Wild radish (Raphanus raphanistrum)

Wild radish is one of the most widespread, damaging and difficult to control weeds in southern Australia’s cropping systems costing an estimated $210 million per year (Madafiglio 2002). A 2001 survey of landholders throughout Australia ranked it as the third most difficult to control weed (Madafiglio 2002). It is common throughout the Murrumbidgee catchment (Figure 1).

Figure 1. Wild radish in a canola crop at flowering.

KEY POINTS
- Prevent seed production and deplete the seed bank.
- Use an integrated weed management program to delay or manage herbicide resistance.
- Knowledge of the biology and ecology of wild radish is essential for effective management.

Legislation

Wild radish is a Schedule 4 – Class 4 Noxious Weed and “the growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority”. For more information visit http://www.dpi.nsw.gov.au/agriculture/noxweed.

Origin, Introduction to Australia and Distribution

Wild radish originates from Western Europe to central Asia and was introduced into Australia accidentally as a contaminant of agricultural produce in the middle of the 19th century.

Wild radish is found in all Australian states and territories except the Northern Territory. In New South Wales it occurs in all cropping areas.

Wild radish is predominantly found in winter crops but also on roadsides, in orchards, degraded pastures, wastelands and other disturbed habitats. It is found less in pastures and undisturbed areas as soil disturbance stimulates germination and it is affected by grazing and competition with other weed species. Wild radish grows over a range of soil types but prefers slightly acidic, fertile soils with a high level of nitrogen.

Biology and Ecology

Wild radish is a major weed because:
- It has a flexible life cycle
- It has high genotypic and phenotypic variability enabling it to adapt to different environments
- It is a prolific seed producer
- The seeds have high longevity and dormancy
- It has staggered germination
- It has low requirements for flower initiation
- It has rapid growth and competes vigorously with crops
- It is easily spread as a contaminant of hay, chaff and grain
- Germination rates of grain contaminated with wild radish seeds rapidly decreases
- Wild radish seeds increases the moisture content of harvested grain
- Fibrous stems choke header combs at harvest
- It is toxic to stock if consumed in large amounts
- It has allelopathic activity on some crops

Taxonomy

Wild radish is in the Brassicaceae (mustard) family and the Raphanus genus. Related species include wild turnip (Brassica tournefortii), shepherd’s purse (Capsella bursa-pastoris), sand rocket (Diploptaxis tenuifolia), turnip weed (Rapistrum rugosum), charlock (Sinapis arvensis), hedge mustard (Sisymbrium officinale), and Indian hedge mustard (Sisymbrium orientale). Wild radish is also known as white weed, jointed charlock, white charlock, wild charlock, wild kale, wild turnip, jointed radish and cadlock.
Wild radish can cause significant crop yield losses as it establishes quickly, has a fast growth rate and competes vigorously. Yield losses depend on wild radish density (Table 1) and time of emergence in relation to the crop. Wild radish that emerges with the crop can cause more than 90% yield loss whereas populations that emerge more than 7 weeks later cause less than 20% yield loss (Blackshaw 2001).

Table 1. Effect of wild radish population density on crop yield loss (Cheam 2005; Hashem, Wilkins & Piper 2001).

<table>
<thead>
<tr>
<th>Wild radish density (plants/m²)</th>
<th>2-4</th>
<th>10</th>
<th>25</th>
<th>50</th>
<th>64</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>7</td>
<td>20%</td>
<td>37%</td>
<td></td>
<td></td>
<td>56%</td>
</tr>
<tr>
<td>Canola</td>
<td>11%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>91%</td>
</tr>
<tr>
<td>Lupin</td>
<td>15%</td>
<td>28%</td>
<td>56%</td>
<td>81%</td>
<td></td>
<td>92%</td>
</tr>
</tbody>
</table>

Wild radish pods shatter into small segments during harvest contaminating grain and aiding dispersal. When wild radish is stored with grain it releases toxic compounds causing grain death.

