Potato information kit

Reprint – information current in 1997

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 1997. We advise readers to take particular note of the areas most likely to be out-of-date and so requiring further research: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- Financial information—costs and returns listed in this publication are out of date.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 1997. 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 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

Key ISSUES

This section contains more detailed information on some of the important decision making areas and information needs for potatoes. The information supplements our growing and marketing recipe in Section 3 and should be used in conjunction with it. The information provided on each issue is not designed to be a complete coverage of the issue but instead the key points that need to be known and understood. Where additional information may be useful, reference is made to other parts of the kit. Symbols on the left of the page will help you make these links.

Understanding the potato plant

The normal growth of a potato plant can be divided into four distinct stages:

- *vegetative growth*
- *tuber initiation*
- *tuber growth*
- *maturation.*

As each stage requires different management practices, it is important to understand what happens to the plant during each stage.

Stage 1: Vegetative growth

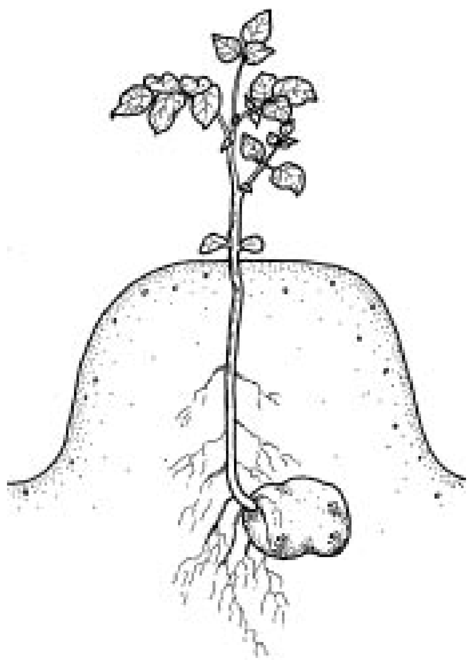


Figure 1. *Stage 1: vegetative growth*

Here are the important things that happen during Stage 1.

- Dormancy has to be broken before planting. This is indicated by the appearance of sprouts from the eyes.
- The emergence of sprouts is favoured by dark, warm, moist conditions.
- Leaves and branch stems develop from above ground nodes. Roots and underground stems, called stolons, develop from underground nodes.
- Developing stems are susceptible to diseases such as Rhizoctonia black scurf and blackleg. Vigorous sprout growth is more resistant to infection from diseases. Generally, the more rapidly sprouts emerge, the less susceptible they are to damage.
- The rate of sprout growth and emergence is reduced by low temperatures.
- Starch in the seedpiece supplies energy for sprout growth and development.
- There is usually enough starch in a sound potato seedpiece to support plant growth for 30 days. About half of it is used by the time the plant starts to produce its own energy to support further growth and development and accumulate reserves for tuber production.
- Additional nutrients are necessary for active early growth. This is supplied from soil reserves and added fertilisers.

Stage 2: Tuber initiation (tuberisation)

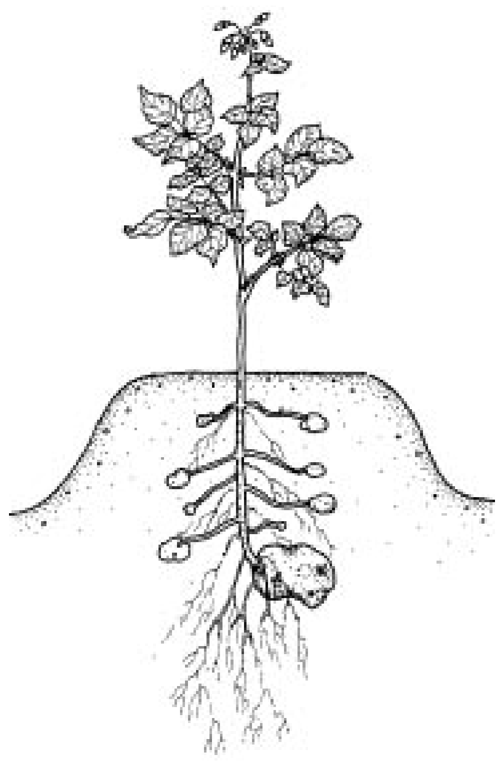


Figure 2. *Stage 2: tuber initiation (tuberisation)*

Here are the important things that happen during Stage 2.

- This stage of potato growth is controlled by growth regulating hormones produced in the plant.
- Before tuber initiation can start, carbohydrate must be produced by photosynthesis at a rate greater than that needed to support the growth of leaves, stems and roots.
- The excess carbohydrate, in the form of sucrose, is moved from the leaves to the tips of the stolons, where tuber initiation begins.
- Tuber initiation usually begins when the leaf area index is 1.5 to 2.0. (The leaf area index is the ratio of total plant leaf area to the area of soil surface covered by the plant).
- Tuber initiation is affected by soil moisture, soil temperature, and soil nitrogen.
- Tubers usually first appear on the lower, older stolons when high amounts of sucrose begin to build up in the stolon tips.
- Tuber initiation is usually spread over two to three weeks.

Stage 3: Tuber growth (bulking)

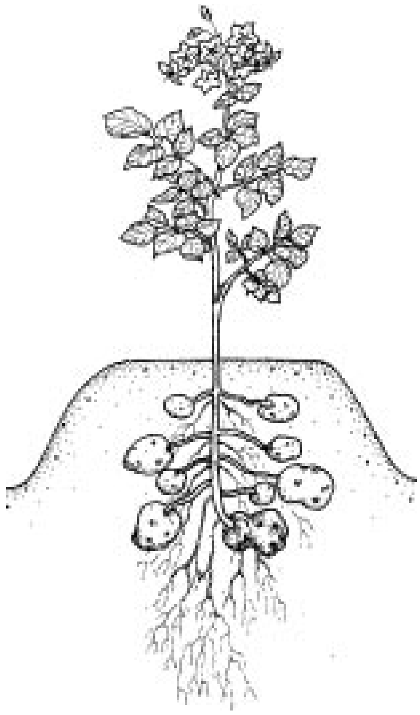


Figure 3. *Stage 3: tuber growth (bulking).*

Here are the important things that happen during Stage 3.

- Tuber growth is the period when cells formed during the initiation phase expand 7 to 18 times from the accumulation of water and starch reserves.
- The tubers become the dominant sink for the carbohydrates produced by photosynthesis in the leaves, as well as for inorganic nutrients such as nitrogen, phosphorus and potassium.

- The sucrose from the leaves is rapidly converted into starch.
- If problems during plant growth reduce the ability of the plant to take up inorganic nutrients, then nutrients are drawn from the foliage to support continued tuber growth. The vines then begin to show symptoms of premature aging. The problems here can be disease, too much or too little water, soil compaction or poor nutrition.
- When plants age prematurely, the effects of diseases such as Verticillium wilt, target spot and blackleg become more devastating.
- Towards the end of this stage of growth, the protective skin (periderm) of the tubers develops. Surface pores of this skin are called lenticels.
- Under high moisture conditions, the structure of the skin may react and cause enlarged lenticels. These enlarged lenticels make the tuber more susceptible to infection from diseases.

Stage 4: Maturation

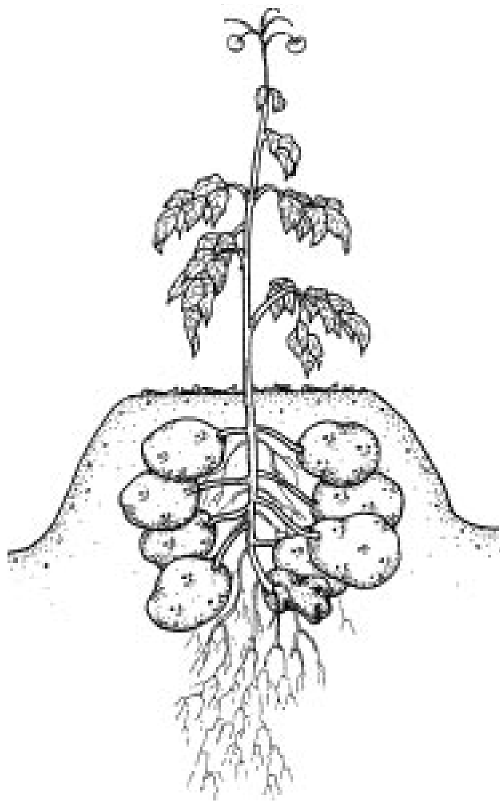


Figure 4. *Stage 4: maturation*

Here are the important things that happen during Stage 4.

- During this stage, there are three main changes to the plant:
    1. The tuber skin thickens or sets.
    2. The tuber dry matter reaches a maximum level.
    3. The plant top (or vine) starts to die.
- As the vines die, leaves turn yellow, so photosynthesis decreases.

- Some increase in tuber weight can take place during this stage. This is due mainly to the movement of carbohydrates from the foliage into the tuber.
- The skin of the tuber continues to thicken after the tops have died.

