Sweet potato information kit

Reprint – information current in 2000

REPRINT INFORMATION – PLEASE READ!

For updated information please call 13 25 23 or visit the website www.deedi.qld.gov.au

This publication has been reprinted as a digital book without any changes to the content published in 2000. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research:

- Chemical recommendations—check with an agronomist or Infopest www.infopest.qld.gov.au
- Financial information—costs and returns listed in this publication are out of date. Please contact an adviser or industry body to assist with identifying more current figures.
- Varieties—new varieties are likely to be available and some older varieties may no longer be recommended. Check with an agronomist, call the Business Information Centre on 13 25 23, visit our website www.deedi.qld.gov.au or contact the industry body.
- Contacts—many of the contact details may have changed and there could be several new contacts available. The industry organisation may be able to assist you to find the information or services you require.
- Organisation names—most government agencies referred to in this publication have had name changes. Contact the Business Information Centre on 13 25 23 or the industry organisation to find out the current name and contact details for these agencies.
- Additional information—many other sources of information are now available for each crop. Contact an agronomist, Business Information Centre on 13 25 23 or the industry organisation for other suggested reading.

Even with these limitations we believe this information kit provides important and valuable information for intending and existing growers.

This publication was last revised in 2000. The information is not current and the accuracy of the information cannot be guaranteed by the State of Queensland.

This information has been made available to assist users to identify issues involved in sweet potato production. This information is not to be used or relied upon by users for any purpose which may expose the user or any other person to loss or damage. Users should conduct their own inquiries and rely on their own independent professional advice.

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained in this publication.

Queensland Government

Growing THE CROP

This section is our summary for growing and marketing a commercial crop of sweetpotatoes for the fresh market. To keep the section as brief as possible and easy to follow, we provide little explanation with recommendations. Where more information may help, we refer you to other sections of the kit. Symbols on the left of the page will help you make these links.

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The steps from harvesting to marketing

The sweetpotato plant

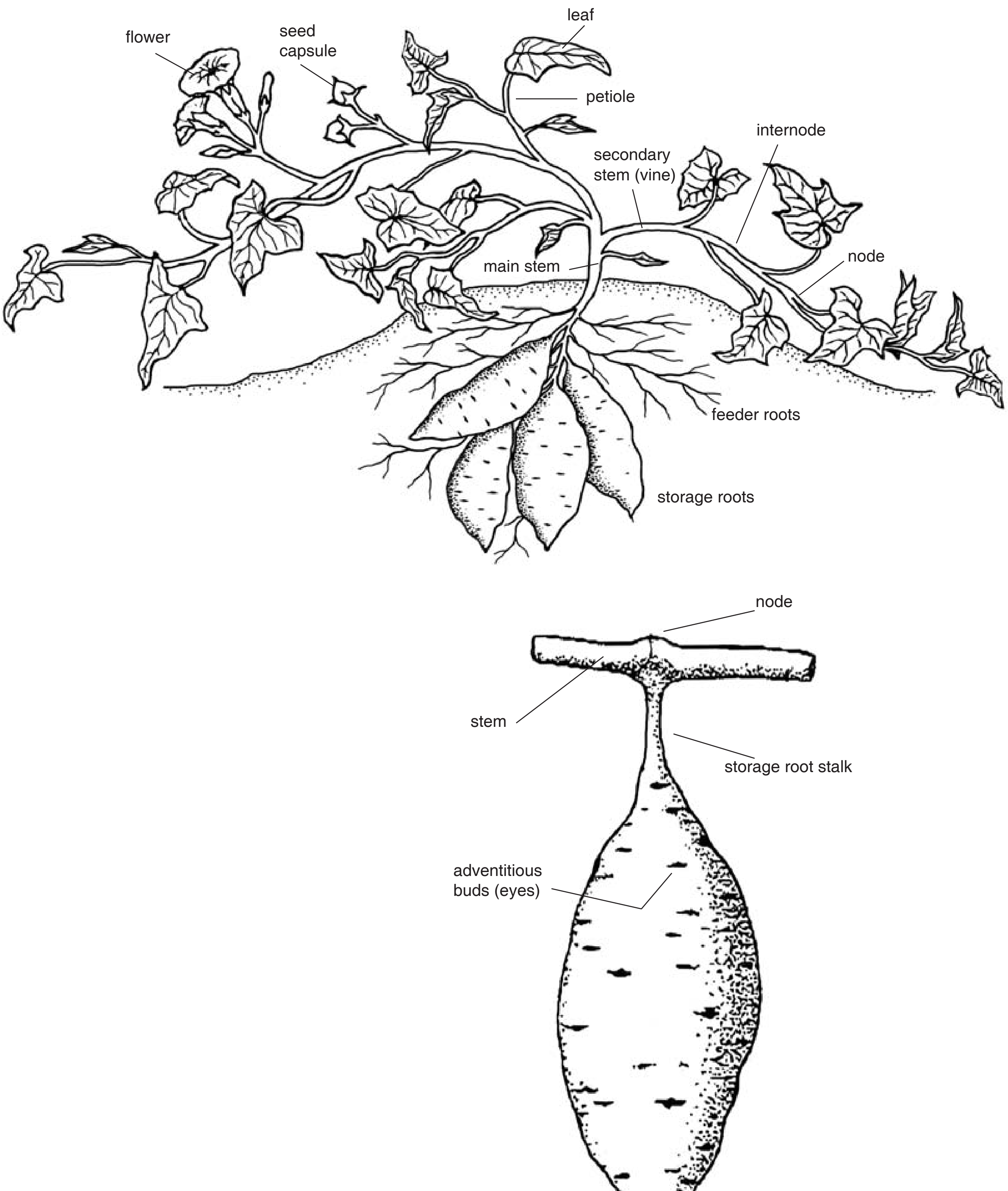

Figure 1. *Parts of the sweetpotato plant*

Getting the crop started

Sweetpotatoes are grown from cuttings or sprouts. Small quantities of virus-free planting material can be obtained from the Department of Primary Industries. It takes about 24 weeks in warm conditions to produce enough planting material from 100 cuttings of your choice of varieties, to establish 2 ha of crop. Established growers can use tip cuttings from their own plants or produce sprouts from their own storage roots.

To give yourself the best chance of success you need to start your land preparation up to four months before the crop is planted, so that seedbeds are free of undecomposed organic matter and are of a fine tilth. This involves 13 steps.

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Decide when to plant

Your market and climatic constraints, for example wet season rains, cool weather and frosts, will influence the time of planting.

Rural centres have a small local requirement for year-round production. Brisbane and interstate markets are most lucrative from August to January. Plantings in south-east Queensland coastal areas usually start in September and end in January. Later plantings are less favourable in terms of yield and quality compared to spring plantings.

In north Queensland coastal areas, planting is possible at any time during the year, depending on wet season rains. On the cooler Atherton Tableland planting goes from January to June.

March to May plantings in north Queensland will mature between September and December, when capital city market prices are at their highest. Table 1 shows the main varieties, planting and harvesting times for the major production areas.

Table 1. *Main varieties, planting and harvesting times for the major production areas*

Varieties (all districts)	District	Plant	Harvest
Beauregard	North Queensland	March to June	September to December
Hernandez	Central Queensland	September to March	October to July
Beerwah Gold	(Bundaberg,		
Centennial	Rockhampton)		
Northern Star	Southern Queensland	Late September to	February to June
WSPF		January	

Temperature

Sweetpotatoes are sensitive to temperature, the degree of sensitivity varying with the growth stage of the crop. Cool periods during storage root development result in distorted roots. Sweetpotatoes are also susceptible to frost damage at all stages of growth.

The optimum range for growth is between 24 and 30°C; temperatures below 15°C are detrimental to growth and storage root development. Warm to hot weather encourages rapid growth.

Crop cycle

Table 2 shows the normal time range for each stage of plant growth. The short intervals are in the hotter weather while each stage takes longer in cooler conditions.

Table 2. *Normal time range for each growth stage*

Plant stage	Time
Taking cuttings to transplanting	2 – 5 days
Planting to storage root initiation	5 – 8 weeks
Storage root initiation to harvest	12 – 17 weeks
Duration of harvest	up to 4 weeks

Select varieties

The varieties listed are available from the virus-free nurseries maintained by the Department of Primary Industries at Redland Bay Research Station. Many other varieties exist and new varieties are being evaluated by the Department of Primary Industries.

In the USA sweetpotatoes are divided into two broad categories—dessert and staple—based on their consumption and use. These categories are used less within Australia, where both types are sold on the fresh market. The dessert type is used for sweet and savoury dishes, and the staple type for savoury dishes. Yield and time to harvest vary with growing conditions.

a key issue
Varieties
Section 4 page 32

Dessert types

Dessert types are orange-fleshed, sweeter and softer than staple types. They have a lower dry matter percentage. Some of the more commonly grown or promising varieties are Beauregard, Beerwah Gold, Centennial, Hernandez and NC-3.

Staple types

Staple types are white-fleshed and have a higher complex carbohydrates content than dessert types. Some of the more commonly grown or promising varieties are Kestle, Northern Star, WSFP and Red Abundance.

Obtain planting material

Order cuttings

more info
Buying cuttings
Section 6 page 4

Small quantities of virus-free planting material can be bought from the Queensland Department of Primary Industries' research station at Redland Bay. These cuttings are used as mother plants to produce planting material for commercial plantings.

Depending on availability, 200 cuttings of up to four varieties, with a maximum of 100 per variety, can be bought from Redlands from the first week of October to the end of April. Larger supplies may be available after December. From 100 cuttings it will take about 24 weeks in warm conditions to produce enough cuttings to plant 2 ha of crop.

In north Queensland a nursery planted in October will produce enough vine tip cuttings for a commercial planting in March or April. In southern and central Queensland the nursery may have to be maintained over winter to supply enough vine tip cuttings for a spring planting of a commercial crop. Alternatively in southern and central Queensland, roots from the nursery area could be used to produce sprouts in spring.

Produce planting material

a key issue
Planting material
Section 4 page 40

The best and most economical source of planting material is sprouts produced in nursery beds grown from storage roots selected from the previous crop for yield and quality. However, vine tip and back cuttings can also be used.

Work out how many cuttings you need

Row width and plant spacing

Row spacing varies from 80 cm to 1.5 m, depending on the machinery available. Narrow rows make it harder to get enough soil for good hills. Plants in the row are usually 20 to 45 cm apart.

Use the closer spacing for summer crops and wider spacing for winter crops. Use close spacing for varieties that set two to three storage roots per plant, as these tend to become too large at wide spacings. Use wider spacing for varieties that set many storage roots per plant to reduce competition between plants and allow more storage roots to reach marketable size.

Plant densities

Optimum plant population will depend on variety. As a general rule the wider the row spacing the closer the plants in the row. A plant population of about 25 000 to 30 000 is considered ideal. A spacing of 1.2 m between rows and 30 cm between plants in the row requires about 27 780 cuttings or nursery bed sprouts per hectare.

Deciding how many cuttings you need

A commonly used planting arrangement is shown in Figure 2.

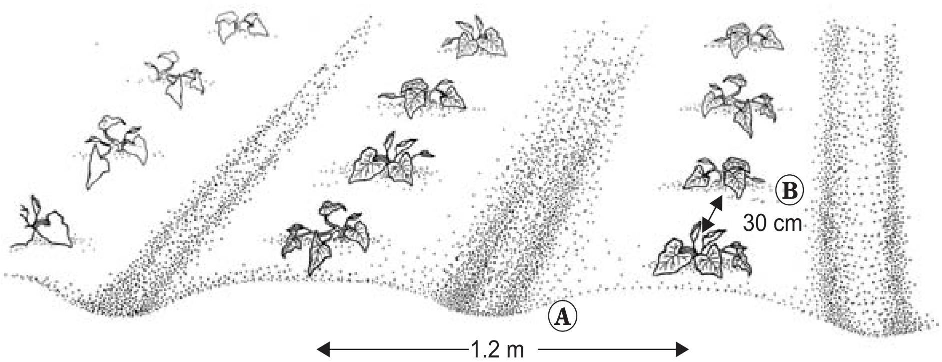


Figure 2. *A commonly used planting arrangement for sweetpotatoes*

Excluding headlands, the number of plants required per hectare (10 000 sq. m) is determined by:

- the distance in metres between the centre of each bed (A);
- the distance in metres between plants in the row (B).

Use a calculator to calculate the following formula:

$$(10\,000 \div A) \div B$$

For example: How many plants will you need at 1.2 m bed centres (A) and 30 cm (0.3 m) between plants (B)?

10 000 ÷ 1.2 = 8333 ÷ 0.3 = 27 778 plants per hectare

Table 3 shows our calculations for several different row and plant spacings.

Table 3. *Approximate number of plants per planted hectare at different row and plant spacings*

Distance (m) between rows	Distance between plants 25 cm	30 cm	35 cm	40 cm	45 cm	50 cm
0.8	50 000	41 670	35 710	31 250	27 780	25 000
0.9	44 440	37 040	31 750	27 780	24 690	22 220
1.0	40 000	33 330	28 570	25 000	22 220	20 000
1.2	33 330	27 780	23 810	20 830	18 520	16 670
1.5	26 670	22 220	19 050	16 670	14 810	13 330

Note: The length of rows and the size of headlands will determine what area is required to plant 1 ha of crop.

