

Nutgrass

Cyperus rotundus

Weed management guide for
Australian vegetable production



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Identification

Nutgrass (*Cyperus rotundus*) is a highly variable perennial sedge.

Although not a grass species, the name 'nutgrass' is commonly used for this plant in Australia. It is also sometimes called 'nutsedge'.

It usually grows to between 20 and 50cm tall, and occasionally taller under favourable conditions. Stems are erect, smooth, not branched, and triangular in cross-section. Leaves are dark to bright green, glossy, up to 2-6 mm wide and 20cm in length, grass-like, and have a prominent vein on the underside. They are slightly serrated, and generally shorter than the plant stems. There are up to 20 leaves per plant, mostly emerging in three rows near ground level.

The flowers are a cluster of brown to reddish-brown/purplish-brown narrow flattened spikelets of varying lengths. These tend to emerge from a common point on several slender flower stalks.

Beneath the ground, the plant features a network of bulbs, roots, rhizomes, and multiple tubers in chains (over six per chain in some circumstances).

Tubers are dark brown to black, irregularly shaped and up to 2 cm in length when fully grown. Each tuber has multiple buds, most of which remain dormant and are available as a reserve in the event the active shoot is destroyed. Dormant tubers can commonly persist in the soil for 3-4 years, but remain viable for up to 10 years in ideal conditions.

Individual plants form a basal bulb, mostly within 7-18 cm of the soil surface. This basal bulb contains the plant growing point. The fibrous root system can extend up to 1.2 metres below the soil surface. Because the growing point remains in the basal bulb, leaves can regrow easily after being severed at the soil surface.



Figure 1 Nutgrass plants before flowering.



Figure 2 Nutgrass flower detail.



Figure 3 Single small nutgrass tuber.



Figure 4 Nutgrass chain showing network of larger and smaller plants, rhizomes and tubers.



Figure 5 Close-up of nutgrass leaf, showing prominent vein on leaf underside.

Distinguishing nutgrass from similar species

Nutgrass is one of several *Cyperus* species found in Australia, and shares many characteristics with other sedge species such as *C. esculentus*, *C. eragrostis*, *C. brevifolius*, *C. difformis* and *C. congestus*.

Nutgrass may be distinguished from other common *Cyperus* species by the colour of its leaves (generally a darker green), the colour of its flower heads (reddish-brown/purplish-brown), the form of its flower head in an umbrella shape rather than a dense or bottlebrush-style head, and the tendency of many other *Cyperus* species found in Australia to favour wet growing sites, such as along waterways, in wetlands, and roadsides and drains (Figure 6).

Of the similar species, yellow nutgrass (*C. esculentus*) is the next most common in Australia. Yellow nutgrass is distinguished from nutgrass by its brighter green foliage, its yellow/straw-coloured flowers and the fact that tubers are found singly rather than being found in chains as is the case with nutgrass. Yellow nutgrass is also more likely to grow in cooler climate regions than nutgrass. It is most commonly troublesome in high-moisture soils in temperate irrigated regions, and can have a similar impact to nutgrass in Australia's temperate vegetable producing regions.



Figure 6 Comparison of flower head colours and form of:
 1. Nutgrass *C. rotundus* (reddish-brown and umbrella shaped),
 2. Yellow nutgrass *C. esculentus* (yellow-straw colour and bottlebrush shaped), and
 3. Dense flat-sedge *C. congestus* (reddish-yellow and bottlebrush shaped).
 (*C. esculentus* photo sourced from Michigan State University, n.d.)

Characteristics

Key Characteristics

Table 1 Key characteristics of nutgrass

Time of new growth	Spring
Time of flowering	Late spring to summer
Reproduction	Primarily by tubers; seed reproduction rare
Reproductive capacity	Up to 15 tubers per plant; 6 to 10 viable buds per tuber
Tuber dormancy	3-4 years; up to 10 years in ideal conditions
Optimum soil depth	Within 10-15 cm of the soil surface
Soil type/s	Favours high fertility soils with moderate moisture, but capable of growing in nearly all soil types.
Competitive advantages	Dense mat of rhizomes and tubers; difficult to control with tillage, selective herbicides or plastic mulch film; perennial species with tubers capable of laying dormant in the soil for several years .

