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FABA BEAN

SECTION 7

WEED CONTROL

KEY POINTS | IMPACT/COST OF WEEDS | KEY POINTS FOR MANAGING WEEDS IN FABA BEAN | USING PULSE CROPS FOR STRATEGIC WEED CONTROL | INTEGRATED WEED MANAGEMENT (IWM) | DECISION-SUPPORT TOOLS | FREE ALERT SERVICES FOR WEEDS | USING HERBICIDES | HERBICIDE-RESISTANT WEEDS | RISK OF HERBICIDE DAMAGE | KNOCKDOWN HERBICIDES | PRE-EMERGENT HERBICIDES | POST-EMERGENT HERBICIDES | DIRECTED SPRAYS | CROP-TOPPING | SELECTIVE SPRAYER TECHNOLOGY | EXOTIC WEEDS OF FABA BEAN

Weed control

Key points

- **Growing pulses provides the opportunity to use different herbicide groups and target grass weeds, including herbicide-resistant weeds. Preventing weed seedset is a priority for this phase of the rotation.**
- **There are limited options for broadleaf weed control in faba and broad bean. They need to be heavily 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.**
- **In particularly weedy crops, cutting for hay or silage, or green or brown manuring, provide an opportunity for improved weed control compared to harvesting for grain.**
- **As crops that can be harvested early, faba bean provide a good opportunity for collecting weed seeds at harvest.**

MORE INFORMATION

See Weed ID: The Ute Guide App, https://grdc.com.au/resources-and-publications/app

7.1 Impact/cost of weeds

Weeds cost Australian grain growers $3.3 billion each year.[1] That is, $2.6 billion in control costs and another $745 million in lost yield. The cost to southern growers ranges from $105/ha in the low-rainfall zone, including the South Australian and Victorian Mallee and Upper Eyre Peninsula, up to $184/ha in the higher-rainfall zones including SA's Mid North, Yorke Peninsula and Lower Eyre Peninsula.

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

It is a challenge that is also 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 have increased, with the latter showing rapid recent increases in some areas.

Grasses top the list of the most costly weeds in the southern region (Table 1). Brome grass has increased in importance since the previous rankings were determined in the year 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

Source: Llewellyn *et al* (2016) Impact of weeds on Australian grain production

Weeds affect yield and management across all seasons and sometimes the price received for grain.

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 as there are limited herbicide options in pulse crops.

Weed management aims to reduce the overall number of weeds competing with the crop and in some cases target particular 'hard to manage' weeds such as herbicide-resistant ryegrass. Growers need to select crop rotations that will provide opportunities for the weed control required in each paddock. Crop rotation also allows for rotation of herbicide groups to minimise the build-up of herbicide resistance.

1 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, https://grdc.com.au/ImpactOfWeeds

7.2 Key points for managing weeds in faba bean

Faba and broad bean provide some advantages for weed control including:[2]

- The opportunity to use different herbicide groups, particularly to target grass weeds such as annual ryegrass and wild oats.
- The possibility for delayed sowing in higher-rainfall areas, so there is better opportunity for knockdown weed control before sowing.
- When sowing into dry soil, there is a delay (14–28 days) before beans emerge after germinating rains. This can allow a non-selective knockdown herbicide application to kill weeds that emerge before the beans.
- The opportunity to grow in wider rows in a stubble system, which allows inter-row herbicide application with shielded sprayers.
- The choice to opt for green or brown manure or crop-topping if weed burdens are high.

Particular challenges and problem weeds in faba and broad bean crops include:

- Annual ryegrass that is resistant to Group A products ('Dims' and 'Fops'), particularly where high rates of clethodim are required.
- Annual ryegrass that is resistant to trifluralin.
- Snail and other medic.
- Wild radish: there are no safe treatments for post-emergent control.
- Hoary cress, soursob, vetch, bifora, bedstraw and tares.
- Limited post-emergent control options for broadleaf weeds.
- Bean crops are initially poor competitors with weeds in southern Australia because of slow germination, low plant populations and an extended period before canopy closure.
- Crop-topping to prevent seedset of ryegrass often provides the most effective control before faba bean are sufficiently mature and will reduce yield and quality. Broad bean consistently matures too late for crop-topping.
- Bean crops are often sown early or into dry soil limiting the opportunity for knockdown weed control before seeding and growers need to rely on herbicides and low weed numbers for in-crop weed control.

7.3 Using pulse crops for strategic weed control

The impact of weeds on bean yield is not well quantified. As bean crops are often thin during early development weeds don't necessarily inhibit bean growth at this stage. Tall, bulky crops are good competitors against later-germinating weeds.

Growers need to focus on limiting weed seedset and ensuring that green weed material does not delay harvest or reduce grain quality.

Research at Tamworth in 2001–03 found that faba bean had a similar competitiveness against weeds to canola, and was less competitive than wheat, but more competitive than chickpea.[3] In general, better weed management is required to grow faba bean than to grow wheat. In these trials faba bean, chickpea and canola stubble provided poor groundcover after harvest when compared with cereals.

2 Pulse Australia (2016) Southern faba & broad bean best management practices training course – 2016. Pulse Australia.

3 WL Felton, BM Haigh and S Harden (2004) Comparing weed competition in chickpea, faba bean, canola and wheat. 14th Australian Weeds Conference, Wagga Wagga, New South Wales, pp. 304-307, http://caws.org.au/awc/2004/awc200413041.pdf

MORE INFORMATION

For details on annual ryegrass, see https://grdc.com.au/resources-and-publications/iwmhub/common-weeds-of-cropping/annual-ryegrass

GRDC has produced Fact Sheets on Wild radish: https://grdc.com.au/Resources/Factsheets/2014/07/Wild-radish and Brome grass: https://grdc.com.au/Resources/Factsheets/2011/05/Brome-Grass

7.3.1 Grass weeds

Pulse crops provide a good opportunity to control grass weeds that have been difficult to manage in cereals. Preventing weed seedset is a priority for pulse rotations, particularly where there are resistant weeds.

Grass-control herbicides can control most grass weeds in pulses, and volunteer cereals can also be controlled with some of these herbicides. Effective control of grass weeds will reduce root disease carry-over and provide a true break crop.

Where grass weeds have herbicide resistance faba bean can provide the opportunity to use alternative herbicide groups or to use other techniques such as crop-topping or green or brown manuring.

7.3.2 Broadleaf weeds

A weakness of pulse crops is the limited options for broadleaf weed control. In faba bean, chickpea and lentil there are few effective broadleaf post-emergent herbicides available.[4] It is important to have a 'plan of attack', which is likely to include the use of a pre-emergent herbicide.

Broadleaf weeds need to be heavily targeted in the preceding crop and/or fallow. The broadleaf weed risk is based on

- grower's experience;
- the previous crop and herbicides used; and
- an assessment of winter weeds germinating in the fallow year prior to planting.

Paddocks with substantial populations of wild radish, musk weed or vetch should be avoided.

Wild radish is a particular problem weed. Western Australian trials showed that 10 wild radish plants per square metre can reduce faba bean yields by 36%.[5]

In WA, 60% of wild radish is resistant to herbicides.[6] As southern region growers move to a more intensive cropping system, with fewer sheep and more herbicide applications the number of resistant wild radish populations are increasing. More than 90% of seed can be captured at harvest for destruction or removal.

4 GRDC (2014) Integrated Weed Management Hub. GRDC, https://grdc.com.au/weedlinks

5 AH Cheam *et al* (2008) Managing wild radish and other brassicaceous weeds in Australian cropping systems. CRC for Australian Weed Management.

6 GRDC (2013) Emerging Issues with Diseases Weeds and Pests. GroundCover™ Supplement, Issue 102, January–February 2013, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS102

7.4 Integrated weed management (IWM)

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

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

	Herbicidal	Non-herbicidal
Crop phase	• Use knockdown herbicides e.g. double-knock before sowing • Occasionally it may be possible to delay sowing to get maximum weed control before sowing • Use selective herbicides before and/or after sowing but ensure escapes do not set seed • Avoid high resistance-risk herbicides • Crop-topping • Brown manure crops	• Rotate crops • Rotate varieties • Grow a dense and competitive crop • Use cultivation • Delay sowing • Green manure crops • Cut crops for hay/silage • Burn stubbles/windrows • Collect weed seeds at harvest and remove/burn • Destroy weed seeds harvested e.g. use Harrington Seed Destructor
Pasture phase	• Spray-topping • Winter cleaning • Use selective herbicides but ensure escapees do not set seed	• Good pasture competition • Cut for hay/silage • Cultivated fallow • Grazing

Source: Pulse Australia (2016) [7]

MORE INFORMATION

GRDC booklet *Integrated weed management in Australian cropping systems*, see http://www.grdc.com.au/IWMM

GRDC booklet *Summer fallow weed management: A reference manual for grain growers and advisers in the southern and western grains regions of Australia*, http://www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement

7.4.1 Strategy – paddock choice and crop rotation

It is preferable to sow faba bean into paddocks with a low burden of grass and broadleaf weeds. Those with a severe broadleaf weed problem should be avoided.