Wild radish is an alternate host for thrips, flea beetles, club root, tobacco streak virus, cucumber mosaic virus, blackleg, and the aphid borne viruses beet western yellow, cauliflower mosaic and turnip mosaic.

**Identification**

Wild radish cotyledons are heart shaped and hairless with long stems (Figure 2). The first true leaves are oval shaped, irregularly lobed, have a toothed margin, have one separate lobe at the base of the leaf and develop into a flat rosette. The lower leaves have a strong turnip odour when crushed and are covered in prickly hairs. Mature plants are up to 1.5 m tall. The flowers have four petals, commonly yellow or white, but sometimes pink or purple. Wild radish has a yellowish brown pod 5-7cm long containing 1-10 seeds. The pod breaks up into single seeded segments when it is ripe to release the yellow or reddish brown seeds. Wild radish has a strong tap root over 1m deep allowing it to survive periods of moisture stress and regrow following slashing or grazing due to root reserves.

Wild radish can be misidentified as charlock (*Sinapis arvensis* L.), wild turnip (*Brassica tournefortii* Govan) or garden radish (*Raphanus sativus* L.). In contrast to wild radish, wild turnip has irregularly serrated lobes, warts on the upper surface of the leaves, the basal rosette persists until late in the growing season, it has very few stem leaves and the seed pods split length wise to release the ripe seeds. Charlock has smaller, broader flowers, widely spreading sepals and the leaves are smoother and somewhat shiny with shallower veins. The seed pods of turnip weed contain only 1-3 seeds. Garden radish never has yellow flowers and has spongy seed pods which lack distinct joints.

**Seed Dormancy**

Up to 70% of the wild radish seedbank is dormant at the start of the winter cropping season. Dormancy is due to the seed pod (physical restriction), seed coat (chemical inhibition) and embryo. Plants with white or purple flowers, from cooler areas and that emerge early produce seeds with a higher level of dormancy. Prevent these plants setting seed to avoid the addition of highly dormant seeds to the seedbank. Wild radish seeds commonly remain viable in the soil for 6 years but up to 15 years at depth in undisturbed soil (Madafiglio 2002; Newman 2003).

**Germination and Emergence**

Six percent of wild radish emergence occurs in early autumn, 73% in late autumn/early winter and 21% in late winter/early spring (Cheam & Code 1998). The biggest germination flush (up to 800 plants/m²) follows opening rains and later germinations are smaller (as few as 1-10 plants/m²) (Cheam & Code 1998; Madafiglio 2002). Up to 1800 plants/m² can occur in wheat crops however natural thinning occurs at high plant densities (Madafiglio 2002).

Wild radish can germinate all year round if moisture is adequate however the optimum temperature for germination is 20-25°C (ranging from 5°C to 35°C) (Cheam & Code 1998). Later emerging cohorts (4 weeks) can have no noticeable effect on crop growth but still produce viable seed. Bare seeds or those in thin or damaged pods germinate faster than seeds.
enclosed by thick pods. Plants from larger seeds grow more rapidly than from smaller seeds.

**Flowering**

Wild radish has low requirements for flowering and can reproduce in most areas. Flowering occurs from late July (4-12 weeks after emergence) and can continue for 12-42 weeks. Wild radish is pollinated by bees which can transfer genes via pollen over long distances. Plants within a population can have different flower colour (Figure 3).

![Figure 3. Wild radish flowers and seed pods.](Photo: Andrew Storrie)

**Seed Production and Dispersal**

Wild radish produces up to 45000 seeds/m² (Cheam & Code 1998). One plant in a wheat crop can produce 292 seeds and 52 plants/m² can produce 17275 seeds/m² (Cheam & Code 1998). Later emerging plants have a lower chance of setting viable seed and produce less seeds. Figure 4 shows wild radish seed pods and seeds at maturity.

