Know-how for Horticulture™

An agronomic and economic blueprint for using whole, round seed for processing potatoes

John Maynard
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Horticulture Australia

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This report outlines the results of progressive research and financial analysis that brings together the agronomic aspects and economics of round potato seed production.

In undertaking this project we wish to acknowledge the assistance of commercial growers and the management and staff of Forthside Vegetable Research Station, as well as valuable technical contributions from Dr Rowland Laurence, Leon Hingston and Suzanne Morris of the Tasmanian Institute of Agricultural Research. We also wish to acknowledge the support of the Tasmanian Vegetable Agricultural Research and Advisory Committee and funding supplied by Horticulture Australia through the potato levy.

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Media Summary

This project was designed to investigate how seed growers could produce round seed, what price it could be grown for and under what conditions processing growers could benefit from the use of round seed.

The project concentrated initially on the effect of using round and cut setts as well as increasing density on the yield of round seed. For the purposes of these trials round seed was defined as tubers with a width range of between 30 and 60mm and a maximum length of 85mm. Trials were conducted in Tasmania on red ferrosol soils at Riana and Forth in the North-West and on duplex soils near Cressy in the Northern Midlands, over the period 1999-2001 and 2002-03. At no site did whole setts produce higher yields of total tubers or round seed tubers than cut setts. Under these circumstances of relatively good growing conditions, it seemed that similar yields could be expected irrespective of whether cut setts or whole setts were used. As crop rotations and hygiene conditions for seed crops are more demanding than for processing crops, it was reasonably concluded that seed growers would be best to establish seed crops by adopting the cheaper method of using cut seed.

With the exception of Cressy in 1999-2000, increasing density from 1.5 to 20 setts per square metre had no effect on total yield or total tuber number but significantly increased round seed yield and round seed number. The highest yield and number of round seed occurred at the highest density trialed at each site. However, a gross margin analysis showed there was no economic advantage in exceeding a sett density of 6.5 per m^2 in most situations. 6.5 setts per m^2 is very close to the average density currently used by Russet seed growers.

Clearly, if seed growers were required to maximise round seed yield, a density of at least 20 setts per m^2 would be required and a premium price would be required. This premium equates to a effective round seed price of $490 per tonne (ferrosol soils) and $1,000 per tonne (duplex soils) respectively. The higher premium for Cressy-grown seed is due, in part, to a tendency to produce higher round seed yields at lower densities than on ferrosol soils. A much higher premium is therefore required to satisfy the criteria set above.

These results indicate that the response of Russet crops to different densities can vary from one location to another. They suggest that the production of round seed in Tasmania should be centred on the ferrosol soils on the North-West Coast in preference to the duplex soils near Cressy.

It was not possible in this Project to set up trials to simulate adverse soil and environmental conditions to test the potential advantages of round seed over cut seed. However, using gross margin models developed as part of this Project, it was possible to estimate the theoretical affordability of round seed under various reduced yield conditions. The underlying assumption here is that round seed can fully overcome yield losses incurred in crops established from cut setts.

If round seed is used at the same *sett* density as cut seed, growers of processing crops suffering yield losses of 10% or more could afford to pay $490 per tonne for round seed. However, round setts generally produce less stems than cut setts. To make a more accurate comparison, a re-calculation is needed at the same *stem* density. More seed is needed per hectare to produce the same stem number, hence processing growers can afford to pay less for round seed. Under these conditions, processing growers suffering yield losses of 22.2% or more could afford to pay $490 per tonne for round seed. However, if processing growers are confident that round seed will prevent yield reductions, $490 per tonne for round seed is still a relatively cheap price to pay.

Although density studies were the main focus of field trials, other studies were conducted to determine if the reversible sprout inhibitor s-Carvone could increase round seed yields. Results in two field trials showed a slight increase in round seed yield and tuber number. However, in other trials in Tasmania, the efficacy of s-Carvone varied considerably between seed lots, and as it is not possible to predict which seed lots will be responsive to the material, the treatment is of limited commercial applicability.

In further work seed from different generations, methods of storage and times of harvest were trialed for round seed yield response. No significant effect was measured, except G4 seed collected from Oatlands (Southern Midlands) produced higher round seed yield than G3 seed from the same location.

The Project has successfully produced a blueprint for the production of round Russet Burbank seed. However, other factors need to be studied in greater detail such as the variation between seed lots, the effect of pre-mature desiccation of haulms and the effect of higher densities on round seed yield. The economic studies undertaken in this Project probably represents the most in-depth analysis of its type in Australia. It has successfully highlighted the interaction between the economics of seed and processing crops as well as between sett and stem densities. In this context the modelling is readily adapted to similar situations in other potato growing districts.

Technical Summary

Seed quality and planting efficiency have been recognised as key factors influencing the yield and returns for processing potatoes. Many seed lines contain tubers that are too large for efficient machine cutting, resulting in blind and miss-planted setts. Under certain soil and environmental conditions, the surfaces of cut seed can break down resulting in poor stands, misshapen tubers and low yields.

This project was designed to investigate how the use of round seed would benefit the processing French fry industry in Australia. Potential benefits of round seed to the processing growers include more reliable yield, more uniform size and higher returns. Potential benefits to the processor include more uniform raw material, greater predicability of yield forecasting, in higher recovery rates in the factory and lower per unit costs. However, for processors and their suppliers to achieve these gains, the seed grower must be able to successfully grow round seed profitably. The results of this project shows how seed growers can maximise the yield of round seed and what its price needs to be to be profitable. It also reports upon the conditions under which processing growers can afford to pay for round seed.

In order to evaluate how seed growers could successfully grow round seed, a total of five Tasmanian field trials were conducted on red ferrosol soils at Riana and Forth in the North-West and on duplex soils near Cressy in the Northern Midlands, over the period 1999-2001 to 2002-03. At no site did whole setts produce higher yields of total tubers or round seed tubers than cut setts. For the purposes of these trials round seed was defined as tubers with a width range of between 30 and 60mm and a maximum length of 85mm. Under these circumstances of relatively good growing conditions, it seemed that similar yields could be expected irrespective of whether cut setts or whole setts were used. As crop rotations and hygiene conditions for seed crops are more demanding than for processing crops, it was reasonably concluded that seed growers would be best to establish seed crops by adopting the cheaper method of using cut seed.

With the exception of Cressy in 1999-2000, increasing density from 1.5 to 20 setts per square metre had no effect on total yield but significantly increased round seed yield and tuber number. The highest yield and number of round tubers occurred at the highest density trialed at each site. However, there was no economic advantage in exceeding a sett density of 6.5 per m^2 in most situations (Table i). 6.5 setts per m^2 is very close to the average density currently used by Russet seed growers.

Table i: Relationship Between Density and Round Seed Yield

(Shaded Cells Represents Treatment Producing Highest Gross Margin at Each Site)

Setts/m^2		1999-2000				2000-01				2002-03	
		Cressy (T/Ha)		Riana (T/Ha)		Cressy (T/Ha)		Forth (T/Ha)		Forth (T/Ha)	
20		18.2	*a*	16.8 *	*a*	34.9	*a*	33.4	*a*		
12		13.5	*b*	14.2	*b*	28.9	*b*	27.1	*b*	29.5	*a*
12	(Bed)	8.0	*c*	8.9	*c*						
6.5		8.5	*c*	8.4 *	*c*	17.2	*c*	15.4	*c*	19.6	*b*
3		5.6	*d*	4.3	*d*						
1.5		3.1	*e*	3.0	*d*						

Duncans Multiple Range – figures followed by the same letter are not significantly different.
* Equal Gross Margins

Clearly, if seed growers were required to maximise round seed yield, a density of at least 20 setts per m^2 would be required. This would require more seed at an increased cost. To compensate for these extra costs, a premium price is required.

The required premium has been calculated to enable a seed grower to make around $500 per hectare higher gross margin using a sett density of 20 setts per m^2 than at 6.5 setts per m^2. $500 represents an allowance to cover the additional interest costs on the extra seed planted compared to the "normal" density of around 6.5 setts per m^2 (an extra 8.7 tonnes per hectare of seed) plus associated costs of storage, cutting, treatment and transport, at 10% interest for an average of 11 months.

Using this criteria, the premium price required for round seed produced on ferrosol soils is 45% and the same for round seed grown on Cressy soils is 200%. This equates to an effective round seed price of $490 per tonne and $1,000 per tonne respectively (Table ii). The higher premium calculate here for Cressy-grown seed is due largely to a tendency to produce higher round seed yields at lower densities than on ferrosol soils. A higher premium is therefore required to satisfy the criteria set above.

Table ii: Calculated Premium Round Seed Price

Round Seed Premium	Riana, Forth (Ferrosol)	Cressy (Duplex)
Increase Over Existing Certified Price*	+45%	+200%
Effective Price per Tonne	$490	$1,000

* Compared to the 2002-03 effective contract price of $335 per Tonne

These results indicate that the response of Russet crops to different densities can vary from one location to another. They suggest that the production of round seed in Tasmania should be centred on the ferrosol soils on the North-West Coast in preference to the duplex soils near Cressy.

It was not possible in this Project to set up trials to simulate adverse soil and environmental conditions to test the potential advantages of round seed over cut seed. However, using gross margin models developed as part of this Project, it was possible to estimate the theoretical affordability of round seed under various reduced yield conditions. The underlying assumption here is that round seed can fully overcome yield losses incurred in crops established from cut setts.

If round seed is used at the same *sett* density as cut seed, growers of processing crops suffering yield losses of 10% or more could afford to pay $490 per tonne for round seed. However, round setts produce less stems than cut setts. To make a more accurate comparison, a re-calculation is needed at the same *stem* density. More seed is needed per hectare to produce the same stem number, hence processing growers can afford to pay less for round seed. Under these conditions, processing growers suffering yield losses of 22.2% or more could afford to pay $490 per tonne for round seed (Table iii). However, if processing growers are confident that round seed will prevent yield reductions, $490 per tonne for round seed is still a relatively cheap price to pay.

Table iii: Break-Even Price for Using Round Seed in Processing Crops

Cut Setts		Break-Even Round Seed Price	
Total Yield (T/Ha)	(Change)	Equivalent Stems/Ha Basis ($/T)	Equivalent Setts/Ha Basis ($/T)
60	0%	92	226
54	-10%	271	490
48	-20%	451	751
46.7	-22.2%	490	
42	-30%	630	1,013
36	-40%	810	1,276
30	-50%	990	1,538

Although density studies were the main focus of field trials, other studies were conducted to determine if the reversible sprout inhibitor s-Carvone could increase round seed yields. Two field trials were conducted in 2000-01 at Cressy and Forth. There was no effect of s-Carvone on total yield or total tuber number, but it did increase the production of round seed yield and round seed number. However, the benefit was less than that found by Dr Philip Brown in other trials in Tasmania (PT98008). Dr Brown concluded that the efficacy of s-Carvone varied considerably between seed lots, and as it is not possible to predict which seed lots will be responsive to the material, the treatment is of limited commercial applicability. As a consequence, no further work with s-Carvone was undertaken as part of this Project.

To test the variation between seed lots, a further field trial was conducted in 2002-03 using seed collected from a range of sources around Tasmania and from different generations, methods of storage and times of harvest. No significant effect was found on round seed yield, except G4 seed collected from Oatlands (Southern Midlands) produced higher round seed yield than G3 seed from the same location.

The Project has successfully produced a blueprint for the production of round Russet Burbank seed. However, to complete the blueprint, other factors need to be studied in greater detail such as the variation between seed lots, the effect of pre-mature desiccation of haulms and the effect of higher densities than those used in this Project on round seed yield. The variation between seed lots is considered the most important area for future study. Dr Brown concluded that seed performance is influenced by the interaction between the physiological condition of the tuber when planted and the environment into which it is planted. Until these factors are better understood, processing growers will need to continue to purchase seed from seed growers who's product gives a consistently good performance.

The economic studies undertaken in this Project probably represents the most in-depth analysis of its type in Australia. It has successfully highlighted the interaction between the economics of seed and processing crops as well as between sett and stem densities. In this context the modelling is readily adapted to similar situations in other potato growing districts.

