WILD RADISH
FACT SHEET

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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 growers to adopt diverse and integrated weed-control strategies to deal with this weed.

KEY POINTS

- Wild radish is one of the most widespread and competitive weeds of grain cropping
- Wild radish is an out-crossing, genetically diverse species – making it highly adaptable
- Wild radish has evolved resistance to multiple herbicide modes of action. Many growers have only a few effective herbicide groups remaining
- Resistance to phenoxy herbicides is widespread in WA and SA, and has been detected in the other regions
- Populations with low-level resistance to Group H herbicides and populations that are difficult to control with glyphosate have been identified
- Wild radish has significant seedbank dormancy: one year of seed allowed to go into the soil can mean more than six years of subsequent emergence
- Often multiple germinations occur during the growing season
- Wild radish can germinate and emerge at any time of the year
- Seed can be captured at harvest and destroyed using harvest weed seed control systems
- The focus must be on preventing seed return to the seedbank
- Effective management is based on control strategies that drive down weed seedbank numbers over a prolonged period. This will require an integrated program of herbicide and non-herbicide tactics, such as harvest weed seed control and crop competition
- Herbicides remain an important tactic to manage wild radish. Mixing and rotating herbicide modes of action and targeting small weeds is essential
- An integrated program of herbicide and non-herbicide tactics is needed to preserve the continued use of remaining herbicides, even in regions where resistance levels are low or have not been detected

Photo: GRDC

Wild radish grows to more than 50cm high and produces white, yellow or mauve flowers.

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;
- able to produce large numbers of seeds;
- able to adapt to herbicide and non-herbicide-based weed-control tactics;
- prone to evolving resistance to a broad range of herbicide modes of action;
- easily spread on machinery and in contaminated grain and fodder;
- a contaminant of grain samples, especially wheat and canola, which potentially affects quality and viability of seed;
- difficult to control in pulses due to fewer herbicide options and poorer crop competition;
- able to interfere with harvest where immature green plants are present at high densities at crop maturity.

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Photo: Peter Newman

Wild radish seedlings have distinctive heart-shaped cotyledons.

Photo: Bruce Wilson

Wild radish forms rosettes with strongly lobed leaves.

Photo: Bruce Wilson

Mature wild radish plant.

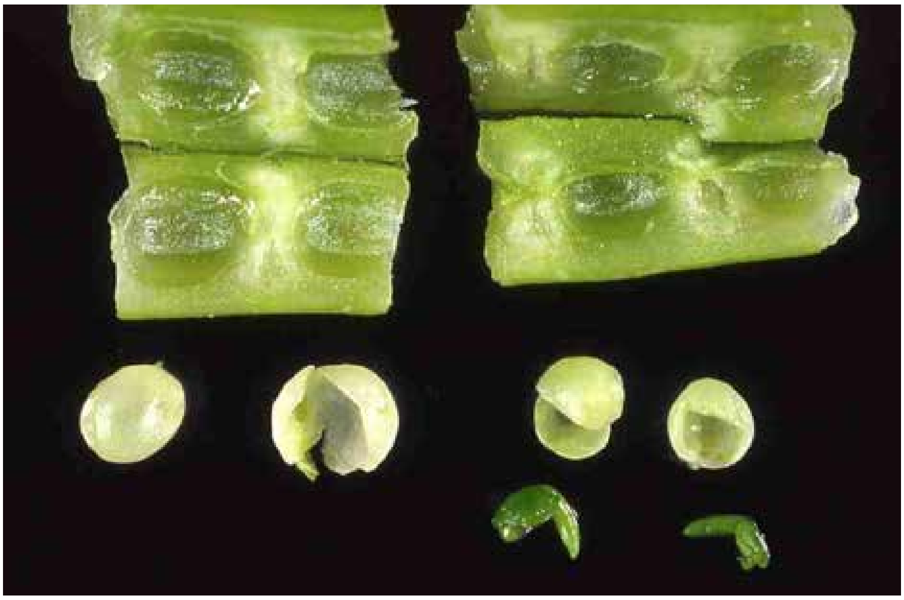
These traits combine to ensure that wild radish is a long-term problem that is difficult and expensive to control. Integrating non-chemical weed-control tactics, including harvest weed seed control, with herbicides has proven effective in preventing further contribution to the seedbank.