A well-managed rotation of crops in each paddock provides the opportunity to target different weeds and can prevent a build-up of particular weed species. Grasses are easier to control in broadleaf crops such as pulses.

7.4.2 Good agronomic practice

Of the pulses, faba bean have a medium competitive ability, similar to field pea, and better than chickpea, lentil and lupin.

Getting the agronomy right means a more competitive crop. Use weed-free seed and sow on time. Faba bean in particular should not be sown after their optimum sowing date. Plant at optimal plant populations and use adequate nutrition with careful placement of fertiliser.

7.4.3 Pre-plant weed control

All weeds growing in a paddock should be controlled before the crop emerges.

Tillage is a valuable method for killing large, mature weeds and preparing seedbeds. There are varying combinations of mechanical and chemical weed control to manage fallows or stubbles. Large, advanced weeds not controlled prior to or during the sowing operation are difficult if not impossible to control with in-crop herbicides.

Knockdown herbicides are generally used instead of cultivation for fallow commencement, as well as for pre-planting weed control in the autumn. Knockdown

7 Pulse Australia (2016) Southern faba & broad bean best management practices training course – 2016. Pulse Australia.

VIDEO

AHRI video: Narrow row spacing: more crop, fewer weeds https://www.youtube.com/watch?v=qM-Pl4vMliw

MORE INFORMATION

GRDC Integrated Weed Management hub, https://grdc.com.au/weedlinks

herbicides benefit soil structure and provide more timely and effective weed control. However, it is important to understand and manage the risk of herbicide resistance.

Cultivation can spread grass weed seeds such as ryegrass, wild oat and brome grass through the soil profile and prolong their seedbank dormancy.[8] For these weeds a light cultivation with an autumn tickle (1–3 cm deep) can encourage germination and can assist in depleting the seedbank. This needs to be combined with delayed sowing and is more appropriate for faba bean in seasons with a very early break.

7.4.4 In-crop weed control

A wide range of pre emergent and early post-emergent herbicides are available for grass weed control in faba and broad bean. However, post-emergent options are very limited for broadleaf weeds.

Weeds should be removed from crops early, and certainly no later than 6 weeks after sowing, to minimise yield losses. The yield response 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 to successfully use post emergent herbicides. The growth stages of faba bean are detailed in Section 5 Plant growth and physiology. 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.

7.4.5 Selective grazing

Although no longer a common practice, grazing weeds and crop contaminants in pulses can be useful where selective herbicides are not available. There may still be limited opportunities in crop salvage situations. This will not provide a disease break as the host weeds are not killed by selective grazing.

Plants vary in their palatability. When the stocking rate is light, animals will selectively graze the more palatable plants. This may be useful with volunteer crop weeds when herbicides are not available or their use would damage the sown crop, e.g. graze field peas in a faba and broad bean crop.

The relative palatability for some crops was determined by the University of Adelaide (Table 3). Palatability was rated as highly palatable – most of the crop eaten, through to low palatability – very little of the crop eaten.

Table 3: Relative palatability of various crops to sheep.

Highly palatable	Moderately palatable	Low palatability
Nine weeks after sowing		
Field pea, lathyrus, fenugreek, lentil, canola, wheat, safflower, lupin, common vetch	Chickpea	Coriander, faba bean, narbon bean
Thirteen weeks after sowing		
Field pea, lathyrus, canola	Lentil, lupin, mustard, safflower	Chickpea, coriander, faba bean, narbon bean, fenugreek

Source: Grain Legume Handbook (2008)[9]

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

9 J Lamb, A Podder (2008) Grain Legume Handbook for the Pulse Industry. Grain Legume Hand Book Committee, https://grdc.com.au/grainlegumehandbook

MORE INFORMATION

For information on managing weeds at harvest, please see https://grdc.com.au/resources-and-publications/iwmhub/section-7-managing-weeds-at-harvest

The WeedSmart website has details on capturing weed seeds at harvest, see http://www.weedsmart.org.au/10-point-plan/capture-weed-seeds-at-harvest/

The AHRI Web site has 'Rules of thumb for weed seeds', please see http://ahri.uwa.edu.au/rules-of-thumb/

VIDEO

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

For best results:

- Introduce sheep early, before crop canopy closes.
- Use older sheep.
- Use low stocking rates.
- Spray weeds along fence lines to concentrate sheep in crop.
- Remove sheep before they do too much damage to crop.
- Remove sheep before flowering.
- Observe grazing withholding periods if any chemicals are used in crop.

7.4.6 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 potential to remove the weed seed from cropping systems at harvest.[10]

Research by the Australian Herbicide Resistance Initiative (AHRI) 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. As faba bean can be harvested before wheat this presents an excellent opportunity to reduce the weed seedset.[11]

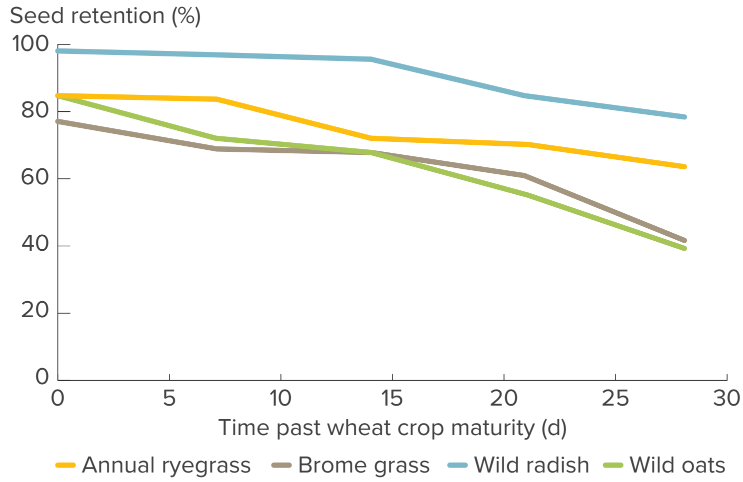

Figure 1: *Weed seed retention in WA measured from the date of wheat crop maturity.*

Source: Australian Herbicide Resistance Initiative (2014) [12]

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 remove chaff.

10 M Walsh, P Newman (2013) Cart, crush or cremate weed seeds to manage resistance. Herbicide Resistance, GRDC GroundCover™ Supplement, Issue 104, May–June 2013, pp. 8-9, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104

11 Australian Herbicide Resistance Initiative (2014) Rules of thumb. Australian Herbicide Resistance Initiative, http://ahri.uwa.edu.au/rules-of-thumb/

12 Australian Herbicide Resistance Initiative (2014) Rules of thumb. Australian Herbicide Resistance Initiative, http://ahri.uwa.edu.au/rules-of-thumb/

FEEDBACK

VIDEO

GRDC Video: Harvest weed-seed control for the high-rainfall zone, https://youtu.be/RrvQQYqSmdE

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;
- pulverising the chaff to crush and destroy the weed seeds before they exit the harvester – this can be achieved with the Integrated Harrington Seed Destructor; and
- in controlled-traffic farming, funnel chaff onto tramlines, confining weeds to a hostile environment separate from the crop.

Another weakness of weeds in southern Australian is that for many their seed does not remain viable in the soil for very long and seedbanks decline rapidly if not replenished each year.[13]

Harvest weed-seed control methods can lower a very large seedbank of more than 1,000 seeds/m^2 to 100 seeds/m^2 in only 4 years.[14] In paddocks with low ryegrass burdens harvest weed-seed methods reduced ryegrass emergence by as much as 90%.[15] Paddocks with high ryegrass burdens (>2,000 seeds/m^2) were less responsive, with a 30–40% reduction in ryegrass emergence. This means that harvest weed seed management will take longer to lower ryegrass populations in highly infested paddocks where the residual seedbank is still being exhausted.