1. Introduction

Seed quality and planting efficiency have been recognised as key factors influencing the yield and returns of processing potatoes in Australia. Samples of seed collected annually from Simplot's Tasmanian seed growers and planted at a single site have consistently shown variations in processing yield of up to 25-35% (pers comm). Currently, in Tasmania, virtually all seed crops and around 95% of processing potatoes are established using cut setts. However, it is known that cut setts can break down under certain soil and environmental conditions resulting in poor yields of often variably sized and misshapen tubers. Field performances of this type are costly for the grower and the industry.

When tubers are cut, the surface is more susceptible to attack by disease organisms particularly if the surface does not cure and conditions are suitable for diseases to develop. Under some conditions, round setts can perform much better than cut setts (Strange & Blackmore, 1990[1]). Poor emergence of Russet Burbank grown from cut seed can be common in cool, wet spring conditions in Tasmania especially if the seed has been cut for several days and poorly stored waiting for a break in the weather. Other varieties susceptible to seed piece breakdown and suitable for planting of round seed include Atlantic, Coliban, Norchip, Sebago, Sequoia and Tarago (Blackmore, 1995[2]).

This Project was initiated to investigate the production of round seed in Russet Burbank and to estimate the potential benefits of processing growers using round seed. Field trials initially concentrated in measuring the effect of increasing sett density on total and round seed yields. Field trials in Tasmania in 1996-97 using Atlantic showed that density had the greatest influence on round seed yields, but there were also significant interactions between density and site (Laurence et al, 1997[3]). The best way of manipulating round seed yield is by increasing the number of seed tubers planted, the size of the seed tuber planted and its physiological age (Struik and Wiersema, 1999[4]).

The physiological status of the seed tuber is crucial for its quality as planting material. The term physiological age (p-age) can be defined as the physiological state of the tuber which influences its productive capacity. It can also be defined as the stage of development of a tuber, which is modified progressively by increasing chronological age, depending on growth history and storage conditions (Struik and Wiersema, 1999[5]). Therefore p-age is determined by chronological age (ie age from the time of tuber initiation) and by the conditions during production and storage of the seed tuber.

The main factors influencing that rate of physiological ageing of tubers include (Struik and Wiersema, 1999[6]);

- Cultivar
- Tuber size
- Storage conditions and duration
- Seed treatment
- Previous growing conditions
- Degree of tuber maturity at harvest

This Project concentrated on the effect of increasing density. The optimum seed rate in practice depends on the price of seed tubers, the multiplication factor and the yield and price for the various components of harvested yield (Struik and Wiersema, 1999[7]). In this Project, gross margin models for seed and processing crops were developed based upon Simplot's Tasmanian 2002-03 contract system. These were used to measure seed growers' returns and to determine the price at which round seed could be sold. It was not possible in this Project to simulate adverse soil and environmental conditions to test the benefit of round seed over cut seed. However, it was possible to manipulate the gross margin models to determine under what conditions processing growers could afford to pay the required round seed price.

The economic models developed here are unique as they were designed to fit the contract system of one particular processor and the production costs representative of Tasmanian growers. However the models and methodology can be adapted to represent other situations in other potato growing areas. Some previous economic modelling has been done in Australia. In a series of trials in Queensland, Jackson and Johnson, 1997[8] found that round seed produced more stems per plant than cut seed and had greater emergence, higher yields in the 80-350g range, a more impressive top growth and usually higher yields. However, when the extra costs of round seed was taken into account, the extra yield did not always translate into improved returns. However, these workers suggested that a varying physiological age of round seed used in the trials may have limited its potential.

The yield component formula for potatoes can be expressed as (Stuik, PC and Wiersema, SG. (1999[9]);

Yield = No. Main Stems per Hectare *x* No Useable Tubers per Stem *x* Average Tuber Weight

This illustrates the importance of stem density, as opposed to sett density, as a key determinant of final crop yield.

This Project was undertaken in close collaboration with another project managed by Dr Philip Brown from the Tasmanian Institute of Agricultural Research (Improving Seed Potato production – PT98008[10]). Dr Brown's main focus was physiological age and specifically the indicators of p-age and factors influencing it. He also investigated the efficacy of a reversible sprout inhibitor s-Carvone in increasing stem and tuber number.

Consequently, in the second year of this Project, s-Carvone treatments were added in order to evaluate its effect in increasing the yield of round seed. Whilst we were able to show increases in round seed yield, they were less than the effect found by Dr Brown. Dr Brown in the meantime had shown that s-Carvone treatment was effective in increasing round seed yield but the results were inconsistent across seed lots. He concluded that the level of variation, together with the fact that it was not possible to predict which seed lots will be responsive to the treatment, s-Carvone is of limited commercial applicability. On this basis, further work on s-Carvone in this Project was abandoned.

It seemed that the variation between lots was an over-riding and poorly understood factor influencing processing crop performance. It was considered appropriate that some investigation of these factors should be incorporated into the Project. Approval from HAL was then granted to extend and vary the original objectives of the Project to include collecting and evaluating the effect on round seed yield of different seed lots and different harvest dates, storage conditions and generation.

The results of this Project should reinforce to seed and processing growers that the economics of round seed production and its future use in the industry is intimately linked with the contract payment system for both seed and processing crops. It also highlights that the traditional concept of sett or plant numbers as the main measure of crop density should be abandoned and replaced with stem density. Along with the normal factors such as soil and environmental conditions, it is the latter that exerts the main influence over final crop yield and size distribution.

It is true that the influence of factors such as seed growing conditions, p-age, haulm destruction vs natural senescence and other treatments capable of managing tuber number in seed crops all need to be better understood. However, if put into context, all of these factors have a lesser influence on round seed production than density. Further work on these factors and the associated economics in seed production is warranted. This will help "put the icing on the cake" and the current 25-35% variation in the performance of seed lots from different seed growers can then be reduced.

2. Materials & Methods

2.1 Field Studies

1999-2000

The initial research in this project concentrated on determining the role of growing methods and laboratory produced minitubers in the production of round seed.

Two field trials were established in November 1999 on private properties in Tasmania at Riana (North-West coast on a red ferrosol soil) and near Cressy (Northern Midlands on a duplex soil). These sites were selected to represent a traditional seed potato growing district (Riana) and a relatively new district for seed production (Cressy). At each site a split plot randomised block design was adopted to evaluate the effects of three sett types (cut, whole and Technituber®), planted by hand in moulded rows spaced 810mm apart, at five different densities (1.5, 3, 6.5, 12 and 20 setts per m^2). The sett types were also evaluated in flat beds at 1.64m centres, using three rows per bed at 300mm spacings and setts planted to achieve a density of 12 plants per m^2. Each treatment at each site was replicated four times. Cut and whole setts were selected from a single original source of seed with a known history in order to minimise the variation and physiological age differences.

Basal fertiliser was pre-drilled at each site with the growers' commercial mixture. Subsequent weed, pest and disease control and irrigation treatments were applied to coincide with the surrounding commercial crop.

Each trial was allowed to grow out to natural haulm senescence. Harvesting occurred in April and May 2000 at Cressy and Riana respectively, by twin row digger and hand pickup. Tubers were then counted and individually size-graded and weighed.

2000-01

The results in 1999-2000 trials showed that cut and whole sets produced higher yields and tuber numbers than Technitubers®. Whilst it is possible that the Technituber® progeny could have produced more favourably if replanted in the following season, it was decided to discontinue work with Technitubers® and redirect effort to investigating the efficacy of s-Carvone.

Two trials were conducted in 2000-01 at Forthside Vegetable Research Station (North-West coast on a red ferrosol soil) and Cressy (duplex soil). At each site a split plot randomised block design was adopted to evaluate the effects of two sett types (cut and whole), planted by hand in moulded rows spaced 810mm apart, at three different densities (6.5, 12 and 20 setts per m^2). Each treatment was grown with and without s-Carvone. Treated tubers, previously stored at 4˚C following harvest, were transferred to temperature controlled shipping containers for s-Carvone treatment in early October. S-Carvone (commercial formulation 'Talent®', supplied through BV Luxan, Netherlands), was applied at the rate of 100 mls/tonne. It was applied directly into the refrigerated container with vents closed, but with air continuing to circulate. Control seed was treated in an identical manner in a separate container, although no chemical was applied. The containers were opened back to air circulation after 24 hrs.

Planting occurred in early November 2000. Basal fertiliser was pre-drilled at each site with a commercial mixture. Subsequent weed, pest and disease control and irrigation treatments were applied to coincide with normal commercial practice.

Each trial was allowed to grow out to natural haulm senescence. Harvesting occurred in April and May 2000 at Cressy and Forthside respectively, by twin row digger and hand pickup. Tubers were then counted and individually size-graded and weighed.

While the positive effect of s-Carvone application on the production of round tuber grades of seed crop was statistically significant, it was less than found by Dr Brown in his earlier work. Interactions between seed sett type (cut or whole), planting densities and s-Carvone treatment were generally insignificant.

2001-02

Collaboration with Dr Brown on his project revealed in 2001 that there was a strong influence of the seed planting environment on sprouting behaviour of tubers. Identical seed lots planted under two different environments may display different sprouting behaviour. Dr Brown concluded that seed crop production conditions exerted a significant influence on seed performance by influencing the sprouting behaviour (number and position of sprouts likely to develop after different periods of storage) and the vigour of the seed lot. While some genetic influence could be discounted (although all sources used in the trial were of one clonal type), the variation in mother crop husbandry, harvest and storage conditions of the seed lots was considered likely to have been a major cause of the variation found between seed lots. Dr Brown concluded that, whereas there was significant potential to improve the quality of Australian seed potatoes through manipulation of physiological quality during seed production, further investigation was required.

Following Dr Brown's results, it was decided to apply to Horticulture Australia for approval to vary the original work plan of PT99022. The main reason was to further evaluate the effect of the previous generation growing conditions on the production of small whole tubers in the following crop. However, there was also a need to bulk up tubers harvested from the previous season's trials in readiness for the 2002-03 season. With the assistance of Simplot's field staff, a restricted survey of seed crops was undertaken to identify those with varying harvest dates and methods of storage. From Dr Brown's work, it was expected that later harvests and field stored tubers would be physiologically older than earlier harvested and cool stored crops respectively, and hence, more likely to produce more round seed.

After the survey, samples were harvested from crops at Forth and Riana (North-West Tasmania) and Oatlands (Southern Midlands). After collection, all tubers from non-farm stored treatments were cool stored at 4°C. Details are outlined in Table 1.

Table 1: Details of Seed Crops Sampled

Seed Source	Generation	Treatment	Harvest Date	Date Cool Stored
Forth	G6	Various *	17/4/02	19/4/02
Riana	G3	Harvest 1	22/5/02	22/5/02
Riana	G3	Harvest 2	24/6/02	2/7/02
Oatlands	G3	Cool stored	2/7/02	17/7/02
Oatlands	G3	Farm stored	2/7/02	-
Oatlands	G4	Cool stored	15/5/02	17/7/02
Oatlands	G4	Farm stored	15/5/02	-

* Material sourced from Forthside constituted a collection of tubers grown in the previous year from whole and cut setts planted at densities of 6.5, 12 and 20 setts per m^2.

2002-03

On 3rd and 6th December 2002, cuts setts of tubers collected in the previous season were planted at Forth at two densities of 6.5 and 12 plants per m^2. As for in the previous years, a commercial fertiliser and crop protection program was adopted. Harvesting occurred on 6th May 2003 by twin row digger and hand pickup. Tubers were then counted and individually size-graded and weighed.

2.2 Potato Planter Trials

The preferred physical size of round seed needed to be determined. This was defined as being that size that could be most successfully planted by potato planting machines.

Establishing field trials and monitoring grow-outs was one method of determining round seed size. However, this was very time consuming and was not considered justified in this case. As a practical alternative, a "shop floor" trial was established in conjunction with a key Tasmanian potato machinery agent, using two planting machines using different planting mechanisms. The Dobmac® clamp planter and a Harriston® needle planter were selected for the test. The Dobmac® was a popular Tasmanian built model used by many commercial growers and had been available on the market for some years. The Harriston® was an imported machine and whilst a relative newcomer to the market, adopted a modified needle pickup system that had been the basis of more traditional planting machinery used in the past.

