SOUTHERN
JUNE 2018

GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

LUPIN

SECTION 5

WEEDS AND HERBICIDES

OVERVIEW | HERBICIDE TYPES AND USE | MANAGING RESIDUAL HERBICIDE ISSUES | BROADLEAF WEED CONTROL IN LUPIN CROPS | GRASS WEED CONTROL IN LUPIN CROPS | CROP-TOPPING FOR WEED CONTROL | HARVEST WEED SEED CONTROL (HWSC) TACTICS | SUMMER WEED CONTROL | DECISION SUPPORT TOOLS

MORE INFORMATION

GRDC 'Integrated Weed Management Manual': www.grdc.com.au/IWMM

GRDC 'Integrated Weed Management Hub': www.grdc.com.au/Resources/IWMhub

GRDC Fact Sheet 'Stewardship for pre-harvest application of herbicides in winter crops': https://grdc.com.au/resources-and-publications/all-publications/factsheets/2017/11/preharvest-herbicide-use-fact-sheet

GRDC 'Grain Legume Handbook – Chapter 5 Weed Control': https://grdc.com.au/grainlegumehandbook

GRDC 'Fact Sheet – In-crop Herbicide Use': grdc.com.au/GRDC-FS-InCropHerbicideUse

GRDC 'Weed seedbank Destruction Video': https://www.youtube.com/watch?v=6nTo_n47TxE#t=12

GRDC 'Weed ID: The Ute Guide' App: https://grdc.com.au/apps

GRDC 'Ground Cover Supplement – Herbicide Resistance': https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104

WeedSmart: www.weedsmart.org.au

WeedSmart App: https://grdc.com.au/apps

Pulse Australia 'Lupins Weed Management': http://www.pulseaus.com.au/growing-pulses/bmp/lupin#weed-management

HerbiGuide: http://www.herbiguide.com.au/

Australian Glyphosate Sustainability Working Group: http://www.glyphosateresistance.org.au/

Weeds and herbicides

5.1 Overview

When planting lupin crops in the southern region, best practice weed control involves an integrated weed management (IWM) plan.

This is particularly important for this crop, as lupin is known to be a poor competitor with weeds – especially early, before canopy closure.

The most widely accepted, efficient and cost effective methods of weed control in the southern region typically include the use of selective herbicides to remove grass weeds in broadleaf crops and broadleaf weeds in cereal crops.

An effective kill of grassy weeds in the pulse crop can also help reduce soil-borne root disease carry over and provide a break crop benefit to the following cereal crop.

Herbicides are available that can help control most grassy weeds in pulses and volunteer cereals can also be controlled with some of these products.

Simazine (Group C) alone and in mixtures with trifluralin (Group D) in lupin crops can be used to control or suppress some grasses that are not readily controlled by the specific grass herbicides.

In general, options for broadleaf weed control with selective herbicides in pulse crops are limited, compared to the treatments available for use in cereal crops.

Major weeds that impact on lupin production in South Australia, Victoria and New South Wales are:

- Annual ryegrass (*Lolium rigidum*)
- Wild oats (*Avena fatua L.*)
- Brome grass (*Bromus diandrus and B. rigidus*)
- Barley grass (*Hordeum*)
- Wild radish (*Raphanus raphanistrum L.*).

Other weeds impacting on lupin productivity in the southern region include:

- Capeweed (*Arctotheca calendula*)
- Silver grass (*Miscanthus sinensis*)
- Wild mustard (*Sisymbrium orientale*)
- Doublegee (*Emex australis*)
- Common sowthistle (*Sonchus oleraceus*).

If weed control is a priority, it is recommended lupin crops are sown after the break of season to obtain an effective weed knockdown. This ensures good soil moisture is available to activate soil herbicides, such as simazine.

Effective use of pre-emergence herbicides results in fewer weeds in the crop and this puts less pressure on post-emergent herbicide use.

FEEDBACK

MORE INFORMATION

Pulse Australia 'Residual Herbicides and Weed Control' hub: http://www.pulseaus.com.au/growing-pulses/publications/residual-herbicides

NSW Department of Primary Industries 'Weed control for winter crops 2016': www.dpi.nsw.gov.au/

GRDC Fact Sheet 'Stewardship for pre-harvest application of herbicides in winter crops': https://grdc.com.au/resources-and-publications/all-publications/factsheets/2017/11/preharvest-herbicide-use-fact-sheet

Agriculture Victoria 'Victorian winter crop summary': http://agriculture.vic.gov.au/agriculture/grains-and-other-crops/crop-production/growing-lupin

Agriculture Victoria 'Avoiding crop damage from residual herbicides': http://agriculture.vic.gov.au/agriculture/farm-management/chemical-use/agricultural-chemical-use/chemical-residues/managing-chemical-residues-in-crops-and-produce/avoiding-crop-damage-from-residual-herbicides

NVT online: www.nvtonline.com.au/

NVT Herbicide Tolerance information: http://www.nvtonline.com.au/wp-content/uploads/2013/03/Herbicide-Tolerance-WA-Lupin-1998-2006.pdf

5.2 Herbicide types and use

The two types of herbicides are residual and non-residual. Residual types 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 isoxaflutole, 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 characteristics. The persistence of herbicides will affect the enterprise crop rotation.

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

Herbicides are applied pre or post-emergent. Pre-emergent refers to application of the herbicide to the soil before weeds have emerged. Post-emergent refers to foliar application of the herbicide after the target weeds have emerged from the soil.

A list of herbicide modes of action can be found here https://www.croplife.org.au/resistance-strategy/2017-herbicide-mode-of-action-groups/

The Australian Pesticides and Veterinary Medicines Authority (APVMA) has a complete list of registered herbicide products and actives at https://apvma.gov.au/

5.3 Managing residual herbicide issues

Lupin crops can be affected by herbicide residues where rainfall has been insufficient in both summer and the previous growing season.

Lupin has particular sensitivity to Group B sulfonamide residues and, in high pH soils, some sulfosulfuron active residues can create problems.

Figure 1: *A lupin plant showing shrivelling from Group B herbicide damage (sulfonylurea).*

(SOURCE: Tony Cook)

FEEDBACK

All pulses, including lupin, are vulnerable to Group I phenoxy residues (such as 2,4-D amine and MCPA), particularly in sandy soils with low rates of microbial breakdown.

Clopyralid is another Group I active that has shown significant residual effects in lupin crops the following season after summer application in some areas of the southern region. The Group I chlorophenoxy herbicide Dicamba can be an issue if it is used in autumn prior to sowing lupin crops in some areas. Other Group I amicide formulations tend to result in more residual issues than ester formulations in some regions and situations.

There may also be residue issues arising from the use of some newer herbicide options, such as the Group K metolachlor-prosulfocarb combination, Group C terbuthylazine and Group K dimethenamid, as outlined below.

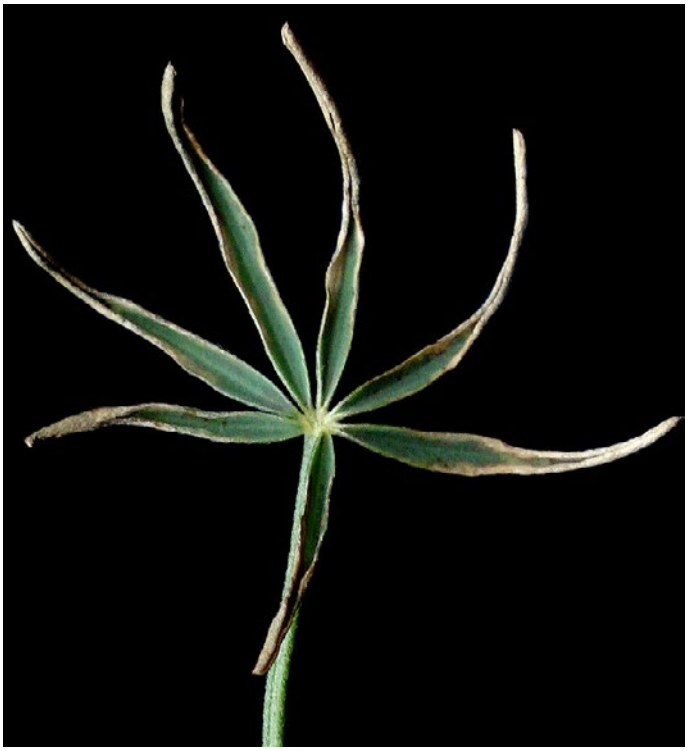

Figure 2: *Some Group C herbicides can cause damage to lupin plants, as shown here with necrotic leaf tips that are rolled and fold in a claw shape.*

(SOURCE: DPIRD)

For long-term, effective and sustainable weed control and herbicide efficacy, the key is to use a combination of herbicide, physical and cultural management tactics.

Newer narrow leafed lupin varieties, such as PBA Bateman$^{\Phi}$, PBA Jurien$^{\Phi}$, PBA Barlock$^{\Phi}$ and Mandelup$^{\Phi}$, have been shown to be higher yielding than older varieties under weed pressure and have better tolerance to some key herbicides, as illustrated in Table 1 (from data in NSW).

FEEDBACK

Table 1: Lupin variety herbicide tolerance, NSW.

The sensitivity of the variety compared to unsprayed controls of the same variety is summarised, using the following symbols based on the yield responses across all trials:

- N (narrow margin) significant yield reductions at higher than recommended rate in 1+ trials ONLY.
- x% yield reduction (warning) significant yield reduction at recommended rate in 1 trial only.
- x-y% yield reductions (warning) significant yield reductions at recommended rate in 2+ trials.
- – not tested or only tested at higher than recommended rate (Please check Preliminary Evaluation tables)
- ✓ no significant yield reductions at higher than recommended rates in (Z) trials

Always follow label recommendations. All pesticide applications must accord with the currently registered label forthat particular pesticide, crop, pest and region. Any research regarding pesticides or their use reported in this website does not constitute a recommendation for that particular use by the authors, the author's organisations or ACAS. It must be emphasised that crop tolerance and yield responses to herbicides are strongly influenced by seasonal conditions.