How climate affects growth

Stage 1

Low soil temperatures (below 15°C) are undesirable as emergence is slower and plants are more susceptible to soil-borne diseases. Growth of potato tops is best at temperatures about 25°C. The rate of top and stolon growth is reduced at lower temperatures while the initiation of tubers is hastened.

Stage 2

High temperatures are detrimental to high yields. Low temperatures are more favourable for tuber set, the optimum average temperature being about 15° to 20°C. At temperatures above about 29°C, new tubers are unlikely to set.

Stages 3 and 4

Temperatures are not as critical as in Stage 2, although temperatures above 32°C at maturity can result in tuber damage. Low soil moisture at any time during this stage will reduce yields.

Other temperature effects

In southern Queensland, night temperatures can limit production. If a significant drop in temperature does not occur at night, plant respiration continues at a high rate, using up carbohydrate reserves built up during the day. Potato crops planted from August to January in low lying coastal and subcoastal areas are unsuccessful because of this effect.

The temperature issue is complicated by daylength. In tropical and subtropical latitudes, the short days of the potato growing season limit yield potential.

Varieties differ in their response to temperature. For example, of all the varieties available commercially, Atlantic and Sebago are the most tolerant to high temperatures.

The high temperatures in southern Queensland potato growing areas also result in tubers with lower solid matter content compared with those produced in cooler southern states.

Economics of potato production

One way of assessing the economics of potato production is by calculating what are known as gross margins. A gross margin is the difference between the gross income and the variable or operating costs. The variable or operating costs include the growing, harvesting and marketing costs. The calculation does not consider fixed or overhead costs such as rates, capital, interest, electricity, insurance and living costs. These fixed or overhead costs must be taken into account in calculating a whole farm budget.

Two gross margin calculations are provided - one for south Queensland and the other for the Atherton Tableland in north Queensland.

Assumptions

The calculations assume Sebago potatoes are being grown under irrigation with good management by a family unit. All machinery operations include fuel and oil costs. No allowance is made for owner operator labour.

Gross margin for south east Queensland

Enterprise unit : 1 hectare

REVENUE	Amount	$/ unit	Total $/ha
PRICE		$300.00 /t	
Less:			
Freight (to Brisbane)		$30.00 /t	
Commission	12.5%	$37.50 /t	
On farm price		$232.50 /t	
TOTAL REVENUE	**25 t/ha**	**$232.50 /t**	**$5 812.50**

VARIABLE EXPENSES		/ha	$/ unit	$/ha	Total $/ha
Land preparation					
Machinery usage					
Ripping		1	$9.00 /ha	$9.00	
Disc harrowing		2	$8.70 /ha	$17.40	
Rotary hoeing		2	$10.50 /ha	$21.00	
Cultivator		1	$6.20 /ha	$6.20	
TOTAL LAND PREPARATION EXPENSES					**$53.60**
Planting					
Seed		2.5 t	$400.00 /t	$1,000.00	
Cutting		2.5 t	$20.00 /t	$50.00	
Casual labour		5 h	$9.21 /h	$46.05	
Planter		1	$12.00 /ha	$12.00	
TOTAL PLANTING EXPENSES					**$1 108.05**
Fertiliser					
Basal:					
Crop King 88		625 kg	$0.45 /kg	$281.25	
Side dressing:					
Urea		200 kg	$0.50 /kg	$100.00	
Hill up		1	$6.90 /ha	$6.90	
Spreader		1	$1.20 /ha	$1.20	
TOTAL FERTILISER EXPENSES					**$389.35**
Weed control					
Herbicide:					
Sencor 700		0.5 kg	$64.80 /kg	$32.40	
Sprayer		1	$1.70 /ha	$1.70	
Mechanical:					
Harrow		1	$1.80 /ha	$1.80	
Cultivate		1	$6.90 /ha	$6.90	
TOTAL WEED CONTROL EXPENSES					**$42.80**
Insect control					
Insecticide:					
Nitofol	5 applications	0.7 L	$31.75 /L	$111.13	
Sprayer		3	$1.70 /ha	$5.10	
Aerial spraying		2	$8.00 /ha	$16.00	
TOTAL INSECT CONTROL EXPENSES					**$132.23**
Disease control					
Fungicide:					
Dithane M45	5 applications	2.2 kg	$6.00 /kg	$66.00	
NB Applied with Nitofol.					
TOTAL DISEASE CONTROL EXPENSES					**$66.00**

Irrigation	/ha	$/unit	$/ha	Total $/ha
Water charges	3 ML/ha	$9.15 /ML	$27.45	
Electricity - double pumped.				
3.7 kW pump	4 L/sec	$0.10 /kW h	$77.08	
30 kW pump	40 L/sec	$0.10 /kW h	$62.50	
TOTAL IRRIGATION EXPENSES				**$167.03**
TOTAL GROWING EXPENSES				**$1 959.06**
HARVESTING	**Unit**	**Cost/Unit**	**$/t**	**$/ha**
Casual labour	bag	$2.00	$40.00	
Bags & tags	bag	$0.80	$16.00	
Sewing	bag	$0.50	$10.00	
Harvesting	tonne	$3.80	$3.80	
Slashing	tonne	$0.20	$0.20	
Total harvesting expenses			**$70.00**	
TOTAL HARVESTING EXPENSES		**25 t/ha**		**$1 750.00**
TOTAL VARIABLE EXPENSES				**$3 709.06**

Gross margin = Total revenue minus Total variable expenses:

Total revenue	$5 812.50
Total variable expenses	– $3 709.06
GROSS MARGIN per HECTARE	**$2 103.44**
BREAK EVEN YIELD at a PRICE of $300/tonne	**12 t/ha**
BREAK EVEN PRICE at a YIELD of 25t/ha	**$148.36 /t**

ACTUAL GROSS MARGIN WHEN PRICE OR YIELD CHANGES

		Price per tonne		
		Low	Medium	High
Yield	**t/ha**	**$225**	**$300**	**$375**
Low	20	$ –21	$1 291	$2 603
Medium	25	$463	$2 103	$3 393
High	30	$948	$2 916	$4 884

ENTERPRISE CHARACTERISTICS	
1. Growing risk	Low
2. Price fluctuations	Medium
3. Working capital requirement	Low
4. Harvest timeliness	Low
5. Management skills	Medium
6. Quality premium	No
7. Spray requirements	Moderate
8. Labour requirements—growing	Low
9. Labour requirements—harvesting	Medium

Last update: May 1996

Gross margin for the Atherton Tableland

Reference: *Sebago potatoes, costs and returns for the Atherton Tableland.* Andrew Hinton, DPI Mareeba. Farmnote/Agdex 262/821

INCOME	Amount	$/ unit		Total $/ha
Yield (t/ha)	30 t			
Yield (50 kg bags/ha)	600 bags			
Price		$15.00 /bag		
(A) TOTAL INCOME				**$9 000.00**
VARIABLE EXPENSES	**/ha**	**$/ unit**	**$/ha**	
Ground preparation				
Soil analysis			$80.00	
Liming	5 t	$63.00 /t	$315.00	
Deep ripping	1.67 h	$24.45 /h	$40.75	
Plough/discing	1.25 h	$24.45 /h	$30.56	
Sorghum seed	25 kg	$1.76 /kg	$44.00	
Sowing sorghum seed	0.17 h	$10.32 /h	$1.72	
Minispan operation	0.31 h	$12.92 /h	$4.04	
Fertiliser (DAP)	150 kg	$0.53 /kg	$78.96	
Cutting	2 x 0.63 h	$10.32 /h	$12.89	
Roundup spray	3 L	$9.75 /L	$29.25	
Roundup application	0.25 h	$9.21 /h	$2.30	
Rotary hoeing	2 x 1.25 h	$24.45 /h	$61.13	
Ripping	1.25 h	$24.45 /h	$30.56	
TOTAL GROUND PREPARATION EXPENSES				**$731.16**
Planting				
Potato seed	3 t	$700.00 /t	$2100.00	
Treating seed (Rovral)	1.2 L	$68.41 /L	$82.09	
Cutting seed (tractor & tipper)	1.5 h	$10.32 /h	$15.47	
Cutting seed (labour)	1.5 h	$11.00 /h	$16.50	
Planting (tractor & planter)	2.5 h	$26.98 /h	$67.45	
Planting labour (2 casuals)	2.5 h	$22.00 /h	$55.00	
Hilling up & urea application	1 h	$10.32 /h	$10.32	
TOTAL PLANTING EXPENSES				**$2 346.83**

