768	Prickly lettuce / whip thistle	\$729.4k
13	Amsinkia / yellow burr weed	90,024	Brassica weeds	2367	Doublegee	\$588.9k
14	Doublegee	89,428	Lincoln weed	2268	Cape weed	\$577.0k
15	Wireweed	89,068	Cape weed	2082	Lincoln weed	\$533.7k
16	Skeleton weed	86,023	Sow thistle / milk thistle	2049	Brassica weeds	\$516.5k
17	Sow thistle / milk thistle	81,454	Paterson's curse/ salvation Jane	1834	Paterson's curse/ salvation Jane	\$422.8k
18	Prickly lettuce / whip thistle	77,518	Thistle species	1501	Cutleaf mignonette	\$406.1k
19	Thistle species	55,960	Cutleaf mignonette	1417	Bedstraw	\$400.8k
20	Brassica weeds	50,418	Wild turnip	1086	Thistle species	\$395.1k

Source: Llewellyn et al. (2016) https://grdc.com.au/ImpactOfWeeds





FEEDBACK

MORE INFORMATION

Weed ID: The Ute Guide, https://grdc.com.au/apps Weeds affect yield and management of broadacre crops across all seasons and sometimes the price received for grain.¹

Weeds may:

- lower crop yields by competing for soil moisture, nutrients, space and light;
- carry diseases and viruses that can infect crops;
- impede harvest;
- contaminate grain; and
- restrict cropping options due to limited herbicide options in pulse crops.²

7.1.2 Identifying weeds

The Grains Research and Development Corporation (GRDC) has developed an application (App) to assist in the identification of the most common weeds found in paddocks throughout Australia.

The App is called 'Weed ID: The Ute Guide'. Where possible, photos are shown for each stage of a weed's life cycle, from seed and seedling through to mature and flowering plants.

Weeds are categorised by plant type, and results for each can be refined by state and life cycle, and whether they are native, currently flowering or have a distinctive smell.

The Weed ID App allows users to search, identify and compare photos of weeds in their own paddock to weeds in the App.



Figure 1: Weed ID: The Ute Guide (GRDC 2016).



R Llewellyn, D Ronning, M Clarke, A Mayfield, S Walker and J Ouzman (2016) Impact of weeds on Australian grain production: the cost of weeds to Australian grain growers and the adoption of weed management and tillage practices, GRDC, <u>https://grdc.com.au/</u> ImpactOfWeeds

² Pulse Australia (2016) Southern Lentil: Best Management Practices Training Course. Pulse Australia







Click on the weed name below to be taken to further information on this weed

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Annual ryegrass (Lolium rigidum) Barley grass (Hordeum spp.)

Barnyard grasses (Echinochloa spp.)

Black bindweed (Fallopia convolvulus)

Bladder ketmia (Hibiscus trionum)

Brome grass (Bromus spp.)

Capeweed (Arctotheca calendula)

Doublegee (Emex australis)

Feathertop Rhodes grass (Chloris virgata)

Fleabane (Conyza spp.)

Fumitory (Fumaria spp.)

Indian hedge mustard (Sisymbrium orientale)

Liverseed grass (Urochloa panicoides)

Muskweed (Myagrum perfoliatum)

Paradoxa grass (Phalaris paradoxa)

Silver grass (Vulpia spp.)

Sweet summer grass (Brachiaria ericuformis)

Turnip weed (Rapistrum rugosum)

Wild oats (Avena fatua and Avena ludoviciana)

Wild radish (Raphanus raphanistrum)

Windmill grass (Chloris truncata)

Wire weed (Polygonum aviculare and Polygonum arenastrum)

7.1.4 Alerting service for weeds

Growers can subscribe to a newsletter that provides local weed updates. The services listed below are all free:

Agriculture Victoria

General grains information is available on the twitter @VicGovGrains

Australia wide

The GRDC has a GrowNotes[™] Alert for the latest weed, pest and disease issues in the users' area. The GrowNotes™ Alert is delivered via app, SMS, voice, email, social media or web portal (or a combination preferred methods). Subscription to the GrowNotes[™] Alert is on the GRDC website.





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(i) MORE INFORMATION

For more information see the GRDC's Integrated Weed Management Hub & Integrated Weed Management Manual https://grdc.com.au/resources-andpublications/iwmhub

Watch Harvest seed control for the high rainfall zone. https://youtu.be/RrvQQYqSmdE





Watch Integrated weed management in 2017 by Peter Newman at the Bendigo Grains Research Update, https://youtu.be/Wh4ozniPCNQ





7.2 Integrated weed management

An integrated weed management (IWM) system combining all available methods is the key to successful control of weeds. IWM includes both herbicide and non-herbicide options (Table 2).

Table 2: Weed control options for integrated weed management (IWM).

	Herbicide	Non-herbicide		
Crop phase	Crop topping in pulse/legume	Rotate crops		
	crops	Rotate varieties		
	 Knockdown herbicides e.g. double-knock strategy before sowing 	• Grow a dense and competitive crop		
	Selective herbicides before	Use cultivation		
	and/or after sowing but ensure	Green manure crops		
		 Cut crops for hay/silage 		
	 Otilising moderate resistance risk herbicides 	Burn stubbles/windrows		
	• Delayed sowing (as late as	 Delay sowing 		
	spring in some case) with weeds controlled several times before sowing	Collect weed seeds at harvest and remove/burn		
	Brown manure crops	 Destroy weed seeds harvested (Harrington Seed Destructor) 		
Pasture phase	Spray-topping	Good pasture competition		
	• Winter cleaning	Cut for hay / silage		
	• Use selective herbicides and	Cultivated fallow		
	ensure escapee weeds do not set seed	• Grazing		

Source: Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 5-2016.

7.2.1 Strategy – paddock choice and crop rotation

A well-managed rotation in each paddock, which alternates broadleaf crops with cereal crops, and may also include pastures, is a very useful technique for controlling weeds. For example, grass weeds are more easily and cheaply controlled chemically in broadleaf crops, whereas broadleaf weeds are much easier to control in cereal crops. Good crop rotation management can substantially reduce the cost of controlling weeds with chemicals.

Pulses grown in rotation with cereal crops offer opportunities to easily control grass weeds with selective herbicides that cannot be used when the paddock is sown to a cereal. An effective kill of grass weeds in pulse crops will reduce root disease carryover and provide a 'break crop' benefit in following cereal crops. Grass-selective herbicides can control most grass weeds in pulses, along with volunteer cereals.³

7.2.2 Good agronomic practice

Using weed-free seed and sowing on time with optimal plant populations and adequate nutrition will all contribute to good weed-control management.

Some crops and varieties are more competitive against weeds than others. Of the pulses, field pea and faba bean have a medium competitive ability, whereas lentil, lupin and chickpea have poor ability to compete with weeds in the paddock.⁴



³ Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 5-2016

⁴ GRDC (2014) Integrated Weed Management Hub. GRDC, <u>https://grdc.com.au/resources-and-publications/iwmhub</u>



FEEDBACK

Watch Over the Fence South: Summer weed control saves moisture for winter crops https://youtu.be/97qRnGHP2hM





Watch AHRI Insight #70: Narrow row spacing: more crop, fewer weeds. https://youtu.be/qM-PI4vMliw



i MORE INFORMATION

See GRDC Videos in the Weed Management Manual https://grdc.com.au/resources-andpublications/iwmhub



Watch IWM: Weed Seed Destruction https://youtu.be/a6b4SCmbqUA





7.2.3 Pre-plant weed control

All weeds growing in a paddock should be controlled before the crop emerges. Large, advanced weeds not controlled before or during the sowing operation prove most difficult and often impossible to remedy with in-crop herbicides.

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Tillage is a valuable method for killing weeds and preparing seedbeds. There are varying combinations of mechanical and chemical weed control to manage weeds in fallows or stubbles.

Knockdown herbicides are generally used instead of cultivation for fallow commencement, as well as for pre-planting weed control in the autumn. This improves soil structure through a reduction in cultivation. Knockdown herbicides also provide more timely and effective weed control. However, it is important to understand and manage the risk of herbicide resistance.⁵

Cultivation can spread grass weed seeds such as ryegrass, wild oat and brome grass through the soil profile and prolong their seedbank dormancy. For these weeds a light cultivation (1–3 cm deep) at autumn can encourage germination and assist in depleting the seedbank. This needs to be combined with delayed sowing.⁶

7.2.4 In-crop weed control

A wide range of pre-emergent and early post-emergent herbicides are available for grass weed control in field pea. With broadleaf weeds, post-emergent options are very limited.

Weeds should be removed from crops early, and certainly no later than 6 weeks after sowing if to minimise yield loses. Yield responses will depend on weed species, weed and crop density and seasonal conditions.

The growth stage of the weed and the crop are vital factors to consider when planning the successful use of post-emergent herbicides. The growth stages of field pea are detailed in <u>Section 5 Plant and growth physiology</u>. Read herbicide labels carefully for these details and information on the best conditions for spraying.

The risk of crop damage from herbicide application should be balanced against the potential yield loss from weed competition. In heavy weed infestations, some crop damage can be tolerated, as it is easily offset by the yield loss avoided by reducing weed competition.

7.2.5 Managing weeds at harvest

Managing weeds at harvest is an effective way to reduce carryover of problem weeds, particularly those with herbicide resistance.

Most southern Australian cropping weeds have seed that does not shatter before harvest. This major biological weakness provides the possibility to collect the weed seed at harvest, for example using a chaff cart.⁷

Research by the Australian Herbicide Resistance Initiative (AHRI) (2014) found that ryegrass, wild radish, brome grass and wild oats all retained at least 75% of weed seeds at the first opportunity to harvest wheat.⁸ As field pea can be harvested before wheat this presents an excellent opportunity to reduce the weed seedset, particularly if used in conjunction with crop-topping.

These same weeds will shed between 0.8 and 1.5% of their seeds each day that harvest is delayed. To improve control of problem weeds, harvest weedy crops first and collect chaff containing the weed seeds.

- 5 Pulse Australia (2016) Southern Faba & Broad Bean Best Management Practices Training Course, module 5-2016
- 6 GRDC (2012) Herbicide resistance fact sheet, Southern Region, GRDC, May 2012, https://grdc.com.au/Resources/Factsheets/2012/05/ Herbicide-Resistance
- 7 GRDC (2013) Herbicide Resistance. GRDC Ground Cover^{**} Supplement, Issue 104, May–June 2013, <u>https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104</u>
- 8 Australian Herbicide Resistance Initiative (2014) Rules of thumb. Australian Herbicide Resistance Initiative, http://ahri.uwa.edu.au/rules-of-thumb/





VIDEO

Watch GRDC video Weed Seed Capture https://youtu.be/x26mblVV9F4



Watch Ground Cover TV Harvest Weed Seed Control https://youtu.be/8LPGaqHyF_s





Watch Capture Weed Seeds at Harvest – Harrington Seed Destructor https://youtu.be/wZUSmRdafAs

Capture Weed Seeds at Harvest HARRINGTON DESTRUCTOR Options for removing weed seeds in the chaff include:

- removing the weed-laden chaff via baling;
- tow a chaff cart and burn the heaps;
- concentrate the chaff into narrow windrows for burning;
- pulverise the chaff to crush and destroy the weed seeds before they exit the harvester; and
- in controlled-traffic farming: funnel chaff onto tramlines, confining weeds to a hostile environment separate from the crop.



Photo 1: The integrated Harrington Seed Destructor is not a silver bullet but allows growers to destroy weed seed at harvest, facilitating the use of non-chemical weed control as part of an IWM package.

Photo: WAHRI, GRDC (2012)



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FEEDBACK

Harvest – the time to get on top of resistant weeds. https://youtu.be/uURyKaaq-_I

A beginner's guide to harvest weed seed control. https://youtu.be/H5-yVmJ1pKs

Burning Snails & Weed Seeds. https://youtu.be/zqQKFFqndKQ



A weakness of weeds in southern Australian is that, for many, their seed does not remain viable in the soil for very many years, and seedbanks decline rapidly if not replenished each year.

Control methods for weed seed at harvest can lower a very large seedbank of more than 1,000 seeds per square metre to 100 seeds/m² in only 4 years. In paddocks with low ryegrass burdens, harvest weed seed methods reduced ryegrass emergence by as much as 90%. Paddocks with high ryegrass burdens (>2,000 seeds/m²) were less responsive, with 30–40% reduction in ryegrass emergence. This means that harvest weed seed management takes longer to lower ryegrass populations in highly infested paddocks where the residual seedbank is still being exhausted.

Trials in South Australia and New South Wales show that narrow windrow burning and the use of a chaff cart are as effective at removing ryegrass seed.⁹

7.2.6 Alternatives to harvesting the crop

Operations such as cutting hay or silage, or green or brown manuring provide an opportunity for improved weed control when compared with harvesting crops for grain. These techniques are particularly valuable where herbicide-resistant weeds are a problem. When timed well they can prevent almost all seedset.¹⁰

Additional benefits of manuring include boosting soil nitrogen and conserving soil moisture to benefit yield in subsequent years.¹¹

Green manuring uses cultivation and brown manuring uses chemical control to stop the growth of both crop and weed.

