NORTHERN
SEPTEMBER 2018

GRDC GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

# CHICKPEA

## SECTION 6

## WEED CONTROL

PLANNING YOUR WEED CONTROL STRATEGY | HERBICIDE RESISTANCE | HARVEST WEED-SEED CONTROL | OTHER NON-CHEMICAL WEED CONTROL | HERBICIDES EXPLAINED | INTEGRATED WEED MANAGEMENT IN CHICKPEA | WEED ISSUES SPECIFIC TO CHICKPEAS | BROADLEAF WEED CONTROL | POST-EMERGENT GRASS WEED CONTROL | WEED CONTROL REQUIRES A PLANNED APPROACH | OTHER WEED CONTROL STRATEGIES | GRAZING STUBBLES OR FAILED CROPS | HERBICIDE PERFORMANCE | HERBICIDE DAMAGE IN PULSE CROPS | GETTING BEST RESULTS FROM HERBICIDES | CROP-TOPPING AND DESICCATION | MONITORING | MODE OF ACTION | FURTHER READING

October 2016

SECTION 6

# Weed control

## Videos

http://www.grdc.com.au/Media-Centre/Media-News/North/2013/05/Harvest-weed-seed-control-key-to-overcoming-resistance

## More information

http://www.grdc.com.au/uploads/documents/GRDC_HerbicideCard.pdf

http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/publications/nhrr

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/155148/herbicide-resistance-brochure.pdf

NSW DPI, Weed control in winter crops 2015

Pulse Australia (2016), Chickpea production: northern region

## More information

http://www.rbgsyd.nsw.gov.au/plant_info/identifying_plants/plant_identification_service

Weeds are estimated to cost Australian agriculture AU$2.5–4.5 billion per annum. For winter cropping systems alone, the cost is $1.3 billion. Consequently, any practice that can reduce the weed burden is likely to generate substantial economic benefits to growers and the grains industry. See more at www.grdc.com.au/weedlinks. [1]

Weed control is essential if the chickpea crop is to make full use of stored summer rainfall, and in order to prevent weed seeds from contaminating the grain sample at harvest. Weed management should be planned well before planting, with chemical and non-chemical control options considered. [2]

The Grains Research and Development Corporation (GRDC) supports integrated weed management. Download the Integrated Weed Manual.

Weed control is important, because weeds can:

- rob the soil of valuable stored moisture
- rob the soil of nutrients
- cause issues at sowing time, restricting access for planting rigs (especially vine-type weeds such as melons, tar vine or bindweed, which wrap around tines)
- cause problems at harvest
- increase moisture levels of the grain sample (green weeds)
- contaminate the sample
- prevent some crops being grown where in-crop herbicide options are limited, i.e. broadleaf crops
- be toxic to stock
- carry disease
- host insects

## 6.1 Planning your weed control strategy

1. Know your weed species. Ask your local adviser or service provider, or use the Sydney Botanic Gardens plant identification service, which is free in most cases (see link).
2. Conduct in-crop weed audits prior to harvest to know which weeds will be problematic the following year.
3. Ensure that seed is kept from a clean paddock (Figure 1).
4. Have a crop-rotation plan that considers not just crop type being grown but also the weed-control options this crop system may offer (e.g. grass control with triazine-tolerant (TT) canola).

[1] GRDC (2005) Weedlinks. Integrated weed management. GRDC, www.grdc.com.au/weedlinks

[2] DAFF (2012) Wheat—planting information. Department of Agriculture, Fisheries and Forestry, Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/planting-information

*Figure 1: Ensure that chickpea seed is kept from a clean paddock. (Photo: G. Cumming, Pulse Australia)*

## 6.2 Herbicide resistance

Herbicide resistance is an increasing threat across Australia's northern grain region for growers and agronomists. Already, 14 weeds have been confirmed as herbicide-resistant in various parts of this region, and more have been identified at risk of developing resistance, particularly to glyphosate.

In northern New South Wales (NSW), 14 weeds are confirmed resistant to herbicides of Group A, B, C, I, M or Z (Table 1). Barnyard grass, liverseed grass, common sowthistle and wild oat have confirmed cases of resistance to Group M (glyphosate) herbicides (Table 2). Glyphosate-resistant annual ryegrass has been identified within about 80 farms in the Liverpool Plains area of northern NSW (Figure 2). [3]

*Table 1: List of confirmed resistant weeds in northern NSW (as at November 2016)*

| Weed | Herbicide group and product/chemical (examples only) | Areas with resistance in NSW | Future risk | Detrimental impact |
|---|---|---|---|---|
| Wild oats | A. Topik® and Wildcat®<br>B. Atlantis®<br>Z. Mataven® | Spread across the main wheat-growing areas. More common in western cropping areas | Areas growing predominantly winter crops | High |
| Paradoxa grass | A. Wildcat® | North and west of Moree | Areas growing predominantly winter crops | High |
| Awnless barnyard grass | C. Triazines<br>M. Glyphosate | Mainly between Goondiwindi and Narrabri | No-till or minimum tilled farms with summer fallows | High<br>Very high |
| Charlock, black bindweed, common sowthistle, Indian hedge mustard, turnip weed | B. Glean®, Ally® | Spread across the main wheat growing areas | Areas growing predominantly winter crops | Moderate |
| Annual ryegrass | M. Glyphosate<br><br>B. Glean®<br>A. Verdict® | Group M widespread in Liverpool Plains.<br>Group A and B resistance in central west NSW | Areas with predominantly summer fallows.<br>Winter cropping areas | High<br><br>High |
| Fleabane | M. Glyphosate | Spread uniformly across the region | Cotton crops and no-till or minimum tilled systems | Moderate |

[3] A Storrie, T Cook, P Moylan, A Maguire, S Walker, M Widderick. Managing herbicide resistance in northern NSW, NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/155148/herbicide-resistance-brochure.pdf

| Weed | Herbicide group and product/chemical (examples only) | Areas with resistance in NSW | Future risk | Detrimental impact |
|---|---|---|---|---|
| Wild radish | I. 2,4-D amine | Central west NSW | Continuous winter cereal cropping | High |
| Windmill grass | M. Glyphosate | Central west NSW | Continuous winter cropping and summer fallows | High |
| Liverseed grass | M. Glyphosate | A few isolated cases | No-till or minimum tilled systems | Moderate |
| Sowthistle | M. Glyphosate | Liverpool Plains | Winter cereal dominated areas with minimum tillage | High |
| Feather-top Rhodes grass | M. Glyphosate | Widespread, more common in the north | No-till or minimum tilled systems, sorghum and cotton crops | High |

*Table 2: List of potential new resistant weeds in northern NSW (as at November 2016)*

| Weed | Herbicide group and product/ chemical (examples only) | Future risk | Detrimental impact |
|---|---|---|---|
| Barnyard, liverseed and windmill grasses | A. Verdict®<br>L. Paraquat | No-till and minimum tilled systems | Very high<br>Very high |
| Common sowthistle | I. 2,4-D amine | Winter cereals | High |
| Paradoxa grass | B. Glean®, Atlantis® | Western wheat growing areas | High |
| Other brassica weeds including wild radish | B. Glean®,, Ally® | Areas growing predominantly winter crops | Moderate |
| Annual ryegrass | L. Paraquat | Areas with predominantly summer fallows | Very high |
| Wireweed, black bindweed, melons and cape weed | I. 2,4-D amine, Lontrel®, Starane® | Areas growing predominantly winter crops | High |
| Fleabane | I. 2,4-D amine | Cotton crops and no-till or minimum tilled systems | Very high |
| Other fallow grass weeds | M. Glyphosate | No-till or minimum tilled systems | High |

## More information

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/155148/herbicide-resistance-brochure.pdf

http://www.grdc.com.au/uploads/documents/GRDC_NorthernWeeds.pdf

M Street, B O'Brien (2016), Report on the 2014 GOA herbicide resistance survey

*Figure 2: Glyphosate resistant annual ryegrass on the Liverpool Plains, NSW. (Photo: D. Freebairn)*

*Testing services*

For testing of suspected resistant samples, contact:

Charles Sturt University Herbicide Resistance Testing
School of Agricultural and Wine Sciences
Charles Sturt University
Locked Bag 588
Wagga Wagga, NSW 2678
02 6933 4001
https://www.csu.edu.au/__data/assets/pdf_file/0009/1688904/2015-report.pdf

Plant Science Consulting
22 Linley Ave
Prospect, SA 5082
0400 664 460
info@plantscienceconsulting.com.au
www.plantscienceconsulting.com

### 6.2.1 Be a WeedSmart farmer


*Figure 3: WeedSmart logo.*

The Australian grain industry stands at the crossroads with two options. Which direction will it take?