Seasonality and climate preference

Nutgrass is a perennial plant that favours tropical and subtropical climates, and its presence is assumed in all tropical and sub-tropical countries of the world. It grows particularly well in low-lying areas where water accumulates. Below 20°C, plant growth is slow and tuber sprouting is inhibited.

In temperate areas, new growth (seedlings or shoots from tubers) will commence in spring, once temperatures start to increase. In more arid climates, an increase in soil moisture appears to be a more significant stimulant of nutgrass growth. Some above-ground shoots will produce flower stems in late spring, however flowering more commonly occurs during summer. Above-ground growth tends to die off in autumn. Under favourable conditions, plants may flower in as little as 3-6 weeks after emergence. Nutgrass growth can be restricted by shade (including dense leafy crops), as well as by lower temperatures and saline soils.

Nutgrass appears to be susceptible to extended dry conditions. When tubers are dried out until their water content reaches 15% (down from the 85% normal for this species), the tubers will not survive. However, this drying process can take several days or weeks to occur, and is therefore unlikely to be an issue within a regularly irrigated vegetable crop.

Nutgrass is well adapted to growing rapidly in hot weather and under high levels of light, and shows good tolerance of high temperatures. In extreme heat or cold, or during drought or flooding, tubers and bulbs, which are commonly located several centimetres underground, are shielded from weather extremes, and can remain dormant and viable for future regrowth once conditions suit.

Reproduction

The fruits ('nuts') of nutgrass are approximately 1.5mm long, either dark brown or black, and contain one seed. However, almost no viable seed is produced, and therefore tubers form the primary method of reproduction and dispersal of nutgrass.

Shoots can emerge from as deep as 45 cm below the soil surface (where some 95% of tubers form), but rhizome and tuber formation is higher in the soil profile, and shoot emergence is quicker, within 10 to 15 cm of the surface.

Within 2-3 weeks after shoot emergence, the plant's basal bulb sends out new rhizomes that form additional bulbs and daughter plants. This cycle, repeating itself several times in a single growing season, means that a single sprouting bulb can produce hundreds of daughter plant shoots, potentially proliferating into a colony covering several square metres after a single growing season.

Nutgrass plants usually flower within 7-8 weeks of emergence, though flowering can occur as soon as 3 weeks post-emergence in suitable conditions. However plants do not appear to flower consistently, and as stated above, viable seeds are rarely produced. On the other hand, underground tubers may continue to form and develop for several weeks after flowering and shoot growth ceases.

Soil preference

Nutgrass is usually associated with moderate to high fertility soils, and moderate moisture levels. However, around the world it has been observed growing in almost every soil type, moisture level and soil pH, with the exception of soils that have high salt content.

Methods of spread

Under normal circumstances in an undisturbed site, rhizome and tuber growth can extend the boundary of a nutgrass patch by more than a metre per year. Tuber dormancy is also higher in undisturbed sites.

However, nutgrass has a preference for disturbed sites (e.g. cultivated paddocks), and tillage is therefore considered the primary method of dispersal for nutgrass, especially rotary hoes and chisel ploughs. Tillage also stimulates growth by breaking the dormancy of tubers along the rhizome chain.

Other important methods of spread include soil transport (for example on tractor tyres), and flooding.

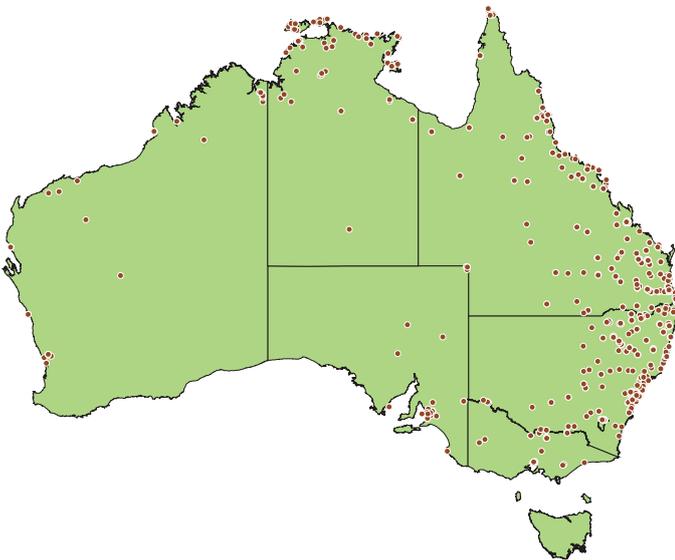


Figure 7 The high fertility soils and frequent tillage generally associated with vegetable production in Australia provide an ideal environment for the spread of nutgrass.