Fertiliser	/ha	$/ unit	$/ha	Total $/ha
Solubor	2 x 0.2 kg	$2.78 /kg	$1.11	
Urea	150 kg	$0.45 /kg	$67.50	
Foliar zinc	0.2 kg	$0.92 /kg	$0.18	
Foliar magnesium	2 x 0.2 kg	$0.63 /kg	$0.25	
Q5	2.5 t	$490.00 /t	$1 225.00	
Tractor operations	2 x 0.25 h	$10.32 /ha	$5.16	
TOTAL FERTILISER EXPENSES				**$1 299.20**
Irrigation				
Setting out		$65.00 /ha	$65.00	
Watering	15 x 3.26 h	$9.00 /h	$440.10	
TOTAL IRRIGATION EXPENSES				**$505.10**
Crop protection				
Sencor	1 L	$65.50 /L	$65.50	
Rovral	2 x 2 L	$35.02 /L	$140.08	
Bravo	10 x 2.6 L	$12.35 /L	$321.10	
Nitofol	6 x 0.7 L	$31.10 /L	$130.62	
IPM		$50.00 /ha	$50.00	
Tractor spraying operations	4 x 0.25 h	$9.21 /h	$9.21	
Aerial spraying operations	8 x	$20.00 /ha	$160.00	
TOTAL CROP PROTECTION EXPENSES				**$876.51**
TOTAL GROWING EXPENSES				**$5 758.80**

HARVESTING/PACKING	Amt/tonne	Cost	$/t	$/ha
Pulverise	0.5 h	$10.32 /h	$5.16	
Harvesting (tractor and harvester)	7.5 h	$46.43 /h	$348.20	
Bag costs	600 bags	$1.20 /bag	$720.00	
Pallet costs		$1.00 /t	$30.00	
String costs	3.5 rolls	$3.50 /roll	$12.25	
Forklift costs	2.5 h	$8.00 /h	$20.00	
Casual labour (six casuals)	6 x 7.5 h	$11.00 /h	$495.00	
TOTAL HARVESTING/PACKING EXPENSES				**$1 630.61**
(B) TOTAL VARIABLE EXPENSES				**$7 389.41**

GROSS MARGIN equals	
Total income (A) minus	**$9 000.00**
Total variable expenses (B)	**– $7 389.41**
	$1 610.59

The gross margin varies with yield and price received. The table below shows the gross margins for a range of prices and yields.

GROSS MARGINS ($/ha)

Price	Yield (t/ha)					
($/bag)	15	20	25	30	35	40
5	- 5 514	- 5 139	- 4 764	- 4 389	- 4 014	- 3 639
10	- 4 014	- 3 139	- 2 264	- 1 389	- 514	361
15	- 2 514	- 1 139	236	1 611	2 986	4 361
20	- 1 014	861	2 736	4 611	6 486	8 361
25	486	2 861	5 236	7 611	9 986	12 361
30	1 986	4 861	7 736	10 611	13 486	16 361
35	3 486	6 861	10 236	13 611	16 986	20 361
40	4 986	8 861	12 736	16 611	20 486	24 361
45	6 486	10 861	15 236	19 611	23 986	28 361
50	7 986	12 861	17 736	22 611	27 486	32 361

Last update: April, 1996

Selecting and storing potato seed

As seed quality plays such an important role in the success of a potato crop, knowledge about seed selection, seed characteristics and seed storage is vital. This section outlines the important things you need to know about seed.

Use certified seed

Certified seed has been grown and inspected under Government supervision and has these characteristics:

- has been tested as being true-to-type for the variety
- free from specified diseases and within specified limits for other pests and diseases
- generally sound
- has been bred from high yielding stock
- graded to fall within the weight range of 35 g to 250 g for 'run' grade and not exceeding 350 g for special large size
- bears a label of certification from the state department which performed the certification.

The importance of using certified seed is emphasised by the fact that it is impossible to assess seed potato quality by appearance alone. Some diseases such as Rhizoctonia black scurf, powdery scab, Fusarium rot and soft rot may be visible on the surface of seed, but important and potentially devastating diseases such as leaf roll virus, bacterial wilt, blackleg, Fusarium wilt and Verticillium wilt cannot be seen. These diseases not only present a threat to the crop grown from the seed but also increase the possibility of infesting valuable potato ground with persistent diseases such as bacterial wilt.

With non-certified seed, the grower also has no assurance of varietal purity and age of seed (see below).

Brochures on certified seed are available each year from certified seed grower organisations.

more info
Certified seed producers
Section 6 Page 4

Age of seed

The ageing process in mature potato tubers can be assessed by the degree of visible sprout development and the feel of the tuber. The potato tuber remains dormant for weeks after maturity, then commences to sprout at the apex. Finally all 'eyes' sprout and eventually thicken.

Small, marble-sized tubers may eventually develop on the outside of the original tuber which by this time has generally become flabby and rubbery.

Potato tubers age more quickly if harvested under hot conditions. Cool storage after harvest slows the aging process. Physiological age of seed tubers has a marked effect not only on the size of sprout and plant growth rate, but also on the size, maturity and yield of the crop.

Plants grown from physiologically old seed are stunted and have thin stems and narrow leaves. They may develop symptoms similar to leaf roll virus. Plants are also very susceptible to disease and produce a low yielding crop with large numbers of small tubers.

Dormancy

Dormancy is the absence of consistent sprout growth because of chemical and physiological conditions in the tuber. Dormancy is influenced by a number of factors including variety, growing conditions of the parent plant, time of harvesting and storage temperature and humidity. Varieties such as Sequoia, Pontiac and Kennebec have a longer dormancy period than Sebago.

High temperatures during crop growth shorten dormancy, whereas low temperatures increase dormancy. Sebago sprouts readily after 6 weeks when stored at 21°C but can be kept for 11 weeks if held at 10°C. Planting wholly or partly dormant seed may result in delayed and uneven emergence, seedpiece breakdown and uneven maturity.

In general, there are few dormancy problems with seed potatoes bought from Victoria for the spring crop. Similarly, cool-stored, carry-over seed for autumn planting is usually sprouting on removal from the cool store. The main problems with breaking dormancy are with Sequoia and Exton seed for autumn and winter plantings.

Chemical sprouting agents are available but are rarely used due to their human toxicity and possible side effects on the growing crop.

An old method of breaking dormancy at planting time for the winter crop is to moisten the bagged seed, stack it on a trailer, and cover it with a tarpaulin to warm for short periods in the sun. However, if too much water is used or too much air excluded, soft rot will be induced.

The best and safest method to break dormancy is to store seed under cool conditions and then warm it up rapidly. This normally produces sprouting of all eyes of the tubers.

Cool storage of seed potatoes

As certified seed is generally not available for autumn plantings, growers store the small, round tubers from their spring crop for the autumn planting. These small round tubers are now cool-stored in most districts. By using this seed, there is of course the risk of building up diseases such as leaf roll, but it is often the only option available. The risk can be lessened a little by keeping the parent crop free from diseases and aphids. Alternatively, grow a small area specially for seed and inspect it regularly, removing and destroying any diseased plants and tubers.

Avoid harvesting the tubers during hot weather. Remove the seed promptly from the field and place in cool store.

Store the seed tubers either in bags or in bulk bins. Bulk bins are preferred as they can be handled easily with forklift trucks, reducing the chances of injury and bruising. The bulk bins must have gaps between the slats to allow air to circulate.

Bags tend to rot in cool store and are more difficult to handle on pallets. They also require more handling, causing a significant increase in tuber damage.

Cool store at 4 to 5°C with a humidity of 90 to 95%. Good circulation of air within the cool store is essential to maintain even temperature and humidity.

Cool stores start accepting seed potatoes in October and commence removing them in February. Seed is generally not cool stored for longer than six months, but with both high seed tuber quality and accurate cool store operating conditions, it is possible to hold seed for up to nine months.

Seed does not need be treated with insecticide before storage as tuber moth cannot survive in cool storage for more than three weeks.

Certified seed delivered to southern Queensland for planting in April-May is sometimes cool stored for a short period to speed up sprouting. On removal from cool store, the potatoes are held to warm up over a period of at least one week before planting. This seed sprouts rapidly on removal from cool store.

Resolving a problem with a seed potato purchase

When seed potatoes are purchased, a contract is made between two parties. In the first instance, it is generally between the seed grower and an agent, and subsequently, between the agent and the potato grower.

On receipt of seed, make a thorough inspection of the seed by tipping out several bags and noting any irregularities in the seed (for example, presence of disease, oversize or undersize tubers). Each certification scheme sets clear guidelines for what level of reject tubers will be tolerated.

IMPORTANT!

Develop a god working relationship with seed growers. This will help in the resolution of any problems.

Should there be a problem, the grower generally has 14 days to register a complaint. Lodge a complaint directly with the agent or seed grower and advise your local DPI officer if possible. It is important to recognise that as there is a contract between the potato grower and another party, DPI's only role is an advisory one.

In some situations with apparently healthy seed, a seed problem such as non-emergence of plants may only show when the seed is planted. In a case like this, it is often difficult to pinpoint the cause of the problem to the seed or crop management. Advice from your local DPI officer is recommended.