Trials in SA and NSW showed that narrow windrow burning and the chaff cart proved as effective as the Harrington Seed Destructor at removing ryegrass seed and cost a similar amount per hectare to destroy ryegrass seed [16]

7.4.7 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.

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

While green and brown manuring cost money without providing an income, the benefits 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 topping.

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

The best crops for manuring are those with good early vigour that are effective at suppressing weed growth. As faba bean provide poor early groundcover, they are not as good as field pea or vetch, but they are better than chickpea. Total biomass is important to maximise the nitrogen benefit so choose a variety that is most likely to produce the highest biomass.

If the growth of the crop is reduced by disease, weeds, drought or sowing time then the nitrogen benefit will also be reduced.

Some in-crop herbicides are still required to maximise crop competitiveness and prevent weeds from getting too large to control. When aiming to control weed

13 M Walsh, P Newman (2013) Cart, crush or cremate weed seeds to manage resistance. Herbicide Resistance, GRDC GroundCover™ Supplement, Issue 104, May–June 2013, pp. 8-9, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104

14 M Walsh, P Newman (2013) Cart, crush or cremate weed seeds to manage resistance. Herbicide Resistance, GRDC GroundCover™ Supplement, Issue 104, May–June 2013, pp. 8-9, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104

15 C Aves (2013) Mechanical options. Herbicide Resistance, GRDC GroundCover™ Supplement, Issue 104, May–June 2013, pp. 12, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104

16 C Aves (2013) Mechanical options. Herbicide Resistance, GRDC GroundCover™ Supplement, Issue 104, May¬–June 2013, pp. 12, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104

seedset, a later sowing date with pre-sowing knockdown will be more advantageous for weed control than sowing on time.

To maximise the effectiveness of herbicide-resistant-weed control, it is important to make sure they are controlled before seedset i.e. before the milky dough stage of the target weed. This may be before the peak dry matter and nitrogen fixing potential of the crop.

A second knockdown herbicide may be required to control weeds that were shielded from the first spray by the crop. Also check for and control regrowth after cutting.

7.5 Decision-support tools

Managing weeds is complicated and requires a long-term strategy. Decision-support models can be useful to assist with planning weed management strategy.

The Weed Seed Wizard (https://www.agric.wa.gov.au/weed-seed-wizard-0) is a computer simulation tool to help you understand and manage weed seedbanks for a range of different weeds and is relevant to all Australian grain-growing areas. It uses farm management records to simulate how different crop rotations, weed control techniques, irrigation, grazing and harvest management tactics can affect weed numbers, the weed seedbank and yields.

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

7.6 Free alert services for weeds

IN FOCUS

Growers can subscribe to newsletters that provide local pest and weed updates. The services listed below are all free.

National

- GrowNotes™ Alert on the latest weed, pest and disease issues in your area delivered via App, SMS, voice, email, social media or web portal (or a combination of preferred methods). Subscribe to this service on the GRDC website. (https://grdc.com.au/resources-and-publications/grownotes/alerts).

Victoria

- General grains information is available on the @VicGovGrains Twitter account (www.twitter.com/VicGovGrains), hosted by Agriculture Victoria. Additional services by Agriculture Victoria can be subscribed to on the GRDC website.

MORE INFORMATION

More information about free weed information services is available on eXtensionAus, extensionaus.com.au

FEEDBACK

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, http://pulseaus.com.au/growing-pulses/crop-protection-products

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

CropLife Australia, Herbicide Mode of Action Groups 2017, https://www.croplife.org.au/resistance.../2017-herbicide-mode-of-action-group

7.7 Using herbicides

Herbicides that are registered for use in faba and broad bean can be found using the Australian Pesticides and Veterinary Medicines Authority (APVMA) database. 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.

Use a herbicide that is legally registered for the particular use in the particular crop at the listed label rates. Using products off-label risks reduced efficacy, exceeded maximum residue limits (MRLs) and litigation.

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

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 (i.e. within the shortest time before harvest that a product can be applied); 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]

7.7.1 Residual and non-residual herbicides

Residual herbicides remain active in the soil for an extended period of time (i.e. months) and can act on successive weed germinations. Residual herbicides must be absorbed through either the roots or the shoots, or through 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 or irrigation, temperature and the herbicide's characteristics. Persistence will affect enterprise sequence (e.g. a rotation of crops such as wheat–barley–chickpeas–canola–wheat).

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.

7.7.2 Post-emergent and pre-emergent

These terms refer to the target and timing of herbicide application. Post-emergent refers to foliar application of the herbicide after the target weeds have emerged from the soil, while pre-emergent refers to application of the herbicide to the soil before the weeds have emerged.

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

MORE INFORMATION

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

CropLife webpage: Herbicide-resistant weeds in Australia, http://www.croplife.org.au/resistance-strategy/2017-herbicide-resistant-weeds-list/

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

CropLife booklet: *Herbicide-resistance management strategies*, http://www.croplife.org.au/resistance-strategy/2017-herbicide-resistance-management-strategies/

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

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

App: WeedSmart to estimate paddock risk (iOS only), https://grdc.com.au/resources-and-publications/app

7.7.3 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 (MUP) on behalf of the pulse industry and is actively involved in the pursuit of new permits and label registrations to meet industry needs.[18]

The current minor use permit for herbicides is:

- **PER14726**
  Imazamox for use in faba bean to control grass and broadleaf weeds.
  Current to 30 September 2019.

7.8 Herbicide-resistant weeds

Herbicide resistance continues to develop and become more widespread. It is one of the biggest agronomic threats to the sustainability of our cropping systems. In 2014 there were 39 weed species in Australia with resistance to one or more herbicide modes of action.[19]

The main reason resistance has developed is because of the repeated and often uninterrupted use of herbicides with the same mode of action (Table 4). Selection of resistant strains can occur in as little as 3–4 years if no attention is paid to resistance management. The resistance risk is the same for products that have the same mode of action.

All herbicides sold in Australia are grouped by mode of action, which is clearly indicated by a letter code on the product label.[20]

GROUP	A	HERBICIDE

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 (https://grdc.com.au/resources-and-publications/app) 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.

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

19 GRDC (2014) Integrated Weed Management Hub. GRDC, https://grdc.com.au/weedlinks

20 CropLife Booklet: Herbicide resistance management strategies http://www.croplife.org.au/resistance-strategy/2016-herbicide-resistance-management-strategies/

Table 4: Herbicide modes of action.

Resistance group	Mode of action
High resistance risk	
GROUP A	Inhibitors of acetyl co-enzyme A carboxylase (inhibitors of fat synthesis/ACC'ase inhibitors)
GROUP B	Inhibitors of acetolactate synthase (ALS inhibitors), acetohydroxyacid synthase (AHAS)
Moderate resistance risk	
GROUP C	Inhibitors of photosynthesis at photosystem II (PS II inhibitors)
GROUP D	Inhibitors of microtubule assembly
GROUP E	Inhibitors of wmicrotubule polymerisation
GROUP F	Bleachers: inhibitors of carotenoid biosynthesis at the phytoene desaturase step (PDS inhibitors)
GROUP G	Inhibitors of protoporphyrinogen oxidase (PPOs)
GROUP H	Bleachers: inhibitors of 4-hydroxyphenyl-pyruvate dioxygenase (HPPDs)
GROUP I	Disruptors of plant cell growth (synthetic auxins)
GROUP J	Inhibitors of lipid synthesis (not ACCase inhibitors)
GROUP K	Inhibitors of cell division / inhibitors of very long chain fatty acids (VLCFA inhibitors)
GROUP L	Inhibitors of photosynthesis at photosystem I via electron diversion (PSI inhibitors)
GROUP M	Inhibitors of 5-enolpyruvyl shikimate-3 phosphate (EPSP) synthase
GROUP N	Inhibitors of glutamine synthetase
GROUP O	Inhibitors of cell wall (cellulose) synthesis
GROUP P	Inhibitors of auxin transport
GROUP Q	Bleachers: inhibitors of carotenoid biosynthesis unknown target
GROUP R	Inhibitors of dihydropteroate synthase (DHP inhibitors)
GROUP Z	Herbicides with unknown and probably diverse sites of action

Source: CropLife Australia (2016) Herbicide mode of action table, CropLife website, http://www.croplife.org.au/resistance-strategy/2016-herbicide-moa-table/

Herbicide resistance evolves following the intensive use of herbicides for weed control.