Identification and ecology

Wild radish belongs to the Brassicaceae family. It will grow on a wide range of soil types and is favoured by lighter textured acidic soils. Wild radish is predominantly an annual weed with a preference for autumn and winter germination, but germination can occur throughout the year if there is adequate moisture. There are typically multiple germination events per season, depending on rainfall. Germinations in late spring and early summer are common in high-rainfall areas and germinations occur following summer rain in all regions. Plants that germinate in late spring and during summer flower and produce seed quickly.

Accurate identification is important for effective control. Wild radish can be confused with wild turnip (*Brassica tournefortii*), turnip weed (*Rapistrum rugosum*), charlock (*Sinapis arvensis*) and garden radish (*Raphanus sativus*). Wild radish has distinctive heart-shaped cotyledons and forms a rosette of strongly lobed leaves. 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

Photo: Aik Cheam, DPIRD



Immature seeds (left) and viable seeds with dark green embryo formed (right).

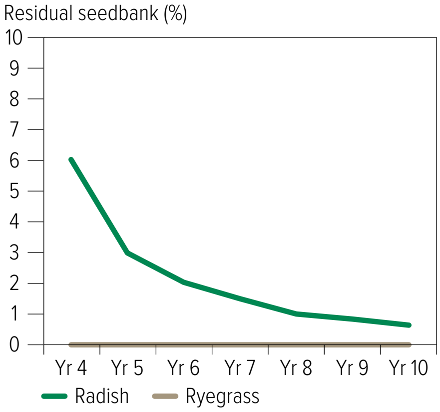
Table 1: The percentage of wild radish populations where resistance was detected in random weed surveys from 2013 to 2017.

Herbicide	Group	WA	SA	Vic	NSW	Tas
		2015	2014–17	2014–16	2013–17	2014
Chlorsulfuron	B	88	39	60	20	8
Imazamox + imazapyr (Intervix®)	B	70	23	0	6	35
Atrazine	C	14	0	0	5	0
Diflufenican (Brodal®)	F	65	0	0	5	0
2,4-D	I	61	39	7	0	18
Pyrasulfatole + bromoxynil (Velocity®)*	H + C	0	-	-	-	-
Glyphosate	M	0	-	0	0	0

*Low-level resistance to Group H herbicides has since been detected in WA. A dash indicates that the herbicide was not used in the testing.

Sources: Owen M & Beckie H (2020) Update on herbicide resistance status in the Western Australian wheatbelt, Grains GRDC Update Papers 2020.
Available at https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/04/update-on-herbicide-resistance-status-in-the-western-australian-wheatbelt
Brown et al. (2019) Weed management in southern mixed farming systems to combat herbicide resistance, GRDC Final Progress Report UCS 00020

Figure 1: Remaining wild radish seed in the seedbank from four to 10 years after seed is produced.



Source: Adapted by Peter Newman from Peltzer SC & Matson PT (2002) How fast do the seedbanks of five annual cropping weeds deplete in the absence of weed seed input. In HS Jacob, J Dodd & JH Moore (eds) *Proceedings of the 13th Australian Weeds Conference*, pp. 553–55.

Table 2: Wild radish resistance to herbicide modes of action (2020).