Table 2: Size Grades of Test Tubers

Width (mm)	Length (mm)
30-40	30-40
30-40	40-50
30-40	50-60
30-40	60-70
40-50	40-50
40-50	50-60
40-50	60-70
40-50	70-80
50-60	60-70
50-60	70-80
50-60	80-90
50-60	90-100
60-70	70-80
60-70	80-90
60-70	90-100
60-70	100-110
70-80	80-90
70-80	90-100
70-80	100-110

200 Russet Burbank tubers (4 replicates of 50) were graded into each size range (Table 2). These ranges were designed to cover the likely sizes that the machinery agent believed each machine could physically handle. Tubers in each size range were then loaded into the seed hopper of each machine. With the machine lifted off the ground, the drive wheels were turned manually at a rate approximately equivalent to the recommended forward speed of operation in the field.

Once testing commenced it became clear that the 50-tuber sample constituted an insufficient volume to enable a reliable pick-up from the hopper. Two replicates of 100 tubers each were then adopted to test all size ranges.

Each size range was tested until all the tubers had been used up or it was obvious that the mechanism, even after readily accessible adjustments, could not handle the size under test.

The percentage of single tubers successfully picked up by each machine was measured for each size grade. On the basis of these results, the physical size of round seed was determined.

2.3 Economic Analysis

The economic analysis was initiated in 2001-02 with initial work concentrating on developing a mathematical gross margin model for seed and commercial potato production. This was achieved in conjunction with Simplot's field staff and was based on the company's Tasmanian seed and processing production system.

A gross margin is defined as Gross Income *less* Variable Costs. Variable costs are normally defined as those costs that vary with the scale of the operation, such as fertiliser, amount of seed used, irrigation, machinery operating costs etc. Casual labour is also included. An allowance for the grower's own labour is sometimes included in gross margins, at an hourly rate equivalent to what would be paid to someone else to do the same job. However, experience has shown that even on similar crops, there can be very large variations between the time inputs of different growers. This often leads to a debate about what is a reasonable time input for the successful production of a crop and what is unreasonable.

It is acknowledged that growers spend a considerable amount of time in the growing of crops. However, to avoid this possible confusion between reasonable and unreasonable levels of time input, the gross margins developed for this analysis exclude grower time inputs for tractor work and management. For this purpose we have interpreted management as including the timely supply of inputs, regular checking of crop progress, pest and disease status, moisture levels, supervision of labour or contractors, liaison with agronomists and so on. An allowance for labour has been included for stone carting, roguing (seed crops), irrigation and harvesting.

Using this technique, the gross margin calculated here represents the return on risk, cash outlays *and* management of the potato crop.

The results of the field trials were then superimposed over the gross margin models. The key variables were seed cost (from varying densities), total yield and round seed yield. From this data, the model computes a gross margin. The gross margin for seed crop production was used to compute a premium price that would need to be charged to processing growers if seed growers were required to produce crops to maximise the yield of round seed.

A critical question then was – can processing growers afford to pay this price? Processing crops grown using cut seed can suffer yield reductions caused by a number of factors including seed piece breakdown and disease. In order to answer this critical question for processing growers, we have assumed that the yield loss could have been entirely prevented by using round seed rather than cut seed. The model was then manipulated to calculate the break-even price that processing growers could afford to pay.

3. Results

3.1 Potato Planter Trials

The results for the two replicates are summarised in Table 3. The Harriston® was more successful in picking up single tubers over the full range of tuber sizes tested. No multiple pick-ups were measured. However the machine's efficiency reduced once tubers in excess of 70mm wide and 90mm long were used.

In contrast, the performance of the Dobmac® was more variable. The machine was unable to pick up single tubers when tuber size was either relatively small or relatively large. However, over a narrow band of sizes, the Dobmac® results were slightly superior to the Harriston®. The Dobmac®'s best performance occurred where tuber size was within the range from 40mm wide by 40mm long and 60mm wide by 70mm long. Planting efficiency reduced to 80% and below when tubers exceeded 60mm wide and 70mm long.

Results for each machine could possibly have been improved if additional "work shop" adjustments were made to the pick-up mechanisms. For example, it could have been possible to reduce the percentage of multiple pick-ups with the Dobmac® clamps set at 50mm instead of the standard 55mm.

On the basis of these data, a tuber with a width range of between 30 and 60mm and a maximum length of 85mm was selected as best representing the size of round seed. In the planter tests, both machines successfully handled this size range with minimal adjustment.

Table 3: Percentage of Single Tubers

Tuber Width	Tuber Length	Dobmac®		Harriston®	
(mm)	(mm)	Rep 1	Rep 2	Rep 1	Rep 2
30-40	30-40	100 *	100 *	95	95
30-40	40-50	100 *	100 *	95	95
30-40	50-60	100 *	100 *	95	95
30-40	60-70	100 *	na	na	na
40-50	40-50	100	100	98	98
40-50	50-60	100	100	98	98
40-50	60-70	100	100	98	98
40-50	70-80	100	100	95	95
50-60	60-70	100	100	95	95
50-60	70-80	90	90	95	95
50-60	80-90	90	90	95	95
50-60	90-100	80	80	95	95
60-70	70-80	80	80	95	95
60-70	80-90	50	50	95	95
60-70	90-100	nr	nr	95	95
60-70	100-110	nr	nr	95	95
70-80	80-90	nr	nr	92	na
70-80	90-100	nr	nr	80	80
70-80	100-110	nr	nr	80	80

* Multiple tuber pickup.
na Insufficient tubers to conduct test.
nr Not recorded, as it was obvious the tuber size was unsuitable.

3.2 Effect of Sett Type

For the purposes of this report, the description 'whole' refers to the nature of the planting material (ie setts), 'round' to the progeny (ie seed harvested).

The first two seasons of this project concentrated on determining whether cut or whole setts had any significant impact on the total and round seed yields. Technitubers® were also included in 1999-2000 trials. The results are illustrated in Table 4 and Table 5 as well as Figure 1 and Figure 2.

In 1999-2000, both cut and whole setts produced significantly higher total and round seed yields than Technitubers®. There was also no advantage of using whole setts over cut setts (Table 4). This latter result was confirmed in trials in the following season (Table 5).

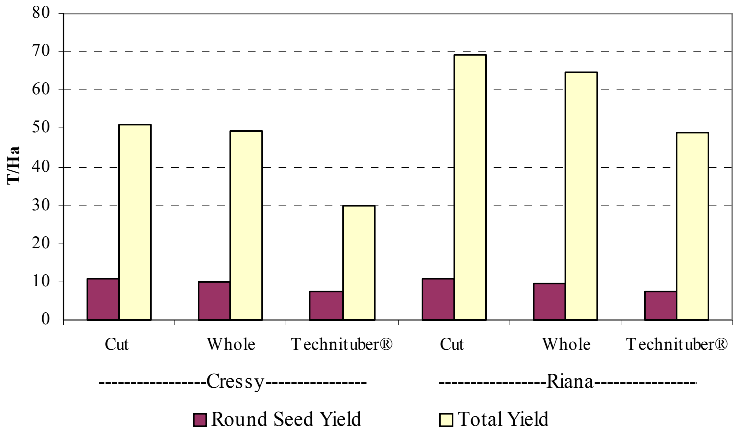
It should be noted that a direct comparison of Technitubers ® against cut and whole setts unfairly favours the latter sett types. The results presented here should not be interpreted as describing them as an inferior product. The original intention was to continue work with the Technituber ® progeny in the following year. However, a decision was made to suspend further work in favour of commencing work in 2000-01 on s-Carvone.

Table 4: Effect of Sett Type on Total and Round Seed Yields, 1999-2000

	Cressy		**Riana**	
Total Yield	(T/Ha)		(T/Ha)	
Cut Setts	51.1	*a*	69.2	*a*
Whole Setts	49.3	*a*	64.6	*a*
Technituber®	30.0	*b*	49.1	*b*
Round Seed Yield				
Cut Setts	10.8	*a*	10.9	*a*
Whole Setts	10.1	*a*	9.5	*b*
Technituber®	7.6	*b*	7.4	*c*
Stems Per m^2				
Cut Setts	15.3	*a*	15.3	*a*
Whole Setts	12.6	*b*	12.3	*b*
Technituber®	8.9	*c*	8.3	*c*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

Figure 1: Effect of Sett Type on Total and Round Seed Yields, 1999-2000



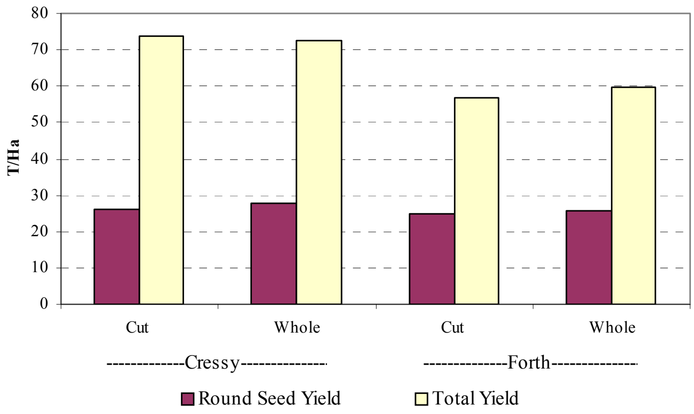
In 1999-2000 at both sites, cut setts produced significantly more stems per m^2 than whole setts (Table 4). However, this was not the case in 2000-01 (Table 5).

Table 5: Effect of Sett Type on Total and Round Seed Yields, 2000-01

	Cressy		Forth	
Total Yield	(T/Ha)		(T/Ha)	
Cut Setts	73.8	*a*	56.8	*a*
Whole Setts	72.7	*a*	59.5	*a*
Round Seed Yield				
Cut Setts	26.2	*a*	24.9	*a*
Whole Setts	27.8	*a*	25.9	*a*
Stems Per m^2				
Cut Setts	29.1	*b*	25.7	*b*
Whole Setts	32.1	*a*	28.2	*a*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

Figure 2: Effect of Sett Type on Total and Round Seed Yields, 2000-01



3.3 Effect of Density

Effect on Yield

With the exception of Cressy in 1999-2000, increasing density had no effect on total yield but a significant effect on round seed yield. At all sites in all years, increasing density mostly resulted in significantly increased yields of round seed (Table 6 to Table 8 and Figure 3 to Figure 5).

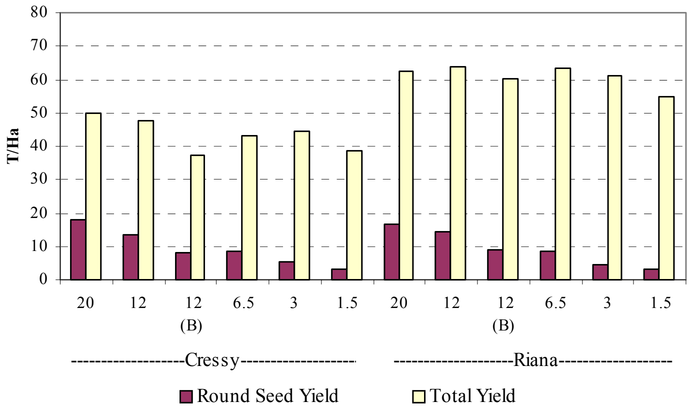
In 1999-2000, a density of 12 plants per m^2 on a bed arrangement produced a significantly lower round seed yield that the same density in traditional moulds. Further, round seed yields (beds) were no different to a density of 6.5 plants per m^2 in moulds. On the basis of these results, the bed arrangement was dropped from subsequent trials. Also dropped were densities of 3 and 1.5 plants per m^2 because these treatments failed to produce satisfactory total and round seed yields in 1999-2000.

