Fat Hen

Chenopodium album

Weed management guide for Australian vegetable production

INTEGRATED WEED MANAGEMENT

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Identification

Fat hen (*Chenopodium album*) is an erect annual herbaceous plant, native to Europe, that grows between 0.2 and 2 metres in height, and has ridged striped stems.

Leaves are between 2-6 cm in length, oval to trowel-shaped, edged with teeth or irregular lobes. They vary in colour but are often blue/green or grey/green, and may have a mealy (powdery) surface. Flowers are green and white, in small clusters and continuous along the stem. The seed remains enclosed by flower segments at maturity.

Fat hen may also be known in Australia as white goosefoot or common lamb's quarters. Nearly all vegetable farmers will be well aware of fat hen and how to identify it. However in some cases, depending on stage of growth and experience in identification, some other common annual heavy-seeding weeds of Australian vegetable production may be mis-named as fat hen, including nettle-leaf goosefoot (*Chenopodium murale*), crumbweeds (*Dysphania spp.*), amaranth (*Amaranthus* spp.), potato weed (*Galinsoga parviflora)* or blackberry nightshade (*Solanum nigrum*).

Figure 1 includes a series of photos of fat hen at different life stages in order to facilitate correct identification on-farm, from a young seedling through to a mature flowering plant.

Figure 1 Life stages, from germination to flowering

Characteristics

Key characteristics

Table 1 Key characteristics of fat hen

Time of germination	Spring (peaking mid-late spring); through to summer and autumn
Time of flowering and seed set	Late summer or early autumn (during spring in some conditions)
Reproduction	By seed only
Seed productivity	200-75,000 seeds/plant
Seed viability	Up to several decades
Optimum germination soil depth	2 mm to 50 mm
Soil type/s	Cultivated calcareous soils favoured. Found on strongly acid to strongly alkaline soils
Competitive advantages	Early emergence; rapid growth; long-term seed viability; high seed production; competes well with crops

Seasonality

As heavily seeding summer annual weed, fat hen persists in crops over time via seeds which can overwinter either on or just below the soil surface. Seed germination occurs mostly in mid to late spring. However, germination can occur through summer and autumn, particularly in irrigated crops. Plants generally flower and set seed in late summer or early autumn, but flowering may also occur during the spring in some conditions. Even small plants are capable of flowering and setting seed.

Seed production

Variations in seed colour and form allow fat hen to germinate under a range of environmental conditions. Approximately 95% of the seeds are almost black in colour, hard coated and dormant, while the remaining 5% are brown, almost uncoated and not dormant. Between 200 and 75,000 seeds may be produced per plant. In heavy fat hen infestations, as many as 50 million seeds may be produced per hectare. Seed production depends on plant density and competition between fat hen plants and crop or cover crop plants. Seeds are circular, averaging 1.2 mm to 1.3 mm in diameter. About a third of fresh seeds may be capable of immediate germination. Seed tends to drop to the ground at the base of the plant.

Seed viability

Under favourable conditions, seeds may remain viable for several decades. Dormancy and germination rates appear to be affected by changes in the amount of daylight available for germination (for example, day length or crop shading of the weed seed bed), while drought also appears to affect fat hen germination rate. Optimum seed depth for germination is approximately 2 mm, and few seedlings emerge from a depth of greater than 25 mm.

Soil preference

Fat hen is found growing in a wide range of soils from strongly acid to alkaline. It shows a preference for cultivated or well drained calcareous soils, but is also competitive in minimal-till soils.

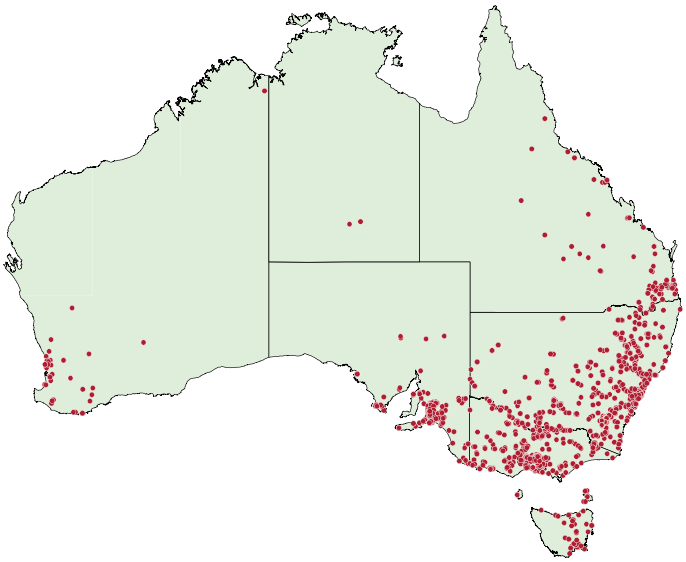
Methods of spread

Fat hen may spread within and between farms through a variety of means:

- ingestion and excretion of seed by livestock and birds;
- machinery and agricultural practices;
- road construction; and
- dispersal via moving water.