		Trifflur®480® IBS	Stomp® IBS	Terbyne® IBS	Boxer Gold® IBS	Simagranz 900g/litre	Brodal® Options 8-10 Leaf	Eclipse® 100SC	Eclipse® 6-10 leaf	Avadex®Xtra IBS	Status®	Sencor750® PSPE	Sniper® 2-6 Leaf	Sencor750® 6-10leaf	Terbyne® PSPE	Simagranz® 900 Cot-2leaf	Diflufenican + metribuzin	Gesatop + Gesaprim	Diuron®500 IBS	Eclipse® + Brodal® 2-6 leaf
Herbicide		Trifluralin	Pendimethalin	Terbyne	Boxer Gold	Simazine	Diflufenican	Metosulam	Metosulam	Triallate	Clethodim	Metribuzin	Picolinafen	Metribuzin	Terbyne	Simazine	Diflufenican + metribuzin	Simazine = Atrazine	Diuron	Metosulam + Diflufenican
Variety	**Years tested**	2000-2015	1997-2014	2010-2015	2008, 09,15	1998-2015	1996-2015	1996-2015	1996-2008	2002-2010	1999, 2013-2015	1997-2015	2000-2012	2004-2012	2010	2010	2003	2009	2009	2009
COROMUP	2008	✓ (1)	✓ (1)	-	-	N (1/1)	✓ (1)	N (1/1)	-	-	-	✓ (1)	✓ (1)	N (1/1)	-	-	-	-	-	-
GUNYIDI	2014	✓ (1)	✓ (1)	✓ (1)	-	✓ (1)	✓ (1)	✓ (1)	-	-	✓ (1)	✓ (1)	-	-	-	-	-	-	-	-
JENABILLUP	2010-2015	✓ (4)	✓ (3)	8 (1/3)	✓ (1)	✓ (4)	N (1/4)	12 (1/4)	-	-	10 (1/3)	✓ (4)	-	-	✓ (1)	-	N (1/1)	N (1/1)	-	-
JINDALEE	1997-2014	N (1/10)	N (1/10)	✓ (2)	-	N (2/11)	N (2/8)	13-15 (2/8)	N (1/6)	✓ (2)	N (1/2)	✓ (8)	N (1/4)	N (1/2)	✓ (1)	-	✓ (1)	7 (1/1)	-	-
KALYA	1998-1999	-	-	-	-	✓ (2)	11 (1/1)	N (1/2)	✓ (1)	-	✓ (1)	✓ (2)	-	-	-	-	-	-	-	-
KIEV MUTANT	1996-2008	✓ (8)	✓ (8)	-	-	N (5/9)	N (1/6)	✓ (7)	✓ (8)	✓ (2)	✓ (1)	N (2/6)	N (1/5)	N (2/3)	-	-	-	-	-	-
LUXOR	2004-2015	✓ (7)	✓ (7)	6 (1/4)	11 (1/3)	N (2/7)	✓ (7)	✓ (6)	✓ (1)	✓ (2)	✓ (3)	N (2/7)	✓ (3)	N (3/3)	12 (1/2)	N (1/1)	N (1/1)	N (1/1)	✓ (1)	8 (1/1)
MAGNA	1999	-	-	-	-	✓ (1)	-	✓ (1)	✓ (1)	-	✓ (1)	✓ (1)	-	-	-	-	-	-	-	-
MANDELUP	2001-2015	✓ (8)	✓ (8)	9 (1/4)	N (1/3)	N (2/8)	N (1/7)	13 (1/6)	N (1/2)	8 (1/3)	14 (1/3)	N (2/7)	N (2/4)	N (2/3)	N (1/2)	✓ (1)	N (1/1)	N (1/1)	✓ (1)	✓ (1)
MERRIT	1996-1999	-	✓ (1)	-	-	✓ (2)	✓ (3)	13 (1/4)	14 (1/3)	-	✓ (1)	✓ (2)	-	-	-	-	-	-	-	-
MOONAH	2000-2002	✓ (1)	-	-	-	N (1/1)	✓ (1)	N (1/1)	N (1/1)	-	-	✓ (1)	-	-	-	-	-	-	-	-
MYALLIE	1996-1999	-	-	-	-	✓ (2)	✓ (2)	N (2/3)	19 (1/2)	-	✓ (1)	✓ (2)	-	-	-	-	-	-	-	-
PBA BARLOCK	2013-2015	N (1/3)	✓ (2)	✓ (1)	✓ (1)	✓ (3)	✓ (3)	✓ (3)	-	-	✓ (3)	✓ (3)	-	-	✓ (1)	-	-	-	-	-
PBA GUNYIDI	2010-2015	✓ (3)	✓ (2)	✓ (1)	✓ (1)	✓ (3)	✓ (3)	✓ (3)	-	-	✓ (2)	✓ (3)	-	-	✓ (1)	-	✓ (1)	N (1/1)	-	-
PBA JURIEN	2014-2015	✓ (2)	N (1/1)	✓ (1)	✓ (1)	✓ (2)	N (1/2)	N (1/2)	-	-	12 (1/2)	19 (1/2)	-	-	-	-	-	-	-	-

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Herbicide		Trifluralin	Pendimethalin	Terbyne	Boxer Gold	Simazine	Diflufenican	Metosulam	Metosulam	Triallate	Clethodim	Metribuzin	Picolinafen	Metribuzin	Terbyne	Simazine	Diflufenican + metribuzin	Simazine = Atrazine	Diuron	Metosulam + Diflufenican
		Triflur®480® IBS	Stomp® IBS	Terbyne® IBS	Boxer Gold® IBS	Simagranz 900g/litre	Brodal® Options 8-10 Leaf	Eclipse® 100SC	Eclipse® 6-10 leaf	Avadex®Xtra IBS	Status®	Sencor750® PSPE	Sniper® 2-6 Leaf	Sencor750® 6-10leaf	Terbyne® PSPE	Simagranz® 900 Cot-2leaf	Diflufenican + metribuzin	Gesatop + Gesaprim	Diuron®500 IBS	Eclipse® + Brodal® 2-6 leaf
Variety	Years tested	2000-2015	1997-2014	2010-2015	2008, 09,15	1998-2015	1996-2015	1996-2015	1996-2008	2002-2010	1999, 2013-2015	1997-2015	2000-2012	2004-2012	2010	2010	2003	2009	2009	2009
QUILINOCK	2000-2005	✓ (7)	✓ (6)	-	-	N (1/7)	N (1/3)	✓ (3)	N (2/5)	✓ (2)	-	N (2/4)	N (1/4)	N (1/2)	-	-	-	-	-	-
ROSETTA	2004-2015	✓ (7)	✓ (7)	N (1/4)	✓ (3)	N (1/7)	✓ (7)	N (1/6)	✓ (1)	✓ (2)	✓ (3)	N (2/7)	✓ (3)	N (2/3)	N (1/2)	4 (1/1)	-	-	✓ (1)	✓ (1)
TANJIL	1998	-	-	-	-	✓ (1)	✓ (1)	N (1/1)	-	-	-	N (1/1)	-	-	-	-	-	-	-	-
WALAN2448	2014-2015	✓ (2)	✓ (1)	✓ (1)	✓ (1)	✓ (2)	✓ (2)	✓ (2)	-	-	10 (1/2)	✓ (2)	-	-	-	-	-	-	-	-
WALAN2474	2014	10 (1/1)	✓ (1)	✓ (1)	-	✓ (1)	✓ (1)	9 (1/1)	-	-	11 (1/1)	✓ (1)	-	-	-	-	-	-	-	-
WALAN2498	2015	✓ (1)	-	-	✓ (1)	✓ (1)	✓ (1)	✓ (1)	-	-	✓ (1)	✓ (1)	-	-	-	-	-	-	-	-
WK338	2014-2015	✓ (2)	✓ (1)	✓ (1)	✓ (1)	✓ (2)	✓ (2)	✓ (2)	-	-	✓ (2)	N (1/2)	-	-	-	-	-	-	-	-
WONGA	1996-2010	✓ (8)	✓ (9)	N (1,1)	14 (1,2)	N (2,10)	N (2,7)	8 (1,8)	14-24 (2,7)	✓ (4)	✓ (1)	N (2/7)	N (1/5)	N (2/3)	N (1/1)	✓ (1)	N (1/1)	N (1/1)	16 (1/1)	✓ (1)
Rates (product/ha)		1.7L	3.0L	1.4L	2.5L	1.66L	200ml	70ml	10g	1.6L	375ml	380g	50g	380g	1.0L	550g	100ml +150g	1.3kg +650g	2.0L	7g + 100ml
Crop stage at spraying		IBS	IBS	IBS	IBS	PSPE	8-10 leaf	2-6 leaf	6-10 leaf	IBS	4 leaf	PSPE	2-6 leaf	6-10 leaf	PSPE	Cot-2 leaf	PSPE	IBS	IBS	2-6 leaf

Herbicide		Metosulam	Simazine + Diflufenican	Simazine	Metribuzin + Diflufenican	Simazine + diflufenican	S-Metolachlo	S-Metolachlor	Clethodim + Haloxyfop	Simazine + Diflufenican	Simazine + Diflufenican	Simazine + Diflufenican	Metosulam	Metosulam	Quizalofop-P-ethyl	Metosulam + Diflufenican	Haloxyfop-R	Sethoxydim	Simazine + Atrazine	Simazine + Atrazine	Simazine + Atrazine	Sakura®850WG
		Eclipse® 2-6 leaf	Gesatop®900W + Brodal	Simazine 4-6 leaf	Sencor750® + Brodal	Simazine900 + Brodal® 4-6 leaf	Dual Gold® IBS	Dual Gold® PSPE	Motsa®	Simazine + Brodal® IBS	Simazine + Brodal® PSPE	Simazine + Brodal® 6-10 leaf	Eclipse® Mid-flowering	Eclipse® mid-podding	Targa®	Eclipse® + Brodal® 4-8 leaf	Verdict®520	Sertin®	Simazine + Atrazine IBS	Simazine + Atrazine PSPE	Simazine + Trifluralin IBS	Sakura®850WG IBS
Variety	Years tested	2009	2009	2004	2004	2005	2002-2004	2002	2004	1998	1997-2002	1996	2002-2003	2002-2003	2002	2001	1998-2001	1998-2000	1997-1998	1998-2000	1998	2012
COROMUP	2008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
GUNYIDI	2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JENABILLUP	2010-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓ (1)	-	-	-	N (1/1)
JINDALEE	1997-2014	-	-	✓ (1)	N (1/1)	N (1/1)	8 (1/1)	✓ (3)	✓ (1)	✓ (1)	✓ (2)	-	7 (1/2)	✓ (2)	✓ (1)	✓ (1)	✓ (3)	✓ (3)	✓ (2)	16 (1/2)	✓ (1)	-