Table 6: Effect of Density on Total and Round Seed Yield, 1999-2000

	Cressy		Riana	
Total Yield	(T/Ha)		(T/Ha)	
20 (/m²)	50.0	*a*	62.5	*a*
12	47.5	*ab*	63.8	*a*
12 (Bed)	37.2	*d*	60.2	*a*
6.5	43.1	*bc*	63.2	*a*
3	44.7	*b*	61.1	*a*
1.5	38.5	*cd*	54.9	*b*
Round Seed Yield				
20 (/m²)	18.2	*a*	16.8	*a*
12	13.5	*b*	14.2	*b*
12 (Bed)	8.0	*c*	8.9	*c*
6.5	8.5	*c*	8.4	*c*
3	5.6	*d*	4.3	*d*
1.5	3.1	*e*	3.0	*d*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

Figure 3: Effect of Density on Total and Round Seed Yield, 1999-2000



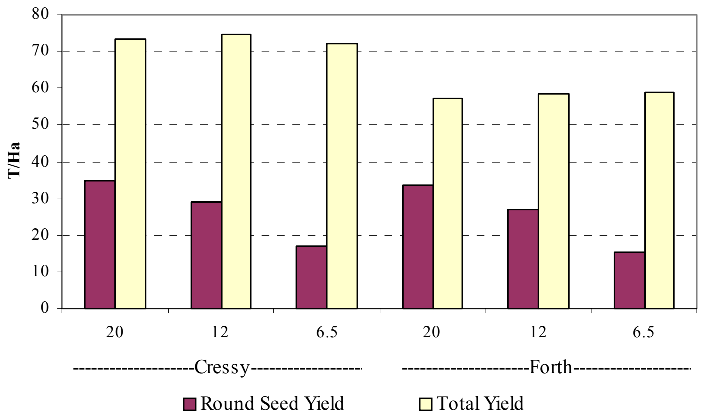
The effects of density on total and round seed yields were similar in 2000-02 trials. Yields were higher at Cressy than the previous year due to the selection of a more favourable trial site. At both sites, densities of 20, 12 and 6.5 setts per m^2 had no effect on total yield. However, round seed yields increased significantly with greater density (Table 7, Figure 4).

Table 7: Effect of Density on Total and Round Seed Yield, 2000-01

	Cressy		Forth	
Total Yield	(T/Ha)		(T/Ha)	
20 (/m²)	73.2	*a*	57.2	*a*
12	74.6	*a*	58.5	*a*
6.5	72.1	*a*	58.7	*a*
Round Seed Yield				
20 (/m²)	34.9	*a*	33.4	*a*
12	28.9	*b*	27.1	*b*
6.5	17.2	*c*	15.4	*c*

Duncans Multiple Range – figures followed by the same letter are not significantly different

Figure 4: Effect of Density on Total and Round Seed Yield, 2000-01



A preliminary analysis of the economics of seed growing was conducted in August 2001 using the results of the first two season's trials. This showed that the highest gross margin was produced at densities less than 20 setts per m^2. These results showed that revenue from the extra yield of round seed was insufficient to cover the costs of the additional seed planted. On this basis, further trials at 20 plants per m^2 were discontinued.

The final field trial at Forth was conducted in 2002-03. Whilst the trial was mainly established to investigate the effect of seed source, treatments were selected to confirm previous effects of density. The results are shown in Table 8 and Figure 5.

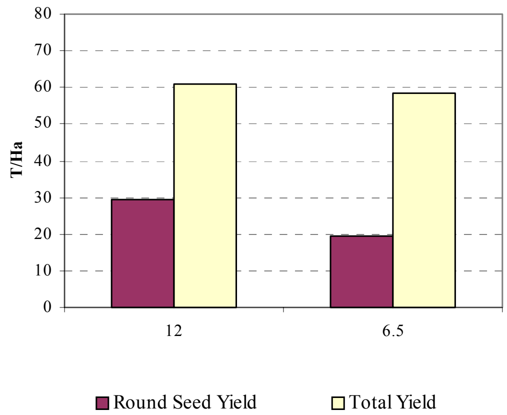
The results confirmed previous results. A density of 12 setts per m^2 showed no advantage in terms of total yield but produced significantly higher round seed yield.

Table 8: Effect of Density on Total and Round Seed Yield, 2002-03

		Forth	
Total Yield		(T/Ha)	
12	(/m²)	61.0	*a*
6.5		58.5	*a*
Round Seed Yield			
12	(/m²)	29.5	*a*
6.5		19.6	*b*

Duncans Multiple Range – figures followed by the same letter are not significantly different

Figure 5: Effect of Density on Total and Round Seed Yield, 2002-03



Effect on Tuber Number

Increasing density significantly increased total and round seed number (Table 9 to Table 11 and Figure 6 to Figure 8).

In 1999-2000, a density of 12 plants per m^2 on a bed arrangement produced similar results to a density of 6.5 plants per m^2 in moulds.

Table 9: Effect of Density on Total and Round Seed Number, 1999-2000

	Cressy		Riana	
	(No./m^2)		(No./m^2)	
Total No.				
20 (/m^2)	49.8	*a*	51.3	*a*
12	40.1	*b*	46.6	*b*
12 (Bed)	27.4	*c*	36.8	*c*
6.5	30.1	*c*	37.1	*c*
3	23.8	*d*	26.4	*d*
1.5	16.9	*e*	21.1	*e*
Round Seed No.				
20 (/m^2)	27.7	*a*	23.6	*a*
12	19.5	*b*	19.4	*b*
12 (Bed)	11.8	*c*	12.0	*c*
6.5	12.2	*c*	10.9	*c*
3	7.5	*d*	5.6	*d*
1.5	4.6	*e*	3.9	*d*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

Figure 6: Effect of Density on Total and Round Seed Number 1999-2000

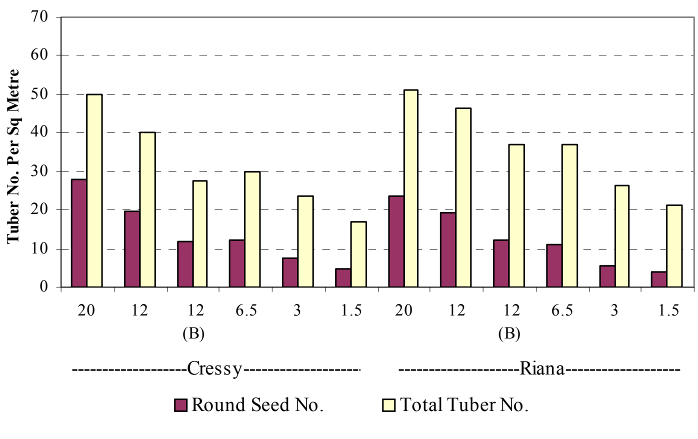


Table 10: Effect of Density on Total and Round Seed Number, 2000-01

	Cressy		Forth	
	(No./m^2)		(No./m^2)	
Total No.				
20 (/m^2)	63.2	*a*	59.7	*a*
12	57.1	*b*	48.9	*b*
6.5	43.9	*c*	36.5	*c*
Round Seed No.				
20 (/m^2)	39.0	*a*	41.6	*a*
12	32.2	*b*	29.4	*b*
6.5	18.8	*c*	15.4	*c*

Duncans Multiple Range – figures followed by the same letter are not significantly different

Figure 7: Effect of Density on Total and Round Seed Number, 2000-01

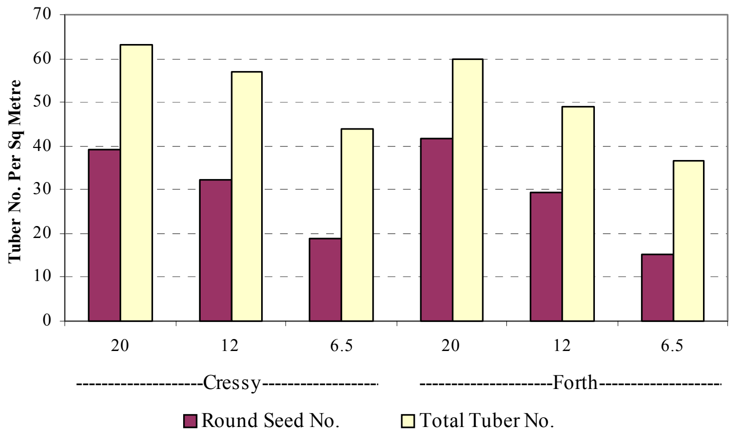
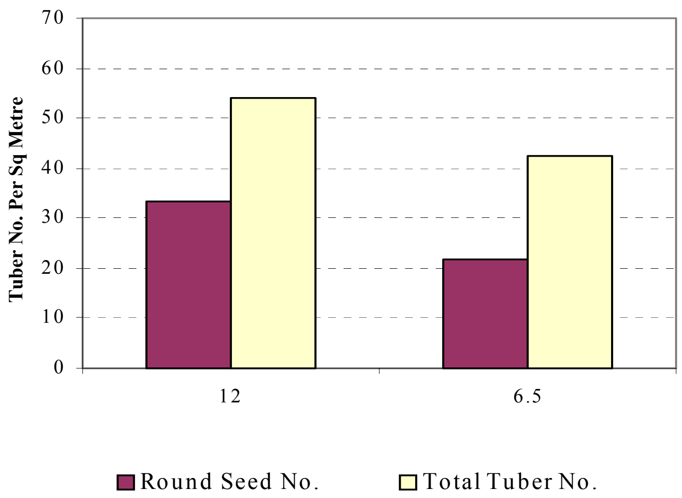


Table 11: Effect of Density on Total and Round Seed Number, 2002-03

	Forth	
Total No.	(No./m^2)	
12 (/m^2)	53.9	*a*
6.5	42.3	*b*
Round Seed No.		
12 (/m^2)	33.4	*a*
6.5	21.6	*b*

Duncans Multiple Range – figures followed by the same letter are not significantly different

Figure 8: Effect of Density on Total and Round Seed Number, 2002-03



3.4 Effect of s-Carvone

Effect on Yield

There was a significant positive effect of s-Carvone application on the production of round seed yield at both sites. However, there was no effect on total yield. The higher round seed yields can be attributed to higher stem numbers per m^2 due to higher stem numbers per plant (Table 12 and Figure 9).

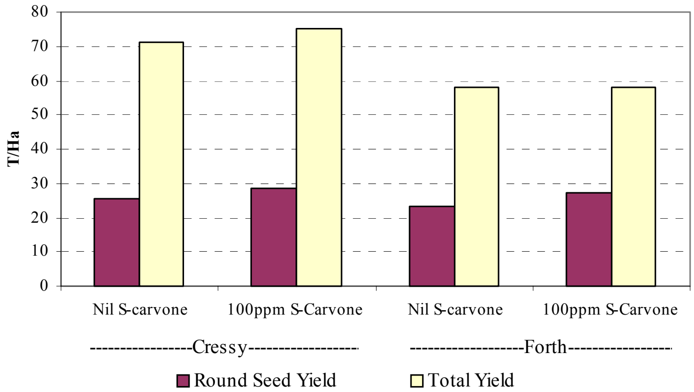
Interactions between seed sett type (cut or whole), planting densities and s-Carvone treatment were generally insignificant. Despite the positive effect of s-Carvone on round seed yield, it was less than found by Dr Brown in his earlier work.

Table 12: Effect of s-Carvone on Total and Round Seed Yields, 2000-01

	Cressy		Forth	
Total Yield	(T/Ha)		(T/Ha)	
Nil S-carvone	71.3	*a*	58.2	*a*
100ppm S-Carvone	75.2	*a*	58.1	*a*
Round Seed Yield				
Nil S-carvone	25.4	*b*	23.2	*b*
100ppm S-Carvone	28.6	*a*	27.4	*a*
Stems Per m^2				
Nil S-carvone	29.5	*b*	24.5	*b*
100ppm S-Carvone	31.8	*a*	29.5	*a*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

Figure 9: Effect of s-Carvone on Total and Round Seed Yields, 2000-01



Effect on Tuber Number

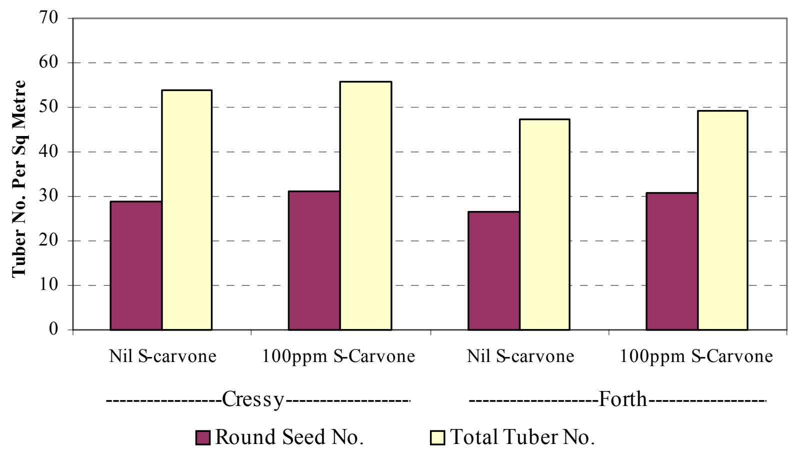
There was a significant positive effect of s-Carvone application on the number of round seed tubers at both sites. However, there was no effect on total tuber number (Table 17 and Figure 10).