Distribution

Fat hen is a common weed of horticultural and agricultural crops (particularly summer crops and winter forage), in all Australian states, particularly in the south-east. In general, it prefers temperate to sub-tropical conditions, with higher rainfall.



Map 1 Australian distribution of fat hen (source: Atlas of Living Australia)

Impacts

Fat hen is considered one of the most important weeds for the Australian vegetable industry, due to its impacts on production and the amount of effort required to manage it effectively on-farm. Across the world, it is considered one of the most important weeds of a number of vegetable crops, including potatoes, beets, corn, and asparagus.

Crop competition and contamination

Some particular impacts of this weed in row crops include:

- crop nutrition deficiency;
- competition for light and water;
- harvesting interference; and
- crop contamination, particularly in leafy vegetable crops.

Early emergence and rapid growth rate gives fat hen a competitive advantage over crop plants. Contamination can result in significant removal costs during processing, or lower prices at sale.

A host of pests and diseases

Fat hen hosts a range of vegetable crop diseases in Australia and elsewhere around the world. These include: cucumber mosaic virus, bean yellow mosaic virus, potato virus, tobacco etch virus, turnip mosaic virus, and watermelon mosaic virus. In Australian vegetable production, fat hen has also been noted as a host of aphids.

Figure 2 The rapid rate of growth and size of Fat hen make it highly competitive for resources with most vegetable crops.

Management

Management methods

Table 2 Fat hen management methods

Activity	Suitability	Notes
Tillage	✔ ✔	No later than 2 weeks after emergence. May include stale seedbed. Inversion ploughing not recommended due to long seed viability period.
Cover crops and crop residues	✔ ✔	Feasibility of cover crops dependent on cash crop produced and viability of non-crop period in annual rotation. Usefulness of crop residues as weed management option dependent on crop. Good establishment is critical.
Planting density	✔ ✔	Plant crop at highest practical density without impacting on crop yield, to increase competition.
Farm hygiene	✔	Best suited to farms with no current fat hen infestation, or an infestation restricted to one part of the farm.
Physical control	✔	As follow-up to early-stage herbicide and tillage. Hand weeding is expensive and not suitable for wide-scale use. Slashing/mowing may not be suitable depending on production system. Better suited to lighter infestations.
Herbicides	✔ ✔ ✔	No later than 3 weeks after emergence. Potential resistance to triazines, glyphosate and dicamba based on overseas examples.
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

Tillage promotes germination of fat hen. Peak emergence may take place approximately 2-3 weeks after tillage where moisture and temperature conditions are suitable. One study found that tillage resulted in a six-fold increase in seedling emergence in the first year. However in this case, tillage was associated with decreased emergence in the following year. This suggests that tillage may contribute to fat hen infestation in the shorter term, but help to reduce the impact of this weed in the longer term.

Soil disturbance by tillage before crop planting at a depth of 2.5 to 5 cm can be highly effective at managing fat hen, by stimulating germination and then controlling recently germinated weeds when they are still small and fragile. This control option is commonly known as the stale seed bed technique, and may be useful in encouraging fat hen emergence prior to crop sowing to deplete the weed seed bank. A stale seed bed may also be effective *within* the crop row in the first 4-6 weeks after crop planting. Feasibility of this option depends on crop type and availability of suitable intra-row tillage equipment. It also requires suitable soil moisture conditions.

Tillage type may also influence fat hen emergence. In one study, emergence of fat hen in chisel plough plots was far more significant than in comparative plots comprising no-till or mouldboard ploughing followed by cultipacking, in a corn production system.

Figure 3 A shallow 'tickle' till within the crop row and between the plants early in their life cycle may help to manage recently germinated fat hen and other important broadleaf weeds, allowing the crop to form a canopy before the weed problem becomes significant within the rows. Relevance of this technique will depend on crop/s grown, and availability of intra-row tillage equipment.

Cover crops and crop residues

Cover crops grown in the period between vegetable cash crops offer growers an opportunity to reduce the impact of fat hen on their farm. They can be expected to reduce fat hen germination, flowering and seed set through competition for resources (soil nutrients, water and light), and potentially as a result of their biofumigant effects. An overseas study indicated that planting a white mustard (*Sinapis alba*) cover crop and then leaving the residue as a mulch resulted in lower fat hen seedling emergence than in bare soil or no-till plots. Other cover crops that have been found to be effective overseas in suppressing fat hen include hairy vetch (*Vicia villosa*) and oats (*Avena sativa*). The importance of biofumigation in management of significant weeds such as fat hen in Australian conditions requires further research.

