



Managing sweetpotato plant beds in Australia

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Innovating new virus diagnostics and plant bed management in the Australian sweetpotato industry



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Key messages

- Plant beds constructed using clean, pathogen-tested, QA bedding roots provide the most cost effective and highest yield sweetpotato planting materials.
- At peak production, a high-performing plant bed should generate around 250 acceptable sprouts/m² every 18-21 days.
- Even, shallow soil coverage of bedding roots is the most critical aspect of plant bed construction. Coverage of 1.5-5 cm is acceptable, with around 3-5 cm favoured. The deeper coverage in this range may be more helpful in hot conditions. More than 7 cm risks poor sprout emergence, and increased rots of sprouts and bedding roots.
- Plant beds should be well-elevated (minimum 20 cm above the ground surface) and freely draining. This is the second most important plant bed construction imperative. Waterlogging and poor aeration dramatically reduces production and longevity.
- High performing plant beds require precision and regular attention, particularly to issues of:
 - Irrigation – regular applications of 5-15 mm, with uniform, full bed coverage. However, to avoid premature bedding root breakdown, err on the side of under-watering until most sprouts have emerged.
 - Nutrition – regular application of fertilisers is required and use a complete fertiliser at least every second cut. Rates will depend on soil condition and fertiliser type, however a minimum 60-80 kgN/ha as a component.
 - Temperature management – it is a fine line between warm enough to promote sprout development, and overheating causing premature bedding root breakdown and causing sprout death. If using plastic systems, remove if soil temperatures rise above 28°C, particularly for sensitive cultivars such as *Bellevue*.
 - Insect pest management (especially aphids, whiteflies and jassids)
 - Sprout harvest – cut at least 3-4 cm above soil surface, higher each cut (above woody scar tissue)
 - Sprout care – tips are precious; store sprouts in a cool and moist area, for no more than 2 days before planting
- Different cultivars require different bedding and plant bed practices. Learn these requirements for the cultivars you grow. For example, *Bellevue* appears to be particularly prone to poor sprouting in cold soil, and premature breakdown. It requires very careful plant bed management.



Why use plant beds for multiplying sweetpotatoes?

Research in the last decade has consistently shown that plant beds constructed using bedding roots are the most cost-effective method for producing consistent, high quality sweetpotato sprouts for commercial field planting.

In Australia, pathogen-tested bedding roots can be purchased (via pre-ordering) in large quantities to generate sufficient planting material for commercial sweetpotato production. These bedding roots are the most reliable source of planting material, with the lowest risk of virus and phytoplasma diseases; the major constraint to quality sweetpotato production.

The advantages of plant beds based on bedding roots are:

- The bedding roots can be stored for several months, giving flexibility to sprout production
- Nursery plant beds can be explicitly managed to reduce the probability and rate of virus re-infection, as well as other issues such as sweetpotato weevil
- Larger numbers of quality sprouts can be collected per hour, compared to field cutting
- Properly managed plant bed sprouts generally have a higher yield potential than field cuttings
- In the absence of severe virus infection, robust sprouts from older plant beds still appear to have high yield potential. You will probably just cut fewer sprouts per metre as the beds age. Be aware it is difficult to prevent severe virus infection of older plant beds in the main commercial growing areas, due to endemic populations of viruses and their vectors.

Sourcing bedding roots

The best results are with roots obtained from a professional supplier, with a QA system for generating clean material.




Growers sourcing materials outside such a system should ensure that roots come from an isolated, well managed, dedicated multiplication site, preferably many kilometres away from any commercial sweetpotato production. Avoid using roots from a commercial sweetpotato crop, as these will almost certainly contain sufficient virus load to compromise performance if used in a plant bed.

Bedding roots should be firm and disease free, with no fresh marks or bruises. The transport chain should also minimise wounding.

Although bedding roots can be pre-sprouted (by heating in a controlled facility at 25-28°C and 90% humidity), particularly for July-September bedding, experience suggests there are risks with this process in some cultivars, particularly *Bellevue*. Recent research suggests this heating can markedly increase respiration and internal physiological changes in the bedding roots, which may increase the risk of premature bedding root breakdown. The risk appears to increase the longer the heat treatment is applied, and with larger roots.

Perhaps one strategy for managing the risk is to only use pre-sprouting for early bed installations; to request the minimum amount of heat load that will achieve sprouting, and where possible to use root lots of small-medium size.