Mode of action 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 subclasses of Group B. However, there are some individual differences between the subclasses 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 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, and are used alone in some legume crops.
G	No resistance to Group G reported in Australia to date. Group G herbicides are used in mixes with non-selective Group M and Group L herbicides as knockdowns, and in cereal crops in a mixture with Group I herbicides. Use pattern has expanded with product-specific registrations for reducing seed-set and viability of wild radish in wheat, barley and triticale, and for pre-emergent control in wheat, faba beans, chickpeas and field peas.
H	Low-level resistance to Group H identified in 2019 in one population of wild radish in WA. Group H is generally still highly effective and should be applied in mixtures with other modes of action at full label rates. Avoid consecutive applications of Group H products and incorporate integrated weed-control tactics to prevent survivors setting seed, for example, 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, Victoria 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	Population variability in response to glyphosate reported in 2014 in WA. These populations are fully controlled by robust rates of glyphosate (fallow use pattern) or sequential glyphosate applications (Roundup Ready® canola use pattern). This emphasises the need for diversity in both the crop and non-crop phases of the rotation. Where glyphosate resistance evolves, growers will need to use a different mode of action and/or double-knock applications for control in the fallow phase.

Sources: Heap I, The International Herbicide-Resistant Weed Database. Online. Available at www.weedscience.org/summary/home.aspx. Busi, R (2020) What do we know of new herbicides for annual ryegrass and wild radish control? 2020 WA Crop Updates. Available at https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/02/what-do-we-know-of-new-herbicides-for-annual-ryegrass-and-wild-radish-control.

mauve, often with purple veins. Seed pods are frequently more than 5cm long with constrictions between each seed-containing pod segment.

Pod formation begins soon after flowering commences. Seeds are viable once seed embryos begin to develop, which is approximately three weeks after the start of flowering. Embryo development can be identified by dissecting the immature wild radish seed. At this stage the seed will be squashy and watery when pressed between the fingers.

Tactics aimed at preventing seed-set, such as late-season herbicide treatments or cutting for hay or silage, must be completed before the seed embryo starts to develop.

Mature wild radish plants have been shown to produce up to 50,000 seeds per plant in the absence of competition; however, the number varies widely depending on growing conditions and competition from the crop or pasture.

Wild radish seeds are dormant when mature. Pods also protect seeds and contribute to delayed germination. Studies have shown that up to 70 per cent of seeds are dormant at the start of the cropping season following seed production, and that a significant proportion of seeds maintain dormancy for 18 months or more, resulting in higher emergence in the second year after seeds are produced. The largest germinations occur in the first or second season following recruitment to the soil seedbank. Seedbanks run down rapidly in the first few seasons; however, germinations can continue to occur for more than six and up to 10 years after recruitment where seed is buried (Figure 1). Depth of burial influences germination and persistence of wild radish seed. Increasing depth of burial reduces germination while increasing persistence of seed.

Resistance status

There is widespread resistance to multiple herbicide modes of action across Australia (Table 1). The incidence of resistance to herbicides is highest in WA where resistance to Groups B, C, F and I, low-level resistance to Group H, and resistance to multiple modes of action have been reported. Resistance to Groups B, C, F and I have been reported in other regions.

Management

The key to managing wild radish over the long term is to drive seedbanks down and to maintain them at low levels. To achieve this, it is necessary to prevent seed returning to the seedbank and to deplete existing seedbanks. The long dormancy of some wild radish seeds (more than six years) means that a concerted effort over many years is needed.

Wild radish is genetically diverse and has demonstrated its ability to adapt by evolving resistance to herbicides and modifying its lifecycle in response to management practices. For example, some wild radish populations are adapting to Harvest Weed Seed Control (HWSC) by maturing and dropping pods earlier and setting more pods closer to the ground, thereby evading capture by the harvester. This highlights the need to implement integrated weed management programs that include a diverse range of herbicide and non-herbicide tactics to reduce lifecycle adaptations and the development of resistance to herbicides; growers should avoid over reliance on one or a few tactics.