Distribution

Nutgrass is a cosmopolitan plant occurring throughout the world. It is thought to be native to Africa and Asia.

Locally, it is more problematic on vegetable farms in northern parts of Australia, including throughout Queensland as well as in northern New South Wales, Western Australia and the Northern Territory, most particularly in coastal and sub-coastal regions. It is particularly common in the Bowen, Bundaberg and Gatton vegetable growing regions of Queensland. It may also be found in all other mainland states and is a serious problem on some vegetable farms in southern growing regions.



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



Figure 8 The significance of nutgrass in northern Australian vegetable growing regions is illustrated by this heavily infested onion crop near Gatton, Qld.

Impacts

Nutgrass is frequently referred to as the world's worst weed. In a recent study of weed impact and management in Australian vegetable production, it was found to be one of the most significant weed species both for its presence and detrimental impact. Very substantial production losses are often recorded when the weed is allowed to compete with crop plants for the entire cash crop growing period.

Nutgrass competes vigorously with most crops for soil moisture and nutrients, and competes with lower-growing or slower-starting crops for light. Competition is particularly significant with crops that do not form a dense canopy. Where higher levels of soil moisture or nutrients are also available in cropping situations, nutgrass competition appears to be even more intense, such that adding fertiliser or water to the crop has in fact been shown to enhance yield losses due to the nutgrass infestation.

In dense infestations, over 5,000 shoots per square metre have been recorded, and at this density nutgrass smothers virtually all other plants while removing significant amounts of moisture and nutrients from the soil.

One greenhouse trial overseas appears to have identified an allelopathic (chemical suppressive) impact of nutgrass on sweet potato crops. However, the potential allelopathic effects of nutgrass on cash crops require further research, and the direct effects of competition by nutgrass alone are sufficient to warrant serious concern.

Across a variety of vegetable crops, nutgrass infestation has been shown to result in crop yield reductions of between 10 and 90% depending on crop and weed density. Nutgrass weed density appears to be significantly higher within vegetable crops such as beans, cabbage, carrot and cucumber than within broadacre crops such as cotton and sorghum, however further research is required to contrast vegetable and broadacre crops within a single study and may be more related to location and production system (especially irrigation and tillage) than crop.

Nutgrass remains a significant problem in crops where plastic mulch is used. It is capable of piercing the plastic film and attaching clods of soil to the underside of the mulch, making it more difficult and expensive to dispose of plastic after harvest.

Nutgrass can also reduce the quality of root vegetables by piercing the crop – a phenomenon that has been noted by farmers in a number of locations across Australia, including in plastic mulch systems.

Rhizomes and tubers from nutgrass plants may also interfere with harvesting operations for root crops such as radishes, onions, carrots and potatoes. This can also increase post-harvest processing costs.

Management

Management methods

Table 2 Nutgrass management methods

Activity	Suitability	Notes
Tillage	✓ ✓	Repeated tillage effective when feasible. However, irregular tillage can contribute to nutgrass spread.
Cover crops, allelopathy and biofumigation	✓ ✓	Thick crop canopy can reduce nutgrass growth in summer. May be susceptible to allelopathic cover crops.
Planting density	✓ ✓	Thick crop canopy can reduce nutgrass growth in summer.
Mulch films	✓ ✓	Black plastic film may be pierced by nutgrass plants. Clear films may provide more effective suppression.
Farm hygiene	✓ ✓ ✓	Best suited to farms with no current nutgrass infestation, or an infestation restricted to one part of the farm.
Physical control	✗	Hand weeding is expensive, not suited to wide-scale use and unlikely to reduce heavier nutgrass infestations.
Herbicides	✓ ✓ ✓	Few registered products in vegetable production. Glyphosate considered effective, as is fumigation with metham sodium.
Biological control	N/A	Not currently available in Australia.
Integrated weed management	✓ ✓ ✓	Precise combination of techniques will vary from farm to farm.

