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WILD RADISH FACT SHEET

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WESTERN, SOUTHERN AND NORTHERN REGIONS

WILD RADISH MANAGEMENT AND STRATEGIES TO ADDRESS HERBICIDE RESISTANCE

Wild radish (*Raphanus raphanistrum*) is one of the most widespread and competitive broadleaf weeds of Australian cereal-growing regions. Increasing resistance to multiple herbicide modes of action is forcing the adoption of diverse and integrated weed-control strategies by growers dealing with this weed.

KEY POINTS

- Wild radish is one of the most widespread and competitive weeds of grain cropping.
- Wild radish has developed resistance to many herbicide modes of action. Many Western Australian growers have only one effective herbicide remaining.
- Resistance to phenoxy herbicides is widespread in WA and is also present in the eastern states.
- Populations resistant to glyphosate have recently been confirmed.
- Wild radish has significant seedbank dormancy: one year of seed allowed to go into the soil can mean more than six years of subsequent weed germinations.
- Often multiple germinations or cohorts occur each season.
- Seed can be captured at harvest and destroyed.
- The focus must be on preventing seed return to the seedbank. Effective management is based on control strategies that drive down weed seed numbers in the soil over time. This will require an integrated program of herbicide and non-herbicide tactics such as harvest weed-seed control and crop competition.

PHOTO: MARK CONGREVE

Wild radish grows to more than 50 centimetres high under good growing conditions and produces white, yellow or mauve flowers, often with purple veins.

Introduction

Wild radish is a widespread broadleaf weed in Australia and is found in almost all grain-growing regions. In addition to its widespread abundance, wild radish is:

- extremely competitive, causing substantial crop yield losses;
- highly persistent, due to strong seed dormancy;
- prone to resistance to a broad range of herbicide groups;
- able to block headers if in high density at harvest; and
- a potential contaminant of grain samples, especially wheat and canola.

These traits combine to make control difficult and expensive. Management is particularly difficult in pulse crops, as crop competition is poor and there are fewer herbicide options.

Integrating non-chemical weed-control tactics, including harvest weed-seed control, has proven popular and is effective in preventing further contribution to the seedbank.

Identification and ecology

Wild radish belongs to the *Brassicaceae* family. It is adapted to a wide range of soil types, particularly those with lightly acidic pH. Germination can occur all year round if adequate moisture is present, however. It has a preference for autumn and winter germination. Typically, there are multiple germination events per season.

Wild radish is an annual weed with distinctive heart-shaped cotyledons, which make early identification relatively simple. Plants form a rosette of strongly lobed leaves, and rosettes are often 20 to 40 centimetres in diameter before stem elongation commences, with a single stem rising to more than 50cm under good growing conditions. Flowers can be white, yellow or mauve, often with purple veins. Seed pods are frequently more than 5cm long and have strong constrictions between each seed.

Pod formation begins soon after the commencement of flowering. Late season herbicide treatments or other integrated control tactics, such as cutting for hay or silage, needs to be completed before the seed embryo develops. Seed embryo development commences approximately three weeks after flower initiation.

PHOTO: PETER NEWMAN

The distinctive heart-shaped cotyledons of wild radish make early identification relatively simple.

Embryo development can be identified by dissection of the immature wild radish seed. At this stage the seed pod will be squashy and watery when pressed between the fingers.

Mature wild radish plants have been shown to produce tens of thousands of viable seeds per plant, however, the number varies widely depending upon growing conditions and relative competition from the crop or pasture.

The largest germination occurs in the first or second season following recruitment to the soil seedbank, however, germinations can continue to occur for more than six years after recruitment.

Resistance status

In Western Australia, random wild radish weed-seed collection surveys of cropping paddocks have been conducted by the Australian Herbicide Resistance Initiative (AHRI). Table 1 shows the rapid development of resistance in WA as recorded by the surveys.

There is widespread resistance to many different herbicide modes of action (MOA), which limits the choice of herbicide control options. A summary of resistance status (as at 2014) is given in Table 2.

