Marshmallow

Malva parviflora

Weed management guide for Australian vegetable production

INTEGRATED WEED MANAGEMENT

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Identification

Marshmallow (also sometimes called 'small-flowered mallow' or 'little mallow') is an annual sprawling herb, native to the Mediterranean region, with a single long taproot. It can grow up to 1.2 m in height and 2.1 m in width.

The plant is woody at the base. Leaves are dull dark green and surrounded with scalloped lobes and radiating veins. They are variable in size, at 2 to 12 cm wide and 1 to7 cm long. Flowers emerge in clusters, with five notched petals white to pale pink, around 5 mm in length. Fruit is a round capsule approximately 1 cm in diameter, containing between 8 and 12 non-hairy seeds. When ripe, these change colour from green to dark brown.

There are several other *Malva* and related species present in Australia, many of which are also weeds of disturbed sites such as cultivation, gardens, drains and roadsides but less prevalent than marshmallow. These include:

- Tree mallow, *Malva arborea*
- Musk mallow, *Malva moschate*
- Dwarf mallow, *Malva neglecta*
- Mallow-of-Nice, *Malva nicaeensis*
- Cretan mallow, *Malva pseudolavatera*
- Tall mallow, *Malva sylvestris*
- Spiked malvastrum, *Malvastrum americanum*
- Red-flowered mallow, *Modiola caroliniana*