Tillage ✓ ✓

Amongst Australian vegetable farmers, there are mixed views regarding the effectiveness of tillage as a management technique for nutgrass. Some consider that ongoing cultivation is important for *eventual* control of this weed, while others believe that tillage is a major cause of nutgrass spread.

Growth from one tuber in an unbroken chain tends to inhibit the growth of other tubers in the chain, a characteristic of this species that is known as 'apical dominance'. As a result, cultivation does arguably tend to facilitate spread and growth of nutgrass rather than hindering it, by breaking the tuber chains and allowing more tubers to flourish.

Nonetheless, some success in managing this weed appears possible through *repeated cultivation* which has been shown to expose nutgrass tubers to desiccation, or to exhaust their food reserves. Schonbeck (2015) summarises the general approach as follows:

Mechanical control ... begins with an initial vigorous tillage to fragment the weed, followed by additional cultivations whenever fragments have regenerated new shoots with 3–4 leaves, at which time the weed's underground reserves have been drawn down to their lowest point.

This approach appears most likely to be successful on lighter (sandier) soils and in dry conditions. It involves a program of repeated tillage every 2–3 weeks. However, in field trials of this approach, an 80% reduction in nutgrass tuber populations was only achieved after a 2

year period of tillage every 2–3 weeks, an approach that is not practical on operating vegetable farm enterprises. However, 2–3 weekly tillage sequences between crops or in fallow periods, combined with a knockdown herbicide application (e.g. glyphosate), could contribute to a significant nutgrass population reduction.

Tillage depth is also an important key to successful mechanical control, with the tillage activity needing to be deep enough to bring as much of the root system as possible to the soil surface. It has been suggested by Parsons and Cuthbertson (2001) that an initial tillage pass at 30 cm in depth with a tined implement, followed by repeated fortnightly tillage at 15 cm during the active growing period of the weed can be effective.

However, the feasibility of this approach in intensive vegetable production faces significant hurdles:

- the time and resources required;
- the likely need to take infested paddocks out of production for an extended period during the summer (possibly justified in very bad infestations);
- the impracticality of maintaining dry soils in a recently planted vegetable crop and/or during rainy summer months (e.g. during the northern wet season); and
- the likely negative impacts on soil structure and soil health of repeated tillage.

Cover crops and allelopathy



Because of the short stature of nutgrass plants and their susceptibility to heavy shading, cover crops that provide good early shading are more likely to succeed in reducing the nutgrass burden, particularly at critical times such as during tuber set in late summer. In practice, this may mean adding a vigorously growing and highly competitive summer cover crop into the annual rotation at a high sowing rate, following a spring cash crop.

Depending on local climate, vigorous summer cover crop options may include buckwheat, tall grasses such as sudangrass, sorghum or millet, or summer legumes with a heavy canopy such as cowpea, soybean, or lablab.

Because nutgrass tends to be a problem during summer and lies dormant during winter, farmers with a severe nutgrass infestation may consider restricting their production of cash crops to cool-season vegetables in autumn, winter and spring, and including a summer cover crop in the rotation to provide more effective competition with this weed.

Research indicates that some cover crops may also potentially retard the growth of nutgrass through allelopathy (production of compounds toxic to other plants), including sorghum (*Sorghum bicolor*) and cowpea (*Vigna unguiculata*). Nutgrass has been shown to have some susceptibility to several phytotoxins present in sorghum, suggesting that this may be worth consideration as an allelopathic cover crop candidate to help restrict the spread of this weed. Intercropping of sorghum and sesame has also shown some promise for nutgrass control in overseas research.



*Figure 9 Cover crops which establish rapidly and produce a lot of biomass have been shown to be effective in suppressing nutgrass growth due to their dense canopy. In this example, tillage radish (*Raphanus sativus*) produced a rapid-growing and thick canopy which was effective in suppressing nearly all weed growth on a farm near Hobart, Tasmania.*

Planting density and crop shading



Cash crops that develop an early closed canopy can restrict the growth and spread of nutgrass. In contrast, crops with an open canopy, or a canopy that takes longer to close, are likely to be vulnerable to this species.