Table 13: Effect of s-Carvone on Total and Round Seed Number, 2000-01

	Cressy		Forth	
	(No./m^2)		(No./m^2)	
Total No.				
Nil S-carvone	53.7	*a*	47.3	*a*
100ppm S-Carvone	55.7	*a*	49.4	*a*
Round Seed No.				
Nil S-carvone	28.9	*b*	26.6	*b*
100ppm S-Carvone	31.2	*a*	30.9	*a*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

Figure 10: Effect of s-Carvone on Total and Round Seed Number, 2000-01



3.5 Effect of Seed Source & Treatment

Seed Source

An analysis of seed source data from a field trial at Forth in 2002-03 was performed ignoring results from the field storage treatments. This data was omitted due to an insufficient number of degrees of freedom.

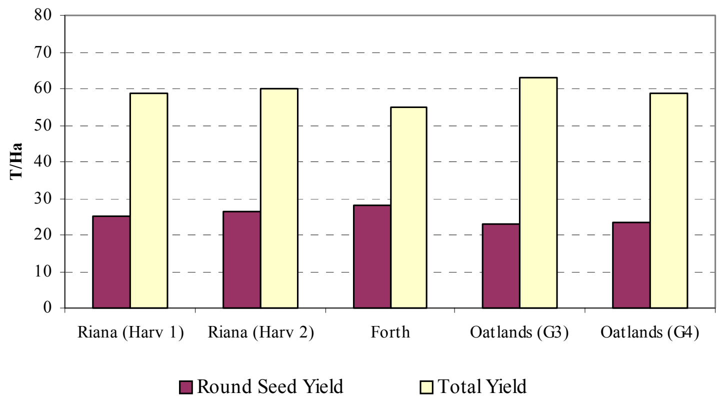
Table 14 and Figure 11 show that seed from all sources except Forth produced statistically similar total yields. There was no difference between sources in the production of round seed yield.

Table 14: Effect of Seed Source on Total and Round Seed Yields, 2002-03

	Yield	
Total Yield	(T/Ha)	
Riana (Harv 1)	58.75	*ab*
Riana (Harv 2)	60.14	*a*
Forth	54.71	*b*
Oatlands G3	62.81	*a*
Oatlands G4	58.63	*ab*
Round Seed Yield		
Riana (Harv 1)	25.02	*a*
Riana (Harv 2)	26.22	*a*
Forth	28.26	*a*
Oatlands G3	22.85	*a*
Oatlands G4	23.25	*a*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

Figure 11: Effect of Seed Source on Total and Round Seed Yields, 2002-03



Time of Seed Harvest

An analysis of the effects of seed harvested on 22nd May (Harvest 1) and 24th June (Harvest 2) on total and round seed yield of the following crop revealed no statistical effect (data not shown).

Method of Seed Storage

An analysis of the effects of seed stored on farm and in coolstore on total and round seed yield of the following crop revealed no statistical effect (data not shown).

Previous Seed Generation

An analysis of the effects of seed sourced as G3 and G4 on total and round seed yield of the following crop revealed no statistical effect on total yield but a higher yield of round seed in G4 (Table 15).

Table 15: Effect of Generation on Total and Round Seed Yields, 2002-03

	Yield	
Total Yield	(T/Ha)	
Oatlands G3	61.38	*a*
Oatlands G4	60.90	*a*
Round Seed Yield		
Oatlands G3	22.29	*b*
Oatlands G4	23.89	*a*

Duncans Multiple Range – figures followed by the same letter are not significantly different.

3.6 Economics

Gross Margin Models

Gross margins were prepared in conjunction with Simplot Australia's Field staff and were designed to emulate the financial performance of an average well-grown crops of seed and processing Russet Burbanks. The prices reflect contract conditions and input costs for the 2002-03 season.

Three gross margins were determined;

1. Processing crop grown from cut setts
2. Processing crop grown from whole setts (using round seed)
3. Seed crop grown from cut setts

A summary of returns and key cost categories is shown in Table 16. Detailed gross margins are outlined in the Appendices.

Table 16: Model Gross Margin Summary

		Seed Crop	Processing Crop		
		Cut Setts	Cut Setts	Whole Setts (Sett Basis)	Whole Setts (Stem Basis)
Yield					
Net of Waste	(T/Ha)	55.9	58.8	58.8	58.8
Average Price	($/Net T)	318	222	222	222
Total Income	($/Ha)	$17,778	$13,031	$13,031	$13,031
Expenses		($/Ha)	($/Ha)	($/Ha)	($/Ha)
Seed		1,600	1,080	1,909	2,789
Lime/Dolomite		0	29	29	29
Fertiliser		814	1,117	1,117	1,117
Sprays		482	1,030	1,030	1,030
Irrigation		516	696	696	696
Contract Work		1,665	1,281	1,481	1,839
Contract Harv/Cart		2,347	2,280	2,280	2,280
Tractor/Plant		246	165	165	165
Casual Labour		1,206	748	748	748
Other		28	29	29	29
Total Expenses		$8,903	$8,456	$9,485	$10,724
Gross Margin		$8,874	$4,574	$3,546	$2,307

It should be noted that these margins are specifically tailored to Simplot Australia's contract in Tasmania in 2002-03. For instance the price paid for progeny in the seed crop ($318 per tonne) is made up of a combination of $335 per tonne paid for the certified seed component and a total of $221 per tonne for the non-certified component. According to the contract, this latter proportion of the crop can be processed provided it meets processing specifications. Seed costs quoted in Table 16 relate to the purchase of tubers only and vary due to different average sett weights and different costs per tonne. Other costs associated with seed (coolstorage, cutting, treatment etc) are included in Contract Work (see Appendices for details).

The summary in Table 16 illustrates that, under good growing conditions, a higher gross margin can be achieved in processing crops by using cut setts. This is because we have assumed that yields are identical (confirmed in field trials in this Project) and higher seed costs where whole setts are used. Seed crops produce a higher gross margin than processing crops, providing the progeny tubers pass certification for the certified component and processing specifications for the non-certified component. Usually, the non-certified component consists of tubers that are too large to be accepted as certified seed.

Maximising Round Seed Yield

In Section 3.3, results in all years clearly showed that the highest yield of round seed was produced at the highest density used in each trial. Results are reproduced in Table 17.

Table 17: Relationship Between Density and Round Seed Yield

Setts/m^2		1999-2000				2000-01				2002-03	
		Cressy (T/Ha)		Riana (T/Ha)		Cressy (T/Ha)		Forth (T/Ha)		Forth (T/Ha)	
20		18.2	*a*	16.8	*a*	34.9	*a*	33.4	*a*		
12		13.5	*b*	14.2	*b*	28.9	*b*	27.1	*b*	29.5	*a*
12	(Bed)	8.0	*c*	8.9	*c*						
6.5		8.5	*c*	8.4	*c*	17.2	*c*	15.4	*c*	19.6	*b*
3		5.6	*d*	4.3	*d*						
1.5		3.1	*e*	3.0	*d*						

Duncans Multiple Range – figures followed by the same letter are not significantly different.

For the years 1999-2000 and 2000-01, this occurred at a density of 20 setts per m^2. In 2002-03, this occurred at 12 plants per m^2 which was the highest density used in that year. The choice to restrict densities to a maximum of 12 setts per m^2 in 2002-03 followed a preliminary economic analysis that showed that higher densities were likely to be uneconomic at the price paid for certified seed.

Seed Crop Gross Margin

Of the elements tested during this Project, the factor that consistently exerted a strong influence over round seed yields was density. Using the seed crop gross margin model and the field density data, we needed to confirm the preliminary economic analysis and to finally establish which sett density produced the greater gross margin.

Superimposing the seed crop gross margin model over the field data in Table 17 revealed that the highest gross margin per hectare was mostly achieved at the mid-range density. Table 18 shows there was no economic advantage in exceeding a density of 6.5 setts per m^2 in most situations.

Table 18: Relationship Between Density and Seed Crop Gross Margin

(Maximum Gross Margins Per Hectare are Shaded)

Setts/m^2	1999-2000		2000-01		2002-03
	Cressy ($/Ha)	Riana ($/Ha)	Cressy ($/Ha)	Forth ($/Ha)	Forth ($/Ha)
20	3,273	13,912 *	8,067	11,956	
12	5,465	13,799	11,370	12,365	8,996
12 (Bed)	1,633	12,579			
6.5	5,804	13,910 *	11,606	12,014	10,215
3	6,780	11,102			
1.5	2,732	6,694			

* Equal Gross Margins

These results also revealed that at Riana in 1999-2000 and Forth in 2000-01, sett densties of 12 and 20 per m^2 produced at least as good or slightly higher gross margins than at 6.5 setts per m^2. However, in practice, growers would judge that the additional seed cost and risk would not justify using the higher rates.

6.5 setts per m^2 is around the average density already used by Tasmania's growers of Russet seed.

This result showed that the 2002-03 payment system for seed crops did not encourage growers to strive for maximum round seed yields. Clearly, if the industry is to support greater use of round seed, a higher price would need to be paid.

Minimum Round Seed Price Required by Seed Growers

The required price has been calculated here to enable a seed grower to make around $500 per hectare higher gross margin using a sett density of 20 setts per m^2 than at 6.5 setts per m^2. $500 represents an allowance to cover the additional interest payable on the extra seed planted compared to the "normal" density of around 6.5 setts per m^2 (an extra 8.7 tonnes per hectare of seed plus associated costs of storage, cutting, treatment and transport , at 10% interest for an average of around 11 months).

Whilst the $500 per hectare compensates seed growers for the additional financial outlays, it does not compensate them for the additional risks and managements skill needed to grow a very high-density crop. Therefore, the round seed price calculated here represents the *minimum* required by seed growers.

Using this criteria, the seed model and the trial data, the premium price required for round seed produced on ferrosol soils is 45% and the same for round seed grown on Cressy soils is 200%. This equates to a effective round seed price of $490 per tonne and $1,000 per tonne respectively (Table 19).

Table 19: Calculated Minimum Round Seed Price

Round Seed Premium	Riana, Forth (Ferrosol)	Cressy (Duplex)
Increase Over Existing Certified Price*	+45%	+200%
Effective Price per Tonne	$490	$1,000

* Compared to the 2002-03 effective contract price of $335 per Tonne

The higher premium calculate here for Cressy-grown seed is due largely to a tendency to produce higher round seed yields at lower densities on duplex soils than on ferrosol soils. A much higher premium is therefore required to satisfy the criteria set above. Lower priced round seed could still be grown at Cressy, but, on the results of these trials, growers would be relinquishing valuable gross margin.

These results indicate that the response of Russet crops to different densities can vary from one location to another. These trials clearly show that a much higher premium price is required for round seed grown at Cressy. As such, it would be very unlikely that processing growers would pay $1,000 per tonne for round seed if good quality round seed was available at $490 per tonne.

On the basis of these trials, the production of round seed in Tasmania should be centred on the ferrosol soils on the North-West Coast in preference to the duplex soils at Cressy. From hereon, then, we will concentrate solely on round seed being made available at an efective price of $490 per tonne.

Affordability of Round Seed

Table 16 shows that under good growing conditions, processing crops grown from cut setts should produce a higher gross margin that those established with whole setts (round seed). However, it is acknowledged that under adverse soil and environmental conditions, the risk of seed piece breakdown is increased. Under these conditions and despite the benefits of protective seed treatments, cut seed would be expected to break down more quickly and to a greater extent than round seed.

It was not possible in the trials in this Project to simulate a range of adverse soil or environmental conditions in order to measure the potential advantages of round seed over cut seed. However, the gross margin models developed here can be adapted to calculate the price per tonne that processing growers could afford to pay for round seed to overcome yield losses suffered in crops grown from cut seed.

Key Assumptions 1

- Under certain adverse conditions, cut seed has a higher likelihood of break down, resulting in yield losses and reduced gross margins.
- Under these conditions, round seed can fully compensate for these yield losses.
- Round seed is planted at the same density as cut seed crops.

Results

The gross margin of processing potato crops grown from cut setts reduces rapidly as total yield is reduced (Table 20). For every 10% reduction in yield, the gross margin reduces by around $1,000 per hectare. For example, a 30% yield reduction means that yield is reduced to 42 tonnes per hectare and the gross margin is reduced to only $1,507 per hectare (down $3,067 per hectare or 67%).