TABLE 2 Wild radish resistance to herbicide modes of action (2014)

MOA group	Resistance status and implications
B	• First reported in 1997 in WA, followed by SA in 2008. • Resistance now widespread across Australia. High levels of resistance exist to all of the sub-classes of Group B. However, there are some individual differences between the sub-classes in some populations. • Most growers are unlikely to rely on Group B chemistry alone for control of wild radish, however, Group B chemistry is frequently used for its value in controlling other non-resistant weed species.
C	• First reported in 1999 in WA. • Despite early detection of resistant individuals the spread of resistance has been slower than for many other modes of action. Group C chemistry is still used extensively for control of wild radish in a range of situations, however, some individual populations in WA now have high levels of resistance.
F	• First reported in 1998 in WA, followed by SA in 2006. • Resistance is now widespread, especially in WA. Typically Group F products will be mixed with MCPA or bromoxynil (or both) for use in cereals, although can be used alone in some legume crops.
G	• No resistance to Group G reported to date in Australia. • Registrations for use on wild radish typically require the addition of a Group I herbicide when used in cereal crops, or Group M or L when used in fallow.

H	• No resistance to Group H reported to date in Australia.
	• Due to the importance of this herbicide for controlling wild radish:
	  • apply in combination with a Group C mode of action where possible;
	  • do not apply consecutive applications of Group H products; and
	  • incorporate the use of integrated weed control tactics to prevent survivors setting seed e.g. harvest weed-seed control in cropping situations and double knock, cultivation and/or grazing in fallow situations.

I	• First reported in 1999 in WA followed by SA in 2006, Vic in 2009 and NSW in 2013. • Despite widespread and increasing resistance, phenoxys are still an important mixing partner for many herbicide strategies.
L	• No resistance to Group L reported to date in Australia.
M	• First reported in 2014 in WA. • The recent discovery of glyphosate resistance focuses attention on the need for diversity in both the crop and non-crop phases of the rotation. Where glyphosate resistance exists, growers will need to use a different mode of action and/or double knock applications for control in the fallow.

Source: The International Survey of Herbicide Resistant Weeds. www.weedscience.org/summary/home.aspx

Management

The key to long-term management is to drive the wild radish seedbank down to very low levels. Extended seedbank persistence means a concerted effort over many years is needed.

Crop competition can be a valuable tool for reducing weed numbers. Where possible strive for high sowing rates and narrow row spacing to maximise crop competition.

Wheat and barley compete more aggressively than broadleaf crops and there are generally a wider range of available herbicide options. Barley has some added benefits in that it provides even greater crop competition than wheat and, with a generally shorter growing season, sowing can be delayed to allow a germination and subsequent knockdown treatment prior to sowing. There are also differences in early season vigour and ground cover between cereal varieties that can be exploited.

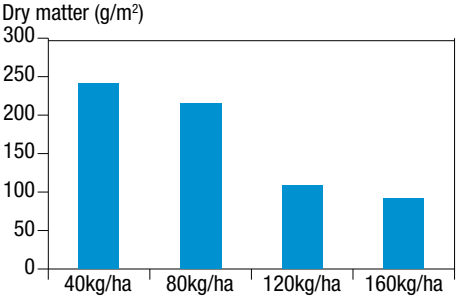
The most critical step is to do 'whatever

TABLE 1 Development of wild radish herbicide resistance across three surveys conducted in WA.

Herbicide	Mode of action herbicide group	Percentage of resistant populations		
		1998	2003	2010
Chlorsulfuron (Glean®)	B	21	54	84
Imaxamox + imazapyr (Intervix®)	B	–	–	49
2,4-D	I	–	60	76
Diflufenican (Brodal®)	F	–	39	49
Atrazine	C	–	15	1
Pyrasulfotole + bromoxynil (Velocity®)	H + C	–	–	0
Glyphosate	M	–	–	0

– Indicates samples were not tested
Source: Australian Herbicide Resistance Initiative www.ahri.uwa.edu.au/page/Research/Surveys/wild-radish#WR1998

FIGURE 1 Biomass of wild radish at different sowing rates of wheat (Binnu, WA, 2012).



SOURCE: Peter Newman and Christine Zaicou-Kunesch. 2013 WA crop updates. *Compete with weeds – Give your crop heaven and your weeds hell*

PHOTO: MARK CONGREVE

Don't let in-crop wild radish patches go to seed.

it takes to stop a weed-seed blowout'. If a spray failure occurs, radical and drastic action should be considered to prevent more seed from replenishing the seedbank, which will then need to be controlled for a further six or more years.

Thoroughly check all crops prior to commencement of flowering and if wild radish plants are detected, consider sacrificing that part of the crop via a spray-out (brown manuring), cultivation, slashing, cutting for hay or silage or hand rogueing. Wild radish seeds become viable within three weeks from the appearance of first flowers, so it is important to kill wild radish plants before this stage.