Competitive vegetable crops such as bean, cucumber and transplanted cabbage have been used with some success in shading nutgrass to reduce its impact. In order to begin having an effect on nutgrass, it has been suggested that at least 80% shading of the crop rows is necessary.



Figure 10 On this farm near Gatton, Queensland, appropriate planting density of the lettuce crop was combined with tillage and non-selective herbicides to suppress nutgrass and other weeds effectively within the crop beds.

Mulch films

Nutgrass readily penetrates black polyethylene film mulch (Figure 11). In contrast, clear or translucent polyethylene film mulches can reduce nutgrass tuber production because the emerging shoots open their leaves in response to light but become soft and unable to penetrate the mulch due to higher temperature and humidity compared with fully opaque films.

Farmers using plastic mulches may therefore consider clear or translucent films to be an alternative to black polyethylene films in situations where the nutgrass infestation is heavy, providing these plastics do not have any other adverse impacts on their cash crop.

Nonetheless, despite the potential for nutgrass to pierce black polyethylene mulch films, they have been used with some success as a summer fallow soil solarisation treatment



to control nutgrass infestations in hot climates in research completed in southern California. This approach compared favourably with both repeated cultivation and out-shading via a cover crop, with regard to reducing the impact of nutgrass in a subsequent broccoli crop.

Research also suggests that paper mulch alternatives (such as those coated with soy oil or linseed oil) may be more likely to resist piercing by nutgrass plants than black polyethylene mulches. However, there is a range of drawbacks using these paper mulches compared with plastic, including slower application times, higher initial costs, and variability in rate of degradation depending on soil and weather conditions. Biodegradable mulch films, for example made from corn starch, are increasingly available and may be suitable, though they have not been widely evaluated in vegetable crops.



Figure 11 On this cucurbit crop near Bundaberg, Queensland, nutgrass readily pierced the plastic mulch film and caused significant in-crop and post-harvest management issues.

Farm hygiene ✓✓✓

Once introduced on to vegetable farms, nutgrass can become such an intractable problem. Therefore, it is preferable to prevent its introduction and spread. Effective hygiene strategies are likely to be central to integrated management of this weed on farms with few or no infestations, but that remain at risk of infestation.

Research in Australia has identified farmers who have successfully implemented farm hygiene strategies specifically to restrict the spread of nutgrass both onto their farm, and from infested parts of the farm to uninfested parts. In one instance, a farmer's property was largely free of nutgrass but the farmer was leasing nearby land which was heavily infested with this weed. To ensure nutgrass did not spread onto their own property, the farmer implemented strict farm hygiene practices including regular wash-down of all equipment used in infested fields, continual checking for outbreaks on non-infested fields followed by immediate control of any outbreaks found, and staff training in nutgrass identification, quarantine and hygiene strategies.

Farm hygiene may be less relevant for managing nutgrass where it has already spread across the farm. Farm hygiene also requires considerable time to wash equipment down thoroughly.



Figure 12 Establishing a fixed equipment wash-down bay can help restrict the spread of nutgrass on the farm, particularly where it is not present at all or only present on part of the farm.

Physical control ✗

Physical control options include manually digging or hoeing plants out, or potentially pulling larger plants out by hand. Usually, hoeing can contribute to achieving commercially acceptable levels of weed control. However, the characteristics of nutgrass mean that successful hand weeding will require digging relatively deeply into the soil (perhaps up to 40cm in depth) and then ensuring that all viable tubers are removed.

It can also be assumed that, as with tillage, hand weeding has a high potential to exacerbate the nutgrass problem by breaking the tuber chains and encouraging otherwise dormant tubers to sprout.

Hand weeding is also prohibitively expensive as an option for management of nutgrass infestations, to the extent that it is unlikely a profit could be realised from a cash crop where effective management of nutgrass had been attempted through extensive hand weeding.

It is therefore unlikely to be a viable component of a nutgrass management strategy in vegetable production, except as a targeted control option for new incursions in otherwise uninfested fields.



Figure 13 The dense formation of viable tubers characteristic of nutgrass makes physical control impactful, particularly when tubers can easily break off when controlled by hand, giving rise to new nutgrass plants.

