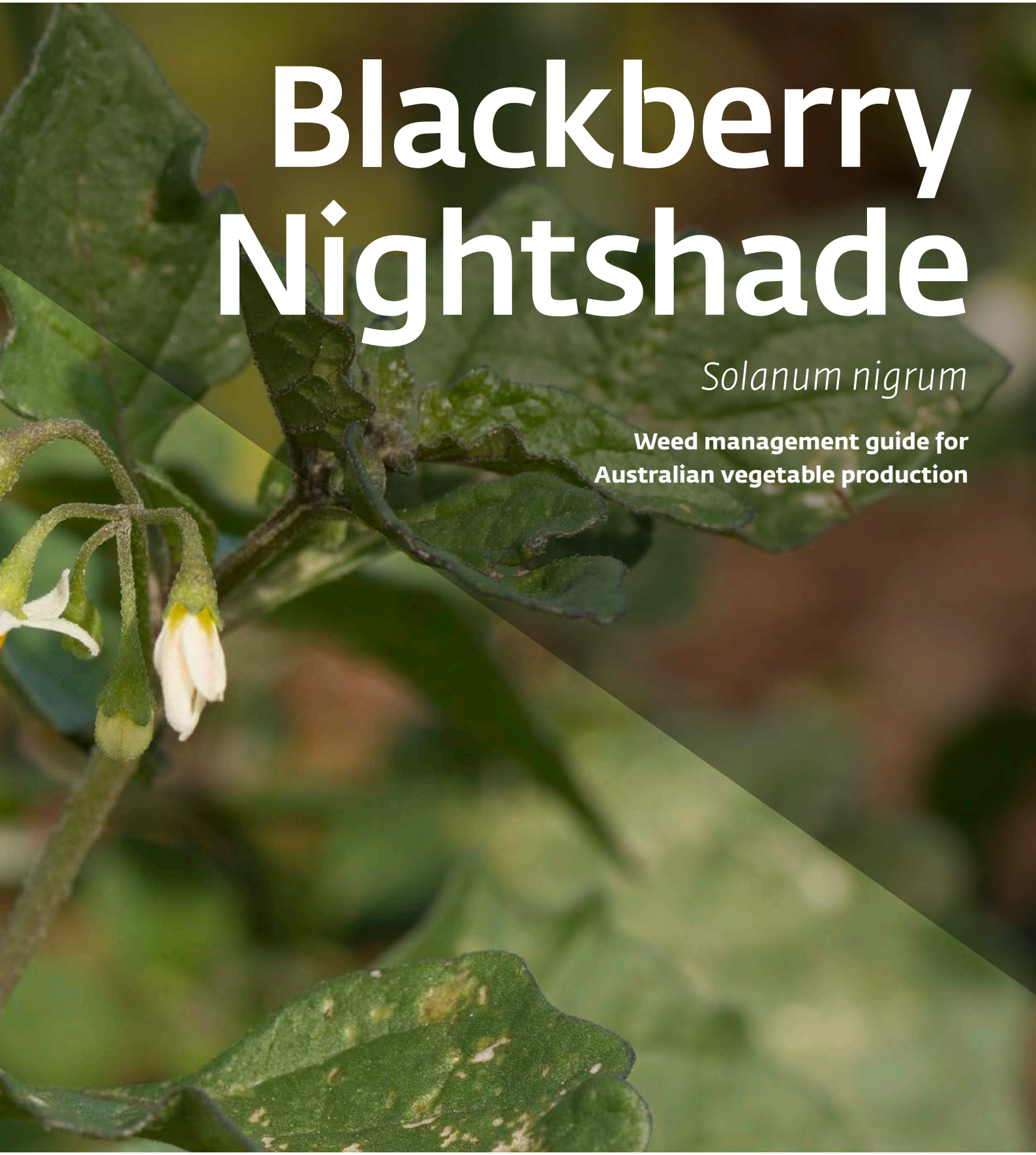

Blackberry Nightshade

Solanum nigrum

Weed management guide for Australian vegetable production

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Identification

Blackberry nightshade (*Solanum nigrum*) is an annual (and sometimes perennial) herbaceous plant, native to Europe, that grows between 0.1 m and 1 m in height.