One road is for every grower to make herbicide sustainability their number one priority so that it influences decision-making and practices on all Australian grain farms. Armed with a clear 10-point plan for what to do on-farm, grain growers have the knowledge and specialist support to be WeedSmart (Figure 3).

On this road, growers are capturing and/or destroying weed seeds at harvest. They are rotating crops, chemicals and modes of action. They are testing for resistance and aiming for 100% weed kill, and monitoring the effectiveness of spray events.

In addition, they are not automatically reaching for glyphosate, they do not cut on-label herbicide rates, and they carefully manage spray drift and residues. Growers are planting clean seed into clean paddocks with clean borders. They use the double-knock technique and crop competitiveness to combat weeds.

On this road, the industry stands a good chance of controlling resistant weed populations, managing difficult-to-control weeds, prolonging the life of important herbicides, protecting the no-till farming system, and maximising yields.

The other option is for growers to think resistance is someone else's problem, or an issue for next year, or something they can approach half-heartedly.

If herbicide resistance is ignored, it will not go away. Managing resistance requires an intensive but not impossible effort. Without an Australia-wide effort, herbicide resistance

## Videos

Richard Daniel, NGA, discusses herbicide resistance tactics: http://www.weedsmart.org.au/media-releases/rethinking-weed-control/

threatens the no-till system, land values, yields and your hip pocket. It will drive down the productivity levels of Australian farms.

Jump on board WeedSmart and take the road of least resistance. [4]

### 6.2.2 Ten ways to weed out herbicide resistance

1. Act now to stop weeds from setting seed:

- Destroy or capture weed seeds.
- Understand the biology of the weeds present.
- Remember that every successful WeedSmart practice can reduce the weed seedbank over time.
- Be strategic and committed—herbicide resistance management is not a 1-year decision.
- Research and plan your WeedSmart strategy.
- You may have to sacrifice yield in the short term to manage resistance—be proactive.
- Find out what other growers are doing, and visit www.weedsmart.org.au.

2. Capture weed seeds at harvest. Options to consider are:

- Tow a chaff cart behind the header.
- Check out the new Harrington Seed Destructor.
- Create and burn narrow windrows.
- Produce hay where suitable.
- Funnel seed onto tramlines in controlled traffic farming (CTF) systems.
- Use crop-topping where suitable (southern and western grains region).
- Use a green or brown manure crop to achieve 100% weed control and build soil nitrogen levels.

3. Rotate crops and herbicide modes of action:

- Look for opportunities within crop rotations for weed control.
- Understand that repeated application of effective herbicides with the same mode of action (MOA) is the single greatest risk factor for evolution of herbicide resistance.
- Protect the existing herbicide resource.
- Remember that the discovery of new, effective herbicides is rare.
- Acknowledge that there is no quick chemical fix on the horizon.
- Use break-crops where suitable.
- Growers in high-rainfall zones should plan carefully to reduce weed populations in the pasture phase prior to returning to cropping.

4. Test for resistance to establish a clear picture of paddock-by-paddock weed status:

- Sample weed seeds prior to harvest for resistance testing to determine effective herbicide options.
- Use the ‘Quick Test’ option to test emerged ryegrass plants after sowing to determine effective herbicide options before applying in-crop selective herbicides.
- Visit the WeedSmart website, www.weedsmart.org.au or www.ahri.uwa.edu.au for more information on herbicide-resistance survey results.
- Collaborate with researchers by collecting weeds for surveys during the double-knock program (northern region).

[4] WeedSmart, http://www.weedsmart.org.au

**More information**

www.weedsmart.org.au

http://www.ahri.uwa.edu.au

http://www.grdc.com.au/BGC00001

5. Aim for 100% weed control and monitor every spray event:

- Stop resistant weeds from returning into the farming system.
- Focus on management of survivors in fallows (northern grains region).
- Where herbicide failures occur, do not let the weeds seed. Consider cutting for hay or silage, fallowing or brown manuring the paddock.
- Patch-spray areas of resistant weeds only if appropriate.

6. Do not automatically reach for glyphosate:

- Use a diversified approach to weed management.
- Consider post-emergent herbicides where suitable.
- Consider strategic tillage.

7. Never cut the on-label herbicide rate and carefully manage spray drift and residues:

- Use best management practice in spray application. The GRDC has produced a series of Fact Sheets, available at www.grdc.com.au.
- Consider selective weed sprayers such as WeedSeeker or WeedIt.

8. Plant clean seed into clean paddocks with clean borders:

- It is easier to control weeds before the crop is planted.
- Plant weed-free crop seed to prevent the introduction of new weeds and the spread of resistant weeds.
- A recent Australian Herbicide Resistance Initiative survey showed that 73% of grower-saved crop seed was contaminated with weed seed.
- The density, diversity and fecundity of weeds are generally greatest along paddock borders and areas such as roadsides, channel banks and fence lines.

9. Use the double-knock technique:

- Double-knock technique is the use of any combination of weed control that involves two sequential strategies; the second application is designed to control survivors of the first method of control used.
- Access GRDC research results at www.grdc.com.au or www.nga.org.au.

10. Employ crop competitiveness to combat weeds:

- Consider narrow row spacing and increased seeding rates.
- Consider twin-row seeding points.
- Use barley, canola and varieties that tiller well.
- Use high-density pastures as a rotation option.
- Consider brown manure crops.
- Rethink bare fallows. [5]

**More information**

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/Harvest-weed-seed-control

http://www.grdc.com.au/Research-and-Development/GRDC-Update-Papers/2012/04/What-percent-of-northern-weed-seed-might-it-be-possible-to-capture-and-remove-at-harvest-time-A-scoping-study

## 6.3 Harvest weed-seed control

Controlling weed seeds at harvest is emerging as the key to managing the increasing levels of herbicide resistance that are putting Australia's no-till farming system at risk.

For information on harvest weed-seed control and its application for the northern grains region, see *GrowNotes* (*Chickpeas*) *Section 12: Harvest*.

[5] WeedSmart, http://www.weedsmart.org.au

**Videos**

http://www.youtube.com/playlist?list=PL2PndQdkNRHGRipNhkDYN2dJWAY1-oH9W

http://www.grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS104/Lift-sowing-to-outcompete-weeds

http://www.ahri.uwa.edu.au

http://www.agronomo.com.au/giving-a-rats/

**More information**

http://www.grdc.com.au/Media-Centre/Hot-Topics/Herbicide-Resistance

## 6.4 Other non-chemical weed control

Crop rotation, especially with summer crops, can be an effective means of managing a spectrum of weeds that result from continuous wheat cropping. Barley is a more vigorous competitor of weeds than is wheat, and it may be a suitable option for weed suppression. Increased planting rates and narrow rows may also help where the weed load has not developed to a serious level. [6]

The use of rotations that include both broadleaf and cereal crops may allow an increased range of chemicals—say three to five MOAs—or non-chemical tactics such as cultivation or grazing. For the management of wild oats, the inclusion of a strategic summer crop such as sorghum means two winter fallows, with glyphosate an option for fallow weed control. Grazing and/or cultivation are alternative, non-chemical options.

Where continuous summer cropping has led to development of Group M resistant annual ryegrass, a winter crop could be included in the rotation and a Group A, B, C, D, J or K herbicide used instead, along with crop competition and potential harvest-management tactics.

For summer grasses, consider a broadleaf crop such as mungbean, because a Group A herbicide and crop competition can provide good control.

Strategic cultivation can provide control of herbicide-resistant weeds and those that continue to shed seed throughout the year. It can be used to target large, mature weeds in a fallow, for inter-row cultivation in a crop, or to manage isolated weed patches in a paddock. Take into consideration the size of the existing seedbank and the increased persistence of buried weed seed, but never rule it out.

Most weeds are susceptible to grazing. Weed control is achieved through reduction in seed-set and competitive ability of the weed. The impact is optimised when the timing of the grazing is early in the life cycle of the weed. [7]

## 6.5 Herbicides explained

### 6.5.1 Residual and non-residual

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

**More information**

L van Zwieten et al (2016), Herbicide residues in soils – are they an issue? (Northern)

The persistence of herbicides will affect the enterprise's sequence (a rotation of crops, e.g. wheat–barley–chickpeas–canola–wheat).