While green and brown manuring cost money without providing an income, the benefit for subsequent years can make it worthwhile. Manuring is usually suited to longer-seasoned forage crops, crop-topping for earlier-maturing grain crops. If income is important, crop-topping and grain harvest may be a more economically viable option even though yield may be reduced by crop-topping.¹²

The best crops for manuring are those with early vigour that are effective at suppressing weed growth. Total biomass is important to maximise the nitrogen benefit so choose a variety that is most likely to produce the highest biomass.¹³ (See <u>Section 3 Pre-planting.</u>)

Two varieties (PBA Hayman^b and PBA Coogee^b have been released for suitability for forage (hay/silage) or green or brown manuring. Morgan^b is also a dual-purpose field pea variety that is still grown.

7.2.7 Weed Seed Wizard

The Weed Seed Wizard helps growers understand and manage weed seedbanks on farms across Australia's grain-growing regions.

It is a computer simulation tool that uses paddock management information to predict weed emergence and crop losses. Different weed management scenarios can be compared to show how different crop rotations, weed control techniques, irrigation, grazing and harvest management tactics can affect weed numbers, the weed seedbank and crop yields.

- 9 <u>https://grdc.com.au/resources-and-publications/groundcover/groundcovertm-129-july-august-2017/lesson-and-optimism-after-first-ihsd-harvest</u>
- 10 A Glover, I Trevethan, L Watson, M Peoples, T Swan (2013) Research for the Riverine Plains 2013, Riverine Plains Inc., pp. 38-41, Online farm trials website, <u>http://www.farmtrials.com.au/trial/16519</u>
- 11 GRDC (2013) Manuring of pulse crops. GRDC Fact Sheet, September 2013, <u>https://grdc.com.au/Resources/Factsheets/2013/09/Manuring-of-Pulse-Crops</u>
- 12 E Armstrong (2015) Weigh up the risks, benefits of pulse harvest. Ground Cover[®] Supplement, Issue 155: Profitable pulses and pastures, GRDC, <u>https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-115-Profitable-pulses-andpastures/Weigh-up-the-risks-benefits-of-pulse-harvest</u>
- 13 GRDC (2014) Integrated Weed Management Hub. GRDC, https://grdc.com.au/resources-and-publications/iwmhub



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The 'Wizard' uses farm-specific information and users enter their own farm management records, their paddock soil type, local weather and one or more weed species. The 'Wizard' has numerous weed species to choose from including annual ryegrass, barley grass, wild radish, wild oat, brome grass and silver grass in the southern states and liverseed grass, barnyard grass, paradoxa grass, feathertop Rhodes grass, bladder ketmia, fleabane, sow thistle, sweet summer grass, cowvine and bellvine in the north.¹⁴

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A free download is available from: <u>https://www.agric.wa.gov.au/weed-seed-wizard-0</u>

7.3 Key points for managing weeds in field pea

Field pea have the greatest selection of herbicides of any pulse crop. There are more post-emergent herbicide options for field pea than for other pulses, as long as they are applied at the correct crop growth stage. However, field pea does not compete well with weeds, particularly early in the season. Despite field pea having more effective broadleaf weed control options than other pulses, it is important to understand potential weed problems in individual paddocks. Avoid paddocks with high weed seed loads or where weeds are unlikely to be controlled.¹⁵

Field pea provides valuable management strategies for integrated weed management and unique features to assist weed control in the cropping rotation. These include:

- a relatively late sowing window compared to other crops;
- the availability of competitive varieties such as Morgan^b, which compete well against weeds;
- the availability of earlier maturing varieties such as PBA Wharton^(b), PBA Twilight^(b), PBA Oura^(b), PBA Gunyah^(b), SW Celine and Maki, that enable 'crop-topping' for grasses to be undertaken when the crop is close to maturity but the weeds are not. (See <u>Section 3 Pre-planting.</u>)

There are a number of soil-applied residual herbicides registered that provide an opportunity to use alternative chemistries as part of a herbicide-resistance management program. They may also be more cost effective and cause less crop damage than post-emergent herbicide options for weed control. Some residual herbicides applied to the previous cereal crop can affect the establishment and growth of field pea. Refer to the current pesticide labels for further information on plant-back periods.¹⁶

7.4 Using herbicides

Herbicides that are registered for use in field pea can be found using the Australian Pesticides and Veterinary Medicines Authority (APVMA) database (https://apvma.gov.au/node/10831). An iOS app is also available. Seek the advice of your local agronomist or reseller.

Make sure you have the current information on the registration status, rates of application and warnings related to withholding periods, OH&S, residues and off-target effects before making decisions on which pesticide to use.

Herbicides must only be used if they are legally registered for the particular use in the particular crop at the listed label rates and timings. Using products off-label risks reduced efficacy, exceeding Maximum Residue Limits (MRLs) and litigation.

Always read the product label and Materials Safety Data Sheet (MSDS) before using herbicides.



¹⁴ DPIRD (2017) Weed Seed Wizard. https://agric.wa.gov.au/n/1522

¹⁵ Pulse Australia (2010) Northern Region Field Pea Management Guide. Pulse Australia, <u>https://sydney.edu.au/agriculture/documents/pbi/</u> pbi_region_north_field_pea_management_guide.pdf

¹⁶ P Matthew, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015, NSW– DPI Management Guide. NSW Government Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/___data/assets/pdf__file/0011/272945/winter-crop-variety-sowingguide-2016.pdf</u>



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Residue limits in any crop are at risk of being exceeded or breached where pesticides are applied:

- at rates higher than the maximum specified;
- more frequently than the maximum number of times specified per crop;
- within the specified withholding period; and
- where they are not registered for the particular crop.

The National Residue Survey (NRS) is part of an Australian Government and industry strategy to minimise chemical residues and environmental contaminants in Australian food products. NRS programs support primary producers and commodity marketers by confirming Australia's status as a producer of clean food and facilitating access to key domestic and export markets. The compliance rate for pulses in 2013-14 was 99.5%.¹⁷

The NRS survey helps protect our export markets and Australian reputation.

7.4.1 Getting best results from herbicides

Successful results from herbicide application depends on careful planning and application of the herbicide treatment.

Annual weeds compete with cereals and broadleaf crops mainly when the crops are in their earlier stages of growth. Weeds should be removed no later than 6 weeks after sowing to minimise losses. Early post-emergent control nearly always results in higher yields than treatments applied after branching in broadleaf crops.

Points to remember for the successful use of herbicides:

- Plan the operation. Check paddock sizes, tank capacities, water availability and supply.
- Do not spray outside the recommended crop growth stages as damage may result.
- Carefully check crop and weed growth stages before deciding upon a specific post-emergent herbicide.
- Read the label. Check to make sure the chemical will do the job. Note any mixing instructions, especially when tank mixing two chemicals.
- Follow the recommendations on the label.

Conditions inhibiting plant cell growth, such as stress from drought, waterlogging, poor nutrition, high or low temperatures, low light intensity, disease or insect attack, or a previous herbicide application, are not conducive to maximum herbicide uptake and translocation.

- Use good quality water, preferably from a rainwater tank. Water quality is very important.
- Hard, dirty or muddy water can reduce the effectiveness of some herbicides.
- Use good equipment that has been checked for output.
- Use sufficient water to ensure a thorough, uniform coverage.
- Check boom height with spray pattern operation for full coverage of the target.
- Check accuracy of GPS or boom width marking equipment.
- Check wind speed.
- A light breeze helps herbicide penetration into crops.
- Do not spray when wind is strong (>15 km/h).
- Do not spray if rain is imminent or when heavy dew or frost is present.
- Calculate the amount of herbicide required for each paddock and tank load. Add surfactant where recommended.
- Select the appropriate nozzle type for the application.



¹⁷ National Residue Survey (2014) Residue results for 2013-14. Australian Government, Department of Agriculture and Water Resources, http://www.agriculture.gov.au/ag-farm-food/food/nrs/nrs-results-publications/industry-brochures-2013-14/results-2013-14



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(i) MORE INFORMATION

APVMA webpage: Registration database https://portal.apvma.gov.au/pubcris

APVMA webpage: Permits database https://portal.apvma.gov.au/permits

APVMA app: Permit app for iOS http://apvma.gov.au/ node/10831#iphone_app

Pulse Australia webpage: Permits for pulses <u>http://pulseaus.com.au/growing-</u> pulses/crop-protection-products

Grain Producers booklet: Safely managing risks with crop inputs and grain on-farm <u>http://grainsguide.grainproducers.</u> <u>com.au/</u>



- Beware of compromising nozzle types when tank-mixing herbicides with fungicides or insecticides.
- Be aware of spray conditions to avoid potential spray drift onto sensitive crops and pastures, roadways, dams, trees, watercourses or public places.

Seek advice before spraying recently released field pea varieties as they may differ in their tolerance of herbicides. (See <u>Section 7.5.7 Specific guidelines for Group F</u><u>herbicides</u>)

Information on herbicide tolerance is available in the variety management package for the variety. PBA varieties and brochures are available here: <u>https://grdc.com.au/</u> <u>research/trials,-programs-and-initiatives/pba/varieties-and-brochures</u>

Keep appropriate spray records for each spray operation.¹⁸

7.4.2 Current minor use permits (MUP)

Some products may be available under permit, with conditions attached, until enough data is generated for full registration. In other cases, a temporary permit may be granted when there is a particular seasonal issue.

Pulse Australia holds several minor use permits on behalf of the pulse industry and is actively involved in the pursuit of new permits and label registrations to meet industry needs.¹⁹

7.5 Mode of action (MOA)

Herbicides have been classified into a number of groups. The group refers to the way a chemical works: different chemical make-up and mode of action (see <u>Section 7.5.2</u> <u>Grouping by MOA and ranked by resistance risk</u>, for a full list of options).

The main reason resistance has developed is because of the repeated and often uninterrupted use of herbicides with the same mode of action. Selection of resistant strains can occur in as little as 3–4 years if no attention is paid to resistance management. Remember that the resistance risk remains for products having the same MOA. If you continue to use herbicides with the same MOA and do not follow a resistance management strategy, problems will arise.

7.5.1 Mode-of-action labelling in Australia

In order to facilitate management of herbicide-resistant weeds, all herbicides sold in Australia are grouped by mode of action (MOA). The MOA is indicated by a letter code on the product label. The MOA labelling is based on the resistance risk of each group of herbicides. Australia was the first country to introduce compulsory MOA labelling on products, and the letters and codes used in Australia are unique. Labelling is compulsory and the letters and codes reflect the relative risk of resistance evolving in each group. Since the introduction of MOA labelling in Australia, other countries have adopted MOA classification systems; however, caution is advised if cross-referencing MOAs between Australia and other countries, as different classification systems are used. The herbicide MOA grouping and labelling system in Australia was revised in 2007. This is the first major revision of the classification system since its introduction.

The original groupings were made based on limited knowledge about MOAs. Groupings have been changed to improve the accuracy and completeness of the MOAs to enable more informed decisions about herbicide rotation and resistance management. The general intent of groups based on their risk has not changed. However, six additional herbicide mode of action groups were created to more accurately group herbicides.



¹⁸ GRDC (2016) Spray application manual GrowNotes™, GRDC, <u>https://grdc.com.au/resources-and-publications/grownotes/technical/</u> spray-application-manual

¹⁹ Pulse Australia (2016) Crop protection products. Pulse Australia website, <u>http://pulseaus.com.au/growing-pulses/crop-protection-products</u>





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7.5.2 Grouping by MOA and ranked by resistance risk

Growers and agronomists are now better able to understand the huge array of herbicide products in the marketplace in terms of mode of action (MOA) grouping and resistance risk by reference to the mode of action chart

All herbicide labels now carry the mode of action group clearly displayed, such as:

GROUP G HERBICIDE	
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Not all MOA groups carry the same risk for resistance development therefore specific guidelines for Groups E, O, P and R have not been developed to date because there are no recorded cases of weeds resistant to members of these groups in Australia.

Products represented in Group A and Group B are HIGH RESISTANCE RISK herbicides and specific guidelines are written for these products.

Specific guidelines are also included for the MODERATE RESISTANCE RISK herbicides, Groups C, D, F, G, I, J, K, L, M, N, Q and Z herbicides.

HIGH RESISTANCE RISK herbicides

Group A (mostly targeted at annual ryegrass and wild oats); and

Group B (broadleaf and grass weeds).

Specific guidelines are written for use of these products in winter cropping systems.

MODERATE RESISTANCE RISK herbicides

Group C (annual ryegrass, wild radish and silver grass);

Group D (annual ryegrass and fumitory);

Group F (wild radish);

Group I (wild radish and Indian hedge mustard);

Group J (serrated tussock and giant Parramatta grass);

Group L (annual ryegrass, barley grass, silver grass, square weed and capeweed);

Group M (annual ryegrass, barnyard grass, fleabane, liverseed grass and windmill grass);

Group Q (annual ryegrass); and

Group Z (wild oats and winter grass).

Group K

Specific guidelines have been developed for Group K due to the reliance on this MOA to manage annual ryegrass and prevent future resistance development.

Groups with no resistant weeds listed:

Group E
Group G
Group H
Group N
Group O
Group P
Group R
There are no

There are no recorded cases of weeds resistant to members of these groups in Australia.









7.5.3 Specific guidelines for Group A herbicides

The following charts have been compiled from chemical labels on the APVMA web site and PIRSA Spraying Charts and in consultation with chemical companies.²⁰

Group A herbicides

High resistance risk.