In any weed population there are likely to be a small number of individuals that are naturally resistant to herbicides due to genetic diversity, even before the herbicides are used. When herbicide is used, these individual weeds survive and set seed, whereas the majority of susceptible plants are killed. Continued use of one herbicide, or herbicide group, will eventually result in a significant fraction of the weed population with resistance.

FEEDBACK

MORE INFORMATION

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

Australian Glyphosate Sustainability Working Group www.glyphosateresistance.org.au

GRDC Updates 2015: Herbicide-resistance management, a local, in-field perspective, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/07/herbicide-resistance-management-a-local-infield-perspective

VIDEO

GRDC Video: Glyphosate-resistant weeds, https://youtu.be/Ke8kIYNQzI8

VIDEO

See GRDC GroundCover™ TV Episode 19 for more about glyphosate resistance in feathertop Rhodes grass, https://youtu.be/Yk95mS_hvhM8

There are four main factors that influence the evolution of resistance:

1. The intensity of selection pressure.

This refers to how many weeds are killed by the herbicide. It is good practice to use labelled rates of herbicides to control weeds, as this will lead to the highest and most consistent levels of weed control. Failure to control weeds adequately will lead to increases in weed populations and put pressure on all herbicides used.

2. The frequency of use of one herbicide or mode of action group.

For most weeds and herbicides, the number of years of herbicide use is a good measure of selection intensity. The more often herbicide is applied the higher the selection pressure and the higher the risk of herbicide resistance developing.

3. The frequency of resistance present in untreated populations.

If the frequency of resistant genes in a population is relatively high, such as with Group B herbicides, resistance will occur quickly. If the frequency is low, such as with Group M herbicides, resistance will occur more slowly.

4. The biology and density of the weed.

Weed species that produce large numbers of seed, and have a short seedbank life in the soil, will evolve resistance faster than weed species with long seedbank lives.

Weed species with greater genetic diversity are more likely to evolve resistance.

Resistance is also more likely to be detected in larger weed populations.

7.8.1 Glyphosate (Group M)

Continued reliance on glyphosate is leading to increased resistance. The loss of glyphosate will increase the cost of weed management. Glyphosate-resistant weeds have a lower fitness and are more vulnerable to IWM techniques. Controlling weeds using integrated weed management will be more costly, but will have long-term benefits of delaying the development of resistance 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.

In 2017 glyphosate resistance was present in populations including annual ryegrass, awnless barnyard grass, liverseed grass, brome grass, red brome grass, windmill grass, flaxleaf fleabane, milk/sow thistle, wild radish, winter grass, willow-leaved lettuce, tridax daisy, feathertop Rhodes grass, sweet summer grass and prickly lettuce.[21]

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

7.8.2 Paraquat (Group L)

In 2017 paraquat-resistant weeds included capeweed, northern barley grass, barley grass, annual ryegrass, small square weed, silvergrass, cudweed, blackberry nightshade, crowsfoot grass and flaxleaf fleabane.

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

21 GRDC (2014) Integrated Weed Management Hub. GRDC, https://grdc.com.au/weedlinks

7.8.3 Other herbicides

Annual ryegrass in Australia is now resistant to 8 different herbicide groups.[22] The major herbicides are Group A (>20,000 sites in Australia), Group B (>20,000 sites) and Group D (>5,000 sites). Resistance to trifluralin (Group D) and the Dims (Group A) is increasing in southern Australia.[23]

Annual ryegrass is highly competitive against faba bean.

Clethodim (Group A) resistance is a major issue in pulse production. Clethodim is the last Group A herbicide that provides effective control of herbicide-resistant ryegrass. There are no highly effective alternatives to clethodim for controlling annual ryegrass in faba bean or canola. Medic, vetch and tares may also be resistant to clethodim.

Wild oats in some areas have a high rate of resistance to all of the Group A herbicides (Fops, Dims and Dens).

In trials with clethodim-resistant ryegrass at Roseworthy, South Australia, the sole reliance on pre-emergent herbicides failed to adequately manage annual ryegrass and there were large yield penalties for faba bean.[24] Early competition by ryegrass reduced bean yield. Tank-mixing butroxydim (Factor®) with clethodim gave improved ryegrass control and protected yield. Simazine pre-emergent combined with clethodim + butroxydim post-emergent are the most effective of the current registered options.

7.8.4 Managing herbicide resistance

Weedsmart (http://www.weedsmart.org.au/10-point-plan/) lists 10 ways to weed out herbicide resistance:

1. Act now to stop weeds from setting seed.
2. Capture weed seeds at harvest.
3. Rotate crops and herbicide modes of action.
4. Test for resistance to establish a clear picture of paddock-by-paddock status.
5. Never cut the rate.
6. Don't automatically reach for glyphosate.
7. Carefully manage spray events.
8. Plant clean seed into clean paddocks with clean borders.
9. Use the double-knock technique.
10. Employ crop competitiveness to combat weeds.

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. Techniques to manage resistant ryegrass include:

- Know your resistance status. What herbicides are 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-knock before seeding
- 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, etc.

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22 CropLife Australia (2016) Herbicide-resistant weeds, CropLife website, http://www.croplife.org.au/resistance-strategy/2016-herbicide-resistant-weeds-list/

23 G Brooke, C McMaster (2016) Weed control in winter crops 2016. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/content/agriculture/broadacre/guides/weed-control-winter-crops

24 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, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/07/managing-resistant-ryegrass-in-break-crops-and-new-herbicides-for-resistant-ryegrass

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

7.8.5 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 – 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: info@plantscienceconsulting.com.au
  http://www.plantscienceconsulting.com.au/
- **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: jbroster@csu.edu.au
  https://www.csu.edu.au/weedresearchgroup/herbicide-resistance

7.9 Risk of herbicide damage

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 bean varieties.

Plants weakened by herbicide injury are more susceptible to diseases, especially chocolate spot. The most common problems come from residual herbicides applied to prior cereal crops, but non-residual herbicides have also been implicated.

MORE INFORMATION

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

7.9.1 Herbicide residues

Pulse types differ in their sensitivity to residual herbicides used in earlier crop or fallow situations. Check the re-cropping period on the label of each herbicide used.

Group B:

- Lentil and chickpea are most vulnerable to sulfonylurea residues (e.g. chlorsulfuron, Logran®), with field pea, faba and broad bean the least. Residues persist longer in high pH soil. Moisture favours breakdown and residues will persist longer in dry conditions.
- At low pH (<6.5 pH in water) faba and broad bean are more sensitive to Monza® residues (sulfonylurea) than chickpea, lentil, lupin and field pea. All are sensitive at higher pH (>6.5 pH in water).
- Faba and 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 and broad bean are least sensitive to the imidazolinones (IMIs e.g. Spinnaker®, Raptor®, Midas®). Lentil is most sensitive. Lupin and vetch are intermediate.
- Raptor® (IMI) has no minimum re-cropping interval if field pea is being sown.
- IMI herbicides persist longer in heavy soils and under dry conditions.
- When Group B residues are present, there is an increased risk of damage from using another Group B herbicide in-crop.

Group I:

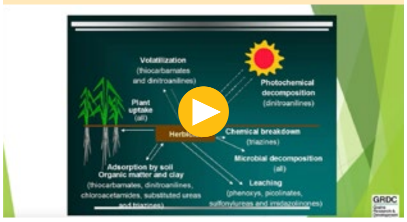
- All pulses are vulnerable to pyridine residues (e.g. clopyralid/Lontrel®) but beans are more vulnerable than lupin. Lontrel® is more likely to persist in stubble-retention systems.
- Spikes (e.g. dicamba, 2,4-D) used on late summer weeds or added to knockdown sprays may persist under dry conditions and can reduce pulse crop establishment. Some plant-backs require 15 mm of rain before the re-cropping period commences. Faba bean and lentil are not listed on label for these herbicides.
- Picloram and aminopyralid (e.g. Grazon Extra® and Tordon 75D®) applied to previous summer fallows are more likely to persist and damage crops under dry conditions. Residues from spot spraying of picloram can show up as bare patches in faba bean crops.
- Group I herbicides can accumulate on stubble and also persist longer under dry conditions.

VIDEO

GRDC Video: Pre-emergent herbicides – solubility and binding, https://youtu.be/s63GYYyflzw

VIDEO

GRDC Webinar: Stubble & soil binding of pre-emergent herbicides for annual ryegrass control in winter crops, https://youtu.be/mrJvg5ZmdOU



VIDEO

WeedSmart webinar: Understanding pre-emergent herbicides, http://weedsmart.org.au/webinars/setting-crops-up-for-success/

Group C:

- Triazine herbicides (e.g. simazine, cyanazine, terbuthylazine) applied in-crop can potentially cause crop damage in some circumstances. This also applies to diuron and metribuzin.
- They are more likely to persist in soil that is high pH, heavy or duplex.
- All residual herbicides require moist soil to break down. Where dry conditions have persisted between herbicide application and sowing, there will be a higher risk of residual herbicide damage.