Blackberry nightshade can vary widely in its growth form, with stems either erect or spreading and occasionally prostrate. Stems are smooth or very sparsely hairy, becoming woody with age. Plants are usually considerably branched with fully mature (flowering) specimens regularly observed at as little as 10 cm in height. Leaves are elliptic to oval with pointed tips, 3 to 7 cm in length, sometimes edged with coarse irregular teeth and wavy margins, and generally dark green to purple-green in colour. Flowers are white with five petals fused at the base with yellow centres, 8 to 12 mm across. The fruit is between 5 and 13 mm in diameter, a shiny berry that is dark green when initially produced and changing to purple-black when ripe.

Young plants can bear some resemblance to *Amaranthus* spp., but are generally darker and distinguishable with experience by their cotyledons and first true leaves. Depending on stage of growth and experience in identification, some other common annual heavy-seeding weeds of Australian vegetable production may also be mis-named as blackberry nightshade, including potato weed (*Galinsoga parviflora*) or fat hen (*Chenopodium album*).

Figure 1 includes a series of photos of blackberry nightshade at different life stages in order to facilitate correct identification on-farm, from a young seedling through to a mature flowering plant, including images of the flowers and unripe and ripe fruit.

Figure 1 Life stages, from emergence to flowering and fruiting

Characteristics

Key characteristics

Table 1 Key characteristics of blackberry nightshade

Time of germination	Spring and summer
Time of flowering and seed set	Through spring and summer (between 5 and 9 weeks after germination)
Reproduction	By seed only
Seed productivity	Between 5,000 and 800,000 seeds per plant estimated
Seed viability	Up to four decades, but most seeds are not viable after approximately 8 years
Optimum germination soil depth	2.5 mm to 15 mm; no deeper than 75 mm
Soil type/s	Adapted to a range of soil types
Competitive advantages	Early emergence; rapid growth; long-term seed viability; high seed production; competes well with crops; able to germinate in low light conditions

Seasonality

Blackberry nightshade seed germination usually commences in spring and continues through summer depending on climatic conditions. Seeds germinate best under an alternating temperature regime with a high of between 20°C and 30°C, as well as relatively constant soil moisture. Constant temperatures have been found to inhibit germination. Plants generally flower between 5 and 9 weeks after germination, with seed produced soon after. Germination of new plants ceases in autumn and seed remains dormant over winter. Plants usually die in winter as well, however in relatively mild winter conditions they are capable of surviving through to the next warm season, and some research suggests that biennial/perennial blackberry nightshade plants may survive for as long as 5 years under such conditions.

Seed production

Seed production has been estimated at anywhere between 5,000 and 800,000 seeds per individual plant. Between 15 and 60 seeds are produced within each fruit of blackberry nightshade. Seeds are flattened, yellow to dark brown in colour, and generally around 1.5 mm in diameter. Exposure to full sunlight is required to maximise flowering (and therefore seed production).

Seed viability

One overseas study has suggested that approximately 90% of seed remain viable 5 years after production, with this percentage falling to as little as 2% over the next 3 years. Other research suggests that some seed may remain viable for up to 4 decades under ideal conditions. Reports vary on the effect of exposure to light on germination rate, however rates of germination appear to be increased by exposure to intermittent and less intense light as opposed to stronger direct light. Seeds also appear readily capable of germinating in darkness. Lack of moisture as well as extremes in temperature (very high or very low temperatures) appears to destroy otherwise viable seed. The optimum depth for blackberry nightshade seed germination is approximately 2.5 to 15 mm, with little seedling emergence occurring below this depth and no emergence occurring below 75 mm.

Soil preference

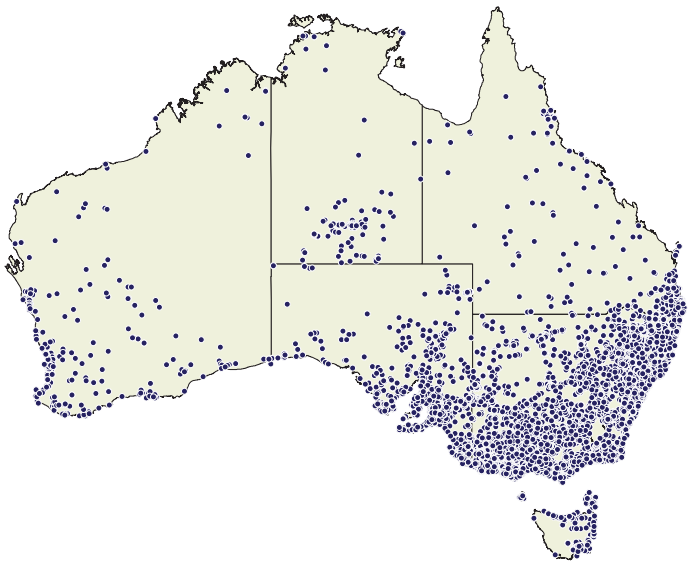
Blackberry nightshade is considered adapted to a range of well drained moist soils, including sandy, loamy and heavy clay soils. Seedling emergence rates do not appear to be significantly different across various soil types. It is more likely to emerge on bare or recently disturbed ground.