Group A resistance exists in Australia in the grass weeds, including annual ryegrass, wild oats, phalaris, brome grass, crab grass, goose grass and barley grass. Resistance has developed in broadacre and vegetable situations.

Research has shown that as few as six applications to the same population of annual ryegrass can result in the selection of resistant individuals. A population can go from a small area of resistant individuals to a whole-paddock failure in one season.

'Fops', 'Dims', and 'Dens' are Group A herbicides and carry the same high resistance risk. Where a Group A herbicide has been used on a particular paddock for control of any grass weed, avoid using a Group A herbicide to control the same grass weed in the following season, irrespective of the performance it gave.

Frequent application of Group A herbicides to dense weed populations is the worst scenario for rapid selection of resistance.

Where resistance to a member of Group A is suspected or known to exist, there is a strong possibility of cross-resistance to other Group A herbicides. Therefore, use other control methods and herbicides of other MOA groups in a future integrated approach.

The above recommendations should be incorporated into an integrated weed management (IWM) program. In all cases, try to ensure that surviving weeds from any treatment do not set and shed viable seed. Keep to integrated strategies, including rotation of MOA groups.

Table 3: Active ingredients of Group A MOAs.

Chemical family	Active constituent (first registered trade name)
Group A	Inhibitors of acetyl co-enzyme A carboxylase (Inhibitors of fat synthesis/ACC'ase inhibitors)
Aryloxyphenoxypropionates (Fops)	clodinafop (Topik®), cyhalofop (Barnstorm®), diclofop (Cheetah® Gold*, Wildcat®), fluazifop (Fusilade®, Fusion®), haloxyfop (Verdict®), propaquizafop (Shogun®), quizalofop (Targa®)
Cyclohexanediones (Dims)	butroxydim (Falcon®, Fusion®*), clethodim (Select®), profoxydim (Aura®), sethoxydim (Cheetah® Gold*, Decision®*), tralkoxydim (Achieve®)
Phenylpyrazoles (Dens)	pinoxaden (Axial®)

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, <u>https://www.croplife.org.au/resistance-strategy/2017-</u> herbicide-resistance-management-strategies/



²⁰ CropLife Australia Herbicide Resistance Management Strategies—September 2011. <u>https://www.croplife.org.au/resistance-strategies/</u>







7.5.4 Specific guidelines for Group B herbicides

Group B herbicides

High resistance risk.

Group B resistance exists in Australia in the grass weeds annual ryegrass, barley grass, brome grass, wild oats and crab grass, and in at least 16 broadleaf weeds including wild radish, common sowthistle, climbing buckwheat, turnip weed, wild mustard, Indian hedge mustard, prickly lettuce, wild turnip and African turnip weed. Resistance has developed in broadacre, rice and pasture situations. With respect to rice, three broadleaf weeds have been discovered: dirty dora, arrowhead, and starfruit.

Research has shown that as few as four applications to the same population of annual ryegrass can result in the selection of resistant individuals and as few as six applications for wild radish. A population can go from a small area of resistant individuals to a whole paddock failure in one season.

Avoid applying more than two Group B herbicides in any 4-year period on the same paddock.

Broadleaf weed control

If a pre-emergent application is made with a Group B herbicide for broadleaf weed control, monitor results and, if required, apply a follow-up spray with a non-Group B herbicide for control of escapes and to reduce seedset.

If a post-emergent application is made with a Group B herbicide for broadleaf weed control, it should preferably be as an APVMA-approved tank-mix with another MOA that controls or has significant activity against the target weed. If no APVMA-approved tank-mix is available, then monitor results and if required, apply a follow-up spray with a non-Group B herbicide for control of escapes and to reduce seedset.

A Group B herbicide may be used alone on flowering wild radish only if a Group B herbicide has not been previously used on that crop.

Grass-weed control

If there are significant escapes following the herbicide application, consider using another herbicide with a different mode of action or another control method to stop seedset.







Table 4: A	ctive ingred	lients of Gro	up B MOAs.
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Chemical family	Active constituent (first registered trade name)
Group B	Inhibitors of acetolactate synthase (ALS inhibitors), acetohydroxyacid synthase (AHAS)
Imidazolinones (IMIs)	imazamox (Intervix®*, Raptor®), imazapic (Bobcat I-Maxx®*, Flame®, Midas®*, OnDuty®*), imazapyr (Arsenal Xpress®*, Intervix®*, Lightning®*, Midas®*, OnDuty®*), imazethapyr (Lightning®*, Spinnaker®)
Pyrimidinylthiobenzoates	bispyribac (Nominee®)
Sulfonylureas (SUs)	azimsulfuron (Gulliver®), bensulfuron (Londax®), chlorsulfuron, ethoxysulfuron, foramsulfuron (Tribute®), halosulfuron (Sempra®), iodosulfuron (Hussar®), mesosulfuron (Atlantis®), metsulfuron (Ally®, Stinger®*, Trounce®*), prosulfuron (Casper®*), rimsulfuron (Titus®), sulfometuron (Oust®, Eucmix Pre Plant®*), sulfosulfuron (Monza®), thifensulfuron, triasulfuron (Logran®, Logran® B Power®*), tribenuron (Express®), trifloxysulfuron (Envoke®, Krismat®*)
Triazolopyrimidines (Sulfonamides)	florasulam (Paradigm®*, Vortex®*, X-Pand®*), flumetsulam (Broadstrike®), metosulam (Eclipse®), pyroxsulam (Crusader®, Rexade®*)

* This product contains more than one active constituent

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, https://www.croplife.org.au/resistance-strategy/2017herbicide-re istance-management-strategies/

7.5.5 **Specific guidelines for Group C herbicides**

Group C herbicides

Moderate resistance risk.

Group C resistance exists in Australia in the weeds annual ryegrass, wild radish, liverseed grass, silver grass, stinging nettles and barnyard grass. Resistance has developed in broadacre, horticultural and non-crop situations.

CropLife Australia gives specific guidelines for the use of Group C herbicides in triazine-tolerant (TT) canola and in winter legume crops, following increasing reports of resistance development.

Avoid using Group C herbicides in the same paddock in consecutive years. Growing TT canola in a paddock treated with triazine herbicides in the previous season is a high resistance risk and is not recommended.

Watch and record for weed escapes, especially in paddocks with a long history of Group C use.

Consult the 'Integrated Weed Management Strategy for TT Canola' for further details. The resistance status of the 'at-risk' weeds should be determined prior to sowing. Always use the label rate of herbicide, whether a single active ingredient (e.g. bromoxynil) or combination of active ingredients is applied (e.g. bromoxynil/ MCPA, pyrasulfotole/bromoxynil). Apply to weeds at the labelled growth stage and ensure that no weeds set or shed viable seed. To prevent seedset, control survivors with a herbicide of different MOA from Group C, or use another weedmanagement technique.



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Chemical family	Active constituent (first registered trade name)
Group C	Inhibitors of photosynthesis at photosystem II (PS II inhibitors)
Amides	propanil (Stam®)
Benzothiadiazinones	bentazone (Basagran®, Basagran® M60*, Lawnweeder plus®*)
Nitriles	bromoxynil (Buctril® MA*, Eliminar C®*, Flight®*, Jaguar®*, Talinor®*, Triathlon®*, Velocity®*), ioxynil (Actril DS*, Totril®)
Phenylcarbamates	phenmedipham (Betanal®)
Pyridazinones	chloridazon (Pyramin®)
Triazines	ametryn (Amigan®*, Gesapax®Combi*, Krismat®), atrazine (Gesapax® Combi*, Gesaprim®, Primextra® Gold*), cyanazine (Bladex®), prometryn (Cotogard®*, Gesagard®), propazine, simazine (Gesatop®), terbuthylazine (Terbyne®), terbutryn (Agtryne® MA*, Amigan®*, Igran®)
Triazinones	hexazinone (Bobcat I-Maxx®*, Velpar® K4*, Velpar® L), metribuzin (Aptitude®*, Sencor®)
Uracils	bromacil (Hyvar®, Krovar®*), terbacil (Eucmix Pre Plant®*, Sinbar®)
Ureas	diuron (Krovar®*, Velpar® K4*), fluometuron (Cotogard®*, Cotoran®), linuron (Afalon®), methabenzthiazuron (Tribunil®), siduron (Tupersan®), tebuthiuron (Graslan®)

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, https://www.croplife.org.au/resistance-strategy/2017-

herbicide-resistance-management-strategies/

7.5.6 Specific guidelines for Group D herbicides

Group D herbicides

Moderate resistance risk.

Resistance to Group D herbicides is known for an increasing number of populations of annual ryegrass and fumitory. Resistance has generally occurred after 10–15 years of use of Group D herbicides.

Where possible, avoid the use of Group D herbicides on dense ryegrass populations. Consider using alternative methods of weed control to reduce weed numbers before applying herbicides.

Rotate with herbicides from other MOA. For annual ryegrass, consider rotating trifluralin with products such as Boxer Gold[®].

These recommendations should be incorporated into an IWM program. Try to ensure that surviving weeds from any treatment do not set and shed viable seed. Use integrated strategies, including rotation of MOA groups.



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Table 6: Active ingredients of Group D MOAs.

Chemical family	Active constituent (first registered trade name)
Group D	Inhibitors of microtubule assembly
Benzamides	propyzamide (Kerb®)
Benzoic acids	chlorthal (Dacthal®, Prethal™)
Dinitroanilines (DNAs)	oryzalin (Rout®*, Surflan®), pendimethalin (Stomp®), prodiamine (Barricade®), trifluralin (Jetti Duo®*, Treflan®)
Pyridines:	dithiopyr (Dimension®)

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, https://www.croplife.org.au/resistance-strategy/2017herbicide-resistance-management-strategies/

7.5.7 **Specific guidelines for Group F herbicides**

Group F herbicides

Moderate resistance risk.

Resistance to Group F herbicides is known for a small number of populations of wild radish. Resistance has generally occurred after a long history of use of Group F herbicides. The number of populations with Group F resistance is increasing following increased use of these herbicides.

Group F includes herbicides that reduce carotenoid biosynthesis through inhibition of phytoene desaturase (PDS).

Avoid applying Group F herbicides in any two consecutive years unless one application is a mixture with a different MOA that is active on the same weed, or a follow-up spray is conducted (using a different MOA) to control escapes. Always use the label rate of herbicide, whether a single active ingredient (e.g. diflufenican) or combination of active ingredients is applied (e.g. diflufenican/MCPA, picolinafen/ MCPA). Apply to weeds at the labelled growth stage and ensure that no weeds set or shed viable seed. To prevent seedset, control survivors with a herbicide of different MOA from Group F, or use another weed-management technique.

If applicable, apply a follow-up spray with a non-Group F herbicide for control of escapes and to reduce seedset. Aim to ensure that surviving weeds from any treatment do not set and shed viable seed.

These recommendations should be incorporated into an IWM program. Try to ensure that surviving weeds from any treatment do not set and shed viable seed. Use integrated strategies including rotation of MOA groups.

Table 7:	Active	ingredients	for	Group	F	MOAs.
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Chemical family	Active constituent (first registered trade name)		
Group F	Bleachers: Inhibitors of carotenoid biosynthesis at the phytoene desaturase step (PDS inhibitors)		
Pyridazinones	norflurazon (Zoliar®)		
Pyridinecarboxamide	diflufenican (Brodal®, Spearhead®*, Jaguar®*, Tigrex®*, Triathlon®*, Yates Pathweeder®*), picolinafen (Eliminar C®*, Flight®*, Paragon®*, Sniper®)		

This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, https://www.croplife.org.au/resistance-strategy/2017herbicide-resistance-management-strategies/



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7.5.8 Specific guidelines for Group H herbicides

Group H Herbicide

Moderate resistance risk.

There are currently no known weeds resistant to Group H herbicides in Australia. Resistance to Group H herbicides is known for a number of populations of Amaranthus species in the United States, which demonstrates the potential for weeds to develop resistance to this mode of action. Continuous usage of Group H herbicides in the US has resulted in resistance in *Amaranthus* species in a relatively short time.

- Broadacre cropping: Of particular concern in Australia is the potential for development of Group H resistance in wild radish. In some areas, because of a lack of alternate herbicide options growers are heavily reliant on Group H herbicides for control of wild radish populations. It is essential to integrate additional cultural weed control techniques to reduce the seedbank and minimise seedset, thereby decreasing the selection pressure on Group H herbicides.
- 2. Fallow: In high summer rainfall areas, weed control in fallow is heavily reliant on herbicides. Multiple sprays are often required to maintain a clean fallow between winter crops. Integrated weed management principles should be incorporated wherever possible, including cultivation, the double-knock technique, grazing and combining more than one mode of action in a single application. To assist in delaying the onset of Group H resistance, rotate and/or tank mix with herbicides from other modes of action.
- 3. Rice: Where benzofenap has been applied to rice, a follow-up application of MCPA or bentazone and MCPA is recommended where appropriate to provide a secondary mode of action. To reduce the likelihood of resistant weeds developing it is recommended that products containing benzofenap (e.g. Taipan[®], Viper[®]) not be used in consecutive rice crops.

Synergistic interactions have been documented for several Group H and Group C herbicide combinations. Where possible, apply a Group H herbicide in combination with a Group C herbicide to maximise efficacy. Always use the label rate of herbicide whether or not a single active ingredient (eg. isoxaflutole) or combinations of active ingredients are applied (eg. isoxaflutole + simazine, pyrasulfotole/bromoxynil).