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

### 6.5.2 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,

[6] DAFF (2012) Wheat—planting information. Department of Agriculture, Fisheries and Forestry, Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/wheat/planting-information

[7] GRDC (2012) Herbicide resistance. Cropping with herbicide resistance. GRDC Hot Topics, http://www.grdc.com.au/Media-Centre/Hot-Topics/Herbicide-Resistance

whereas pre-emergent refers to application of the herbicide to the soil before the weeds have emerged. [8]

## 6.6 Integrated weed management in chickpea

Good weed control management is vital to successful and profitable crop production. Yield losses caused by weeds can vary enormously, from almost negligible to a complete loss.

Weeds lower crop yields by competing for soil moisture, nutrients, space and light and can carry diseases that attack crops. This competition reduces grain yield and quality, and can impede harvesting. Some weeds can restrict cropping options, as herbicides for control are sometimes limited. Investigate which weed species are likely to germinate in a paddock before sowing crops and determine the availability of suitable herbicide options.

**Videos**

Videos: IWM—Integrated weed management videos: http://www.youtube.com/playlist?list=PL2PndQdkNRHGRipNhkDYN2dJWAY1-oH9W

Weed control is a numbers game. Growers should aim to reduce weed numbers and keep them low with an ongoing program. A weed-management program should make the most of rotations and hence opportunities to use selective herbicides from a different herbicide group in each crop in the rotation to reduce the weed problem in the following crop. Care should be taken in planning a cropping rotation to avoid herbicide resistance, or growing a crop that may become a 'weed' or lead to uncontrolled weeds that cannot be controlled with selective herbicides in the subsequent crop.

An integrated weed management system combining all of the available methods is the key to successful control of weeds. [9]

### *Crop rotation*

A well-managed rotation in each paddock, which alternates pastures and broadleaf and cereal crops, is a very useful technique for controlling weeds. For example, chemical control of grass weeds is easier and cheaper in broadleaf crops, whereas control of broadleaf weeds is much easier in cereal crops. Good crop rotation management can substantially reduce the cost of controlling weeds with chemicals.

Pulses grown in rotation with cereal crops offer opportunities to control grassy weeds with selective herbicides that cannot be used in the cereal phases. This is possible only if the grower can still effectively use Group A chemistry. An effective kill of grassy weeds in pulse crops will reduce carry-over of root disease and provide a 'break crop' benefit in following cereal crops. Grass-control herbicides can control most grassy weeds in pulses. Volunteer cereals can also be controlled with some of these herbicides.

### *Good agronomic practice*

Practices such as using weed-free seed (preferably registered or certified) and sowing on time with optimal plant populations and adequate nutrition all contribute to good weed-control management. Some crops and varieties are more competitive than others against weeds. All weeds growing in a paddock should be controlled before the crop emerges. Large weeds that have not been controlled prior to, or by, the sowing operation prove most difficult and often impossible to remedy with in-crop herbicides.

### *Timely cultivation*

Timely cultivation is a valuable method for killing weeds and preparing seedbeds. Some growers use combinations of mechanical and chemical weed control to manage their fallows or stubbles. Increasing numbers of growers are using knockdown herbicides instead of cultivation for fallow commencement, as well as for pre-planting weed control in autumn.

[8] T McGillion, A Storrie (Eds) (2006) Integrated weed management in Australian cropping systems—A training resource for farm advisors. Section 4: Tactics for managing weed populations. CRC for Australian Weed Management, Adelaide, http://www.grdc.com.au/~/media/A4C48127FF8A4B0CA7DFD67547A5B716.pdf

[9] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

These practices are providing clear benefits to soil structure, as well as more timely and effective weed control.

## In-crop weed control

A wide range of pre-emergent and early post-emergent herbicides is available for in-crop weed control. Weeds should be removed from crops as early as possible, certainly no later than 6 weeks after sowing, if yield losses are to be minimised. Yield responses will depend on weed species, weed and crop density, and seasonal conditions. The growth stage of the weed and the crop are vital considerations when planning the use of post-emergent herbicides. Read herbicide labels carefully for relevant details and information on the best conditions for spraying.

http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0007/431269/Fleabane-management-in-crop-rotations.pdf

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/ngrt-results

## Herbicide resistance

Herbicide resistance is a problem that is becoming more widespread, and growers should be alert. It is one of the biggest agronomic threats to the sustainability of our cropping systems. However, the problem can be managed with good crop rotations, by rotating herbicide groups and by combining chemical and non-chemical methods of weed control (Table 3).

Options for control of broadleaf weeds with selective herbicides in chickpeas are generally limited compared with the treatments available for use in cereal crops.

*Table 3: Weed control options for integrated weed management (IWM)*

| | Herbicidal | Non-herbicidal |
|---|---|---|
| Crop phase | Crop-topping in pulse/legume crops | Rotating crops |
| | Knockdown herbicides, e.g. double-knock strategy before sowing | Rotating varieties |
| | Selective herbicides before and/or after sowing but ensuring that escapes do not set seed | Growing a dense and competitive crop |
| | Utilising moderate resistance risk herbicides | Cultivation |
| | Delayed sowing (as late as spring in some cases) with weeds controlled in the interim | Green/brown manure crops |
| | | Delayed sowing |
| | | Cutting crops for hay/silage |
| | | Burning stubbles/windrows. Chickpeas offer a very good opportunity to utilise this tactic. The lower biomass of stubble makes fires easier to manage |
| | | Collecting weed seeds at harvest and remove/burn |
| | | Destroying weed seeds harvested |
| | | (Use of Harrington Seed destructor) |
| Pasture phase | Spray topping | Good pasture competition |
| | Winter cleaning | Hay making or silage |
| | Selective herbicides but ensuring that escapes do not set seed | Cultivated fallow |
| | | Grazing |

Keep yourself informed and be pro-active in the prevention of, or fight-back against, resistance. [10]

### More information

For further information on resistance management strategies refer to Integrated Weed Management Manual on the following websites:
www.croplifeaustralia.org.au

www.glyphosateresistance.org.au

[10] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

## 6.7 Weed issues specific to chickpeas

Chickpeas are poor competitors with weeds because of slow germination and early growth. There are limited options for pre-emergent and post-emergent weed control. Chickpeas should always be planted into planned paddocks that have low weed populations. Please consult your agronomist for further information.

## 6.8 Broadleaf weed control

Paddock selection and effective application of pre-emergent broadleaf herbicide is critical in chickpea. Paddocks with a severe broadleaf weed problem should be avoided because broadleaf weed control is very limited in chickpeas.

Chickpeas are slow to emerge and initially grow slowly. They are notoriously poor competitors with weeds. Even moderate weed infestation can result in severe yield losses and harvesting problems. The best form of weed control is rotation and careful selection of paddocks largely free from winter weeds (e.g. double-cropped from sorghum or cotton, or country with a sequence of clean winter fallows).

### *Post-emergent herbicides*

Only one herbicide is currently registered for post-emergent use in chickpeas, Broadstrike® (active ingredient flumetsulam), and caution must be taken with its use. Broadstrike® gives good control of cruciferous species (turnip, etc.) but has no activity on many thistle species such as sow thistle and prickly lettuce. Broadstrike® can result in significant crop damage and can delay harvest, as is clearly stated on the label. Broadstrike® should mainly be used in salvage situations and even then should only be applied under conditions of good soil moisture and on very small, actively growing weeds, as per the label.

**More information**

www.apvma.gov.au/pubcris

### *Pre-emergent herbicides*

In the absence of safe post-emergent broadleaf herbicides, control is limited to a few pre-emergent herbicides such as Balance® (active ingredient isoxaflutole), simazine and Terbyne® (active ingredient terbuthylazine). Most of these chemicals are very dependent on rainfall for activation; hence, results are often limited under dry conditions.

Pre-emergent herbicides for use in chickpeas are generally registered for either incorporation by sowing or use as a post-sowing pre-emergent (PSPE). Please read the labels carefully to minimise the chance of crop damage.

It is important that broadleaf populations are considered when selecting a paddock for chickpea production. Broadleaf weeds should be heavily targeted in the preceding wheat or barley crop or fallow. Paddocks with severe broadleaf weed infestation should be avoided. [11] If broadleaf weeds that are not well controlled by registered broadleaf herbicides are present, then consider altering the cropping rotation until the weed species is controlled.

## 6.9 Post-emergent grass weed control

Control of post-emergent grass weeds is often inconsistent, with variable levels of control achieved. This particularly applies to many broadacre situations where marginal rates of Group A herbicides are being used.

More reliable and cost-effective control can be achieved through the adoption of a management package that addresses all of the following key issues:

- Correctly identify the weed.
- Match the product used to the weeds present.