Use of round seed

Winter and spring crops in Queensland are traditionally planted using cut certified seed. Round (whole) seed is now available from certified seed schemes and offers some advantages over cut seed. These include:

- less seedpiece breakdown
- less opportunity for disease entry
- more stems per seedpiece
- more even plant stands
- eliminates the need for the mancozeb seed dressing.

The main disadvantage is that it costs more than cut seed. Because of the advantages offered, research has been underway since 1993 to establish the performance of this seed. Here are the main findings to date.

- For spring crops (planted June), whole seed has provided an economic advantage over cut seed for all varieties. However, for winter crops (planted May), an economic advantage has only been achieved with some varieties. See Figure 1.

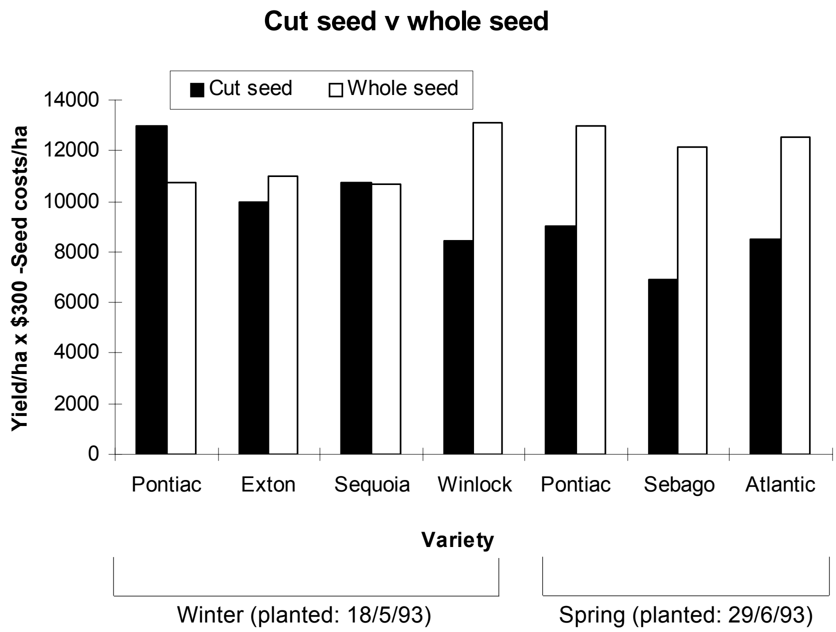
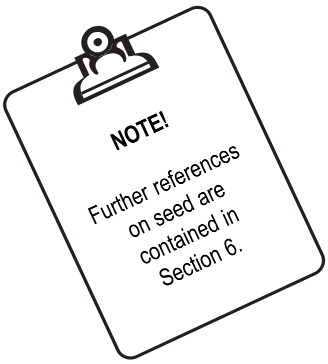


Figure 1. *Comparison of cut and whole seed*



The performance of round seed appears to depend largely on its age at planting. If the seed is in the juvenile stage where only the first eye has sprouted, there appears to be no advantage in using round seed. Best results from round seed appear to be when all apical dominance has regressed and all eyes are sprouting. This means that growers will need to obtain seed earlier in the season to allow the ageing to advance to this stage. Future research with seed obtained earlier in the season is planned.

- Although round certified seed is generally supplied in a mixed range of sizes from 30 g to 150 g, there appears to be no economic advantage in grading out the larger seed and planting it separately to the smaller seed.
- A spacing of 20 to 25 cm appears optimum for best overall economic performance.

Varieties

The main fresh market varieties grown in Queensland are Sebago, Red La Soda, Snow Gem, Pontiac, Exton and Sequoia. Atlantic is the main crisping variety. Minor fresh market varieties include Winlock, Desiree and Bison. The variety grown depends largely on the market which you are supplying - the fresh unwashed market, the fresh washed market or the processing market. Other factors which should be considered include frost or heat tolerance, susceptibility to disease and yield potential. This section contains details on the main varieties.

Sebago

Sebago is the main variety produced in Queensland and comprises more than 70% of the area planted. Sebago has maintained this position for 43 years and despite widespread testing of new varieties, some of which are higher yielding, no suitable replacement variety is yet available.

Sebago has been the most popular variety for the fresh market, for pre-packing and washing. Because the trend in the fresh market is to washed potatoes, and Sebago is generally unsuitable for this, it is likely to lose its current market dominance. The variety is particularly versatile and can be used for all purposes including new grade. The tubers can be boiled, mashed, fried, deep-fried, roasted and baked when fresh. They are also suitable for commercial processing as French fries or chips, and are well suited for crisps and dehydrated potatoes.

The crop matures in 110 to 115 days. Yields of 20 to 30 t/ha can be expected, with some very well grown crops reaching 40 t/ha.

Usual planting time for certified seed is June - July to produce a crop harvested in October - November. In the Lockyer Valley, seed saved from this crop is used to plant a second crop in February - March.

Seedling emergence is rapid. Plants are large, erect to spreading, with a slightly reddish-purple stem and purple flowers with paler tips. Sebago is resistant to late blight, mild mosaic, and common and russet scab, but is susceptible to target spot, blackleg and Fusarium wilt. Sebago withstands extreme conditions of heat and moisture very well, and is particularly suited to heavier alluvial soils. It has low resistance to wind and frost.

Tubers are elliptical to round, regularly shaped and medium-large to large in size. The skin is smooth and white, the eyes shallow and numerous, lenticels are conspicuous and the flesh is creamy-white. Keeping quality is fair. The tubers sprout readily in five to eight weeks.

Over recent years, growers have complained that the current strain of Sebago has lost its vigour compared with the variety they had grown before. As a result, research is currently in progress to evaluate new Sebago strains. The New Brunswick strain appears promising and is being evaluated further.

Sequoia

This variety was in the past favoured for winter and early spring crops in southern Queensland but it has now lost favour in most areas. It is similar in maturity to Sebago but matures the fastest of all commercial varieties during the winter.

The crop matures in 110 to 115 days. Yield expectancy is in the range of 25 to 40 t/ha of No. 1 or new grade.

Sequoia is a non-mealy potato, but if it is sown in April and May, a better cooking type of tuber is produced. It is acceptable for household use for cooking and baking but is not favoured by the processing trade.

The tubers are oval to flattish in shape with smooth, white skin. There are few shallow eyes and they are concentrated mainly at the apical end of the tuber. The flesh is creamy-white, keeping quality is very good and the tubers sprout in 10 to 12 weeks.

Plant growth is strong and vigorous, stems are large, erect and green, and the flowers are white.

The variety has good resistance to common scab and fair resistance to late blight, but is very susceptible to powdery scab. It also has fair resistance to frost, wind and drought. Sequoia tends to overgrow and produce poor quality tubers if planted during the warmer weather.

Exton

Exton has gained popularity on the heavier soil types, particularly in the Lockyer Valley. Here it has found favour with the pre-packing trade for sale in supermarkets. It is accepted early in the season for household use, including baking, but cannot compare with Sebago in the fresh market. Exton is tolerant to powdery scab and this has been a factor in its use as a replacement for Sequoia for many plantings.

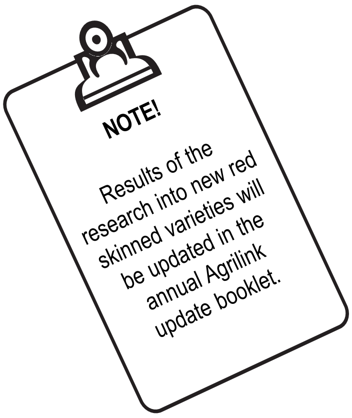
Planted from March to June, Exton's main disadvantage is its slow maturity during cold weather, taking one to two weeks longer to mature than Sequoia. The crop matures in 116 to 120 days. The yield range of 25 to 35 t/ ha is slightly superior to Sebago.

The tubers are white-skinned, thick and oval. They are very similar to Sebago tubers except for a characteristic roughness of the skin and a marked tendency to adhere to the stolon at harvest. The flesh is creamy-white, eyes are mainly apical, and the tuber keeping quality is good. Seedling emergence is late, growth is vigorous, and plants are upright with purple flowers. Exton is susceptible to late blight (foliage only), target spot and russet scab.

Pontiac

In the past, Pontiac has been the main red skinned variety grown for the fresh market in Queensland. It has been the main variety for the washed potato trade. Although it is the best yielding of the red skinned varieties, it has now been superseded by Red La Soda because of ts superior skin colour.

The tubers tend to overgrow and are prone to growth cracking and the formation of odd-shaped tubers. This is the main reason the variety has fallen from favour for household use. The crop matures early in 90 to 100 days. Tubers are round to oblong with red skin and with eyes medium to deep. Keeping quality is variable. The yield range of 25 to 35 t/ ha is slightly higher than Sebago.



Poor skin colour, from early planted crops in particular, has been a problem. This problem appears to be partly genetic but may also occur when tuber bulking occurs under low soil temperatures. Evaluation of new red skinned varieties is in progress. Some of these are showing better colour than Pontiac and at least one is expected to be released in the near future.

