Development of integrated strategies for sustainable processing beetroot production

Tim Wolens
Golden Circle Limited

Project Number: VG05083

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HORTICULTURE AUSTRALIA LIMITED
PROJECT NUMBER: VG05083

DEVELOPMENT OF INTEGRATED STRATEGIES FOR SUSTAINABLE PROCESSING BEETROOT PRODUCTION

FINAL REPORT

Principal Researcher: Tim Wolens
Golden Circle Limited
2nd March 2010

Horticulture Australia Limited (HAL)

Project number VG05083 – Development of Integrated Strategies for Sustainable Processing Beetroot Production

Purpose: To develop best management practices for beetroot farming in Australia

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- Golden Circle
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MEDIA SUMMARY

The beetroot industry in Australia is located primarily in the Lockyer Valley 100 kilometres west of Brisbane. Beetroot has continued to be marketed domestically as a canned product through Golden Circle for the last 34 years. However, the benchmark for farmers to produce consistently high yields, at low cost and high quality, has become increasingly important. Achieving these key elements in farming ensures the long term sustainability of the industry.

Development of integrated strategies for sustainable processing beetroot production is a project targeting the achievement of these objectives. This is achieved by identifying best practices for beetroot production and standardising them across all growers in the industry.

The key outcomes of the project are in the following areas:

- Evaluation of the causes of beetroot quality rejections;
- Standardised fertiliser programs for slice and baby grade beetroot;
- Standardised planting densities and geometry for slice and for baby grade beetroot; and
- Recommended varieties specifically targeting quality, yield and seasonal requirements for each slice and baby grade beetroot.

The clear conclusion from the project is a range of standardised practices for producing beetroot for the slice and baby grade market. These practices target improvements in on farm yield, quality and reducing the cost of production, thus sustaining a viable beetroot supply chain, that can compete strongly in the global market.

Recommendations for future research and application to the industry include further work into the “canker” issues throughout the supply chain, and restructure of the current harvesting group, and further expansion of the model into other areas of beetroot production. In addition, continuation of grower workshops is also suggested.

TECHNICAL SUMMARY

Nature of the Problem

The issue for the beetroot industry has been continuing decline in sustainability resulting from fluctuating yields and quality plus rising costs. The benchmark for farmers to produce consistently maximum yields, at low cost and high quality has become increasingly important. Achieving these key elements in farming ensures the long term sustainability and competitiveness of the industry. In the absence of standardised practices and with no facility to share information between growers, the issues were being perpetuated.

Description of the Science

The target objective of the project was to identify best production practices for beetroot production, either currently being used or to fulfil technical gaps through research. A grower survey was initially used to determine the current practices, respective yields and resultant quality. The results were examined and a single document compiled which became the draft best practice manual. In addition, the survey identified technical gaps in production where research was undertaken. The findings were then updated into the final best practices manual, which is used as a point of reference to begin standardising best production practices across the industry through individual visitations and workshops.

Research Findings

The project findings provided valuable information for the industry in key areas of production and less essential issues. The key outcomes were in the following areas:

- Evaluation of the causes of beetroot quality rejections;
- Standardised fertiliser programs for slice and baby grade beetroot;
- Standardised planting densities and geometry for slice and for baby grade beetroot; and
- Recommended varieties specific targeting quality, yield and seasonal requirements for each slice and baby grade beetroot.

Recommendations

Recommendations for future research and application to the industry include further work into the “canker” issues throughout the supply chain, restructure of the current harvesting group, and further expansion of the model into other areas of beetroot production. Continuation of the grower workshops is also suggested.

INTRODUCTION

The beetroot industry in Australia is located primarily in the Lockyer Valley 100 kilometres west of Brisbane. Beetroot has continued to be marketed domestically as a canned product through Golden Circle for the last 34 years.

The issue for the beetroot industry has been a continuing decline in sustainability resulting from fluctuating yields and quality plus rising costs. The benchmark for farmers to produce consistently high yields, at low cost and high quality has become increasingly important. Achieving these key elements in farming ensures the long term sustainability and competitiveness of the industry.

In the absence of standardised practices and with no facility to share information between growers, the target of the project was to identify best production practices for beetroot production. This was achieved through the documentation and examination of current practices, identification of gaps in beetroot production practices, then through conducting research projects to fulfil these gaps. These projects consisted of a number of areas.