7.9.2 Drift

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

7.9.3 Spray tank contamination with sulfonylurea herbicides

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 faba and broad bean and other legumes 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.

7.9.4 Minimising damage from pre- and post-emergent herbicides

Herbicide damage does not always result in reduced grain yield. Damage may be very obvious, such as scorched leaves, or it may be subtle, such as poor establishment or delayed maturity. Symptoms can easily be confused with symptoms produced by other causes, such as frost, disease or nutrition.

The risk of crop damage from a herbicide should be balanced against the potential yield loss from weed competition. In heavy weed infestations, some herbicide crop damage can be tolerated as this is easily offset by the yield loss avoided by removing competing weeds.

Some precautions for using pre-emergent residual herbicides can reduce the likelihood of crop damage:

- Do not apply if rain is imminent.
- Plant seed at least 7.5–10 cm deep.
- Avoid leaving a furrow or depression above the seed that could allow water (and chemical) to concentrate around the seed/seedling.
- Avoid leaving an exposed, open slot over the seed with disc openers and avoid a cloddy, rough tilth with tyned openers.

If 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. It may be more appropriate to use incorporation by seeding (IBS), or splitting the application between IBS and post-sowing pre-emergent (PSPE) to minimise risk.

Metribuzin leaches at almost 3 times the rate of simazine and 7 times the rate of diuron. The relative tolerance of the crop type and variety will also affect crop damage from these herbicides. For more specific details on soil-active herbicides and the risk of crop damage in your cropping situation seek advice from an experienced agronomist.

FEEDBACK

MORE INFORMATION

GRDC GrowNotes™ Spray Application manual for grain growers, https://grdc.com.au/GrowNotesSprayApplication

VIDEO

GRDC Video: Spray application workshop, https://youtu.be/UskthCWjeug

VIDEO

GRDC Webinar: Spray application in summer fallows, https://youtu.be/kDuz6ADMjA0

Some spray oils used with post-emergent selective-grass herbicides can cause minor leaf spotting and/or burning, which should not be confused with disease symptoms.

7.9.5 Symptoms of herbicide damage

Pulses have narrow crop safety margins to most registered herbicides.

Group A

Group A herbicides can occasionally cause leaf spotting in faba and broad bean (Photo 1). This is usually associated with either frost or high temperatures soon after spray application. Unlike with disease, new growth does not show spots (Photo 2).

Photo 1: *Group A grass herbicide. Chemical leaf spotting from oils in a group A herbicide applied post-emergent. Note that spots are numerous, small, irregular in shape and differ on top and bottom sides of leaf.*

Photo: R. Kimber, SARDI

Photo 2: *Group A grass herbicide. Chemical leaf spotting on lower leaves after application of a grass herbicide. Do not confuse this with Cercospora or Ascochyta leaf diseases.*

Photo: R. Kimber, SARDI

MORE INFORMATION

GRDC App: Herbicide injury: the Ute Guide, http://www.uteguides.net.au/UteGuides

Obtain a copy of the GRDC *Field Crop Herbicide Injury: The Ute Guide*, https://grdc.com.au/resources-and-publications/all-publications/bookshop

Group B

Seedlings may emerge and grow normally for several weeks before plants become stunted. Group B herbicides cause yellowing sometimes with a red-purple tinge (Photo 3). Damage is more common on areas where there has been overlapping such as headlands. Roots are often pruned and this leads to other symptoms such as nutrient deficiency (often zinc) and greater risk of disease development. Symptoms can be more severe in compacted soil.

IMI products that are registered for use in faba bean can still cause problems under dry conditions, when residues remain in the soil and where there is spray overlap.

Photo 3: *Group B imazethapyr (Spinnaker®) damage.*

Photo: Wayne Hawthorne, formerly Pulse Australia

Group C

The group C chemistry applied post sowing pre-emergent in low-rainfall areas and on light soils can often lead to crop damage reducing establishment and plant growth. This mainly occurs when rainfall washes herbicide applied to dry soils into the seed furrow, or on calcareous soils where these herbicides are highly soluble.

Initial symptoms are stunting and chlorosis and then as the herbicide accumulates in the tips and margins there is bleaching and necrosis (Photo 4).

Photo 4: *Group C simazine. High rates of simazine can damage faba bean. Lower leaves turn black and die back from the edge.*

Photo: Allan Mayfield, Grain Legume Handbook (2008)

Group D

Trifluralin can cause stunted plants (Photo 5). Emergence may be intermittent with plant shoots are shortened or unable to emerge. Emerging leaves can be twisted and distorted. Roots can be shortened and thickened.

Photo 5: *Group D trifluralin. Trifluralin injury (left) causing stunted growth. It can also cause development of multiple growing points.*

Photo: C. Preston, Univ. of Adelaide

Group F

Diflufenican (e.g. Brodal®) damage is usually white to yellow spots 3–4 days after application (Photo 6). Plants turn light green and whole leaves to yellow to cream in colour. Effects disappear as new growth develops.

Photo 6: *Group F diflufenican. Symptoms of Brodal® (diflufenican) damage: white to pale yellow leaves with yellow blotches.*

Photo: Allan Mayfield, Grain Legume Handbook (2008)

Group G

Carfentrazone is a contact herbicide causing leaf spotting (Photo 7). Numerous white spots develop within 1–2 days of spraying. It can lead to desiccation and death in bean crops.

Photo 7: *Group G carfentrazone. Leaf spotting from spray droplets of Affinity® (carfentrazone).*

Photo: C. Preston, Univ. of Adelaide

Group I

Typical symptoms of Group I herbicides is twisting of the leaf and stem (Photo 8). The less obvious symptoms of residues may be slow growth, thickening and callusing of the stem and a proliferation of short lateral roots.

Spray drift can lead to less obvious symptoms such as narrow leaves with crinkled edges (Photo 9). Leaf spotting from MCPB can be confused with Ascochyta or chocolate spot (Photo 10).

Photo 8: *Group I. Beans are susceptible to Tordon® or Lontrel® residue in soil. Note the stem distortion and severe leaf curl.*

Photo: Allan Mayfield, Grain Legume Handbook (2008)

Photo 9: *Group I, 2,4-D. Spray drift causing narrow leaves with crinkled edges.*

Photo: Allan Mayfield, Grain Legume Handbook (2008)

Photo 10: *Group I, MCPB. Leaf spotting caused by MCPB herbicide can be confused with Ascochyta and chocolate spot infections in beans.*

Photo: Allan Mayfield, Grain Legume Handbook (2008)

Group J

Symptoms appear underground or as plants emerge with reduced or poor seedling emergence. Symptoms include pruned roots with stubby root knobs and shoots that are swollen and bright green.

Group K

Visual symptoms appear as the crop emerges with reduced or poor seedling emergence (Photo 11). In most cases weeds do not appear. Seedlings are malformed and twisted, with transitory crop yellowing.

Photo 11: *Group K damage (left) from Dual Gold® (metalachlor).*

Photo: C. Preston, University of Adelaide

Group L

Paraquat and diquat are contact herbicides and cause necrotic spots (Photos 12 and 13). Symptoms appear within hours of application. There may also be wilting and interveinal yellowing followed by browning and blackening of the leaf edges.

Plants shrivel up within 4 days of application if damage is severe. Signs are often worse on one side of the plant or stem. Effects disappear as new growth develops.

Photo 12: *Group L paraquat. Leaf spotting from spray droplets of paraquat.*

Photo: C. Preston, University of Adelaide

Photo 13: *Group L paraquat and diquat. Leaf damage and plant set-back from post-emergent application of SpraySeed® (paraquat plus diquat).*

Photo: Wayne Hawthorne, formerly Pulse Australia

Group M

Glyphosate typically causes yellowing of the leaves (Photo 14).

Photo 14: *Group M glyphosate. Limp leaves and yellowing after glyphosate application. Young leaves are stunted and twisted.*

Photo: C. Preston, University of Adelaide

FEEDBACK

MORE INFORMATION

For herbicide-tolerance trials, see NVT Online, http://www.nvtonline.com.au/herbicide-tolerance/

7.9.6 Herbicide tolerance trials

Faba and broad bean varieties differ in their herbicide tolerance, depending on season, soil type and rate of application. Herbicide labels generally do not reflect these subtleties.