The above recommendations should be incorporated into an integrated weed management (IWM) program. In all cases try and ensure surviving weeds from any treatment do not set or shed viable seed. Keep to the integrated strategies mentioned in this brochure including rotation of mode of action groups. Where possible, rotate between products from different mode of action groups.

Table 8: Active ingredients for Group F MOAs.

Chemical family	Active constituent (first registered trade name)
Group H	Bleachers: Inhibitors of 4-hydroxyphenyl-pyruvate dioxygenase (HPPDs)
Isoxazoles	isoxaflutole (Balance®)
Pyrazoles	benzofenap (Taipan®), pyrasulfotole (Precept®*, Velocity®*)
Triketone	bicyclopyrone (Talinor®*)

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, <u>https://www.croplife.org.au/resistance-strategy/2016-herbicide-resistance-management-strategies/</u>







7.5.9 Specific guidelines for Group I herbicides

Group I herbicides

Moderate resistance risk.

Resistance to Group I herbicides is known for a number of populations of wild radish and Indian hedge mustard. Resistance has occurred after a long history of use of Group I herbicides. The number of populations with Group I resistance is increasing.

It is of particular concern that in addition to Group I resistance in wild radish, which is the most important broadleaf weed in broadacre agriculture, some populations are cross-resistant to other MOAs, e.g. Group F herbicides, which can be important for control of wild radish in lupins where other selective, non-Group I options are limited. Because of the long soil life of wild radish seed, measures to reduce the return of seed to the soil would be useful for this weed. Wild radish seed that is confined to the top 5 cm of soil has a shorter life than seed buried deeper.

As a rule, in situations of high resistance risk:

- Avoid applying two applications of Group I herbicides alone onto the same population of weeds in the same season.
- Where possible, combine more than one MOA in a single application. Each product should be applied at rates sufficient for control of the target weed alone to reduce the likelihood of weeds resistant to the Group I herbicide surviving. These recommendations should be incorporated into an IWM program. Try to ensure that surviving weeds from any treatment do not set and shed viable seed. Use integrated strategies, including rotation of MOA groups.

Table 9: Active ingredients of Group I	MOAs.
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Chemical family	Active constituent (first registered trade name)
Group I	Disruptors of plant cell growth (Synthetic Auxins)
Arylpicolinate	halauxifen (ForageMax®*, Paradigm®*, Rexade®*)
Benzoic acids	dicamba (Banvel®, Banvel M®*, Barrel®*, Casper®*, Lawnweeder plus®*, Mecoban®, Methar Tri-Kombi®*)
Phenoxycarboxylic acids: (Phenoxys)	2,4-D (Actril DS®*, Amicide®, Fallow Boss Tordon®*, Methar Tri-Kombi®*, Pyresta®*, Vortex®*), 2,4-DB (Trifolamine®), dichlorprop (Lantana 600®), MCPA (Agtryne® MA*, Basagran® M60*, Buctril® MA*, Flight®*, Lawnweeder plus®*, MCPA, Midas®*, Paragon®*, Precept®*, Silverado®*, Spearhead®*, Tigrex®*, Triathlon®*), MCPB, mecoprop (Methar Tri- Kombi®*)
Pyridine carboxylic acids: (Pyridines)	aminopyralid (FallowBoss Tordon®*, ForageMax®*, Grazon Extra®*, Hotshot®*, Stinger®*, Vigilant II®*), clopyralid (Lontrel®, Spearhead®*), fluroxypyr (Hotshot®*, Starane®), picloram (Fallow Boss Tordon®*, Grazon Extra®*, Tordon®, Tordon Regrowth Master®*, Vigilant II®*), triclopyr (Garlon®, Grazon Extra®*, Tordon Regrowth Master®*, Tough Roundup® Weedkiller*)
Quinoline carboxylic acids:	quinclorac (Drive®)
* This product contains more than one active constituent.	

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, https://www.croplife.org.au/resistance-strategy/2016-

herbicide-resistance-management-strategies/









7.5.10 Specific guidelines for Group J herbicides

Group J herbicides

Moderate resistance risk.

There are isolated cases of weeds resistant to Group J in Australia. Two populations of serrated tussock and six populations of giant Parramatta grass are confirmed resistant to flupropanate.

To assist in delaying the onset of resistance, consider alternating with herbicides from other MOA.

The recommendations should be incorporated into an IWM program. Try to ensure surviving weeds from any treatment do not set and shed viable seed. Use integrated strategies, including rotation of MOA groups.

Table 10:	Active	ingredients	of Group	J MOAs.

Chemical family	Active constituent (first registered trade name)
Group J	Inhibitors of lipid synthesis (not ACCase inhibitors)
Benzofurans	ethofumesate (Tramat®)
Chlorocarbonic acids	2,2-DPA (Dalapon®), flupropanate (Tussock®)
Phosphorodithioates	bensulide (Exporsan®)
Thiocarbamates	EPTC (Eptam®), molinate (Ordram®), pebulate (Tillam®), prosulfocarb (Arcade®, Boxer® Gold*), thiobencarb (Saturn®), triallate (Avadex®, Jetti Duo*), vernolate

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, <u>https://www.croplife.org.au/resistance-strategy/2017-herbicide-resistance-management-strategies/</u>









7.5.11 Specific guidelines for Group K herbicides

Group K herbicides

Moderate resistance risk.

Resistance to Group K herbicides is possible in Australia and may develop in broadacre situations.

Where possible, avoid the use of Group K herbicides on dense populations of ryegrass. Consider using alternative methods of weed control to reduce weed numbers before applying herbicides.

Rotate with herbicides from other modes of action. The recommendations should be incorporated into an IWM program. Try to ensure surviving weeds from any treatment do not set and shed viable seed. Use integrated strategies, including rotation of MOA groups.

Active constituent (first registered trade name)
Inhibitors of cell division / inhibitors of very long chain fatty acids (VLCFA inhibitors)
napropamide (Devrinol®)
dimethenamid (Frontier®-P, Outlook®), metazachlor (Butisan®), metolachlor (Boxer® Gold*, Dual® Gold, Primextra® Gold*), propachlor (Ramrod®)
pyroxasulfone (Sakura®)

Table 11: Active ingredients of Group K MOAs.

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, <u>https://www.croplife.org.au/resistance-strategy/2017-</u> herbicide-resistance-management-strategies/

7.5.12 Specific guidelines for Group L herbicides

Group L herbicides

Moderate resistance risk.

Group L resistance exists in Australia in annual ryegrass, barley grass (two species), silver grass, cape weed and square weed. Most instances have occurred in long-term lucerne stands treated regularly with a Group L herbicide, but Group L-resistant barley grass has also occurred in no-till situations.

The following factors are common to all cases of Group L resistance:

- a Group L herbicide is the major or only herbicide used; and
- a Group L herbicide has been used for 12–15 years or more.

There has been minimal or no soil disturbance following application. The risk of resistance to Group L herbicides is higher in no-tillage broadacre cropping. Other situations of high resistance risk include irrigated clover pivots, orchards, vineyards or pure lucerne stands where frequent applications of a Group L herbicide are made each season, cultivation is not used and there is reliance on a Group L herbicide alone for weed control. Below are strategies to reduce the risk of Group L resistance developing in situations of high resistance risk.

No-tillage

Rotate Group L herbicides with other knockdown herbicides with a different mode of action.

Consider utilising the double-knock technique, with glyphosate sprayed first, followed within 1–7 days by a paraquat application. A full label rate for the weed size targeted should be used for the paraquat application for resistance management. Consider occasional mechanical cultivation to aid weed control.





Lucerne

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If using a Group L herbicide for winter cleaning, where possible include another MOA, e.g. diuron (Group C).

Use alternative MOAs to selectively control grass and broadleaf weeds. Rotate Group L herbicides with other knockdown herbicides with a different MOA prior to sowing lucerne and prior to sowing future crops in that paddock.

Horticulture

Rotate Group L herbicides with other knockdown herbicides with a different MOA. Where possible, use residual herbicides (that are effective on the same weeds as the Group L herbicides) where applicable, either alone or in mixture with Group L herbicides. Where possible, use an alternative MOA to selectively control grass and broadleaf weeds. Consider using the double-knock technique, with glyphosate sprayed first, followed within 1–7 days by a paraquat application. A full label rate for the weed size targeted should be used for the paraquat application for resistance management.

These recommendations should be incorporated into an IWM program. Try to ensure surviving weeds from any treatment do not set and shed viable seed. Always try to apply herbicides to the smallest weed density. Use integrated strategies, including rotation of MOA groups.

Chemical family	Active constituent (first registered trade name)
Group L	Inhibitors of photosynthesis at photosystem I (PSI inhibitors)
Bipyridyls	diquat (Reglone®, Spray.Seed®*), paraquat (Alliance®*, Gramoxone®, Spray.Seed®*)

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, https://www.croplife.org.au/resistance-strategy/2016-

herbicide-resistance-management-strategies/

7.5.13 Specific guidelines for Group M herbicides

Group M herbicides

Moderate resistance risk.

Group M resistance occurs in Australia in annual ryegrass, awnless barnyard grass, fleabane, liverseed grass and windmill grass.

Herbicide resistance to glyphosate was first discovered in annual ryegrass in Australia in 1996. Since then, several new cases of glyphosate resistance in annual ryegrass, awnless barnyard grass, fleabane, liverseed grass and windmill grass have been confirmed.

The following factors are common to all cases of Group M resistance:

- a Group M herbicide is the major or only herbicide used;
- a Group M herbicide has been used for 12–15 years or more; and
- there has been minimal or no soil disturbance following application.

Given the important role of glyphosate in Australian farming systems, the Australian agricultural industry has developed strategies for sustainable use of glyphosate.

For more information, refer to the Australian Glyphosate Sustainability Working Group website (<u>http://www.glyphosateresistance.org.au</u>).







All cases of glyphosate-resistant weeds confirmed to date share three common factors:

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- intensive (year-to-year) use of glyphosate;
- lack of rotation with other herbicide modes of action; and
- little or no tillage or cultivation following the application of glyphosate

Several cases of ryegrass resistance to glyphosate have occurred in horticultural and non-cropping situations (e.g. firebreaks, fence lines, driveways, irrigation ditches), with the balance occurring in no-till, broadacre cropping systems.

Given the demonstrated propensity of annual ryegrass to develop resistance to multiple herbicide classes, IWM principles should be incorporated wherever possible to minimise the risk of selecting for glyphosate-resistant ryegrass. Strategies may include the use of cultivation, the double-knock technique (using a full-cut cultivation OR the full label rate of a paraquat-based product (Group L) following the glyphosate (Group M) knockdown application), strategic herbicide rotation, grazing and baling.

Try to ensure that surviving weeds from any treatment do not set and shed viable seed. Always try to apply herbicides to the smallest weed density. Use the integrated strategies mentioned, including rotation of MOA groups.

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Chemical family	Active constituent (first registered trade name)
Group M	Inhibitors of 5-enolpyruvyl shikimate-3 phosphate (EPSP) synthase
Glycines	glyphosate (Arsenal Xpress®*, Broadway®*, Illico®*, Resolva® Weedkiller*, Roundup®, Tough Roundup® Weedkiller*, Trounce®*, Yates Pathweeder®*)
* This was done to the barrier does not be a set of the	

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, <u>https://www.croplife.org.au/resistance-strategy/2016-</u> herbicide-resistance-management-strategies/

7.5.14 Specific guidelines for Group Q herbicides

Group Q herbicides

Moderate resistance risk.

Group Q resistance exists in Australia in annual ryegrass resistant to amitrole. This has only occurred in three populations and this type of resistance is rare in Australia.

To assist in delaying the onset of resistance, consider alternating Group Q herbicides with herbicides from other modes of action, e.g.Group L (e.g. paraquat), Group N (e.g. glufosinate) or Group M (e.g. glyphosate).

Consider using alternative methods of weed control to reduce weed numbers before applying herbicides.

All the above recommendations should be read in conjunction with the integrated weed management (IWM) strategies.

Table 14: Active ingredients of Group Q MOAs.

Chemical family	Active constituent (first registered trade name)
Group Q	Bleachers: Inhibitors of carotenoid biosynthesis unknown target
lsoxazolidinones	clomazone (Command®)
Triazoles	amitrole (Alliance®*, Amitrole®, Illico®*)

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, <u>https://www.croplife.org.au/resistance-strategy/2016-</u> herbicide-resistance-management-strategies/









7.5.15 Specific guidelines for Group Z herbicides

Group Z herbicides

Moderate resistance risk.

Group Z resistance exists in Australia in wild oats resistant to flamprop. Many of these flamprop-resistant wild oats also show cross-resistance to Group A herbicides. Resistance to endothal is confirmed in winter grass.

To assist in delaying the onset of resistance, rotate with herbicides from other MOAs. Consider using alternative methods of weed control to reduce weed numbers before applying herbicides. These may include summer crop rotations, delayed sowing to control wild oats with a knockdown herbicide, higher seeding rates and brown manuring to stop seedset.

The recommendations should be incorporated into an IWM program. Try to ensure that surviving weeds from any treatment do not set and shed viable seed. Use integrated strategies, including rotation of MOA groups.

Table 15: Active ingredients of Group Z MOAs.