[11] DAFF (2012) Chickpea—weed management. Department of Agriculture, Fisheries and Forestry, Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas/weed-management

- Weeds should be controlled when small, preferably at the 2–5 leaf stage.
- Larger weeds will require higher rates of Group A herbicides.
- Spray when weeds are actively growing and free from temperature, water, and nutritional stress.
- Weeds enter into moisture stress quickly, especially if secondary roots have not established.
- The leaves can also become water repellent under dry, dusty conditions.
- Seedling grasses stress very quickly and usually there is a narrow window of ideal conditions for applying Group A herbicides.
- Application techniques and boom sprayer setup are critical in achieving coverage of seedling grasses.
- Nozzle selection should be made to achieve a medium spray quality.
- Operating pressures should be >3 bar.
- Water volumes should be >60 L/ha.
- Use the preferred adjuvant listed on the product label.
- Know your resistance status. [12]

**More information**

http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/weed-control-winter-crops

### 6.9.1 Mode of action

All of the grass herbicides are systemic and rely on absorption through the leaves and translocation to the growing points (meristematic tissue) of the plant. Treated grasses usually stop growing within 1–2 days of spraying.

Visible symptoms first appear 7–10 days after treatment, usually as a yellowing of the youngest leaves and a browning of the growing points at the base of the youngest leaves. Unfurled leaves are easily pulled out, revealing brown rotting buds at the leaf base.

The young leaves turn pale and chlorotic and then brown off. The older leaves eventually collapse, with complete plant death occurring 4–6 weeks after spraying. Some weed species may also exhibit reddening of lower leaves and leaf sheaths.

### 6.9.2 Managing wild oats in chickpeas

Chickpea rotations provide an opportunity to control wild oats, which is otherwise a costly weed in a wheat-based system. [13] However, care should be taken to ensure that surviving weeds are identified and removed to reduce the chance of resistance developing.

Herbicide-resistant wild oats are becoming a key threat to sustainable northern farming systems. Herbicide resistance in wild oats poses management problems in any crop where these herbicides have previously been relied upon, but the threat appears greater to chickpea production.

Chickpeas are most at risk because they are a poorly competitive crop and often produced on wide rows. In addition, they have only Group A herbicides available for post-emergent control.

Chickpeas are the major northern winter rotation crop; therefore, any threat to chickpea production area could have a major impact on our regional farming system.

Effective use of crop rotation must be made to assist in management of wild oats. This will allow the use of the winter fallow and other effective herbicides (differing MOAs

[12] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

[13] DAFF (2012) Chickpea—weed management. Department of Agriculture, Fisheries and Forestry, Queensland, http://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/chickpeas/weed-management

including knockdowns) as well as improved crop competition to reduce seed-set of wild oats.

### *Winter fallow leading into, or out of, sorghum and other summer crops*

Winter fallow enables the use of low-risk knockdown herbicides such as glyphosate and paraquat to control the multiple wild oat germinations that will emerge through winter and spring. Atrazine can also be applied in spring before sorghum planting to assist in the control of late-emerging wild oats.

Two summer crops in succession will reduce the wild oat seedbank, particularly in a no-till system. This is primarily because weed seeds are removed from the seedbank faster if they are left on the soil surface. These seeds are exposed to fluctuations in temperature and moisture, which increases the rate of seed decay. Figure 4 shows that the seedbank of 'fop'-resistant wild oats declined to very low numbers after 2 years of total seed-set control in a no-till fallow. Starting with a higher initial seedbank would increase the time taken to reduce the seedbank to manageable levels for chickpeas. [14]

Wild oat seeds are relatively short-lived, with a half-life of about 6 months. This effectively means that if no new seed is allowed to develop, half of the seed reserves are depleted in 6 months, 75% in 12 months, and >92% in 2 years.

Maximum reduction of oat reserves will be achieved if seed-set is prevented over the course of two winter seasons, for example, by combining oat control in chickpeas with the inclusion of a sorghum crop in the rotation and a clean winter fallow.

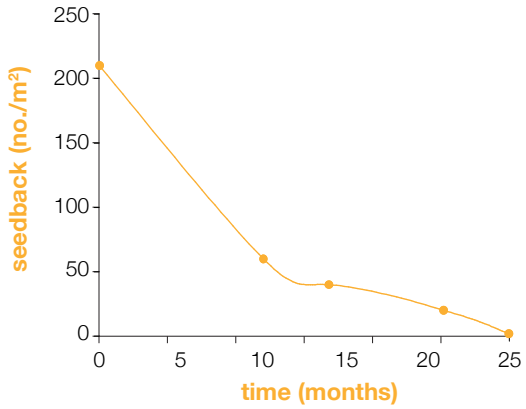


*Figure 4: Decline in wild oat seedbank with total seed-set control, North Star, New South Wales.*

**More information**

http://www.nga.org.au/results-and-publications/download/45/australian-grain-articles/weeds-1/wild-oats-in-chickpeas-tip-of-the-iceberg-september-2007.pdf

## 6.9.3 Avoidance of stress conditions

All grass herbicides labels emphasise the importance of spraying only when the weeds are actively growing under mild, favourable conditions. Any of the following stress conditions can significantly impair both uptake and translocation of the herbicide within the plant, likely resulting in incomplete kill or only suppression of weeds:

- moisture stress (and drought)
- waterlogging
- high temperature–low humidity conditions
- extreme cold or frosts
- nutrient deficiency, especially effects of low nitrogen
- use of pre-emergent herbicides that affect growth and root development, i.e. simazine, Balance®, trifluralin, and Stomp®

[14] A Storrie (2007) Managing wild oats in chickpeas—our practices must change. Northern Grower Alliance, http://www.nga.org.au/results-and-publications/download/45/australian-grain-articles/weeds-1/wild-oats-in-chickpeas-tip-of-the-iceberg-september-2007.pdf

- excessively heavy dews resulting in poor spray retentions on grass leaves

Ensure that grass weeds have fully recovered before applying grass herbicides.

Research from overseas has verified that translocation rates of fluazifop are 2–3 times higher in oats grown under high nitrogen status than in low-fertility situations (Table 4). [15]

*Table 4: Impact of low nitrogen fertility on translocation of fluazifop*

| | Uptake (% applied dose) | Translocation (% applied dose) | Translocated to youngest leaf (dpm[A]/mg) |
|---|---|---|---|
| Low nitrogen status | 69% | 9% | 8 |
| High nitrogen status | 63% | 26% | 24 |

Source: Dickson et al. 1990.
[A]Disintegrations per minute.

### 6.9.4 Grass herbicide damage in chickpeas

Group A herbicides can occasionally cause leaf spotting in chickpeas (Figure 5). This is usually associated with either frost or high temperatures occurring soon after spray application. [16]

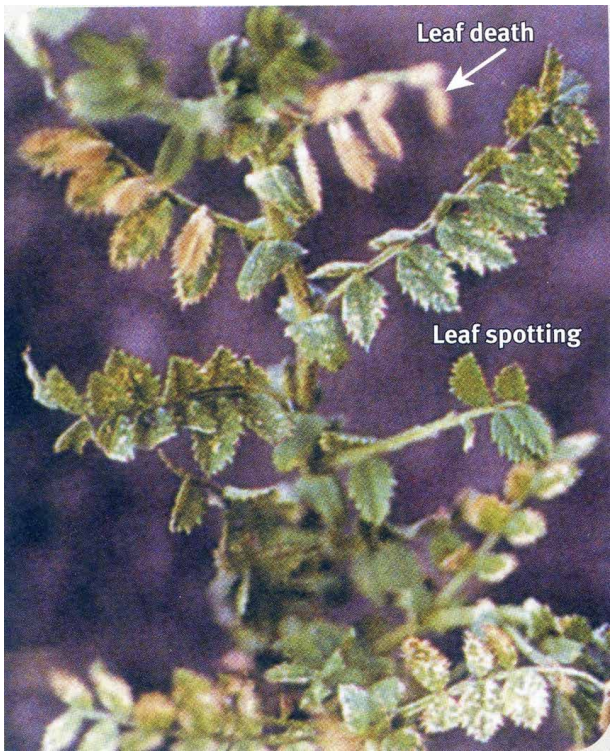


*Figure 5: Group A grass selective herbicide injury. (Photo: T. Bretag)*

### 6.9.5 Sulfonylurea residues in boom sprays

Traces of sulfonylurea (SU) herbicides in boom sprays have the potential to cause significant damage to chickpea crops (Figure 6). The risk of residue damage is greater in the presence of grass-selective herbicides.