As each farm is different, integrated weed management programs must be tailored to suit. Not every tactic can be used every year or in every situation; however, a successful system deploys as many tactics as possible during each season. The WeedSmart Big 6 provides practical guidelines on implementing integrated weed management programs to reduce weed seedbanks and minimise the risk of developing more resistance, while maintaining profitability.

Integrated weed management programs that focus on seedbanks have allowed farmers to get on top of high populations of wild radish that are resistant to multiple herbicide modes of action. This approach is equally important where populations are small and resistance levels are low, to protect the longevity of existing and new herbicides.

Resistance testing

Herbicides remain a key tool for managing wild radish populations, and testing for resistance is critical to know which herbicide options remain available. When ordering a resistance test, it is important to test for all the key herbicides that may be used to manage wild radish across the farm. More information on resistance testing can be found on the WeedSmart website.

Two types of commercial resistance tests are available. Seed tests are suited to planning wild radish management in following seasons. Seeds are collected from surviving plants and sent away for resistance testing, preferably before mid-December, to ensure results are available for decision-making next season. The 'Quick Test' tests live wild radish plants, up to the four-leaf stage, from the paddock. It is suited to confirming resistance where there are control failures and for planning management in the current and future seasons. See 'Further information' for providers of resistance-testing services.

Photo: Mark Congreve

Preventing seed-set of survivors is critical step to stop a weed seed blowout.

CONTROL TACTICS

Stop seed-set of survivors

The most critical step is to do 'whatever 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 start 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 roguing. Wild radish seeds become viable within three weeks of the appearance of the first flowers, so it is important to kill wild radish plants before this stage.

Rotating crop types and diversity in the system

Rotating crop types and paddock use is part of a robust long-term strategy to manage wild radish. It allows a variety of different herbicide modes of action and non-herbicide control tactics to be used over time and makes it harder for wild radish to adapt to the farming system.

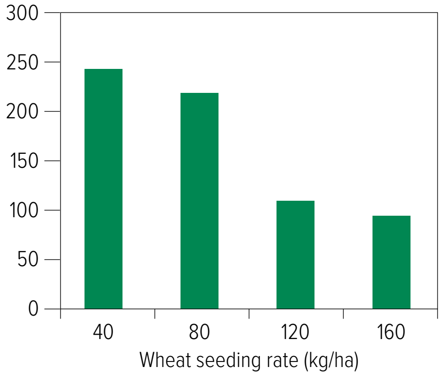
Pastures, green and brown manuring, hay and fodder are paddock uses that allow non-herbicide-based control of seed-set. Operations to prevent seed-set have to be done within three weeks of wild radish flowering, before seeds are viable. It is also essential that any regrowth is controlled and not allowed to set seed. There is evidence from the high-rainfall zone that a pasture phase over several years effectively reduces wild radish seedbanks provided grazing is managed to prevent flowering and seed-set.

Harvest weed seed control

Harvest weed seed control (HWSC) has proven to be an excellent non-herbicide tactic to reduce wild radish numbers when applied to paddocks over multiple years, especially when used in conjunction with effective herbicides.

The success of HWSC depends on the amount of wild radish seed that is retained on the plant at a height that can be harvested. Seed that enters the harvester will either be retained in the grain box or will exit the header via

Figure 2: Biomass of wild radish at different sowing rates of wheat (Binnu, WA, 2010).



Source: Newman P & Zaicou-Kunesch C (2013) Compete with weeds – give your crop heaven and your weeds hell. 2013 Agribusiness Crop Updates, WA, p. 31.

the chaff fraction. This weed seed is collected and either removed from the paddock via chaff carts, concentrated into a windrow for burning in autumn, delivered into a seed impact mill and killed, or moved to narrow chaff lines via chaff lining or to machinery tracks with chaff decks (chaff tramlining).

Chaff lining and chaff decks have increased in popularity and are well suited to controlled-traffic farming systems. The main difference between these systems and other control strategies is that the seed is retained in the paddock. While germination and establishment are reduced in the chaff rows, populations can be relatively high in these areas. Having the majority of weeds concentrated opens up the opportunity to manage these areas separately using site-specific weed-control (SSWC) technology.