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Herbicide		Eclipse® 2-6 leaf	Gesatop®900W + Brodal	Simazine 4-6 leaf	Sencor750® + Brodal	Simazine900 + Brodal® 4-6 leaf	Dual Gold® IBS	Dual Gold® PSPE	Motsa®	Simazine + Brodal® IBS	Simazine + Brodal® PSPE	Simazine + Brodal® 6-10 leaf	Eclipse® Mid-flowering	Eclipse® mid-podding	Targa®	Eclipse® + Brodal® 4-8 leaf	Verdict®520	Sertin®	Simazine + Atrazine IBS	Simazine + Atrazine PSPE	Simazine + Trifluralin IBS	Sakura®850WG IBS
		Metosulam	Simazine + Diflufenican	Simazine	Metribuzin + Diflufenican	Simazine + diflufenican	S-Metolachlo	S-Metolachlor	Clethodim + Haloxyfop	Simazine + Diflufenican	Simazine + Diflufenican	Simazine + Diflufenican	Metosulam	Metosulam	Quizalofop-P-ethyl	Metosulam + Diflufenican	Haloxyfop-R	Sethoxydim	Simazine + Atrazine	Simazine + Atrazine	Simazine + Atrazine	Sakura®850WG
Variety	Years tested	2009	2009	2004	2004	2005	2002-2004	2002	2004	1998	1997-2002	1996	2002-2003	2002-2003	2002	2001	1998-2001	1998-2000	1997-1998	1998-2000	1998	2012
KALYA	1998-1999	-	-	-	-	-	-	-	-	✓ (1)	✓ (1)	-	-	-	-	-	✓ (1)	✓ (1)	✓ (1)	15 (1/2)	✓ (1)	-
KIEV MUTANT	1996-2008	-	-	✓ (1)	11 (1/1)	N (1/1)	✓ (1)	✓ (3)	✓ (1)	-	✓ (3)	N (1/1)	N (1/2)	✓ (2)	✓ (1)	✓ (1)	✓ (2)	✓ (1)	✓ (1)	N (2/2)	-	-
LUXOR	2004-2015	✓ (1)	✓ (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓ (1)	-	-	-	6 (1/1)
MAGNA	1999	-	-	-	-	-	-	-	-	-	✓ (1)	-	-	-	-	-	-	-	-	N (1/1)	-	-
MANDELUP	2001-2015	N (1/1)	N (1/1)	-	-	-	✓ (1)	✓ (1)	-	-	-	-	8 (1/1)	✓ (1)	✓ (1)	-	-	✓ (1)	-	-	-	N (1/1)
MERRIT	1996-1999	-	-	-	-	-	-	-	-	✓ (1)	✓ (2)	18 (1/1)	-	-	-	-	✓ (1)	✓ (1)	N (1/2)	12 (1/2)	✓ (1)	-
MOONAH	2000-2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓ (1)	✓ (1)	-	✓ (1)	-	-
MYALLIE	1996-1999	-	-	-	-	-	-	-	-	✓ (1)	✓ (1)	N (1/1)	-	-	-	-	✓ (1)	✓ (1)	✓ (1)	N (1/2)	✓ (1)	-
PBA BARLOCK	2013-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PBA GUNYIDI	2010-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓ (1)	-	-	-	-
PBA JURIEN	2014-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
QUILINOCK	2000-2005	-	-	✓ (1)	14 (1/1)	N (1/1)	✓ (1)	✓ (3)	N (1/1)	-	✓ (1)	-	12 (1/2)	✓ (2)	✓ (1)	✓ (1)	✓ (2)	✓ (1)	-	✓ (2)	-	-
ROSETTA	2004-2015	✓ (1)	✓ (1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	✓ (1)	-	-	-	✓ (1)
TANJIL	1998	-	-	-	-	-	-	-	-	✓ (1)	-	-	-	-	-	-	✓ (1)	✓ (1)	✓ (1)	17 (1/1)	✓ (1)	-
WALAN2448	2014-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WALAN2474	2014	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WALAN2498	2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WK338	2014-2015	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WONGA	1996-2010	21 (1/1)	✓ (1)	✓ (1)	15 (1/1)	N (1/1)	✓ (1)	✓ (3)	✓ (1)	✓ (1)	✓ (3)	22 (1/1)	13 (1/2)	✓ (2)	N (1/1)	✓ (1)	✓ (3)	✓ (2)	✓ (2)	N (2/3)	✓ (1)	-
Rates (product/ha)		70ml	556g+ 150ml	1.5L	133g+ 100ml	1.0L+ 150ml	1.0L	1.0L	300ml	1.0L+ 75ml	1.0L+ 150ml	2.0L+ 200ml	7g	7g	375ml	5g+ 100ml	100ml	1.0L	2.0L+ 1.0L	2.0L+ 1.0L	1.5L+ 1.5L	118g
Crop stage at spraying		2-6 leaf	2-6 leaf	4-6 leaf	3-leaf	4-6 leaf	IBS	PSPE	6-8 leaf	IBS	PSPE	8-10 leaf	Mid flower	Mid pod	2-6 leaf	4-8 leaf	6-10 leaf	6 leaf	IBS	PSPE	IBS	IBS

(SOURCE: NVT Online)

FEEDBACK

5.3.1 Tips for managing newer herbicide options

It is recommended, if using the Group K and Group E metolachlor and prosulfocarb Boxer Gold® herbicide as a pre-emergent, to apply to soil surface up to seven days before sowing lupin crops and incorporate it mechanically through the seeding process.

Application should be into a moist seedbed and when the outlook is for sufficient rain to thoroughly wet the top 3-4 cm of soil within 10 days of application.

It is advised to use Boxer Gold®:

- In seeding systems that ensure accurate seed placement and adequate separation of seed and herbicide
- On soils not prone to waterlogging
- When there are no heavy rains likely to cause run-off forecast within two days of application.

It is advised to not use Boxer Gold® where:

- Seeding or tillage systems are used that cannot ensure accurate seed placement and adequate spatial separation of seed and herbicide
- Soils are prone to waterlogging, on sodic soils or soils affected by physical compaction
- Heavy rains or storms that are likely to cause run-off are forecast within two days of application.

Accuracy of seed placement is critical in ensuring crop selectivity. Unacceptable crop injury (such as reduction in crop vigour and yield loss) can potentially occur where there is inadequate spatial separation of seed and herbicide, 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 (over-lapping) of the crop with herbicide

More information about this herbicide can be found at: http://www.herbiguide.com.au/Descriptions/hg_Boxer_Gold.htm can https://www.syngenta.com.au/cereals/herbicides/boxer-gold

If using the Group K pyroxasulfone herbicide Sakura® 850 WG, it is best applied just before sowing and incorporated by the seeding process using knife points and press wheels (avoiding throwing treated soil into adjacent rows) or narrow points and harrows.

Note that Sakura® 850 WG can only be applied before sowing a lupin crop and lupin cannot be sown for nine months after this herbicide is used in situations such as a failed establishment of a wheat crop.

If using Sakura® 850 WG, it is advised to apply if:

- There is no heavy rain forecast within two days of application
- Incorporation with seeding can be achieved within three days of application
- Soil is not waterlogged.

It is advised not to use Sakura® where:

- Heavy rain has been forecast within 48 hours of application
- Incorporation by sowing (IBS) cannot be performed within three days of application
- There are waterlogged soils.

FEEDBACK

Other factors that may reduce weed control from Sakura® 850 WG include: uneven application; application to ridged or 'clodded' soils; high levels of stubble, plant residue or other ground cover; or if there is heavy rain on sandy soil types prone to leaching.

More information about Sakura® 850 WG is available at: https://www.crop.bayer.com.au/find-crop-solutions/by-product/herbicides/sakura-850-wg-herbicide

If considering the Group C herbicide terbuthylazine, apply to lupin as Terbyne® Xtreme® 875 WG. This is best used at the lower registered rate on lighter soils (such as sandy loams and loamy sands) and at higher registered rates on heavier soils (such as loams or silt-clay).

Best results will come from ensuring lupin seed is covered with 3-5 cm of soil at seeding and when there is sufficient rainfall (about 20-30 mm) within two or three weeks of application to wet the soil right through the weed root zone.

It is recommended to apply Terbyne® Xtreme®, if being considered for use in lupin crops, if there are no heavy rains forecast for two days, soils are not waterlogged and at rates less than 0.86 kilograms per hectare on soils with a pH of 8 or more. Some early crop phytotoxicity may be observed, particularly on light soils. Heavy, intense rainfall following application may cause crop damage. At the higher rates, it is advised to avoid overlapping sprays and spraying-out corners.

The Group K herbicide dimethenamid-P, applied to lupin as Outlook®, controls annual ryegrass in low populations of typically less than 100 plants per square metre. It will act to only suppress weeds in higher populations.

It is advised, if using, to apply this herbicide as late as possible before sowing and to use a knifepoint and press wheel system before weeds germinate. Weeds that are emerging, or emerge soon after application, are typically unlikely to be controlled, necessitating the use of a post-emergent knockdown.

It is recommended if using Outlook® to apply if soil is moist, or rain is forecast within seven days of application, but there is not likely to be heavy rain within two days of application. Areas prone to waterlogging are best avoided.