Chemical family	Active constituent (first registered trade name)
Group Z	Herbicides with unknown and probably diverse sites of action
Arylaminopropionic acids	flamprop
Dicarboxylic acids	endothal
Organoarsenicals	DSMA - disodium methylarsonate (Trinoc®*), MSMA - monosodium methylarsonate (Daconate®)

* This product contains more than one active constituent.

Source: CropLife Australia (2011). Herbicide Resistance Management Strategies, <u>https://www.croplife.org.au/resistance-strategy/2016-herbicide-resistance-management-strategies/</u>

Refer to the APVMA website to obtain a complete list of registered products from the PUBCRIS database (<u>https://apvma.gov.au/</u>).





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7.6 Herbicide performance

Characteristics that determine herbicide performance and activity are:

- Herbicide uptake: how and where the chemical is taken up by the plant.
- Herbicide solubility: how readily it dissolves or leaches in soil water.
- Herbicide adsorption: how much is lost by binding to the soil.
- Herbicide persistence: how long it will last in the soil, affected by:
 - » volatilisation: loss to the atmosphere;
 - » leaching potential: how much is lost below the root zone; and
 - » decomposition by light: loss of product by decomposition.

Understanding these factors will assist in ensuring more effective herbicide use.

For best performance, pre-sowing and pre-emergent herbicides should be placed in the top 7.5 cm of soil. They must enter the germinating weed seedling in order to kill it. These herbicides can be mixed in by cultivation, rainfall or sprinkler irrigation, depending on the herbicide.



Figure 2: Fate of applied herbicides in soil, plants and sunlight.

Source: Shaner (2013) via Pulse Australia (2016). Southern Lentil – Best management practices training course, Module 5 – Weed management.

7.7 Herbicide types

7.7.1 Residual v. non-residual herbicides

Residual herbicides remain active in the soil for an extended period (months) and can act on successive weed germinations. Residual herbicides must be absorbed through the roots or shoots, or both. Examples of residual herbicides include imazapyr, chlorsulfuron, atrazine and simazine.

The persistence of residual herbicides is determined by a range of factors including application rate, soil texture, organic matter levels, soil pH, rainfall and irrigation, temperature and the herbicide's characteristics.

Persistence of herbicides will affect the choice of crop sequences (a rotation of crops, e.g. wheat–barley–chickpeas–canola–wheat).

Non-residual herbicides, such as the non-selective paraquat and glyphosate, have little or no soil activity and they are quickly deactivated in the soil. They are either





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(i) MORE INFORMATION

GRDC Update paper: Optimising the impact of glyphosate https://grdc.com.au/Researchand-Development/GRDC-Update-Papers/2015/02/Optimising-theimpact-of-glyphosate

GRDC Video: IWM: Double Knock Applications – a Grower's Experience https://youtu.be/pEIEGsQDzBg

DOUBLE KNOCK APPLICATIONS





GRDC Video: Double-knock timing https://youtu.be/tNNRziB3MKc





GRDC Video playlist: Double-knock playlist https://youtu.be/1bfSRteU5SY?list= PL2PndQdkNRHGRipNhkDYN2dJW <u>AY1-oH9W</u> broken down or bound to soil particles, becoming less available to growing plants. They also may have little or no ability to be absorbed by roots.

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7.7.2 Knockdown herbicides

The most important part of the pulse weed control strategy is to control the majority of weeds before sowing, either by cultivation or with knockdown herbicides such as glyphosate (Group M) or Spray Seed® (Group L).²¹

Double knockdown refers to any two different weed-control tactics practised in close succession, where the second measure controls survivors of the first, e.g. any sequence that includes a herbicide and a non-chemical measure, such as heavy grazing or cultivation. It most commonly refers to two herbicide applications from different mode-of-action (MOA) groups, between 2 and 10 days apart. This is often glyphosate (Group M) or glyphosate plus 2,4-D (Group I) followed by paraquat or paraquat plus diquat (both Group L).²²

It may be necessary to delay sowing for up to 2 weeks after rain to enable a greater percentage of annual weeds to emerge. When the opening break is late this can compromise optimal sowing time.²³

7.7.3 Pre-emergent herbicides

Pre-emergent herbicides control weeds at the early stages of the life cycle, between radicle (root shoot) emergence from the seed and seedling leaf emergence through the soil.

Some pre-emergent herbicides also have post-emergent activity through leaf absorption and can be applied to newly emerging weeds.

The residual activity of a pre-emergent herbicide controls the first few flushes of germinating weeds while the crop is too small to compete. As a result, pre-emergent herbicides are often excellent at protecting the crop from early weed competition.²⁴

Pre-emergent herbicides offer the following advantages:

- Alternative modes of action to post-emergent and knockdown herbicides.
- Some are very effective on hard-to-kill weeds, such as annual ryegrass and barley grass.
- Herbicide resistance to pre-emergent herbicides is low for some chemicals or in some districts.
- Pre-emergent herbicides control weeds early in the crop's life and potentially over several germinations, maximising crop yield potential.
- They suit a no-till sowing system with knife points and press-wheels and/or disc seeders, as well as conventional tillage systems.
- Can be cost effective.

These pre-emergent herbicides are primarily absorbed through the roots, but there may also be some foliar absorption.

When applied to soil, best control is achieved when the soil is flat and relatively free of clods and trash. While most pre-emergent herbicides are suitable for use in moderate stubble load paddocks, product labels will suggest adequate control with 50% groundcover.

Sufficient rainfall (20–30 mm) to wet the soil through the weed root zone is necessary within 2–3 weeks of application. The efficacy of most soil residual herbicides is greater where applied to moist soil rather than to dry soil. Best weed control is often

- 21 (Pulse Australia 2016) Southern Lentil Best management practices training course, Module 5 Weed management, Pulse Australia Limited.
- 22 GRDC (2012) Herbicide resistance Fact Sheet, Southern Region. GRDC, May 2012, <u>https://grdc.com.au/Resources/Factsheets/2012/05/</u> Herbicide-Resistance
- 23 MJ Walsh and SB Powles (2007) Management strategies for herbicide-resistant weed populations in Australian dryland crop production systems. Weed Technology 21, 332–338
- 24 GRDC (2014) Integrated Weed Management Hub. GRDC, https://grdc.com.au/resources-and-publications/iwmhub







VIDEO

Watch Pre-emergent Herbicides – Part 1 Solubility & Binding https://youtu.be/s63GYYyflzw



Mark Congreve & John Carne

Watch the Webinar – Understanding pre-emergent herbicides. <u>http://weedsmart.org.au/webinars/</u> <u>setting-crops-up-for-success/</u> achieved from a post-sowing pre-emergent application because rainfall provides the best incorporation (compared to pre-sowing, which can occur without rainfall).

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Mechanical incorporation of herbicides is less uniform than spraying after seeding and so weed control may be less effective. If applied pre-sowing and sown with minimal disturbance, then some of the incorporation will essentially be by rainfall after application. Weed control in the sowing row may be less effective because some herbicide will be removed from the crop row during the sowing operation.

Pre-emergent herbicides will not adequately control large weed populations by themselves. They need to be used in conjunction with paddock selection, crop rotation and pre-sowing weed control.

In no-till sowing systems, incorporation by sowing (IBS) is generally considered safer for the crop than post-sowing pre-emergent (PSPE). This is because there is little protection within the sowing row, unless there is potential for crop damage when soil is thrown into the sowing furrow.²⁵

To avoid PSPE damage sow deeper. Apply to moist soil, not dry, and do not apply if there is heavy rainfall forecast. Apply to a level soil surface to limit the possibility of herbicide concentrating in the furrow and causing damage to the crop. Use lower rates on lighter soils.²⁶

Use in field pea

Pre-emergent chemicals are the most effective tool in field pea crops to control broadleaf weeds and generally result in less crop damage than the in-crop options. Pre-emergents are becoming increasingly important in grass weed control, as they offer alternative chemical modes-of-action (MOA) to control herbicide-resistant weeds. Examples of this chemistry include trifluralin (Treflan®) and triallate (Avadex®).

Pre-emergent herbicides for use in field pea are generally registered for either incorporation by sowing (IBS) or use as a post-sowing pre-emergent (PSPE). Most of these chemicals are very dependent on rainfall for activation, therefore results are often limited under dry conditions or damage can be severe under heavy rainfall conditions.

Sufficient moisture and a level soil surface must be present at application for some soil-active broadleaf herbicides to be fully effective and to avoid crop damage. A ridged soil surface can cause problems if heavy rain falls between sowing and germination. The rain can wash the herbicide into the furrow and leave a concentrated band of chemical on top of the germinating seed, which can result in crop damage. Leave the soil surface flat to minimise herbicide damage. A flat surface can also assist harvest by ensuring clods or stones don't enter the harvester.²⁷

See NSW DPI Weed Control in Winter Crops 2017 guide, pages 96-97 (early postemergence herbicides for field peas, tables 32-34) (<u>http://www.dpi.nsw.gov.au/</u> agriculture/broadacre-crops/guides/publications/weed-control-winter-crops).



²⁵ Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 5-2016

²⁶ B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/content/agriculture/farm/conservation/information/pre-emergent-herbicides</u>

²⁷ GRDC (2015) Field pea Northern Region GrowNotes[™], –Chapter 5, p 10, https://asp-au.secure-zone.net/v2/index.jsp?id=1229/1381/7682&Ing=en







New pre-emergents for field pea: Groups J & K

Boxer Gold®

Apply as a pre-emergent to soil surface up to 7 days prior to sowing and incorporate mechanically by the sowing operation (IBS). Application should be made to a moist seedbed. Sufficient rain to thoroughly wet the top 3–4 cm of soil should occur within 10 days after spraying.

DO NOT:

- use in seeding/tillage systems that cannot ensure accurate seed placement and adequate spatial separation of seed and herbicide;
- apply to soils prone to waterlogging, sodic soils or soils affected by physical compaction; or
- apply if heavy rains or storms that are likely to cause run-off are forecast within 2 days of application.

Accuracy of seed placement is critical in ensuring crop selectivity. Unacceptable crop injury (reduction in crop vigour and yield loss) may occur where inadequate spatial separation of seed and herbicide occurs or where heavy rainfall occurs during the early stages of crop establishment. Avoid soil throw into adjacent seeding rows or sites where furrow walls may collapse. Shallow sowing is not recommended due to the greater potential for movement of herbicide within close proximity of the emerging crop, especially in sandy soils. Application of Boxer Gold® to crops sown in soils of high leaching potential and those low in clay or organic matter may result in crop damage. Avoid double spraying (overlapping) of the crop with herbicide.

Sakura®

Apply pre-sowing and incorporate by sowing (IBS) using knife points and presswheels, or narrow points and harrows. For best results apply just before sowing. Avoid throwing treated soil into adjacent crop rows when sowing with knife points and press-wheels

DO NOT APPLY:

- if heavy rain has been forecast within 48 hours;
- unless incorporation by sowing (IBS) can be performed within 3 days of application; or
- to waterlogged soil.

Other factors that may adversely affect weed control include: uneven application, application to ridged or cloddy soil, stubble, plant residue or other groundcover, particularly where this exceeds 50%.

Terbyne® Xtreme®

Use the lower rate on light soils (sandy loams to loamy sands) and the higher rate on heavier soils (loams, silt plus clay 40–60%). The soil should be free of excessive clods, trash and deep furrows. Sufficient rainfall (20–30 mm) to wet the soil through the weed root zone is necessary within 2–3 weeks of application. Ensure lupin seed is covered with at least 3 cm and preferably 5 cm of soil.

DO NOT APPLY:

- if heavy rains or storms that are likely to cause surface run-off are forecast within 2 days of application;
- to waterlogged soil; or
- at rates higher than 0.86 kg/ha on soils with pH 8.0 and above as unacceptable crop damage may occur.

NOTE: Some early crop phytotoxicity may be observed particularly on light soils. Heavy, intense rainfall following application may cause crop damage. At the higher rates, avoid overlapping sprays and spraying-out corners.





Outlook®

Outlook[®] only controls annual ryegrass in low weed populations only (<100 plants/m²). Use in higher weed populations will only yield suppression. Apply as late as possible before sowing and sow with a knife-point and press-wheel seeder before weeds germinate.

Weeds that have emerged or that emerge soon after application are unlikely to be controlled. A post-emergent herbicide to control annual ryegrass may be needed to control escapes and late germinations.

Ensure that soil throw during seeding is not into adjacent furrows. Apply to moist soil if possible. If applied to dry soil, rain must follow within 7 days for best results.

DO NOT APPLY:

- if heavy rain is expected within 48 hours; or
- to areas that may be prone to waterlogging.

7.7.4 Post-emergent herbicides

There are more post-emergent herbicide options for field pea than for other pulses.²⁸

Selective post-emergent herbicides give high levels of control (often >98%) when applied under recommended conditions on susceptible populations. When used early in crop development the yield benefit provides significant economic returns.

Application of post-emergent herbicides to stressed crops and weeds can result in reduced levels of weed control and increased crop damage.

Stress from waterlogging, frost or dry conditions can result in greater crop damage from the herbicide because crops cannot produce sufficient levels of the enzymes that normally break down the herbicide.²⁹

See NSW DPI Weed Control in Winter Crops 2017 guide, pages 96-97 (early postemergence herbicides for field peas, Table 34) (<u>http://www.dpi.nsw.gov.au/agriculture/</u> <u>broadacre-crops/guides/publications/weed-control-winter-crops</u>).