Choose an irrigation system

Consult an irrigation equipment supplier or designer in your area and get them to develop an irrigation plan.

a key issue
Irrigation methods
Section 4 page 61

Irrigation methods

Overhead irrigation systems, that is sprinklers or travelling irrigators, are generally used in Queensland but trickle irrigation is used in some areas.

Overhead irrigation includes travelling irrigators and sprinkler systems. It is suitable for any soil type and undulating country. Overhead irrigation can increase the risk of leaf diseases while poor quality water applied over the plants will result in leaf damage.

Trickle irrigation is the most easily controlled irrigation method. The equipment is expensive, but has a long life. If trickle tubing is to be reused it should be treated with chlorine to reduce the risk of blockages. Soluble fertilisers and some pesticides can be applied easily through the irrigation system. The main disadvantage of trickle irrigation is it may not seal cracks in the soil, allowing entry of sweetpotato weevil.

Water quality

Sweetpotatoes are susceptible to saline irrigation water. Poorer quality water can be used on sandy soils with good drainage. Irrigation water should be low in sodium (Na) and chlorides, and have a low conductivity; have it checked by a laboratory. Acceptable conductivity, measured in deciSiemens per metre (dS/m), varies with soil type (Table 4). Conductivities above these figures may cause serious yield reductions.

Table 4. Maximum conductivity above which yield may be reduced

Soil type	Sand	Loam	Clay
Conductivity	3.0 dS/m	1.7 dS/m	1.0 dS/m

Source: DNR Water Facts, W55

Water quantity

Sweetpotatoes need up to five megalitres (ML) of water per hectare of crop; this is about 500 mm total of rain and irrigation. Most of the roots are in the top 60 cm of soil and readily available soil moisture should be kept in that root zone.

a key issue

Irrigation management
Section 4 page 60

The amount of water required varies with the locality and the soil type. Sandy soils have a much lower water-holding capacity than clay-based soils and consequently need more frequent irrigation. The soil texture will also determine the amount of water applied at any one time.

Prepare the land

Protect against wind

Wind damage is not normally a problem with sweetpotatoes, but strong winds can move cuttings in the soil, delay establishment, tear leaves and turn vines over. Topsoil may be blown away by high winds during the late stages of land preparation. Wind will also increase moisture loss from the soil and plants, increasing stress.

A windbreak such as bana grass, or an artificial windbreak, will greatly reduce these problems. More permanent tree windbreaks may be practical in some situations. Strips of sorghum are sometimes planted between the lands to give some protection to young plants.

Sweetpotatoes are sometimes grown between rows of tree crops when orchards are being established.

Protect against soil erosion

Planting on steep slopes can cause soil erosion. If sprinkler or trickle irrigation are used, uniform slopes are preferred but not essential.

Whichever irrigation system is used, some form of land levelling is necessary, as sweetpotatoes are highly prone to waterlogging. Laser levelling is carried out in most districts and will improve irrigation efficiency.

Uncontrolled runoff water removes valuable topsoil while the land is being prepared. The hills used for growing sweetpotatoes can concentrate water, which may cause overtopping of the banks.

There are six important steps in avoiding erosion from runoff.

1. Build a grassed contour drain across the top of the block. This drain should have a grade of between 2 and 4% and will catch runoff water from above the block and divert it into waterways running down the slope.

2. Space waterways 50 m apart. Make them flat-bottomed, at least 2 m wide, and lower than the surrounding land. Where possible, use natural depressions in the block.
3. Form beds parallel to the top drain so that water can be channelled between the beds into the waterways.
4. Build trafficways beside the waterways.
5. Plant seed or runners of couch, kikuyu or carpet grass in the base of waterways and trafficways. Once these structures are established, they can remain as permanent fixtures.
6. Run beds across the slope, parallel to the contour drain. This layout minimises loss of soil between beds and combines good water infiltration and safe removal of runoff.

These layouts can be used safely on all slopes with a fall of up to 8%. Sweetpotatoes should not be grown on steeper slopes.

Crop rotation

A fallow period must follow a crop of sweetpotatoes to prevent the build up of soil-borne pests and diseases and eliminate volunteer plants. Do not re-plant sweetpotatoes back into the same ground for at least three years. Most other crops can be used in a rotation.

Cover crops in rotation with cash crops improve soil structure and productivity, and reduce pest and disease problems. Cover cropping combined with other soil conservation methods, such as contour banks on steeper slopes, will reduce erosion and help maintain your most valuable asset, your soil.

A guide to land preparation

The soil type and cropping history of the block influence soil fertility and land preparation. If you don't have information on the soil's nutrient status, get a soil analysis done. Table 5 shows a suggested land preparation schedule based on the number of weeks before planting.

Table 5. *A suggested land preparation schedule for sweetpotatoes*

Weeks before planting	Activity
20	Cultivate soil, rip and fertilise if necessary. If soil pH is below 5.5 add lime or dolomite. Plant a green manure crop.
10 – 12	Slash or cut with a mulcher to avoid hard fibrous stems.
8	Sample soil for a nutrient analysis.
6	Mulch, then plough in green manure crop. Act on soil nutrient analysis if necessary.
2 – 4	Cultivate soil as necessary to speed break down of green manure crop and bring the soil to a suitable tilth for forming hills.
0 – 1	Apply basal fertiliser and hill up just before planting.
0	Plant the crop.

Initial cultivation. If your land is under grass or weeds, plough or disc-cultivate the block. A hard pan or compaction layer may have formed from regular use of a rotary hoe and other cultivation equipment or from heavy traffic movement (Figure 3). This causes reduced plant growth and waterlogging in some situations. A compaction layer may also cause storage roots to bend or expand at the end, and cause the tops of storage roots to be pushed out of the ground, allowing infestation by sweetpotato weevils.

If you suspect that you may have a hard pan, dig a hole and check. Deep rip in both directions to break this hard pan. If the soil is wet, it will not shatter; if too dry, large clods will be formed.

Ripping is best immediately after final harvest to allow water to penetrate deeply during fallow and salts to be leached out of the root zone.

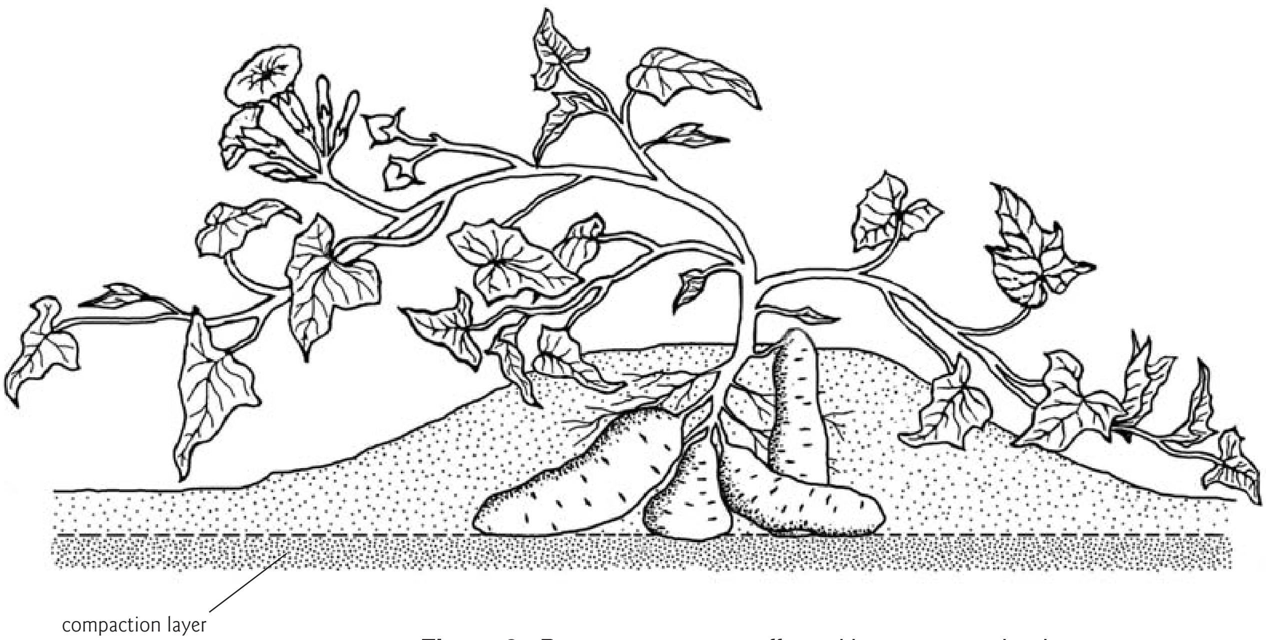


Figure 3. *Bent storage roots affected by a compaction layer*

Organic additives. Organic additives such as filter press or mill mud from sugar mills (15 t/ha), deep litter fowl manure (5 t/ha) or cattle feedlot manure (10 t/ha), may be used to increase organic matter in the soil. They should be applied before planting a cover crop.

Cover crops or green manure. Cover crops help to improve soil structure and build up soil organic matter, which is reduced by cultivation. These crops are particularly important in light, sandy soil. Organic matter is usually expressed as organic carbon in a soil analysis.

Other benefits of cover crops include:

- improved soil structure and internal soil drainage;
- improved water-holding capacity;
- reduced leaching of nutrients;
- increased activity of micro-organisms;
- reduced soil erosion;
- reduced pest and disease problems;
- reduced weed growth;
- recycling of nutrients.

If growth is slow apply 100 kg/ha of nitram (30 kg/ha of nitrogen) after emergence. A well-grown cover crop will add more organic matter and help smother weeds. Extra nitrogen may be needed if the cover crop is slashed several times.

Legumes, such as cowpea and dolichos, are susceptible to nematodes. The cover crops suggested here should not result in any build-up of nematodes.

Summer. Broadcast hybrid forage sorghum seed over the cultivated land at 20 to 30 kg/ha. Use the higher rate where the seedbed is rough and the seed will not have good soil contact. For best germination, use harrows or a light tined implement after planting to mix seed into the soil. Light rolling will improve germination by ensuring that seed is in closer contact with the soil. Water as required.

Forage sorghum can be ratooned several times by slashing. Extra nitrogen may be required if the crop is slashed and allowed to regrow. Slash back to a height of 20 to 30 cm, or plough in before seed heads develop and the stems get too fibrous to decompose rapidly.

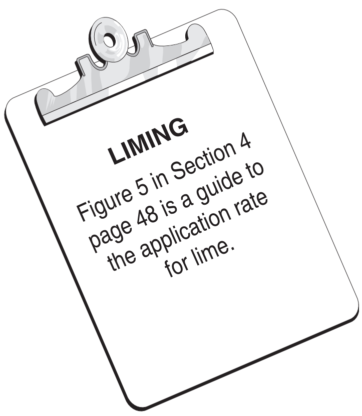
In north Queensland, the legume dolichos or hybrid forage sorghum are planted from November to January.

Winter. Few northern producers grow a winter cover crop. In south Queensland cereals such as oats, triticale or barley at 75 kg/ha are suitable. Use oats for early planting and barley for late planting.

Soil analysis. A soil analysis takes the guesswork out of fertiliser scheduling. Take the sample six to eight weeks before your intended planting date. Follow the sampling instructions supplied by the laboratories.

A soil analysis measures the pH, conductivity, organic matter and the level of nutrients in the soil. Results will be interpreted by the laboratory and should be back in about two weeks, allowing time for the treatments to be incorporated into the soil. Your experience of the block of land, and the way you wish to manipulate the growth pattern of the crop, will influence your interpretation of the soil analysis.

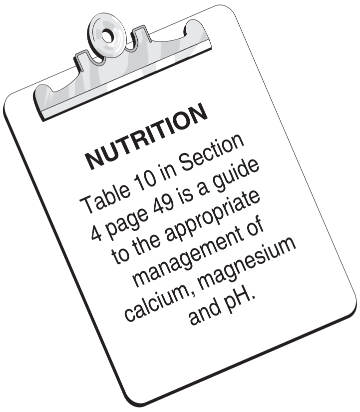
Soil pH. The pH level is a measure of the soil's acidity or alkalinity on a scale from 0 to 14, with 7 being neutral. A pH of 5 is 10 times more acid than a pH of 6. Soil pH between 5.5 and 6.0 is desirable. In this range, most major and trace elements present in the soil are available to the plants, without being at toxic levels. However, where soil rot (pox) is a problem, raising pH above 5.5 increases the incidence of soil rot. Many Queensland soils are acidic and require the addition of lime or dolomite to raise the pH. A complete soil analysis will show which liming material is most suitable and indicate an appropriate rate by showing the available levels of calcium and magnesium.



Gypsum. Application of gypsum will increase soil calcium levels but not change soil pH. Naturally occurring gypsum is preferred to phosphogypsum in vegetable crops because of the cadmium in phosphogypsum. It takes about one year for the physical effects of gypsum on the soil structure to become apparent. Apply gypsum before the wet season so that it can leach accumulated salts beyond the root zone well before planting.