[15] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

[16] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

Decontaminate the boom if you have previously used an SU herbicide. See product labels for specific product recommendations on decontamination.

*Figure 6: Damage to field peas from failing to decontaminate the spray tank after use of Eclipse®.*

## 6.10 Weed control requires a planned approach

Chickpeas are late-maturing compared with other pulses; hence, crop-topping to prevent ryegrass and other weed seed-set is not possible, even in the earliest maturing varieties (e.g. Genesis 079). Chickpeas are relatively slow to emerge, with slow early growth during the colder, winter months. Consequently, they are poor competitors with weeds. Even moderate weed infestations can cause large yield losses and harvest problems.

Trials in northern New South Wales and central Queensland have shown that populations of 5–10 turnip or 10 wild oat plants per m2 can cut yields by as much as 40–60% (D White 2000; J Whish 1998). Because of the slow growth and open canopy of chickpeas, narrow or wide row-spacing (30 *v.* 70 cm) made little difference to the chickpea plant's ability to compete with weeds.

Broadleaf weed control options can be very limited in chickpeas, and this is a reason producers commonly give for not growing chickpeas.

The weed-control strategy for growing a successful chickpea crop is based on substantially reducing the viable weed seedbank in the soil before the crop emerges, as post-emergence weed control options are limited.

Selection of paddocks that are relatively free or carry only a low burden of grass and broadleaf weeds is important.

Broadleaf weeds must be heavily targeted in the preceding crop and/or fallow. Always assess the broadleaf weed risk prior to planting.

This should be based on:

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

Paddocks with a severe broadleaf or grass weed problem should be avoided. [17]

### 6.10.1 Knockdown herbicides

The most important part of a weed-control strategy is to control the majority of weeds before seeding, either by cultivation or with knockdown herbicides such as glyphosate or SPRAY.SEED®

A technique used with varying success by growers has been to sow chickpea and then use a knockdown herbicide tank-mixed with a pre-emergent herbicide to control

[17] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

germinating weeds before the crop has time to emerge. Chickpea crops may take up to 21 days to emerge under cool, drying soil conditions, but under favourable warm, moist soil conditions, they may emerge after 7 days. Growers considering this option should sow deeper (10–15 cm) and carefully check their paddocks for the emergence of the chickpeas immediately before spraying. Done correctly, this can be an effective weed-control option. [18]

### 6.10.2 Pre-emergent herbicides

These herbicides are primarily absorbed through the roots, but there may also be some foliar absorption (e.g. Terbyne®). When applied to soil, best control is achieved when the soil is flat and relatively free of clods and trash. Sufficient rainfall (20–30 mm) to wet the soil through the weed root-zone is necessary within 2–3 weeks of application. Best weed control is achieved from PSPE application because rainfall gives the best incorporation. Mechanical incorporation pre-sowing is less uniform, and so weed control may be less effective. If applied pre-sowing and sown with minimal disturbance, incorporation will essentially be by rainfall after application. Weed control in the sowing row may be less effective because a certain amount of herbicide will be removed from the crop row.

#### *Weed control*

The absence of cost-effective and safe post-emergent herbicides effectively limits broadleaf weed control options in chickpeas to a small number of pre-emergent herbicides. Most of these chemicals are dependent on rainfall soon after application and, consequently, often result in inconsistent or partial weed control under drier conditions.

The pre-emergent herbicides alone will not adequately control large weed populations, and so they need to be used in conjunction with paddock selection and pre-seeding weed control.

Selection of the appropriate pre-emergent herbicide can only be made after assessing such factors as weed spectrum, soil type, farming system and local experience.

Refer to the complete product label for directions for use, application rates, weeds controlled and conditions for best results.

#### *Crop safety*

The safety of chickpea crops will depend in part on chemical tolerance of the crop and variety, in part on ensuring that the seed is below the treated soil, and in part on ensuring that there is no wash of herbicide into the seeding furrow.

Pre-sowing application is possible with some products and is often safer than post-sowing application because the sowing operation removes a certain amount of the herbicide from the crop row. Higher rates can often be used pre-sowing, but in both cases, the rate must be adjusted to soil type, as recommended on the product label.

The pH of a soil can strongly influence the persistence of herbicides. Many labels have warnings about high pH (≥8.0) and the need to reduce application rates to avoid crop damage.

The movement of herbicides down the soil profile after rain can affect crop safety. Movement is greater on sandy soils (and those with less organic matter), and so the rate must be lower than on heavier soils (loams, silt plus clay 40–60%).

Heavy rainfall following application may cause crop damage. This will be worse if the crop has been sown shallow (less than 3–5 cm), where there is light soil and where

**More information**

J Cameron, M Congreve (2016), Recropping issues with pre emergent herbicides

C Preston, S Kleemann, G Gill (2016), Coupling pre emergent herbicides and crop competition for big reductions in weed escapes

R Daniel (2016), Pre emergent herbicides: part of the package for FTR management?

[18] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

the soil surface is ridged. The soil surface should not be ridged as this can lead to herbicides being washed down and concentrated in the crop row. [19]

### 6.10.3 Pre-sowing (incorporation by sowing) herbicides

Herbicides that may be used in some situations with chickpeas include trifluralin (i.e. TriflurX®), pendimethalin (i.e. Stomp®), triallate (i.e. Avadex®), cyanazine (i.e. Bladex®), simazine and some diuron brands (e.g. Diurex®); these are registered for use on chickpea. Most require mechanical incorporation by sowing, and they are often used in mixtures.

**More information**

www.apvma.gov.au/pubcris

Registrations differ broadly across states, formulations and soil types. This is particularly true for weeds falling into the suppression ranges rather than those registered for outright control. Please consult your agronomist and read the labels of the products you are considering using. These herbicide labels also have information on the timing of incorporation, advice on how to avoid damage, as well as plant-back restrictions.

Most products work best if thoroughly mixed with soil, either mechanically or by irrigation or rainfall. The aim of incorporation is to produce an even band of herbicide to intercept germinating weed seeds. Some herbicide incorporation occurs when sowing is done with knife-points, provided sowing speed is adequate to throw soil into the inter-row without throwing into the adjacent seed furrow. Hence, these products are still compatible with the shift to minimum tillage and reduced-tillage farming practices. However, there may be insufficient soil throw with some low-disturbance, disc seeding systems.

Typically, a follow-up, post-emergent grass weed herbicide is still required to provide the level of grass weed control desired by growers, particularly in the seed furrow.

With the continued development of Group A, Group B and Group D resistant populations of annual ryegrass and wild oats, growers are again using these ‘older’ products as part of their resistance strategy because of the opportunity that they provide to rotate chemical groups.

### 6.10.4 Post-sowing pre-emergent (PSPE) herbicides

Herbicides that may be suitable for PSPE applications to chickpeas include simazine, Balance®, Terbyne®, prometryn and diuron. As with pre-sowing herbicides, registrations differ broadly across states, formulations and soil types, and the same advice applies regarding consulting your agronomist and reading product labels.

### 6.10.5 Post-emergent herbicides

Flumetsulam (e.g. Broadstrike®) can result in significant crop damage in our environment, particularly if dry conditions are experienced after application. As stated on the product label, Broadstrike® usually causes some transient crop yellowing and can cause reddish discoloration and height suppression. Flowering may be delayed (Figure 7), resulting in yield suppression.

Broadstrike® is used mainly in salvage situations (as a last resort), and even then should be applied only under good growing conditions. Figure 8 depicts effective use of Broadstrike® against turnip weed adjacent to a chickpea crop.

With the shift into row-crop chickpeas, some growers are successfully using Broadstrike® as a directed spray into the inter-row area. This keeps a large proportion of the herbicide off the chickpea foliage and minimises crop damage.

[19] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

*Figure 7: To control turnip weed, a single boom width of Broadstrike® was applied. Flowering and maturity of treated chickpeas (left) was delayed significantly, so they are still green compared with the untreated chickpeas that have matured (right). (Photo: G. Cumming, Pulse Australia)*

*Figure 8: The same single boom width of Broadstrike® applied along the chickpea crop edge (centre) alongside the unsown, weedy headland (right) and untreated crop (far left). Broadstrike® did an excellent job on the turnip weed (centre and unsown front) compared with the untreated headland (right). (Photo: G. Cumming, Pulse Australia)*

## 6.11 Other weed control strategies

### 6.11.1 Directed sprays in-crop

With the shift to row-cropping chickpeas on wide rows, there is increasing adoption of 'directed sprays' of Broadstrike®, either alone or in tank-mixes with simazine. This largely avoids crop damage and improves weed control through the ability to add wetters or mineral oils safely to the spray mix.