Know your nodes

Counting the number of nodes on the main stem of field pea is the key to safely applying herbicides (<u>Table 16</u>). It is the system researchers around the world use when testing new herbicides and the system most labels use.

Individual field pea plants will have a dominant main stem and several basal branches, with the main stem simply being the longest one you can find. All references to node number on labels and so on refer to the number of nodes on the main stem.



²⁸ Pulse Australia (2010) Northern Region Field Pea Management Guide. Pulse Australia, <u>https://sydney.edu.au/agriculture/documents/pbi/pbi_region_north_field_pea_management_guide.pdf</u>

²⁹ GRDC (2014) Integrated Weed Management Hub. GRDC, <u>https://grdc.com.au/resources-and-publications/iwmhub</u>





Table 16: Post-emergent herbicides and field pea crop stage.

Herbicide	Crop stage (as per herbicide label)
Grass herbicides	From 2nd node
Metribuzin	3rd node
Imazamox	Do not apply beyond the 4th-node stage
Diflufenican	After 3rd node and before flowering
Flumetsulam	2nd node to 6th node, no later than 6 weeks after emergence
Cyanazine	Between 3rd node and 5th node stage
MCPA Na	6th node to 8th node, 10–15 cm tall. Do not apply if flowering has begun*
Paraquat	No specific crop guide on label. In practice, when 75% of the crop has brown pods
Diquat	As soon as crop has reached full maturity
Glyphosate	At or after crop maturity. When average seed moisture content is below 30%

* Varieties grown in Western Australia are unlikely to be at 6th to 8th node when flowering.

Source: M. Seymour (2016). A visual guide to key stages in the growth and maturity of field pea. https://agric.wa.gov.au/n/369

7.7.5 Weed control in wide-row cropping

With the shift to cropping pulses on wider rows, weed management tactics may include;

- inter-row tillage;
- shielded spraying; and
- band spraying.

In this system weeds can be given more time to become more established between the rows with greater scope for the use of inter-row, spraying.³⁰ This can also be combined with banding of fertiliser to favour the crop over the weed.

Shielded sprayers

Shielded sprayers are becoming increasingly common in or around the cottongrowing areas as they provide very cheap grass and broadleaf weed control with glyphosate, but the label does not list use for field pea.³¹

Some disadvantages of shielded spraying are the potential to damage crop plants, particularly the lower branches, and the ability of weeds within the row to escape control and set seed.³²

7.7.6 Crop-topping

Desiccation and crop-topping are well established techniques to improve the rotational fit, benefits and profitability of the pulse crop. While they are essentially the same physical operation of applying a desiccant herbicide close to final maturity of the pulse, they do achieve different objectives and must be applied with care.

Crop-topping aims to stop the seedset of survival weeds without substantially affecting crop yield and grain quality. Crop-topping is timed for the weed growth stage to control weed seedset from survivors of normal in-crop weed control. Crop–



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³⁰ GRDC (2014) Integrated Weed Management Hub. GRDC, https://grdc.com.au/resources-and-publications/iwmhub

³¹ Pulse Australia (2016) Draft Southern/western field pea best management practices training course, module 5-2016. Pulse Australia Limited

³² S Kleemann, G Gill (2012) Herbicide Application Strategies for the Control of Rigid Ryegrass (Lolium rigidum) in Wide-Row Faba Bean (Vicia faba) in Southern Australia. Weed Technology 26, 284-288



MORE INFORMATION

B Haskins (2012) Using pre-emergent

systems. NSW Department of Primary

herbicides in conservation farming

http://www.dpi.nsw.gov.au/__data/

Using-pre-emergent-herbicides-in-

conservation-farming-systems.pdf

assets/pdf_file/0003/431247/

Industries,



topping cannot be used in all pulses, but is effective in early-maturing species like field pea with very low risk of damage to grain quality from the herbicide application.

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The ideal timing for crop-topping occurs when the field pea seeds have reached 30% moisture, or when the lower 75% of pods are brown with firm seeds and leathery pods.

Note: Field pea destined for seed or the sprouting market should not be desiccated or crop-topped using glyphosate. Germination percentage of normal seedlings is affected by glyphosate.

Crop-topping and desiccation should be used as part of an integrated weed management strategy with techniques such as seed capture at harvest to maximise the effectiveness.33

Desiccation

Desiccation is the application of a non-selective herbicide to the crop to dry off green growth to reduce the time to harvest and improve efficiency of harvesting. It may or may not control weed seedset depending on the weed growth stage at application.

Further information is available in Section 10 Pre-harvest treatments.

7.8 Herbicide residues

Herbicides applied to paddocks in previous years may not have broken down adequately due to insufficient rainfall. Summer rainfall is not necessarily as effective as growing-season rainfall in breaking down herbicide residues, so it needs to be substantial and to keep the soil wet for long enough. This detail is on the herbicide label. You will need to know the chemical type used, as well as the plant-back periods, and the soil pH, rainfall and other requirements for breakdown. Herbicides applied 2 years ago could still have an impact too, as could the presence of cereal stubble with herbicides like Lontrel® (clorpyralid).

Pulse types differ in their sensitivity to residual herbicides. While the largest selection of in-crop herbicides is available for use in field pea, out of all the pulse crops, it is still important to check each herbicide and its plant-back requirements prior to use.³⁴

Group B:

- Lentil, faba bean, broad bean and chickpea are most vulnerable to sulfonylurea residues (e.g. Lusta®, Logran®), while field pea is the least vulnerable. Residues persist longer in high pH soil.
- At low pH (<6.5) faba and broad bean are more sensitive to Monza® residues (sulfonylurea) than chickpea, lentil, lupin or field pea. All are sensitive at higher pH (>6.5).
- Faba bean, broad bean, lentil and lupin are more sensitive to sulfonamide residues (e.g. Broadstrike®), particularly on shallow duplex soils where breakdown is slower.
- Chickpea, field pea, faba bean and broad bean are least sensitive to the imidazolinones (IMIs e.g. Spinnaker®, Raptor®, Midas®). Lentil is extremely sensitive unless it is an 'XT' variety with herbicide tolerance. Lupin and vetch are intermediate.
- Raptor® (IMI) has no minimum re-cropping interval if field pea is being sown.
- Lentil cannot immediately follow after bean or field pea if IMIs (e.g. Spinnaker® or Raptor®) or sulfonamides (e.g. Broadstrike®) were used.



Pulse Australia (2016) Pulses: Desiccation and croptopping. Pulse Australia, http://pulseaus.com.au/growing-pulses/publications/ d-croptopping

³⁴ Pulse Australia (2016) Field Pea: Residual herbicides and weed control. Australian Pulse bulletin, http://www.pulseaus.com.au/growingons/residual-herbicides



Group I:

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- All pulses are vulnerable to pyridine residues (e.g. clopyralid/Lontrel®). Lontrel® is more likely to persist in stubble-retention systems.
- Spikes (i.e. dicamba) added to knockdown sprays may persist under dry conditions and can reduce pulse crop establishment. Dicamba plant-backs require 15 mm of rain. Faba bean and lentil are not listed on label.
- Picloram (e.g. Grazon Extra®) applied to previous summer fallows is more likely to persist and damage crops under dry conditions.

Group C:

 Triazine herbicides (e.g. cyanazine, terbuthylazine) applied in-crop can potentially cause crop damage in some circumstances.^{35 36}

7.8.1 Plant-back intervals

Plant-back periods are the obligatory times between the herbicide spraying date and safe planting date of a subsequent crop.

Some herbicides have a long residual. The residual is not the same as the half-life. Although the amount of chemical in the soil may break down rapidly to half the original amount, what remains can persist for long periods (e.g. sulfonylureas (chlorsulfuron)). This is shown in <u>Table 18</u> and <u>Table 19</u> where known. Herbicides with long residuals can affect subsequent crops, especially if they are effective at low levels of active ingredient, such as the sulfonylureas. On labels, this will be shown by plant-back periods, which are usually listed under a separate plant-back heading or under the 'Protection of crops etc' heading in the 'General instructions' section of the label.

Part of the management of herbicide resistance includes rotation of herbicide groups. Paddock history should be considered. Herbicide residues (e.g. sulfonylurea, triazines etc) may be an issue in some paddocks. Remember that plant-back periods begin after rainfall occurs.³⁷



³⁵ P Matthews, D McCaffery, L Jenkins (2017) Winter crop variety sowing guide 2017, NSW DPI Management Guide. NSW Department of Primary Industries, <u>https://www.dpi.nsw.gov.au/about-us/media-centre/releases/2017/2017-winter-crop-variety-sowing-guide-nowavailable</u>

Pulse Australia (2016) Field Pea: Residual herbicides and weed control. Australian Pulse bulletin

³⁷ B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf</u>







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Table 17: Residual persistence of common pre-emergent herbicides and noted

 residual persistence in broadacre trials and paddock experiences.

Herbicide	Half-life (days)	Residual persistence and prolonged weed control
Logran® (triasulfuron)	19	High. Persists longer in high pH soils. Weed control commonly drops off within 6 weeks.
Glean® (chlorsulfuron)	28–42	High. Persists longer in high pH soils. Weed control longer than Logran®.
diuron	90 (range: 1 month to 1 year, depending on rate)	High. Weed control will drop off within 6 weeks, depending on rate. Has had observed long-lasting activity on grass weeds such as black/stink grass (<i>Eragrostis</i> spp.) and to a lesser extent broadleaf weeds like fleabane.
atrazine	60–100, up to 1 year if dry	High. Has had observed long-lasting (>3 months) activity on broadleaf weeds such as fleabane.
simazine	60 (range 28–149)	Med/high. 1 year residual in high pH soils. Has had observed long-lasting (>3 months) activity on broadleaf weeds such as fleabane.
Terbyne® (terbulthylazine)	6.5–139	High. Has had observed long lasting (>6 months) activity on broadleaf weeds such as fleabane and sow thistle.
Triflur® X (trifluralin)	57–126	High. 6—8 months residual. Higher rates longer. Has had observed long-lasting activity on grass weeds such as black/stink grass (<i>Eragrostis</i> spp.).
Stomp® (pendimethalin)	40	Medium. 3–4 months residual.
Avadex® Xtra (triallate)	56–77	Medium. 3–4 months residual.
Balance® (isoxaflutole)	1.3 (metabolite 11.5)	High. Reactivates after each rainfall event. Has had observed long-lasting (>6 months) activity on broadleaf weeds such as fleabane and sow thistle.
Boxer Gold® (prosulfocarb)	12-49	Medium. Typically quicker to break down than trifluralin, but tends to reactivate after each rainfall event.
Sakura® (pyroxasulfone)	10–35	High. Typically quicker breakdown than trifluralin and Boxer Gold®, however weed control persists longer than Boxer Gold®.

Source: B Haskins (2012) Using pre-emergent herbicides in conservation farming systems. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/_data/assets/pdf_file/0003/431247/Using-pre-emergent-herbicides-in-conservation-farming-systems.pdf







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Table 18: Minimum re-cropping intervals and guidelines. (NOTE: always read labels to confirm.)

Group and type	Product	pH (H ₂ O) or product rate (ml/ha) as applicable	Minimum re-cropping interval (months after application), and conditions
B, sulfonylurea (SU)	Chlorsulfurons	<6.5	3 months
	e.g. Glean [®] , Seige [®] , Tackle [®]	6.6–7.5	3 months, minimum 700 mm
		7.6–8.5	18 months, minimum 700 mm
B, sulfonylurea (SU)	Triasulfuron, e.g. Logran®, Nugrain®	7.6–8.5	12 months, >250 mm grain, 300 mm hay
		>8.6	12 months, >250 mm grain, 300 mm hay
B, Sulphonamide	Flumetsulam e.g. Broadstrike®		0 months
B, sulfonylurea (SU)	Metsulfuron	5.6–8.5	1.5 months
	e.g. Any [®] , Associate®	>8.5	Tolerance of crops grown through to maturity should be determined (small scale) previous season before sowing larger area.
B, sulfonylurea (SU)	Metsulfuron + thifensulfuron	7.8–8.5 organic matter >1.7%	3 months
	E.g. Harmony [∞] M	>8.6 or organic matter <1.7%	Tolerance of crops grown through to maturity should be determined (small scale) previous season before sowing larger area.
B, sulfonylurea (SU)	Sulfosulfuron	<6.5	0 months
	e.g. wonza∞	6.5–8.5	10 months

Source: GRDC (2017) GrowNotes –Chickpea, southern, draft Chapter 6, p 51, <u>https://grdc.com.au/resources-and-publications/grownotes</u>

7.8.2 Rotational crop plant-back intervals for southern Australia

Where areas have received limited rain during the spring and summer months, there is potential for herbicide residues to still be present in the soil when sowing commences in autumn, unless there are mild temperatures and adequate moisture at least a month or more before sowing (<u>Table 19</u>).

Conditions required for breakdown

Warm, moist soils are required to break down most herbicides through the processes of microbial activity. For the soil microbes to be most active, they need good moisture and an optimum soil temperature range of 18°C–30°C. Extreme temperatures above or below this range can adversely affect soil microbial activity and slow herbicide breakdown. Very dry soil also reduces breakdown. To make matters worse, where the soil profile is very dry it requires a lot of rain to maintain topsoil moisture for the microbes to be active for any length of time.