An application of 5 to 10 t/ha of gypsum can benefit heavy clay loams that have high sodium levels and a pH higher than 8.0.

Final land preparation. Plough in the organic matter to 20 to 25 cm deep, then work the soil to a fine tilth for planting. All organic matter should be incorporated into the soil well before planting. This allows it to decompose completely, avoiding serious crop damage by soil-borne insects and diseases which live on undecomposed organic matter. Decomposition takes about four weeks in warm, moist soil and eight weeks or longer in cold or dry weather.



In very dry conditions it may be necessary to apply about 25 kg/ha of urea and irrigate to encourage decomposition by soil micro-organisms. Otherwise the organic matter decomposes when the crop is first irrigated, resulting in heavy plant losses.

Soils are normally worked twice with disc or tine cultivators and then brought to a clod-free condition using rigid or spring tine cultivators and harrows. A rotary hoe is used for final land preparation when applying fertiliser and bedding up.

Trace elements. If trace elements are deficient, some may be applied to the soil before the final cultivation. They may also be included in fertiliser blends as a pre-plant application. Soil applications will often last for a few years, whereas foliar applications only benefit the plants to which they are applied. Sweetpotatoes have a relatively high requirement for boron. Table 6 lists the most commonly deficient trace elements.

Table 6. *Soil application rates to prevent boron and zinc deficiencies*

Element	Product	Rate	Comments
Boron	borax (11.3% B)	16 – 30 kg/ha	Use low rate on sandy soil and high rate on clay soil. Deficiency is more likely on sandy soils, particularly if heavily limed, alkaline or low in nitrogen.
	Solubor (20.5% B)	8 – 15 kg /ha 200 – 500 g/100 L	Spray on the soil and incorporate. Solubor is not compatible with zinc sulfate heptahydrate.
Zinc	zinc sulfate monohydrate	20 kg/ha	Broadcast onto the soil before planting and work it in.
	zinc sulfate heptahydrate	30 kg/ha 500 g/100 L	Spray on soil; do not mix with boron.

more info
Pest control
Problem Solver Handy Guide

Treat for soil pests

Insect pests

The following pests can cause problems: cutworm, wireworm, white grub, and field and mole crickets.

Cutworm can chew off vine cuttings soon after planting. They feed on the storage roots, reducing crop value and making it easier for soil rot organisms to enter. Control cutworm with a chemical from the *Problem Solver Handy Guide*. Apply this treatment to the soil surface and incorporate before hilling. Fumigation will also control these pests.

Before planting, monitor for soil insects using the 'germinating seed bait' technique described in the DPI Note *Control of Soil Insects in Central Queensland.*

NEMATODES
For information about managing nematodes see Section 4 page 91 and Section 5 pages 15 and 16.

Nematodes

Nematodes can be a serious problem, even in virgin soils, and especially in sandy soils, or soils that have previously grown susceptible crops or weeds. Soil nematode counts can be a useful guide, but may be misleading because some nematodes survive deep down and move up to the root zone once soil moisture improves. Check the previous history of the block or dig up some susceptible host plants and check roots for nematode galling.

A nematicide or fumigant is often used as insurance against future losses, because once plant damage is noticed, it is too late to control nematodes. Chemicals used to control nematodes are listed in Table 7.

Table 7. *Chemicals used to control nematodes*

Chemical	Trade name	Rate	Comments
chloropicrin	Chloropicrin	300 – 600 g/20 sq.m	See chemical label for details. Also controls some soil fungi and weeds.
dazomet	Basamid	500 – 700 kg/ha 50 – 70 g/sq.m	See chemical label for details Also controls some soil fungi and weeds.
fenamiphos	Nemacur 400	24 L/ha or 16 mL/10 m of row	Apply as an overall treatment or as a 60 cm wide band any time from 7 days before, up to planting. Withholding period is 84 days.
metham-sodium	Metham	250 – 500 L per treated hectare	Soil injection or rotary tiller.
	Metham Sodium	250 – 800 L per treated hectare	Through certified trickle irrigation systems. See chemical label for details. Also controls some soil fungi and weeds.
methyl bromide + chloropicrin	Vertafume	500 kg/ha	See chemical label for details Also controls some soil fungi and weeds.

Fumigation

Fumigation refers to the injection or incorporation of chemicals into the soil before planting to control nematodes, weeds and some soil-borne pests and diseases. Use a broad-spectrum fumigant.

There are two ways of applying fumigants:

- fumigate the whole block before the beds are formed;
- only treat the strips to be planted. (The beds are formed, the fumigant applied and the plastic mulch laid, all in the one operation. For some fumigants, the soil is rolled after application then lightly irrigated to seal in the fumigant.) Treating strips is cheaper, but diseases and weed seeds can remain between the rows in the unfumigated soil.

After treatment the soil must be aerated to allow the gas residues to escape or plants can be damaged. If the whole block is fumigated, remove and discard the covering sheet. If strips are fumigated, leave the plastic mulch in place and delay planting for at least one week and probably longer in winter. If cress or lettuce seed will germinate in the treated soil, it is safe to plant.

a key issue
Alternatives to methyl bromide Section 4 page 103

Methyl bromide + chloropicrin. This fumigant is an extremely efficient chemical on nematodes. However, it is costly, and its use can only be justified if other soil diseases and weeds such as nut grass are an anticipated problem. Although methyl bromide is gradually being phased out it is still the recommended fumigant.

Before application, work the soil to a fine tilth to 25 cm deep. Soil must be moist but not wet, free from clods and undecomposed organic matter, and warmer than 10°C. Methyl bromide is highly toxic and is applied under plastic sheeting. Hire an experienced operator with the necessary specialised equipment to perform this operation safely.

Metham sodium. This is an alternative to methyl bromide. It is a broad-spectrum chemical that works well against nematodes, fungi and germinating weed seeds but is not as effective as methyl bromide against bacteria. It is less volatile than methyl bromide and generally moves more slowly through the soil profile.

Movement down and laterally from the injection site of methyl isothiocyanate, the 'fumigant' breakdown product of metham sodium, may be very limited. It moves better in soil water than in the air spaces in soil. It is important to inject metham sodium slightly below the intended depth of control, say 25 cm. Multi-depth application (at 10 cm and 25 cm) may be more effective at providing protection through a broader soil profile.

Metham sodium can also be applied effectively through sprays immediately in front of a rotary hoe, which incorporates the product throughout the root area. The seedbed must be well worked and have sufficient moisture for metham sodium to be effective. Good moisture is necessary to allow methyl isothiocyanate to move within the soil.

Moisture also ensures that weed seeds begin to germinate and fungal organisms become active, allowing the product to kill these targets more effectively. Soil temperatures above 30°C reduce the efficacy of methyl isothiocyanate.

Metham sodium can be injected into the soil or sprayed on the soil and mixed in with a rotary tiller, then rolled and lightly watered to seal in the gas. It can also be applied through trickle irrigation systems that have been designed to apply agricultural chemicals, however, the beds must be covered with plastic mulch.

Mark out and form the hills

Mark out the area to be planted. Match the number of rows per land to thearea covered by the irrigation sprinklers and boom sprays (Figure 4). Some growers use two-sided booms and don't have roadways between lands.

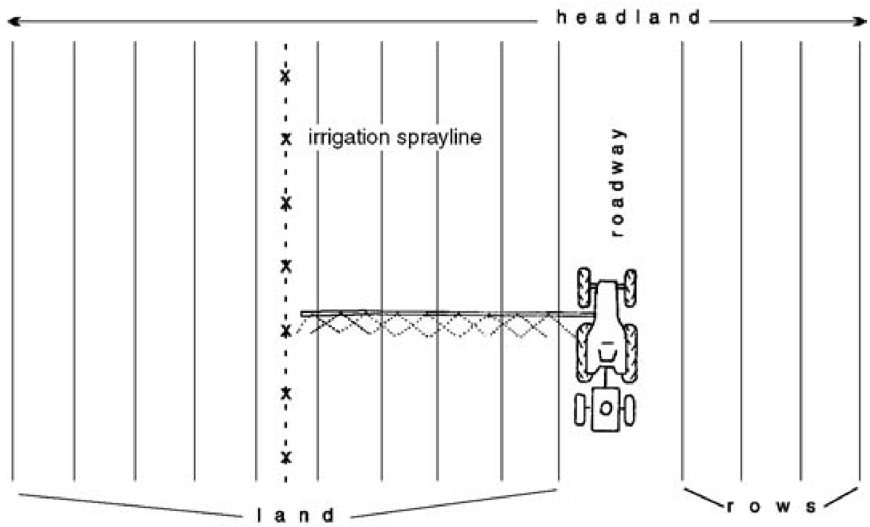


***Figure 4.** A field layout for sweetpotatoes*

If possible, divide blocks into uniform soil types for easier and more efficient cultivation, irrigation and fertilising. Provide all weather access to the block and allow room for vehicles to turn easily at the end of the rows.

Mark out rows

Rows are marked out using the wheel marks of a tractor that is set at the normal row spacing. After the first row is marked out the driver need only follow on the outside wheel mark to obtain the correct spacing. Establishment fertiliser can be applied when the rows are marked out.

Hill forming

Sweetpotatoes are grown on low broad hills (beds) for increased soil depth to improve drainage, reduce the risk of waterlogging and root breakdown, and make harvesting easier. The width and height of beds varies according to wheel spacing, planting machinery and soil types. Narrow, steep hills dry out too quickly and stress the plants. Form beds like those shown in Figure 5.

Beds are usually formed with a bed shaper or other implements, for example roller cultivators, tines and furrowers, during final land preparation. If you are using plastic mulch, the plastic layer will usually fom the beds when laying the mulch and trickle irrigation tube. The establishment fertiliser must be applied before the plastic mulch is laid.

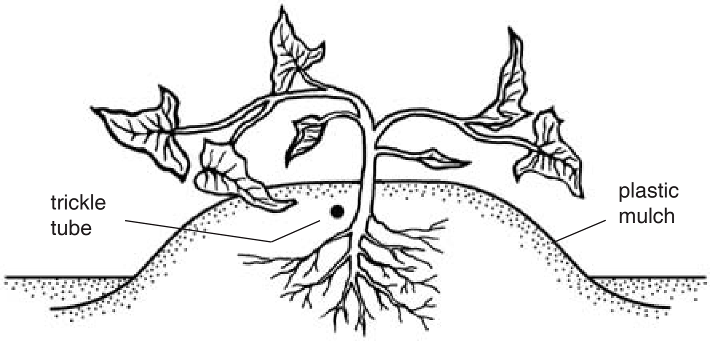


Figure 5. *Plastic mulch over a well-formed bed; note trickle tube*

Mulches

Polyethylene mulch is common and appears to have potential for sweetpotato plantings. Overseas trials have shown plastic mulch and trickle irrigation to be very effective, with increased early and total yields more than covering the extra costs. Other types of mulch are being evaluated.

Table 8. *Advantages and disadvantages of plastic mulch and trickle irrigation*

Advantages	Disadvantages
Soil temperatures are higher, providing a better growing environment and establishment in cool weather.	Higher initial and ongoing costs.
Overseas research has shown early and total yields are increased.	Trickle irrigation must be used.
Mulches reduce water use by preventing moisture evaporation from the soil.	Specialised machinery is needed to lay both trickle tape and plastic.
Water is applied to the root area of the plant.	Specialised machinery is needed to plant directly through holes made in the plastic.
Soil cracking is eliminated, preventing sweetpotato weevil from entering the storage roots.	The plastic may harbour rodents or soil insects, which may damage storage roots and trickle tape.
Plastic mulches improve the lateral spread of water in some soils.	The environment under the plastic can favour the build-up of nematodes and other soil-borne pests.
Poorer quality water can be used with trickle irrigation.	The plastic and trickle tape must be lifted and disposed of after use.
Supplementary fertiliser applications can be made accurately with trickle irrigation.	Runoff after rainfall is increased.
Weed growth in the plant row is restricted.	
Leaching of nutrients from the hills is reduced.	

If plastic mulches are to be used, trickle irrigation must be installed for water and nutrient application (fertigation). Table 8 shows the advantages and disadvantages of using plastic mulch and trickle irrigation.

Laying mulch

Forming beds, laying the plastic mulch and installing trickle tubing is carried out in one operation by a specially designed machine. Some machines also mark out rows and apply and incorporate establishment fertiliser at the same time. The trickle tubing can be laid on top of the soil directly under the plastic, but is best buried about 5 cm deep. This helps prevent any ‘snaking’, so the trickle tubing maintains its position beside the plants.

Beds can be formed and mulch laid several weeks or immediately before planting. Laying mulch well before planting ensures that the beds are ready. The crop can be planted, even if wet weather would otherwise have interrupted land preparation. In hot weather, if the polyethylene mulch is laid for some time before planting, fewer weeds may grow through the planting hole after planting.

Plastic mulches come in various thicknesses, widths and colour. The common practice is to use white or grey-blue plastic during hotter weather to reduce soil temperatures and black plastic when temperatures are lower.