Research indicates that the size and shape of bedding roots does not affect the quantity of sprouts produced per square metre of plant bed. Very small roots (<5 cm diameter) may take longer to produce premium sprouts, particularly in Cuts 2-4, while oversize roots (>9 cm diameter) may be more prone to breakdown in unfavourable conditions, particularly elevated temperatures above 35°C in wet soil. The most economical grade is probably a small-medium (around 5-6 cm diameter), although a few large or distorted roots in a commercial lot are of minimal concern. There are probably practical benefits from having an evenly graded planting bed lot, as it allows consistent depth coverage and more even sprout emergence, both of which promote good sprout performance and reduced plant bed deterioration. Bedding root suppliers may adjust prices to even out the cost per sprout value for different sizes.



On receiving roots, growers should check their lot, and remove any diseased or obviously wounded roots. Bedding roots should be stored in a cool, dark place, however avoid temperatures below 10°C, as these can cause chilling injury to the roots.

As in the rest of the PT chain, growers should minimise damage to bedding roots during all handling and bedding processes.

In calculating the plant bed requirements of bedding roots the following rule of thumb may be useful:

Quantity of bedding roots required (kg) = 3 * Area of plant bed (m²) * median diameter of bedding roots (cm)

For example, given a 100 m long plant bed 1 m wide; a bedding root supply of median diameter 6 cm, the grower would need approximately 1.8 t of bedding roots to install that bed.

Preparing the plant bed

Location

The best sites for nursery plant beds are well away from commercial production. However this should be balanced by the need to meticulously observe and manage the plant beds, so they should be easily accessible to the responsible manager on a regular (e.g. daily) basis.



Plant beds should be in full sun.

Ideally, use windbreak plantings to further isolate plant beds. Windbreaks can promote superior irrigation distribution, as well as reduce the spread of virus vectors into the plant bed area.

Avoid locating plant beds in ground previously used for that purpose, or that have grown sweetpotatoes in the last 3-4 years, or with a known history of soil-borne diseases. *Fusarium spp.*, *Sclerotinia rolfsii* and bacteria e.g. *Erwinia spp.* will probably be problematic where other vegetables have recently been grown.

Avoid areas with nutgrass, as this weed interferes with sprout development, and can increase disease through bedding root damage as well.

Prefer sites with well-drained soils, and obviously avoid sites prone to flooding or waterlogging. Wet conditions are a prime cause of plant bed failures or premature deterioration.

Ground preparation

Over time, build up soil organic matter by crop rotation, and good general soil health practices. In soils prone to crusting, regularly apply 10 t/ha of gypsum to reduce aggregate dispersion and surface sealing.

In sites with known disease or weed issues, fumigation may be a short term option, either chemically, or using soil solarisation. This is not a substitute for optimal site selection and soil management.



It is **critical** to prepare plant beds with good drainage, as waterlogging is a prime cause of increased soil borne diseases, poor aeration, plant bed breakdown, and curtailed seasonal plant bed productivity. Recent observations suggest that after bed preparation, bedding roots should be situated at least **20 cm** above the inter-bed soil surface. In wet areas, or inherently poorer draining soils, this height may need to be increased. This is particularly important for cultivars prone to breakdown (e.g. *Bellevue*).

During the season, continually rebuild beds and wheel tracks to preserve good drainage and runoff, as well as maintain bedding root cover.

The distance between beds is predominantly a practical issue, with many variants successfully used by growers.

It depends on land availability, irrigation layout, requirement for machinery access, and the plan for ensuring adequate soil for good bed height, as well as the method for bed covering.

In addition, there may be some consideration for warming structures, such as mulches, plastic tunnels or row covers.

Planning should understand the principle of keeping people off the raised beds. If beds are too wide, or the distance between beds is too narrow, it can be very difficult to avoid stepping or kneeling on the beds when moving or harvesting sprouts.

Sprouting beds should be as wide as manageable, as this promotes vertical sprout growth, and reduces elongated sprouts at the side of the bed. As a practical limitation, most beds are seldom wider than 1.2 m. Bed height and drainage is more important than maximising bed width.

Installing the bedding roots

Depending on the size grade of the bedding roots, growers will require 15-25 kg of bedding roots per m² of plant bed. Research suggests there is trivial difference in the numbers of acceptable sprouts produced by assorted sizes of roots in the plant beds; managing other factors appears more important.