![Figure 4. Wild radish seeds and pods at maturity.](Photo: Andrew Storrie)

Large wild radish plants drop seed at a greater distance from the stem of the parent plant resulting in a greater dispersal distance. Seed is spread via agricultural produce (e.g. in grain and hay), human activity (footwear, machinery, and vehicles), livestock (hooves), wind and water.

**Management**

The increasing availability of selective herbicides over the past few decades has seen herbicides become the most common and effective form of weed control in Australian cropping systems. The advantages of herbicides have caused over reliance and high selection pressure resulting in widespread herbicide resistance. The sustainability and profitability of farming systems now depends on integrated weed management incorporating a range of chemical, cultural and biological weed control techniques and a proactive approach to weed management (Table 2).

The threshold concept of weed management which aims to keep weed levels below an arbitrary threshold density (5-10 plants/m²) only considers the economic effect in the current year rather than the long term effect including the consequences of weed seed carryover. Alternatively, a population management approach aims to reduce the seed bank over time via integrated weed management. The threshold is up to 3 times lower than the economic threshold and aims for low or near zero seedbank density which can be justified when the long-term economic impacts are considered (Madafiglio 2002).

**Chemical Options**

There are wild radish populations resistant to Group B (ALS inhibitors eg chlorsulfuron and imidazolinone), Group C (PS II inhibitors eg triazines), Group F (carotenoid synthesis inhibitors eg diflufenican) and Group I (disruptors of plant cell growth eg 2,4-D) herbicides (Hashem, Pathan & French 2006; Madafiglio 2002; Newman 2003). Some populations are resistant to three of the four groups (Cheam 2005). An estimated 63% of wild radish populations are resistant to Group B herbicides, 60% to 2,4-D (Group I) and up to 90% in intensively cropped regions to Group C herbicides (Walsh, Friesen & Powles 2006).

The optimum use for each herbicide needs to be considered, eg triasulfuron effectively prevents seed set when applied at the reproductive stage in wild radish but only provides suppression when applied pre-sowing therefore should be used during the reproductive stage. For herbicide options visit www.dpi.nsw.gov.au/aboutus/resources/majorpubs/guides/weed-control-winter-crops.
Table 2. Tactics for wild radish management and their likely control rate (Cheam 2005).

<table>
<thead>
<tr>
<th>Tactic</th>
<th>Likely control (%) (control range)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burning residues</td>
<td>70 (20-90)</td>
<td>Concentrated windrows for hot burn. Fire risk &amp; environmental damage.</td>
</tr>
<tr>
<td>Autumn tickle</td>
<td>45 (15-65)</td>
<td>Rain following tickle needed.</td>
</tr>
<tr>
<td>Knockdown (non-selective herbicide)</td>
<td>80 (70-90)</td>
<td>Late germinations won’t be controlled</td>
</tr>
<tr>
<td>Post-emergent spray (selective herbicide)</td>
<td>90 (70-99)</td>
<td>Control weeds early when actively growing.</td>
</tr>
<tr>
<td>Spray-topping (selective herbicide)</td>
<td>80 (70-95)</td>
<td>Control regrowth if any.</td>
</tr>
<tr>
<td>Wick wiping</td>
<td>70 (50-80)</td>
<td>For low growing pulses.</td>
</tr>
<tr>
<td>Silage and hay cutting</td>
<td>80 (70-95)</td>
<td>Cut before seed set. Control regrowth</td>
</tr>
<tr>
<td>Green/brown manuring</td>
<td>95 (90-100)</td>
<td>Brown manuring more effective than green. Hay freezing most effective.</td>
</tr>
<tr>
<td>Grazing</td>
<td>70 (50-80)</td>
<td>Use spray-grazing technique</td>
</tr>
<tr>
<td>Residue collection at harvest</td>
<td>75 (65-85)</td>
<td>Variable results.</td>
</tr>
<tr>
<td>Sow weed free seed</td>
<td></td>
<td>Vial management technique.</td>
</tr>
<tr>
<td>Herbicide tolerant crops</td>
<td>90 (80-99)</td>
<td>Herbicide tolerant canola essential for wild radish infested paddocks.</td>
</tr>
</tbody>
</table>