The areas of technical gaps in information were:

1. Baseline data survey

The baseline data survey was conducted with all Golden Circle Beetroot growers in the Lockyer Valley. The survey consisted of a comprehensive outline of each grower's farming practices. The results were collated into the Interim Best Practice Manual (IBPM) (See appendix One – Baseline Data Survey. The IBPM was distributed to all contributing members of the project including growers, and technology transfer sessions were scheduled throughout the project.

2. Varietal assessments

The industry standard variety - Detroit Dark Red (DDR) has shown decreased yields and increased susceptibility to diseases. In an attempt to further develop an integrated and sustainable approach to beetroot production, new varieties were trialled on a small and large scale basis aimed to analyse the best performing varieties that met processing requirements. In addition, an opportunity to analyse the yield, quality characteristics and growing aspects of these varieties.

Varieties were trialled in small scale plots in 2005 during an early season and mid season harvest both in the Lowood and Forest Hill areas of Ironbark Pty Ltd and Ashley Zelinski. In 2006 and 2007, further evaluations of varieties found to be suitable through the small scale trials were undertaken through early and mid season large scale commercial trials in Forest Hill.

Small scale variety trials were harvested by hand and packed off by Golden Circle which also evaluated the suitability for processing. Samples were analysed with pre-cook assessment on commercial loads of beetroot. The focus was on quality i.e. taste, texture and colour, but also the common issues of canker, misshapen, splits, tops and tails were assessed. Other secondary factors such as the price for seed and the on-farm limitations were taken into consideration.

Planting was difficult in some cases as varying seed sizes affected the density and thus may had an impact on beetroot quality. Harvesting and timing of the harvesting was an issue, as some varieties matured at different times to the others which impacted on the quality.

3. Beetroot nutrition requirements

There has been little in-depth research into the benefits of nutrient requirement and timing for beetroot production. Therefore a trial was commissioned to –

1. Analyse the efficiency and effectiveness of soil and leaf analysis;
2. Develop an understanding of nutritional requirements;
3. Examine optimal application methods;
4. Chart growth patterns and
5. Develop an understanding of the most economic nutritional program.

The beetroot nutrition trials consisted of four commercial sized blocks, two blocks slice grade and two blocks of baby grade. Each block equated to approximately one hectare in size and there was a treatment block and a standard block for each grade. Both trial sites were located on B C Lerch, Forest Hill. The manner in which slice grade treatment block was cultiivated, resulted from outcomes of the IBPM survey and agronomic assumptions for the nutritional requirements of beetroot. The baby grade treatment blocks were based off assumed modifications from the slice grade programme that met the nutritional requirements of baby beetroot.

For each slice and baby treatment block, an adjacent block was cultivated using the growers standard fertiliser programme. Throughout the entire cropping cycle regular leaf testing and growth measurements were undertaken. The yield, rejects and payment information for each treatment block was calculated and a comparative cost analysis to industry results was undertaken. Two days prior to harvest on-farm yield was determined through 12 x $1m^2$ random samples undertaken for both the slice and baby grade beetroot.

Quality alignment to Golden Circle requirements was measured through current Golden Circle sampling procedures. This consists of a random sample obtained at Golden Circle before and after the cookers within beetroot processing. The sample is then inspected by Golden Circle inspection staff to determine the percentage of material not suitable for processing for each consignment.

In addition, nutritional programs were based on supplying nutrients to the plant at the correct timing and quantity that best achieves maximum growth and highest market quality at the most economical cost. To develop the most optimal nutritional program the growth curve needs to be established. To determine the beetroot growth curve numerous physiological measurements were undertaken. They were:

- Number of true leaves;
- Leaf length;
- Root length;
- Stem length;
- Bulb diameter;

- Bulb height;
- Bulb weight; and
- Plant weight.

4. Alternative growing locations

Currently, Golden Circle's beetroot supply comes from 9 beetroot farms spread over a 50 km areas in the Lockyer Valley. One the risks associated with the current structure of the beetroot grower base is potential effects of natural disasters or other larger scale events at a regional level. In the event of such incidences potential reductions in available supply can be devastating for the industry, especially within the production seasons. Strategically, new areas of production must be identified to allow for out of season production if the Lockyer Valley experienced such events.