Herbicide-tolerance trials in South Australia (alkaline sandy loam soils) demonstrate some of the varietal differences (Table 5).

Table 5: Herbicide tolerance of faba bean varieties to commonly used herbicides, South Australia.

Herbicide		Boxer Gold®	Diuron®	Outlook®	Simazine	Simazine	Lexone ®	Spinnaker®	Raptor®*	Status®*	Terbyne®
		Prosulfocarb + S-metolochlor	Diuron	Di-methenamid-P	Simazine	Simazine	Metribuzin	Imazethapyr	Imazamox	Clethodim	Terbuthylazine
Variety	**Years**	2015	2000-2015	2011-2013	2000-2015	2001-2008	2003-2010	2000-2015	2003-2015	2014	2009-2015
PBA Samira	2013 2015	✓(1)	✓(3)	✓(1)	✓(3)	-	-	✓(3)	**30-35** (2/3)	✓(1)	✓(3)
Farah	2002-2008	-	✓(7)	-	**N** (1/7)	**6-18** (3/7)	✓(6)	**28-39** (2/3)	**N** (3/6)	-	-
Fiesta	2000-2007	-	**N** (1/8)	-	**18** (1/8)	**21** (1/7)	✓(5)	**11-32** (2/8)	**N** (4/5)	-	-
Fiord	2000-2002	-	**N** (1/3)	-	**N** (2/3)	**N** (1/2)	-	**18-30** (2/3)	-	-	-
PBA Rana	2009-2011	-	✓(3)	✓(1)	✓(3)	-	**N** (1/2)	**14** (1/3)	**18** (1/3)	-	**N** (1/3)
Nura	2003-2015	✓(1)	✓(12)	✓(2)	**N** (2/12)	**N** (1/7)	✓(8)	**10-53** (8/12)	**8-20** (4/12)	✓(1)	**10** (4/6)
Rates (product/ha)		2.5 L	1 kg	1 L	1 kg	1.5 L	280 g	85 g	45 g	1 L	1 kg
Crop stage at spraying		IBS	PSPE	IBS	PSPE	6 weeks	PSPE	PSPE	3-4 leaf	3 node	PSPE

* Denotes an off label use. This use is not endorsed by this data and no responsibility will be taken for its interpretation.

The sensitivity of the variety is summarised, using the following symbols based on the yield responses across all trials:

- not tested or insufficient data

✓ (z) no significant yield reductions at recommended rates or higher than recommended rates in (z) trials

N (w/z) narrow margin, significant yield reductions at higher than recommended rate, but not at recommended rate, significant event occurring w years out of z years tested. Eg. (2/5) = tested for 5 years, 2 returning a significant yield loss

x% (w/z) yield reduction (warning) significant yield reduction at recommended rate in 1 trial only in z years of testing

x-y% (w/z) yield reductions (warning) significant yield reductions at recommended rate in w years out of z years tested.

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

Source: NVT Online (2016)

All varieties exhibit some yield loss to imazathapyr (Group B, IMI), but Nura⁽ᴾ⁾ appears to be more sensitive than others.

Raptor® (imazamox, Group B) has a narrow safety margin in all faba bean varieties. It can be applied post-emergent under APVMA permit. Field experience is that damage is more severe under moisture stress and conditions of slow growth. It should be considered a salvage option rather than a routine application.

Simazine (Group C) applied post emergence can be more damaging than when applied PSPE, especially with the variety Farah⁽ᴾ⁾. Simazine does have a narrow safety margin or some yield loss (to 21%) at standard rates.

Diuron (Group C) has been safe in Farah⁽ᴾ⁾ and Nura⁽ᴾ⁾ over 7 or more trials, but check current registration status with broadacre crops.

Broad bean are not evaluated in the tolerance trials, but visual observations from PBA breeding trials in the high-rainfall zone suggest that PBA Kareema⁽ᴾ⁾ and Aquadulce have a similar tolerance to registered herbicides as faba bean.

FEEDBACK

VIDEO

Watch GRDC Video: Pulse herbicide tolerance, https://youtu.be/j7JEfzclUfg

7.9.7 Breeding for improved tolerance

Faba bean lines with tolerance to imidazolinone herbicides (Group B) are currently being evaluated with potential for commercialization in 2018–19.[25] There is some cross-tolerance to other Group B herbicides in some of the lines.

Screening techniques have been developed for metribuzin tolerance (Group C). Low level tolerance has been identified in faba bean genetic resources and will be incorporated into breeding programs to improve the safety margin to currently registered use rates.

7.10 Knockdown herbicides

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

Group I herbicides used pre-sowing as spikes (e.g. dicamba) in knockdown sprays may persist under dry conditions and can reduce pulse crop establishment. Dicamba plantbacks require 15 mm of rain before the re-cropping period commences. Faba bean and lentil are not listed on the label. Alternative products with lesser or no residual may be more appropriate such as carfentrazone-ethyl, oxyfluorfen or flumioxazin (Group G).

A technique used with varying success by growers has been to sow faba and broad bean and then use a knockdown herbicide tank mixed with a pre-emergent herbicide to control germinating weeds just before the crop emerges. Faba and broad bean crops may take up to 28 days to emerge under cool, drying soil conditions, but under favourable warm, moist soil conditions may emerge after 7–10 days. Growers considering this option should sow deeper and carefully check their paddocks for the emergence of the faba and broad bean immediately before spraying. Done well, this can be an effective weed-control option.

Double-knock is the sequential application of two different weed-control tactics where the second tactic controls survivors from the first. A common technique is to apply glyphosate (Group M), followed 2–10 days later by paraquat/diquat (Group L). Non-chemical options such as burning or grazing may also be used.

It may be necessary to delay sowing for up to 2 weeks after rain to enable a greater percentage of annual weeds to emerge and so is not suitable for faba bean unless there is an early break (see Section 7.10 Knockdown herbicides for more information).

Please see the GRDC Update paper for details on optimising the impact of glyphosate, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2015/02/optimising-the-impact-of-glyphosate

The GRDC has produced a video on double-knock timing, please see https://grdc.com.au/Media-Centre/GroundCover-TV/2013/05/GCTV10/tNNRziB3MKc

Watch GRDC video: IWM: Double-knock applications – double-knock strategies for resistant weed populations, https://youtu.be/bL0sbdQAYK0

Watch GRDC Video: Double knock-applications – a grower's experience, https://youtu.be/pElEGsQDzBg

25 D Mao, J Paull, C Preston, S Yang, T Sutton and L McMurray (2016) Developing improved herbicide tolerance in pulse crops. GRDC Update Paper, 9 February 2016, https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2016/02/developing-improved-herbicide-tolerance-in-pulse-crops

7.11 Pre-emergent herbicides

Pre-emergent herbicides are essential because there are limited post-emergent options for broadleaf weed control in faba bean.

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.

With the continued development of Group A, Group B and Group D resistant populations of annual ryegrass and wild oats, growers are returning to older products to rotate herbicide-resistance groups.

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

Pre-emergent registrations for use on faba and broad bean include:

- Group B: imazethapyr (e.g. Spinnaker®)
- Group D: trifluralin (e.g. TriflurX®) and pendimethalin (e.g. Stomp®)
- Group J: triallate (e.g. Avadex®)
- Group C: cyanazine (e.g. Bladex®), simazine, terbuthylazine (Terbyne®), metribuzin (Sencor®) and some diuron brands (e.g. Diurex ®)
- Groups J+K: prosulfocarb + S-metolachlor (e.g. Boxer Gold®).

Outlook® (dimethenamid, Group K) and Sakura® (Pyroxasulfone, Group K) are registered in some pulses to provide control options for ryegrass that is resistant to other herbicide groups. However, Outlook® and Sakura® **ARE NOT REGISTERED FOR USE IN FABA BEAN** because they are too damaging. Most pre-emergent chemicals are very dependent on rainfall soon after application. They provide inconsistent or partial weed control under drier conditions.

Crop tolerance of several pre-emergent herbicides (i.e. trifluralin, prosulfocarb) is often related to spatial separation of the young crop from the herbicide. This depends on the level of solubility and potential movement in the soil of the herbicide, the crop establishment process, the level of soil displacement over the crop row, follow-up rainfall and physical nature of the seed furrow.