Bedding roots should be laid on the plant bed surface, with about 1 cm of space between the roots, to try and reduce the rate of spread of soil-borne diseases.

Roots can be arranged either parallel or perpendicular to the direction of the bed. Parallel can more effectively cover the bed top, while perpendicular can reduce rolling of roots, particularly during mechanical covering. If there is a large range of diameters in the bedding root grade, the larger roots should be pressed into the bed surface, to increase the evenness of soil depth above the bedded roots once covered.

Roots should be covered as evenly as possible, with 1.5-5 cm of soil acceptable. Targeting 3-5 cm of covering soil may aid sprouts to develop independent root systems, as well as enhancing root aeration. The deeper coverage in this range may be more helpful in hot conditions.

Depth of soil coverage is the most critical factor in planting bed installation.

Where bedding roots are more than 7 cm below the soil surface, establishment and emergence of sprouts may be slowed or prevented, particularly with newer cultivars. There is also much increased disease incidence in the deeper buried roots and sprouts, as seen in recent seasons.

Hand covering can provide an even and relatively shallow depth of covering soil. If plant beds are mechanically covered, it is very important to ensure equipment is calibrated and operated to provide consistent, shallow coverage of bedding roots. Spend time getting this right, as it is critical for plant bed performance and longevity.





Nutrition

Depending on soil test, generally apply a complete fertiliser (e.g. a 5:6:5, N:P:K mix) at a rate of 100 g/m². Unlike with commercial sweetpotatoes, higher rates are unlikely to be an issue, so ensure good coverage, rather than risk some areas being under-fertilised.

Some growers prefer to use composts or other organic products. Because sprout production is focussed on rapidly generating vegetative material, composts should be derived from high N sources, particularly where the soil is inherently low in nitrogen. Target 100 kg/ha of available N from the organic mix.

Fertilisers should be watered in with the initial irrigation.

After each sprout harvest, add an additional with 60-80 kgN/ha (e.g. as potassium nitrate), or a compost alternative. Alternatively, this can be metered in by fertigation during the growing period. The most recent research suggests that there may be benefit from other nutrients apart from nitrogen, so consider a complete fertiliser at least every second cut. There does not appear to be any damaging effects from high fertiliser rates on the quality of sprouts produced, or the rate of breakdown in plant beds.

Irrigation

Irrigation water should be clean, and not include runoff from commercial fields, or packing sheds, as these may act as sources of disease.



Uniform and reliable irrigation is vital to good sprout production. Overhead systems should be designed with the idea of maximising distribution uniformity, even in windy conditions. High rate irrigation systems that compact/crust the soil surface should be avoided. If drip irrigation systems are used, these should be properly designed, and have at least two rows of drip per 1 m wide bed, to achieve complete bed surface coverage. There is an industry theory that cooling from overhead irrigation can assist sprout regeneration and growth. However, any benefit will be lost if the irrigation distribution uniformity is not high.

Because plant bed systems have minimal root system development, irrigation should be capable of reliably delivering small volumes of water uniformly and regularly. Overwatering can exacerbate plant disease, waterlogging and bed breakdown.

Depending on initial soil moisture content, the first irrigation after bedding should only be 10-20 mm, as the initial sprouts are generated from the bedding roots. Although bedding roots do develop their own feeder roots, the role of those root systems in sprout development is unclear. High, well drained plant beds can reduce the risks of over-irrigation. Err on the side of under-irrigation if using plastic to heat beds.

Subsequent irrigations should never be more than 20 mm, and usually 10-15 mm every few days, depending on the leaf area developed by the sprouts, and the weather conditions.

Temperature management

Roots require a minimum soil temperature of 15.6°C for sprouting to occur. Therefore, winter or early spring plantings may require additional heating to promote sprout growth.

Beds can be heated by clear plastic during winter and early spring. Never use black plastic to cover plant beds, as research shows this reduces plant bed performance.

If the covers are too airtight, carbon dioxide can build up, lowering the available oxygen levels. This can result in bedding root and sprout breakdown. Covers should be aerated regularly along the side of the mulch (e.g. punch 25-50 mm holes every metre) to promote gas exchange with the atmosphere. Alternatively, use hooped plastic, with the option to ventilate via the end covers. A hooped plastic system is particularly desirable for sensitive cultivars such as *Bellevue*.



