Wild radish

Raphanus raphanistrum

Weed management guide for Australian vegetable production

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Identification

Wild radish (*Raphanus raphanistrum*) is an erect or spreading annual herbaceous plant, native to the Mediterranean region, growing up to 1 m in height.

Wild radish stems are bluish-green, often red towards the base, covered with prickly hairs, and up to 1 m in height. The young plant forms as a rosette, branching from near the base as it matures. Plants form a taproot which can be up to 160 cm in length, with a dense mass of roots in the upper 20 cm of soil.

Rosette and lower stem leaves are grass-green through to blue-green, stalked, 15 to 30 cm in length, and deeply lobed. Upper stem leaves are narrow, shorter and often undivided. Leaves are covered with short stiff bristles, making them rough to touch.

Flowers are usually either white or pale yellow, but occasionally purple. Flowers have violet-coloured veins, and feature four petals between 12 and 20 mm in length. They are grouped in open arrangements at the end of stem branches.

The fruit forms as a celled pod, up to 8 cm in length and 3 to 6 mm in width, constricted between the seeds, on stalks about 1.5 cm long. When mature, the yellow-brown seed pods break into distinct segments resembling a string of beads, with 1 to 10 seeds per pod.

Figure 1 includes a series of photos of wild radish at different life stages, from a young seedling through to a mature flowering plant. This includes images of the flowers (white and yellow varieties) and seed pod.

Figure 1 Life stages, from emergence to seed pod (seed pod photo: Biosecurity Queensland 2016)

Characteristics

Key characteristics

Table 1 Key characteristics of wild radish

Time of germination	Autumn (optimum time) through to summer
Time of flowering and seed set	Late autumn through to mid-summer depending on climate
Reproduction	By seed only
Seed productivity	Up to 800 seeds/plant
Seed viability	Up to 20 years. Seeds more likely to remain viable at greater burial depths.
Optimum germination depth	Approximately 1 cm below the soil surface
Soil type/s	Favours acidic sandy soils
Competitive advantages	Able to germinate and set seed across much of the cool season; favoured by cultivation; long-term seed viability; high seed production; competes well with crops

Seasonality

Wild radish is largely a temperate climate weed in Australia, and is classified as a winter annual. The main flush of germination usually occurs following autumn rainfall, although seeds can continue to germinate sporadically across the entire growing season providing sufficient soil moisture is available.

Usually, the rosette develops slowly until approximately June or July, at which point the branching stems begin to emerge from the centre. The first flowers generally appear in late July, although flowering can continue until as late as January, after which time plants usually die after producing many seeds. Plants emerging in the spring are therefore relatively short-lived.

Germination can occur in temperatures ranging from 5°C to 35°C, with an optimum germination temperature of 20°C (typical of temperatures found in a southern Australian autumn).

Seed production

Each segment of a seed pod on a wild radish plant contains a reddish to yellow-brown oval seed between 2 and 4 mm in diameter. Pods can contain between 1 and 10 seeds of varying size. Seed production depends in part on the time of year at which the parent plant germinates. In one Australian study, plants germinating in mid-autumn produced approximately 800 seeds per plant on average, while plants germinating in September produced under 10 seeds per plant on average. The capacity of wild radish to seed prolifically has led to estimates of as much as 45,000 seeds being produced per square metre in heavy infestations.

Seed germination and viability

Wild radish seed can remain dormant in the soil for up to 20 years, although this can vary across geographical regions. Research in Western Australia suggested that seed dormancy capacity was longer in cooler southern climates compared to warmer northern climates. Plants germinating early in the growing season are also more likely to produce seed with greater dormancy capability.

Seedling emergence is relatively low on the soil surface. The optimum seed burial depth for successful germination appears to be approximately 1 cm, with relatively few seeds observed to emerge at depths of 5 cm or 10 cm in previous research. Wild radish germination is favoured by cultivation systems, as tillage practices are likely to bury seed just below the surface from where it can germinate. Furthermore, wild radish has been shown to be more likely to remain viable if buried at greater depths (up to 25 cm) compared to on or just below the soil surface.