Some herbicides are registered for late season application as a salvage spray (always observe withholding periods). This can be a useful management tool in reducing the amount of viable seed that may return to the soil, provided the population is susceptible to that mode of action. However, these late season applications rarely provide 100 per cent weed kill or seed sterilisation, so are better used as another integrated tactic to further drive down weed seed numbers rather than a method relied on to 'fix blowouts'.

Harvest weed-seed control has proven to be an excellent non-chemical tactic to reduce wild radish numbers when applied to a paddock over multiple years, especially when used in conjunction with effective herbicides.

Significant wild radish seed is retained on the plant at harvest time. This will either be retained in the grain box, or will exit the header via the chaff fraction. This weed seed can be collected and removed from the paddock via chaff carts, concentrated into a windrow for burning in autumn, removed to machinery tracks in controlled-traffic farming systems, or delivered into a Harrington Seed Destructor and killed.

See 'More Information' for further details on harvest weed seed control.

Herbicide control remains a key tool for managing wild radish populations; however, the choice of herbicide is increasingly dictated by resistance to multiple modes of action (MOA). Typically, most herbicide strategies under high pressure situations will contain a mixture of two or three modes of action and two application timings.

One of the keys to effective herbicide control is to target small weeds. The timing of the first post-emergent application in cereals should be when weeds are a rosette of less than 5cm in diameter (the size of the top of a beer can). Ensure that application is thorough, including using high water rates, slow application speeds and correct nozzle selection.

Triazine-tolerant (TT), Clearfield® and Roundup® Ready canola varieties may also be useful tools as they allow the use of different herbicides in the canola phase of the rotation where populations are sensitive to these herbicides.

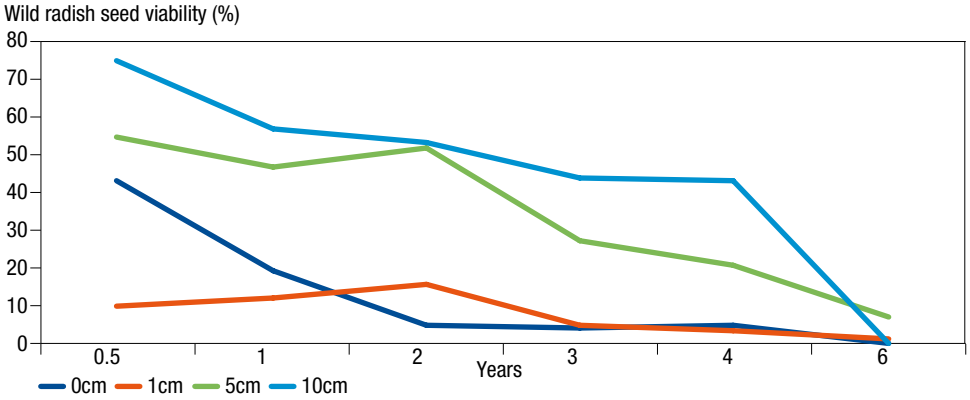
Some growers have resorted to full inversion tillage (for example mouldboard plough used with a skimmer, to place weed seed right at the bottom of the furrow) as a wild radish control option, where the aim is to bury the seed to a depth of more than 20cm, preventing germinating. However, deep burial of wild radish seed will increase the length of time that this seed remains viable in the soil, so further cultivation should be avoided for at least 10 or more years.

An integrated strategy for wild radish control

As each farming situation will be different, the farm adviser will need to tailor an integrated management program suited to each. The following is an example of a potential strategy to reduce the weed seedbank by preventing further additions to it.

Spray wild radish before plants reach this size.

FIGURE 2 Wild radish seed (%) remaining viable after burial at various depths over time.



SOURCE: Code, G.R., Walsh, M.J. and Reeves, T.G. (1987). Effect of depth and duration of burial of wild radish seed on seed viability and seedling emergence. Proceedings of the Weed Seed Biology Workshop. Orange, NSW, pp. 136–138.

Situation:

During cereal harvest in December, moderate levels (0.1 to 1 plants/m^2) of mature wild radish were noticed, indicating that the herbicide strategy employed was not completely effective. Seed from these plants was allowed to return to the soil at harvest. Previous control strategies had relied exclusively on herbicides, with choice of herbicide mixture largely selected by cost.