More information about this herbicide is available at: http://www.herbiguide.com.au/informationherbicides.aspx

FEEDBACK

MORE INFORMATION

GRDC Integrated weed management hub 'Common sowthistle': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/common-sowthistle

GRDC 'Update Paper – Common Sowthistle and Flaxleaf Fleabane – Understanding the Weed's Lifecycles for Management Strategies that Work': https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2009/09/COMMON-SOWTHISTLE-AND-FLAXLEAF-FLEABANE-UNDERSTANDING-THE-WEEDS-LIFECYCLES-FOR-MANAGEMENT-STRATEGIES-THAT-WORK

GRDC 'YouTube – Ecology and Management of Common Sowthistle': https://www.youtube.com/watch?v=I_5gm-ZhGE0

Seventeeth Australasian Weeds Conference 'Update Paper – Genetic Diversity among ALS-inhibiting Herbicide Resistant and Susceptibly Populations of *Sonchus oleraceus L.* (sowthistle) in Australia': http://caws.org.au/awc/2010/awc201012811.pdf

5.4 Broadleaf weed control in lupin crops

5.4.1 Sowthistle (*Sonchus oleraceus*)

Figure 3: *Sowthistle is a major broadleaf weed affecting lupin crop production in the southern region.*

(SOURCE: DPIRD)

- A major weed of fallow
- Uses vital stored soil moisture
- A prolific seed producer
- Difficult to control
- An alternate host for insects
- Populations in southern region resistant to Group B herbicides
- Four NSW populations resistant to glyphosate (Group M).[1]

1 GRDC (2016) Integrated Weed Management hub, weed profile 'Common sowthistle', https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/common-sowthistle

FEEDBACK

Management and control of sowthistle

Table 2: Tactics that should be considered when developing an integrated plan to manage common sowthistle.[2]

Common sowthistle (*Sonchus oleraceus*)		Most likely % control (range)	Comments on use
Agronomy	Improve crop competition	95 (75–99)	Increased competition results in lower weed pressure. Competition improves herbicide efficacy.
Tactic	Fallow and pre-sowing cultivation	80 (30-90)	Cultivation or full disturbance sowing buries seeds and prevents their germination.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	95 (75–99)	Better control is achieved when treating small weeds. A reduction in herbicide efficacy occurs when 2,4-D is tank-mixed with glyphosate due to antagonism within the plant.
Tactic	Selective post-emergent herbicides	95 (75–99)	Better control is achieved when treating small weeds.
Tactic	Spray-topping with selective herbicide	95 (75–95)	Seed reduction of escapes. Timing is critical to avoid crop damage.
Tactic	Grazing crop residues	95 (up to 100)	To control escapes in fallow before seedset. Common sowthistle is very palatable and is preferentially grazed.

Numerous populations of sowthistle across southern Australia are resistant to Group B herbicides, such as chlorsulfuron. Incidences now equal estimates of Group B resistance in the northern cropping region. This has rendered the weed a national problem in cropping and fallow situations.

Switching to alternative mode-of-action (MOA) herbicides is an effective management strategy. But the universal distribution of this species and widespread resistance to Group B herbicides is a future threat to cropping systems, according to researchers. Integrated use of cultural and chemical weed control methods can provide effective control of common sowthistle.[3]

Other management tactics to help control this weed in southern region lupin crops include:

- Apply herbicides to small, non-stressed and actively growing weeds
- Use a double-knock
- If glyphosate resistance is an issue, treat before the 10 centimetres diameter rosette stage with a Group I herbicide followed by paraquat.[4]

2 GRDC (2016) Integrated Weed Management hub, weed profile 'Common sowthistle', https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/common-sowthistle

3 GRDC (2009) Common sowthistle and flaxleaf fleabane – Understanding the weed's lifecycles for management strategies that work, GRDC, https://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2009/09/COMMON-SOWTHISTLE-AND-FLAXLEAF-FLEABANE-UNDERSTANDING-THE-WEEDS-LIFECYCLES-FOR-MANAGEMENT-STRATEGIES-THAT-WORK

4 GRDC (2016) Integrated Weed Management hub, weed profile 'Common sowthistle', https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/common-sowthistle

FEEDBACK

Sowthistle is commonly a problem in zero or reduced tillage systems and occurs in both fallow and cropped areas.

It can be found on most soil types, but favors soils with a high water-holding capacity.

This weed is a problem in many different production enterprises, including dryland and irrigated broadacre cereal production.

By including a range of management tactics as part of an IWM approach, the risk of resistance to glyphosate and other herbicide MOA will be reduced and management of already resistant populations will improve. This includes using a double-knock and strategic tillage.

The double-knock is a common tactic for the control of other weed species, including flaxleaf fleabane and awnless barnyard grass. It involves the sequential application of two different herbicides – where the second is applied to control survivors of the first.

It is advised that management strategies for common sowthistle should also take into account:

- Glyphosate resistance (confirmed in the northern region)
- Reported widespread Group B resistance
- Targets for 100 percent elimination of seed set, including on road verges and in channels
- An aim to maximise crop competition in the rotation.
- There are no post-emergent herbicide options.[5]

5 GRDC (2016) Integrated Weed Management hub, weed profile 'Common sowthistle', https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/common-sowthistle

FEEDBACK

MORE INFORMATION

GRDC 'Fact Sheet – Wild Radish': www.grdc.com.au/GRDC-FS-WildRadishManagement

GRDC Integrated weed management hub 'Wild radish': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/wild-radish

GRDC 'Herbicide Resistance Testing': www.grdc.com.au/Media-Centre/Media-News/South/2014/04/Herbicide-resistance-testing-autumn-2014

DPIRD 'Wild Radish': https://www.agric.wa.gov.au/grains-research-development/wild-radish

Weed Seed Wizard: https://www.agric.wa.gov.au/weed-seed-wizard-0

5.4.2 Wild radish (*Raphanus raphanistrum*)

Figure 4: *Wild radish affects lupin crop production in the southern region.*

(SOURCE: GRDC)

- One of the most widespread and competitive broadleaf weeds in Australia
- Can cause yield losses of 10-90 percent in lupin crops
- A prolific seeder with high seedbank dormancy
- Up to 70 percent of seeds still dormant in the next cropping season
- High resistance to some Group B and Group I herbicides (sulfonylureas, sulfonamides and phenoxy)
- Populations with resistance to some Group F and C herbicides
- Important to kill in-crop weeds while small
- Seeds become viable within three weeks of first flowers
- Retains seed pods at harvest height, making harvest weed seed control (HWSC) effective
- Long-term management requires driving seed numbers down to low levels
- Hand picking of resistant plants in-crop is being evaluated.[6,7]

6 DPIRD (2016) Wild Radish, https://www.agric.wa.gov.au/grains-research-development/wild-radish

7 GRDC (2014) Fact Sheet – Wild radish, www.grdc.com.au/GRDC-FS-WildRadishManagement

FEEDBACK

Management and control of wild radish

Table 3: Tactics that should be considered when developing an integrated plan to manage wild radish.[8]

Wild radish (*Raphanus raphanistrum*)		Most likely % control (range)	Comments on use
Agronomy	Herbicide tolerant crops	90 (80–99)	If growing canola in a wild radish infested area it is best to use a herbicide resistant variety and associated herbicide package.
Tactic	Burning residues	70 (20–90)	In concentrated windrows. Burn when conditions are conducive to a hot burn.
Tactic	Inversion ploughing	98 (20-100)	Plough must be correctly 'set up' and used under the right conditions. Must use skimmers.
Tactic	Autumn tickle	45 (15–65)	Follow-up rain is needed for better response.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	80 (70–90)	Add a reliable herbicide spike for more reliable control. Late germinations will not be controlled.
Tactic	Selective post-emergent herbicides	90 (70–99)	Apply to young and actively growing weeds. Repeat if necessary to control late emerging weeds or survivors.
Tactic	Spray-topping with selective herbicides	80 (70–95)	Wild radish may regrow if there are late rains. Good for seedset control. Spray before embryo development for best results.
Tactic	Wiper technology	70 (50–80)	Has potential in low growing pulses such as lentils
Tactic	Silage and hay – crops and pastures	80 (70–95)	Cut before embryo formation in developing wild radish seed (21 days after first flower). Graze or spray regrowth.
Tactic	Manuring, mulching and hay freezing	95 (90–100)	Brown manuring more efficient than green manuring and more profitable. Grazing before spraying to open sward will improve results. Hay freezing works well and is the most profitable manuring option in most cases.
Tactic	Grazing – actively managing weeds in pastures	70 (50–80)	Rotationally graze and use spray-grazing. Can also use slashing to improve palatability and reduce pasture growth rate in spring.
Tactic	Weed seed collection at harvest	75 (65–85)	Most reliable in early harvested paddocks
Tactic	Sow weed-free seed	95 (90-100)	Very important as resistance in wild radish is increasing and introduction via crop seed is increasingly likely

8 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

High seed dormancy and increasing levels of herbicide resistance make wild radish difficult to control in lupin crops, which are also poor competitors with this weed.

Lowering the wild radish seedbank can take up to 10 years, as any plants that survive one season to set seed will replenish the soil with a new wave of dormant seed that can take up to 18 months to germinate.[9]

Wild radish tends not to be highly damaging to lupin yield potential very early in the growing season in most areas of the southern region. This means post-emergent control was effective until herbicide resistance emerged as an issue.

Effective control in the lupin phase of the rotation requires an integrated management approach that can include tactics such as:

- Testing seed from surviving wild radish plants at harvest for herbicide resistance
- Application of glyphosate and/or paraquat herbicide during summer
- A double herbicide application at full label rates when wild radish plants are small
- Narrow row spacing or paired rows at seeding to boost crop competition
- Harvest weed seed capture and destruction
- Weed detection technology if cost-effective
- Use of decision-support tools, such as Weed Seed Wizard.[10]

The main post-emergent herbicides registered to control wild radish in lupin crops in the southern region are the Group F actives diflufenican and picolinafen and the Group B active metosulam in some varieties (such as Jindalee, Quilinock$^{\Phi}$ and Wonga$^{\Phi}$).

There is widespread resistance to diflufenican herbicide in the southern region, which has reduced its effectiveness.

Wild radish with resistance to sulfonylureas (Group B) herbicides has also become widespread, making the use of Eclipse® herbicide in lupin crops less effective.

Tips for post-emergent herbicide use for wild radish in lupin crops include:

- Use full label rates
- Diflufenican is best for early control (but unlikely to kill big weeds)
- Metosulam can be used for later control in some varieties (Jindalee, Quilinock$^{\Phi}$ and Wonga$^{\Phi}$)
- Metosulam has been known to reduce yields in Moonah$^{\Phi}$ and Mandelup$^{\Phi}$
- Paraquat can be applied at 80 percent leaf drop for desiccation of any surviving wild radish
- Mixing broadleaf and grass herbicides will damage lupin crops and should be avoided.[11]

Wild radish can reduce lupin yields by decreasing pod number, grain size and germination rates.

Increasing lupin crop density to a target of 50 plants per square metre has been found to reduce the adverse yield effects of this weed.