In general, wild radish is the best suited of the major weeds to HWSC as pods are retained at maturity and are set high enough to be collected by the harvester. There are situations where a high proportion of seed pods drop before harvest. This is related to environmental conditions prior to harvest such as hot dry spells, wind, rain, and the length of time between wild radish maturity and harvest.

Seed pod drop is an issue in high-rainfall areas in long-season crops, such as winter wheat, that mature much later than the wild radish and are harvested a long time after wild radish has matured. In these situations, it may be possible to avoid planting crops which mature very late to increase the capture of wild radish seed with HWSC systems.

More information on harvest weed seed control is on the WeedSmart website and the GRDC website.

Crop competition

Crop competition is a valuable tool for reducing weed numbers and for reducing seed-set of plants that survive other control measures. Crop competition contributes to overall weed control when used in conjunction with effective herbicides and other tactics, and is an important component when deploying multiple control tactics.

Cereals compete more aggressively than broadleaf crops, and a wider range of herbicide options is available. Generally, the competitive ability of oats is greater than barley, which is greater than wheat, and there are also differences in the competitiveness of varieties that can be exploited.

The competitive ability of crops is increased by higher sowing rates, narrow row spacing and an east–west orientation of sowing rows. Timely sowing, good establishment and sound agronomy promote vigorous early growth and crop health. Higher sowing rates have the biggest impact on competition, while east–west orientation has little effect in broadleaf crops. Crop competition also complements HWSC. Weed seed tends to be set higher in the canopy of competitive crops where it is more easily gathered by the harvester.

Canola varieties that are more vigorous and produce more biomass early tend to have greater ability to suppress weeds. This is supported by research and grower experience, where hybrid canola varieties have proved to be more competitive with weeds than less vigorous open pollinated varieties. Hybrid canola crops sown early with even establishment suppress weeds and add to overall weed control by reducing growth and seed-set of the weeds that survive herbicide applications and that germinate later in the season.

Pulse crops are poor competitors with wild radish and plants that are not controlled with herbicide and emerge later in the season typically go onto set large numbers of seeds.

Tillage

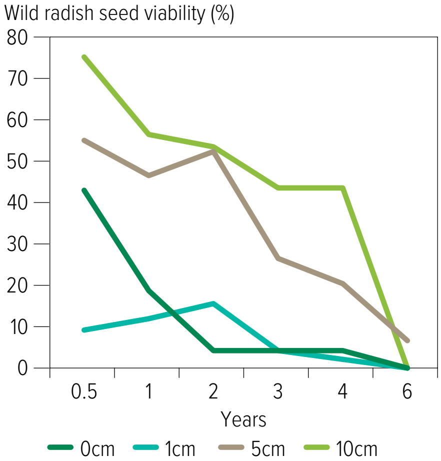
Tillage influences wild radish seed germination and longevity in the seedbank. Germination is reduced with increasing depth of burial, but seed remains viable for longer with deeper burial (Figure 3). While tillage is not suited to many soil types and farming systems, it can be used opportunistically to manipulate the emergence of wild radish. It can also be used in combination with soil amelioration programs.

A shallow cultivation during autumn (also referred to as an autumn tickle, 'autumn scratch' or shallow cultivation)

Photo: Simon Craig, BCG

Surviving wild radish plants can set large amounts of seed in pulse crops.

Figure 3: Percentage of wild radish seed remaining viable after burial at various depths over time.



Source: Code GR, Walsh MJ & Reeves TG (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. 136–38.

stimulates wild radish germination, and can be followed with knockdown herbicides to reduce the population in crop. This technique can be used opportunistically where populations are high and moisture is adequate for germination before sowing. Early maturing varieties can be used to manipulate sowing time in paddocks with high populations to provide a wider window to use this tactic.