Avoid covering the beds with plastic if the soil is wet rather than moist. This is most common after rain, rather than if irrigated correctly. Let the soil dry out, and heat more slowly, rather than risk complete plant bed failure from poor aeration and disease in prematurely covered beds.

Soil temperatures above 28°C can increase breakdown of bedding roots underneath plastic mulches. These high temperatures can also burn the tips.

In this circumstance, use covers that can be opened at the ends or rolled back from the bed during the hotter part of the day and replaced at night to retain the residual heat. Being prepared to check temperatures and react is one of the key issues for successful plant bed longevity. It is likely that soil temperature loggers and warning systems will become more common. Alternatively, respond to weather predictions.

Remove any polyethylene covers at least 10 days before the first sprout harvest, or those first sprouts will be too soft. If sprouts are planted out from a covered bed, they will wilt and perform poorly.



Another option is to replace polyethylene covers with woven row covers as the season warms up. Long term use of these covers has the added advantage of excluding most of the insect vectors, while the covers remain intact.

Insect and nematode management

Prevent plant beds from being an infestation source of nematodes or soil insects by discarding obviously infected bedding roots. Ensure plant bed areas are as pest-free as possible, via crop hygiene, rotation and preventative and curative application of appropriate chemicals. Australian growers should refer to products currently registered in this country.

For sweetpotato weevil, intensive sex pheromone trapping around plant beds could be a useful additional preventative measure. Sticky traps may also be useful for checking for presence of beetle species. Other imperatives are hygiene around the plant bed areas, including removal of volunteer plants and crop debris. Also maintain soil moisture to prevent cracking, and cover soil cracks or exposed roots.

Management of virus vectors such as aphids and whitefly is critical to maximise the performance of plant beds and subsequent commercial crops. Cultural methods include isolation as far as practicable from host crops or weeds, strict farm hygiene, use of windbreaks, and encouragement or possible inundative releases of parasitoids (e.g. *Encarsia formosa* or *Eretmocerus spp.* for whitefly management). Unfortunately such parasitoids are unlikely to survive the regular spraying regime within the plant beds, so are more useful in managing whitefly populations in surrounding vegetation or crops.

Regularly inspect plant beds for any plants with virus or phytoplasma symptoms, removing those whole plants.



Apart from the cultural methods referred to previously, growers can rely on regular spraying of registered pesticides (see Infopest for specific uses). Be prepared to be more thorough, with higher intensity monitoring and management of plant beds compared to production fields, both to prevent contamination when planting out in broad-acre areas, as well as preserve PT integrity as long as possible.

- Maintain a regular program for keeping vectors out of the planting beds. Non-organic growers can rotate a sequence of systemic and contact pesticides according to registered uses.
- Vectors of non-persistent viruses will eventually be killed after feeding on plants sprayed with systemic insecticide. However, because these viruses can be transmitted within seconds, many plants become infected before the insect dies or moves out of the crop. Do not simply rely on systemic insecticides to manage virus vectors.
- Insecticides are more effective against persistently transmitted viruses because insects are killed before they have time to acquire and transmit the virus.

Disease management

Diseased sprouts are obvious; first signs are wilting, yellowing, or poorer growth than their neighbouring sprouts. Discolouration of stems, and below ground parts are other easily detected symptoms. As diseases progress, the sprout root systems deteriorate and the sprout dies. In the case of *Sclerotium rolfsii*, infestation may also be accompanied by a white fungal network on the soil surface.

Unfortunately, there are few options for managing soil-borne diseases once they occur in plant beds. Minimisation is the key, by using clean material, constructing high, well drained and aerated beds, on a previously cover-cropped site and managing irrigation effectively.



When harvesting sprouts for field planting, ensure any cut is made at least 3-4 cm above the soil surface, and the cutting implements do not penetrate the soil. Many infective organisms are seldom found in the above ground portion of the sprout, but can be retained if the sprout is pulled rather than cut in the act of harvesting.

Perhaps growers should avoid harvesting sprouts within a 'quarantine' zone around obviously infected sites. This may reduce the rate of disease spread within the plant bed.

Harvesting sprouts


Shoots should begin to appear within 4-6 weeks of planting. Once most roots have sprouted, the seedbed can be pruned back to 3-4 cm above the ground. This will help to produce more uniform regrowth and stimulate the formation of secondary sprouts. Harvest sprouts when they are 30-45 cm long (up to 40 days after the first pruning).