Herbicides ✔✔✔

Few herbicides kill nutgrass, however some may suppress its growth until after crop establishment. Amitrole, 2,4D, dichlobenil, MSMA, norflurazon, S-metolachlor, sulfentrazone and a range of other herbicides have also all been used and/or trialled against nutgrass overseas with varying degrees of success, however many of these products are either not available in Australia, or not registered for nutgrass control within vegetable crops. Therefore, herbicide control of nutgrass is most likely to be effective when implemented alongside other control strategies in an integrated approach (see 'integrated weed management' below).

Halosulfuron has been shown to have success against nutgrass as a post-emergence option in broadacre production, however at the time of writing it was not registered in Australia for use within vegetable crops. It was registered for maize, but not for application on sweetcorn, popcorn or hybrid maize crops.

One of the most effective herbicides for nutgrass control is glyphosate. Applied post-emergence at the flowering stage, glyphosate is taken up by actively growing shoots and translocated to the tubers. Research suggests that tuber populations can be reduced by 95% with multiple in-crop applications of glyphosate, or by single applications at the

beginning of four consecutive seasons within two years. It is important to note, however, that glyphosate largely becomes inactive on contact with the soil, and has no effect on tubers that are not connected to emerged shoots.

In the Australian vegetable industry, some success has been achieved in controlling nutgrass with glyphosate. However, some farmers have also reported that glyphosate was ineffective against this weed on their farm, and that using non-selective herbicides to manage nutgrass required that an impractical fallow period be maintained. Extensive fallow periods may be possible on some broader-scale vegetable farms, but are often difficult to incorporate into smaller, busy, year-round vegetable production systems.

There is some use of metham sodium to manage severe infestations of nutgrass. While this approach may be successful against the weed, it is also likely to kill all other soil biota, including those which are important for maintaining healthy soil. Therefore, metham sodium may be seen as an option of 'last resort' and would ideally be followed up with strategies to recolonise the soil biota, for example using compost applications.

Table 3 Herbicides registered for management of nutgrass in Australian vegetable production

Herbicide Active Ingredient*	Trading name/s	Group	Vegetable crop/s in which registered	Timing/crop stage
Chlorthal-Dimethyl	Dacthal 900 WG	D	Brassicas, beans, peas, garlic, onions, carrots, lettuce, potatoes, turnips	At time of seedling or transplanting.
EPTC	Eptam	E	Beans, potatoes, corn	Pre-emergence in spring or when tubers and roots starting to sprout; immediately following thorough 20-25 cm cultivation.
Metham	Metham Sodium; Tamafume (fumigants)	N/A	All crops	Use outside cropping periods.

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



Figure 14 When used appropriately, herbicides can be a key component of nutgrass management in vegetable crops.

Herbicide resistance

Herbicide resistance has not yet been noted in nutgrass, however vegetable growers should remain aware of the potential for herbicide resistance to develop, particularly given that herbicide control of nutgrass involves heavy reliance on a very limited range of registered selective and non-selective herbicides.

Integrated weed management is of particular importance in reducing the risk of herbicide resistance developing, whereby non-herbicide control methods are used where possible.

Biological control

Some potential candidates have been identified as biological control agents for nutgrass overseas, including a variety of fungi and arthropod predators.

Unfortunately, no biological control options are currently available for nutgrass in Australia. 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.

Additionally, a range of other difficulties have made identifying an effective biological control agent for nutgrass problematic around the world, including:

- a tendency for recently introduced biological agents to be attacked by agents already present in the region of introduction;
- difficulty in achieving nutgrass control without the biological agent having a detrimental effect on native or introduced but beneficial *Cyperus* spp.;
- its cosmopolitan nature (worldwide presence), making identifying natural enemies of the plant difficult; and
- its large regenerative capacity.

Other management methods

Vegetable farmers in Central America reportedly have had some success in reducing the impact of nutgrass on their crop by providing fertiliser and water close to the crop plants only, rather than providing these resources across the entire field.

Mowing nutgrass at 5cm height has been shown in one study to improve management of the weed by 6% compared with not mowing on bare ground. This method can also contribute to reduced rhizome length, tuber numbers and plant size, but it is unlikely to result in eradication, and will not be feasible on most vegetable farms.