Full inversion tillage (for example, a mouldboard plough used with skimmer plates to place the topsoil-located weed seed at the bottom of the furrow) can be used to bury the seed to a depth of more than 20cm and prevent emergence of wild radish. This technique has been used where few herbicide options remain.

However, deep burial of wild radish seed will increase the length of time that this seed remains viable in the soil. Further cultivation should be avoided or should be shallow enough to avoid disturbing the seed for at least ten or more years, so that viable seed is not brought back to the surface.

Farm hygiene

Contaminated seed and fodder, weed residues on vehicles and machinery, and weeds growing in non-arable areas are major sources of introduction and spread of weeds on farms. Practices such as using clean seed, following cleaning protocols for machinery coming onto the farm and moving machinery from weed-infested to non-infested areas, feeding livestock in confined areas and stopping seed-set of weeds growing in non-arable areas reduce the spread of wild radish.

In-crop herbicides

In WA, the choice of herbicide is increasingly dictated by resistance to multiple modes of action. In other regions, resistance is less frequent and to fewer modes of action, but experience shows that resistance will increase if management does not focus on managing seedbanks.

Research and farmer experience have demonstrated that the 'mix and rotate' strategy (that is, mixing maximum lethal label rates of two or more modes of action and rotating between herbicide modes of action) is an effective strategy to control wild radish and delay herbicide resistance.

Correct spray application is important to get the best performance from herbicides. This means using the correct water rate, travel speed, droplet size, timing and adjuvant to get good coverage, and spraying in the right weather conditions. More information on spray application can be found in the GRDC GrowNotes *Spray application manual for grain growers*.

Cereals

Where wild radish populations are high and resistance to herbicides exists, the most effective strategy is to mix and rotate herbicide modes of action and apply herbicides to small weeds (up to 5cm, which is approximately the size of the top of a drink can). Typically, a mixture of two or more modes of action is applied to young crops to control small weeds followed by a second application using a mixture of two or more different modes of action. The second application is needed to clean up later germinations and is typically applied four to five weeks later in mid to late-tillering crops, while weeds are small and herbicide can reach the weeds through the crop canopy.

Numerous products and mixes of products have been registered for post-emergent control of wild radish in cereals, and the best advice is to check labels for rates and crop stage. Examples include Jaguar® (Groups C + F), Velocity® and Talinor® (Groups H + C), and Frequency® (Group H), which can be applied from the two-leaf stage, and Triathlon®, Flight® and Quadrant® (Groups C + F + I), and Affinity® Force plus MCPA (Groups G + I), which can be applied from the three-leaf stage.

A recent development is registration and impending registration of pre-emergent herbicides to control a range of broadleaf weeds, including wild radish in cereals, for example, Callisto® (Group H). These provide early weed control, potentially replacing an in-crop herbicide application. There are logistical advantages on farms that have large areas to spray in a short period of time and in areas where trafficability and weather conditions limit spraying opportunities.

Where weed pressure is low and resistance is not an issue, there is more flexibility in herbicide choice and timing. However, the general principle of spraying small weeds, using multiple modes of action, getting the highest level of control possible and cleaning up later germinations to prevent seed-set still applies, and should be followed to minimise the risk of developing herbicide resistance.

Canola

It is necessary to grow herbicide-tolerant canola where wild radish is present. Wild radish competes with canola and is able to set large amounts of seed; however, crop competition does complement herbicides in reducing seed-set. Triazine-tolerant (TT), Clearfield® and Roundup Ready® canola varieties allow wild radish to be controlled in crop, and allow different herbicides to be used in the canola phase of

Photo: Mark Congreve

Spray wild radish before plants reach this size.

the rotation. Use of these systems is dictated by the resistance status of the wild radish. Resistance to atrazine (Group C) is increasing, resistance to Group B herbicides is widespread and populations difficult to control with glyphosate (Group M) have been identified. These technologies will have limited use in some situations and over-reliance can speed up the evolution of resistance. It is essential that these systems are used as part of an integrated weed management program to minimise the risk of developing resistance.