DURING OR JUST BEFORE HARVEST:
Conduct a resistance test

Collect seed from surviving plants and send away for resistance testing. Seed samples need to be dispatched before Christmas to ensure results are available for decision-making next season.

Knowing what herbicide options remain available is vital. When ordering your resistance test, it is critical to test for all the key herbicides that you may want to consider using the next season.

SUMMER YEAR 1:
Double knock in fallow

If climatic conditions result in summer germinations, ensure that these plants are not allowed to set seed.

With the recent discovery of glyphosate-resistant weeds, the double knock application strategy is recommended. This typically involves following the initial glyphosate (Group M) application with a second application of a paraquat-based herbicide (Group L) within 7 to 14 days. This second application is designed to control any resistant survivors of the initial application.

AUTUMN YEAR 1:
Autumn tickle and delayed sowing

Consider using an autumn tickle to stimulate germination. An autumn tickle (also referred to as an 'autumn scratch' or shallow cultivation) stimulates weed seed germination in wild radish and several other species. An autumn tickle can be conducted using a range of equipment including tyned implements, skim ploughs, heavy harrows, pinwheel (stubble) rakes, dump rakes and disc chains.

Follow with a knockdown herbicide and if possible use the double-knock strategy. As this may delay sowing, consider crop choice and variety carefully to select one suited to the later planting window.

AUTUMN YEAR 1:
Control germinations with a knockdown spray

If glyphosate resistance is suspected, or there has been a long history of glyphosate use, then consider using a paraquat-based product.

Group G herbicides can be added to either

SOURCE: MARK CONGREVE

PHOTO: MARK CONGREVE

Spraying at the stage shown above is likely to achieve poor results.

glyphosate or paraquat herbicides. Group G herbicides will improve levels of control, offer an additional mode of action and, in the case of the glyphosate tank mix, increase the speed of visual results. Do not apply Group G herbicides prior to sowing canola as crop injury may occur.

AUTUMN YEAR 1:
Choice of crop

Review the results of the resistance test and decide on the choice of crop and in-crop herbicide strategy.

As there are known levels of seed in the soil in this example, a cereal is preferable to a broadleaf crop. Select a variety with early season vigour. Consider increasing crop competition using narrow row spacings, sowing a variety with good early season growth and high seeding rates. Barley will usually be more competitive than wheat.

WINTER YEAR 1:
Early post-emergent (2-3 leaf cereal growth stage)

A two-spray herbicide strategy is likely to be required in order to achieve very high levels of in-crop control. Herbicide selection will be dictated by resistance status.

An example of a robust early post-emergent herbicide is Velocity® (Group H + C). Other common options at this growth stage include Flight® (C + F + I), Jaguar® (C + F) tank mixed with MCPA (I), or a tank mix of MCPA (I) plus either Affinity® or Ecopar® (both G).

WINTER YEAR 1:
Late post-emergent (tillering, 5-7 leaf cereal growth stage)

Examine the crop and look for any survivors or recent germinations. Always apply a second application if there is any evidence of wild radish.

Avoid the same mode of action that was used in the early post-emergent application. An example of a commonly used late post-emergent application would be a tank mix of 2,4-D plus a Group B herbicide. If the radish is resistant to these herbicides, poor control would be expected so alternate herbicides should be selected.

WINTER YEAR 1:
Flag leaf stage

Scout for weed escapes following the second herbicide application and take action (within three weeks of first wild radish flowers) to stop these escapes from setting seed.

Use late post-emergent herbicides where registered (take care on withholding periods) or sacrificial patch management using non-selective herbicides (brown manuring), slashing/mowing, tillage or hand rogueing.

SPRING YEAR 1:
Harvest weed-seed control

Implement a harvest weed-seed control strategy via the use of chaff charts, Harrington Seed Destructor or windrow burning.

Growers who are focused on driving down weed seed numbers consider harvest weed-seed control to be an ‘every crop, every year approach’, not just when weed-seeds are present at harvest.

SUMMER YEAR 2:
Double knock in fallow

As per year 1.

AUTUMN YEAR 2:
Burn windrows or chaff dumps

If windrows or chaff dumps were established in the previous harvest, plan to burn these in autumn. A slow, hot burn is desired. Best conditions for windrow burning are when there is a light breeze across the direction of the rows.