Pontiac is a good table potato for boiling, mashing or baking, but is unsuited to frying or chipping.

Seedling emergence is rapid and plant growth is vigorous and upright. Flowers are purple. Pontiac is susceptible to target spot, common scab, russet scab and late blight (both tubers and foliage).

Planting time is similar to Sebago.

Red La Soda

This variety is largely replacing Pontiac in the washed potato trade because it is more reliable in maintaining its bright-red skin colour. It is smooth skinned. Average yields are 25 to 30 t/ha.

As with Pontiac, the production of oversize tubers should be avoided as these result in deep eyes which are unwanted on the fresh potato market. Large tubers also have a pronounced depression at the heel end where the stolon attaches to the tuber. Red La Soda is suitable for boiling, mashing and baking.

It is mainly planted in June and July for a spring crop and February for an autumn crop.

Snow Gem

Snow Gem is gaining importance, particularly in southern Queensland, as a variety suitable for washing. It has less pronounced lenticels than Sebago and consequently produces an attractive whiter, smoother skin after washing.

Tuber size can be large but is variable. Tubers are oblong and slightly flattened but not distorted. It has low dry matter and produces dark crisps. Tuber dormancy is short and plants are early maturing with rapid early growth. Plants are reported to be more susceptible to wind and frost damage than Sebago.

It is mainly planted in June and July for a spring crop and February for an autumn crop.

Atlantic

Atlantic is the main variety grown for processing and now comprises about 10% of total Queensland plantings. Plants are upright, stems are thick and purplish towards the base, and flowers are profuse and lavender in colour.

It is medium to late in maturity with a yield potential similar to Sebago. In winter, it will perform better then Sebago but not as well as Sequoia. The crop matures in 110 to 115 days.

Tubers are oval to round, smooth and white fleshed. Skin is white and may be lightly netted to heavily scaled. Eyes are shallow and white, and the sprouts are purple.

Processors have encouraged increased plantings of this variety because of its high solid content and its suitability for crisps. It is not suitable for boiling. Processors provide advice to growers about when to plant to meet factory requirements.

Although the variety is well accepted by the processing industry, it does have some limitations including susceptibility to bruising and short storage life before processing. New processing varieties have been evaluated but none have yet out-yielded Atlantic in trials in south Queensland.

Other varieties

Minor varieties grown include:

- Winlock—white skinned, fresh market, planted May–June
- Desiree—pink skinned, fresh market, planted June–July
- Bison—red skinned, fresh market, planted June–July

Table 1 summarises the important characteristics of each variety.

Table 1. *Characteristics of the main varieties grown in Queensland*

Variety	District	Main planting time	Average time to maturity (days)	Average yield (t/ha)	Uses	Comments
Atlantic	All	Processors decide	110–115	20–30	Crisps	Grown under contract to processors.
Exton	Lockyer Valley Redland Bay	March–June	116–120	25–35	Boiling	Tolerant to powdery scab.
Pontiac	All* Atherton Tableland Lockyer Valley	June–July March–April Feb–March	90–100	25–35	Boiling, mashing, baking & potato salad	Mainly sold washed. Losing favour.
Red La Soda	All* Lockyer Valley	June–July Feb–March	105–120	25–35	Boiling, mashing, baking & potato salad	Mainly sold washed.
Sebago	All* Atherton Tableland Lockyer Valley Killarney	June–July March–Sept Feb–March Oct–Nov	110–115	20–30	All household including French fries	70% of plantings.
Sequoia	Lockyer Valley Redland Bay	May–June	110–115	25–40	Boiling	Fastest maturing variety in winter. Not commonly grown.
Snow Gem	Lockyer Valley	Feb–March June–July	100–110	20–30	Boiling, mashing, baking	Slightly resistant to powdery scab.

*Except Killarney

Nutrition

Because potato tubers are essentially storage organs, yield depends largely on the amount of plant food or carbohydrate available for storage after the plant's requirements for growth have been met. For this reason, adequate nutrition is vital in maintaining vigorous rates of carbohydrate manufacture. In addition, nutrition is closely linked to the solid matter content of tubers which largely determines the eating and processing qualities of potatoes.

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The extent of nutrient need

The potato crop places a substantial demand on soil nutrients. This is illustrated in the following table of nutrient removal by an average crop.

Table 1. *Major nutrients (kg/ha) removed by a 25 t/ha potato crop*

Part of plant	N Nitrogen	P Phosphorus	K Potassium	Ca Calcium	Mg Magnesium
Tops	50	3	78	40	17
Tubers	90	15	134	6	6
Roots	6	1	6	5	2
TOTAL	146	19	218	51	25

These figures show that the main draws on the soil nutrient bank are for nitrogen and potassium. It is obvious that considerable inputs of fertiliser will be required to achieve yields of 25 t/ha and above.

Nitrogen

Any deficiency in nitrogen causes stunted growth, crop yellowing, leaf rolling and early maturity. Provided phosphorus and potassium are in adequate supply, added nitrogen provides a marked increase in vegetative growth and in the size and dry matter content of tubers. However, if excess nitrogen is applied to a healthy crop late in the growing season, maturity may be delayed, excessive vegetative growth may occur and tuber quality declines.

Part of the crop's nitrogen requirement is normally applied in high analysis mixed fertiliser. Additional nitrogen is usually applied as urea, but on alkaline soils, sulphate of ammonia may be more effective. Aqua ammonia can also be used where bulk supplies and applicators are available. However, the relatively small size of individual potato plantings favours the use of solid forms of nitrogen fertiliser.

Phosphorus

As applied phosphorus becomes available to plants relatively slowly, the total phosphorus fertiliser requirements must be applied early, preferably before or at planting.

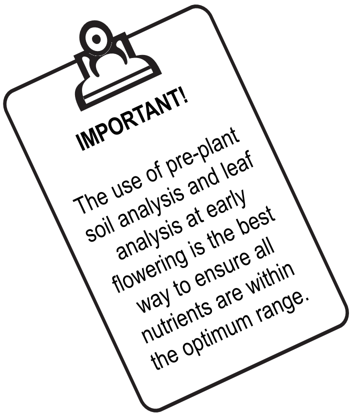
Adequate phosphorus increases the number of tubers rather than the size, shortens the growing season and improves quality. Excessive applications of phosphorus may reduce yield. Phosphorus deficiency results in stunted, dark-green plants.

The dark grey alluvial soils of the West Moreton district are usually fairly high in phosphorus. On the other hand, the red loams of districts such as the Atherton Tableland, Redland Bay, the South Burnett, Killarney and the Near North Coast, are usually low in phosphorus.

Potassium

Potatoes need large amounts of potassium and deficiency symptoms usually become obvious at bulking up or filling out of tubers. The leaves become bronzed and show a distinctive crinkling and firing or burning of the leaf edges. Potassium deficient plants are also more susceptible to disease attack.

Potassium sulphate is the preferred form of potassium to apply. The high chloride levels in muriate of potash may increase salt problems. The alluvial soils of the West Moreton district normally contain ample amounts of potassium.



Calcium

Apart from being an important plant food in itself, calcium improves soil structure and neutralises soil acidity. Most of the soils used for potatoes in southern Queensland are neutral and do not usually require lime or dolomite. In general, the pH needs to drop to below 5.5 before calcium either as lime or dolomite is applied. Trace elements such as boron, copper, manganese and zinc become less available where the soil pH is higher than 6.5.

Zinc

Applications of zinc may be beneficial where zinc soil levels fall below 2 ppm (parts per million). Zinc may be applied at the rate of 840 g of zinc sulphate heptahydrate in 500 L of water in one or two foliar sprays. Alternatively, it can be applied in the solid form as a pre-plant soil application of 30 kg of zinc sulphate heptahydrate per hectare.

Other nutrients

Application of other nutrients such as sulphur, boron and magnesium is rarely necessary. The use of sulphate fertilisers in the case of sulphur, and foliar sprays of boron and magnesium can be applied to rectify any deficiencies. Professional advice should be sought on rates to apply.

Irrigation

As potatoes are very sensitive to water stress, irrigation is a key factor in profitable production. Research has shown that consistently moist soil is required to produce high yielding crops. However, in most current production areas, crops are not irrigated frequently enough, and are watered excessively at each irrigation. This has two effects. Yields are below what they should be, reducing profitability to the grower. Water is also wasted, a practice that is in conflict with current environmental demands for more efficient use of the water resource and the reduction in contamination of water reserves with soil chemicals and nutrients.

This section describes irrigation management for potatoes, with particular reference to production in southern Queensland, although the principles are more widely applicable.