**Herbicide Tolerant Crops**

Herbicide tolerant crops such as TT (triazine tolerant) canola and Clearfield® (imidazolinone tolerant) wheat and canola allow the use of alternative herbicides. They provide farmers with more cost-effective opportunities for wild radish control despite the associated yield and oil penalties, lower resistance to blackleg and persistence of triazine herbicides in the soil.

**Pre-Emergent Herbicides**

Knockdown existing wild radish plants prior to sowing every year with herbicides or cultivation. See Figure 5 for options and their efficacy.

![Graph of wild radish plants per plot](image)

*Figure 5. The efficacy of knockdown treatments on wild radish populations (Newman 2005).*
Early Post-Emergent Herbicides

The effects of wild radish competition begin early in the crop. Yield increases are greatest when wild radish is controlled at the 2-5 leaf stage of the crop (Table 3) (Cheam & Code 1998). Residual herbicides are often preferred due to the staggered germination of wild radish. Survivors of pre-emergent and early post-emergent herbicide applications should be prevented from setting seed in case of resistance.

Table 3. Effect of early and late control of wild radish on wheat yield in central west New South Wales (Cheam 2005).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Wheat yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsprayed</td>
<td>0.14</td>
</tr>
<tr>
<td>Sprayed late (after tillering)</td>
<td>0.36</td>
</tr>
<tr>
<td>Sprayed early (2-5 leaf)</td>
<td>1.66</td>
</tr>
</tbody>
</table>

Control options include:
- a single herbicide application at the vegetative stage- essential at high weed densities to minimise yield loss; survivors will contaminate grain
- a single herbicide application at the reproductive stage- suitable for low weed densities which will not cause significant yield loss; will prevent grain contamination
- Sequential herbicide applications at the vegetative and reproductive stages- to prevent yield loss and grain contamination.

In cereal crops, there is a very wide range of effective herbicides available for wild radish control. Fewer herbicides are available for use in pulse crops.

Late Post-Emergent

Application of non-selective herbicides at physiological maturity of the crop (crop-topping) can reduce wild radish seed set by 50-80% (Newman & Adam 2006). It is less effective in wheat than other crops as wild radish reaches physiological maturity before wheat. If the herbicide is applied when wild radish is at the reproductive stage, the wheat will not have reached physiological maturity and significant yield losses can occur. However if spraying is delayed until the wheat reaches physiological maturity, the wild radish would have already produced viable seed. Blanket wiping can be more effective than crop-topping in reducing wild radish seed set but can cause a greater yield loss.

Applying selective herbicides at the reproductive stages of wild radish (selective spray-topping) can reduce seed set by up to 100% when sprayed immediately after pollination and within two weeks of flowering (GS 4.9-7.0, bud to mid-flowering) (Madafiglio 2002). Five herbicides that consistently reduce seed production in wild radish over a range of dose rates, developmental stages, geographic locations and environmental conditions are triasulfuron 15g/ha, flumetsulam 20g/ha, MCPA 700g/ha, triasulfuron + MCPA 7.5 + 350g/ha and bromoxynil + MCPA 140 + 350 g/ha (Madafiglio 2002). To minimise seed set, control wild radish before the embryo is formed (Table 4).

Table 4. The embryo developmental stages and seed viability (Cheam et al. 2005).