Plastic mulch is usually bought as 1000 m rolls. Width varies from 900 mm to 1200 mm and thickness from 25 to 35 microns. Table 9 shows the length of plastic mulch and trickle tubing required per hectare at various row spacings.

Table 9. *Length of plastic and trickle tubing required per hectare*

Distance (m) between rows	Metres of plastic mulch and trickle tubing per hectare
0.8	12 500
0.9	11 111
1.0	10 000
1.2	8 333
1.5	6 667

Trickle tubing

The capacity, quality and price of trickle tubing varies, depending on the type and manufacturer. Cheaper, thinner tubing is commonly used and discarded after the crop has been harvested. Thicker, more expensive tubing is used if crickets have chewed the tape. This tubing can be re-used if you are careful when retrieving it.

a key issue
Cleaning trickle tubing
Section 4 page 69

Emitters are usually 20 or 30 cm apart. The closer spacing is used where lateral movement of water is poor, for example in sandy soils, and the wider spacing is used where lateral water movement is good, for example in heavier clay soil types. Lay trickle tubing with the holes up, to prevent blockages from sediments.

Apply fertiliser

Fertiliser applications should be based on the results of a soil nutrient analysis. Discuss the results of your soil analysis with your agronomist or farm supply agent and work out how much fertiliser is needed.

Dessert varieties are reported to respond better to higher fertiliser rates than the staple type. Total requirements for dessert types on an average fertility soil are about 100 kg/ha nitrogen, 40 kg/ha phosphorus and 120 kg/ha potassium. Soil nutrient status, cropping history and treatments to adjust soil pH should all be considered.

Fertilisers are commonly sold as mixtures of nitrogen (N), phosphorus (P), and potassium (K). The percentage of each of these elements in the mix is expressed as a ratio of N:P:K. For example 100 kg of a fertiliser with an N:P:K ratio of 14:15:13 contains 14 kg nitrogen, 15 kg phosphorus and 13 kg potassium.

Fertilisers should be applied as an establishment application with supplementary applications as the crop grows. The establishment application may be applied before planting, at planting or after the cuttings are established, up to 10 days after planting.

a key issue

Nutrition
Section 4 page 47

Poultry manure should be used with caution as excessive rates promote top development with very little root production.

Establishment fertiliser

The establishment fertiliser should provide an even, vigorous, but not over-vegetative vine. The plants should develop a strong root system and early plant structure that can produce a heavy crop. Generally about 40% of the total nitrogen requirement, all the phosphorus and about 50 to 60% of the potassium should be applied before or at planting, or after cuttings are established.

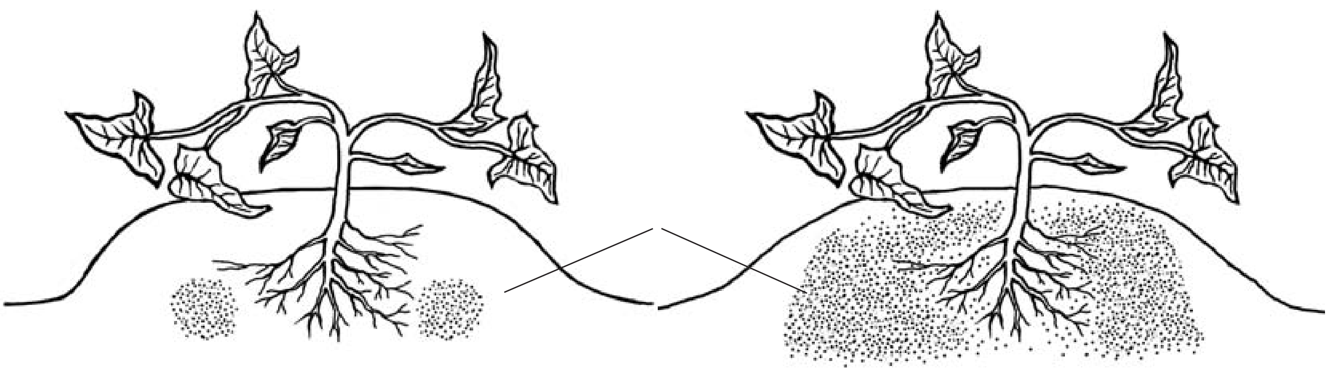


Figure 6. Establishment fertiliser, (a) drilled and (b) banded

Apply the establishment fertiliser to the soil surface in a 60 cm wide band and incorporate it with a rotary hoe during final soil preparation or bed-forming. On some soils (mainly krasnozems and red earths) where phosphorus may be tied-up in the soil, basal fertilisers are drilled into the bed in narrow bands 10 cm to the side and below the plant roots

(Figure 6). Fertiliser can also be applied as bands and incorporated into the hills during their formation.

Major elements

Establishment fertiliser requirements should be determined from the results of a complete soil analysis. The establishment fertiliser required will contain mainly nitrogen (N), phosphorus (P) and potassium (K). In the absence of a soil analysis, Tables 10 and 11 are a guide to establishment fertiliser requirements and application rates.

Table 10. *A guide to establishment fertiliser rates*

Element	Quantity (kg/ha) Fertile soil	Average soil	Infertile soil
Nitrogen (N)	0	40	60
Phosphorus (P)	30	40	40
Potassium (K)	40	80	100

Table 11. *Fertiliser rates and element supplied for two common N:P:K mixtures*

N:P:K mixture	Amount kg/ha	Element applied (kg/ha) N	P	K	S	Ca	Mg
14 : 15 : 13	250	35	38	33	3	0	0
6.4 : 6.1 : 22.8	625	40	38	143	13	28	33

Elements other than nitrogen, phosphorus and potassium that are required in relatively large amounts include calcium, magnesium and sulfur. Sulfur is usually found in sufficient quantities in most commercial N:P:K fertilisers, superphosphate, gypsum and sulfate of potash. Lime, dolomite and gypsum are sources of calcium. Dolomite and magnesium sulfate are sources of magnesium.

a key issue
Using these products, Table 10
Section 4 page 49

Prepare planting material

Cuttings

Cuttings may be tip cuttings (the vine tips) or back cuttings (from further back on the vine). Tip cuttings are preferred as back cuttings are less vigorous and may carry scurf or sweetpotato weevil. Back cuttings must be planted with the 'top' end up, that is the end closest to the roots goes into the soil. Take tip cuttings only from healthy plants free of virus disease and pests. If tip cuttings are taken from an established commercial planting this should be done only once or storage root production can be reduced.

Tip cuttings will keep for up to two weeks in cool weather, provided they are kept moist with clean tank or chlorinated water, shaded and out of the wind. However, it is best to plant them within four days of cutting. They are usually wrapped in hessian and stood on their cut end.

Trim the cuttings to remove the lower, fully expanded leaves. If the cuttings are to be held for more than four days, trim the middle leaves,

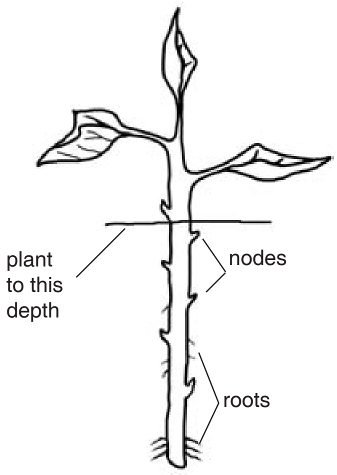


Figure 7. A tip cutting ready for planting

leaving only the immature leaves at the top. Trimming can be time consuming, but it reduces transpiration and assists establishment if planted in hot conditions, or immediately after collecting. Trimming also makes planting easier. Figure 7 shows a cutting ready for planting.

The length of cuttings may affect yield, depending on the variety and the number of buried nodes. Usually 25 cm long cuttings are planted. Cuttings can be planted immediately after removal, but it is best to wait two to four days until some roots appear.

Sprouts

Sprouts make ideal planting material, as they are vigorous, straight, have short internodes and are quick, easy and therefore cheap to produce.

Sprouts are produced in a seedbed from storage roots. When they are about 250 mm long, the sprouts are cut 25 mm above soil level with a knife or reciprocating mower, to allow them to produce more sprouts. Do not pull them, as this will reduce further sprout production and can result in sweetpotato weevil or disease being taken into the field.

Sprouts have more nodes than cuttings and should be at least 200 mm long when planted. Although it is less important to hold them before planting, as adventitious roots have usually started to develop, it is best to hold them for two days.

Plant

Planting methods

Plant cuttings or sprouts after the hottest part of the day. Heat stress will cause poor plant survival, establishment and vigour. Poor plant survival will result in a higher percentage of oversized storage roots because the greater distance between plants will allow storage roots to grow bigger.

A tractor-drawn mechanical transplanter is the most labour efficient transplanting method. Three people including the tractor driver can set 2500 to 3000 plants per hour, that is 30 hours per hectare. Hand planting takes around 75 hours per hectare.

Planting depth

Adjust planting depth to 10 to 15 cm so that at least three nodes on each cutting are underground. Lay cuttings on an angle rather than vertical in the direction of the row. The growing point should be about 10 cm out of the ground. Early plant growth will then be along the row, allowing later cultivation, and storage roots will also develop along rather than across the row.

Reform hills

Hills may need reforming immediately after planting. Various implements may be used, including roller cultivators, tines and furrowers. This is not possible if plastic mulch is used.

Control weeds

Plan your farm crop rotation to minimise weeds and hard-to-control crop plants in sweetpotatoes. If possible select a field with few weeds. Early weed control is essential, the aim being to destroy weeds before seeds are produced. Regular cultivation with tined implements will prevent a build-up of weeds and cause less damage to soil structure than discs or a rotary hoe. If a good cover crop is planted, most weeds will be smothered.

Plastic mulch and methyl bromide are not commonly used; however, where plastic mulch is used it gives excellent weed control over most of the cropped area. Weeds in the unmulched interrow strips can be controlled in their early growth stages by a low-pressure, directed spray with paraquat, using shielded fan nozzles, or by cultivation. Some weeds may grow up around the plants through the planting holes in the plastic. Fumigation before planting will reduce this. Any weeds that do grow must be removed by hand.

Methyl bromide will control nut grass and prevent it from growing through the plastic mulch. Where plastic mulch is not used, inter-row cultivation, hilling, hand chipping or the use of herbicides can control weeds.

Apply pre-emergent herbicide

The pre-emergent herbicides, metolachlor and S-metolachlor, can be applied immediately after planting for early control of a range of grasses and broadleaf weeds. They can be applied by boom spray. Table 12 shows the pre-emergent herbicides registered to control weeds in sweetpotatoes.

Table 12. *Pre-emergent herbicides to control weeds in sweetpotatoes*

Chemical	Product	Rate per ha	WHP* (days)	Comments
metolachlor	Bouncer Clincher Metolachlor Support	3 L	161	Apply immediately after transplanting before weeds have germinated. Sufficient irrigation to wet the soil through the weed zone (3 to 4 cm) should be applied within 24 hours. More weeds may germinate after re-hilling exposes untreated soil. It has a long withholding period.
S-metolachlor	Dual Gold	1.5 L	161	As above.

*WHP: Withholding period—the time which must pass between last application and harvest.

Irrigate

Immediately after planting, apply 18 to 25 mm of irrigation to establish the crop.

Planting to storage root initiation

This stage usually takes about five to eight weeks (Figure 8). There are five important things to manage during this stage.

Control weeds 22
Monitor plant nutrients and fertilise 23
Monitor soil moisture and irrigate....26
Managing pests and diseases 28
Control frost....31

Figure 8. *The frame indicates planting to storage root initiation*

Control weeds

Unmulched crops

Hilling is used to control weeds and to apply fertiliser in addition to increasing hill size. Various implements may be used for hilling, including roller cultivators, tines and furrowers. Well-formed hills reduce sweetpotato weevil damage and provide optimum growing conditions for storage roots.

Mechanical and chemical methods, and hand weeding are employed. Inter-row cultivation is used to control weeds, and form hills before vines cover the rows. The knockdown herbicide, sethoxydim (Sertin) will only control grasses, not broadleaved weeds, and can be sprayed over the sweetpotato plants. The knockdown herbicides paraquat and diquat must be directed between the rows. Table 13 lists the registered chemicals for use on sweetpotato.

Table 13. Herbicides to control emerged weeds in sweetpotatoes

Chemical	Trade name	Rate per ha	Rate per 100 L	Comments
These chemicals are for use between the rows				
diquat	Reglone	1.4 – 4 L + Agral		Shield the nozzle to stop drift. Use where broadleaf weeds predominate. See chemical label for more details. 14 days withholding period.
paraquat	BOA Gramoxone Maxitop Paradox Paraquat Sprayquat	1.2 – 2.4 L	200 – 400 mL	Use shielded nozzles. Direct the spray so that it does not touch the crop. Apply after crop seedlings have emerged or when transplanted crops are established. Diquat can be added to improve control of some broadleaf weeds. See chemical label for more details. 0 days withholding period.
	Nuquat	1.5 – 3 L	250 – 500 mL	
paraquat + diquat	Spray.Seed Tryquat	2.4 – 3.2 L 3 – 4 L	240 – 320 mL 300 – 400 mL	Shield the nozzle to stop drift. Spray when weeds are growing vigorously and not covered with soil or dust, or wilting due to dry conditions. See chemical label for more details. 0 days withholding period.
This chemical controls grasses only				
sethoxydim	Sertin 186	1 L + 1 – 2 L crop oil		Apply when most of the grass weeds are in the 2 to 6 leaf stage and are actively growing.
	Sertin Plus	1.6 L		See chemical label for more details. 0 days withholding period.