Effects of too little and too much water

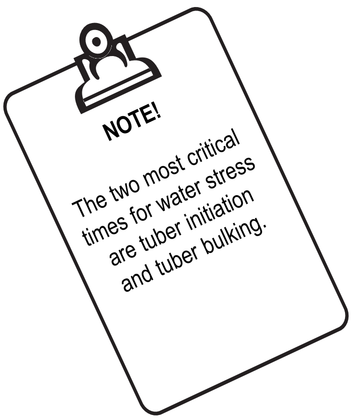
Potato plants are sensitive to water status, with substantial declines in tuber yields and quality when subject to under or over-watering. The plant has a shallow, fibrous root system, with most roots in the top 30 to 40 cm of the soil profile. Potato roots have a limited ability to extract soil water. Potatoes recover more slowly from water stress than do other crops. This is due to the physiology of potato plants, particularly the operation of the stomata and water uptake by the roots.

For optimum yields, potatoes need to be irrigated when the crop has taken up 30 to 40% of the available water in the root zone. In Queensland, a well-grown potato crop gets 85% of its water from the upper 40 cm of the soil profile (measured from the top of the potato hill). In the alluvial soils of the Lockyer Valley, this means potatoes need irrigation (or rain) when they have used 25 to 30 mm of water from the soil profile.

Compared to other crops, potatoes are sensitive to water stress throughout their growing period. A worldwide research survey suggests potato yields decline by 11% for each 10% that irrigation is below optimum. The same survey showed yields and quality of potatoes were particularly sensitive to stress during tuber initiation and bulking. Using a theoretical example, a potato crop receiving 350 mm of irrigation may yield 35 t/ha. If it received 10% less irrigation (35 mm), with the deficit spread evenly over the life of the potato crop, the expected yield reduction is around 4 t/ha. However, if that 35 mm deficit occurred entirely during the tuber initiation period, the yield loss is estimated at 10 t/ha, or about 25%.

Although lack of water is the most common irrigation problem in potatoes, excessive irrigation can also cause difficulties, particularly during early growth, or when soil temperatures are low. Over-watering reduces soil aeration, increases nutrient and pesticide leaching, and creates conditions favourable for disease development. Waterlogging following planting can delay emergence and promote seedpiece breakdown. In cool conditions, even optimal irrigation may reduce soil temperatures, predisposing tubers to powdery scab infection, as well as inhibiting tuber initiation. Physiological disorders such as brown centre and hollow heart are also exacerbated by over-watering.

The critical periods for water stress



The most critical time is during tuber initiation. Although it is only a short two week period, it is when yield potential is determined. Water deficits during this stage reduce the number of tubers set per plant. Research at Gatton Research Station has shown that stress at tuber initiation reduced yields of No. 1 grade and No. 1 large tubers by 60% to 70%.The number of tubers initiated during this phase places an upper yield limit. Once this has been restricted, any yield loss cannot be regained by improved watering during the rest of the growth period.

The other critical time is during tuber bulking. Water stress here reduces tuber size (and hence yield), but also results in misshapen potatoes. Dry matter, specific gravity and other aspects of tuber quality can also be reduced. The sugar content in the stem-end may also be increased, affecting processing quality.

Diseases such as common scab are increased by water stress during tuber initiation and bulking. Substantial water stress followed by irrigation can cause tubers to crack, and develop brown centre and hollow heart.

The early vegetative stage, prior to tuber initiation and bulking, is less sensitive to water stress. However, severe lack of water during this stage will reduce the amount of leaf area developed. This can limit the ability of the potato plant to produce the necessary carbohydrate to fill the tubers during the rest of the growing period.

At maturity, soil water content should be reduced to promote firming of the skin and closure of the lenticels (potato skin pores). This will also reduce the risk from diseases such as bacterial soft rot. Moderate water deficits at maturity can enhance the specific gravity of tubers and reduce susceptibility to peeling or bruising during harvesting. However, excessively dry soil at maturity increases harvesting costs from machinery having to work harder. It also leads to tuber damage from dry cloddy soil. In clay soils, excessive drying and substantial soil cracking increases the risk of damage from potato tuber moth and skin greening.

Irrigation requirement 1—a good irrigation system

The first essential requirement of efficient irrigation is a water supply and irrigation system capable of delivering the required amounts of water when needed.

Most potato crops in southern Queensland are irrigated with overhead sprinklers (either solid set or hand shift), travelling guns or lateral move systems. There is some use of drip irrigation, but this is uncommon. For optimum potato performance and overall irrigation efficiency, a system that can apply between 15 and 30 mm on a regular basis is necessary. During peak tuber bulking in warm conditions, irrigation may be required every four days for maximum production. On sandier soils, or where frosts are common, irrigation may be needed more often. Hand shift sprinklers or travelling guns may not be capable of applying small amounts at that frequency.

Irrigation requirement 2—a scheduling system

The second essential requirement of efficient irrigation is a system to tell you when and how much water your crop needs. This is known as a scheduling system. The importance of scheduling is confirmed by research which shows that water use can be reduced by up to 40% with scheduling, without affecting yield and tuber quality. It also makes sure you are applying enough water at the critical times such as tuber initiation. For example, in research at Gatton Research Station, a crop which yielded 40 t/ha with regular scheduled irrigation of 370 mm, was reduced to 20 t/ha with just 40 mm less water at the critical tuber initiation and tuber bulking stages.

A range of equipment and techniques are available for scheduling irrigation. Currently, the most common methods include assessing soil water status (using neutron soil moisture probes, tensiometers, or newly developed soil capacitance systems), or using a water budget.

Water budget systems based on estimates of evapotranspiration can work, provided good pan and crop coefficients are available. Even so, such systems probably require occasional cross checking with direct soil monitoring devices, to ensure that water balance errors do not accumulate during the growing period.

Because potatoes have the bulk of their roots in the top 30 cm of soil, any soil water monitoring device used for irrigation scheduling needs to concentrate on this part of the soil profile. Without intensive calibration, neutron probes are not very accurate at determining moisture contents in the upper 20 cm of the soil profile, although they are good at showing drainage beyond the root zone. New systems based on capacitance probes, for example the Enviroscan, work well at showing soil moisture contents at various depths. However, at $7000 to $10 000 for an eight sensor system, they are a substantial capital investment.

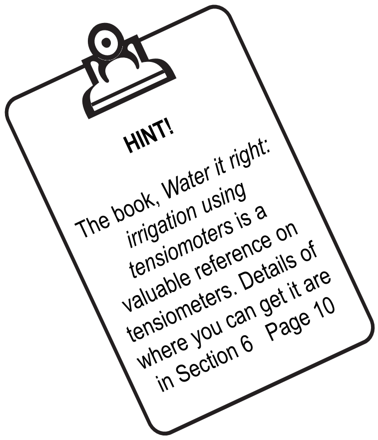
At Gatton Research Station, tensiometers are used as the most cost-effective method for monitoring soil water for shallow-rooted, quick-maturing vegetable crops such as potatoes. They are easy to install and use, give accurate, reliable readings, require little maintenance and are relatively cheap. One complication with tensiometers is determining the correct quantities (as opposed to frequencies) of irrigation to apply, to avoid excess losses through drainage beyond the root zone. Unlike the neutron probe, tensiometers do not measure the amount of water needed to refill the root zone. The quantity of irrigation applied at a given tensiometer reading relies on previous experience with the particular crop/soil type combination.

Determining water stress by visual appearance of the potato crop, or using infrared thermometry to measure leaf canopy temperatures, are not recommended. Neither method is sensitive, and allows levels of water stress sufficient to reduce yields and tuber quality.

Using a water budget approach

If you use this approach, a potato crop should only use 30 to 40% of the available soil water in its root zone before irrigating. On the alluvial soils of the Lockyer Valley, research has shown potatoes should be irrigated according to the following schedule:

- For the first month after planting (minimise irrigations between planting and emergence), irrigate after the crop has used the equivalent of 15 mm.
- For the following month, allow 20 to 25 mm of water use between irrigations.
- From then until the maturation stage, irrigate when the potatoes have used 30 to 35 mm.



Using tensiometers

Tensiometers measure availability of soil water to plants. Common designs consist of four basic parts (Figure 1). In wet soil, the vacuum gauge displays 0 to 5 (kPa or centibars). As the soil dries over several days, water moves from inside the instrument, through the porous ceramic tip, into the soil. The gauge reading steadily increases, to a maximum of about 90 kPa. When the soil is re-wet after rain or irrigation, water moves from the soil back into the tensiometer and gauge readings fall.