Research has demonstrated that increased lupin crop density and competition with wild radish can be achieved by using a combination of:

- High seeding rates of about 110 kg/ha
- Narrow row spacing of 23 cm
- Using east-west sowing row orientation in some areas.[12]

9 GRDC (2014) Fact Sheet – Wild radish, www.grdc.com.au/GRDC-FS-WildRadishManagement

10 DPIRD (2016) Wild Radish, https://www.agric.wa.gov.au/grains-research-development/wild-radish

11 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

12 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

MORE INFORMATION

GRDC Integrated weed management hub 'Wild /Indian hedge mustard': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/indian-hedge-mustard

5.4.3 Wild mustard/Indian hedge mustard (*Sisymbrium orientale*)

Figure 5: *Wild mustard is a prolific seed producer and is widespread across the southern region.*

(SOURCE: Agronomo)

- Produces vast numbers of seeds – up to 30,000/m^2
- Causes problems at harvest
- Populations been found to be resistant to Group B and I herbicides
- Small seeds can cause grain contamination.[13]

13 HerbiGuide, Wild Mustard, http://www.herbiguide.com.au/Descriptions/hg_Indian_Hedge_Mustard.htm

FEEDBACK

Management and control of wild mustard

Table 4: Tactics that should be considered when developing an integrated plan to manage Indian hedge mustard.[14]

Indian hedge mustard (*Sisymbrium orientale*)		Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	85 (0-99)	Avoid crops with no post-emergent herbicide options.
Agronomy	Herbicide tolerant crops	80 (0-95)	Very useful for non-cereal portions of the rotation
Tactic	Autumn tickle	25 (10–50)	Use with early breaks to the season and combine with delayed sowing.
Tactic	Delayed sowing	95 (90–99)	Follow by knockdown with non-selective herbicides targeting small weeds.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	75 (50–80)	Use high rates to control biennial plants. Tank-mixing with phenoxy herbicides improves control in absence of Group I resistance. Late germinations are not controlled.
Tactic	Pre-emergent herbicides	75 (50–80)	Dry conditions post-sowing reduces herbicide efficacy.
Tactic	Selective post-emergent herbicides	80 (60–90)	Spray young actively growing plants and repeat if necessary. Be aware of resistance status.
Tactic	Spray-topping with selective herbicides	95 (85–99)	Be aware of resistance status. The control range assumes no Group B resistance.
Tactic	Wiper technology	80 (60–95)	Useful tactic in lentil
Tactic	Grazing – actively managing weeds in pastures	70 (50–80)	Rotationally graze. Use spray-grazing with herbicide suited to pasture species present.
Tactic	Weed seed collection at harvest	50 (10–70)	Useful on early harvested crops

(SOURCE: GRDC)[15]

Wild mustard is widespread and germinates in autumn and winter to compete with lupin crops.

Simazine is the pre-emergent herbicide option to control wild mustard in lupin crops in the southern region and diflufenican (Group F) can be used post-emergence.

14 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

15 GRDC (2016) Integrated Weed Management hub, weed profile 'Indian hedge mustard', https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/indian-hedge-mustard

FEEDBACK

MORE INFORMATION

GRDC Integrated weed management hub 'Wireweed': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/wireweed

5.4.4 Wireweed (*Polygonum aviculare, P. arenastrum*)

Figure 6: *Wireweed can be difficult to control in the southern region due to its tendency to have a delayed germination.*

(SOURCE: Agronomo)

- Autumn to early summer germinating, annual or biennial
- Delayed germination makes control difficult
- Competes for moisture and nutrients
- Often causes problems with machinery
- Has phytotoxic properties.[16]

16 HerbiGuide, Wireweed, http://www.herbiguide.com.au/Descriptions/hg_Wireweed.htm

FEEDBACK

Management and control of wireweed

Table 5: Tactics that should be considered when developing an integrated plan to manage wireweed.[17]

Wireweed (*Polygonum* spp.)		Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	80 (0–50)	Avoid continuous cereals or broadleaf crops where control is difficult. Avoid growing pulses in heavily infested paddocks. Wireweed increases in triazine tolerant canola.
Agronomy	Herbicide tolerant crops	90 (50–95)	Some imidazoline herbicides provide useful control in legume and imidazoline tolerant crops. Glyphosate will provide good control in glyphosate tolerant crops.
Agronomy	Fallow phase	80 (0–80)	Control early in the fallow to reduce vining (i.e. kill small plants).
Tactic	Inversion ploughing	90 (80–95)	Use once to bury resistant seed deeply then avoid bringing that seed back to the surface for at least 10 years.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	90 (75–90)	Glyphosate, dicamba and some sulfonylurea herbicides are the most effective.
Tactic	Pre-emergent herbicides	90 (50–80)	Trifluralin, pendimethalin, chlorsulfuron and triasulfuron provide good control, but are dependent on rain after application.
Tactic	Selective post-emergent herbicides	90 (75–90)	Metsulfuron and dicamba provide good control. Target small weeds for better control. Few options exist in broadleaf crops.
Tactic	Manuring, mulching and hay freezing	90 (50–80)	Good for controlling late germinations and reducing problems in summer fallow.

Wireweed tends to germinate during or after crop emergence and competes for soil moisture and nutrients.

Typically this weed does not affect lupin yields significantly, but it can cause problems in blocking sowing equipment and/or interfering with harvesting due to its lengthy branching. It can affect rhizobia bacteria required for lupin nodulation due to its phytotoxic properties and it is tolerant of atrazine.[18]

Pre-emergent herbicide options for control of wireweed in lupin crops in the southern region include trifluralin, pendimethalin (Group D) and simazine.

17 GRDC (2016) Integrated Weed Management hub, weed profile 'Wireweed', https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/wireweed

18 HerbiGuide, Wireweed, http://www.herbiguide.com.au/Descriptions/hg_Wireweed.htm

FEEDBACK

MORE INFORMATION

GRDC Integrated weed management hub 'Annual ryegrass': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/annual-ryegrass

GRDC/University of Adelaide 'Herbicides for Control of Clethodim-Resistant Annual Ryegrass': www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Herbicides-for-control-of-clethodim-resistant-annual-ryegrass

GRDC/AHRI 'Update Paper – Why the Obsession with the Ryegrass Seedbank': www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2015/02/Why-the-obsession-with-the-ryegrass-seed-bank

HerbiGuide 'Annual Ryegrass': http://www.herbiguide.com.au/Descriptions/hg_Annual_Ryegrass.htm

Ryegrass Integrated Management (RIM): www.ahri.uwa.edu.au/RIM

5.5 Grass weed control in lupin crops

5.5.1 Annual ryegrass (*Lolium rigidum*)

Figure 7: *Annual ryegrass in a cereal crop.*

(SOURCE: GRDC)

- Highly competitive as early as two-leaf stage
- Can cause lupin yield losses of 5 percent for every 25 annual ryegrass plants/m^2
- Late sown crops affected more by weed competition
- Can produce up to 45,000 seeds/plant in ideal conditions
- About 80 percent seed germination after season break
- Several waves of germination typically make control difficult
- Can carry crop root diseases between seasons and years
- Seed cleaning costs may increase due to contamination by weed seeds
- Increasing levels of resistance to herbicides in southern Australia
- Multiple herbicide resistance to some selective/non-selective herbicides in SA
- HWSC can be effective, as seed is retained at harvest height.[19,20]

19 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

20 HerbiGuide, Annual Ryegrass, http://www.herbiguide.com.au/Descriptions/hg_Annual_Ryegrass.htm

FEEDBACK

Management and control of annual ryegrass

Table 6: Tactics that should be considered when developing an integrated plan to manage annual ryegrass.[21]

Annual ryegrass (*Lolium rigidum*)		Most likely % control (range)	Comments on use
Agronomy	Improve crop competition	50 (20–80)	Optimum sowing rates essential. Row spacing <250 mm to increase crop competitiveness. Sow on time.
Tactic	Burning residues	50 (0–90)	Avoid grazing crop residues. Use a hot fire back-burning with a light wind.
Tactic	Inversion ploughing	95 (80–99)	Bury seed greater than 100 mm deep. Use of skimmers on the plough is essential for deep burial.
Tactic	Autumn tickle	15 (0–50)	Only effective on last year's seedset. Use in conjunction with delayed sowing.
Tactic	Fallow and pre-sowing cultivation	60 (0–90)	Cultivation may lead to increased annual ryegrass in the crop. Use in combination with a knockdown herbicide. Use cultivators that bury seed.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	80 (30–95)	Avoid overuse of the one herbicide MOA group. Wait until annual ryegrass has more than 2 leaves.
Tactic	Double knockdown or 'double-knock'	95 (80–99)	Reduces the likelihood of glyphosate resistance. Use glyphosate followed by paraquat or paraquat + diquat 3 to 10 days later.
Tactic	Pre-emergent herbicides	70 (50–90)	Note incorporation requirements for different products and planting systems.
Tactic	Selective post-emergent herbicides	90 (80–95)	Apply as early as possible after the annual ryegrass has 2 leaves to reduce yield losses in cereals.
Tactic	Spray-topping with selective herbicides	80 (60–90)	Apply before milk dough stage of annual ryegrass.
Tactic	Crop-topping with non-selective herbicides	70 (50–90)	Note stage of crop compared to stage of annual ryegrass. Often not possible to achieve without crop yield loss. Most likely to occur with quick finish to season.
Tactic	Pasture spray-topping	80 (30–99)	Graze heavily in spring to synchronise flowering.
Tactic	Silage and hay – crops and pastures	80 (50–95)	Most commonly used where there is a mass of resistant annual ryegrass growth. Follow up with herbicides or heavy grazing to control regrowth.
Tactic	Manuring, mulching and hay freezing	90 (70–95)	Most commonly used where there is a mass of resistant annual ryegrass growth. Follow up with herbicides or heavy grazing to control regrowth.
Tactic	Grazing – actively managing weeds in pastures	50 (20–80)	Graze heavily in autumn to reduce annual ryegrass plant numbers. Graze heavily in spring to reduce seedset.
Tactic	Weed seed collection at harvest	65 (40-80)	Best results when crop is harvested as soon as possible before annual ryegrass lodges or shatters
Tactic	Sow weed-free seed	85 (50-99)	Reduces the risk of introducing resistant annual ryegrass to the paddock with crop seed

21 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

Harvest weed seed control (HWSC), delaying sowing and/or using a double-knock with full label rates of glyphosate and paraquat before sowing lupin crops can be good options in heavily infested annual ryegrass paddocks, or to help manage herbicide resistance issues.

When seasonal conditions are conducive, a light cultivation, or tickle, in autumn can encourage weed germination.