Soil preference

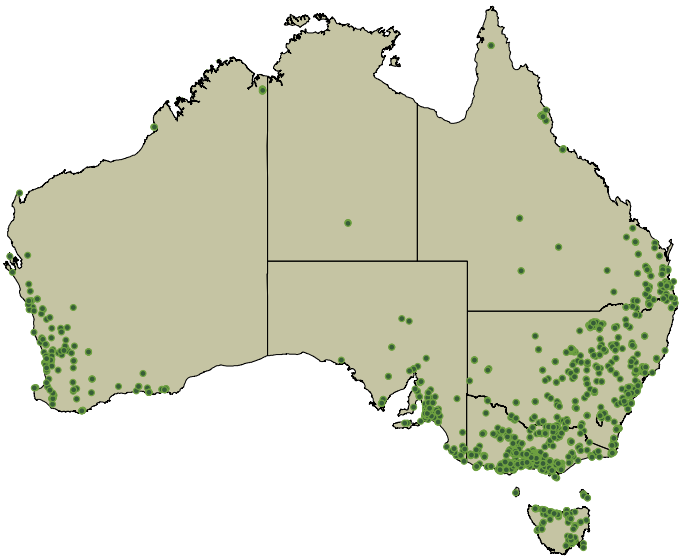
Wild radish occurs in all soil types, but has been shown to have a preference for acidic sandy soils.

Methods of spread

Spread of wild radish is wholly reliant on seed spread, and methods of spread can include water, animals (including livestock), and human activities such as use of machinery and vehicles, produce contamination, and sticking to clothing and footwear. In Australia, contaminated grains have been a major method of spread.

Distribution

Wild radish is a common and important weed of cultivation in Australia, affecting broadacre as well as horticultural crops. After having been first identified around Melbourne in the 1860s, it has since spread widely, and is now commonplace in vegetable production regions from south-east Queensland through much of New South Wales and Victoria, and in south-eastern South Australia. It also occurs widely in vegetable producing regions of Western Australia and Tasmania. It is becoming increasingly important as a weed of cultivation in south-east Australia in particular.



Map 1 Australian distribution of wild radish (source: Atlas of Living Australia)

Impacts

Wild radish is a notable weed in all forms of cultivation where it occurs, including vegetables (Figure 2). It is particularly noted for its competitiveness with crops for light, space, water and nutrients. Extensive spread of wild radish across much of the temperate world has resulted in it becoming a common weed of cultivation in Europe, South Africa, much of North America, temperate regions of South America, as well as New Zealand and Australia. It is particularly important for its impact within winter crops, and around the world has been noted as a weed of beans, cabbage, onions, peas, potatoes, and a variety of other unspecified vegetable crops given its ubiquitous nature.

Wild radish competes with crop plants soon after emergence, with the plant rosette claiming space and suppressing the emergence of both crop plants and other weed species. Its tap root makes it particularly competitive for soil moisture and nutrients. In Australian vegetable production , wild radish has been noted to reduce the final yield of crops.

In brassica crops, Australian farmers have noted that wild radish seed is a potential contaminant of crop produce, reducing prices obtained at sale.

A host of pests and diseases

Wild radish hosts a range of vegetable crop pests and diseases in Australia. These include thrips, flea beetle, cabbage seedpod weevil, cabbage root fly, and several moth species. The melon pathogen *Fusarium oxysporum* f.sp *melonis* is hosted by wild radish, as is club root and blackleg in brassicas, turnip yellow mosaic virus, beet western yellows virus, turnip mosaic virus, cauliflower mosaic virus, and cucumber mosaic virus. Wild radish hosts a number of bacteria that can act as disease reservoirs in vegetable crops.

Figure 2 Frequent cultivation and irrigation make wild radish a significant autumn and winter weed of vegetable crops in Australia, as this brassica crop in South Australia illustrates.

Management

Management methods

Table 2 Wild radish management methods

Activity	Suitability	Notes
Tillage	✔ ✔	Shallow repeated pre-plant tillage to bury, germinate and control germinating plants recommended. Inversion ploughing carried out with caution due to long seed viability period.
Cover crops	✔ ✔	Feasibility of cover crops dependent on cash crop produced and viability of non-crop period in annual rotation. Thick canopy effective in reducing wild radish germination and seed set. Good establishment is critical.
Planting density	✔ ✔	Plant crop at highest practical density without impacting on crop yield, to increase competition.
Mulching and solarisation	✔	Can suppress weed growth and reduce the number of viable seeds in the soil. Only applicable to certain high-value crops.
Farm hygiene	✔ ✔	Best suited to farms with no current wild radish infestation, or an infestation restricted to one part of the farm.
Hand weeding	✔	As follow-up to early-stage herbicide and tillage. Suited to lighter infestations or occasional larger plants.
Herbicides	✔ ✔ ✔	No later than 3 weeks after emergence. Resistant populations to a range of herbicide Groups evident in Australia.
Biological control	**N/A**	Not currently available in Australia.
Integrated weed management	✔ ✔ ✔	Precise combination of techniques will vary from farm to farm. Early control with herbicides or tillage is critical, while the plants are vulnerable and before further weed seed production.