Incorporation by sowing (IBS) is generally considered safer on the crop than post-sowing pre-emergent (PSPE) in no-till sowing systems. There is little protection within the sowing row, or else there is potential for crop damage if soil is thrown into the seeding furrow.

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

7.11.1 Imazethapyr (Group B)

Imazethapyr is registered for the pre-emergent weed control in faba and broad bean and may be mixed with simazine. Listed weeds include deadnettle, Indian hedge mustard, wild radish and wireweed.

Do not use on faba bean on light, sandy soils. The risk of crop damage may be increased on alkaline soils in adverse growing conditions.

MORE INFORMATION

GRDC booklet *Soil behaviour of pre-emergent herbicides in Australian farming systems*, https://grdc.com.au/SoilBehaviourPreEmergentHerbicides

7.11.2 Trifluralin and pendimethalin (Group D)

Both trifluralin and pendimethalin are used on annual ryegrass and provide partial control of wild oats. They are also effective on a range of broadleaf weeds including wireweed.

When using trifluralin and pendimethalin on faba and broad bean, avoid shallow planting (below 2.5 cm). Very deep planting (below 5 cm) is usually safe. Be aware though that deep planting may also cause problems if the emerging shoots absorb greater quantities of the chemical. Affected shoots tend to swell and deform, and can result in a weak, patchy plant stand.

7.11.3 Triallate (Group J)

Triallate provides control of wild oats and assists in the control of trifluralin-resistant ryegrass when used in a mixture with trifluralin.

7.11.4 Cyanazine (Group C)

Cyanazine is recommended in combination with trifluralin or pendimethalin for control of annual ryegrass and wireweed.

7.11.5 Simazine (Group C)

Simazine alone controls a range of broadleaf weeds including capeweed, fumitory, mustards and geranium. It is often mixed with trifluralin or other products to provide a broader spectrum of both broadleaf and grass weed control including annual ryegrass and wild oats.

If grass weeds are present at application, consider tank-mixing with glyphosate or SpraySeed®.

Avoid shallow planting as tolerance of faba and broad bean is based on physical separation. Sow the crop at least 5 cm deep. Avoid overlapping when applying simazine, and double spraying on headlands. Simazine damage is more likely on lighter soils.

7.11.6 Terbuthylazine (Group C)

Terbuthylazine controls a wide range of broadleaf weeds, with some suppression of grasses, particularly if there is good soil moisture. It is generally safer on crops than the older triazine herbicides, atrazine and simazine.

7.11.7 Metribuzin (Group C)

Metribuzin is effective against grass and broad leaf weeds and has foliar and root uptake. However, activity is highly variable depending on soil type and environmental conditions such as light intensity, temperature, soil moisture and humidity.

Metribuzin is commonly used in pulse crops as a post-sowing-pre-emergent application, or in some cases as a post-emergent. However, it often results in crop damage and needs to be used with care.

7.11.8 Diuron (Group C)

Not all diuron brands are registered for use in faba and broad bean. As well, the APVMA is currently reviewing use of diuron with the intent of removing it from use. Some brands of diuron (e.g. Diurex®, some proprietary diurons) are currently registered for use IBS or PSPE in faba and broad bean in all states. Weeds controlled include capeweed, crassula, doublegee, erodium, wild radish, wild turnip, toad rush.

If applied IBS, diuron should be applied to bare soil prior to or at sowing and incorporated by the sowing operation. For PSPE, apply as a post-plant application to moist soil before weed and crop emergence. Use the lower rate on light, sandy soils

FEEDBACK

MORE INFORMATION

NSW DPI booklet *Weed control in winter crops 2017* can be found at: http://www.dpi.nsw.gov.au/content/agriculture/broadacre/guides/weed-control-winter-crops

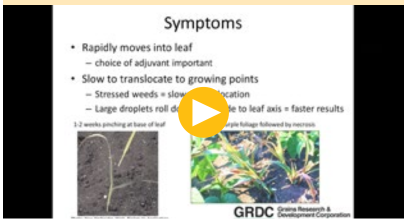
GRDC Fact Sheet: In-crop herbicide use, https://grdc.com.au/GRDC-FS-InCropHerbicideUse

VIDEO

GRDC video: Spray application: Group A herbicides, https://youtu.be/ev75wYd1lRg

VIDEO

A GRDC Webinar (Video/slides) on Grass weed control with Group A herbicides is at https://www.youtube.com/watch?v=HlkxBITNs1c



and do not apply to excessively ridged or waterlogged soils. Sow the crop at least 5 cm deep. Trifluralin or imazethapyr can be tank mixed at the recommended rates.

7.12 Post-emergent herbicides

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 results because crops cannot produce sufficient levels of the enzymes that normally break down the herbicide.

7.12.1 Broadleaf herbicides (Group B)

Imazamox (e.g. Raptor® WG) is the only broadleaf herbicide currently approved under permit for post-emergence use, and it is only used to a very limited extent. It is effective on cruciferous weeds (turnip etc).

Imazamox can result in significant crop damage in our environment, particularly where dry conditions are experienced after application. It usually causes some transient crop yellowing and can cause reddish discolouration and height suppression. Flowering may be delayed resulting in yield suppression. Stunting also causes stunting (Photo 15).

It is used mainly in salvage situations (as a last resort) and even then should only be applied under good growing conditions.

Photo 15: *Raptor® stunting. Raptor® in broad bean post-emergent (left) shows crop shortening but broadleaf weed control compared with untreated plot (right). Raptor® post-emergent can be damaging in beans, especially if dry conditions with growth under moisture stress.*

Photo: Wayne Hawthorne, formerly Pulse Australia

7.12.2 Grass herbicides (Group A)

Faba and broad bean are not highly competitive crops and early post-emergent grass control is often still required.

Control of grass weeds with post-emergent Fop or Dim (Group A) herbicides is often variable depending on the rate used and the level of herbicide resistance. This particularly applies where marginal rates of the Group A herbicides are being used because of cost constraints.

It is important to know your resistance status before selecting a grass herbicide.

Getting the spray application right is very important with Group A herbicides. They do not translocate readily so good coverage is needed. Larger droplet sizes that roll down the leaf blade into the leaf axis can provide faster results. Keep the nozzle pressure up when using oil-based adjuvants. If the pressure drops, the droplet can collapse resulting in large droplets with poor coverage.

Only spray grass herbicides when weeds are actively growing. Group A herbicides often fail to kill weeds if applied too soon after a frost. Other stresses such as drought and low nitrogen will reduce herbicide uptake and translocation resulting in less effective control.

Group A herbicides can occasionally cause leaf spotting in faba and broad bean. This is usually associated with either frost or high temperatures soon after spray application.

Traces of sulfonylurea herbicides that contaminate spray equipment used to apply post-emergent grass herbicides can cause significant damage to faba and broad bean crops. It is vitally important to properly clean and decontaminate spray equipment before applying herbicides. See product labels for specific product recommendations on decontamination.

The application of grass-selective herbicides also renders the crop more sensitive to damage from residues of herbicides applied previously.

7.13 Directed sprays

With the shift to cropping faba and broad bean on wide rows, weeds will have more time to become established between the rows, but it also provides the opportunity to use inter-row spraying.[26] This can be combined with fertiliser banding at sowing to favour the crop over the weed.

Shielded sprayers are becoming increasingly common in or around the cotton-growing areas, as they provide very cheap grass and broadleaf weed control with glyphosate.

The use of directed sprays of glyphosate and other chemicals, either alone or in tank-mixes with simazine, largely avoids the problem of crop damage and improves weed control through the ability to safely add wetters or mineral oils to the spray mix.

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.[27]

While faba and broad bean do have a degree of tolerance to glyphosate during the vegetative stage, caution is still required as the branches arising from the base and main stem contribute a large proportion of the total faba and broad bean yield. Shorter plants will be more susceptible to damage.

26 WL Felton, BM Haigh and S Harden (2004) Comparing weed competition in chickpea, faba bean, canola and wheat. 14th Australian Weeds Conference, Wagga Wagga, New South Wales, pp. 304-307, http://caws.org.au/awc/2004/awc200413041.pdf

27 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, pp 284-288.

Propyzamide is NOT currently registered for use on faba bean. However, the following trials have been conducted.

Field trials at Roseworthy, South Australia, looked at herbicide application strategies for herbicide-resistant annual ryegrass (*Lolium rigidum*) in wide row (54 cm) faba bean. Annual ryegrass is extremely competitive against faba bean particularly in wide rows.[28]

Standard farmer practice of PSPE simazine + post-emergent clethodim in the wide row achieved ≥96% control and had the best yield benefit for bean. In conventional row spacing (18 cm), this combination provided 84–95% control of ryegrass.