This will facilitate more effective annual ryegrass control with pre-seeding herbicide options, typically glyphosate and/or paraquat.

The most effective double-knock interval between glyphosate and paraquat application has been shown in many research trials to be between two and 10 days for seedling annual ryegrass plants.[22]

At sowing, Western Australian research has found increasing crop seeding rate and banding fertiliser below the lupin seed can improve lupin plant competition and help reduce annual ryegrass establishment and seed set. A target plant density of 40-45 plants/m^2 is recommended for narrow leafed lupin crops to be competitive with annual ryegrass and to optimise yield potential, but this will vary widely between locations and seasons. Using narrow row spacings (about 25 cm) has been found to improve weed control in lupin crops grown in cooler, longer-season environments.[23]

Pre-emergent herbicides registered for use to control annual ryegrass in lupin crops in the southern region are:

- Simazine (Group C)
- Trifluralin (Group D)
- Pendimethalin (Group D)
- Boxer Gold® (metolochlor + prosulfocarb – Group J and K)
- Sakura® (pyroxasulfone – Group K)
- Outlook® (dimethanemid-P – Group K).
- Terbyne® Xtreme (terbuthylazine – Group C).

Figure 8: *Simazine (Group C) can cause leaf stunting and crop damage.*

(SOURCE: Tony Cook)

22 GRDC (2014) Integrated Weed Management Manual: www.grdc.com.au/IWMM

23 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

The competition effect from annual ryegrass tends to be later in the season when lupin and weed plants vie for soil moisture.

Tips for pre-emergent herbicide applications for annual ryegrass control in lupin crops in the southern region include:

- Simazine and trifluralin are most effective when incorporated in wet soil
- Maximum rate of simazine (600 g/ha) registered for light and gravely loam soils is up to 1.7 L/ha
- It is recommended not to use simazine on deep white or grey/gritty sands
- Trifluralin can be added if levels of grass weeds are expected to be high
- To manage resistance issues, try to avoid trifluralin in multiple crops in the rotation
- Trifluralin is added mainly for wireweed control
- An integrated approach is most effective, with strategic use of grass herbicides and cultural grass control methods
- Crop damage can occur from Group C pre-emergent herbicides, such as simazine.[24]

Post-emergent herbicides registered for use to control annual ryegrass in lupin crops are:

- Haloxyfop (Group A)
- Clethodim (Group A)
- Sethoxydim (Group A)
- Butroxydim (Group A)
- Diclofop (Group A)
- Fluazifop (Group A)
- Quizalofop (Group A)
- Propaquizafop (Group A)
- Paraquat (Group L) - for crop topping.

There are high levels of 'fop' resistant annual ryegrass in the southern region and fop chemicals used without a 'dim' partner are likely to have poor results, according to advisers.

Other tips for post-emergent herbicide applications to control annual ryegrass in southern region lupin crops include:

- Spray small weeds early
- Grass weeds need to be actively growing
- Avoid spraying weeds stressed by dry soil, cold weather or frost
- Use the highest registered label rate
- Use the recommended adjuvant
- Avoid mixing grass-selective and broadleaf herbicides
- If applying paraquat during the season (for desiccation) use before weed seed set
- Test and monitor herbicide resistance status of annual ryegrass.[25]

24 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

25 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

MORE INFORMATION

GRDC Integrated weed management hub 'Wild oats': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/wild-oats

GRDC 'Ute Guide – Wild Oats': www.grdc.com.au/Resources/Ute-Guides/Weeds/Grass/West/Wild-oats

GRDC 'Podcast – Controlling Wild Oats': https://grdc.com.au/Media-Centre/GRDC-Podcasts/Southern-Weekly-Update/2015/10/103-south

HerbiGuide 'Wild oats': www.herbiguide.com.au/Descriptions/hg_Wild_Oat.htm

5.5.2 Wild oats (*Avena sativa* ssp. *Fatua* and *A. ludoviciana*)

Figure 9: *Group A resistant Wild oats on the inter-row of wheat.*

(SOURCE: GRDC)

- Highly competitive as early as two-leaf stage
- Produces up to 20,000 seeds/m^2 if uncontrolled
- About 40 percent of seed germinates at season break
- Another 10-30 percent germinates later in the season
- Seedbank can be depleted by 75 percent per year with good control
- Minimum tillage, narrow row spacings and banded fertiliser boost crop competition
- Seed catching at harvest is only partially effective
- In early harvested crops, up to 75 percent of seed is typically captured
- In late harvested crops, very few seeds are caught
- Harvesters can spread seed up to 250 metres from the parent plant
- Host for Cereal Cyst Nematode (*Heterodera avenae*) and the Root Lesion Nematode (RLN) *Pratylenchus neglectus*
- Poor host of RLN *P. thorneii*.[26]

26 HerbiGuide, Wild Oats, http://www.herbiguide.com.au/Descriptions/hg_Wild_Oat.htm

FEEDBACK

Management and control of wild oats

Table 7: Tactics that should be considered when developing an integrated plan to manage wild oats.[27]

Wild oats (*Avena* spp.)		Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	95 (30–99)	Summer crop–winter fallow rotation is very effective; numbers build up in winter pulse crops. Maintaining a clean winter fallow is the key to success.
Agronomy	Improve crop competition	70 (20–99)	Competitive crops at optimum sowing rates are very effective. High levels of control are achieved with barley, much lower with wheat.
Agronomy	Herbicide tolerant crops	90 (80–99)	Good to excellent control achieved with glyphosate resistant and triazine tolerant crops.
Tactic	Autumn tickle	40 (30–60)	Needs an early break to season. Combine with delayed sowing.
Tactic	Delayed sowing	40 (30-60)	Must be used with autumn tickle.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	80 (70–90)	Wait until youngest plants have 2 leaves if possible. Late germinations will not be controlled.
Tactic	Pre-emergent herbicides	80 (70–90)	Works best when combined with competitive crops.
Tactic	Selective post-emergent herbicides	80 (70–90)	Test for resistance before spraying. Use in combination with competitive crops.
Tactic	Spray-topping with selective herbicides	90 (60–99)	Flamprop methyl is very effective on flamprop susceptible wild oats. Best results with competitive crops, warmer conditions and at very early jointing stage of wild oats. Group Z resistance is common in many areas.
Tactic	Pasture spray-topping	80 (70–90)	Graze or spray survivors. Hay freezing works well.
Tactic	Silage and hay – crops and pastures	97 (95–99)	Harvest when wild oats are flowering. Control regrowth.
Tactic	Grazing – actively managing weeds in pastures	75 (60–80)	Graze heavily and continuously in spring.
Tactic	Weed seed collection at harvest	70 (20–80)	Works well on early harvested crops before wild oats drop their seeds.
Tactic	Sow weed-free seed	95 (0-100)	Only sow seed produced in wild oat-free paddocks.
Tactic	Clean farm machinery and vehicles	80 (0-100)	Ensure harvesters are well cleaned before moving to clean property or paddock.

(SOURCE: GRDC)[28]

27 GRDC (2016) Integrated Weed Management hub, weed profile 'Wild oats': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/wild-oats

28 GRDC (2016) Integrated Weed Management hub, weed profile 'Wild oats', https://grdc.com.au/Resources/IWMhub/Section-8-Profiles-of-common-weeds-of-cropping/Wild-oats

FEEDBACK

It is advised to plant weed seed-free crop and pasture seed, use clean tillage and harvesting machinery and clean any imported hay/grain for livestock to keep paddocks clean.

Controlling wild oats early in the season will help maximise lupin yields.

A knockdown herbicide, such as a full label rate of glyphosate, followed five to seven days later with a full label rate of paraquat and use of minimum tillage can set up lupin paddocks well.

Pre-emergent herbicides that can be used for wild oats in lupin crops in the southern region include simazine and some newer products – for suppression – and triallate (Group J).

Post-emergent selective herbicides registered to control wild oats in lupin crops are:

- Fluazifop-P (Group A)
- Butroxydim (Group A)
- Haloxyfop (Group A)
- Quizalofop (Group A).

Tips for post-emergent herbicide applications to control wild oats in lupin crops include:

- On sandy soils use lower simazine rates (registered for suppression only)
- Group A herbicides (fops and dims) usually provide best in-crop control
- Repeated herbicide use may lead to resistance
- Rotation with triallate + trifluralin can help delay resistance.[29]

29 GRDC (2014) Integrated Weed Management Manual: www.grdc.com.au/IWMM

FEEDBACK

MORE INFORMATION

GRDC Integrated weed management hub 'Brome grass': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/brome-grass

DPIRD 'Brome Grass': https://www.agric.wa.gov.au/grains-research-development/management-brome-grass-bromus-spp

HerbiGuide 'Brome Grass': www.herbiguide.com.au/Descriptions/hg_Great_Brome.htm

5.5.3 Brome Grass (*Bromus diandrus* and *B. diandrus rigidus* – previously known as *B. rigidus*)

Figure 10: *An illustration of fop and dim-resistant brome grass that has died-off when first sprayed, but recovered to produce new tillers.*

(SOURCE: GRDC)

- Widespread across southern Australia
- Highly competitive with crops
- More aggressive than annual ryegrass, barley grass or silver grass
- Tolerant to drought and phosphorus (P) deficiency
- Produces high numbers of seeds – 600-3000 per plant
- Host for nematodes and cereal diseases
- Declining use of some Group A and B herbicides
- Resistance to Group A herbicides in one population in Victoria
- Most seeds shed before harvest, so HWSC not highly effective.[30,31]

30 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

31 GRDC (2014) Integrated Weed Management Manual: www.grdc.com.au/IWMM

FEEDBACK

Management and control of brome grass

Table 8: Tactics that should be considered when developing an integrated plan to manage brome grass.[32]

Brome grass (*Bromus* spp.)		Most likely % control (range)	Comments on use
Tactic	Burning residues	70 (60–80)	Sufficient crop residues are needed.
Tactic	Autumn tickle	50 (20–60)	Depends on seasonal break. Seed burial through shallow cultivation enhances seed depletion through germination, especially in *B. diandrus* with its shorter dormancy and faster germination.
Tactic	Delayed sowing	70 (30–90)	Best results with early seasonal break.
Tactic	Fallow	80 (70-90	Start the chemical fallow before weeds set seed (i.e. early spring).
Tactic	Knockdown non-selective herbicides for fallow and pre-sowing control	80 (30–99)	If possible delay spraying until full emergence and youngest plants have 2 leaves.
Tactic	Pre-emergent herbicides	80 (40–90)	Follow label directions, especially on incorporation requirements of some herbicides.
Tactic	Selective post-emergent herbicides	90 (75–99)	Apply when weeds have 2 to 6 leaves and are actively growing.
Tactic	Pasture spray-topping	75 (50–90)	Spray before viable seedset. Respray or graze survivors. Use this technique 2 years before going back to crop.
Tactic	Silage and hay – crops and pastures	60 (40–80)	Silage is better than hay. Graze or spray regrowth.
Tactic	Manuring, mulching and hay-freezing	90 (75-95)	Manuring works well if done before seed set. Any regrowth must be controlled.
Tactic	Grazing – actively managing weeds in pastures	50 (20–80)	Graze infested areas heavily and continuously in winter and spring.
Tactic	Weed seed collection at harvest	70 (10–75)	Works best on early harvested crops before weeds drop their seeds.