Bringing the control methods together

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



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

Integrated management of nutgrass

Once it has become established on a farm, nutgrass has the potential to become a major problem. Consequently, farms that are free of nutgrass or only have small infestations require careful preventive strategies to avoid the introduction and/or spread of the weed. 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 weed species such as nutgrass under control on Australian vegetable farms. An effective integrated management strategy for nutgrass must focus on exhausting the bank of viable tubers in the soil.

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 nutgrass infestation, whole-farm integrated weed management strategies may include the following:

- Shifting most cash crop production to the parts of the farm where the nutgrass infestation is lower, while focusing on reducing tuber numbers without being limited by a standing cash crop.
- Including an alternative cash crop or cover crop during the traditional non-cash crop period in the rotation may allow for use of *selective herbicide options* that have been registered for nutgrass control in Australia. Fewer weeds may be expected to appear in the paddock when an out of season cover crop is grown and suitable herbicides used. The APVMA [Public Chemical Registration Information System](#) database may be searched for 'nutgrass' to identify a range of herbicides suited to a range of cropping situations.
- Including a fallow period in the crop rotation may also allow *non-selective herbicide* application to reduce the nutgrass tuber bank in the soil. This is significant given that glyphosate is considered to be effective in managing this weed if applied at the right time. However, apart from fumigation with metham sodium, herbicide application is limited by not having the capacity to control tubers lying dormant beneath the surface.
- Depending on the crop rotation cycle on the farm, it may be feasible to grow crops only in the period from autumn to spring, in the period when nutgrass is not actively growing. Non-selective control techniques such as tillage and herbicide may then be used over the summer period when nutgrass is growing, to reduce its population.
- Implementing and rigorously adhering to a *farm hygiene* program is vital to avoid the spread of nutgrass onto the farm, and from infested to uninfested parts of the farm,

and may also contribute to successfully bringing small infestations under control. Successful farm hygiene may involve: 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.

- *Repeated cultivations* may be used to reduce the population of nutgrass before each crop planting. Given the burial depth of tubers and their likely high numbers, frequently repeated cultivations are likely to be required, with less frequent cultivation potentially making the nutgrass problem worse. Tillage that breaks tuber dormancy and stimulates growth may also be used in conjunction with follow-up *herbicide application* to maximise the number of viable tubers controlled. Important considerations regarding this approach will include implementing a sufficient cultivation depth to bring the root system to the soil surface, ensuring cultivation of dry soil to maximise the chance of tuber desiccation, and taking the infested paddock out of production for an extended period to implement an effective repeated cultivation program.



Integrated management of nutgrass - continued

- Use of a *drip irrigation system* can mean that the non-irrigated inter-rows remain dry (unless rain falls) throughout the growing period, with consequent reductions in nutgrass populations outside the crop beds. Where fertiliser is applied using fertigation, this strategy also places the fertiliser close to the crop plants rather than in the inter-rows where nutgrass and other weeds may be growing.
- Combining a drip irrigation system with *plastic mulch* in high-value vegetable crops such as cucurbits. Black plastic mulches are vulnerable to piercing by nutgrass, which will make post-harvest removal of the mulch film more difficult. Transparent mulch films may suppress nutgrass to a greater extent than the commonly used black plastic films, and may be worth considering providing they do not have other detrimental impacts on crop yield and quality.
- *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 presence of nutgrass in the vegetable crop, given that it is susceptible to low light conditions. A similar approach may be used in cover crop rotations, where varieties that rapidly produce a thick canopy may be preferred.
- *Hand weeding* is unlikely to be a feasible method within an integrated nutgrass management strategy. Hand removal of sporadic individual plants may be warranted in fields where nutgrass has not previously been growing.
- *Fumigation* using metham sodium may be considered for use in severe nutgrass infestations. However, the likelihood that this will kill all other soil biota, it should be considered a last resort and will need to be followed up with strategies to recolonise beneficial soil biota (such as composting).

An integrated management system of this nature can be expected to result in a gradual decline in weed numbers over time. Farmers need to remain aware of the potential for nutgrass tubers to remain dormant for up to a decade, and therefore for growth flushes (and potentially rapid reinfestation) to occur at any stage given suitable conditions.

The key to integrated management of nutgrass 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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