### 6.11.2 Shielded sprayers

These are becoming increasingly more common in or around cotton-growing areas, as they provide very cheap control of grass and broadleaf weeds with glyphosate.

Although chickpeas do have a degree of tolerance to glyphosate during the vegetative stage, caution is still required as the lower branches arising from the main stem make a large contribution to the total chickpea yield. Issues that need to be considered include:

- selection and operation of spray shields (speed, nozzle type, etc.)
- height of the crop (small chickpea plants are more susceptible)

- variety (upright types are more suited to this technique than the more prostrate types) [20]

## 6.12 Grazing stubbles or failed crops

When putting stock onto crop stubbles or failed crops, there are several considerations, the most important being:

- pulpy kidney
- acidosis, also known as grain poisoning
- nitrates or cyanides in weeds
- wind erosion of soil
- withholding periods

Some simple actions can overcome these issues:

- Ensure that stock have had their 5-in-1 vaccinations and boosters.
- Pulpy kidney is the weakest of the vaccines in 5-in-1, and it is cheap insurance to vaccinate again.
- Ensure that stock have a full rumen prior to going onto a crop.
- This can be easily done by providing hay or stubble as gut-fill.
- This will avoid over gorging on weeds or grain and give the rumen time to adjust to the change in feed.
- Spread large piles of grain out to minimise excessive intakes and risk of acidosis.
- Double-check previous crop chemical treatments and make sure all withholding periods are met before introducing stock.
- Slowly introduce stock to feed by allowing increasing periods over a week, starting with 2 hours.

Watch stock closely for the first week to ensure no problems occur, including unpalatability, which will result in decreased intake and loss of condition.

## 6.13 Herbicide performance

Characteristics that determine herbicide performance and activity are:

- herbicide uptake—how and where the chemical is taken up by the plant
- herbicide solubility—how readily it dissolves or leaches in soil water
- herbicide adsorption—how much is lost by binding to the soil
- herbicide persistence—how long it lasts on the soil, affected by:
- volatility, loss to the atmosphere
- leaching potential, i.e. how much is lost below the root-zone
- decomposition by light

Understanding these factors will assist in ensuring effective use of herbicide. For best performance, some pre-emergence herbicides (i.e. trifluralin) should be incorporated into the top 0–7.5 cm of soil. They must enter the germinating weed seedling in order to kill it. These herbicides can be mixed in by cultivation, rainfall or sprinkler irrigation, depending on the chemical.

Poor herbicide efficacy can occur under dry conditions at application. Some soil-active herbicides (e.g. Balance® or simazine) can damage chickpeas where wetter conditions favour greater activity and leaching. [21]

[20] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

[21] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

## 6.14 Herbicide damage in pulse crops

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 offset by the yield loss avoided by removing competing weeds.

If herbicide is applied to dry soils, the risk of crop damage is increased greatly when rains do occur, particularly if the soil is left ridged so that 'herbicide wash' into the seed row occurs. Incorporation by seeding may be more appropriate in dry conditions, or a split application to minimise risk. The PSPE herbicides should be applied to moist soil regardless of sowing time.

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

Herbicides have different leaching potentials, as shown by the leaching index (Table 5). For example, metribuzin leaches at almost three times the rate of simazine and seven times the rate of diuron.

*Table 5: Relative leaching of some soil-active herbicides (where 1 = the least leaching)*

| Chemical | Example of product | Leaching index |
|---|---|---|
| Pendimethalin | Stomp® | 1 |
| Trifluralin | Treflan® | 1 |
| Diuron | Diuron | 2 |
| Prometryn | Prometryn | 3–4 |
| Simazine | Simazine | 5 |
| Metolachlor | Dual Gold® | 6 |
| Atrazine | Atrazine | 10 |
| Metribuzin | Sencor® | 14 |

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 on the risk of crop damage in your cropping situation, seek advice from an experienced agronomist.

### 6.14.1 Symptoms of crop damage caused by herbicides

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

Herbicide injury may be obvious (e.g. scorched leaves) or it may be more subtle (e.g. poor establishment or delayed maturity) (Figures 9–14). Herbicide crop-injury symptoms can easily be confused with symptoms produced by other causes, such as frost (Figures 15 and 16), disease or nutrition.

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

Pulse crops can be severely damaged by some herbicides whether as residues in soil, contaminants in spray equipment, spray drift onto the crop, or by incorrect use of the herbicide.

Herbicide efficacy and crop safety of the new crop can suffer if the soil is dry at application time.

## More information

For descriptions and pictures of herbicide injury refer to 'Field crop herbicide injury: The ute guide' and 'Chickpea disorders: The ute guide'. Both are available from GRDC Ground Cover direct: http://www.grdc.com.au/uploads/documents/GRDC-GroundcoverDirectCatalogue201105-101.pdf

Taking some general precautions can help to reduce the likelihood of crop damage with residual herbicide use:

- Do not apply if rain is imminent.
- Maintain at least 7.5–10 cm soil coverage.
- 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 tined-openers. [22]

*Figure 9: Simazine post-sowing pre-emergent (PSPE) injury may be confused with frost injury. (Photo: G. Cumming, Pulse Australia)*

[22] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

*Figure 10: Balance PSPE injury. (Photo: T. Knights, NSW DPI)*

*Figure 11: 2,4-D spray drift causing stem twisting. (Photo: G. Cumming, Pulse Australia)*

*Figure 12: Glyphosate spray drift, causing narrowing (spear) of new leaflets. (Photo: G. Cumming, Pulse Australia)*

*Figure 13: Trifluralin injury causing stunted growth and development of multiple growing points. (Photo: A. Mayfield Consulting)*

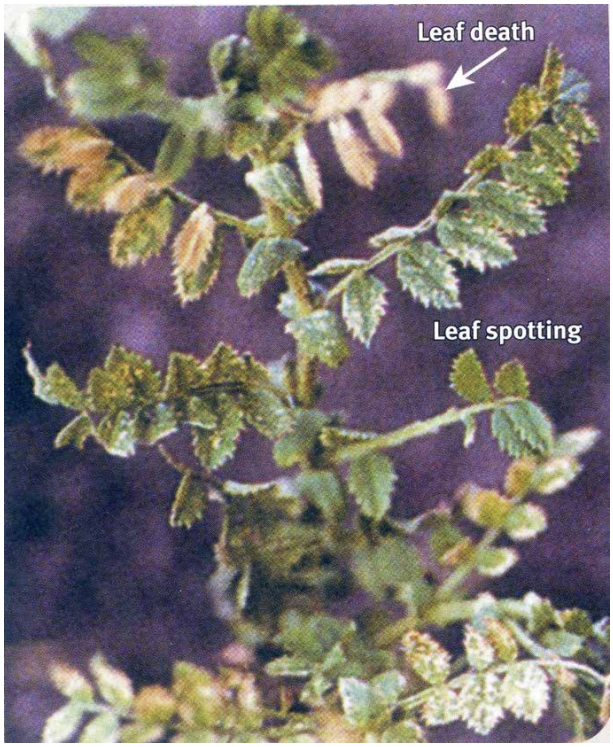


*Figure 14: Group A grass-selective herbicide injury. (Photo: T. Bretag)*

*Figure 15: Frost damage. (Photo: G. Cumming, Pulse Australia)*

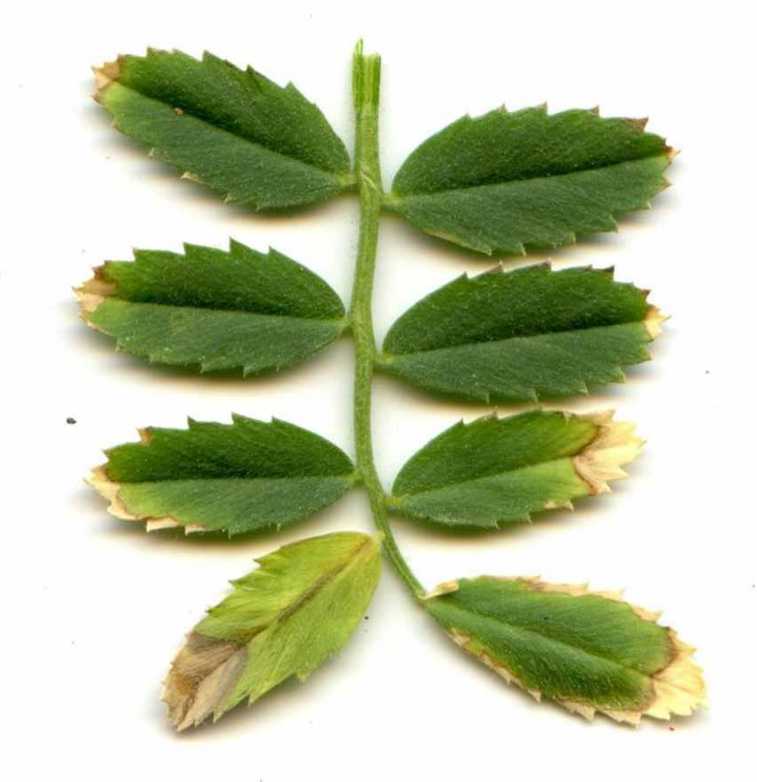

*Figure 16: Frost damage. Note the water soaking. (Photo: G. Cumming, Pulse Australia)*