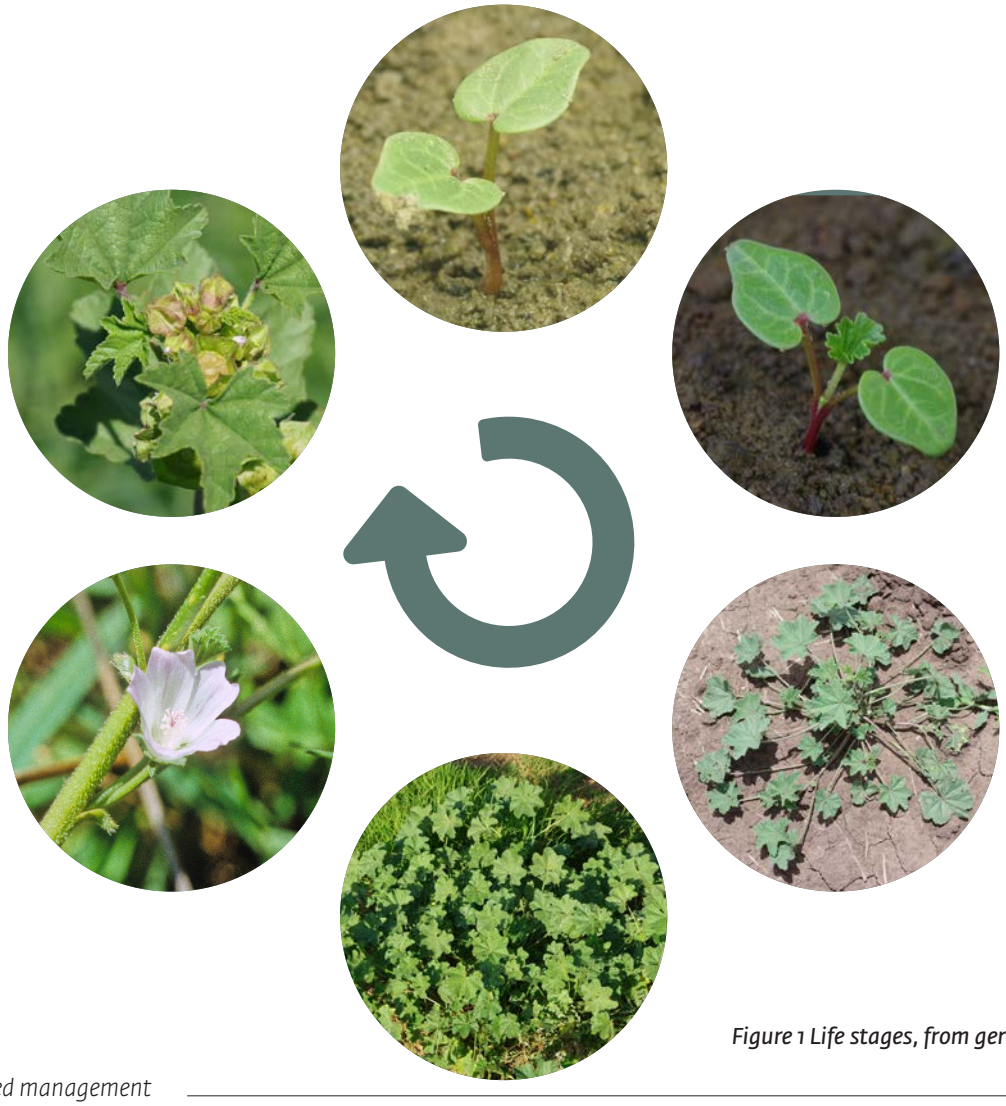


Figure 1 Life stages, from germination to seed set

Characteristics

Key characteristics

Table 1 Key characteristics of marshmallow

Time of germination	Autumn
Time of flowering and seed set	Autumn through to early summer depending on local climate and conditions
Reproduction	By seed only
Seed productivity	Assumed to be several thousand seeds per plant
Seed viability	Several decades depending on conditions
Optimum germination soil depth	0.5 to 2 cm ideal; no seed emerges at depths of 8 cm or greater
Soil type/s	Capable of growing in nearly all soil types
Competitive advantages	Grows in a variety of soil types and a range of soil temperatures; grows for a long part of the season; taller than most cash crop canopies; high seed production; long-term seed viability

Seasonality

Marshmallow is typically considered a winter growing annual species that germinates in autumn, in response to fluctuating summer temperatures that break seed dormancy. However in different climate zones in Australia it is reportedly found flowering for a large portion of the year, for example from August through to early summer in Western Australia, or from April through to November in South Australia. In ideal conditions, it is capable of reproducing within two months of germination. Bienniality is possible where spring-germinating plants survive over summer.

Seed production

Marshmallow produces approximately 10 seeds per flower. At the time of writing no research appears to have been completed to determine the number of seeds produced per plant, however observations of other *Malva* species suggests that each plant is capable of producing several thousand seeds, depending on environmental conditions and the level of competition from surrounding crop plants, other marshmallow plants or other weeds.

Seed germination and viability

Marshmallow seed has an impermeable seed coating that prevents seeds from absorbing water and imposes a physical dormancy. Dormancy is released during the summer months as a reaction to natural variations in temperature. Seed dormancy can also be broken in response to scarification, suggesting that crop management activity (e.g. tillage) plays a role in stimulating marshmallow germination. In cultivated cropping, most marshmallow germination occurs within two weeks of crop sowing. If their physical dormancy is retained, marshmallow seeds can remain viable for several decades.

The plant also produces non-dormant seeds, which can germinate over a wide range of temperatures (from 3.3°C through to 37°C), within a soil pH range of 4-10. Marshmallow is an inbreeding species, meaning that a single plant is capable of colonising a new habitat if it is allowed to produce seed.

The highest rate of seed germination occurs within the 0.5 to 2 cm soil depths. Maximum seed emergence in previous research was found to be 60% within this depth range, some 13% more than seeds remaining on the surface. Lack of moisture on the surface in comparison with this ideal germination depth is considered a possible cause of reduced surface germination. Seed emergence decreases progressively at depths of greater than 2 cm, with no seed emergence occurring at depths of 8 cm or greater.

Soil preference

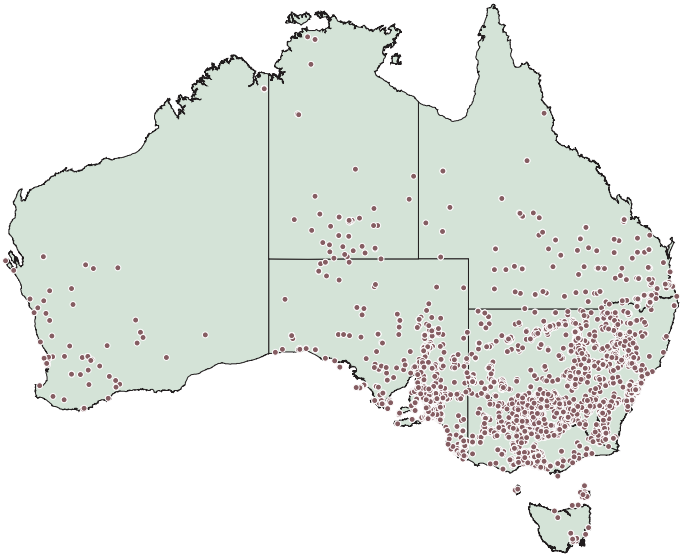
Marshmallow is capable of growing in a broad range of soil conditions including rocky, sandy, loamy and clay soil types. It has also been noted to inhabit saline soils.