Mulched crops

Some weeds may grow up through the planting holes around the plants. They must be carefully removed by hand without disturbing plant roots.

The space between rows can be kept weed-free by using a knockdown herbicide from Table 13. Apply these sprays at low pressure and use shielded fan nozzles to prevent drift onto the crop.

Monitor plant nutrients and fertilise

more info
Fertilising
This section page 24

If establishment fertiliser was not applied before planting it should be applied as soon as the cuttings are established, up to 10 days after planting.

The application of fertiliser every few weeks without knowing whether the plants need it wastes money and is environmentally irresponsible. Take the guesswork out of fertiliser applications by monitoring plant nutrient levels.

Plant nutrient monitoring

more info
Leaf testing
This section page 24

Plant nutrient content can be monitored either by doing a leaf analysis eight weeks after planting, or using sap analysis starting when vines are about 50 cm long.

Sap testing is a means of rapidly assessing a plant's nutrient status during crop growth. This test has a 24-hour turn-around time. It can be used to highlight deficiencies of any essential element or to monitor the nitrate and potassium levels during the crop cycle. Sap testing

Planting to storage root initiation

allows growers to manage the crop more precisely and to correct any nutrient problems before yield or quality are affected.

Sap testing involves collecting leaf stalks (petioles) of the youngest fully expanded leaves, usually the fourth or fifth back from the growing point, extracting sap with a garlic press, and nalysing the nutrient content of the sap. Sap testing may start when runners are 50 cm long and continue to mid-bulking stage (when the storage roots are increasing in size). Figure 9 shows which leaf to collect.

SAP TESTS
For more information, see Sap testing, Section 4 page 56. For sap testing services, see Section 6 page xx.

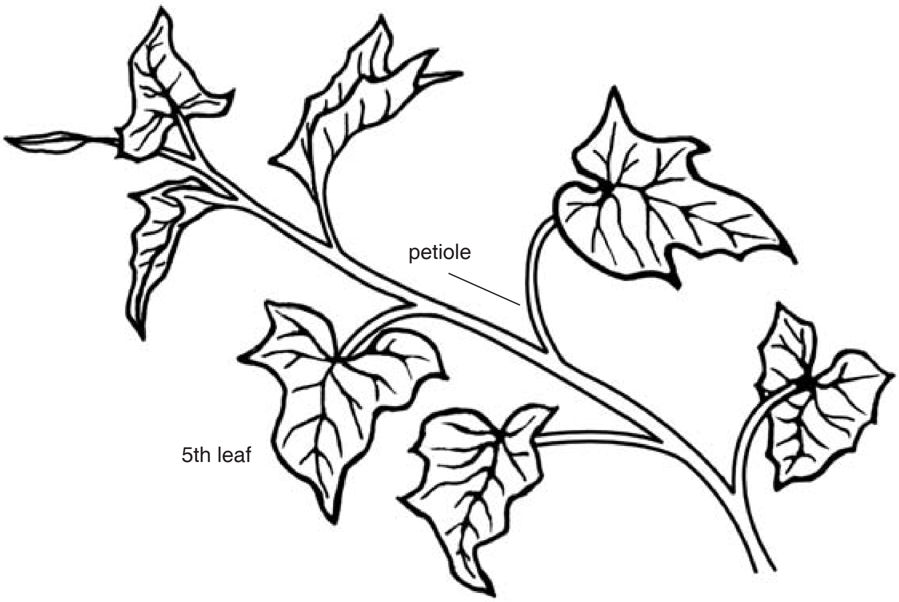


***Figure 9.** The youngest fully expanded leaf (5 th) from the growing point*

You can do the tests yourself, but we recommend you use a commercial sap testing service to perform the tests and advise on the results.

Nitrogen and potassium are the two most easily managed and influential nutrients in sweetpotatoes. Sap testing for nitrogen, phosphorus, potassium, calcium, magnesium and zinc should be done about monthly. Other nutrients should be tested at least twice during the season.

Apply supplementary fertiliser

Most Queensland coastal soils used for growing sweetpotatoes may require a supplementary dressing of nitrogen at the last cultivation (seven to eight weeks after planting). Leaf and sap tests are useful guides for deciding on supplementary dressings. These tests are usually available from the same laboratories as soil analyses.

a key issue
Nutrition
Section 4 page 47

This supplementary fertiliser may be drilled in beside the plant at the last working, spun on as broadcast dressings, applied with irrigation (fertigation) or applied as a combination of all these, starting at about six to eight weeks after planting. The total amount of fertiliser required can be applied in several split applications from this stage to bulking (when the storage roots are increasing in size). Table 14 gives some options for applying less soluble supplementary fertiliser.

Planting to storage root initiation

These fertilisers can be drilled in beside the plant at the last working or broadcast over the crop and irrigated in. Your choice of application method and rate of fertiliser to apply should be based on a plant nutrient test, previous applications, cropping history and crop removal. The rates shown in Table 14 are for irrigated areas with high plant populations.

Table 14. *Supplementary fertiliser rates and element supplied*

Fertiliser	Amount	Element applied (kg/ha)		
	kg /ha	N	P	K
Potassium nitrate OR	250	33	0	95
Urea plus	130	60	0	0
Sulfate of potash	100	0	0	41

Fertilising through irrigation water (fertigation)

Fertiliser can be applied through overhead sprinkler or trickle irrigation systems, but most growers use an overhead system. Fertigation has advantages over manual application of solid fertilisers because it uses less labour. With these systems fertilisers can be applied more regularly and closer to the roots.

HINT
Before fertigating get a water-testing laboratory to analyse your irrigation water

The fertiliser schedule used should be based on the results of soil, leaf and sap tests. If these tests are unavailable, Table 14 is a guide to fertigating sweetpotatoes. Higher rates may be required on poor soil, while lower rates could be used on fertile soil.

With fertigation, fertiliser is dissolved in water in a drum or tank and sucked or injected through the watering system. Fertilisers used must be highly soluble to avoid damaging the pump and blocking pipes. Suitable soluble fertilisers are listed in Table 15. There is also a range of soluble commercial fertiliser blends.

Table 15. *Fertilisers that can be dissolved in water for fertigation*

Fertiliser	Elements applied	% of elements
Urea	Nitrogen	46% N
Calcium nitrate	Calcium, nitrogen	18.8% Ca, 15.5% N
Ammonium nitrate	Nitrogen	34% N
Magnesium sulfate	Magnesium, sulfur	9.6% Mg, 12.4% S
Potassium nitrate	Potassium, nitrogen	38.3% K, 13 % N
Potassium chloride	Potassium, chlorine	50% K, 50% Cl
Potassium sulfate	Potassium, sulfur	41% K, 18% S
MAP (mono ammonium phosphate, technical grade)	Nitrogen, phosphorus	12% N, 26.6% P
MKP (mono potassium phosphate)	Potassium, phosphorus	28.6% K, 22.8% P

a key issue

Nutrition
Section 4 page 47

Note: Overuse of potassium (K) and calcium (Ca) can induce magnesium (Mg) deficiency in soils low in magnesium or with low cation exchange, that is less than 2 milli-equivalents per 100 g (meq per cent) of soil on your soil test. In this situation apply 250 kg/ha of magnesium sulfate ($MgSO_4$) through overhead solid set systems, or smaller more frequent applications through a trickle irrigation system.

Planting to storage root initiation

Trace elements

Apply trace elements if deficiencies have developed in previous crops or where soil analysis results suggest a possible deficiency. Do not exceed the rates suggested in Table 16. The addition of urea at 500 g/100 L of water will increase the leaf's absorption of trace elements. Only spray to wet the leaves, not to have runoff, otherwise leaves may burn. Apply foliar nutrients separately, not combined with pesticide sprays. Table 16 gives the application rates to control a range of trace element deficiencies.

Table 16. *Application rates for boron, copper, iron, manganese, molybdenum and zinc*

Element	Product	Rate	Comments
Boron	Solubor (20.5% B)	200 – 500 g/100 L	Foliar spray, 2 to 4 applications 1 to 2 weeks apart once cuttings start to grow. Do not exceed a total of 5 kg/ha. Solubor is not compatible with zinc sulfate heptahydrate.
Copper	copper sulfate	500 g/100 L + 500g/100 L hydrated lime	Apply one spray when vines start to run.
Iron	iron sulfate iron chelate	100 g/100 L	Apply once plants start to grow and repeat if necessary.
Manganese	manganese sulfate	100 g/100 L	Apply three foliar applications two weeks apart after plants are established.
Molybdenum	sodium molybdate	100 g/100 L	Foliar spray about two weeks after planting if indicated.
Zinc	zinc sulfate heptahydrate	500 g/100 L	Foliar spray, 2 to 3 applications 1 to 2 weeks apart once cuttings start to grow. Do not mix with boron.

Foliar fertilisers

Foliar fertilisers contain soluble nutrients that are sprayed onto the crop and absorbed through the leaves. These may be as simple as urea or potassium nitrate dissolved in water, or a 'shotgun' mixture of many major and trace elements. They can be useful when plants are under stress from waterlogging, disease or nematodes affecting the roots. Foliar fertilisers help the plants survive until new roots develop and can again support the plant.

Monitor soil moisture and irrigate

a key issue

Irrigation
Section 4 page 60

Consistent high yields of quality sweetpotatoes can only be achieved where there is adequate soil moisture at planting and through the growing and developing period of the plant and storage roots. Yields and quality are seriously affected if the crop is stressed when the storage roots begin to develop – normally five to eight weeks after planting.

The amount of water required will depend on the weather conditions, for example rainfall, temperature and wind. Crops grown without irrigation are generally poor and not economically viable.

Planting to storage root initiation

Irrigating from planting to establishment (up to two weeks)

Maintaining adequate soil moisture is critical until the cuttings have become established. Irrigate immediately after planting and apply small quantities frequently until plants are well established and have sufficient root volume for tensiometers to be effective. Do not over-water, as this will cause nutrient leaching and waterlogging around the young plants.

Sandy soils have a much lower water-holding capacity than clay-based soils and need smaller, more frequent applications of water.

Irrigating once plants are established

Do not overwater. If using an overhead system, irrigate in the morning, so that plant foliage is dry by evening. This will reduce the risk of spread of diseases. Once the plants have become established the soil can be allowed to dry out a little to encourage the development of a bigger, deeper root system. However, once storage root initiation has begun, ensure that plants are not stressed.

Irrigation timing

The critical times are while the cuttings are establishing and from storage root initiation through the bulking stage (when the storage roots are increasing in size). Uneven watering will result in growth cracks and too much water could cause enlarged lenticels and rotting of storage roots. Less frequent but increasing quantities of water are required as plants grow, particularly if temperatures are increasing, for example, a spring crop.

Irrigation scheduling

The decision on when to irrigate has often been made by feeling the soil, looking at the plants or watering at a pre-determined time interval. After the first two weeks when the plants are established, it is better to schedule irrigation with much greater precision by using instruments such as capacitance probes, for example Enviroscan, Gopher, or tensiometers.

Capacitance probes are expensive pieces of equipment that are generally used only by crop consultants and large growers. They use electrical induction to give a complete profile of moisture conditions throughout the root zone. By using this information, you can determine the daily water use and time to the next irrigation.

Tensiometers are comparatively cheap and effective instruments for irrigation scheduling. They show changes in soil moisture, indicating the actual needs of the crop. Select at least two sites per 5 ha, depending on soil variability, and install two tensiometers per site. Place the tip of the shallow tensiometer in the root zone about 20 cm deep and the other, the deep tensiometer, just below the main root one at about 60 cm deep. Place the tensiometers midway between plants

Planting to storage root initiation

in the row. Figure 10 shows the correct placement for tensiometers. The shallow tensiometer indicates when to irrigate, while the deep tensiometer indicates how much water to apply.

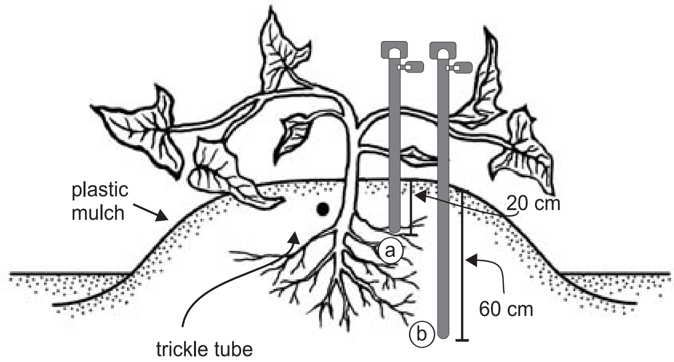


***Figure 10.** Tensiometers in place, (a) in root zone and (b) below main roots*

Once tensiometers are installed, read the gauge to determine when to water. Read tensiometers between sunrise and 8 a.m., because at that time there is little movement of water in the soil or plants and they are almost in equilibrium. Errors caused by heating of the gauge or water column are also avoided.