### 6.14.2 Contamination of spray equipment

The importance of cleaning and decontaminating spray equipment for the application of herbicides cannot be over-emphasised. Traces of SU herbicides (such as chlorsulfuron, metsulfuron or triasulfuron) in spray equipment can cause severe damage to chickpea and other legumes when activated by grass-control herbicides. [23]

### 6.14.3 Spray drift

When applying pesticides the aim is to maximise the amount reaching the target and minimise the amount reaching off-target areas. This results in:

- maximum pesticide effectiveness
- reduced damage and/or contamination of off-target crops and areas

In areas where various agricultural enterprises co-exist, conflicts can arise, particularly from the use of pesticides.

Pulse crops can be severely damaged by some hormone herbicide sprays, such as 2,4-D ester, drifting into the crop. This can happen when those sprays are applied nearby in very windy or still conditions, especially where there is an inversion layer of air on a cool morning.

When using these hormone herbicides, spray when there is some wind, to mix the spray with the crop. Do not use excessively high spray pressure, as this will produce too fine a spray, which is more likely to drift onto a neighbouring pulse crop.

[23] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

All pesticides are capable of drift. People have a moral and legal responsibility to prevent pesticides from drifting and contaminating or damaging neighbours' crops and sensitive areas (Figure 17). [24]

*Figure 17: Glyphosate spray drift from the road verge on the left. Note the barrier effect of the tall weeds on the fence line. (Photo: G.D Bardell, Nufarm)*

**More information**

http://www.weedsmart.org.au/media/watch-out-for-residuals/

## 6.15 Getting best results from herbicides

Successful results from herbicide application depend on numerous interacting factors. Many of the biological factors involved are not fully understood and are out of your control, so give careful attention to the factors that you can control.

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

Points to remember for the successful use of herbicides:

- Plan the operation. Check paddock sizes, tank capacities, water availability and supply.
- Do not spray outside the recommended crop growth stages, as damage may result.
- Carefully check crop and weed growth stages before deciding upon a specific post-emergent herbicide.
- Read the label. Check to make sure the chemical will do the job. Note any mixing instructions, especially when tank-mixing two chemicals.
- Follow the recommendations on the label.
- Conditions inhibiting plant cell growth, such as stress from drought, waterlogging, poor nutrition, high or low temperatures, low light intensity, disease or insect attack, or a previous herbicide application, are not conducive to maximum herbicide uptake and translocation.
- Use good quality water, preferably from a rainwater tank. Water quality is very important. Hard, dirty or muddy water can reduce the effectiveness of some herbicides.
- Use good equipment checked frequently for performance and output.
- Use sufficient water to ensure a thorough, uniform coverage regardless of the method of application.

[24] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

- Check the boom height with spray pattern operation for full coverage of the target.
- Check the accuracy of boom width marking equipment.
- Check the wind speed. A light breeze helps herbicide penetration into crops. Do not spray when wind is strong (over 10–15 km/h).
- Do not spray if rain is imminent or when heavy dew or frost is present.
- Calculate the amount of herbicide required for each paddock and tank load. Add surfactant where recommended.
- Select the appropriate nozzle type for the application.
- Beware of compromising nozzle-types when tank-mixing herbicides with fungicides or insecticides.
- Be aware of spray conditions to avoid potential spray drift onto sensitive crops and pastures, roadways, dams, trees, watercourses or public places.
- Note that all chemicals can drift.
- After products such as Atlantis®, chlorsulfuron, Hussar® metsulfuron or triasulfuron have been used in equipment, it is essential to clean that equipment thoroughly with chlorine before using other chemicals. After using Affinity®, Broadstrike® or Eclipse®, decontaminate with liquid alkali detergent.
- Seek advice before spraying recently released pulse varieties. They may differ in their tolerance to herbicides.
- Keep accurate spray records for each spray operation. [25]

**More information**

http://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS105

## 6.16 Crop-topping and desiccation

With correct timing, crop-topping and desiccation can improve overall weed control and increase profitability in pulse crops. However, crop-topping is not possible in most chickpea crops.

Yield loss and grain quality impacts are severe when application timing is based on the correct ryegrass stage. However, crop-topping done when the chickpeas are ready is typically too late for preventing seed-set of the ryegrass.

Even early-maturing varieties such as Genesis™ 079 often mature too late to be safely crop-topped (see crop-topping trial data, Table 6).

The major differences between crop-topping and desiccation are:

- Herbicides used for crop-topping and desiccation are not always the same.
- Timing is not the same, as desiccation occurs after crop maturity. Crop-topping is earlier, aimed to reduce seed-set of weeds before crop maturity.
- Herbicides are registered for desiccation, as 'harvest aids', and rates used are higher than those used for crop-topping.
- Both desiccation and crop-topping will cause reduced grain quality and yield if applied at the wrong maturity stage of the crop.

See *GRDC GrowNotes (Chickpeas) Section 11: Crop desiccation.*

### 6.16.1 Crop-topping trials in chickpea

Key findings and comments from a South Australian Research and Development Institute (SARDI) crop-topping trial at Melton in South Australia in 2009 with chickpeas (Table 6) were as follows:

- A dry and hot November led to early senescence of pulse varieties and reduced grain yields in later maturing varieties. Many responses to the crop-topping

[25] Pulse Australia (2013) Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

treatments may have been masked by this rapid senescence (e.g. Almaz and Genesis™114 chickpeas).

- When crop-topped 3 weeks ahead of the recommended ryegrass stage, yields of chickpeas were 17–48% of the untreated control (i.e. a yield loss of 83–52%). When crop-topped at the recommended stage, yields of chickpeas were 69–86% of the untreated control (i.e. a yield loss of 31–14%). When crop-topped 2 weeks after the optimum ryegrass stage, yields of chickpeas were 92–114% of the untreated control. Grain size was less affected by crop-topping than was yield. However, visual grain quality may have been affected to prevent delivery under national receival standards.
- Mid–late-maturing pulse varieties also showed a yield loss when crop-topped later than recommended for ryegrass control. These results indicate poor suitability of some pulse varieties and crops such as chickpea to crop-topping.
- Early-maturing chickpea lines showed yield losses from crop-topping at the recommended timing, demonstrating the difficulty in employing crop-topping to prevent ryegrass seed set in chickpeas. [26]

*Table 6: Impact of timing of crop-topping on chickpea varieties of differing maturity in 2009*

| | Control yield (t/ha) | Yield (% of control) for each timing | | | Control grain weight (g/100 seeds) | Grain weight (% of control) for each timing | | |
|---|---|---|---|---|---|---|---|---|
| | | Minus 3 weeks (9 Oct.) | Recommended (30 Oct.) | Plus 2 weeks (12 Nov.) | | Minus 3 weeks (9 Oct.) | Recommended (30 Oct.) | Plus 2 weeks (12 Nov.) |
| AlmazA | 1.18 | 19 | 83 | 92 | 27.4 | 91 | 92 | 91 |
| PBA SlasherA | 1.96 | 30 | 70 | 99 | 15.5 | 87 | 84 | 100 |
| PBA HatTrickA | 1.37 | 36 | 69 | 85 | 18.1 | 77 | 81 | 93 |
| Genesis™079 | 2.09 | 25 | 80 | 107 | 18.0 | 95 | 104 | 104 |
| Genesis™090 | 1.43 | 25 | 84 | 97 | 22.1 | 79 | 93 | 93 |
| Genesis™114 | 0.90 | 17 | 86 | 114 | 22.1 | 96 | 102 | 104 |
| Genesis™509 | 1.96 | 32 | 71 | 96 | 13.6 | 129 | 101 | 94 |
| HowzatA | 1.70 | 21 | 72 | 94 | 16.6 | 87 | 87 | 117 |
| Sonali | 2.13 | 40 | 77 | 104 | 14.5 | 96 | 80 | 101 |
| Mean (t/ha) | 1.90 | 0.6 | 1.5 | 1.90 | 18.6 | 16.3 | 15.9 | 18.2 |
| Mean (g/100 seeds) | | | | | 18.6 | 16.3 | 15.9 | 18.2 |

Green shading denotes significant difference from the control (nil herbicide) treatment. Note: Always read the label supplied with the product before each use

Source: M. Lines and L. McMurray (SARDI), Southern Pulse Agronomy Research Trials.