Tillage ✔ ✔

Research shows that emergence of wild radish seedlings is greatest in approximately the first two months following initial tillage.

This trend appears to be linked to two factors: firstly, tillage operations incorporate wild radish seed to just below the surface (where the rate of germination is higher); and secondly, initial cultivation will most likely be followed by a rainfall event (or irrigation) which provides sufficient soil moisture for seeds to germinate.

Research suggests that a shallow pre-plant till to germinate surface-level seeds, followed by another shallow till to destroy resulting seedlings, may be helpful in managing the wild radish seed bank. This approach can be even more effective if used repeatedly as part of a stale seed bed strategy. However, it requires sufficient time being available in the annual crop rotation to implement several shallow tillage passes - or taking a paddock out of production for up to two seasons if the infestation is severe.

Inversion ploughing may also reduce wild radish germination by burying seed at a depth from which they cannot germinate (> 10 cm). However, seed can remain viable for a considerable period at depth, and future inversion ploughing may bring these back nearer the surface for germination.

Figure 3 A shallow 'tickle' tillage between the crop plants early in their life cycle may help to manage recently germinated wild radish and other important broadleaf weeds, allowing the crop to form a canopy before the weed problem becomes significant. Relevance of this technique will depend on crop/s grown, and availability of inter-row tillage equipment. In this crop in South Australia, a Weed Fix cultivator was used to manage weeds such as wild radish within the crop beds.

Cover crops

Cover crops grown in the period between vegetable cash crops offer growers an opportunity to reduce the impact of wild radish on their farm. When cover crops are well established and maintained, they can be expected to reduce wild radish seedling emergence, flowering and seed set through competition for resources (soil nutrients, water and light). The practicality of planting a cover crop for management of this weed will depend on there being sufficient time to implement an autumn-winter cover crop cycle within the annual crop rotation.

Research from South Africa indicates that a number of cover crop varieties, including white mustard (*Sinapis alba*), canola (*Brassica napus*) and Caliente (*Brassica juncea*) can all improve management of wild radish. Management of the weed was found to be more effective when the cover crop was killed off by a non-selective herbicide application, compared with cover crop slashing and incorporation to a depth of 200 mm.

Selection of cover crop variety will need to take several factors into account, such as cost of and ability to grow the cover crop, its expected soil health benefits, relevance for breaking any disease cycles within the cash crop, and overall contribution to cash crop productivity. Good early establishment will be critical for achieving effective management of wild radish using a cover crop, in order to suppress wild radish emergence and growth.

*Figure 4 Rapidly establishing and high biomass brassica cover crops have been shown to be effective in suppressing wild radish emergence and growth due to their high biomass and dense canopy. Here, tillage radish (*Raphanus sativus*) was effective for managing a variety of broadleaf weed species on a farm near Hobart, Tasmania.*

Planting density

Agronomic practices, such as increased crop density, that contribute towards the rapid development of a thick canopy cover will result in fewer and shorter wild radish plants, fewer flowers, reduced seed production, and less return of wild radish seed to the soil. This principle is similar to selecting a competitive cover crop variety, as discussed above.

Competitive winter crop variety selection may result in more rapid establishment of crop canopy, and is likely to have similar effectiveness in suppressing wild radish emergence, growth and seeding.

Where it is appropriate to the crop, higher plant density and variety selection (including shading of wheel tracks where this is possible) may contribute to reduced wild radish impact in the longer term.

Higher planting density may have some adverse effects, such as increased competition among crop plants (lowering yield) and greater risk of soil and plant diseases.

Mulching and solarisation

Mulching has been shown to reduce the impact of wild radish in tree and vine horticulture, with suggestions including straws, woven mulches and plastics. However, organic mulches are relatively rarely used in vegetable production in Australia, and plastic mulch use is generally restricted to within certain high-value crops such as cucurbits.