TT canola – pre and post-emergent applications of the triazine herbicides atrazine, simazine and terbuthylazine (Group C) are registered for wild radish control in TT canola. Products that are more persistent, such as terbuthylazine, have an advantage in longer growing season environments for controlling later emerging wild radish.

Clearfield® canola – applying imidazolinone (imi) herbicides in Clearfield® canola provides good control where wild radish is susceptible to Group B herbicides. The risk of developing resistance is high and an integrated weed management strategy that includes alternative mode of action herbicides in the rest of the rotation is required to preserve the effectiveness of this system.

Roundup Ready® canola – glyphosate controls wild radish in young Roundup Ready® canola but the limitations on timing of applications (up to six-leaf stage of canola) mean that later germinations are not controlled and the system relies on crop competition for suppression. The introduction of TruFlex® and equivalent technologies, where glyphosate can be applied up until the start of flowering, allow later germinations of wild radish to be controlled. Using glyphosate in-crop increases the selection pressure for resistance, so it is essential that the guidelines in the stewardship program are followed.

Photo: Mark Congreve

Spraying plants at this stage is likely to achieve poor results.

Varieties with stacked resistance to two herbicide groups have been released onto the market. These include TT + Clearfield®, TruFlex® + TT and TruFlex® + Clearfield®. Dual-herbicide tolerances in varieties allow multiple modes of action to be used in the same year and extend the window of control of wild radish in-crop, provided the population is susceptible.

While herbicide-tolerant systems allow canola to be grown where wild radish is present, some plants get through and set seed. Late-season applications of glyphosate have been effective in reducing the amount of viable wild radish seed returning to the seedbank; however, this technique applies more selection pressure for resistance to glyphosate. Harvest weed seed control is very effective at capturing wild radish seed in canola.

Pulses

Herbicide strategies for broadleaf weed control in pulse crops rely more heavily on pre-emergent Group B, Group C and, in the case of chickpeas, Group H herbicides. Resistance issues aside, activity of pre-emergent herbicides declines as the season progresses, allowing wild radish to emerge later in the season. It is common for late-emerging wild radish to set significant amounts of seed in pulse crops, resulting in blowouts in the population.

Registrations for post-emergent herbicides in pulse crops are limited and their effectiveness on wild radish depends on weed size and resistance status. Diflufenican (Group F) is registered for post-emergent application in lentils, field peas and lupins. It is most effective on small weeds with some residual control of later germinating weeds. Resistance to Group F is widespread in WA and has been detected in other areas. Eclipse® (Group B) is registered for post-emergent application in lupins, although resistance is widespread in WA and has been detected in other areas. Diuron (Group C) is registered for use in lupins in light soil only (WA only). Broadstrike® (Group B) has a registration for suppression of wild radish in chickpeas, field peas and lentils. The label claims 50 to 70 per cent reduction in wild radish biomass in susceptible populations, which is inadequate where populations are high and will not prevent seed-set.

The post-emergent applications of registered imi herbicides to imi-tolerant lentil and faba bean varieties have provided more options to control broadleaf weeds in these crops, including Group B–susceptible wild radish, and resulted in fewer population blowouts. As resistance to Group B herbicides is widespread and easily acquired, it is essential to know the resistance status of the populations before relying on this technology to control wild radish. Where wild radish populations are still susceptible to Group B herbicides, management should include herbicides with alternative modes of action in other crops to preserve this technology.

Late-season weed control can be useful for reducing wild radish seed-set. However, in many areas wild radish will have produced viable seed by the time the crop is mature enough for herbicide application, hence this tactic cannot be relied on to prevent population blowouts.