## 6.17 Monitoring

Monitoring of weed populations before and after any spraying is an important part of management.

- Keep accurate records.
- Monitor weed populations and record results of herbicide used.
- If herbicide resistance is suspected, prevent weed seed-set.
- If a herbicide does not work, find out why.
- Check that weed survival is not due to spraying error.
- Conduct your own paddock tests to confirm herbicide failure and determine which herbicides remain effective.

[26] Pulse Australia (20130 Northern chickpea best management practices training course manual—2013. Pulse Australia Limited.

- Obtain a herbicide-resistance test on seed from suspected plants, testing for resistance to other herbicide (MOA) groups.
- Do not introduce or spread resistant weeds in contaminated grain or hay.

Regular monitoring is required to assess the effectiveness of weed management and the expected situation following weed removal or suppression. Without monitoring, we cannot assess the effectiveness of a management program or determine how it might be modified for improved results. Effective weed management begins with monitoring weeds to assess current or potential threats to crop production, and to determine best methods and timing for control measures.

Regular monitoring and recording details of each paddock allows the grower to:

- spot critical stages of crop and weed development for timely cultivation or other intervention;
- identify the weed flora (species composition), which helps to determine best short- and long-term management strategies; and
- detect new invasive or aggressive weed species while the infestation is still localised and able to be eradicated.

Watch for critical aspects of the weed-crop interaction, such as:

- weed seed germination and seedling emergence
- weed growth sufficient to affect crops if left unchecked
- weed density, height, and cover relative to crop height, cover, and stage of growth
- weed impacts on crops, including harbouring pests, pathogens, or beneficial organisms; or modifying microclimate, air circulation, or soil conditions; as well as direct competition for light, nutrients, and moisture
- flowering, seed-set, or vegetative reproduction in weeds
- efficacy of cultivations and other weed management practices

Information gathered through regular and timely field monitoring helps growers to select the best tools and timing for weed-control tactics. Missing vital cues in weed and crop development can lead to costly efforts to rescue a crop, efforts that may not be fully effective. Good paddock scouting can help the grower to obtain the most effective weed control for the least fuel use, labour cost, chemical application, crop damage and soil disturbance.

### 6.17.1 Weed monitoring—a practical approach

Check each paddock regularly and often enough to identify critical stages of crop and weed development for timely intervention, and to evaluate efficacy of weed-management practices. This weed scouting can be done whenever you search for insect pests and beneficials, or enter the paddock to plant, tend, irrigate or harvest crops. Inspect for weeds every few days during crop germination, emergence and early establishment. Later, checking once a week is usually sufficient.

To scout weeds, walk slowly through the paddock, examining any vegetation that was not planted. In larger paddocks, walk back and forth in a zigzag pattern to view all parts of the paddock, noting areas of particularly high or low weed infestation. Identify weeds with the help of a good weed guide or identification key for your region, and note the weed species that are most prominent or abundant. Observe how each major weed is distributed through the paddock. Are the weeds randomly scattered, clumped or concentrated in one part of the paddock?

Keep records in a field notebook. Prepare a page for each paddock or crop sown, and take simple notes of weed observations each time the paddock is monitored. Over time, your notes become a timeline of changes in the weed flora over the seasons and in response to crop rotations, cover crops, cultivations and other weed control practices. Many growers already maintain separate records for each paddock; weed observations (species, numbers, distribution, size) can be included with these.

### *When to scout, and what to look for in a new paddock or farm*

When purchasing farmland, it is important to look at the weeds. Presence of highly aggressive or hard-to-kill weeds, intense weed pressure, stressed and nutrient-deficient weeds, or a weed flora indicative of low or unbalanced soil fertility or pH may foretell problems that should be considered when deciding whether to buy or rent, or how much to offer.

During your first year or two on a new farm or paddock, study the weeds carefully throughout the season, and be sure to get correct identification of the 5–10 most common weeds.

Note the weeds that emerge, grow or reproduce at different times of the annual cropping cycle:

- over winter
- after primary tillage and during seedbed preparation
- after crop planting
- during crop growth and maturation
- after harvest
- during cover crop emergence and establishment

Questions to ask include:

- What are the main weed species present at different times of year?
- When does each weed species emerge, flower, and set seed?
- What paddocks or areas have the worst weed pressure? The least?

## 6.18 Mode of action

### 6.18.1 Mode of action matters

Resistance has developed primarily because of the repeated and often uninterrupted use of herbicides with the same mode of action. Selection of resistant strains can occur in as little as 3–4 years if attention is not paid to resistance management. Remember that the resistance risk remains for products having the same MOA. If you continue to use herbicides with the same MOA and do not follow a resistance-management strategy, problems will arise.

### 6.18.2 Mode-of-action labelling in Australia

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

The herbicide MOA grouping and labelling system in Australia was revised in 2007. This is the first major revision of the classification system since its introduction.

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

**More information**

Refer to the APVMA website to obtain a complete list of registered products from the PUBCRIS database: www.apvma.gov.au

Refer to the APVMA website to obtain a complete list of registered products from the PUBCRIS database: www.apvma.gov.au.

## 6.19 Further reading

Bayer Crop Science. 'Balance® technical guide for the control of certain broadleaf weeds in chickpeas.' 2nd edn. Bayer Crop Science, http://www.bayercropscience.com.au/resources/uploads/TechGuide/file7636.pdf

BCG and Hart Field Site Group (2007) Managing herbicide resistant ryegrass—Report on project BWD00005. GRDC Groundcover Direct.

G Brooke, C McMaster (2014) Weed control in winter crops. NSW DPI, http://www.dpi.nsw.gov.au/agriculture/broadacre/guides/weed-control-winter-crops

CRC for Weed Management (2012) 'Integrated weed management manual.' GRDC Weedlinks, www.grdc.com.au/director/events/linkpages/weedlinks?shortcut=1

CropLife Australia web site: www.croplifeaustralia.org.au/

CropLife Australia (2011) List of herbicide resistant weeds in Australia. CropLife Australia, www.croplifeaustralia.org.au/files/resistancemanagemen/herbicides/2011%20Herbicide%20Resistant%20Weeds%20List.pdf.

CropLife Australia Resistance Management Review Group and Industry Researchers (2011) 'Herbicide Resistance Crop Management Strategies.' CropLife Australia, www.croplifeaustralia.org.au/files/resistancemanagemen/herbicides/2011%20Herbicide%20Resistance%20Management%20Strategies.pdf

DAF (2007) Growing pulses in Western Australia—WA pulses. Department of Agriculture and Food WA, www.agric.wa.gov.au/PC_92171.html

GRDC (2002) Summer weeds: the Ute Guide. GRDC Groundcover Direct.

GRDC (2012) Field crop herbicide injury: the Ute Guide. GRDC Groundcover Direct.

GRDC Weeds: the Ute Guide—Southern & Western edition (Version 2). GRDC Groundcover Direct.

GRDC (2008) 'Grain legume handbook for the pulse industry.' Grain Legume Hand Book Committee, supported by the Grains Research and Development Corporation,

GRDC Integrated Weed Management. Ground Cover Supplement (GRDC321).

W Hawthorne (2007) Residual herbicides and weed control. Pulse Australia Bulletin, http://www.pulseaus.com.au/storage/app/media/crops/2007_SPB-Pulses-residual-herbicides-weed-control.pdf

D Holding, A Bowcher (2004) Weeds in winter pulses—Integrated solutions. CRC for Australian Weed Management Technical Series No. 9.

A Meldrum (2011) Desiccation and croptopping pulses. Australian Pulse Bulletin, Pulse Australia, http://www.pulseaus.com.au/growing-pulses/publications/desiccation-and-croptopping

P White et al. (Eds) (2005) Producing pulses in the northern agricultural region. Bulletin No. 4656. Department of Agriculture Western Australia, www.agric.wa.gov.au/objtwr/imported_assets/content/fcp/lp/bn4656_northern_pulse_manual.pdf