32 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, www.grdc.com.au/GRDC-FS-PreHarvestHerbicide

Lupin crops can provide a better opportunity to control brome grass than cereal crops, as there are more herbicide options available.

Preventing seed set later in the season with mowing, cultivation and/or burning windrows/paddocks can be effective in reducing the brome grass seedbank in the longer term.

Despite Australian Herbicide Resistance Initiative (AHRI) herbicide resistance surveys finding brome grass populations with resistance to some Group A, B and M herbicides, a range of pre and post-emergent options are still available to control this weed.

Crop-topping with glyphosate in lupin crops may also reduce brome grass seed set. Timing is the main issue to consider, as brome grass matures a lot faster than some crops and will set seed before the crop can be legally sprayed. Lupin crops typically mature early enough that desiccation is rarely warranted in some southern region areas.

Simazine can be used pre-emergence, but is registered for suppression only in the southern region.

Post-emergent herbicide options registered to control brome grass in southern region lupin crops include:

- Clethodim (Group A)
- Butroxydim (Group A)
- Fluazifop (Group A)
- Haloxyfop (Group A)
- Quizalofop (Group A)
- Propaquizafop (Group A).

5.5.4 Barley grass (*Hordeum glaucum* and *H. leporinum*).

Figure 11: *Barley grass can be a source of stripe rust disease in grain cropping and pasture areas of the southern region.*

(SOURCE: GRDC)

- Germinates rapidly in autumn
- Group A herbicides generally provide good control
- Other states have barley grass with resistance to paraquat and diquat; several Group A fops; and cross resistance to the Group A dim herbicides.[33]

MORE INFORMATION

GRDC Integrated weed management hub 'Barley grass': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/barley-grass

DPIRD 'Barley Grass': https://www.agric.wa.gov.au/grains-research-development/barley-grass

Herbiguide, 'Barley Grass': http://www.herbiguide.com.au/Descriptions/hg_Barley_Grass.htm

33 DPIRD (2016), Barley Grass, https://www.agric.wa.gov.au/grains-research-development/barley-grass

FEEDBACK

Management and control of barley grass

Table 9: Tactics that should be considered when developing an integrated plan to manage barley grass.[34]

Barley grass (*Hordeum* spp.)		Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	85 (0-95)	Avoid planting barley in infested areas.
Agronomy	Herbicide tolerant crops	80 (40-95)	Triazines and imidazolinone herbicides provide useful control in triazine and imidazolinone tolerant crops respectively.
Tactic	Burning residues	50 (0–75)	Dropping chaff and straw into windrows improves control.
Tactic	Inversion ploughing	90 (70–99)	Use skimmers to ensure deep burial.
Tactic	Delayed sowing	60 (50–90)	Level of control depends on break.
Tactic	Fallow and pre-sowing cultivation	50 (30–80)	Requires dry weather following cultivation.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	80 (50–90)	Works best if delayed until the 2- to 4-leaf stage after good opening rains.
Tactic	Double knockdown or 'double-knock'	80 (60–95)	Works best if delayed until the 2- to 4-leaf stage after good opening rains.
Tactic	Pre emergent herbicides	85 (75–99)	Pyroxasulfone provides good control in wheat.
Tactic	Selective post-emergent herbicides	90 (80–95)	Several 'fop' herbicides provide good control in broadleaf crops. Sulfosulfuron provides suppression in wheat.
Tactic	Crop-topping with non-selective herbicide	80 (50–90)	Timing is aimed at maximising weed seed kill and minimising effect on the crop.
Tactic	Pasture spray-topping	60 (50–90)	Graze heavily or winter-clean with 'fop' herbicides to induce more uniform emergence of heads. Timing is critical. Graze or spray regrowth.
Tactic	Silage and hay – crops and pastures	50 (30–80)	Silage provides better control than hay making. Heavily graze or spray regrowth.
Tactic	Manuring – green and brown, mulching and hay freezing	75 (50–90)	Graze heavily to induce more uniform emergence of heads. Timing is critical. Graze or spray regrowth.
Tactic	Grazing – actively managing weeds in pastures	30 (0–50)	Use high stocking rates early in the season to reduce numbers, and late in the season to reduce seedset on infested paddocks.

34 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, www.grdc.com.au/GRDC-FS-PreHarvestHerbicide

Simazine can be used pre-emergence to control barley grass in southern region lupin crops and Sakura® can be used for supression.

Post-emergent herbicide options to control barley grass in lupin crops in the southern region are:

- Clethodim (Group A)
- Butroxydim (Group A)
- Fluazifop (Group A)
- Haloxyfop (Group A)
- Quizalofop (Group A)
- Propaquizafop (Group A).

5.5.5 Silver Grass (*Vulpia myuros* and *V. bromoides*)

Figure 12: *Silver grass can reduce lupin crop yields when at high densities.*

(SOURCE: Agronomo)

- Can severely reduce crop yields when at high densities
- A host for diseases and pests, including cereal root diseases, webworm and some RLN
- There are cases of paraquat resistance in some states
- Many herbicides provide suppression, rather than control
- Some herbicides only control surface germinating seeds (always check the label)
- Seed has little dormancy, making early control of the initial flush of germination highly effective.

MORE INFORMATION

GRDC Integrated weed management hub 'Silver grass': https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/vulpia

DPIRD 'Silver Grass': https://www.agric.wa.gov.au/grains-research-development/silver-grass?page=0%2C1

FEEDBACK

Management and control of silver grass

Table 10: Tactics that should be considered when developing an integrated plan to manage silver grass.[35]

Silver grass (*Vulpia* spp.)		Most likely % control (range)	Comments on use
Agronomy	Crop choice and sequence	80 (70–95)	Rotate to a triazine tolerant or glyphosate resistant canola in heavily infested areas.
Agronomy	Herbicide tolerant crops	95 (90–99)	Using pre and post-emergent applications of triazine herbicide in triazine tolerant crops will almost eradicate most species of *Vulpia*.
Agronomy	Improve pasture competition	Variable	Reduces seed production, helping to maintain a low incidence of silver grass in a pasture. Winter clean with simazine.
Tactic	Burning residues	50 (30–70)	Use a hot fire back-burning into the wind.
Tactic	Inversion ploughing	90 (80–99)	Use a plough with skimmers to bury seed more than 75 mm deep.
Tactic	Autumn tickle	60 (50–80)	Requires an early break to the season. Combine with delayed sowing.
Tactic	Delayed sowing	75 (50–90)	Works well in most seasons. Tends to fail on non-wetting soils.
Tactic	Fallow and pre-sowing cultivation	70 (50–90)	Generally works well. Crop using full soil disturbance with late sowing to enable use of knockdown herbicides plus cultivation.
Tactic	Knockdown (non-selective) herbicides for fallow and pre-sowing control	Up to 95%	Ensure good herbicide coverage.
Tactic	Double knockdown or ‘double-knock’	80 (70–95)	If this is required, pasture cleaning or spray-topping should have occurred 2 years before cropping.
Tactic	Pre emergent herbicides	80 (70–95)	Triazines are very good on most species of *Vulpia*.
Tactic	Selective post-emergent herbicides	Up to 95%	If silver grass is the main component of the pasture there will be a loss of winter fodder. The treated pasture should be resown in the following season or renovated to increase the component of desirable species.
Tactic	Pasture spray-topping	Up to 85%	Timing is critical. Heavy grazing leading up to topping will induce uniform head emergence. Gives the ability to keep desirable pasture species while reducing the incidence of silver grass. Conduct two seasons before cropping.
Tactic	Silage and hay – crops and pastures	Up to 90%	Cut for silage at commencement of flowering. Control regrowth.
Tactic	On-farm hygiene	Variable	Contaminated hay should not be moved to clean areas.

35 Walsh, M, Aves, C, Powles, S (2014) Evaluation of harvest weed seed control systems, AHRI, Nineteenth Australasian Weeds Conference paper, 4 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, http://caws.org.au/awc/2014/awc201412881.pdf

FEEDBACK

5.6 Crop-topping for weed control

- Apply the non-selective herbicide paraquat prior to harvest
- Always check label for registration, rate and timing details
- Time application to target weeds at flowering and early grain fill
- This will minimise production of viable weed seed and crop yield loss
- Success requires sufficient gap in physiological maturity between crop and weed
- Ideal time is when 80 percent of lupin leaves have fallen off or turned brown
- Works best with early maturing lupin varieties.[36]

Management tips and tactics for crop-topping

In the southern region, paraquat is registered for crop-topping and can be applied at the 80 percent leaf drop point of the lupin crop. Crop-topping at this time has been shown to minimise lupin yield losses.[37]

Short season varieties, such as PBA Gunyidi$^{\phi}$, Belara and Mandelup$^{\phi}$, typically reach 80 percent leaf drop stage seven to 10 days earlier than longer season varieties and are well suited to crop-topping.