In summary, there are areas to expand the production windows of beetroot production. However, these areas must meet basic criteria needed for beetroot production requirements:

- Irrigation
- Temperature range
- Alkaline soils
- Farming infrastructure

5. Planting geometry and population

Plant density and geometry trials were undertaken on Greg Lerch farm in 2006. The trials used standard varieties of Detroit Dark Red for slice grade and New Globe for baby grade beetroot. The area under trial was approximately 1 acre and grown under standard practices. The trial was planted in May 2006 and harvested October 2006.

Currently planting geometry is based on mechanical harvesting suitability only. This may result in poorly shaped bulbs, thus increasing misshapen rejects and decreasing farm yields. Therefore a small trial using standard cultural practices was planted on different row spacing to determine if the current industry standard of 24 inch row spacing still delivers the optimum yield and quality.

Achieving an optimum plant population in beetroot growing is difficult. This is primarily because the beetroot seed used is a 'poly germ' meaning it has more than one shoot per seed. The other factors which affect population are soil tilth, the time of season being planted, variety, soil moisture etc.

The aim of this research was to determine if there was a relationship between beetroot population and yield, quality & size range. Using random sampling and assessing techniques, a wide range of facts and measurements were recorded from each block planted during the season.

6. Inter-fallow management

The trials and observations on inter-fallow management were undertaken on current beetroot farms within the Lockyer Valley. These were Linton Brimblecombe, Michael Newman and Ashley Zelenski. Agronomic issues were identified on each farm and relevant fallow cropping was applied.

Numerous crops had been identified across the grower base as suitable for fallow cropping and new crops were included into the trials. Inter-fallow crops were classified under various attributes – disease break, cash crops, soil health, etc and planted on farms with the relevant issues.

A cost analysis was undertaken on each crop. The analysis costed standard practices and identified savings created by the inter-fallow cropping. Research undertaken in inter-fallow management consisted a number of observations and evaluations of inter-fallow cropping systems currently used across the industry. In many situations inter-fallow management is a critical consideration in the management of a beetroot production system. The fallow is a primary opportunity to replenish or balance the chemical and physical properties of the soil. More importantly break the monoculture and directly minimise the disease cycles that effect beetroot production. In addition, create direct financial benefits to the profit of the business and indirect or cost neutral financial benefits by improving production or supplementing input costs. There are many benefits of inter-fallow cropping:

- Generates cash flow for the farming business
- Spreads the cost of capital and risk
- Breaks the monoculture of beetroot farming and the effects of pest and disease pressure
- Improves the soil physical and chemical characteristics for subsequent beetroot crops

7. <u>Harvesting, grading and washing evaluations</u>

The harvesting process evaluations in 2007 consisted of a number of trials and assessments. The current harvesting process has a number of limitations that dramatically effect grower returns and processing efficiencies. These range from harvester machine capabilities and limitations, harvesting damage and advantages of cleaning and grading beetroot.

Evaluating the harvesting process consisted of numerous observations and evaluations in each of the three key areas of the harvesting process, which are 1) Harvesting, 2) In-field cleaning and grading and 3) In-field washing and grading.

The advantages and disadvantages were observed through the commercial use of beetroot in-field cleaning and grading systems. The process was observed and key points listed and evaluated.

8. <u>Pest and disease management</u>

In the beetroot industry a major focus on traditional pests such as Rhizoctonia are very important, but implementation in the field of integrated pest management strategies is limited.

The objectives of pest and disease management:

- To review current practices for the management of beetroot disease, insect, weed and other pests

- To identify gaps in pest management practices for beetroot production; and

- To find solutions to gaps in pest management strategies.

Methodology

- Will revisit the initial beetroot grower surveys undertaken to establish the best practices manual (BMP) for pest management.

- Update any new management practise that has been proven in the last 2 years.

- Identify any changes to pest / s of economical importance to beetroot production.

- Evaluate effectiveness of current pest management practises and identify any deficiencies.

9. <u>Pesticide registration review</u>

A full pesticide review was undertaken on all registered and permitted pesticides in the beetroot industry. From the review two pesticides were identified as having requirements for the beetroot industry and with very separate issues.