If round seed can prevent the yield reduction (ie. yield is maintained at 60 tonnes per hectare), Table 20 reveals the break-even price a grower could afford to pay for round seed and be no worse financially. Using the same example as in the previous paragraph, a grower suffering a yield reduction of 30% using cut seed can switch to round seed (and pay up to $1,013 per tonne) and maintain yield at 60 tonnes per hectare. The gross margin achieved by using round seed would be the same as the cut seed crop ($1,507 per hectare).

Further, a processing grower suffering a 20% reduction in yield can afford to pay up to $751 per tonne for round seed. In contrast, growers achieving 60 tonnes per hectare using cut seed can only afford to pay $226 per tonne.

In the previous section, we have calculated that seed growers on ferrosol soils need at least $490 per tonne for round seed. Table 20 indicates that this would be an acceptable price for all processing growers suffering a yield reduction of 10% or more. In other words, if processing growers are confident that round seed will prevent yield reductions, a price of $490 per tonne for round seed is a relatively cheap price to pay.

Table 20: Break-Even Price for Using Round Seed in Processing Crops

(Same Sett Density Basis)

Cut Setts				Round Setts
Total Yield		Gross Margin	Gross Margin Lost	Break-Even Round Seed Price
(T/Ha)	(Change)	($/Ha)	($/Ha)	($/T)
60	0%	4,574	0	226
54	-10%	3,546	1,028	490
48	-20%	2,530	2,044	751
42	-30%	1,507	3,067	1,013
36	-40%	485	4,089	1,276
30	-50%	-537	5,111	1,538

However, the analysis here assumes that round seed is planted at the same density as cut seed ie. identical number of setts per hectare. However a comparison on this basis is misleading as the basic unit for crop stand density is not the number of *setts* per hectare but more the number of *stems* per hectare.

On this new basis, the key assumptions outlined above need modification.

Key Assumptions 2

- Under certain adverse conditions, cut seed has a higher likelihood of break down, resulting in yield losses and reduced gross margins.
- Under these conditions, round seed can fully compensate for these yield losses.
- Round seed is planted to produce the same stem density as cut seed.

Results

The relationship between sett density and stems per sett need to be determined from field data collected in this Project for cut and round setts at all locations and in all years. The details for Cressy were discarded as round seed from there was likely to be too expensive (See Section Minimum Round Seed Price Required by Seed Growers on Page 22).

From the analysis, it soon became clear that the relationship between sett density and stems per sett varied between cut setts and round setts as well as between years. For the purposes of this report, the relationship calculated at the Riana site in 1999-2000 was selected as being representative. This was due to the greater number of treatments tested in that year. The relationship was best described by the following formulae (See Appendix 8.5 for details).

Formula 1: Cut Setts $y = -0.1005x + 3.1396$ ($R^2 = 98\ \%$)
Formula 2: Round Setts $y = -0.0576x + 2.2115$ ($R^2 = 96\ \%$)

Where y = Stems per Sett and x = Setts per m^2

A processing crop that was established with 41,130 cut setts per hectare would be expected to produce a crop with 112,100 stems per hectare. This would require the purchase of 3 tonnes per hectare of seed. If the same crop was established with the same sett density using round setts, a total of 3.9 tonnes of seed would need to be purchased. However, according to Formula 2, the resultant crop would only produce 81,200 stems per hectare (Table 21).

Table 21: Cut Setts vs Round Setts

		Cut Setts	Round Setts (Same Setts/Ha)	Round Setts (Same Stems/Ha)
Setts per Ha		41,130	41,130	
Equiv. No. Stems		112,100*	81,200**	
Seed Rate	(T/Ha)	3.0	3.9***	
Stems per Ha				112,100
Equiv. No. Setts**				60,090
Seed Rate	(T/Ha)			5.7***

* Using Formula 1

** Using Formula 2

*** Seed rate for round setts also takes account of a higher average sett weight (90g round, 57g cut) and a reduced wastage rate during seed storage and cutting (5% round, 15% cut).

To produce 112,100 stems per hectare using round setts, Formula 2 determines that 60,090 setts per hectare must be planted, requiring the purchase of 5.7 tonnes per hectare of round seed. This extra 2.7 tonnes of seed (5.7 *minus* 3.0) is a significant additional cost that will significantly affect the break-even cost of using round seed.

Table 22 outlines the break-even price of round seed on an equivalent stem density basis. The price on an equivalent sett density basis is reproduced from Table 20 again for comparison.

On an equivalent stem density basis, these results indicate that processing growers can only afford to pay $490 or more per tonne for round seed when losses in cut sett crops exceed 22.2% (previously 10%). However, if processing growers are confident that round seed will prevent yield reductions, a price of $490 per tonne is still a reasonable price to pay.

Table 22: Break-Even Price for Using Round Seed in Processing Crops

(Same Stem Density Basis)

Cut Setts		Break-Even Round Seed Price	
Total Yield		Equivalent Stem/Ha Basis	Equivalent Sett/Ha Basis
(T/Ha)	(Change)	($/T)	($/T)
60	0%	92	226
54	-10%	271	490
48	-20%	451	751
46.7	-22.2%	490	
42	-30%	630	1,013
36	-40%	810	1,276
30	-50%	990	1,538

4. Discussion

The key outcomes from this Project were as follows –

1. Russet Burbanks growing under good conditions produced similar yields irrespective of whether they were established with cut or round setts.
2. Increasing density up to 20 setts per m^2 exerted a major influence over round seed yield and round tuber number but not necessarily total yield and total tuber number.
3. The highest yield of round seed was produced at the highest density trialed. In four out of five trials, this was at 20 setts per m^2.
4. The current payment structure for seed growers favours sett densities of around 6.5 setts per m^2 and therefore will not encourage seed growers to maximise the yield of round seed.
5. To encourage profitable round seed production, a price premium is required, this being calculated to be 45% or $490 per tonne (ferrosol soils on the North-West) and 200% or $1,000 per tonne (duplex soils in the Cressy area). This strongly favours the North-West as a more cost-effective production area for round seed.
6. If round seed can overcome problems associated with poorly performing cut seed, processing growers can afford to pay $490 per tonne if their cut seed crops are suffering yield reductions of 10% (same sett density basis) or 22.2% (same stem density basis).
7. The stem density basis is the most appropriate basis for comparison.
8. A transportable economic methodology that can be adapted to other situations in potato crops throughout Australia.

Potato yield can be described by the following formula;

Yield = No. Main Stems per Hectare *x* No Useable Tubers per Stem *x* Average Tuber Weight

The potential number of stems can be manipulated by the seed grower through a balanced selection of sett density, sett size and p-age. The number of tubers per stem can also be manipulated independent of stem number, but this is very difficult to control and is therefore less reliable in practice. Average tuber weight is a function of soil and environmental conditions, management and the time of haulm destruction.

Stem density is probably the simplest factor controllable by growers. Although a number of other factors play a role (sett size, p-age, seed treatment, number of sprouts per sett, soil conditions, planting method etc), the single-most controllable factor is sett density. This Project has shown that sett density has an over-riding influence on round seed yield and number. In four field trials, the highest yield and number of round seed tubers occurred at a sett density of 20 per m^2. However, the density supporting the highest possible yield of round seed was not found. This may have occurred at a sett density exceeding 20 per m^2.

Despite this however, the density resulting in the highest gross margin for seed crops was determined to be 6.5 setts per m^2. This has important implications for seed growers as the density is close to that currently adopted by the majority of growers producing Russet Burbank seed, at least in Tasmania. The price calculated for round seed, therefore, should have some direct practical relevance for the processing sector.

One of the objectives of the Project was to determine the economic benefits to processing growers and processors of using round seed. This was not achieved directly from trials as it was not possible to simulate the adverse soil and environmental conditions that would have been necessary to affect yields. However, an understanding of the pricing structure and gross margin of processing crops has enabled a determination of the level of crop performance that would trigger a decision to use round seed. This will have immediate implications for the industry. It is known that interest in using round seed is increasing, with most supplies being made available by grading seed crops and removing the small tubers. Whilst this method will suffice for now, it will not be adequate if demand increases. If this occurs, dedicated round seed crops will be required and processing growers must be prepared to pay a premium price.

The Project initially included an evaluation of the potential role for Technitubers ® in the production of round seed. Trial results in 1999-2000 showed that cut and whole setts outperformed Technitubers ®. The original intention was to continue work with the Technituber® progeny from this trial. In this context a direct comparison against cut and round setts unfairly favours the latter sett types. The results presented here should not be interpreted as indicating that Technitubers ® were an inferior product. A decision was made to suspend further work on Technitubers ®, but only in favour of commencing work with s-Carvone. in 2000-01. A further evaluation of the potential role of Technitubers ® in round seed production should probably be resumed in a separate Project.

Mother seed treatments such as using the reversible sprout inhibitor s-Carvone were evaluated in this Project. Whilst some benefit was found, it was less that that found by Dr Brown in his recent work (PT98008). Dr Brown concluded that s-Carvone was unlikely to be commercially viable due to an inconsistent effect on different seed lots. An attempt was made in this Project in 2002-03 to measure the variation between some seed lots. Despite evaluating the performance of seed sourced from different locations, time of seed harvest, methods of storage and generation, no differences were found in the yield of round seed. This does not help explain the reported 25-35% variation in performance between seed lots sampled annually from seed growers. A more in-depth investigation and analysis of the issues is therefore warranted.

5. Technology Transfer

This Project has created considerable interest amongst seed and processing growers, processors and industry organisations within Tasmania and Victoria.

A bibliography of technology transfer events that have (or will) occur during the management of the Project are listed below.

The methodology adopted and economic results emanating from this Project are very suitable to be included in any potato seed research and development studies being undertaken or planned in the future by Australia's potato processing companies. The inter-relationship and inter-dependence of agronomy and economics should be considered integral to any work conducted in this area. Material presented here can be readily adapted to achieve this outcome.

Publications

1. Potato Australia Issues 2000-2004.

Presentations and Papers

1. Potato and Vegetable Research Presentation Days, Ulverstone and Devonport, Tasmania 2001-2004 – conducted by the Combined Potato and Vegetable Research & Advisory Committees, Tasmania
2. "Potatoes by the Sea", August 2003, Portland Victoria – A paper invited by the Victorian Seed Potato Authority.

Field Days

1. Field trials at Cressy, April 2000 and Riana, May 2000
2. Forthside Vegetable Research Station Open Days – December 2000, 2002

Liaison

1. Field Managers and Field Officers of Simplot Australia Pty Ltd and McCain Foods (Aust) Pty Ltd
2. Dr Rowland Laurence, Tasmanian Institute of Agricultural Research
3. Dr Philip Brown, Tasmanian Institute of Agricultural Research

6. Recommendations

The key recommendations from this Project include;

1. Russet Burbank seed growers are best to use sett density as the key criteria for maximising the production of round seed.
2. Processing growers must be prepared to pay a premium for round seed produced from dedicated round seed crops.
3. Under good growing conditions, similar yields should be expected from crops grown from cut or whole setts.
4. Due to greater isolation and conditions imposed by certification standards, the general “health” of seed crops would be expected to be very good and should exceed those of processing crops. Under these conditions, seed growers should establish crops using the cheaper cut seed method.
5. Work should continue to evaluate the potential benefit of mother seed treatments in the production of round seed.
6. However, before this proceeds, a more in-depth investigation and analysis is required to explain the variation in field performance between seed lots. This might best be undertaken as a collaborative effort between a plant physiologist, economist, processors and seed growers.
7. Such an analysis might identify the importance of p-age in the production of seed and processing potatoes.
8. Until these factors are better understood, the best strategy for processing growers continues to be to identify a reliable seed supplier whose potatoes perform well under your their own conditions and stick to that supplier.

7. References

[1] Strange, PC and Blackmore, KW (1990). Effect of whole seed tubers, cut seed and within row spacing on potato (cv Sebago) tuber yield. Australian Journal of Experimental Agriculture 30, 427-432.