For annual ryegrass, crop-topping is most effective when the weed is at flowering to soft dough stage. If dough cannot be squeezed from the annual ryegrass seed, it will be viable even if crop-topping is used. In wet spring conditions, the duration of flowering and podding of the lupin crop can be extended due to the indeterminate growth habit of the crop. This prolongs the time until 80 percent leaf-drop in the crop and annual ryegrass can develop past the dough stage before the crop is ready. This highlights that crop-topping is a highly seasonally dependent tool that cannot be used each year unless lupin yield impact is accepted to ensure annual ryegrass is controlled.[38]

36 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, www.grdc.com.au/GRDC-FS-PreHarvestHerbicide

37 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, www.grdc.com.au/GRDC-FS-PreHarvestHerbicide

38 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

MORE INFORMATION

WeedSmart 'HWSC Guide and Case Studies': www.weedsmart.org.au/wp-content/uploads/2013/12/AHRI-Harvest-Weed-Seed-Control-Booklet_2013-version.pdf

5.7 Harvest weed seed control (HWSC) tactics

Figure 13: *The new integrated Harrington Seed Destructor (iHSD) system is one HWSC method that destroys weed seeds by pulverising the chaff fraction as it leaves the harvester.*

(SOURCE: McIntosh & Son)

A major biological weakness of most cropping weeds of southern Australia is that their seed does not shatter before harvest, providing a good opportunity for removal at this time.

Capturing the weed seed and destroying it substantially reduces carry-over from the lupin crop into the next crop phase.

Common HWSC tactics include:

- Collecting chaff in chaff carts
- Burning or grazing chaff residue
- Depositing chaff on narrow windrows for burning the next autumn
- Using seed capture and destruction technology to pulverise and destroy chaff and weed seed fraction as it leaves the harvester
- Diverting weed seeds onto permanent tramlines
- Towing a baler behind the header to remove all harvest residue.

These HWSC systems remove both resistant and susceptible weed seeds that have survived earlier herbicide applications. This reduces the risk of herbicide resistance evolution and the selection pressure on herbicides.

Research at 25 sites across southern Australia during the 2010 and 2011 harvests found windrow burning, chaff cart and seed capture and destruction systems were equally effective at removing annual ryegrass seed from cropping paddocks. Each of these HWSC methods led to a 55 percent reduction in annual ryegrass germination the following year. Research has also shown that the seed capture and destruction systems consistently destroys 95 percent of annual ryegrass, wild radish, wild oats and brome grass seed present in the chaff fraction. Trials in WA have found chaff carts offer a reliable method of catching seed and are very effective at rapidly reducing large banks of weed seed.[39]

39 Walsh, M, Aves, C, Powles, S (2014) Evaluation of harvest weed seed control systems, AHRI, Nineteenth Australasian Weeds Conference paper, 4 GRDC Fact Sheet (2015) Pre-harvest Herbicide Use, http://caws.org.au/awc/2014/awc201412881.pdf

FEEDBACK

Typically, 45 to 75 percent of annual ryegrass seed and 70 to 80 percent of wild radish seed is collected in a chaff cart. Baling behind the header can be a successful method to reduce weed seed banks. Trials have shown this can remove up to 98 percent of the weed seed that enters the header. But increased mineral nutrient input is required to budget for exported nutrients in the straw and a powerful header is required to tow the baler. To be viable, a market for the hay is needed – such as an export hay market or feed processing plant. Burning entire paddocks on sandplain soils needs to be carried out with extreme caution. This is generally undertaken very close to seeding, if at all. Burning lupin chaff that has been placed in a narrow windrow can be a more effective method than paddock burning to destroy annual ryegrass and radish seed. The burn kills almost all the seed in the windrow, but any burning needs to be balanced with the risks of erosion.[40]

40 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

MORE INFORMATION

GRDC 'Summer Fallow Weed Management Guide': www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement

GRDC 'Hot Topic – Summer Fallow Weed Management': www.grdc.com.au/Media-Centre/Hot-Topics/Summer-fallow-weed-management

5.8 Summer weed control

- Conserves soil moisture and nutrients for crop use
- Reduces the need for high rates of herbicide knockdown before seeding
- Better controls large taproot species in knife point cultivation sowing systems
- Reduces risks of seeding delays
- Reduces weed allelopathic effects (such as toxin secretion) and can boost lupin emergence.[41]

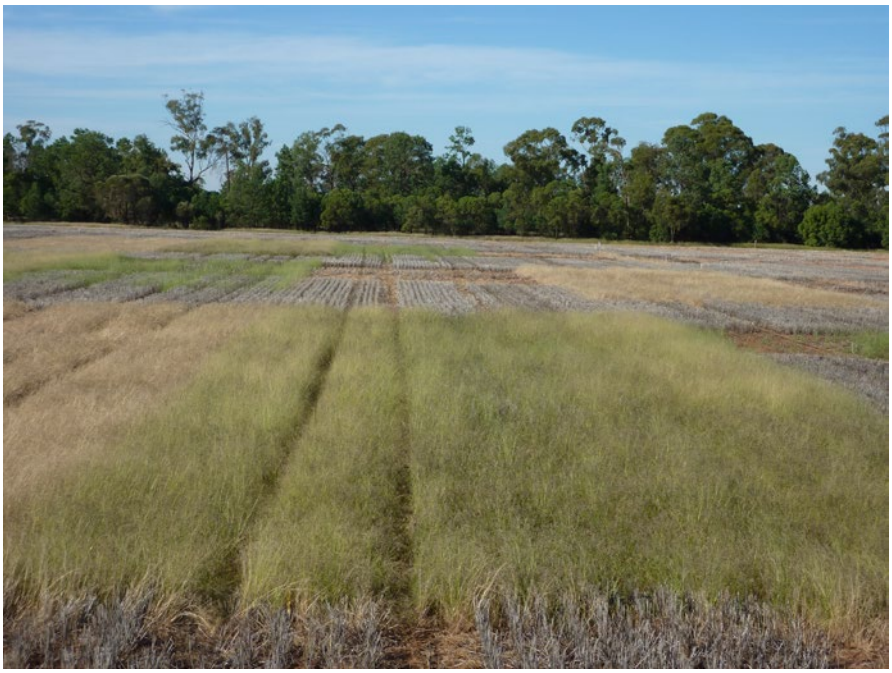

Figure 14: *Summer weeds are a scourge of WA lupin crops.*

(SOURCE: DPIRD)

The main summer weed species impacting on lupin crops in the southern region are:

- Flaxleaf fleabane (*Conyza bonariensis*)
- Windmill grass (*Chloris truncata*)
- Feathertop Rhodes grass, or FTR (*Chloris virgata*)
- Caltrop (*Tribulus terrestris*)
- Skeleton weed (*Chondrilla juncea*)
- Heliotrope (*Heliotropium europaeum*)
- Afghan melon (*Citrullus lantatus*)
- Paddy melon (*Cucumis myriocarpus*).

Growth rates of these weeds after summer rain are high and control in early stages of development is typically more reliable and cost effective than waiting until they are more robust.

Summer-growing weeds, especially melons, skeleton weed and heliotrope, are very effective at extracting water from the soil profile and this can rapidly remove crop yield benefits from summer rain.

Research has found weeds such as fleabane can only be adequately controlled in summer using a well-timed double-knock.

41 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

This is typically a full registered rate of glyphosate (Group M), followed by a full label rate of paraquat (Group L). But this adds pressure to spray all paddocks in a timely manner and increases weed control costs.

Group B herbicides cannot be used for summer weed control on paddocks that will be sown to lupin crops, due to the re-cropping interval.[42]

It is also advised in low rainfall areas with low summer moisture to take a cautious approach to timing the use of 2,4-D amine (Group I) products during summer and before a lupin crop. Due to the residual nature of some Group I products in low-organic soils, these herbicides are often best to have rates reduced progressively after mid-December and alternatives found after mid-February. Plant back periods for these phenoxy (Group I) chemicals on sands with low organic matter can often be longer than the plant back periods provided on product labels. In some seasons and situations, there is not enough moisture in the topsoil of the sands for long enough to allow microbial breakdown of the herbicides.[43]

A light cultivation, or 'tickle', in autumn before sowing lupin crops can cover weed seeds with soil to provide good conditions for an early flush of germinating weeds. These can then be controlled with non-selective herbicides and cultivation during the seeding operation (if sowing after the break). An autumn tickle is most effective when the soil is moist for two weeks after cultivation and prior to the use of any knockdown herbicides.[44]

42 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

43 Cameron, J, Storrie, A (2014) Summer Fallow Weed Management – A reference manual for grain growers and advisers in the southern and western grains regions of Australia, GRDC, www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement

44 White, P, French, B, McLarty, A (2008) Producing Lupins, Department of Agriculture and Food WA, Bulletin 1-2008, http://researchlibrary.agric.wa.gov.au/cgi/viewcontent.cgi?article=1009&context=bulletins

FEEDBACK

5.9 Decision support tools

Adoption of successful IWM involves complex interactions, multiple year timeframes, many possible interventions, major environmental influences and high levels of uncertainty.

The use of computer-based models can be a valuable tool to aid decision making.

Developed by AHRI, with GRDC investments, the Ryegrass Integrated Management (RIM) model evaluates the long term profitability of annual ryegrass control methods and reducing the weed seedbank.

Weed Seed Wizard is a simulation tool, developed in a national collaboration, which uses paddock management information to predict weed emergence and crop losses now and in the future to help growers devise effective IWM plans.

MORE INFORMATION

Ryegrass Integrated Management 'User Guide and Video Tutorials': http://ahri.uwa.edu.au/research/rim/rim-videos-tutorials-and-examples/

5.9.1 Ryegrass Integrated Management (RIM)

RIM enables users to assess the effectiveness and budget implications of 10-year cropping and weed management scenarios using up-to-date economic parameters.

It has options for four crops, including lupin, three pastures and 43 practices that include herbicide use and rates, timing of application, soil preparation, crop type, grazing and HWSC options.

Graphs can be produced and exported to other software programs for analysing annual ryegrass survivors, gross margins across 10 years, yield loss from competition and ryegrass seedbank levels. See the link to this resource in the 'More information' box.

MORE INFORMATION

DPIRD 'Weed Seed Wizard': https://www.agric.wa.gov.au/weed-seed-wizard/weed-seed-wizard-download-and-help

5.9.2 Weed Seed Wizard

This model can investigate the impact of a wide range of IWM strategies (such as HWSC, increased crop competition, rotation change and various weed seed set controls such as crop-topping and hay making) on weed and weed seed numbers.

It was developed by DPIRD in partnership with The University of Western Australia, University of Adelaide, the New South Wales Department of Primary Industries and the Department of Agriculture Fisheries and Forestry in Queensland, with investments by GRDC.

The user enters site-specific weather data and soil type, the weed species to be investigated and information about past and future weed management.

The model uses real weather data and gives an estimate of crop yield loss as a result of weed pressure from a range of species. See the link to this resource in the 'More information' box.