Firstly, Rizolex™ a fungicide critical in the management of soil-borne diseases are the greatest on-farm problem that exists for beetroot growers. Which Rizolex™ is for main control measure for Rhizoctonia and Pythium and is currently on an expiring permit with the APVMA. Measures to attain full registration are critical to the beetroot industry with no other economical options available to growers. To undertake this task Golden Circle Limited has been communicating with the manufacturer Sumitomo. Sumitomo with the support of Golden Circle have decided to take Rizolex to registration with the APVMA. The Qld beetroot growers are providing their assistance and support also.

The second pesticide is Dimethoate (Rogar™) which is a systemic insecticide for the control of sucking insects. The APVMA has been reviewing this product and have advised of their intention to lapse registration for all users in the coming years. Dimethoate is only a minor pesticide for secondary pests in the beetroot industry and other alternatives are available to replace this pesticide.

Objectives

- To identify the key chemical requirements of the beetroot industry;
- To identify key individual chemicals to fulfil gaps in beetroot production; and
- To allow access to key individual chemicals through the permit or full registration process with the Australian Pesticide and Veterinary Medicines Authority (APMVA).

Methodology

- Undertake a full chemical review of beetroot production and identify the longevity of pesticide registrations, permits and other factors i.e. resistance, pesticide rotational requirements.
- Where additional pesticides are required, undertake small scale screening trials to identify potential for use in the beetroot industry.
- For those pesticides identified as suitable, commence the registration process with the APVMA.

10. Causes for beetroot quality rejection

An analysis of the 2007 rejection reports for all growers for slice grade beetroot was undertaken, with each rejection parameter ranked in order of severity. The most economically damaging rejections parameters to both growers and factory were identified. An investigation into the main causes of the defects through literature review, in field and factory monitoring and small scale trials was completed on numerous farms across the beetroot grower base.

Objectives

- To identify the all slice grade rejections from the 2007 production year;
- To quantify each slice grade rejection and list in order of highest to lowest the most economically damaging;
- List the top three slice grade rejections and investigate the causes of each rejectable parameter; and
- Investigate potential solutions to each rejectable parameter.

Development of integrated strategies for sustainable processing beetroot production achieves these objectives by identifying best practices and standardising them across all growers in the industry. Once growers adopt and standardise these practices across the industry, the impacts will directly affect yield, costs and quality at the farm and processing level.

RESEARCH PROJECTS

The target objective of the research projects is to fulfill technical gaps in the best production practices for beetroot production. This method was first achieved though a baseline data survey of the grower's current practices, and their respective yields and resultant quality. The results were examined and a single document was compiled which became the draft best practice manual.

The areas of technical gaps in information were:

- Baseline data survey
- Varietal assessments
- Beetroot nutrition requirements
- Alternative growing locations
- Planting geometry and population
- Inter-fallow management
- Harvesting, grading and washing evaluations
- Pest and disease management
- Pesticide registration review
- Causes for beetroot quality rejection

The methodology used in this project resulted from very little existing information documented about the production of beetroot either domestically or internationally. Information about growing beetroot under Australian conditions came directly from the growers, and their decades of knowledge in relation to their individual forming operations. What was required, was to compile this information and examine this information to begin the task of documenting a set of practices that could be further analysed to ensure technical gaps were addressed.

Research Project 1: Baseline data survey

The baseline data survey was conducted with all Golden Circle Beetroot growers in the Lockyer Valley in December 2005. The survey consisted of a comprehensive outline of each grower's farming practices. The results were collated into the Interim Best Practice Manual (IBPM) (See appendix One – Baseline Data survey).

It was identified that numerous cultural practices existed, for example different row spacings, where a large variation between growers was present. In these cases, research was undertaken to identify the most optimal practice that best achieved processing requirements.

The IBPM was distributed to all contributing members of the project including growers and technology transfer sessions were scheduled throughout the project.

Research Project 2: Varietal assessments

The industry standard variety - Detroit Dark Red (DDR) has shown decreased yields and increased susceptibility to diseases. In an attempt to further develop an integrated and sustainable approach to beetroot production, new varieties were trialled on a small and large scale basis aimed to analyse the best performing varieties that met processing requirements. In addition, this gave an opportunity to analyse the yield quality characteristics and growing aspects of these varieties.

Season One

Varieties were trialled in small scale plots in 2005 during an early season and mid season harvest both in the Lowood and Forest Hill areas of Ironbark Pty Ltd and Ashley Zelinski farms.