<table>
<thead>
<tr>
<th>Developmental stage</th>
<th>Seed viability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Early flowering/pod development; newly formed thin pods</td>
<td>0</td>
</tr>
<tr>
<td>2 Mid-flowering/pod fill; well formed green pods but squashy and watery when pressed</td>
<td>4</td>
</tr>
<tr>
<td>3 Embryo formed; pods squashy and watery; new embryo present.</td>
<td>65</td>
</tr>
<tr>
<td>4 Late flowering/pod development; pods woody; green/developed embryos present.</td>
<td>90</td>
</tr>
</tbody>
</table>

Cultural Options

Grazing

Wild radish is not preferentially grazed by livestock but they will eat it if confined to a heavily infested area. Grazing is unlikely to reduce seed production unless the stocking rate is very heavy. Spray-grazing is effective if high stocking rates are used. Wild radish, especially the seed, can be toxic to livestock.

Tillage

Cultivating 1-2cm deep following opening rains can increase seedling emergence in the first wild radish cohort from 2.5 plants/m² to 160 plants/m² (Madafiglio 2002). Conversely, deep burial below 10cm can reduce germination by 61% (Table 5) (Madafiglio 2002). Following deep burial, cultivations should be shallow to avoid bringing the seeds up to a depth suitable for germination. Options for rapid depletion of the wild radish seed bank include: 1) shallow cultivation for two consecutive years followed by minimum disturbance and 2) mouldboard ploughing followed by direct drilling or shallow cultivation in subsequent years. Mouldboard ploughing should only be used every 8-10 years with conservation tillage practiced in between. In the absence of cultivation, seeds which remain on the surface of the soil have a reduced level of germination and quickly lose viability.
Table 5. Effect of tillage operation on wild radish density (Cheam & Code 1998).

<table>
<thead>
<tr>
<th>Tillage operation</th>
<th>Wild radish density (plants/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouldboard ploughing</td>
<td>90</td>
</tr>
<tr>
<td>Direct drilling</td>
<td>207</td>
</tr>
<tr>
<td>Cultivation (disc 5cm)</td>
<td>323</td>
</tr>
</tbody>
</table>

**Hygiene**

Thorough cleaning of machinery and equipment, sowing clean seed from wild radish free areas, avoiding buying hay or chaff from wild radish infested areas and quarantining stock that have recently been in infested areas are vital for reducing wild radish spread.

**Swathing (Windrowning)**

Wild radish seeds are often green when canola crops are harvested causing contamination of canola seed. Swathing will desiccate the wild radish pods while minimising yield losses from shattering caused by delayed harvesting. This will not impact on the level of weed seed carryover.

**Burning**

A temperature of 500°C for 10 seconds or 400°C for 60 seconds is needed to kill 100% of wild radish seeds present (Walsh, Friesen & Powles 2005). This is usually achieved only by burning narrow windrows rather than standing crop stubble (Figure 6). Burning narrow windrows has other benefits such as reducing erosion by leaving majority of the paddock unaffected but also has disadvantages including not affecting seed that is shed prior to harvest which is between the windrows.

Crop Species, Cultivar and Density

A non-crop phase should be included at least once every four years in your rotation and preferably 2 in every 5 years (Newman 2003). Tight rotations such as the wheat-lupin rotation commonly used in Western Australia have been shown to favour wild radish.

Cereals are more competitive and have more effective, cheaper in-crop herbicide options than pulses therefore wild radish should be controlled in the cereal phase of the rotation (Table 6). There are also competitive differences within crop species, eg the lupin variety Mandelup is more competitive than Belara and Tanjil (Hashem, Pathan & French 2006).

Table 6. Yield loss of various crops due to a wild radish population of 10 plants/m² (Cheam 2005; Hashem, Wilkins & Piper 2001).

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>7</td>
</tr>
<tr>
<td>Canola</td>
<td>11 (2-4 plants/m²)</td>
</tr>
<tr>
<td>Lupin</td>
<td>28</td>
</tr>
<tr>
<td>Faba bean</td>
<td>36</td>
</tr>
<tr>
<td>Field pea</td>
<td>36</td>
</tr>
<tr>
<td>Lentil</td>
<td>42</td>
</tr>
<tr>
<td>Chickpea</td>
<td>49</td>
</tr>
</tbody>
</table>

Table 7 shows the effect of various rotations on a wild radish population after 2-4 cycles (8-10 years). The model used assumes a seedbank germination of 33% in year 1, 20% in year 2, 7% in year 3, 3% in year 4 and 37% being lost, a herbicide efficacy of 90% in lupins, 95% in cereals and 100% in spray grazed pastures.