Risks

In those areas that do not experience conditions which will allow breakdown of residues until just prior to sowing, it is best to avoid planting a crop that is sensitive to the residues potentially present in the paddock, and opt for a crop that will not be affected by the suspected residues. In most cases, cereals or canola would be better options as these crops are comparatively less affected by herbicide residues. If dry areas do get rain and the temperatures become milder, then they are likely to need substantial rain (more than the label requirement) to wet the subsoil, so the topsoil can remain moist for a week or more. This allows the microbes to be active in the topsoil where most of the herbicide residues will be found. Sensitive crops include





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Table 19: Minimum re-cropping intervals and guidelines for common broadacre herbicides.

Product	Rate	Plant-back period	Wheat	Barley	Oats	Canola	Legume pasture	Pulse crops
2,4-D Ester 680*	0-510 ml/ha	(days)	1	1	1	14	7	7
	510—1,150 ml/ha		3	3	3	21	7	14
	1,150—1,590 ml/ha		7	7	7	28	10	21
Amicide Advance® 700*	0–500 ml/ha	(days)	1	1	1	14	7	7
	500–980 ml/ha		3	3	3	21	7	14
	980—1,500 ml/ha		7	7	7	28	10	21
Kamba® 500*	200 ml/ha	(days)	1	1	1	7	7	7
	280 ml/ha		7	7	7	10	14	14
	560 ml/ha		14	14	14	14	21	21
Hammer® 400 EC No residual effects								
Nail® 420 EC				No residual effects				
Goal®				No residual effects				
Striker®				No residual effects				
Sharpen®	26 g/ha	(weeks)	-	-	-	16	_	-
Lontrel®	300 ml/ha	(weeks)	1	1	1	1	36	36
Garlon [®] 600		(weeks)	1	1	NS	NS	NS	NS
Ally®**		(weeks)	2	6	36	36	36	36
Logran®#		(months)	-	-	-	12	12	12
Glean ^{®**}		(months)	-	9	6	12	12	12
Grazon® Extra/Grazon® DS		(months)	9	9	NS	9	24	24
Tordon [®] 75D, Tordon [®] 242		(months)	2	2	NS	4	9	6
Tordon [®] Fallow Boss		(months)	9	9	NS	12	20	20

* 15 mm rainfall required to commence plant-back period

Period may extend where soil pH is greater than 7 # Assumes 300 mm rainfall between chemical application and sowing NS Not specified

Source: GRDC (2017) GrowNotes™ – Chickpea, southern, draft Chapter 1, p 34, <u>https://grdc.com.au/resources-and-publications/grownotes</u>

7.9 Herbicide damage

The risk of herbicide damage needs to be weighed against potential yield losses from weed competition. In heavy weed infestations some herbicide crop damage can be tolerated as this is more than offset by the yield loss avoided by removing competing weeds.

If the herbicide is applied to dry soils, the risk of movement and crop damage is increased greatly after rainfall, particularly if the soil is left ridged and herbicide washes into the seed row. Incorporation by sowing (IBS) may be more appropriate in dry conditions, or, alternatively, a split application to minimise risk. Post-sowing



³⁸ Dow AgroSciences. Rotational crop plant-back intervals for southern Australia. <u>http://msdssearch.dow.com/PublishedLiteratureDAS/</u> dh_0931/0901b80380931d5a.pdf?filepath=au&fromPage=GetDoc





pre-emergent (PSPE) herbicides should be applied to moist soil regardless of the sowing time.

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Herbicides move more readily in soils with low organic matter and more sand, silt or gravel. Herbicide movement is much less in soils with higher organic matter and higher clay contents. Damage from leaching is also greater where herbicides are applied to dry, cloddy soils than to soils which have been left level and which are moist from recent rainfall.39

Herbicide damage can result from:

- residues in the soil;
- drift from outside the crop;
- pre and post-emergent herbicides applied to the crop; and
- spray tank contamination.

Damage from pre and post-emergent herbicides can be minimised by careful application and by understanding the tolerance of field pea varieties.

Plants weakened by herbicide injury are more susceptible to diseases. The most common problems come from residual herbicides applied to previous cereal crops.⁴⁰ There are also cases where herbicides (such as metribuzin) used in field pea can increase disease severity.

Table 20: The relative leaching potential of some soil-active herbicides (1 indicates the least leaching).

Chemical	Example of product	Leaching index
pendimethalin	Stomp®	1
trifluralin	Treflan®	1
diuron	Diuron	2
prometryn	Prometryn	3-4
simazine	Simazine	5
s-metalochlor	Dual Gold®	6
terbuthylazine	Terbyne®	8*
atrazine	Atrazine	10
metribuzin	Sencor®	14

* Estimated

Source: J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry: Chapter 5 – Weed control. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook

Metribuzin leaches at seven times the rate of diuron. The relative tolerance of the crop type and variety will also affect crop damage from these herbicides. For example, lupin is more tolerant of simazine than other pulses.

7.9.1 Symptoms of herbicide damage

Symptoms of crop injury from herbicides do not always mean a grain yield loss will occur. Recognition of crop injury symptoms allows the cause of the injury to be identified and possibly prevented in future crops. The type of injury depends on how the herbicide works in the plant, the site and seasonal conditions.

Herbicide injury may be very obvious (e.g. scorched leaves) or it may be more subtle (e.g. poor establishment or delayed maturity). Herbicide crop injury symptoms can easily be confused with symptoms produced by other causes, such as frost, disease or nutrition.



³⁹ Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 5-2016

⁴⁰ P Matthews, D McCaffery, L Jenkins (2017) Winter crop variety sowing guide 2017, NSW DPI Management Guide. NSW Department of Primary Industries, https://www.dpi.nsw.gov.au/about-us/ /2017/2017-winter-crop-variety-sowing-guide-nowavailable



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(i) MORE INFORMATION

Field crop herbicide injury: The Ute Guide <u>https://grdc.com.au/resources-</u> <u>and-publications/all-publications/</u> bookshop or as an app

App: Field Peas: The Ute Guide https://grdc.com.au/Resources/Apps

App: Herbicide Injury: The Ute Guide http://www.uteguides.net.au/ <u>UteGuides</u>



Care should be taken when using crop oils and penetrants with herbicides as these can increase the uptake of active chemicals and exceed crop tolerance. Always follow the herbicide label.⁴¹

For information on field pea variety response to herbicides see <u>Section 3.2.1</u> <u>Characteristics of field pea varieties for southern Australia</u>.

Group B – inhibitors of the enzyme ALS (e.g. chlorsolfuron, imazethapyr)

Sulfonlyureas, imidazoliones and sulfonamides are systemic herbicides that are used for pre and/or post-emergent for grass and/or broadleaf weed control in cereals and most are damaging to field pea. Damage can be caused by soil residue or spray contact. Imazamox and imazethapyr are exceptions and are used for post-emergent broadleaf weed control in pea.

Group B soil-residual-herbicide damaged plants germinate normally but become stunted with pale to yellow new leaves. Residual damage is more likely on alkaline (sulfonylureas) or acidic (IMIs) soils.

Affected plants develop brown necrotic spots on leaves and the plant slowly dies. Excessive new shoots form to compensate for growing point death. Root systems are severely stunted.



Photo 2: Stunted field pea with chlorotic new growth that becomes necrotic. Photo: DPIRD image <u>https://agric.wa.gov.au/n/4467</u>

Group C - inhibitors of photosynthesis (e.g. metribuzin)

Seedling emerges normally but tips and edges of older leaflets and tendrils become bleached, pale brown and shrivelled. These symptoms develop on successively younger leaves, as the plant becomes pale and stunted, until it recovers or dies.



⁴¹ GRDC (2015) Field pea Northern Region GrowNotes[™], <u>https://grdc.com.au/GrowNotes</u>







Photo 3: Metribuzin damage: typically scorched edges/ends of leaves and tendrils. Photo: DPIRD https://www.agric.wa.gov.au/mycrop/diagnosing-group-c-herbicide-damage-field-peas

Group D – inhibitors of cell division (e.g. trifluralin)

Group D herbicides can cause reduced plant numbers and delayed or poor seedling emergence. Stunted seedlings with thickened hypocotyl, stem and tendrils. Multiple hypocotyl shoots. Leaves are small, thickened and blotchy yellow-green.



Photo 4: Stunted seedling with thickened hypocotyl, stem and tendrils. Photo: DPIRD https://agric.wa.gov.au/n/4469



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Group F – inhibitors of carotenoid biosynthesis (e.g. diflufenican)

White/yellow spots/bands may develop within 3–4 days after application (2 days in bright sunny weather). Pea plants turn light green and whole leaves turn yellow to cream colour.



Photo: J Moore (2015) Diagnosing Group C herbicide damage in field peas. Department of Agriculture and Food, Western Australia, <u>https://agric.wa.gov.au/n/4468</u>

Group G – inhibitors of protoporphyrinogen (e.g. oxyflurfen)

Group G herbicide damage causes numerous white spots on the leaves from the droplets of herbicide contact within one or two days of application. It may lead to death in field pea, although grasses and cereals generally recover.⁴²









The plants rapidly develop distorted and twisted growth after spray contact, growing points are pale and distorted and may die. Slightly affected plants can gradually recover.⁴³

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Photo 6: Young growth twists rapidly after herbicide application. Photo: DPIRD <u>https://agric.wa.gov.au/n/4471</u>

Group J – inhibitors of fat synthesis (e.g. triallate)

Visual symptoms appear underground or as the crop emerges with reduced or poor seedling emergence. Shoots, if emerged, are often swollen and bright green. Roots are often pruned, leaving stubby root knobs.

Group K – inhibitors of cell division and very long chain fatty acids (e.g. metolachlor)

Visual symptoms appear as the crop emerges with reduced or poor seedling emergence. In most cases weeds do not appear. Seedlings are malformed and twisted, with transitory crop yellowing.

Group L – inhibitors of photosynthesis (photosystem I) (e.g. paraquat)

Visual symptoms appear within hours of application, with spots of dead tissue on otherwise healthy leaves. There may also be wilting and interveinal yellowing, followed by browning and blackening of the leaf edges.



⁴³ S Peltzer (2015) Diagnosing Group I herbicide damage in field peas. Department of Agriculture and Food, Western Australia, <u>https://agric.wa.gov.au/n/4471</u>



Group M – inhibitors of amino acid synthesis (e.g. glyphosate)

Glyphosate symptoms are most obvious at growing points within 5–7 days of application. Plants are stunted (growth stopped until recovery or death) with leaves turning yellow to red, followed by browning. There may be some twisting of plants. Plants look flaccid and tend to lie on the soil surface.⁴⁴



Photo 7: Group M (glyphosate) damage first signs: yellowing/reddening and sometimes interveinal chlorosis of new growth.

Photo: DPIRD https://agric.wa.gov.au/n/4466



Photo 8: Group *M* (glyphosate) damage: tendrils and leaves become wilted and necrotic and the plant dies.

Photo: DPIRD https://agric.wa.gov.au/n/4466









Herbicide resistance continues to develop and become more widespread. It is one of the biggest agronomic threats to the sustainability of our cropping systems.

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As of October 2017, 49 weed species in Australia have populations that are resistant to at least one herbicide mode-of-action (MOA). Australian weed populations have developed resistance to 12 distinct MOAs.

The International Survey of Herbicide-Resistant Weeds website lists herbicideresistant weeds by country, including the list of herbicide-resistant weeds in Australia (http://www.weedscience.org/Summary/Country.aspx?CountryID=1).⁴⁵

Resistance can be managed through good crop rotation, rotating herbicide groups, and by combining both chemical and non-chemical methods of weed control.

The WeedSmart App (<u>https://grdc.com.au/apps</u>) is a simple tool to assess the weed management for a specific paddock. By answering nine short questions about a paddock's farming system, the tool will assess herbicide resistance and weed seedbank risk. It is currently only available for iOS.



Figure 3: WeedSmart App

Source: https://grdc.com.au/apps

7.10.1 Glyphosate (Group M)

Continued reliance on glyphosate is leading to increased resistance. The potential inability to use glyphosate due to resistant weeds will increase the cost of weed management. Glyphosate-resistant weeds have a lower fitness and are more able to be controlled using IWM techniques. Controlling weeds using IWM is more costly, but has long-term benefits in delaying resistance development and reducing weed seedbanks.

Resistance mainly occurs in situations where glyphosate has been used as the main weed control tactic, no other effective herbicides are used, and few other weed management practices are employed. These include chemical fallows, fence lines, irrigation channels, vineyards and roadsides.⁴⁶

Glyphosate resistance was first identified in 1996 in Victoria and since then has been confirmed in another 15 weed species. Resistance is known in 9 grass species and 7 broadleaf species of which 5 are winter-growing weed species and 11 are either non-seasonal or summer-growing weed species. Please see the Australian glyphosate resistance register for the most up-to-date information (http://glyphosateresistance.org.au/register_summary.html).