The varieties were planted in one row, down the length of the paddock and the block grown under normal commercial practices. The remainder of the block was planted with the preferred standard varieties of DDR, Red Cloud, Warrior, Pablo and Lion.

These variety trials were harvested by hand and packed off by Golden Circle which also evaluated the suitability for processing. Samples were analysed with pre-cook assessment using the same process used for commercial loads of beetroot. The focus was on quality i.e. taste, texture and colour, but also the common issues of canker, misshapen, splits, tops and tails were assessed. Other secondary factors such as price for seed and the on-farm limitations were taken into consideration. The trial varieties showing the percentage of unsuitable material are outlined on the following tables.

Early Season

Rank	**Variety**	**Total**	**Canker**	**Misshapen**	**Splits**	**Tops / Tails**
1	*Warrior*	20.04%	5.08%	7.03%	2.81%	5.13%
2	*Red Comet*	21.79%	6.67%	7.17%	4.54%	3.41%
3	*Rhonda*	23.09%	10.53%	6.23%	0.34%	5.99%
4	*Wodan*	23.61%	8.11%	1.49%	5.66%	8.35%
5	*Boro*	24.26%	8.78%	7.09%	3.31%	5.08%
6	*Pablo*	28.43%	15.36%	7.25%	0.92%	4.89%
7	*Big Red*	30.02%	15.12%	9.00%	1.13%	4.78%
8	*Action*	30.03%	10.24%	11.90%	1.38%	6.51%
9	*BT 10086*	30.80%	8.43%	2.32%	11.81%	8.23%
10	*Red Cloud*	31.11%	8.53%	8.39%	7.67%	6.52%
11	*Sapphire*	33.89%	15.65%	7.08%	4.36%	6.80%
12	*Akela*	33.90%	9.70%	5.14%	9.04%	10.02%
13	*Boltardi*	37.17%	17.11%	7.26%	0.72%	12.08%
14	*Crimson*	40.55%	20.16%	8.23%	0.99%	11.18%
15	*Redondo*	40.80%	12.94%	4.63%	7.18%	16.05%
16	*BT 0083*	41.42%	6.83%	5.97%	13.47%	15.15%

Mid Season

Rank	**Variety**	**Total**	**Canker**	**Misshapen**	**Splits**	**Tops / Tails**
1	*Warrior*	5.37%	0.26%	0.00%	1.94%	3.18%
2	*AYO 2114*	7.00%	2.21%	1.97%	0.37%	2.46%
3	*Pablo*	7.97%	3.71%	1.67%	0.00%	2.59%
4	*Ruby Queen*	10.13%	3.38%	2.11%	2.24%	2.41%
5	*Red Cloud*	10.52%	3.77%	3.15%	0.00%	3.60%
6	*HRB-1*	11.28%	2.64%	2.98%	1.64%	4.02%
7	*Rhonda*	11.78%	1.04%	6.20%	1.18%	3.37%
8	*Action*	12.05%	2.88%	4.88%	2.04%	2.25%
9	*Red Comet*	12.26%	2.37%	3.71%	1.40%	4.78%
10	*Lion*	13.00%	4.16%	3.47%	2.09%	3.27%
11	*Terra Nova*	14.01%	1.37%	7.93%	0.44%	4.28%
12	*Red Ace*	15.00%	1.99%	7.08%	1.74%	4.21%
13	*Kestrel*	15.10%	2.45%	5.32%	3.87%	3.46%
14	*Boltardi*	15.21%	2.35%	8.67%	1.59%	2.60%
15	*BT 0083*	16.66%	3.41%	1.33%	7.71%	4.21%
16	*Solo*	16.78%	5.37%	4.37%	2.20%	4.84%
17	*Sapphire*	17.19%	4.89%	4.43%	3.88%	4.00%
18	*BT Coated*	18.48%	4.33%	3.13%	6.40%	4.62%
19	*Crimson*	19.30%	4.64%	8.53%	2.00%	4.13%
20	*5819*	19.33%	10.82%	3.98%	1.65%	2.88%
21	*AYO 2112*	19.87%	2.79%	3.03%	10.00%	4.04%
22	*Big Red*	19.88%	4.65%	9.26%	3.08%	2.89%
23	*DDR*	20.71%	2.57%	8.99%	5.55%	3.59%
24	*Wodan*	20.81%	5.25%	7.78%	3.27%	4.52%
25	*Akela*	21.50%	6.81%	8.73%	2.11%	3.85%
26	*Redondo*	23.45%	6.71%	10.04%	2.37%	4.34%
27	*5820*	23.59%	4.42%	5.56%	9.31%	4.29%
28	*Boro*	25.80%	7.01%	14.73%	0.00%	4.06%
29	*BT 10086*	40.57%	18.25%	14.19%	4.18%	3.95%