A high seeding rate, narrow row spacing and precision fertiliser placement should all be used to maximise the competitive ability of the crop.

Table 7. The effect of crop rotation on the wild radish seedbank (Bowran 2001).
## Slashing

Slashing or mowing promotes regrowth of wild radish so green or brown manuring is a better option. Slashing can prevent seed set however it must be done regularly due to the long flowering season of wild radish.

## Hay and Silage Making

Hay or silage making prevents wild radish plants from setting seed however any regrowth must be controlled. It is especially valuable where resistance is present but the short term economic loss needs to be considered before implementing this option.

## Fertiliser

Nitrate fertiliser reportedly stimulates recruitment of wild radish seeds by over 100% compared to no nitrogen fertiliser however this is not currently used as a management option in Australia (Madafiglio 2002).

## Green/Brown Manuring

Green and brown manuring prevents seed set and increases available nutrients and organic matter in a paddock. Compare the short term economic loss to the long term benefits of a lower weed density when considering this option. Its value increases when high weed densities and herbicide resistance are present.

## Hand Weeding

Hand weeding is effective when infestations are light. Plants should be removed at least 2 weeks prior to flowering.

## Seed Catching

Seed catching and seed destruction at harvest can remove up to 95% of wild radish seeds (Newman 2003). The ‘Rotamill’ developed by Harvestaire® destroys up to 100% of seeds as they exit the harvester (Newman & Walsh 2004). Baling chaff and straw out of the harvester is also very effective however has associated problems such as handling large numbers of bales.

## Multispecies RIM & WEEDEM

Weed management decisions should be based on seedbank dynamics and short and long term profitability. Multispecies RIM is a bioeconomic resistance management program used as decision support tool for annual ryegrass and wild radish management. It assesses the likely biological and economic impacts of control strategies by simulating the effects on seed numbers and economic turnover. For more information contact your local adviser or Robert Barrett-Lennard (rbl@cyllene.uwa.edu.au).

## Biological Options

Biocontrol of wild radish is risky as the plant is closely related to many agricultural and horticultural species. Evidence suggests wild radish is attacked by redlegged earth mites, thrips, flea beetles, white Italian snails, downy mildew, white rust, black rot, club root, turnip mosaic virus, tobacco streak virus, cucumber mosaic virus and blackleg. Wild radish seeds are also attacked by ants, microfauna and microbial decay.

## References


Cheam, A, Lee, S, Lemerle, D, Koetz, E & Starrie, A 2005, ‘When is the right time to maximise seed set control of wild radish’, Agribusiness Crop Updates 2005, Department of Agriculture Western Australia.


Newman, P & Walsh, M 2004, ‘How effectively can weed seeds be removed at harvest?’, Agribusiness Crop Updates 2004, Department of Agriculture Western Australia.


Newman, P & Adam, G 2006, ‘Crop-topping of wild radish in lupins and barley, how long is a piece of string?’, Agribusiness Crop Updates 2006, Department of Agriculture Western Australia.


Disclaimer

The information contained in this publication is based on knowledge and understanding at the time of writing (2008). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of New South Wales Department of Primary Industries/Murrumbidgee Catchment Management Authority or the user’s independent adviser.

The product trade names in this publication are supplied on the understanding that no preference between equivalent products is intended and that the inclusion of a product name does not imply endorsement by NSW Department of Primary Industries or Murrumbidgee CMA over any equivalent product from another manufacturer.

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This project has been funded through the Australian and NSW Governments’ National Action Plan for Salinity and Water Quality.