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 the disease cycle within the cash crop, and overall contribution to cash crop productivity. Good establishment is critical for achieving effective weed management using the cover crop.

Heavier crop residues may also reduce the impact of fat hen. In one overseas study, higher residues of corn crops left in the crop beds after harvesting reduced emergence of fat hen. More specifically, untilled plots saw a greater emergence of fat hen seedlings than tilled plots, but untilled plots with greater crop residue left behind were less prone to this weed species than comparable tilled plots.

Figure 4 Newer cover crop varieties such as Buckwheat (Fagopyrum esculentum) appear to be effective in suppressing broadleaf weeds such as fat hen, as observed on this farm near Hobart, Tas.

Planting density

Agronomic practices, such as increased planting density, that contribute towards the rapid development of a thick crop canopy cover will lead to less return of fat hen seed to the soil, as increased crop density will result in fewer and shorter fat hen plants, fewer flowers, and reduced seed production and less return of fat hen seed to the soil. This principle is similar to selecting a competitive cover crop variety, as discussed above. Competitive crop variety selection may result in more rapid establishment of crop canopy. Narrow row spacing and higher planting density has been shown to suppress fat hen growth in wheat and barley.

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 fat hen impact in the longer term.

Figure 5 Ensuring appropriate planting density to allow good coverage of the crop beds can be useful along with other techniques (such as tillage and pre-plant/pre-emergent herbicide application) to suppress fat hen and other weeds effectively within the crop beds, as this example of a brassica crop near Werribee, Vic, illustrates.

Farm hygiene

Implementing appropriate farm hygiene practices helps limit the spread of fat hen 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 fat hen may be well managed within the crop beds, it may still be observed in wheel tracks, headlands and nearby non-crop areas, to the extent that plants were going to seed and replenishing the seed bank in the fields. Effectively managing off-bed fat hen plants may therefore reduce the burden of this weed within crop beds in the longer term.

Farm hygiene may be less relevant for managing fat hen 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 6 Establishing a fixed equipment wash-down bay can help restrict the spread of fat hen on the farm, particularly where it is not present at all or only present on part of the farm.

Physical control

Hand weeding is effective for removal of fat hen and other important weeds on vegetable farms, particularly those that are flowering or setting seed, and/or plants missed when other management approaches have been implemented. Options include digging or hoeing plants out, or potentially pulling larger plants out by hand. Hand weeding may be necessary to remove fat hen 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.

Fat hen plants that are flowering and/or seeding should be removed from the crop rather than left on the ground, to ensure that viable seed are not left near the crop rows to add to the soil weed seed bank for future seasons.

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 fat hen plants by hand and taking any flowering or seeding plants 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 developing.

Slashing or mowing can be an effective fat hen control measure amongst younger plants where survival is impeded. However, it is critical to undertake such practices before the plants have had a chance to set seed, so that the problem is not made worse in following seasons by spreading viable seed. Fat hen has been shown to be sensitive to flaming.

Figure 7 Diligent hand weeding over several seasons, utilised in combination with other weed management tactics, can result in almost complete eradication of weeds from the crop. In this paddock in Western Australia, farm staff were encouraged to remove all weeds by hand before seed set. They had succeeded in transforming a previously weedy paddock into one almost entirely free of weeds.

Herbicides

Fat hen is susceptible to commonly recommended herbicide options including triazines, thifensulfuron, imazamox, MCPA, bentazon, and glyphosate, though control effectiveness can vary depending on the stage of plant development.

Research in Canada found that herbicide was a much more effective method for fat hen control than tillage. Post-emergence herbicides must be applied when the weed plants are young, as they quickly become woody and more resistant to herbicide effects.

A range of selective and non-selective herbicides are registered to control fat hen, across a variety of vegetable crops. 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 fat hen in Australian vegetable production