Methods of spread

Marshmallow may spread via waterways, however ingestion and excretion of viable seed by livestock and birds is a common method of spread given the hard-coated seed which facilitates survival in the digestive tract of animals. No studies appear to have been conducted regarding spread of this weed by human means, though it is likely to be spread via machinery and agricultural practices as well as other human activities.

Distribution

Marshmallow is a widespread weed and is considered the most prolific of the several *Malva* species found in Australia. It occurs across a variety of climatic regions, but is particularly prevalent in the temperate southern half of the country. It is capable of growing in areas of low annual rainfall (315 mm) through to high annual rainfall (950 mm). It is most commonly found in disturbed ground including gardens, cultivation, roadsides and wastelands, but may also be found in grazed pastures. It is considered one of the most significant weeds of the Australian vegetable industry.



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

Impacts

Crop competition

Although there has been little research on the specific crop competitive ability of marshmallow, other *Malva* species are highly capable competitors with both agricultural and horticultural crops. They are particularly competitive in minimum tillage systems, due to their strong taproots. The size of the marshmallow plant means that it is capable of growing above the crop canopy, and therefore flowering and setting seed if not removed.

In Australia and elsewhere, marshmallow is noted as a weed of cucurbits, lettuce, potatoes, capsicum, brassicas, and a variety of other vegetable crops. Related *Malva* species have been shown to substantially reduce crop yield and quality, particularly if the plants emerge before the crop. In addition to yield and quality impacts, they can also interfere with harvesting operations, and can be problematic as a crop seed contaminant.

On Australian vegetable farms, particularly in more temperate climates, it is relatively common to observe heavy infestations of marshmallow in irrigation lines, at the edges of vegetable fields and around farm sheds.

A host of pests and diseases

Around the world, marshmallow has been identified as a host for several crop viruses (for example mosaic virus in cassava and yellow virus in faba bean), fungi (with 39 different fungal species identified in one overseas study) and insect pests (including cotton tipworm, thrips, and harmful nematodes). The capacity of the weed to emerge year-round in some regions enhances its capacity to host pests and diseases that become prevalent at different times of the year.

Figure 2 The size of marshmallow plants allows them to compete effectively for resources with many vegetable crops, impacting crop quality and yield and replenishing the marhsmallow seed bank.

Management

Management methods

Table 2 Marshmallow management methods

Activity	Suitability	Notes
Tillage	✔ ✔ ✔	Repeated tillage and stale seed beds effective when feasible. Timing critical – early in lifecycle. Infrequent till can contribute to marshmallow colonisation.
Cover crops	✔ ✔	Thick canopy and early crop shading vital to reducing marshmallow growth. Marshmallow plants may still grow above most cover crop canopies.
Planting density	✔ ✔	Plant crop at highest practical density without impacting on crop yield, to increase competition and shading. Plants may still grow above most crops.
Farm hygiene	✔ ✔	Best suited to farms with no current infestation, or an infestation restricted to one part of the farm. Monitor areas adjacent to crop beds closely.
Hand weeding	✔	As follow-up to early-stage herbicide and tillage. Hand weeding is expensive and not suitable for wide-scale use, and may be difficult due to long taproot. Suited to lighter infestations or occasional larger plants above the crop canopy or in areas adjacent to crops.
Herbicides	✔ ✔ ✔	Most effective pre-plant or early post-emergence. Glyphosate considered less effective against marshmallow than many other weeds.
Slashing or mowing	✔	Considered ineffective.
Biological control	**N/A**	Not currently available in Australia.
Integrated weed management	✔ ✔ ✔	Precise combination of techniques will vary from farm to farm. Act early for best effect.