It is a good idea to plot the daily readings on a chart. The chart lines show what has happened in the past and, by extending them, you can anticipate what will happen over the next few days.

Apply irrigation at different readings, depending on soil type and stage of growth. Table 17 is a guide to the optimum range up to storage root initiation.

***Table 17.** Optimum range for tensiometers up to storage root initiation*

Soil type	Tensiometer reading
Sandy loams	10 – 25
Clay soils	15 – 30

Managing pests and diseases

a key issue: Pest and disease management (IPM) Section 4 page 72

Serious pests and diseases are likely at some stage in the crop and can cause major and even total crop losses. Good management of pests and diseases includes monitoring, timely spray applications and using an integrated pest management (IPM) approach.

Problem identification

more info: *Problem Solver* Section 5

Correct identification is the first step to control. Is the problem caused by an insect, mite, nematode, fungus, bacteria, or virus, or is it a nutritional or physiological problem? The treatment would be different in each case. To manage these problems, learn as much as possible about the pests and diseases and their recommended management.

Planting to storage root initiation

Understanding pest and disease management

The saleable product, the storage roots, develop underground, so moderate levels of leaf damage can be tolerated, as they won't affect the marketable yield of storage roots. These roots grow rapidly in warm weather and can tolerate more damage than slow-growing crops.

Some diseases may require regular spraying, up to every 10 days for the life of the crop, depending on disease incidence and weather conditions.

Insect pests, on the other hand, may not require regular spraying. Plants can tolerate small numbers of these pests without significantly affecting yield or quality. In these cases, the cost of spraying is much greater than the benefit gained by controlling the insects. Make sure that insect levels are high enough to warrant spraying, as this will save money and reduce the risk of spray burn and chemical residues in the environment.

Recording pest numbers (insect, mites and disease) is called pest monitoring. This involves inspecting the crop at least once every week and recording pest numbers fortnightly. When these numbers reach levels that cause economic damage, the use of a pesticide is recommended.

PESTS
Refer to Sections 4 and 5 for more details and management of pests and diseases.

Insect and mite pests

Check your crop regularly during the first few weeks for cutworm and wireworm damage. These insects feed on the storage roots, reducing crop value and assisting entry of soil rot organisms into the storage roots. Sweetpotatoes have a very low tolerance to soil insects because they damage the saleable product, the storage roots.

Cutworms can chew off vine cuttings soon after planting. They curl up in the soil at the base of the plant during the day, and can be found by scratching around the base of plants. False wireworms will also chew the plant stem below ground level. If cutworms are known to cause problems, spray to control them before nightfall on the day you plant.

The major insect pests of sweetpotatoes are sweetpotato weevil, sweetpotato leafminer, mites and mole and field crickets.

Minor pests at this stage include flea beetles, jassids, hawk moth larvae, aphids and grasshoppers. If you need to control these pests choose an insecticide that controls the range of insects you have found in the crop. If you use overhead watering, spray late in the afternoon when the plants are dry.

more info
Chemicals to use
Problem Solver Handy Guide

Diseases

The main diseases of sweetpotatoes are scab, scurf, soil rots, sweet-potato feathery mottle virus and little leaf. Check your crop regularly for these diseases. Choose a chemical that will control the range of diseases you found in your crop.

Planting to storage root initiation

WARNING
Only chemicals registered for control of the particular pest or disease on your crop can be used legally. Aways read the label.

Selecting chemicals

Use the most effective chemical for the particular problem. Chemicals are either protectant or curative, and systemic or non-systemic. Protectant chemicals are usually not systemic in the plant and will not eradicate a pest. They provide a protective cover that prevents the pest from getting established, so good coverage is essential. Eradicant chemicals will control a pest that is already established.

Systemic chemicals penetrate the leaf or roots into the sap stream and are transported through the plant with the sap stream. They will control a pest that is already established. Although coverage is not as important with systemic chemicals, good coverage will give best results.

Application of chemicals

Most chemicals are applied as sprays. The results you get from spraying will only be as good as the coverage you achieve with your equipment. An engine-powered sprayer is recommended. These include hydraulic sprayers (hand-held or tractor-mounted boom), air blast machines and controlled droplet applicators. Hand-operated knapsack sprayers do not give sufficient coverage.

a key issue
Calibrating a boom spray
Section 4 page 100

Hydraulic sprayers are the most common and it is important that they are set up to provide maximum coverage of the crop. Some chemicals can be applied as dusts or injections through trickle irrigation systems.

Good pest and disease control is only achieved through good coverage of the plant, particularly for protectant chemicals. The ideal droplet size for insecticides and fungicides ranges from 40 to 100 microns. Spray equipment must be calibrated regularly to achieve this and nozzles changed when they start to wear which may be every 10 hours when wettable powders like copper, are used through brass jets.

Do not apply herbicides with your pest and disease sprayer. This avoids the risk of herbicide residues in the sprayer damaging the crop.

For more detail on safe and efficient spray application refer to the DPI publication *Pesticide Application Manual (3rd edition)*.

HINT
Where to get the DPI book Pesticide Application Manual. See Section 6, page 24

Care with chemicals

Agricultural chemicals should always be handled responsibly and with care. They are most dangerous when undiluted. Protective clothing, including boots, overalls, gloves and a mask, should be worn at all times. Avoid spraying if spray is likely to drift off the crop. Dispose of waste chemicals and containers thoughtfully to protect the environment.

Bird and animal pests

Plants may be chewed off by ducks, hares, rabbits, wallabies or kangaroos. If hares, rabbits, wallabies and kangaroos are a problem, build a netting or electric fence around the perimeter of the block.

Planting to storage root initiation

A trail of dried blood around the block may work for a few days.

Wallabies, kangaroos and native birds are protected and cannot be trapped or destroyed without a permit. Problems with these animals should be referred to your nearest Environmental Protection Agency (EPA) or the Queensland Parks and Wildlife Service (QPWS) office.

Not all birds in the crop will cause damage. Most will be eating insects, so are beneficial. A permit will only be issued after an inspection by a QPWS officer. You must be able to show evidence of significant damage and hat you have tried other deterrent methods. Scare guns and suspended hawk kites are used but are not very effective.

Hares and rabbits are not protected. Mice and rats are best controlled by baiting. Figure 11 is a diagram of an electric fence designed to keep hares and rabbits out of crops.

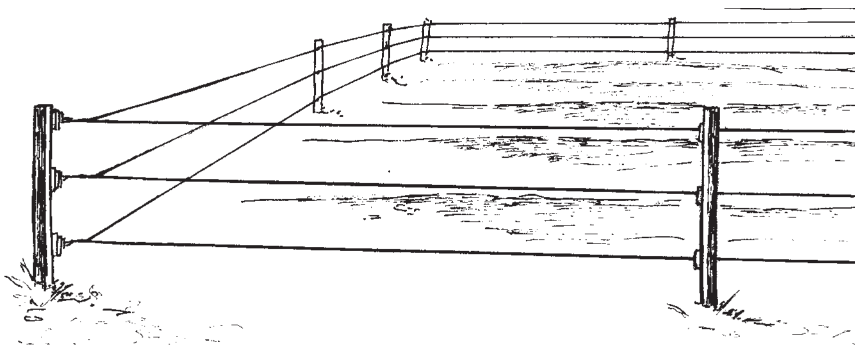


Figure 11. *A diagram of an electric fence to exclude hares and rabbits from crops*

Control frost

Sweetpotato plants are very sensitive to frosts and should not be planted in frosty locations. Lower parts of the block are more susceptible to frost damage. Temperatures below freezing point (0°C) damage plants. Provided the plants are kept covered by a thin film of water they will not be damaged, even if the air temperature falls below 0°C. This procedure is only possible if you have overhead irrigation equipment.

Protect the plants by continual overhead watering while temperatures stay below 0°C. Your overhead watering system should put out about 2 mm of water per hour, with sprinklers rotating at least once every minute. If you have an electric pump, connect it via a thermostat to a temperature sensor in the crop. Set the thermostat to start the pump when the air temperature falls to 1°C. Alternatively, you can have the temperature sensor connected to an alarm that alerts you to start the pump. Continue the overhead watering until the air temperature rises above 0°C and all the ice formed on the plants has melted.

Seek professional advice from your local electricity authority on designing and operating this equipment.

Storage root initiation to harvest

Storage root initiation is the stage when roots arising at the nodes begin to swell (Figure 12). This stage takes about 12 weeks and may be referred to as the bulking stage (when the storage roots are increasing in size). There are five important things to manage during this stage.

Monitor soil moisture and irrigate....................................32
Monitor plant nutrients and fertilise 33
Control weeds 33
Manage pests and diseases 34
Prepare the crop for harvest 35

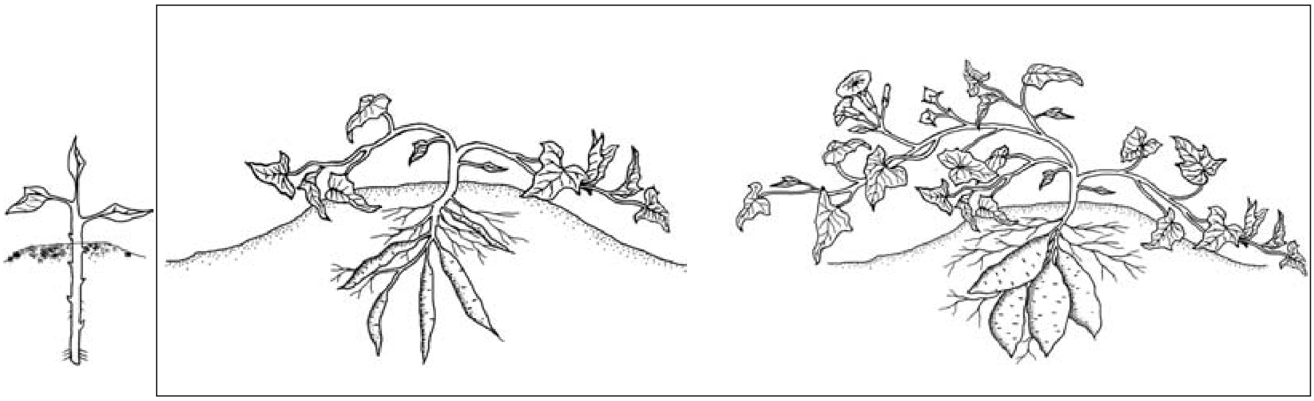


Figure 12. *Storage root initiation stage to harvest*

An understanding of the plant's growth cycle will help with crop management. Refer to the *Crop Production Handy Guide.*

Monitor soil moisture and irrigate

During this stage plants should not be stressed for water. Fluctuating moisture levels will cause storage roots to split, resulting in growth cracks. Excess water may result in enlarged lenticels.

Table 18 is a guide to water requirements from storage root initiation to first harvest.

Storage root initiation to harvest

Table 18. *Water requirements from storage root initiation to harvest*

Soil type	Tensiometer reading
Sandy loams	10 – 30
Clay soils	10 – 40

Monitor plant nutrients and fertilise

Continue to monitor plant nutrient levels with sap tests, take a leaf analysis, or refer to your soil test and apply fertiliser as required.

Leaf testing is a benchmarking tool that has little direct relevance to the current crop. Its value is in judging the fertilising schedule used in this crop and how it may be improved for the next crop. Use the results of soil and leaf testing to refine the fertiliser schedule for the next crop.

Do a leaf analysis when the plants are eight weeks old; take the eighth leaf, including folded young leaf, back from the vinetip (Figure 13). Buy a tissue sampling kit from your farm supply outlet and follow its instructions. The laboratory analysing your sample will interpret your results. The optimum levels for the most recently matured leaf at this stage are shown as a percentage or in mg/kg (ppm) in Table 12 of Section 4.

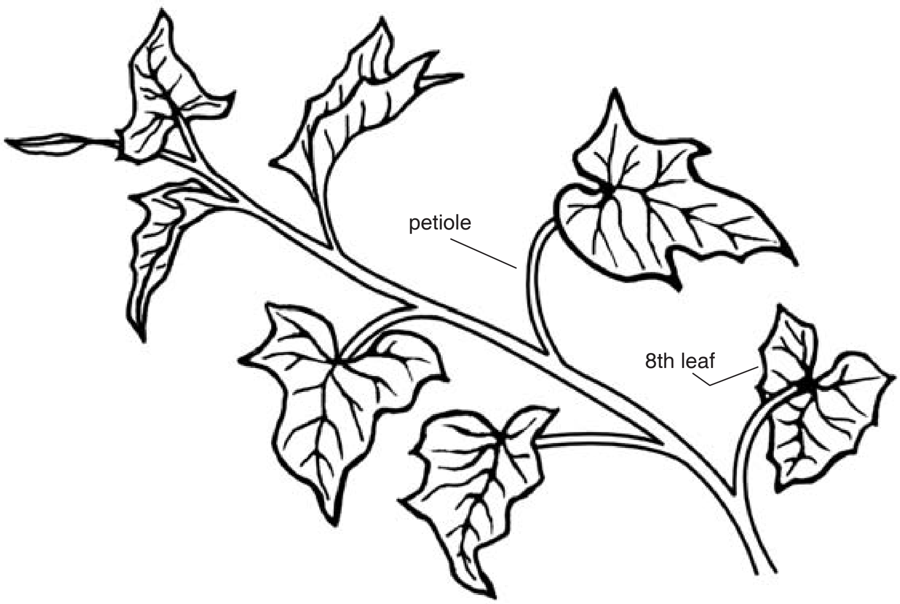


Figure 13. *The eighth leaf from the growing point*

more info
Fertilising
This section page 24

Apply supplementary fertiliser

Apply the rest of the supplementary fertiliser not applied previously.