Harvest weed seed control has proved to be very effective at preventing seed entering the seedbank in pulse crops, as they are harvested close to the ground and, with the possible exception of chickpeas, mature at a similar time to wild radish.

Late-spring germinations

Late-spring germinations in higher rainfall zones have resulted in situations where wild radish plants are growing under maturing cereal crops. Crops are typically too advanced for in-crop herbicides and wild radish is too immature for harvest weed seed control to be effective. Once crops are harvested, these plants go on to produce seed, topping up the seedbank. These need to be controlled using the same strategy used for summer spraying. Grazing can be effective if enough grazing pressure is applied; however, stock will preferentially graze spilt grain before grazing wild radish.

Late-season in-crop herbicide application

This tactic can be a useful management tool to reduce the amount of viable seed that returns to the soil, provided the population is susceptible to that mode of action.

Most late-season herbicide applications are based on Group M and Group L herbicides; however, Sharpen® (Group G) is registered as a stand-alone treatment for the reduction of seed-set and viability of wild radish seeds in wheat, barley and triticale, and in mixtures with Group M and L herbicides for pre-harvest application in pulses. A summary of registrations and guidelines for using herbicides late in the season (which must always observe withholding periods) is in the GRDC Pre-harvest herbicide use fact sheet.

To be effective, herbicides must be applied before the embryo develops, which is within three weeks of the start of flowering, and at a stage when the crop will not be damaged. The limitation of this technique is that weed and crop stages vary across seasons and locations, and the ideal timing for seed sterilisation may not match the ideal crop stage. There is a compromise between controlling wild radish seed-set and crop yield loss, and these late-season applications rarely provide 100 per cent weed kill or seed sterilisation.

Late-season herbicide application is best used as another tactic to further drive down weed seed numbers rather than a method that can be relied on to fix blowouts.

Fallow and pre-sowing knockdown sprays

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 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 brown out. Some Group G herbicides have extended plant backs prior to sowing canola, so consult labels before use.

A double-knock strategy should be considered to control any weeds that survive the first application of herbicide. This involves following the initial glyphosate (Group M) application with a second application of a paraquat-based herbicide (Group L) within 7 to 14 days.

Summer sprays

If climatic conditions result in summer germinations, it is essential that these plants are not allowed to set seed. Glyphosate is the mainstay of summer weed programs and is often applied with Groups I and B as mixing partners.

With resistance to Groups I and B and the variability in response to glyphosate, it is essential that spray jobs are checked for the level of kill. If there are surviving wild radish plants, these must be prevented from setting seed. If resistance to Group M is suspected, a double-knock herbicide application strategy or a non-herbicide control measure is recommended.

USEFUL RESOURCES

Managing wild radish

- https://weedsmart.org.au/the-big-6/
- https://weedsmart.org.au/?s=wild+radish
- https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/02/biology-and-control-options-for-wild-radish,-prickly-lettuce-and-sow-thistle
- https://sciences.adelaide.edu.au/agriculture-food-wine/system/files/docs/2016-wild-radish.pdf
- https://grdc.com.au/IWMM

Harvest weed seed control

- https://weedsmart.org.au/the-big-6/harvest-weed-seed-control-holy-grail/
- https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2020/04/harvest-weed-seed-control-continues-to-evolve

2020 Pre-Harvest Herbicide Use Fact Sheet

- https://grdc.com.au/GRDC-FS-PreHarvestHerbicide

GrowNotes Spray Application Manual for Grain Growers

- https://grdc.com.au/resources-and-publications/grownotes/technical-manuals/spray-application-manual

Herbicide resistance testing

- https://weedsmart.org.au/?s=resistance+testing

Resistance testing services

Plant Science Consulting

- http://www.plantscienceconsulting.com.au/

CSU Herbicide Resistance Testing

- https://www.csu.edu.au/plantinteractionsgroup/herbicide-resistance

MORE INFORMATION

Refer to the **Useful Resources** in this fact sheet.

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