PSPE propyzamide alone provided 79–88% control, but is NOT REGISTERED FOR USE ON BEANS. PSPE propyzamide + shielded inter-row glyphosate or paraquat provided ≥93% control and reduced spike density (≤20 spikes/m^2), but were unable to reduce spike density within the crop row (20–54 spikes/m^2). Shielded spraying resulted in a 13–29% yield reduction (compared to propyzamide alone) that could be a result of spray drift onto the lower leaves. Improvements in timing, crop safety, and integrating with other early season control methods are still required for shielded spraying to become more effective. Some studies showed a greater damage from inter-row glyphosate than paraquat – this study did not.

7.14 Crop-topping

Faba bean provide the opportunity to crop-top for ryegrass and other weed seedset control. However, topping before physiological maturity of beans will reduce yield and may damage quality. Not all faba bean crops will be sufficiently mature at the right crop-top timing for the target weed.

As a later maturing crop, broad bean is not suited to crop-topping to prevent seedset in weeds.

However, when there is a sizeable population of problem weeds such as resistant ryegrass, any yield or grain quality reduction from crop-topping may be an acceptable compromise to achieve a reduction in ryegrass seedset.

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

Further information is available in Section 12 Harvest.

7.15 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.

28 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, pp 284-288.

Rather than spray a blanket amount of the herbicide across a paddock, the weed-detecting 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 16: *Selective sprayer technology uses optical sensors to turn on spray nozzles only when green weeds are detected.*

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

7.15.1 Permits for herbicides using weed detectors

Weed-detecting technology (via WeedSeeker®) is being used to manage glyphosate-resistant grasses in northern NSW fallows with the aid of a minor use permit. This allows growers in the region to use selective-grass herbicides and higher rates of paraquat and diquat (bipyridyl herbicides, Group L). The permit (PER11163) is in force until 28 February 2019 and is for all Australian states.

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 g of glyphosate per litre) rates range from 3–4 L/ha (using a set water rate of 100 L/ha), which far exceeds the label blanket rates of 0.4–2.4L/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.[29]

29 T Cook (2013) Selective spraying to cut costs. GRDC GroundCover™ Supplement, 6 May 2013, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104/Selective-spraying-to-cut-costs

FEEDBACK

MORE INFORMATION

For details on branched broomrape, please see the Plant Health Australia website: http://www.planthealthaustralia.com.au/wp-content/uploads/2013/03/Branched-broomrape-FS.pdf

7.16 Exotic weeds of faba bean

7.16.1 Branched broomrape (*Orobanche ramosa*)

Description and life cycle

Branched broomrape is a serious parasitic pest of lentil and faba bean in the Middle East.[30]

Orobanche spp., commonly known as broomrape, is a parasitic plant that attacks the roots of a considerable number of plant species. This includes a wide range of vegetables, pulses and pasture legumes.

Suitable hosts in Australia include lentil, faba bean, broad bean, chickpea, vetch, field pea, clover, cabbages, canola, capsicums, carrots, cauliflowers, celery, eggplant, lettuce, melons, potato, and tomato. Major crops attacked overseas include sunflowers and tobacco.

Orobanche spp. drains its hosts of nutrients, causing anything from 10–70% yield losses. Lentil and chickpea, for example, can suffer up to 50% yield loss, with remaining seed being of poor quality.

Of the 20 or so *Orobanche* spp. worldwide, five are particularly weedy. These are *O. aegyptiaca*, *O. cernua* var. *cernua*, *O. crenata*, *O. cumana* and *O. ramosa*. Only three *Orobanche* spp. are known to be present in Australia. O. *cernua* var. *australiana* is a native that does not attack crops.

Lesser broomrape (*O. minor*) is a common minor weed. An infestation of *O. ramosa*, or branched broomrape exists in South Australia. One *O. ramosa* plant can produce up to 500,000 seeds. As well as parasitising a range of pulse and vegetable crops, O. *ramosa* is the only broomrape to attack *Cannabis sativa*.

All *Orobanche* spp. are Australian Quarantine and Inspection Service (AQIS) prohibited imports. However, the seeds are very small, like dust, and could enter the country undetected.

The seeds can be spread in contaminated soil, on machinery, or by livestock. Even if these parasites become established in one location, Australian export markets could be affected as many of our trading partners prohibit *Orobanche* spp.

As *Orobanche* spp. has been identified as a major exotic threat, development of an emergency response is a priority.

The life cycle is shown in Figure 2.

30 M Owen, C Preston, S Walker (2013) Resistance rising across Australia. Herbicide Resistance, GRDC GroundCover™ Supplement, Issue 104, May–June 2013, pp. 6-7, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104

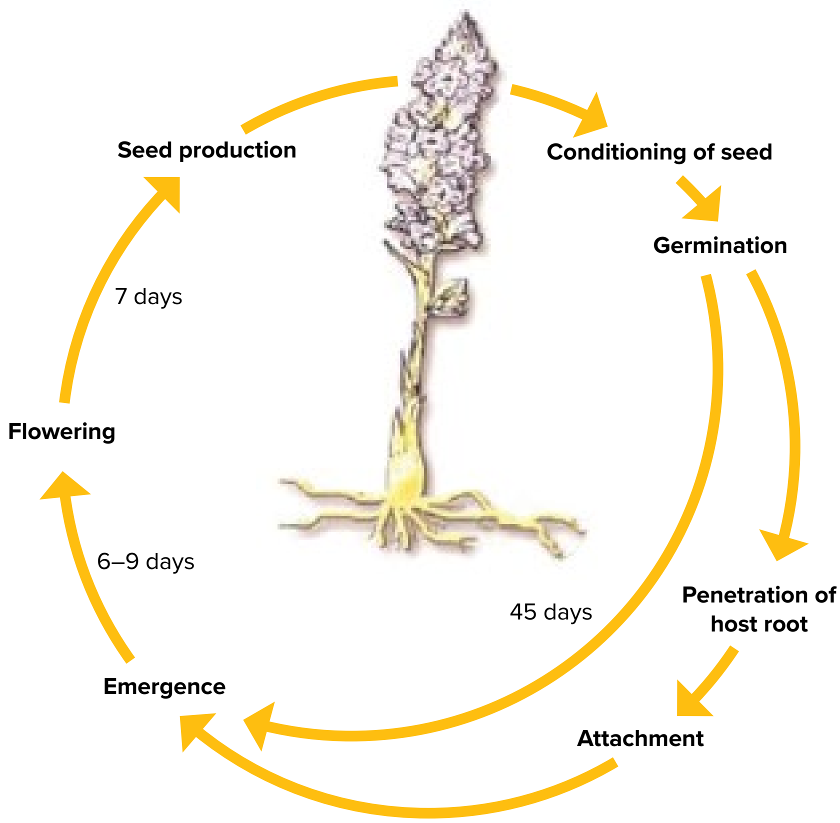


Figure 2: *Life cycle of branched broomrape.*

Source: Grain Legume Handbook (2008)

Photo 17: *Flowering branched broomrape.*

Source: Grain Legume Handbook (2008)

Photo 18: *Branched broomrape setting seed on capeweed.*

Source: Grain Legume Handbook (2008)

Flowers/seed head

Flowers: pale blue, tubular and two-lipped. Lower lip three-lobed and upper lip shallowly two-lobed. An erect spike of flowers appears in spring and summer (Photo 17).

Description

Mature plants are about 20 cm tall with several branches from ground level. Stems have dense, soft, woolly hairs on the upper part. Leaves are reduced to a few brown scales to 8 mm long. The capsule is enclosed in persistent corolla. Seeds are pepper-like, up to 40,000 per plant.

Distinguishing features

Branched yellow-brown glandular-hairy stems; absence of green parts; blue flowers.

Dispersal

Spread by seed (Photo 18).

Confused with

Other species of *Orobanche* in Australia; see a specialist to confirm identification.

Surveillance

As symptoms may be characteristic of a number of seedling weeds of lentil, plant samples of unknown or suspicious looking weeds should be sent for diagnosis.

Entry potential

High. Entry through seed, debris or soil contamination.

Establishment and spread potential

High as is a fine powder-like seed. Also spread by soil and debris to become problematic.

Economic impact

High. Yield and possible market losses could occur.

Overall risk

High