Storage root initiation to harvest

more info
Pests and diseases
Section 5

Control weeds

Once the crop has covered the interrow space, weeds are not a problem. Remove large weeds to prevent them setting seed.

Manage pests and diseases

Insect and mite pests

Monitor regularly for sweetpotato weevil, sweetpotato leafminer, aphids, leafeating insects and mites. Spray if necessary with an appropriate chemical from the *Problem Solver Handy Guide*. Be aware of the withholding period (WHP) of the products you use.

Diseases

more info
Pictures of sweetpotato disorders
Section 5

Monitor for the following diseases during this stage of the sweetpotato crop cycle: scab, scurf, Fusarium and Pythium rots, soil rots, sweetpotato feathery mottle virus, little leaf and leaf spots. Spray if necessary with an appropriate chemical from the *Problem Solver Handy Guide*. Be aware of the withholding period (WHP) of the products you use.

Disorders

There are several disorders that become obvious in sweetpotatoes at harvest.

Alligator-like skin. Some varieties are more prone to this than others.

Anthocyanin. A pink discolouration on the skin of white varieties.

Chilling injury. Caused by exposure to excessively cold conditions, for example 10° to 12°C.

Cracking. This is caused by uneven growth. Cracking may occur if plants have become dry and then received a heavy application of water. Cracking can also appear if growth has been slowed by cold weather and then speeds up in warm weather. Early nematode infestation may also cause cracking. These cracks have often healed by the time storage roots are harvested.

Fresh cracks may develop if storage roots are dug from cold soil and exposed to warm air.

Enlarged lenticels. In excessively wet conditions the pores in the skin of storage roots can enlarge to form rough, corky areas. Some varieties, for example Hernandez, are more susceptible.

Nutritional disorders. Deficiencies of some nutrients, for example copper and boron, can have detrimental effects on storage roots.

Ribs on storage roots. If soil temperatures are cool at the early storage root development stage, storage roots are likely to have a ribbed appearance. Some varieties, for example Beerwah Gold, are more susceptible than others.

Storage root initiation to harvest

Veins on storage roots. These are caused by the development of secondary roots under the skin of the storage root. It occurs more in older crops and some varieties are more susceptible.

Bird and animal pests

Storage roots can be damaged by birds and animals including crows, ducks, geese, rats or mice, kangaroos and wild pigs.

Prepare the crop for harvest

Reduce irrigation about one to two weeks before top removal. Remove the tops from the crop five to ten days before digging to firm the skin and reduce harvest damage. Apply a light irrigation just before you dig to soften the soil surface and any clods that may be present.

Top removal

When ready for harvest, the sweetpotato plants cover the entire ground area in a mat of interlacing vines, which may also be attached to the ground by roots from the nodes. Cut or detach the vines (de-vining) before harvest. Flail-type forage harvesters or slashers are adapted to remove the bulk of the vines.

Harvesting and marketing

As the price you receive for your crop depends largely on appearance and quality, sweetpotatoes must be harvested, handled and marketed with great care. There are 11 important steps in this process.

Manage irrigation....36
Harvesting....37
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Storage....38
Preparing storage roots for market....39
Grading and packing....40
Packaging....41
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Manage irrigation

The following suggestions are a guide to water requirements once harvesting in a planting has started.

Allow plants to dry out a little during harvesting to improve root quality. Maintain higher soil moisture tensions during the harvest period. Table 19 suggests a guide to water requirements during harvest.

Table 19. *A guide to water requirements during harvest*

Soil type	Tensiometer reading
Sandy loams	20 – 30
Clay soils	20 – 40

Harvesting

Yield

An average yield range of 20 to 30 tonnes per hectare could be expected with a plant population of 25 to 30 000 plants per hectare.

Determining when to dig

Unlike most other crops the sweetpotato does not mature and will continue to grow as long as the plant has green leaves. The best time to harvest can be determined only by close inspection and digging a few plants at random across the block.

The time of planting and subsequent growing conditions determine the length of time taken to develop market-sized storage roots. Usually 16 to 25 weeks' growth is required before harvesting. Roots will not all be the same size. Growers should inspect their plantings frequently so they can harvest a high proportion of the crop when it is the preferred market size. Planting at different times or planting varieties with different maturing times will help spread the harvest period.

Sweetpotato storage roots are extremely sensitive to abrasion, especially at harvest time. Younger crops have softer skins and are more susceptible to damage at harvest.

Timing of harvest can also be influenced by:

- pest infestation, for example sweetpotato weevil;
- animal pests, for example pigs, rats;
- root rots;
- weather conditions, that is threat of unfavourable conditions, for example wet or cold;
- price.

To reduce losses it may be necessary to harvest earlier than planned.

How to pick and handle storage roots

Carefully lift the storage roots from the soil with the minimum of mechanical handling to maintain high market quality.

After top removal, two coulters cut the remaining vines on either side of the row. Growers use adapted English potato diggers with shortened chains moving slightly faster than ground speed to lift the roots. The roots are removed from the soil by hand, cut or snapped from the vine and placed into a container for transport to the packing shed.

Machine harvesting

Manufacturers have found it difficult to produce a mechanical harvester that will harvest sweetpotatoes for the table market trade with acceptable levels of damage to the storage roots.

In the USA, large-scale operators use tractor-operated rotary mowers and vine snappers to remove the vines in a separate operation before digging with a harvester, on which the storage roots are hand-graded and placed directly into bulk bins.

Much hand labour is required in harvesting sweetpotatoes and reducing this labour demand is a continuing incentive to improve harvesting equipment.

Transport to the shed

Collect storage roots in the field into strong plastic field containers (Figure 14) or 500 kg bulk crates. Do not throwroots into heaps then load them loose into trucks or trailers because this results in unnecessary bruising, skin damage and poor appearance, and encourages root rots. Exposure to the sun will cause sunburn damage to root surfaces, making them unmarketable. If storage roots are left to stand long before washing and packing, hose roots to keep them wet.

***Figure 14.** A farm trailer of sweetpotatoes in the shade, ready for washing, grading and packing*

Dispose of reject storage roots

All storage roots rejected in the shed during sorting should be removed as soon as possible to reduce the risk of infection of marketable roots. These reject roots should be disposed of quickly, preferably by crushing and burying, or feeding to stock.

Curing

In Australia, sweetpotatoes are marketed as a fresh vegetable. In the USA, curing is a standard practice and is done immediately after harvest. Cured and stored sweetpotatoes attract a premium price in the USA. These sweetpotatoes have a deeper flesh colour and are sweeter when cooked than freshly harvested ones. Curing and storing sweetpotatoes can expand marketing opportunities, for example use as a dessert, the main usage in the USA, and can help even out supply.

The primary purpose of curing is to allow damaged skin to heal rapidly, thereby preventing infection and fungal decay. Curing reduces shrinkage and weight loss, and improves the cooking quality by converting starch to sugars.

a key issue
Curing
Section 4 page 97

Rapid healing of wounds depends on maintaining the correct temperature, high relative humidity, and an adequate supply of oxygen (aeration). A temperature of 30°C and a relative humidity of 90 to 95% is optimum.

Storage

After the sweetpotatoes have been cured, store them at 13° to 16°C and 85 to 90% relative humidity. Storing sweetpotatoes at lower temperatures results in chilling injury, increased shrinkage and decay, and poorer cooking quality. Sprout production of seed stock will also be adversely affected by low temperature storage.

Storage temperatures above 16°C greatly increase the development of internal cork in susceptible varieties such as NC-3, Porto Rico 198 and to a lesser degree in moderately susceptible varieties such as Centennial. Weight loss, sprouting and pithiness also increase at higher temperatures while storage life decreases.

Sweetpotatoes handled in bulk bins or boxes on pallets may be moved by forklift from curing to storage facilities, or from place to place in storage, without increasing shrinkage if they are handled carefully to prevent skinning. Table 20 shows the suitable conditions for sweetpotato storage and their maximum storage life.

Table 20. *Conditions and maximum storage life for sweetpotatoes*

	Temperature	Relative humidity	Maximum storage life
Cured roots (dirty)	13 – 16°C	85 – 90%	52 weeks
Fresh roots (washed)	16 – 18°C	85 – 90%	4 weeks

Preparing storage roots for market

Washing

Wash and grade storage roots before packing. Roots are easiest to clean when dug from sandy soil and kept moist before washing. Water pressure alone is normally sufficient to remove dirt without damaging the skin. The most effective method of washing is through specially built washing machines with rubber-covered, roller conveyors and multiple, high-pressure, fine-nozzle water jets. The roots should be wet before entering the spray chamber for effective cleaning. To achieve a bright appearance, brushes are used in the washing line for crops grown on clay soils.

Treating storage roots

If breakdown losses are occurring in a maturing crop, apply a postharvest treatment immediately after harvest to save unaffected storage roots.

more info
Postharvest rots
Section 4 page 97
and Section 5 page 22

The most common postharvest rots are a bacterial soft rot caused by bacteria of the *Erwinia* spp. and a soft watery rot covered with a mass of grey white growth caused by the fungus *Rhizopus stolonifer*. Entry is normally through wounds and will spread from root to root by contact.

To control postharvest rots avoid skin damage to storage roots during harvest, washing and packing to prevent infection. Do not pack any damaged roots and ensure all soil is removed. A spray or dip with a registered chemical from the *Problem Solver Handy Guide* is recommended to control storage rot.

Grading and packing

Size grading

Size grades no longer legally apply to sweetpotatoes on the Australian market. The following is a guide to what the market has come to expect.

Machines for sizing by diameter can be used for preliminary grading. Trim fine surface roots from the storage root at this stage.

Size grading is based on storage root diameter shown in Table 21 and applies to orange-fleshed dessert varieties. The most desirable sizes of storage roots for market range from 45 to 90 mm in diameter and 150 to 250 mm long.

Table 21. *Orange-fleshed sweetpotato grade sizes*

Grade size	Diameter
Small	40 – 60 mm
Medium	60 – 100 mm
Large	more than 100 mm

White-fleshed varieties currently grown vary greatly in length and therefore length as well as diameter must be considered in grading these types. Do not mix extremes of length in one grade. Medium grade attracts the best prices.

HINT
A sample product description for sweetpotatoes is shown in Section 4 page 23.

Grade standards

To meet both the agents' and consumers' expectations, sweetpotatoes should be prepared so they will arrive at the final destination in a satisfactory condition.

Sweetpotatoes should be sound, free of insect damage and disease symptoms. Storage roots should be fairly smooth-skinned, well-shaped, free of soil, firm, not cracked and of one variety in the same carton.

Discard deformed, diseased and damaged storage roots.

Packing

Storage roots should preferably be dry before packing. Most roots are packed into wilm-lined cartons. These cartons have a wax sprayed onto the inside liner and fluting during manufacture. The wilm lining does not increase carton strength, but gives some water resistance. Waxed cartons cost more, but because they are stronger they do perform better, especially when roots are packed wet.

Pack the top layer in an orderly manner to present an attractive pack. The storage roots should not be above the top of the carton, so the weight of the stacked cartons is supported by the carton, not the produce in it. There is usually an outlet for smaller storage roots at fruit and vegetable prepack warehouses. Figure 15 shows well-packed and badly packed cartons of sweetpotatoes.

Figure 15. *A well-packed and presented carton (left) and badly packed carton (right)*

Quality assurance

Marketing and quality management is a vital step in sweetpotato production. How well you manage this, and the quality of your product, will determine whether you make a profit or loss from your sweetpotato production.

The retail market is now dominated by three major players and the diverse market once enjoyed by sweetpotato growers, where they could sell to a large number of agents and merchants, is slowly shrinking. This concentration of the market to fewer, larger buyers means that, more than ever, sweetpotato growers must make sure they have a customer organised before they plant or they could face an already fully supplied marketplace.

Lack of quality assurance (QA) can restrict your access to markets. It is essential you know to whom you are going to sell your sweetpotatoes before planting. Different customers may have different requirements for third party QA registration and you will not be able to supply these customers unless you satisfy their requirements.

Packaging

Packaging should also reflect the individual customer requirements. Previously a 20 kg pack was common in the industry, but the most common form of packaging now is an 18 kg carton. However, several major retail customers have been using both 15 kg and 10 kg cartons. The 15 kg format is likely to be the most common form of packaging soon, as the major retailers move to reduce the weights that staff in stores and distribution centres have to lift.