Methods of spread

Fruit as well as viable seeds can spread by a range of means within and between farms, including via wildlife, birds and livestock, via human activities such as cultivation or transport, and along water courses. Ingestion of fruit by birds does not appear to negatively impact seed germination rates.

Distribution

In Australia, blackberry nightshade is found in all states and territories, and is a common weed problem of horticulture, other forms of cultivation, and other disturbed sites such as roadsides, wasteland, exposed river beds and banks, and uncompetitive pastures. It appears to prefer temperate to sub-tropical climates, and is most likely to thrive in moist, warm and fertile conditions, with either full or partial sunlight.



Map 1 Australian distribution of blackberry nightshade (source: Atlas of Living Australia)

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

Impacts

Given its preference for disturbed moist habitats, blackberry nightshade is well adapted to the conditions found in vegetable production systems, and has been found to be one of the most significant weeds of Australian vegetable production. Additionally, it is well suited to soils that are high in nitrogen, and nitrogen-rich fertilisers therefore improve the favourability of the environment for this weed species.

Across the world, blackberry nightshade and related species are considered important weeds in over 70 countries, and pests in a wide range of vegetable crops. In Australia, crops identified as being negatively impacted by blackberry nightshade include cucurbits, lettuce, tomato, capsicum, potato, eggplant, chilli, beans, sweet corn, peas and brassicas. The plant, particularly the unripe green fruit, is toxic to livestock and humans.

Crop competition and contamination

The rapid growth rate of blackberry nightshade plants, early flowering, and its ability to out-compete crop plants has been noted as a problem by Australian vegetable farmers.

Various crop harvesting and contamination issues have been directly associated with blackberry nightshade.

- Fruit flesh and liquid 'gluing' of soil and plant parts together during harvesting operations, and consequently causing blockages in harvesting equipment.
- Staining of the crop, caused by the dark liquid found within the fruit.
- Mould in crops arising from the additional moisture of mature blackberry nightshade fruit.
- Fruit being difficult to distinguish from peas in its less mature green stage during harvesting and processing, with subsequent downgrading of the crop value being likely.

A host of pests and diseases

Blackberry nightshade is capable of hosting a range of insect pests, diseases, nematodes, bacteria, fungi and viruses that have a detrimental impact on several vegetable crops. It is in the same botanical family as several important vegetable crops such as tomato, potato, chilli, capsicum and eggplant. In Australia, insect pests harboured by this weed include thrips and whitefly, and it is believed that it hosts a range of fungi significant to potatoes and other vegetable crops.

Management

Management methods

Table 2 Blackberry nightshade management methods

Activity	Suitability	Notes
Tillage	✔ ✔	No later than 2 weeks after emergence. May include stale seedbed. Inversion tillage may be feasible depending on other factors.
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. Plants may survive beneath cover crop canopy.
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 blackberry nightshade infestation, or an infestation restricted to one part of the farm.
Hand weeding	✔	As follow-up to early-stage herbicide and tillage. Hand weeding is expensive and not suitable for wide-scale use. Better suited to lighter infestations or targeted (e.g. mature, escapee) plant removal.
Herbicides	✔ ✔ ✔	Pre-plant, post-plant and early post-emergence options available. Potential resistance to triazines based on overseas examples.
Integrated weed management	✔ ✔ ✔	Precise combination of techniques will vary from farm to farm (see Page 10).

Tillage ✔ ✔

Tillage enhances blackberry nightshade seed germination, by bringing viable seed closer to the soil surface. Nonetheless, repeated tillage reduces the seed bank over time. Tillage can also be particularly helpful in controlling recently emerged blackberry nightshade seedlings, including within recently established crop beds ('intra-row tillage').