Plastic mulches may reduce wild radish growth by intercepting light and providing a physical barrier while also reducing the viability of seed through solarisation. Using this approach, a plastic mulch film is applied and left on the soil surface for 30-50 days during summer. This can raise soil temperatures to the extent that it reduces the number of viable wild radish seed. Soil solarisation may be a useful wild radish management method where plastic mulch is used as part of the standard production system for summer vegetable crops.

Farm hygiene

Implementing appropriate farm hygiene practices helps limit the spread of wild radish seeds across and between properties, and onto crop beds from other parts of a property where the weed is present. Common practices include permanent or set vehicle tracks, equipment wash-down, and restricting movement onto the property.

While wild radish may be well managed within the crop beds, it is regularly observed in wheel tracks, headlands (Figure 2), nearby non-crop areas such as roadways, fencelines (Figure 5) and around sheds and other infrastructure, and within post-harvest crop residues, with plants going to seed and replenishing the seed bank both around and within the fields. Effectively managing off-bed wild radish plants may therefore reduce the burden of this weed within crop beds in the longer term.

Farm hygiene may be less relevant for managing wild radish where it has already spread across the whole farm. Other difficulties associated with this approach include the time required to wash equipment down thoroughly, and the potential for uncontrolled spread in flood prone areas.

Figure 5 This fenceline on a carrot farm in Tasmania is heavily infested with flowering wild radish plants, and these have great potential to spread seed across the paddock. Regular management of this and other non-crop areas will have the added benefit of reducing the wild radish burden within the crop.

Hand weeding

Physical control options include digging or hoeing plants out, or potentially pulling larger plants out by hand. Selective and strategic hand weeding can be a key component of achieving commercially acceptable levels of wild radish control, particularly where higher planting densities or larger crop plant sizes make tillage within the crop impossible.

Hand weeding may also be necessary to remove wild radish plants growing close to crop plants, in crop plant holes in a plastic mulch system, or more generally within the crop bed where selective herbicide options are not available, and where other attempts to manage the weed have been less successful.

Farmers are generally hesitant to implement wide-scale hand weeding due to its high cost. However, selective and timely hand weeding can be a very effective follow-up to tillage and herbicide control in particular, especially when implemented earlier in the crop life cycle. Removing a few remaining wild radish plants by hand and taking any plants with flowers or seed pods away from the paddock may have significant benefits in reducing the weed seed bank in future crop seasons. It may also help prevent herbicide resistance from becoming a more significant issue.

Figure 6 Removing recently germinated weeds such as wild radish before they have a chance to establish is an effective follow-up to pre-plant tillage and herbicide control, and will have longer-term benefits in reducing the weed seed bank. Tools that require relatively little effort, such as the stirrup hoe pictured here, can make this task easier depending on soil type and moisture level, and weed plant size.

Herbicides

Some considerations regarding herbicide use to manage wild radish in vegetable crops include sensitivity of the crop to available herbicides, and the staggered germination pattern of the weed. As a result, sequential herbicide applications, or application of herbicides with some residual effect, are likely to have the most benefit.

Wild radish is particularly difficult to manage in brassica crops in Australia due to a lack of selective herbicide options and its similarity to the crop. At the time of writing, post-emergent selective herbicides were available to manage this weed in beans, onions and asparagus, while pre-emergent or pre-transplant herbicide options were registered for use in beets, asparagus, peas, and brassicas.

Managing wild radish by applying herbicide during fallow periods is considered to have relatively little effectiveness given the dormancy capacity of its seed. Longer-term fallow periods in particular are also unlikely to be feasible for Australian vegetable producers, particularly in smaller-scale intensive production districts. Extensive and repeated use of herbicides in this way also creates potential for herbicide resistance to develop, as outlined in the next section.

Nonetheless, herbicide application may be used alongside regular shallow tillage to implement a stale seed bed to reduce the wild radish weed seed bank, where this option is feasible.

Farmers should consult with their advisor or agronomist for specific product availability in their district, whether herbicide options are registered for the crop/s they grow, and the suitability of these products for their production system.