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[3] Laurence, R et al (1997). Round Seed Production of the Cultivar Atlantic http://www.sardi.sa.gov.au/pages/horticulture/pathology/hort_pn_roundatlantic.html

[4] Stuik, PC and Wiersema, SG. (1999). How to Manipulate Tuber Number. In Seed Potato Technology. Wageningen Pers, Wageningen, The Netherlands, 221

[5] Stuik, PC and Wiersema, SG. (1999). Physiological Age Determines Number and Vigour of Sprouts. In Seed Potato Technology. Wageningen Pers, Wageningen, The Netherlands, 75

[6] Stuik, PC and Wiersema, SG. (1999). Physiological Age Determines Number and Vigour of Sprouts. In Seed Potato Technology. Wageningen Pers, Wageningen, The Netherlands, 85

[7] Stuik, PC and Wiersema, SG. (1999). How to Manipulate Tuber Number. In Seed Potato Technology. Wageningen Pers, Wageningen, The Netherlands, 225

[8] Jackson, K and Johnson, I (1997). Round or Cut Seed – The Answer is Usually Not Cut and Dried. Potato Australia 8, 26-27.

[9] Stuik, PC and Wiersema, SG. (1999). Yield Can be Described by Yield Components. In Seed Potato Technology. Wageningen Pers, Wageningen, The Netherlands, 47

[10] Brown, Philip (2001). Improving Seed Potato Performance. Project Number PT98008.

8. Appendices

8.1 Gross Margin – Processing Russets (Cut Setts)

							$/Ha (Exc GST)	
GROSS INCOME							$	
							(Per Ha)	**(Total)**
Gross Yield:			60.0 T/Ha			May Harvest		
Less Deductable Waste		2.0%	-1.2 T/Ha					
Net Yield:			58.8 T/Ha	@	$199.11 /T	Net Base/Exp Price	11,708	11,708
				+	$2.00 /T	Quality Bonus	118	118
				+	$15.50 /T	Bruise Free Bonus	911	911
				+	$5.00 /T	Size Bonus	294	294
				Effective Price	$221.61 /T			
Total Net Income							**$13,031**	**$13,031**
VARIABLE COSTS								
Seed		Purchased	3.00 T/Ha	@	$360 /T		1,080	1,080
	15%	Loss Allowance	2.55 T/Ha	@	62 g/Sett			
Lime/Dolomite			2.5 T/Ha	@	$35 /T	Spread (1/3 Debit)	29	29
Fertiliser	1	11.13.19	1.75 T/Ha	@	$526 /T Bulk	Base	921	921
	3	Urea	0.05 T/Ha	@	$493 /T Bulk	Top Dressed	74	74
	2	Potash	0.125 T/Ha	@	$492 /T Bulk	Top Dressed	123	123
		Total	2.15 T/Ha					
Sprays								
Weeds	1	Roundup CT/	2 L/Ha	@	$7.80 /L	Pre-Cultivation	16	16
		Kamba	1 L/Ha	@	$19.05 /L	Pre-Cultivation	19	19
	1	Spray Seed	2.5 L/Ha	@	$12.55 /L	Emergence	31	31
	1	Sencor/	1.25 L/Ha	@	$66.80 /L	Post Emergence	84	84
		Bladex	1.5 L/Ha	@	$30.50 /L	Post Emergence	46	46
	35%	Roundup CT	2 L/Ha	@	$7.80 /L	Pre-Harvest	5	5
Pests & Diseases	1	Ridomil Gold 50	10 Kg/Ha	@	$19.90 /Kg	Pink rot	199	199
	2	Ridomil GoldMZ	2.5 Kg/Ha	@	$39.80 /Kg	Pink rot	199	199
	8	Penncozeb	2.2 Kg/Ha	@	$8.20 /Kg	Late Blight	144	144
	2	Ridomil GoldMZ	2.5 Kg/Ha	@	$39.80 /Kg	Late Blight	199	199
	2	Score	0.3 L/Ha	@	$147.00 /L	Early Blight	88	88
Irrigation	5	ML/Ha Average Water Use		@	$0.35 ML/Ha	Average/Applic		
	65%	HEC		@	$120.00 /ML		390	390
	35%	Diesel		@	$175.00 /ML		306	306
Contract Work								
Seed C' Storage	1		3.00 T/Ha	@	$45.00 /T	At Coolstore	135	135
Bin Hire	1		3.00 T/Ha	@	$22.00 /T	At Coolstore	66	66
Seed Cutting	1		3.00 T/Ha	@	$45.00 /T	At Coolstore	135	135
Seed Treatment	1	Maxim/	0.250 L/T	@	$275.00 /L	At Coolstore	206	206
	1	Nubark/	1.7 Kg/T	@	$2.03 /Kg	At Coolstore	10	10
	1	Tatodust	1.30 Kg/T	@	$5.00 /Kg	At Coolstore	20	20
	1	Applic Maxim		@	$4.00 /T	At Coolstore	12	12
Seed Cartage	1		3.00 T/Ha	@	$15 /T	To Farm	45	45
Fertiliser Cartage	1		2.15 T/Ha	@	$15 /T	To Farm	32	32
Planting	1			@	$200.00 /Ha		200	200
Spraying	12	Aerial		@	$35.00 /Ha	Fungicides	420	420
Contract Harvest/Cartage								
Harvesting	100%		60.0 T/Ha	@	$23.00 /T	Exc Pickers	1,380	1,380
Cartage	100%		60.0 T/Ha	@	$15.00 /T	Ulverstone	900	900
Tractor & Plant								
Land Preparation	1	Plough/Cultiv.	8 Hrs/Ha	@	$16.00 /Hr		128	128
Topdressing	3	Applications	0.5 Hrs/Ha	@	$11.50 /Hr		17	17
Sprays	3.35	Applications	0.5 Hrs/Ha	@	$11.50 /Hr	Weed Control	19	19
Casual Labour								
Land Preparation		Units	Hrs/Ha	@	$17.50 /Hr	Level 3/Super/WC		
Irrigation	1	Units	14.3 Hrs/Ha	@	$17.50 /Hr	Level 3/Super/WC	250	250
Harvesting	3	Units	6 T/Hr Av.	@	$16.60 /Hr	Level 2/Super/WC	498	498
Other								
HA Potato Levy				@	$0.50 /Net T		29	29
Total Variable Costs							**$8,456**	**$8,456**
GROSS MARGIN							**$4,574**	**$4,574**

8.2 Gross Margin – Processing Russets (Whole Setts)

Sett Density Basis

									$	
GROSS INCOME									**(Per Ha)**	**(Total)**
Gross Yield:			60.0	T/Ha				May Harvest		
Less Deductable Waste	2.0%		-1.2	T/Ha						
Net Yield:			58.8	T/Ha	@	$199.11	/T	Net Base/Exp Price	11,708	11,708
					+	$2.00	/T	Quality Bonus	118	118
					+	$15.50	/T	Bruise Free Bonus	911	911
					+	$5.00	/T	Size Bonus	294	294
					Effective Price	$221.61	/T			
Total Net Income									**$13,031**	**$13,031**
VARIABLE COSTS										
Seed		Purchased	3.90	T/Ha	@	$490	/T	Round	1,909	1,909
	5%	Loss Allowance	3.70	T/Ha	@	90	g/Sett			
					=	41,129	Viable Setts/Ha			
Lime/Dolomite			2.5	T/Ha	@	$35	/T	Spread (1/3 Debit)	29	29
Fertiliser	1	11.13.19	1.75	T/Ha	@	$526	/T Bulk	Base	921	921
	3	Urea	0.05	T/Ha	@	$493	/T Bulk	Top Dressed	74	74
	2	Potash	0.125	T/Ha	@	$492	/T Bulk	Top Dressed	123	123
		Total	2.15	T/Ha						
Sprays										
Weeds	1	Roundup CT/	2	L/Ha	@	$7.80	/L	Pre-Cultivation	16	16
		Kamba	1	L/Ha	@	$19.05	/L	Pre-Cultivation	19	19
	1	Spray Seed	2.5	L/Ha	@	$12.55	/L	Emergence	31	31
	1	Sencor/	1.25	L/Ha	@	$66.80	/L	Post Emergence	84	84
		Bladex	1.5	L/Ha	@	$30.50	/L	Post Emergence	46	46
	35%	Roundup CT	2	L/Ha	@	$7.80	/L	Pre-Harvest	5	5
Pests & Diseases	1	Ridomil Gold 50	10	Kg/Ha	@	$19.90	/Kg	Pink rot	199	199
	2	Ridomil GoldMZ	2.5	Kg/Ha	@	$39.80	/Kg	Pink rot	199	199
	8	Penncozeb	2.2	Kg/Ha	@	$8.20	/Kg	Late Blight	144	144
	2	Ridomil GoldMZ	2.5	Kg/Ha	@	$39.80	/Kg	Late Blight	199	199
	2	Score	0.3	L/Ha	@	$147.00	/L	Early Blight	88	88
Irrigation	5	ML/Ha Average Water Use			@	$0.35	ML/Ha Average/Applic			
	65%	HEC			@	$120.00	/ML		390	390
	35%	Diesel			@	$175.00	/ML		306	306
Contract Work										
Seed C' Storage	1		3.90	T/Ha	@	$45.00	/T	At Coolstore	175	175
Bin Hire	1		3.90	T/Ha	@	$22.00	/T	At Coolstore	86	86
Seed Cutting	1		3.90	T/Ha	@	$45.00	/T	At Coolstore	175	175
Seed Treatment	1	Maxim/	0.250	L/T	@	$275.00	/L	At Coolstore	268	268
		Nubark/	1.7	Kg/T	@	$2.03	/Kg	At Coolstore		
		Tatodust	1.30	Kg/T	@	$5.00	/Kg	At Coolstore		
	1	Applic Maxim			@	$4.00	/T	At Coolstore	16	16
Seed Cartage	1		3.90	T/Ha	@	$15	/T	To Farm	58	58
Fertiliser Cartage	1		2.15	T/Ha	@	$15	/T	To Farm	32	32
Planting	1				@	$250.00	/Ha		250	250
Spraying	12	Aerial			@	$35.00	/Ha	Fungicides	420	420
Contract Harvest/Cartage										
Harvesting	100%		60.0	T/Ha	@	$23.00	/T	Exc Pickers	1,380	1,380
Cartage	100%		60.0	T/Ha	@	$15.00	/T	Ulverstone	900	900
Tractor & Plant										
Land Preparation	1	Plough/Cultiv.	8	Hrs/Ha	@	$16.00	/Hr		128	128
Topdressing	3	Applications	0.5	Hrs/Ha	@	$11.50	/Hr		17	17
Sprays	3.35	Applications	0.5	Hrs/Ha	@	$11.50	/Hr	Weed Control	19	19
Casual Labour										
Land Preparation		Units		Hrs/Ha	@	$17.50	/Hr	Level 3/Super/WC		
Irrigation	1	Units	14.3	Hrs/Ha	@	$17.50	/Hr	Level 3/Super/WC	250	250
Harvesting	3	Units	6	T/Hr Av.	@	$16.60	/Hr	Level 2/Super/WC	498	498
Other										
HA Potato Levy					@	$0.50	/Net T		29	29
Total Variable Costs									**$9,485**	**$9,485**
GROSS MARGIN									**$3,546**	**$3,546**