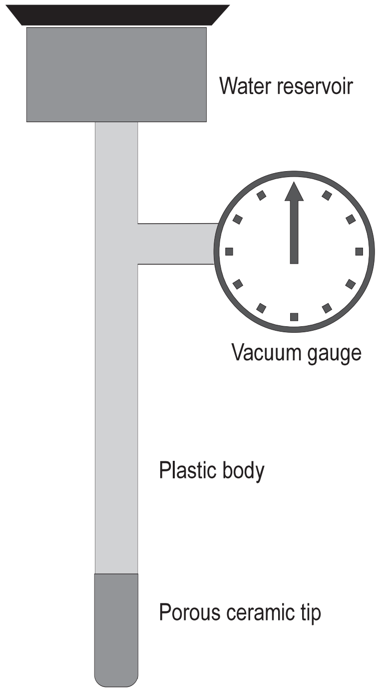


Figure 1. *Design of a standard tensiometer*

Monitoring sites

Tensiometers are installed after planting at monitoring sites throughout the crop. Use at least two sites per five hectares of crop. A monitoring site consists of one shallow tensiometer installed in the major root zone, and one deep tensiometer below most of the roots. One tensiometer is installed 20 cm below the surface of the hill, and another tensiometer 60 cm below the top of the hill (Figure 2). Both tensiometers are placed midway between plants within the row

A good 'grower starter pack' would include two 30 cm and two 60 cm tensiometers, a suitable vacuum pump, algaecide and a 1 m long 50 mm diameter auger (total cost less than $600). The best tensiometers have replaceable tips, gauges and reservoirs.

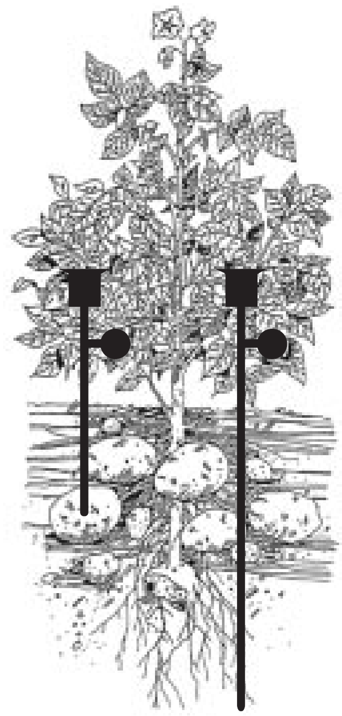
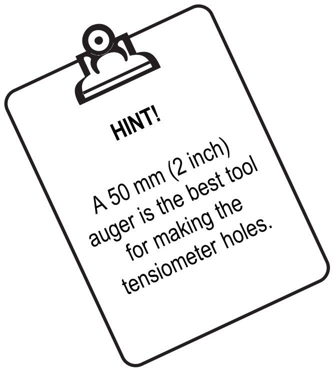


Figure 2. Tensiometer placement in a potato row (section running along length of row)

Installation

Assemble tensiometers and fill with good quality water (to which algaecide has been added). Leave them to stand in a bucket of water at least overnight, but preferably for one to two days. The water does not need to be pre-boiled. Tensiometers are more reliable if an appropriate vacuum pump is used to remove any air. Top up the tensiometers with more water if necessary. They are now ready to install.

Carry the tensiometers to the installation site with the tips either in water or wrapped in wet rags. Provided the ground is moist and well cultivated, the shallow tensiometer can simply be pushed into the soil to the 20 cm depth. Don't push too hard! The tips are strong, but can crack under excessive pressure. Only experience teaches how hard is too hard. At $30 per tip, this can turn out to be an expensive lesson. If you encounter a hard soil layer, either take the tensiometer out and try somewhere else, or use the deep tensiometer procedure.



To install the deep tensiometer, first make a hole to the required depth, keeping the excavated soil nearby in a pile. Place the tensiometer in the hole, over to one side. The next step is critical. Good contact between the ceramic tip and the surrounding soil is very important. Take the most crumbly, moist soil from the dirt pile and pack it around the tip at the base of the hole. A piece of 10 to 15 mm diameter dowel is useful for packing. Don't over-compact the soil into plasticine, but remove any large air gaps. Continue replacing soil until the hole is filled. It doesn't matter which soil you use after you have packed the first 5 cm above the tip. Friable topsoil from a few metres away can be used to create a slight mound around the tensiometer. This minimises water draining down beside the tensiometer leading to false readings. Covers made from silver/blue insulation foil placed over the tensiometers minimise temperature fluctuations and algal growth. The gauge can be left exposed for easy reading. Covers are not essential, particularly where crop canopies develop quickly.

The tensiometers are now ready to operate. The vacuum pump can again be used to remove air bubbles. Tensiometers may take a few irrigation cycles to settle down, so don't take too much notice of the readings for the first few days. During this period, air gaps may appear in the tensiometer. Simply refill with algaecide-treated water. Within a week of installation, readings should rise and fall with irrigation/rainfall.

Clearly mark tensiometer locations otherwise they may fall victim to tractors and other equipment.

Reading

Check tensiometers early in the morning between 7 a.m. and 9 a.m., preferably the same time each reading. Read at least twice a week but preferably every day or second day. Lightly tap the gauge before reading.

The shallow tensiometer indicates when to water. The deep tensiometer indicates whether the right amount of water has been applied.

Irrigating using tensiometers

Overseas data suggests that for maximum production, potatoes should be irrigated when tensiometer values in the root zone reach 30 to 50 kPa (or when the potato crop has depleted 30 to 40% of available water). Our investigations in southern Queensland confirm that optimum production occurs if potatoes are irrigated when values for the shallow tensiometers reach 40 kPa. Lower critical tensiometer values should be used in warmer conditions with high evaporative demand, or on sandier textured soils such as sandy loams. These critical levels are only guides; potato producers can develop different criteria for commencing irrigation as they become familiar with their irrigation and crop water use patterns.

Deep tensiometer readings falling to less than 10 kPa within 2 days after irrigation suggest there is more water than the root zone can hold. Constant values after irrigation indicate the root zone has been filled. Readings continuing to rise immediately after irrigation mean water applied is less than the root zone could hold.

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Using the criterion of irrigating to refill the potato root zone when shallow tensiometers reach 40 kPa, irrigation guidelines can be developed for variety/soil/climate combinations. For example, for Sebago potatoes planted at Gatton Research Station in July, the following program is our estimate of irrigation requirements for the growing period:

- For the first two to three weeks after emergence, irrigate with 15 to 20 mm per week
- Increase this to 25 mm per week during initiation and early bulking
- Then increase this to 25 to 30 mm every five days until maturation commences.

By using tensiometers, this baseline program can be altered during the season to take into account climatic variations and crop vigour. Remember that high levels of crop water use, and thus high yield potential, can only be achieved if other factors, such as nutrition, pest and disease management are also optimised.

Grower case studies with tensiometers

As an example of how tensiometer information can be used, data from two potato growers is shown in Figure 3. Dips in shallow tensiometer values show where irrigation (or rainfall) has occurred.

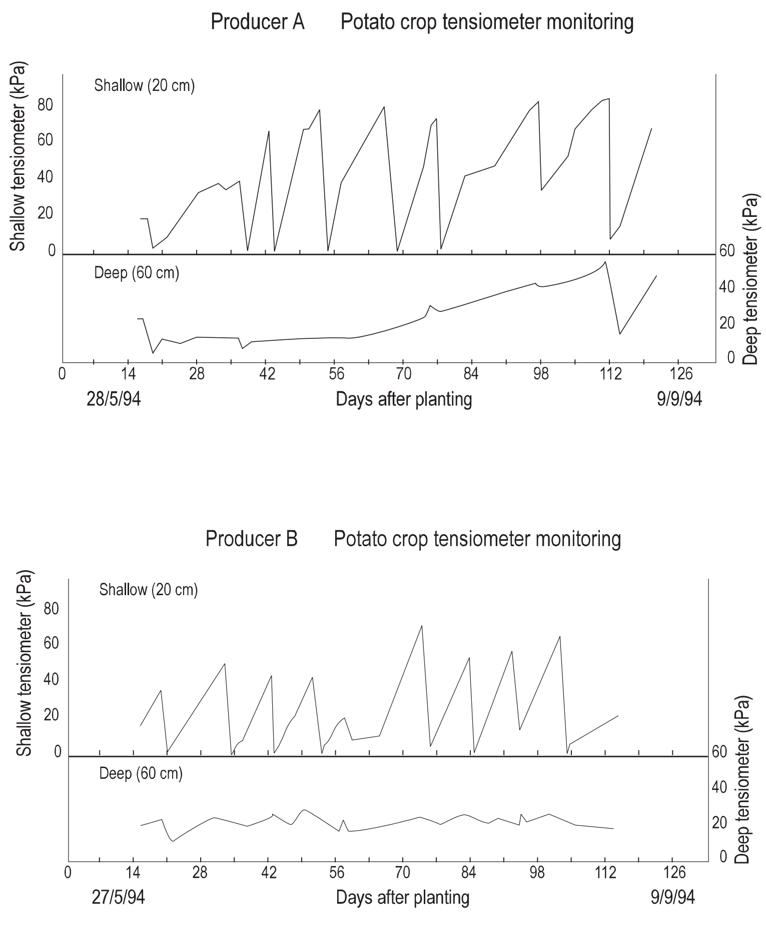

***Figure 3.** Tensiometer fluctuations under two irrigation regimes*

Due to severe drought conditions, Producer A had limited water available, and was unable to irrigate as often as desired, particularly during the latter part of the tuber bulking period. This is confirmed by readings for the deep tensiometers, which gradually rose between 60 and 110 days after planting, indicating water uptake from deeper in the soil profile. This suggests the potatoes were not obtaining enough water from the main section of the root zone (where the shallow tensiometers were located). Insufficient water was applied at each irrigation to refill the potato root zone, until a major irrigation about 112 days after planting (note the dip in both the shallow and deep tensiometer values at that time). The irrigation strategy adopted by Producer A was reasonable, given restricted water availability during the drought. Yields from this crop were still relatively good, indicating no severe or prolonged periods of water stress.