Tillage ✔ ✔ ✔

The long taproot of marshmallow makes it difficult to kill, though tillage can be used to manage this weed if the taproot is severed below the crown.

Soil disturbance by tillage before crop planting may be used to stimulate germination of marshmallow by scarifying the hard-coated seed to break dormancy, with a light follow-up tillage operation being used to control recently germinated plants 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 marshmallow emergence prior to crop sowing to deplete the soil weed seed bank. Light tillage 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.

In Australian broadacre cropping, marshmallow germination has been found to be greater in zero-till production systems where any soil disturbance is limited to the sowing operation (seed drilling), in contrast to a minimum tillage approach involving two pre-sowing tillage operations. Zero-till systems are known to concentrate weed seeds near the soil surface, contributing to a higher rate of success for this particular weed species.

The experience with marshmallow in zero-till broadacre production suggests that the regular tillage characteristic of vegetable production is a key component of successful management of this weed species.

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 marshmallow 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

Cover crops grown in the period between vegetable cash crops offer growers an opportunity to reduce the impact of marshmallow on their farm. When cover crops are well established and maintained, they can be expected to reduce marshmallow germination, flowering and seed set through competition for resources (particularly soil nutrients and water), and potentially as a result of their biofumigant effects.

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.

Early-season cover crop canopy establishment and cover crop planting density to maximise shading are likely to be important factors in restricting marshmallow germination, growth and seed set, and cover crops with high biomass have been observed to suppress marshmallow growth more effectively than varieties with lower biomass. However, it is important to recognise that marshmallow seed does not require light to germinate, so some plants may still manage to emerge and find their way through the cover crop canopy and set seed. Pre-plant tillage or a stale seed bed can help to minimise marshmallow competition with the cover crop.

Figure 4 Newer cover crop varieties such as buckwheat (Fagopyrum esculentum) *appear to be effective in suppressing broadleaf weeds such as marshmallow. On this trial site near Hobart, Tas, few germinated marshmallow plants were observed within the buckwheat crop, while in some other cover crops (such as ryegrass,* Lolium rigidum) *marshmallow plants were observed to be competing effectively with the crop plants.*

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 marshmallow plants, fewer flowers, reduced seed production, and less return of marshmallow 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. It is likely to have similar effectiveness in suppressing marshmallow germination, growth and seeding, though the capacity of marshmallow seed to germinate without light and its growth habit means that some plants may still be able to grow above the crop canopy and set seed.

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 marshmallow impact in the longer term.

Figure 5 In this fennel crop near Werribee, Victoria, marshmallow plants showed a high capacity to penetrate the crop canopy, particularly closer to the edge of the crop. In crops that form a denser canopy (such as brassicas or lettuce), marshmallow is less likely to be observed in the crop rows. Tillage, pre-plant/pre-emergent herbicide application or hand weeding will be more important for marshmallow control in crops such as fennel or carrots that do not form a thick canopy.

Farm hygiene

Implementing appropriate farm hygiene practices helps limit the spread of marshmallow 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 marshmallow may be well managed within the crop beds, it may still be observed in wheel tracks, headlands and nearby non-crop areas. Plants in these areas maintain and expand the marshmallow seed bank and may act as a host for pests and diseases which can impact the vegetable crop. Effectively managing off-bed marshmallow plants may therefore reduce the impact of this weed on vegetable crops in the longer term.

Farm hygiene may be less relevant for managing marshmallow 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 marshmallow on the farm, particularly where it is not present at all or only present on part of the farm.

Hand weeding

Hoeing or otherwise using implements to hand weed marshmallow plants will be of most benefit for controlling smaller plants or seedlings before the taproot has had a chance to establish, for example using a stirrup hoe or similar bladed implement designed to be most effective against smaller plants.

The substantial taproot found on mature marshmallow plants means that hand weeding of select plants to minimise returns to the weed seed bank may require pulling the weed out by hand rather than hoeing it out, to maximise the chance of removing the root from the soil below the crown and avoiding re-growth. But this may still be physically difficult to achieve, particularly in heavier soils.

Hand weeding may be particularly relevant for removal of marshmallow 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 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 marshmallow plants by hand and taking 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.

Figure 7 Removing recently germinated weeds such as marshmallow 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. Larger marshmallow plants are likely to require digging or pulling out, with care taken to ensure that the plant does not have an opportunity to re-grow from the crown at ground-level.