8.3 Gross Margin – Processing Russets (Whole Setts)

Stem Density Basis

									$	
GROSS INCOME									**(Per Ha)**	**(Total)**
Gross Yield:			60.0	T/Ha				May Harvest		
Less Deductable Waste		2.0%	-1.2	T/Ha						
Net Yield:			58.8	T/Ha	@	$199.11	/T	Net Base/Exp Price	11,708	11,708
					+	$2.00	/T	Quality Bonus	118	118
					+	$15.50	/T	Bruise Free Bonus	911	911
					+	$5.00	/T	Size Bonus	294	294
					Effective Price	$221.61	/T			
Total Net Income									**$13,031**	**$13,031**
VARIABLE COSTS										
Seed		Purchased	5.69	T/Ha	@	$490	/T	Round	2,789	2,789
	5%	Loss Allowance	5.41	T/Ha	@	90	g/Sett			
					=	60,090	Viable Setts/Ha			
Lime/Dolomite			2.5	T/Ha	@	$35	/T	Spread (1/3 Debit)	29	29
Fertiliser	1	11.13.19	1.75	T/Ha	@	$526	/T Bulk	Base	921	921
	3	Urea	0.05	T/Ha	@	$493	/T Bulk	Top Dressed	74	74
	2	Potash	0.125	T/Ha	@	$492	/T Bulk	Top Dressed	123	123
		Total	2.15	T/Ha						
Sprays										
Weeds	1	Roundup CT/	2	L/Ha	@	$7.80	/L	Pre-Cultivation	16	16
		Kamba	1	L/Ha	@	$19.05	/L	Pre-Cultivation	19	19
	1	Spray Seed	2.5	L/Ha	@	$12.55	/L	Emergence	31	31
	1	Sencor/	1.25	L/Ha	@	$66.80	/L	Post Emergence	84	84
		Bladex	1.5	L/Ha	@	$30.50	/L	Post Emergence	46	46
	35%	Roundup CT	2	L/Ha	@	$7.80	/L	Pre-Harvest	5	5
Pests & Diseases	1	Ridomil Gold 50	10	Kg/Ha	@	$19.90	/Kg	Pink rot	199	199
	2	Ridomil GoldMZ	2.5	Kg/Ha	@	$39.80	/Kg	Pink rot	199	199
	8	Penncozeb	2.2	Kg/Ha	@	$8.20	/Kg	Late Blight	144	144
	2	Ridomil GoldMZ	2.5	Kg/Ha	@	$39.80	/Kg	Late Blight	199	199
	2	Score	0.3	L/Ha	@	$147.00	/L	Early Blight	88	88
Irrigation	5	ML/Ha Average Water Use			@	$0.35	ML/Ha Average/Applic			
	65%	HEC			@	$120.00	/ML		390	390
	35%	Diesel			@	$175.00	/ML		306	306
Contract Work										
Seed C' Storage	1		5.69	T/Ha	@	$45.00	/T	At Coolstore	256	256
Bin Hire	1		5.69	T/Ha	@	$22.00	/T	At Coolstore	125	125
Seed Cutting	1		5.69	T/Ha	@	$45.00	/T	At Coolstore	256	256
Seed Treatment	1	Maxim/	0.250	L/T	@	$275.00	/L	At Coolstore	391	391
		Nubark/	1.7	Kg/T	@	$2.03	/Kg	At Coolstore		
		Tatodust	1.30	Kg/T	@	$5.00	/Kg	At Coolstore		
	1	Applic Maxim			@	$4.00	/T	At Coolstore	23	23
Seed Cartage	1		5.69	T/Ha	@	$15	/T	To Farm	85	85
Fertiliser Cartage	1		2.15	T/Ha	@	$15	/T	To Farm	32	32
Planting	1				@	$250.00	/Ha		250	250
Spraying	12	Aerial			@	$35.00	/Ha	Fungicides	420	420
Contract Harvest/Cartage										
Harvesting	100%		60.0	T/Ha	@	$23.00	/T	Exc Pickers	1,380	1,380
Cartage	100%		60.0	T/Ha	@	$15.00	/T	Ulverstone	900	900
Tractor & Plant										
Land Preparation	1	Plough/Cultiv.	8	Hrs/Ha	@	$16.00	/Hr		128	128
Topdressing	3	Applications	0.5	Hrs/Ha	@	$11.50	/Hr		17	17
Sprays	3.35	Applications	0.5	Hrs/Ha	@	$11.50	/Hr	Weed Control	19	19
Casual Labour										
Land Preparation		Units		Hrs/Ha	@	$17.50	/Hr	Level 3/Super/WC		
Irrigation	1	Units	14.3	Hrs/Ha	@	$17.50	/Hr	Level 3/Super/WC	250	250
Harvesting	3	Units	6	T/Hr Av.	@	$16.60	/Hr	Level 2/Super/WC	498	498
Other										
HA Potato Levy					@	$0.50	/Net T		29	29
Total Variable Costs									**$10,724**	**$10,724**
GROSS MARGIN									**$2,307**	**$2,307**

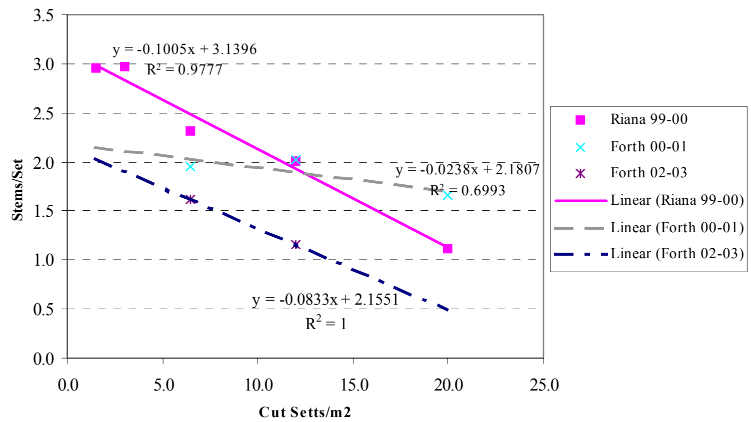
8.4 Gross Margin – Seed Russets (Cut Setts)

							$/Ha (Exc GST) $ (Per Ha)	(Total)
GROSS INCOME								
Gross Yield:			57.0 T/Ha			Supplied in Bulk		
Less Deductable Waste		2.0%	-1.1 T/Ha					
			55.9 T/Ha					
Net Yield:								
Certified Round				@	% Premium Price			
	15%		8.4 T/Ha	@	$315.90 /T	Certified Seed	2,647	2,647
				+	$2.00 /T	Certification Rebate	17	17
					$10.00 /T	May Harvest Bonus	84	84
				+	$7.50 /T	Bruise Free Bonus	63	63
					$335.40 /T	Effective Seed Price		
Certified Std	70%		39.1 T/Ha	@	$315.90 /T	Certified Seed	12,352	12,352
				+	$2.00 /T	Certification Rebate	78	78
					$10.00 /T	May Harvest Bonus	391	391
				+	$7.50 /T	Bruise Free Bonus	293	293
					$335.40 /T	Effective Seed Price		
Oversize	15%		8.4 T/Ha	+	$199.11 /T	May Harvest Bonus	1,668	1,668
					$2.00 /T	Quality Bonus	17	17
					$15.00 /T	Bruise Free Bonus	126	126
				+	$5.00 /T	Size Bonus	42	42
					$221.11 /T	Effective OSize Price		
Total Net Income							**$17,778**	**$17,778**
VARIABLE COSTS								
Seed		Mother Seed	4.00 T/Ha	@	$400 /T	Spot M. Seed Price	1,600	1,600
	10%	Loss Allowance	3.60 T/Ha		57 g/Sett			
Lime/Dolomite			T/Ha	@	$40 /T	Spread (1/3 Debit)		
Fertiliser	1	11.13.19	1.5 T/Ha	@	$526 /T Bulk	Base	789	789
	1	Urea	0.05 T/Ha	@	$493 /T Bulk	Top Dressed	25	25
		Potash	0.125 T/Ha	@	$492 /T Bulk	Top Dressed		
		Total	1.55 T/Ha					
Sprays								
Weeds	1	Roundup CT/	2 L/Ha	@	$7.80 /L	Pre-Cultivation	16	16
		Kamba	1 L/Ha	@	$19.05 /L	Pre-Cultivation	19	19
	1	Spray Seed/	2.5 L/Ha	@	$12.55 /L	Emergence	31	31
		Sencor	1.25 L/Ha	@	$66.80 /L		84	84
	60%	Reglone	2 L/Ha	@	$20.65 /L	Top Dessication	25	25
Pests & Diseases	6	Penncozeb	2.2 Kg/Ha	@	$8.20 /Kg	Late Blight	108	108
	2	Ridomil GoldMZ	2.5 Kg/Ha	@	$39.80 /Kg	Late Blight	199	199
		Tecto/	0.1 L/T	@	$79.20 /L	>Harv, Paid by Simp		
		Fungflor	0.02 Kg/T	@	$385.00 /Kg	>Harv, Paid by Simp		
Irrigation	3.2	ML/Ha Average Water Use		@	$0.35 ML/Ha	Average/Applic		
	25%	HEC		@	$120.00 /ML		96	96
	75%	Diesel		@	$175.00 /ML		420	420
Contract Work								
Seed C' Storage	1		4.00 T/Ha	@	$45.00 /T	At Coolstore	180	180
Bin Hire	1		4.00 T/Ha	@	$22.00 /T	At Coolstore	88	88
Seed Cutting	1		4.00 T/Ha	@	$45.00 /T	At Coolstore	180	180
Seed Treatment	1	Maxim/	0.250 L/T	@	$275.00 /L	At Coolstore	275	275
	1	Nubark/	1.7 Kg/T	@	$2.03 /Kg	At Coolstore	14	14
	1	Tatodust	1.30 Kg/T	@	$5.00 /Kg	At Coolstore	26	26
	1	Applic Maxim		@	$4.00 /T	At Coolstore	16	16
Seed Cartage	2		4.00 T/Ha	@	$15 /T	Mother Seed	120	120
Fertiliser Cartage	1		1.55 T/Ha	@	$15 /T	To Farm	23	23
Planting	1			@	$200.00 /Ha		200	200
Spraying	8	Aerial		@	$35.00 /Ha	Blight Control	280	280
Inspection Costs	1	Seasonal Registration Fee		@	$200.00	Assume Av 4Ha Crop	50	50
	1	Crop Registration Fee		@	$15.00 /Ha		15	15
	2	Field Inspections		@	$30.00 /Ha		60	60
	1	Tuber Inspectn	47.5 T/Ha	@	$2.90 /T	Certified Seed Only	138	138
Grad/Bin Fill CStore	1		57.0 T/Ha	@	$11.00 /T	Bin Fill Paid by Simp.		
Contract Harvest/Cartage								
Harvesting	100%		57.0 T/Ha	@	$25.00 /T	Exc Pickers	1,425	1,425
Cartage to Cstore	100%		57.0 T/Ha	@	$15.00 /T	Spreyton/Latrobe	855	855
Cart Oversize	1		8.38 T/Ha	@	$8.00 /T	To Ulverstone	67	67
Tractor & Plant								
Land Preparation	1	Plough/Cultiv.	10.5 Hrs/Ha	@	$16.00 /Hr		168	168
Stone Carting	50%	of Area:	5 Hrs/Ha	@	$11.50 /Hr		29	29
Topdressing	1	Applications	0.5 Hrs/Ha	@	$11.50 /Hr		6	6
Roguing	1	Roguing	2.5 Hrs/Ha	@	$11.50 /Hr		29	29
Sprays	2.6	Applications	0.5 Hrs/Ha	@	$11.50 /Hr	Weed Control	15	15
Casual Labour								
Land Preparation		Units	Hrs/Ha	@	$17.50 /Hr	Level 3/Super/WC		
Stone Carting	50%	of Area:						
	2	Units	10 Hrs/Ha	@	$16.60 /Hr	Level 2/Super/WC	166	166
Roguing	1	Roguing	3 Hrs/Ha	@	$17.50 /Hr	Level 3/Super/WC	53	53
Irrigation	1	Units	9.1 Hrs/Ha	@	$17.50 /Hr	Level 3/Super/WC	160	160
Harvesting	3.5	Units	4 T/Hr Av.	@	$16.60 /Hr	Level 2/Super/WC	828	828
Other								
HA Potato Levy				@	$0.50 /Net T		28	28
Total Variable Costs							**$8,903**	**$8,903**
GROSS MARGIN							**$8,874**	**$8,874**

8.5 Relationship Between Sett Density and Stem Density

Cut Setts

Setts/m²	1999-2000		2000-01		2002-03
	Cressy 1999-00 (Stems/Sett)	Riana 1999-00 (Stems/Sett)	Cressy 2000-01 (Stems/Sett)	Forth 2000-01 (Stems/Sett)	Forth 2002-03 (Stems/Sett)
1.5	1.9	3.0			
3.0	2.1	3.0			
6.5	1.9	2.3	2.7	2.0	1.6
12.0	1.8	2.0	2.1	2.0	1.2
20.0	1.7	1.1	2.0	1.7	



Whole Setts

Setts/m²	1999-2000		2000-01		2002-03
	Cressy 1999-00 (Stems/Sett)	Riana 1999-00 (Stems/Sett)	Cressy 2000-01 (Stems/Sett)	Forth 2000-01 (Stems/Sett)	Forth 2002-03 (Stems/Sett)
1.5	1.8	2.2			
3.0	1.5	2.0			No Whole Setts Planted
6.5	1.6	1.8	3.1	2.2	
12.0	1.5	1.6	2.4	2.1	
20.0	1.4	1.1	2.3	1.9