Tensiometer fluctuations shown for Producer B were close to ideal for an optimally irrigated planting. Note the shallow tensiometer values were continually less than 50 kPa during the critical tuber initiation and early bulking periods. There were only a few days where tensiometer values were above 50 kPa during the rest of the growth period. The deep tensiometer values stayed around 20 kPa for the whole time the potatoes were in the ground. This indicated no substantial deep drainage of irrigation water, and no periods of extended water stress for the crop.

Troubleshooting tensiometer problems

No water in the tensiometer; gauge reads 0 kPa

There is either a crack in the ceramic tip or a faulty seal. Fill the tensiometer with water and apply suction with a vacuum pump. A stream of large bubbles will indicate the problem area; usually a cracked tip or a missing o-ring.

Air entering over several days; gauge registering >5 kPa

There is either a hairline crack in the tip, or a substantial air gap in the soil around the tip. Remove the tensiometer; and if there are no obvious tip cracks, re-install the tensiometer. If the problem persists, replace the tip.

No change in readings over several days

The gauge may be faulty or blocked. Check the gauge is working by:

- applying suction to the tensiometer with a vacuum pump
- remove the gauge, rinse with clean water and suck it. If the needle does not move, there is a problem with the gauge.

Tensiometer readings increase beyond 80 kPa then fall to 0 kPa, accompanied by air in the tensiometer

The soil has become too dry for the tensiometer to operate. After irrigation, refill the tensiometer and treat as if it had just been installed. If this happens frequently, consider whether you are under-irrigating. If you are happy with your irrigation, try installing the shallow tensiometer slightly deeper. This problem should never occur with the deep tensiometer!

Interaction of irrigation with other crop management factors

In Queensland, frequent irrigation for maximum yield results in large bushes with substantial leaf canopies. This may create a microclimate more favourable for diseases such as Sclerotinia rot and target spot. Potato producers need to take this into account in their pest and disease management programs.

Too much available nitrogen at planting can delay tuber set and increase the number of small tubers. It is advantageous to have multiple nitrogen applications during the growing period, particularly on sandier soils with lower nutrient retention capacities. A nutrient monitoring program, involving pre-plant soil testing and in-crop tissue or sap testing is recommended in conjunction with irrigation scheduling to optimise crop performance and minimise leaching losses.

Potatoes are classified as moderately sensitive to soil salinity. Overseas research suggests a 25% yield reduction where irrigation water has an electrical conductivity of 2500 microSiemens per centimetre. In practice, some producers have successfully grown potatoes with water of this quality, provided adequate leaching of the salt occurs.

Other factors to consider

Where irrigation water is limited, the potato growing enterprise should maximise yields over a reduced area, rather than spread the limited water supply over larger areas. If irrigation per unit area is restricted, irrigation should cover the most critical periods (tuber initiation and bulking), with selection of cultivars more tolerant of water stress. Potatoes are more tolerant of stress during the early vegetative growth stage and late tuber bulking. Water deficits can be allowed immediately prior to and during maturation. This makes harvesting easier, improves the dry matter content of tubers, and makes full use of stored soil water. Soils should not be allowed to dry excessively during this period, otherwise harvesting becomes difficult, with bruising and tuber damage more likely.

An average for the total amount of irrigation required to produce an optimum potato crop in southern Queensland is around 350 mm or

3.5 ML/ha on the ground. Producers may have to pump a greater water volume than this to take into account evaporative losses and other inefficiencies in their irrigation systems. Obviously any rainfall would reduce requirements, although there may still be a need to irrigate for other purposes, such as frost control, fertiliser or pesticide incorporation. Irrigation regimes will also be affected by variety and crop management practices.

Because of high fertiliser requirements, there are significant risks of groundwater contamination where excessive irrigation occurs. In sub-humid and humid production areas, it may be important to leave a reserve of unfilled soil water storage, to act as a buffer against leaching rains. This can be achieved by growing potatoes after a deep-rooted crop such as forage sorghum, used to dry out the soil profile, and/or deficit irrigation (not completely refilling the root zone at each irrigation).

Potato producers may wish to apply sufficient water to get a small amount of drainage at each irrigation. This is essential when using poor quality water. The saltier the water, the more leaching is required at each irrigation. By irrigating to achieve a small amount of drainage beyond the root zone, the interval between irrigations can be slightly extended. This is because such a policy ensures the root zone is completely filled, and some water will move back up into the root zone from the subsoil via capillary action. In many situations, this can be a viable irrigation strategy, provided the drainage is not excessive.

Marketing

Marketing is one of the vital issues in successful potato growing, but regrettably one for which there is currently limited information available. Despite this, the principles are the same as for any product—no matter how good you think your product is, you must market a product that meets consumer needs. Three important elements are briefly covered in this section

Consumer considerations

more info
Reading on consumer research
Section 6 Pages 14,15

Research has shown that the main things considered when buying potatoes are:

- greening
- the amount of mechanical damage, for example cuts and bruising
- firmness (not being flabby)
- size
- skin blemishes, for example scuffing of skin due to premature harvesting, pronounced lenticels and damage from soil diseases
- misshapen tubers
- the boiling quality of the tubers (as a secondary consideration).

Consumers of fresh potatoes buy mainly on appearance and usually prefer clean, bright, white or red smooth skinned tubers in the small to medium (80 to 300 g) range.

To avoid mechanical damage, potatoes should be handled with great care. Throughout the harvesting, packing and handling processes, drops of greater than 15 cm should be avoided to reduce the risk of bruising and surface cracking.

Greening occurs when tubers are exposed to light for one or more days. To avoid greening, keep potatoes away from visible light throughout the entire marketing process.

To achieve the smooth, clean appearance buyers are looking for, the tubers are often harvested when immature but this makes them much more susceptible to mechanical damage and reduces their storage potential.

Trends in the potato market

Washed versus unwashed

more info
Throughput graphs
Section 1 Pages 4,5

more info
Price overview
Section 1 Page 3,4

There is an increasing trend towards washed potatoes. Throughput at the Sydney market is already higher for washed than unwashed potatoes.

Advantages of marketing washed potatoes are:

- higher prices
- increasing demand.

Disadvantages of marketing washed potatoes are:

- washing highlights any damage or injury that has occurred
- washing increases the risk of tuber infections and subsequent breakdown leading to shorter shelf life
- increased costs associated with washing
- tubers are more susceptible to greening under lights.

20 kg bags versus 50 kg bags

Washed potatoes are generally sold in 20 kg bags while unwashed potatoes are generally sold in 50 kg bags. However, there is a trend towards marketing all potatoes in 20 kg bags because of the ease of handling throughout the market chain.

Selling systems

Most potatoes are currently marketed through local merchants. A merchant buys the produce from you at an agreed price, then sells it for whatever price he can get.

There are other options which growers are now considering:

- selling to an agent or merchant at the major metropolitan markets. An agent sells your produce on your behalf, then receives a commission, usually about 12.5%.
- selling direct to a packer
- marketing through a group cooperative
- selling direct to a retailer.

Getting more involved in marketing

Research is showing that potato consumption in Australia is falling. This is happening not only from the impact of changing social patterns on food consumption but also from competition between potatoes and other food items such as rice, pasta and salads.

To maintain a competitive viable industry, growers need to get more involved in the marketing of their product. This ultimately leads to growers achieving more control over the price and return they recieve.

more info
Suppliers of price information
Section 6 Page 5

more info
References on market research
Section 6 Page 14, 15

Here are some of the things growers can do.

- Get an accurate measue of market trends by researching exisiting price and thoughtput data in the main markets.
- Read up on market research that has been conducted for potatoes.
- Support any market research proposed by your industry.
- Consider getting together with other growers to discuss new marketing options. This may merely be a collective examination of the market and agreement of broad product standards to meet market requirements. Preferably, it may lead to group cooperative marketing under a common quality management system. Through the longer lines of consistent quality produced under this system, access is possible to market segments unavailable to most individual growers.
- Review your on-farm production and packing system to bring your quality standards in to line with those identified by market research.
- Consider any value adding oppportunities such as washing, different packaging opportunities and development of convenience products.
- Support any promotional activities implemented by your industry.

Further information

more info
Where to obtain the kit
Section 6 Page 3

The Heavy Produce Committee of Queensland Fruit and Vegetable Growers has conducted extensive market research to develop a marketing plan for fresh potatoes. An information kit on this research may be obtained from QFVG.