A North American study involving the related species *Solanum ptycanthum*, suggested that soil inversion using a mouldboard plough during either autumn or spring buried weed seed deeply enough that emergence was significantly reduced. This approach is also likely to have some success in managing other *Solanum* spp. such as blackberry nightshade, where few seeds emerge from depths below 5 cm. However, inversion tillage is less likely to be feasible where there is a risk of erosion.

Soil disturbance by tillage (2.5 to 5 cm depth) before crop planting can be highly effective at managing blackberry nightshade, by stimulating germination and then controlling recently emerged seedlings 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 blackberry nightshade emergence prior to crop sowing to deplete the weed seed bank. A shallow tillage pass may also be effective between the crop rows in the first 4-6 weeks after crop planting. Feasibility of this option depends on crop type and availability of suitable inter-row tillage equipment. However, cultivation (even within the crop bed) cannot control all late germinating weeds, and is less likely to be effective against larger or even later germinating blackberry nightshade plants.

Figure 3 Regular tillage appears to be effective in reducing the blackberry nightshade seed bank, however it is important to carry this out early in the plant's lifecycle (i.e. soon after germination) as larger plants are more difficult to control effectively with tillage, and may have had time to set seed and increase the weed seed bank.

Cover crops

Cover crops grown in the period between vegetable cash crops offer growers an opportunity to reduce the impact of blackberry nightshade on their farm. When cover crops are well established and maintained, they can be expected to reduce blackberry nightshade emergence, flowering and seed set through competition for resources (particularly soil nutrients and water). Overseas research suggests that blackberry nightshade does not compete well with taller forage crops, suggesting that cover crop options such as sorghum, millet or cowpeas may offer vegetable farmers an option for suppressing this weed between cash crops.

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, including selection of a high yielding variety and using narrow row spacings and higher planting density.

At the time of writing, no research specifically on the biofumigant effect of cover crops on blackberry nightshade had been identified, although this may be a potential benefit of planting a biofumigant cover crop species.

Early-season cover crop canopy establishment and cover crop planting density to maximise shading is likely to contribute to improved management of blackberry nightshade, in particular restricting its capacity to set seed. However, farmers need to remain aware that blackberry nightshade is capable of germination in low light conditions. Therefore, seedlings or small plants may be in evidence below the cover crop canopy, though these are likely to have set less seed.

*Figure 4 Newer cover crop varieties such as buckwheat (*Fagopyrum esculentum*) appear to be effective in suppressing broadleaf weeds like blackberry nightshade, as observed on this farm near Hobart, Tas.*

Planting density

Agronomic practices, such as increased crop density, that contribute towards the rapid development of a thick canopy cover are likely to lead to less return of blackberry nightshade seed to the soil, as increased crop density will result in fewer and shorter blackberry nightshade plants, fewer flowers, and reduced seed production.

This principle is similar to selecting a competitive cover crop variety as discussed above, but once again farmers should remain aware of the possibility that blackberry nightshade seedlings and small plants may be present beneath the crop canopy, and may therefore potentially mature, flower and set seed after the crop is harvested when the weeds are exposed to more sunlight. Selection of competitive crop varieties may result in more rapid establishment of the crop canopy.

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 blackberry nightshade impact in the longer term.

However, the weed control benefits of higher planting density may need to be balanced against potential adverse effects, such as increased competition among crop plants (lowering yield) and greater risk of soil and plant diseases.

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 blackberry nightshade 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 blackberry nightshade 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 blackberry nightshade may be well managed within the crop beds, it can often be observed growing in wheel tracks, headlands and nearby non-crop areas such as around sheds and irrigation infrastructure, to the extent that plants are likely to be setting seed and replenishing the seed bank in the fields. Effectively managing off-bed blackberry nightshade plants may therefore reduce the risk of spread of this weed onto crop beds in the longer term.

Farm hygiene may be less relevant for managing blackberry nightshade where it has already spread across the whole farm. 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 blackberry nightshade on the farm, particularly where it is not present at all or only present on part of the farm.

Hand weeding

Hand weeding is effective for removal of blackberry nightshade and other important weeds on vegetable farms, particularly those that are flowering or fruiting and 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 blackberry nightshade 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.