AUTUMN YEAR 2:
Choice of crop

After two cereal crops in this example, there is likely to be a desire to grow a broadleaf crop. Typically, broadleaf crops will be less competitive and fewer herbicide options are available.

Herbicide strategies in broadleaf crops are more heavily reliant on pre-emergent herbicides, with limited post-emergent options available.

Harvest weed-seed control will be required. It is often easier to implement and can be very effective in most broadleaf crops.

Triazine-tolerant canola will allow the use of atrazine, simazine or terbuthylazine (Group C) residual chemistry at sowing, provided populations are susceptible.

Clearfield® canola will allow the use of imidazolinone (Group B) herbicides early post-emergence, which can provide knockdown and long-term residual control of susceptible populations.

Roundup® Ready canola will allow the post-emergent use of glyphosate over the top of the canola for knockdown control, depending upon the resistance status of weed populations.

AUTUMN YEAR 2:
Pre-plant knockdown

Clean up any existing germinations with a knockdown spray.

If glyphosate resistance is suspected, or there has been an extended history of glyphosate use, consider using a paraquat-based product.

Group G herbicides can be added to either the glyphosate or paraquat herbicides prior to sowing pulses. These Group G herbicides will improve levels of control, offer an additional mode of action, and in the case of the glyphosate tank mix, will increase the speed of visual results. Do not add Group G herbicides prior to sowing canola.

AUTUMN YEAR 2:
Pre-emergent application

Options for pulse crops include a range of Group C and H herbicides alone or, preferably, in combination where labels permit. Refer to specific labels for individual situations.

WINTER YEAR 2:
Post-emergent application

There are limited options for post-emergent herbicides that are effective against wild radish in broadleaf crops.

Group F herbicides can be used in some legume crops for post-emergent application (refer to product labels). Resistance to Group F is high in many areas.

Eclipse® (Group B) can be used in lupins, although resistance is very high in many areas.

Diuron (Group C) is registered for use in lupins in light soil only (WA only).

Scout and use tactics as needed to stop weed seed blowouts and escapes.

SPRING YEAR 2:
Harvest weed-seed control

Due to the lack of effective post-emergent herbicide options and lower crop competition, it is typical to have more wild radish survivors at harvest in broadleaf crops compared to cereals. Implement harvest weed-seed control in all years when broadleaf crops are grown.

Adopting an integrated strategy focused on preventing seedbank replenishment, such as the example above, should result in weed numbers continuing to fall over time. Maintain this approach in subsequent seasons. Low weed numbers will allow for easier and more cost-effective management.

MORE INFORMATION

Harvest weed-seed control

www.ahri.uwa.edu.au/files/files/1100_AHRI_Harvest_Weed_Seed_Control_Booklet_2013_version.pdf

www.ahri.uwa.edu.au/files/files/1098_Walsh_Newman_Powles_Weed_Tech_2013_HWSC_review.pdf

www. grdc.com.au/Resources/IWM-mini-manual/Section-6-Managing-weeds-at-harvest

Autumn tickle

https://www.agric.wa.gov.au/grains-research-development/deplete-weed-seed-target-area-soil-seedbank?page=0%2C4

Herbicide resistance testing

www.grdc.com.au/Media-Centre/Media-News/South/2014/04/Herbicide-resistance-testing-autumn-2014

Windrow burning

www.grdc.com.au/Media-Centre/Over-the-Fence/Over-The-Fence-Videos/Over-the-Fence-Western-Region/-6B6XCN-doc

RESISTANCE TESTING IS CONDUCTED BY:

Charles Sturt University
www.csu.edu.au/research/grahamcentre/people/wwg/strategies/herbicide-resistance.htm

Plant Science Consulting
www.plantscienceconsulting.com/

USEFUL RESOURCES

Cheam A.H. (ed) (2006), *Proceedings of the Wild Radish and other Cruciferous Weeds Symposium* (Department of Agriculture and Food, Western Australia)

Cheam, A.H., Storrie, A.M., Koetz, E.A., Holding, D.J., Bowcher, A.J. and Barker, J.A. (2008), *Managing wild radish and other brassicaceous weeds in Australian cropping systems* (CRC for Australian Weed Management: Adelaide, Australia)

Weeds Mini-manual

www.grdc.com.au/Resources/IWM-mini-manual/

WeedSmart 10 Point Plan

www.weedsmart.org.au/10-point-plan/

Cropping with Herbicide Resistance Fact Sheet

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

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PROJECT CODE

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