Table 3 Herbicides registered for management of wild radish in Australian vegetable production

Herbicide active ingredient*	Trading name/s	Group	Vegetable crop/s in which use is registered	Timing/crop growth stage
2,4-D	Amine	I	Corn	Apply when crop is 10-30 cm high (depending on state of registration)
Bentazone	Basagran; Dictate 480	C	Broad beans, green beans, navy beans	At time of seedling or transplanting
Chloridazon	Pyramin	C	Baby leaf spinach, red beet, silver beet	Post-sowing pre-emergence
Diflufenican	Diflufenican	F	Peas	Post-emergence
Diuron	Diurex WG	C	Asparagus, peas	Pre-emergence
Ioxynil	Totril	C	Onions	Post-emergence
Linuron	Linuron DF and Flowable	C	Carrots, parsnips, onions, potatoes	Pre- or post-emergence depending on crop
Methabenzthiazuron	Tribunil	C	Onions	Post-emergence (one or more true leaves in onion crop)
Metham	Metham Sodium; Tamafume (fumigants)	N/A	All crops	Pre-plant
Oxyfluorfen	Baron 400 WG; Goal; Striker	G	Brassicas	Pre-transplant (7 days prior)
Pendimethalin	Rifle 440; Romper; Stomp 330EC; Stomp 440; Stomp Xtra	D	Carrots, peas, beans, onions, transplanted broccoli, cabbage, cauliflower, processing tomatoes	Pre-emergence
Phenmedipham	Betanal Flow 160 SE	C	Beetroot, silver beet	Post-emergence selective
Prometryn	Gesagard; Prometryn 900DF	C	Carrots, celery, potatoes	Pre-emergence, or early post-emergence in carrots
Simazine	Gesatop; Simagranz	C	Asparagus	Pre-emergence

** Details correct at time of writing; please consult the relevant herbicide label/s, contact your reseller for current registration details, or contact the Australian Pesticides and Veterinary Medicines Authority. This table does not include minor use permits, or non-selective options such as glyphosate or diquat. If using crop rotations, the APVMA Public Chemical Registration Information System database may be searched for 'radish' to identify a range of herbicides suited to a range of cropping situations.*

Herbicide resistance

Recent research focusing on broadacre cropping suggested that there were over 150 sites in Australia where herbicide-resistant wild radish populations had been confirmed. Resistance appears to be particularly widespread in Western Australian broadacre grains production, though field trials have also identified resistant populations in north-western Victoria, South Australia and in New South Wales winter cereal crops.

Herbicide resistant wild radish populations in Australian broadacre cropping encompass a number of Group B, C, F and I herbicides, and have arisen due to overuse of certain herbicides or herbicide Groups. In addition, glyphosate (Group M)-resistant wild radish populations have been documented in winter grains production since 2013.

Vegetable growers should therefore remain aware of the high potential for herbicide resistance to develop in wild radish, particularly if their crop rotation involves heavy reliance on a limited range of registered herbicides. Farms located near cereal cropping may be at increased risk. Integrated weed management is of particular importance in reducing the risk of herbicide resistance developing.

Figure 7 Pre-plant or pre-emergent herbicides are often one of the key techniques for management of wild radish in broadleaf vegetable crops, such as this lettuce crop near Gatton, Qld.

Biological control

At the time of writing, no biological control agents were identified for wild radish.

In general terms however, biological control agents will only suppress growth and/or flowering of weeds, and will not achieve sufficient control alone.

Biological control is no silver bullet for success and therefore needs to be integrated with other methods to achieve effective weed control. In Australia biological control has largely only been introduced for some perennial non-grass weeds in aquatic, pasture, and rangeland habitats.

The short-term cropping season common in vegetable production makes it difficult for biological control agents to become established at effective levels. Therefore, vegetable farmers are unlikely to have the benefit of their use in the near future.

Bringing the control methods together

The three dimensions to success, most likely to provide effective control of major weeds such as wild radish, include 'Deliberation', 'Diversity', and 'Dedication'.

In applying this '3D' approach, a variety of options is available as described on the next page. This is commonly known as 'integrated weed management', and is likely to bring you the greatest chance of longer-term success in restricting the impact of wild radish on your farm.

Integrated management of wild radish

Integrating all available and feasible weed control techniques in a timely and diligent way has been shown to be very effective in bringing heavy infestations of broadleaf weed species such as wild radish under control on Australian vegetable farms.

This section has been adapted from the chapter 'Vegetable Weed Management Systems', written by Craig Henderson, and published in the book *Australian Weed Management Systems* (edited by Brian Sindel, University of New England).