Blackberry nightshade plants that are flowering and/or fruiting should be removed from the crop area rather than left on the ground, to ensure that viable seed are not added 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 hand weeding can be a very effective follow-up to tillage and herbicide control in particular, implemented earlier in the crop life cycle. Removing a few remaining blackberry nightshade plants by hand and taking any flowering or fruiting 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.

Combining tillage with hand weeding and slashing has been shown to significantly reduce blackberry nightshade populations, but requires several years of diligent implementation given the longer-term viability of seed.

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

Various herbicides are registered in Australia for management of blackberry nightshade across most common vegetable crops (Table 3). Most of these herbicides are registered either for pre-emergence application or early post-emergence.

The pre-emergence herbicide clomazone was registered for use following research in Tasmania in the 1990s specifically relating to management of blackberry nightshade within closely related potato crops. At the time of writing, it is also registered for blackberry nightshade management in cucurbits and beans.

Research overseas suggests that including corn in a vegetable crop rotation may allow for a wider range of selective herbicides to be used for blackberry nightshade management, with a resulting reduction in the seed bank for this species.

A range of selective and non-selective herbicides is registered to control blackberry nightshade, 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 blackberry nightshade in Australian vegetable production

Herbicide active ingredient*	Trading name/s	Group	Vegetable crop/s in which registered	Timing/crop 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	Beans, cucurbits, potatoes	Post-plant pre-emergence
Cyanazine	Bladex	C	Peas, onions, potatoes, corn	Post-plant pre-emergence or early post-emergence depending on crop
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
Fluroxypyr	Fluroxypyr	I	Corn	Post-emergence
Linuron	Linuron DF and Flowable	C	Carrots, parsnips, onions, potatoes	Pre- or post-emergence depending on crop
Metham	Metham Sodium; Tamafume (fumigants)	N/A	All crops	Pre-plant
Metolachlor	Metolachlor	K	Brassicas, beans, corn	Pre-emergence or immediately after transplanting depending on crop
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
Prometryn	Gesagard; Prometryn 900DF	C	Carrots, celery, potatoes	Pre-emergence, or early post-emergence in carrots
S-Metolachlor	Dual Gold	K	Brassicas, beans, sweet potatoes	Immediately after transplanting
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 'solanum' to identify a range of herbicides suited to a range of cropping situations.*

Herbicide resistance

Triazine-resistant blackberry nightshade biotypes have been confirmed outside of Australia through comparative field and greenhouse trials. This is notable given the use of atrazine and cyanazine in Australian vegetable production, and farmers therefore need to be aware of the potential for resistance to develop to these herbicides in blackberry nightshade populations.

Bringing the control methods together

The three dimensions to success, most likely to provide effective control of major weeds such as blackberry nightshade 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 blackberry nightshade on your farm.

Figure 8 Dedicated application of a well planned integrated weed management strategy can result in little weed impact by the time of harvest, such as in this Brussels sprout crop in South Australia.

Integrated management of blackberry nightshade

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 blackberry nightshade 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 blackberry nightshade infestation, whole-of-farm integrated weed management strategies may include the following practices:

- Shifting most cash crop production to the parts of the farm where the blackberry nightshade infestation is lower.
- 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 blackberry nightshade 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 blackberry nightshade 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 blackberry nightshade 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 blackberry nightshade 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.
- *Repeated cultivations* and *herbicides* may be used together to reduce the population of blackberry nightshade and other weeds before each crop planting. These approaches may include implementing a stale seed bed, and controlling recently emerged plants either by light tillage or herbicide application. Cultivating in early summer will kill many seedlings during their peak germination period. Encouraging seeds to germinate and then controlling the plants before seed set can reduce the weed seed bank in the longer term.
- 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 blackberry nightshade and other weed populations given their preference for higher levels of soil moisture. 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 blackberry nightshade 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 reduced seed production of blackberry nightshade in the vegetable crop, though farmers need to be aware that blackberry nightshade can still germinate under low light conditions beneath the crop canopy. A similar policy 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 or fruiting) 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 blackberry nightshade 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 blackberry nightshade 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 blackberry nightshade 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 blackberry nightshade 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.

Coleman, M., Kristiansen, P., Sindel, B., Fyfe, C. 2020. Blackberry Nightshade (*Solanum nigrum*): Weed management guide for Australian vegetable production. School of Environmental and Rural Science, University of New England, Armidale.

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