Growers are encouraged to use paraquat for crop-topping in pulses rather than rely on glyphosate, which is frequently used for topping in other crops. However,



Watch GCTV video: Glyphosate Resistant Weeds, https://youtu.be/Ke8klYNQzl8





⁴⁵ GRDC (2014) Integrated Weed Management Hub. GRDC, <u>https://grdc.com.au/resources-and-publications/iwmhub</u>

⁴⁶ C Preston (2012) UA00104 - Understanding and management of weed resistance to glyphosate. GRDC Final report, <u>http://finalreports.grdc.com.au/UA00104</u>



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MORE INFORMATION

WeedSmart: www.weedsmart.org.au

Australian Herbicide Resistance

Initiative: www.ahri.uwa.edu.au

Working Group:

www.grdc.com.au

GRDC:

Australian Glyphosate Sustainability

http://glyphosateresistance.org.au



paraquat resistance is also increasing so weeds should be tested before planning a management strategy.⁴⁷

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7.10.2 Paraquat (Group L)

In 2014, paraquat-resistant weeds included capeweed, northern barley grass, barley grass, annual ryegrass, small square weed and silvergrass.⁴⁸

Ryegrass that is resistant to both glyphosate and paraquat has been found in South Australia.⁴⁹

7.10.3 Other herbicides

Annual ryegrass in Australia is now resistant to eight different herbicide groups. The major herbicides are Group A (>20,000 sites in Australia), Group B (>20,000 sites) and Group D (>5,000 sites).⁵⁰ Resistance to trifluralin (Group D) and the Dims (Group A) is increasing in southern Australia.⁵¹

Clethodim (Group A) resistance is a major issue in pulse production. Clethodim is the last Group A herbicide that provides effective control of Group A herbicide-resistant ryegrass.⁵²

In wild oats there is a high rate of resistance to all of Group A (Fops, Dims and Dens). $^{\rm 53}$

7.10.4 WeedSmart

WeedSmart's mantra has evolved to 'The Big 6' to help make winning the battle against crop weeds simple to follow and apply.

The WeedSmart plan is all about the grower – and not the weeds – calling the shots.

- 1. Rotate crops and pastures
- 2. Double knock to preserve glyphosate
- 3. Mix and rotate herbicides
- 4. Stop weed seed set
- 5. Crop competition
- 6. Harvest weed seed control the holgy grail.

Please see https://weedsmart.org.au/the-big-6 for further details

- 47 C Preston (2012) UA00104 Understanding and management of weed resistance to glyphosate. GRDC Final report, http://finalreports.grdc.com.au/UA00104
- 48 GRDC (2014) Integrated Weed Management Hub. GRDC, <u>https://grdc.com.au/resources-and-publications/iwmhub</u>
- 49 C Preston (2012) UA00104 Understanding and management of weed resistance to glyphosate. GRDC Final report, <u>http://finalreports.grdc.com.au/UA00104</u>
- 50 CropLife Australia (2017) Herbicide-resistant weeds. CropLife website, http://www.croplife.org.au/resistance-strategy/2017-herbicide-resistant-weeds-list
- 51 G Brooke, C McMaster (2016) Weed control in winter crops 2016. NSW Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/</u> content/agriculture/broadacre/guides/weed-control-winter-crops
- 52 C Preston, P Boutsalis, S Kleemann, R Saini and G Gill (2015) Managing resistant ryegrass in break crops and new herbicides for resistant ryegrass. GRDC Update Papers, 28 July 2015, <u>https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/07/Managing-resistant-ryegrass-in-break-crops-and-new-herbicides-for-resistant-ryegrass</u>
- 53 G Brooke, C McMaster (2016) Weed control in winter crops 2016. NSW Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/</u> content/agriculture/broadacre/guides/weed-control-winter-crops





FEEDBACK

(i) MORE INFORMATION

CropLife webpage: Herbicide mode of action table <u>http://www.croplife.org.au/resistance-</u> <u>strategy/2017-herbicide-moa-table/</u>

CropLife webpage: Herbicide resistant weeds in Australia <u>http://www.croplife.org.au/resistance-</u> <u>strategy/2016-herbicide-resistant-</u> <u>weeds-list/</u>

GRDC Fact Sheet: Herbicide resistance <u>https://grdc.com.au/</u> <u>Resources/Factsheets/2012/05/</u> <u>Herbicide-Resistance</u>

CropLife Booklet: Herbicide resistance management strategies <u>http://www.croplife.org.au/resistance-</u> <u>strategy/2017-herbicide-resistance-</u> management-strategies/

Webpage: Weedsmart The Big 6 https://weedsmart.org.au/the-big-6/

Website: Australian Glyphosate Sustainability Working Group <u>http://</u> www.glyphosateresistance.org.au/

App: WeedSmart to estimate paddock risk (iOS only) https://grdc.com.au/apps

AHRI decision-support tool: Ryegrass Integrated Management (RIM) <u>http://ahri.uwa.edu.au/research/rim/</u>

GRDC Updates: Herbicide resistance management, a local, in-field perspective <u>https://grdc.com.au/</u> <u>Research-and-Development/GRDC-</u> <u>Update-Papers/2015/07/Herbicide-</u> <u>resistance-management-a-local-</u> <u>infield-perspective</u>



7.10.5 Annual ryegrass

Annual ryegrass has higher levels of resistance than any other weed. Preventing ryegrass from setting seed and removing weed seeds at harvest before they fall to the ground is the top priority. Aim for 3 years with no weed seedset.⁵⁴

Techniques to manage resistant ryegrass include:

- Know your resistance status. What herbicides is the ryegrass resistant to?
- Use crop rotation to access different treatment options.
- Avoid cultivation that will bury ryegrass seed. Seed on the soil surface is more likely to be burnt, rot naturally or be controlled by pre-emergent herbicide. Cultivation is more suited to large mature weeds in fallow.
- Use double knockdowns before sowing.
- Consider crop-topping even if yield will be reduced.
- Consider green or brown manuring or cutting for hay.
- Capture and destroy weed seeds at harvest.
- Control ryegrass in non-crop areas such as fence lines, channel banks.⁵⁵

Ryegrass Integrated Management (RIM) (<u>http://ahri.uwa.edu.au/research/rim/</u>) is a decision-support tool to evaluate the long-term profitability of strategic and tactical ryegrass control methods. It allows growers to test ideas to reduce ryegrass populations while improving profitability.

7.10.6 Herbicide-resistance testing

There are two types of commercial tests for herbicide resistance:

Seed testing is suitable for pre- and post-emergent herbicides and takes 4–5 months. This requires 3,000 seeds of each weed, which is approximately 1 cup of annual ryegrass seed or 6 cups of wild radish pods. The **quick-test** for post-emergent herbicides only uses live plant seedlings and results are available within 6 weeks. This requires 50 plants (or 20 large tillering plants) for each herbicide tested.

There are two testing services in the southern region:

Plant Science Consulting offers both seed testing and the quick-test.

22 Linley Avenue, Prospect, SA 5082. Ph: 0400 66 44 60 Email: <u>info@plantscienceconsulting.com.au</u> <u>http://www.plantscienceconsulting.com.au/</u>

Charles Sturt University offers the seed test only.

Herbicide Resistance Testing, School of Agricultural and Wine Sciences, Charles Sturt University, Locked Bag 588, Wagga Wagga, NSW, 2678. Ph: John Broster 02 6933 4001 or 0427 296 641 Email: <u>jbroster@csu.edu.au</u> <u>https://www.csu.edu.au/weedresearchgroup/herbicide-resistance</u>

55 GRDC (2012) Herbicide resistance Fact Sheet, Southern Region, GRDC, May 2012, <u>https://grdc.com.au/Resources/Factsheets/2012/05/</u> Herbicide-Resistance



⁵⁴ L Pearce (2015) Herbicide-resistance management: a local, in-field perspective. GRDC Update Papers, 30 July 2015, <u>https://grdc.com,</u> au/Research-and-Development/GRDC-Update-Papers/2015/07/Herbicide-resistance-management-a-local-infield-perspective



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7.11 Spraying Issues

Watch Spray Application Workshop https://youtu.be/UskthCWjeug

7.11.1 Water quality for herbicide application

Good quality water is important when mixing and spraying herbicides. It should be clean and of a good irrigation quality. Poor quality water can reduce the effectiveness of some herbicides and damage spray equipment (Table 21).

Table 21: Herbicide tolerance to water qualities.

Hebicide	Water quality					
	Muddy	Saline	Hard	Alkaline (pH>8)	Acidic (pH<5)	
2,4-DB			Х	NR		
2,4-D or MCPA amine	1	1	Х	NR		
2,4-D or MCPA ester	1	test	test	1	1	
Associate®	1	1	1	Marginal	Х	
Brodal®		1	1	Х		
Dicamba	1	1	NR	NR		
Diuron	1	test	1	1		
Diuron + 2,4-D amine	1	test	Х	NR		
Diuron + MCPA amine	1	test	Х	NR		
Fusilade [®] Forte	1	1	1	NR	Х	
Tackle®	1	1	1	marginal	Х	
Glyphosate	Х	1	Х		1	
Gramoxone®	Х	1	1	1	1	
Logran®B-Power	1	1	1	marginal	Х	
Lontrel [™] Advanced	1	1	Х	Х		
Simazine	1	Х	1	NR		
Spray.Seed®	Х	1	1	1	1	
Elantra® Xtreme®	1	1	1	1	1	
Tigrex®	1	Х	Х	NR		
Trifluralin		1	1	1	1	
Verdict™	1	1	1	NR	1	

 $\sqrt{-}$ OK X = Do not use NR = Not recommended but use quickly if there is no alternative test = Mix herbicides and water in proportion and observe any instability marginal = Not ideal, but acceptable.

Source: Weed control in winter crops 2017, (2017), NSW Department of Primary Industries, <u>http://www.dpi.nsw.gov.au/content/agriculture/</u> broadacre/guides/weed-control-winter-crops







(i) MORE INFORMATION

Weather essentials for pesticide application, <u>https://grdc.com.au/GRDC-Booklet-</u> WeatherEssentials

Spray application manual for grain growers GrowNotesTM, Module 4, 'Drift management strategies: minimising and managing spray drift risk', <u>https://grdc.com.au/resourcesand-publications/grownotes/ technical/spray-application-manual</u>



7.11.2 Spray drift

All pesticides are capable of drifting from neighbouring paddocks. Pulses are particularly vulnerable to damage from volatile phenoxy ester herbicides (Group I) that are more prone to drift as a vapour during or after application.⁵⁶

7.11.3 Spray tank contamination

Traces of sulfonylurea herbicides (Group B, e.g. chlorsulfuron, metsulfuron or triasulfuron) and carfentrazone (Group G, e.g. Affinity®) in spray equipment can cause severe damage to pulses when activated by grass-control herbicides.

It is vitally important to properly clean and decontaminate spray equipment before applying herbicides. See product labels for specific product recommendations on decontamination.⁵⁷

7.12 Selective sprayer technology

As a result of an increase in the use of no-till cropping and the incidence of summer weeds many growers have adopted a spray fallow system that predominantly uses glyphosate over summer to remove weeds and conserve moisture for the next crop.

To reduce the risk of glyphosate resistance developing in fallow weeds some growers are using weed-detecting technology to detect individual weeds that have survived the glyphosate application and spraying these with an alternative knockdown herbicide.

The key to successful resistance management is killing the last few individuals, but this becomes rather difficult on large-scale properties. Left uncontrolled, these last few weeds result in significant seed production and a resetting of the weed seedbank. The introduction of weed-detecting technology is timely as it is well suited to detecting patches of weeds across large areas.

The technology uses optical sensors to turn on spray nozzles only when green weeds are detected, greatly reducing total herbicide use per hectare. The units have their own light source so can be used day or night.

Rather than spraying a blanket amount of herbicide across a paddock, the weeddetecting technology enables the user to apply higher herbicide rates (per plant), which results in more effective weed control as well as saving on herbicide costs.



Photo 9: Selective sprayer technology uses optical sensors to turn on spray nozzles only when green weeds are detected.

Photo: McIntosh Distribution (2016) http://www.mcintoshdistribution.com.au/machinery/show/weedseeker-australia



⁵⁶ Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 5-2016

⁵⁷ Pulse Australia (2016) Southern Faba & Broad Bean – Best Management Practices Training Course, module 5-2016







Weed-detecting technology (via WeedSeeker®) is being used to manage glyphosateresistant grasses in fallows with the aid of a minor use permit (MUP). This allows growers to use selective grass herbicides and higher rates of paraquat and diquat (bipyridyl herbicides, Group L). The permit (PER11163) (<u>http://permits.apvma.gov.au/</u> <u>PER11163.PDF</u>) is in force until 28 February 2019 and is for all Australian states.

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This permit allows the use of about 30 different herbicides from groups with seven modes of action. Additional modes of action are likely to be added to the permit over time.

Some herbicide rates have been increased to enable control of larger or stressed weeds. For example, glyphosate (450 grams of glyphosate per litre) rates range from 3 to 4 L/ha (using a set water rate of 100 L/ha), which far exceeds the label blanket rates of 0.4–2.4 L/ha. Similar increases in rate have also been permitted for paraquat (e.g. Gramoxone®).

The WeedSeeker® permit system is a great help for zero- and minimum-tillage systems battling glyphosate-resistant weeds as it represents a more economical way to carry out a double knock and avoids the need to cultivate for weed seed burial. It also results in significant savings in chemical costs.

The new technology also has the potential to map troublesome weed patches so that these areas can be targeted with a pre-emergent herbicide before sowing.⁵⁸



⁵⁸ T Cook (2013) Selective spraying to cut costs. GRDC Ground Cover³⁹ Supplement, 6 May 2013, <u>https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104/Selective-spraying-to-cut-costs</u>