Herbicides

Compared with many other significant weeds to the Australian vegetable industry, relatively few selective and non-selective post-sowing and pre-emergence or pre-transplant herbicides are registered to control marshmallow. 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 marshmallow in Australian vegetable production

Herbicide active ingredient*	Trading name/s	Group	Vegetable crop/s in which registered	Timing/crop stage
Chloridazon	Pyramin	C	Red beet, silver beet, baby leaf spinach	Post-sowing pre-emergence
Ioxynil	Totril	C	Onions	Post-emergence
Methabenzthiazuron	Tribunil	C	Onions	Post-emergence (one or more true leaves in onion crop)
Metham	Metham sodium; Tamafume (fumigants)	N/A	All crops	Fumigation
Oxyfluorfen	Baron 400 WG; Goal; Striker	G	Brassicas	Pre-transplant (7 days prior)

** 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 'mallow' to identify a range of herbicides suited to a range of cropping situations.*

Herbicide resistance

No instances of herbicide resistant marshmallow biotypes have been reported at the time of writing. However, the non-selective herbicide glyphosate has been shown to provide only partial control of marshmallow and related *Malva* species. These weeds appear to have a tolerance to this herbicide's mode of action. This makes the weed an increasing problem in minimum tillage systems, although this management approach is rare in vegetable production. Tolerance of marshmallow to glyphosate can be reduced markedly by the addition of certain herbicides to a glyphosate mix, including lactofen, diphenyl ether, or fluroxypyr. However, it is important to note that these herbicides are not currently registered for use in vegetable production in Australia.

Slashing or mowing

Mowing or slashing is generally not feasible within cropping beds, although it can be used between rows, on headlands, or post-harvest. However this method appears to be an ineffective management technique for marshmallow, as it has been shown that plants are readily able to re-grow even if cut down to the crown of the plant, with rapid branching occurring below the injured area.

Biological control

The fungal pathogen *Colletotrichum gloeosporioides* has been found to have some effect in controlling weedy *Malva pusilla* in Canada. This suggests there is some potential for biological management of marshmallow, however considerable research would be required to identify and test biological agents that may be considered for management of this weed in Australia. As a pathogen of many economically important crops, there would be concerns about the host specificity of *C. gloeosporioides*.

Biological control agents are no silver bullet for success and would 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 marshmallow 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 marshmallow on your farm.

Integrated management of marshmallow

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 marshmallow under control on Australian vegetable farms.

This section has been adapted for marshmallow 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 marshmallow infestation, whole-of-farm integrated weed management strategies may include the following:

- *Repeated cultivations* and *knock-down herbicides* may be used together to reduce the population of marshmallow and other weeds before each crop planting. It is important that these are done early in the weed's lifecycle as older plants are more difficult to control. These approaches may include implementing a stale seed bed to scarify marshmallow seed and stimulate germination, 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. Minimal or infrequent tillage is likely to increase the marshmallow burden by providing time for weeds to grow and set seed.
- *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 marshmallow in the vegetable crop. A similar policy may be pursued in cover crop rotations, and may help to suppress marshmallow effectively due to competition.
- Including a cash crop or cover crop during the traditional non-cash crop period in the rotation allows the use of *selective herbicide options* that have been registered for marshmallow 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 marshmallow seed bank, though farmers need to remain aware that the most commonly used non-selective herbicide, glyphosate, is considered less effective against marshmallow than most other weeds.
- Shifting most cash crop production to the parts of the farm where the marshmallow infestation is lower.
- 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 marshmallow 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 marshmallow 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 marshmallow 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 marshmallow 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.
- *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. The relative size of marshmallow means that it is capable of growing above the crop canopy and producing large numbers of seeds, and removing selected plants above the canopy by hand will therefore contribute to reducing the soil weed seed bank.

Because annual broadleaf weeds such as marshmallow partly 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 marshmallow seed to remain dormant for up to several decades depending on conditions, and therefore for germination flushes to occur at any stage given suitable circumstances.

However, integrated management of marshmallow 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 marshmallow 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. 2019. Marshmallow (*Malva parviflora*): Weed management guide for Australian vegetable production. School of Environmental and Rural Science, University of New England, Armidale.

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