If sprouts are not harvested and have become too long (most longer than 50 cm, tips tangled), trim the bed back and start again, as longer tips have less vigour and do not perform as well as fresh, new sprouts. It is also likely that the harvesting process will take much longer than usual, and the sprouts will be damaged.



After the first cut of sprouts at 3-4 cm above the ground, cut above the woody, previous-harvest scar with each sequential harvest.

Sprouts with apical tips have consistently been shown to be the highest yielding plant materials, so unless planting material is in short supply, only these should be used. Back-cuttings from long sprouts should be discarded.



Australian references suggest 35-45 cm sprouts are most desired, although this can depend on the planting process and equipment. Research guidelines suggest:

Acceptable sprouts

No visible damage or disease, an intact and vigorous tip, at least 20 cm long, at least 3 mm diameter at the cut end, and at least 1 node within 15 cm of the cut end.

Premium sprout (increased resilience in difficult planting conditions, yield advantage of around 10%)

No visible damage or disease, an intact and vigorous tip, at least 28 cm long, at least 4 mm diameter at the cut end, and 2-5 nodes within 15 cm of the cut end.

When there are sufficient sprouts available for the intended planting area, it is probably worthwhile to sort in either the shed or field and concentrate on preparing premium sprouts. A well-managed plant bed, cut at the correct time, should produce around 90% premium sprouts between Cut 2 and Cut 5.

Currently most sprout harvesting is by hand, with knives or snips. Some growers are experimenting with mechanical cutting, using hedge trimmers or modified cutter bars. This can save on labour, although obviously sprouts still have to be picked up and sorted. A disadvantage is the much greater risk of uneven management of sprout cutting height, and subsequent sprout recovery and growth. Very variable sprout quality from beds that had previously been machine cut is not unusual. Perhaps growers could experiment with their machine cutting techniques on later cuts in the plant bed season, when ongoing plant bed performance and productivity is less critical, until they get their techniques finely tuned?

Research suggests that sprouts with leaves intact will initiate more storage roots, so unless leaves interfere with planting equipment, do not strip them from the sprout.

Caring for harvested sprouts

Use sprouts within one, and at the most 2 days of harvesting. They should not be dipped in a water bath, as this can spread disease. If storing, do so in cool, shady conditions. In hot, drying atmospheres, hose down regularly with clean water i.e. not untreated dam or channel water. Take care not to drop temperatures below 12°C, as sprouts could be damaged.



Sprouts should be handled carefully, as they are your prime source of yield potential. Damage to the tips especially needs to be avoided.

How long to retain plant beds

Because Australia is the only sweetpotato producing country to have an extended commercial planting period coupled with a PT plant bed system, it is not surprising that this is not well explored in the literature.

Recent benchmarking studies suggest even in ideal conditions, plant bed sprout production starts to decline after 5 harvests. Growers should factor this into their decision making.

In the absence of severe virus infection, robust sprouts from older plant beds still appear to have high yield potential. You will probably just cut fewer sprouts per metre as the beds age.

Be aware it is difficult to prevent severe virus infection of older plant beds in the main commercial growing areas, due to endemic populations of viruses and their vectors. Most plant beds more than 6 months after sprout emergence are probably virus infected, particularly if they have grown over summer, when vectors are most active.



Managing difficult cultivars in plant beds (e.g. *Bellevue*)

Where possible, use small-medium bedding roots, preferably no more than a few months old, and kept in consistently cool storage conditions (16°C) prior to installation.

Don't use roots with unhealed wounds or apparent disease.

If using plastic to heat beds, make sure the plastic structure is well ventilated, and monitor soil temperatures. Ideally keep soil temperatures below 28°C, and perhaps even around 25-26°C. If temperatures are likely to rise above that level, take the plastic off. Similarly, for row covers.

Avoid installing *Bellevue* into plant beds in circumstances likely to experience hot temperatures. Established plant beds can potentially survive, but it's possible new beds are more vulnerable.

Ensure any irrigations at installation, and before sprouts are established, are even and light.

Good drainage is essential.

Avoid installing plant beds in ground with a known history of diseases, particularly bacterial.

Benchmarking plant bed performance

Using the above guidelines, growers should be targeting around 200 acceptable sprouts/m² of plant bed in their first cut, and 250 acceptable sprouts/m² in the following four cuts.

High input management of plant beds should result in cuts every 18-21 days during mid-summer, and every 25-30 days during shoulder production periods.