A small number of customers are trying a 10 kg carton. The roots remain fresher because large amounts placed on display may not be sold quickly and therefore deteriorate. Some retailers are using a 5 kg plastic bag that is delivered in half-tonne cardboard bins.

Whatever quantity is stamped on the carton must be supplied. There are numerous instances of sweetpotato growers being fined for underweight packaging. They may have marked their carton a certain weight before checking the weight, or not allowed for weight loss as the roots dehydrate.

Correct carton weight at packing is extremely important because storage roots vary in size and shape, from season to season and from variety to variety. Growers could face substantial fines if they market underweight cartons. Most growers pack extra roots into each carton to allow for shrinkage.

Packages printed with your own brand and colour scheme make it easier for buyers to identify your fruit in the wholesale markets. Specially stamped sweetpotato cartons promote sales on the market floor.

Palletising

Palletising reduces handling of individual cartons of produce. The 18 kg carton is packed eight cartons to a layer and usually six or seven layers high. The way the product is palletised will depend on the strength of the carton and the shape of the carton your customer has requested, and is best worked out with your packaging supplier. Some customers may also have height restrictions on palletised loads in relation to occupational health and safety requirement for maximum lifting heights.

When putting cartons on pallets it is best to stack similar size storage roots on individual pllets to make handling in the market chain easier. This is referred to as unitising. Overfull cartons with incorrectly fitted lids put a lot of pressure on individual storage roots, especially on the bottom of the pallet (Figure 16). This needs to be considered when choosing or designing a sweetpotato carton, as the carton, not the product, should be supporting the weight on the pallet.

Figure 16. *Unevenly stacked pallet and close-up (inset). Note the box tops are not fully closed resulting in poor support for the produce*

When loading a pallet it is most important that all cartons are fitted squarely on it and that the air vents of each layer of cartons face the same direction to allow the maximum air flow through the stack. Pallet stacking aids assist with this operation. The stack is held together by corner stays and strapped, taped or wrapped with stretch nylon netting. The pallet can be shifted with fork lifts or pallet jacks. A pallet hire pool operates in most districts.

Mark packages

more info
Marking cartons and correct weight
Section 6 page 19

Every package of sweetpotatoes must be marked with the following legible information durably stamped, stencilled or printed on at least one end of the carton. Failure to do so may result in prosecution.

- The name and full address, including the state, of the packer or the person on whose behalf it was packed. The address must give enough detail for the person to be identified and located. A post office box number or mail service is not acceptable, but can be included with the other information.
- The word sweetpotatoes or an abbreviation of it, such as 'swt-pot'.
- The net weight or count of storage roots in the package. The roots must be weighed using approved and certified scales. There is no minimum weight that must be in the package provided that, at the time of final sale, it is not less than the net weight marked on the package. The word 'net' may be included but is not compulsory.

a key issue
Quality management
Section 4 page 21

Printing on packages should have a minimum letter height of 5 mm. Failure to correctly mark the package may result in produce being withheld from sale until correctly marked.

Unless pre-printed, sweetpotato packages have a panel with space for you to stamp your name and address, and details of your wholesale agent. Space for the size, colour, net weight of the roots and a traceability code is usually included for you to tick or circle the appropriate box. Most buyers require a traceability code as part of quality assurance, however, you should talk to your buyers about the form of traceability code that they require.

Sweetpotatoes vary greatly in skin and flesh colour, and in preferred use. The current market description of red, white, or gold (skin colour) does not adequately describe the product. e recommend that growers identify their product with the variety name, as is done for other crops, so that buyers can identify their preferred variety and have greater confidence in the product they buy. This will also help growers decide what varieties to grow, as they will be able to identify the variety preferred by the market. An example of a package end panel is shown in Figure 17.

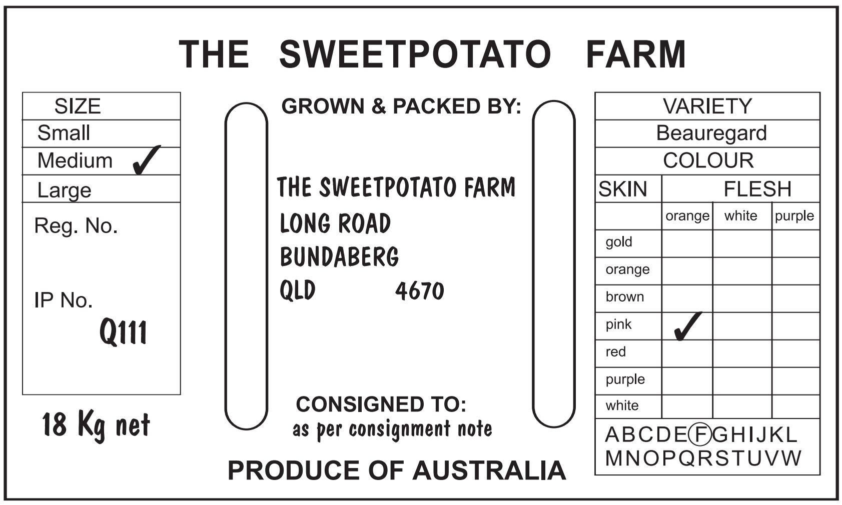

Figure 17. *Suggested end panel labelling for a sweetpotato carton*

Cooling

Consult a refrigeration engineer when designing a cold room. The engineer will need details of:

- maximum volume and weight of product;
- the time required to cool the product;
- the type of container the product will be packed in;
- the maximum temperature of the product at the time of placing in the cold room;
- the minimum temperature to which product will be cooled.

Cooling for transport

After packing, cool storage roots to 16° for transport to market. The forced-air cooling system is the fastest and most efficient system. It ensures uniform cooling throughout the carton as air is passed through the carton, giving rapid and equal cooling. The time taken to cool depends on the capacity of the equipment installed and the ventilation provided in each carton. Figure 18 shows pallets of cartons ready for cooling.

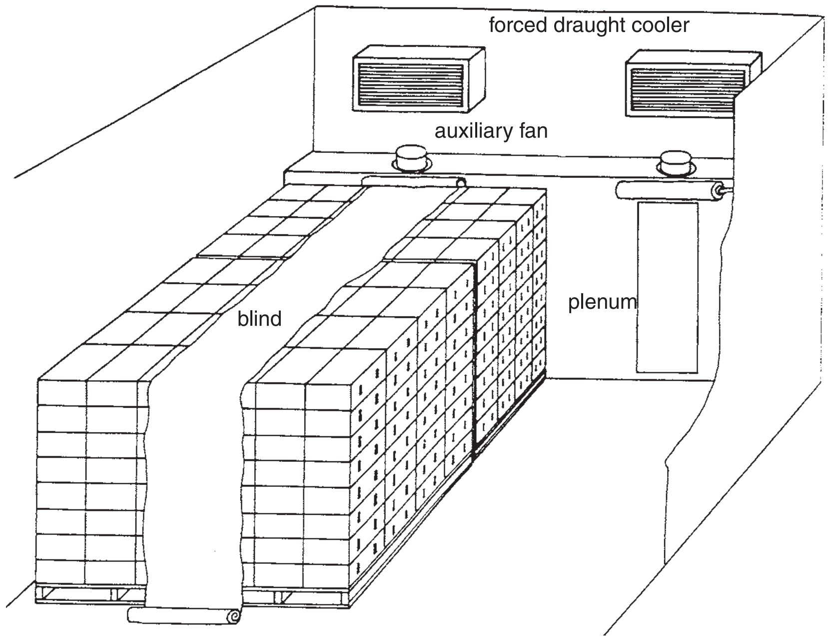

Figure 18. *Cartons ready for cooling (drawing is from the book* Forced-air Cooling *by J.B. Watkins, DPI, Queensland)*

Transport

Palletisation has speeded up turn-around time and resulted in much less transport damage to sweetpotatoes. Cartons are normally stacked 48 or 56 per pallet.

One-tonne pallets of north Queensland sweetpotatoes are precooled to 16°C and loaded onto refrigerated (18°C) road transport destined for southern wholesale markets, primarily in Brisbane, Sydney and Melbourne. Refrigerated containers should contain the following equipment, which should be maintained in good working condition:

- fluming; (This directs cool delivery air evenly over the top of the load.)
- floor channels running the length of the container; (Floor channels allow return air to move back to the refrigeration unit.)
- a bulkhead around the evaporator. (This improves the movement of return air to the refrigeration unit and reduces the risk of freezing.)

HINT
Where to buy Code of Practice for the Road Transportation of Fresh Produce 1996, see Section 6 page 27.

Avoid stabilising sheets placed through the load. These sheets prevent air movement through the load, particularly if the cartons are not palletised.

Produce from southern Queensland is not normally refrigerated.

Both rail and road transport are available to most centres. Road transport is more expensive, but is quicker to its destination. Trucks can be loaded on the farm and unloaded at the market.

Refrigeration systems in rail wagons and road transports are designed to maintain temperature, not to cool produce. If warm produce is loaded into a refrigerated container there is a risk that produce near the refrigeration unit will be chilled, because the refrigeration unit stays on longer to bring the temperature down. Print-out temperature recorders should be fitted to all refrigeration containers.

The *Code of Practice for the Road Transportation of Fresh Produce 1996* is a guide to road transport.

Marketing

There are many options for marketing sweetpotatoes. These include selling:

- to a local merchant;
- to an agent or merchant at the major markets;
- direct to a retailer, for example the major supermarkets or smaller retailers;
- overseas, either direct to buyers or through an exporter.

Note: Agents sell your produce on your behalf, then receive a commission, usually about 12.5%. **Merchants** buy the produce from you at an agreed price, then sell it for whatever price they can get.

Know your market

more info
Market information
Section 6 page 11

To know your market talk to people who are in constant contact with it, that is your agent or wholesaler and your retailer. Maintain a good relationship with your wholesalers and keep them informed of the quantities of produce you are consigning and the standard (quality) of the produce. Ask for feedback on the quality of your sweetpotatoes in the marketplace.

To provide what they want you will need to have a quality management program.

Domestic markets

Most sweetpotatoes are sold in the Brisbane, Sydney or Melbourne wholesale markets through an agent or merchant. Smaller markets are Adelaide, Newcastle, Perth, Townsville and direct selling to retail outlets.

It is best to deal only with a specialist sweetpotato wholesaler. Seek advice on selecting a wholesaler from your local growers' association or the market authority where you sell your product.

Major retailing chains are important outlets for sweetpotatoes. Although some of their requirements are met from market supplies, they commonly also buy direct from growers. This is direct selling and is usually on the basis of an agreed pricing system and some form of quality assurance system. If possible, visit the major market in which your product is sold at least once a season.

Processing

A small quantity of sweetpotato is processed into baby food. Other potential uses are for canning, starch production, ethanol, confectionary and fast food.

Prices

Prices are closely tied to supply, with higher prices paid during periods of lower production, especially if it coincides with a period of high demand.

Levies

All sweetpotatoes marketed by Queensland growers in Queensland through agents, merchants or direct sales are subject to a levy of 1.5 cents per dollar of gross sale price, under the *Fruit Marketing Organisation Act 1923*. The levy, collected by the Queensland Fruit and Vegetable Growers (QFVG), is in three parts: a general levy, a promotion levy and a research levy. The levy is collected from the first point of sale. QFVG also collects a 1% levy on exports and product for processing. The levy on product sold interstate is 4 cents per 20 kg package or less, or $4.50 per tonne.

There is also a national levy for research and development of 0.5% of the value of domestic, export and processing product.

Marketing overseas

The Commonwealth of Australia prints *Export Control (Fresh Fruits and Vegetables) Orders,* which show the requirements for exporting fresh produce. As there is no specific schedule for sweetpotatoes, Schedule 1 of these orders should be used as a guide for exporting sweetpotatoes to other countries. The cartons must be marked with the grower or packer's name and address, export number and the words 'Produce of Australia'. The product must meet any description marked on the package.

Produce for export to countries that require a phytosanitary certificate may be grown and packed in an on-farm Registered Export Establishment (REE) or prepared for export in a premises that has current REE status for the commodity being exported, for example fresh fruit and vegetables.

more info
AQIS offices in Queensland
Section 6 page 16

more info
Interstate movement provisions
Section 6 page 17

Protocols have been established with certain countries (New Zealand and Japan) to access those markets. These guidelines are commodity specific and have been established for the product, within the protocols, from growing through to export. Produce exported to non-phytosanitary certificate countries must, at some stage within the export process, travel through a REE. This may be a packing shed, exporters' premises or a freight forwarder.

Some countries require exporters to obtain an import permit before export. This permit specifies the latest requirements for that country.

The Australian Quarantine and Inspection Service (AQIS) supervises registration of establishments. Quarantine requirements vary between countries and intending exporters should keep informed through local AQIS offices.

Interstate quarantine requirements

Interstate requirements are subject to change so contact your local DPI plant health inspector. Plant health coordinators in major DPI centres can assist businesses with inspection services. Growers are advised to confirm the details of requirements and fulfil these in advance, before sending sweetpotatoes interstate.

There are no restrictions on the movement of sweetpotatoes within Queensland.