Herbicide active ingredient*	Trading name/s	Group	Vegetable crop/s in which use is registered	Timing/crop growth stage
Atrazine	Gesaprim	C	Sweet corn, potatoes	Pre-plant, pre-emergence or post-emergence
Bentazone	Basagran; Dictate 480	C	Beans	Post-emergence
Chloridazon	Pyramin	C	Red beet, silver beet	Post-sowing pre-emergence
Chlorthal-Dimethyl	Dacthal 900 WG	D	Brassicas, beans, peas, garlic, onions, carrots, lettuce, potatoes, turnips	At time of seedling or transplanting
Clomazone	Command 480 EC; Director	F	Cucurbits, potatoes	Post-plant pre-emergence
Dicamba	Cadence	I	Potatoes	Apply after haulm senescence
Dimethenamid-P	Frontier-P	K	Green beans, navy beans, sweet corn, corn, green peas, pumpkins and kabocha	At or immediately after sowing; pre-emergence
Diuron	Diurex WG	C	Asparagus, peas	Pre-emergence
EPTC	Eptam	E	Beans, potatoes	Pre-emergence
Ethofumesate	Tramat	J	Beets, onions	Pre- or post-emergence depending on crop
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	
Metolachlor	Metolachlor	K	Brassicas, beans, corn	Pre-emergence or immediately after transplanting depending on crop
Metribuzin	Sencor; Tomahawk	C	Asparagus, peas, potatoes, tomatoes	Pre-emergence
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
Propachlor	Ramrod	K	Onions, transplanted brassicas, beetroot	Pre-emergence, pre-transplant or at-transplant, depending on crop
S-Metolachlor	Dual Gold	K	Brassicas, beans, sweet potatoes	Immediately after transplanting
Simazine	Gesatop; Simagranz	C	Asparagus	Pre-emergence
Terbutryn	Terbutryn	C	Peas	Early post-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 'fat hen' to identify a range of herbicides suited to a range of cropping situations.*

Herbicide resistance

Vegetable growers should remain aware of the potential for herbicide resistance to develop in fat hen and other key weeds, particularly if their crop rotation involves heavy reliance on a limited range of registered herbicides. Integrated weed management is of particular importance in reducing the risk of herbicide resistance developing.

Herbicide resistant populations of fat hen have not yet been reported in Australia, though instances have been reported overseas. Fat hen is regarded as the fourth most important herbicide-resistant weed worldwide.

Some examples of herbicide resistant fat hen populations are noted in the table below, with a focus on products that are registered for use in Australian vegetable production. In general, management of resistant populations for these products has involved rotating to other herbicide options, relying more heavily on other management approaches such as tillage, or potentially using a higher rate of the herbicide in question to control plants showing resistance traits (more effective against smaller plants than larger plants).

Figure 8 Pre-plant or pre-emergent herbicides are often one of the key techniques for management of fat hen in broadleaf vegetable crops, such as this lettuce crop near Gatton, Qld.

Table 4 Examples of herbicide resistance in fat hen in global vegetable production

Herbicide*	Group	Vegetable crop/s registered for in Australia	Where fat hen resistance discovered and in which crop/s	Potential causal factors
Triazines (e.g. atrazine, cyanazine, prometryn, simazine)	C	Asparagus, carrots, celery, corn, onions, peas, potatoes	Europe (corn); North America (corn, soybeans); New Zealand (corn).	Repeated use on same crop over several seasons; Persistence in soil and subsequent selection for resistant fat hen biotypes; Frequent usage at high rates; Reliance on herbicides due to minimum tillage.
Glyphosate	M	Used widely; prior to sowing, fallow control, inter-row control, non-crop area management.	United States (glyphosate-resistant soybean varieties)	Repeated use of lower than optimal rates that selects for resistant fat hen biotypes.
Dicamba	I	Potatoes	New Zealand (corn)	More frequent use as an alternative product on atrazine-resistant fat hen populations.

** Details correct at time of writing; please consult the herbicide label or contact your reseller for current registration details.*

Biological control

Because of the growing issue of herbicide resistance amongst fat hen populations in a number of crops overseas, alternative management techniques are increasingly being sought. Research in Europe has explored the potential of the fungus *Ascochyta caulina* as a bioherbicide treatment of the weed. Researchers found that up to 70% control was achieved in field conditions.

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 need 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 fat hen 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 success in restricting the impact of fat hen on your farm.

Integrated management of fat hen

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 fat hen 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 fat hen 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 fat hen infestation is lower.
- *Repeated cultivations* and *herbicides* may be used together to reduce the population of fat hen and other weeds before each crop planting. These approaches may include implementing a stale seed bed, and controlling recently germinated plants either by light tillage or herbicide application. Encouraging seeds to germinate and then controlling the plants before seed set can reduce the weed seed bank in the longer term.
- Including a cash crop or cover crop during the traditional non-cash crop period in the rotation allows use of *selective herbicide options* that have been registered for fat hen control. Fewer weeds may be expected to appear in the paddock when an out of season cover crop is grown. Including a fallow period in the crop rotation may also allow *non-selective herbicide* application to reduce the fat hen seed bank.
- Where a weed 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 short crop production period may be beneficial in minimising the renewal of the fat hen soil seedbank, even though the species has a relatively rapid life cycle. Once the crop is harvested, the residue can be quickly ploughed in to prepare the land for the next cropping sequence, also helping to prevent seed set by escapee weed plants.
- 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 fat hen 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 fat hen 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 fat hen emergence within the mulched crop beds, though 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 fat hen 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 fat hen rely 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 fat hen seed to remain dormant for up to several decades, and therefore for germination flushes to occur at any stage given suitable conditions.

However, integrated management of fat hen 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 fat hen 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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