Some practices may be implemented for reasons other than weed management, but still have weed management benefits.

Depending on the farmer's circumstances and resources and the extent of the wild radish infestation, whole-of-farm integrated weed management strategies may include the following.

- Shifting most cash crop production to the parts of the farm where the wild radish infestation is lower.
- *Repeated cultivations* and *knock-down herbicides* may be used together before each crop planting to reduce the population of wild radish and other weeds. These approaches may include implementing a stale seed bed, and controlling recently emerged plants either by light tillage or herbicide application. Encouraging seeds to germinate in autumn (using a light till which buries them just below the soil surface) and then controlling the plants before seed set can reduce the weed seed bank in the longer term.
- Consider growing a cash crop or cover crop during the wild radish growing season that will allow use of *selective herbicide options* registered for wild radish control. Fewer wild radish plants may also be expected to appear in the paddock when a winter cover crop is grown, providing the cover crop canopy provides good coverage.
- Including a winter fallow period in the crop rotation may also allow *non-selective herbicide* application to reduce the wild radish seed bank.
- Where a wild radish infestation is particularly heavy, it may be necessary to produce cash crops only during the warmest months of the year, when crop seeding or transplanting through to harvest is likely to take less time than during the cool season. This approach will allow other management options (such as stale seed beds, winter fallows or winter cover crops) to be considered during the autumn-winter wild radish growing season.
- Implementing and rigorously adhering to a *farm hygiene* program, for example: undertaking thorough vehicle washdown in between farm sites (especially infested and non-infested areas); laying concrete or gravel tracks along major farm laneways to reduce the amount of soil being spread by vehicles; and planting a competitive grass species (e.g. Kikuyu) along laneways and drainage lines, and mowing these areas to minimise the chance of undesirable weed establishment. Farm hygiene reduces the potential for wild radish seeds outside the vegetable beds to act as sources for recolonisation, and is particularly relevant when parts of the farm are infested while others remain free of the weed.
- Use of a *drip irrigation system* can mean that the non-irrigated inter-rows remain dry (unless rain falls) throughout most of the growing period, with consequent reductions in wild radish and other weed populations. Such an irrigation system may be integrated with a *plastic mulch* in some high-value vegetable crops such as cucurbits. This will result in little wild radish emergence within the mulched crop beds, and the plastic may also reduce the amount of viable seed through soil solarisation. However, farmers need to remain aware of the potential for weed seeds to germinate in the crop holes, as well as where the mulch has been punctured during laying or during crop management activities.
- *Close plant spacings*, *rapid crop growth* and *canopy closure*, combined with in-crop spraying of *selective herbicides* (where such options are available) can result in low survival of wild radish in the vegetable crop. A similar approach may be pursued in cover crop rotations.
- *Hand weeding* also has a role to play in an integrated approach. Farm staff should be encouraged where possible to physically remove and destroy older weeds (particularly those flowering) that they come across in the course of their work, especially at harvest time when large numbers of workers are likely to be systematically moving through each field.

Because annual broadleaf weeds such as wild radish rely in part on rapid turnover of large numbers in the weed seed bank to maintain high populations, an integrated management system of this nature can be expected to result in a relatively sharp decline in weed numbers over time. Nonetheless, farmers need to remain aware of the potential for wild radish seed to remain dormant for up to 20 years depending on conditions, and therefore for germination flushes to occur at any stage given suitable circumstances.

Integrated management of wild radish is likely to be effective in reducing its impact at relatively little extra cost to the farmer, given that most of the operations described above would still have been implemented for other reasons and have other farm and crop benefits.

The key to integrated management of wild radish is a planned strategy to link the key management components in a sensible sequence, and the persistence to ensure that each step is diligently carried out. In the longer term, integrated weed management may contribute to improved enterprise flexibility, where cash crops may eventually be grown at any stage of the viable production period without concern that this will result in a vast increase in weed numbers, or that the weed burden will impact too significantly on the cash crop.

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Disclaimer

Descriptions of herbicide use in this guide are not to be taken as recommendations. Herbicides must only be used in accordance with the recommendations provided on herbicide labels. Readers are reminded that off-label use of herbicides may be restricted or not permitted under relevant legislation. Landholders are therefore advised to determine current registrations and legal requirements for herbicides they may be considering, and to consult with their State or Territory government departments regarding the legal requirements they are obligated to adhere to relating to herbicide use and weed control.

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