Season Two and Three

In 2006 and 2007, further evaluations of varieties found to be suitable through the small scale trials, were undertaken through early and mid season large scale trials Forest Hill.

The varieties were planted in larger single areas of approximately 1 acre and grown under normal commercial practices. The remainder of the block was planted with the preferred standard varieties of DDR, Red Cloud, Warrior, Pablo and Lion.

Varieties being trialled were kept separate at harvest to faciliate testing and assessment. Samples were analysed with pre-cook assessments on commercial loads of beetroot using the same process as the 2005 evaluations. The best performing varieties from these trials are ranked in the following tables.

Slicing beetroot trial results

	Reject %	Yield t/ha
Warrior (Standard)	9.6%	31
Merlin - Bt 0086	9.9%	38
Lion	13.7%	31
Pablo (Standard)	13.8%	25
D.D.R. (Standard)	18.7%	19
Red Cloud (Standard)	24.2%	18

Baby beetroot trial results

	Reject %	Yield t/ha
Little Balls	15 %	20
New Globe (Standard)	15.58 %	17

Planting was difficult in some cases as varying seed sizes affected the density and thus may had an impact on beetroot quality. Harvesting and timing of the harvesting was an issue, as some varieties matured at different times to the others which impacted on the quality.

Variety Summary

- Wodan – several of the beets have spots of rot on them Pale skins
- Big Red – healthy shape and rich red skins
- Boro – rock impressions, no spots of rot and dark outside
- Red comet – fibrous look, spots of rot, splitting at the tops and good colour
- Rhonda – splitting tops and elongated shape e.g. potato
- Crimson – some rot and mainly good colour
- Boltarny – couple of disease spots and dark colour
- Redondo – good shape and large top
- Action – large tops, garlic shape and dark colour

Research Project 3: Standardised fertiliser programs for slice and baby grade beetroot

There has been little in-depth research into the benefits of nutrient requirement and timing for beetroot production. Therefore a trial was commissioned to –

1. Analyse the efficiency and effectiveness of soil and leaf analysis;
2. Develop an understanding of nutritional requirements;
3. Examine optimal application methods;
4. Chart growth patterns and
5. Develop an understanding of the most economic nutritional program.

The beetroot nutrition trials consisted of four commercial sized blocks, two blocks slice grade and two blocks of baby grade. Each block equated to approximately one hectare in size and there was a treatment block and a standard block for each grade. Both trial sites were located on B C Lerch, Forest Hill. The manner in which the slice grade treatment block was cultivated resulted from outcomes of the IBPM survey and agronomic assumptions for the nutritional requirements of beetroot. The baby grade treatment blocks were based of assumed modifications from the slice grade programme that met the nutritional requirements of baby beetroot.

For each slice and baby treatment block, an adjacent block was cultivated using the grower's standard fertiliser programme. Throughout the entire cropping cycle regular leaf testing and growth measurements were undertaken. The yield, rejects and payment information for each treatment block was calculated and a comparative cost analysis to industry results was undertaken.

The initial nutrition trial programme was as follows:

Season	Week	Plant Stage	Date	Fertiliser	Rate	Method	Irrigation (mm)	N	P	K	Ca	Mg	B	Zn	Fe	Mn	S	Testing
Autumn	-1	Pre-plant	04-May	Gypsum	1.5 t / ha	Broadacre - incorporate					309						725	Soil
				Tri phos	300kg / ha	together			61		43.8							
	0	Planting	08-May	Green Grove / 77S	250 kg / ha	Pre-plant band	10	33	5.5	34							49	Leaf and daily growth
	1		15-May				10											Leaf and weekly growth
	2	Two true leaf	22-May	Solubor	1.5 kg / ha	Boomspray	10						0.3					Leaf and weekly growth
	3		29-May				5											Leaf and weekly growth
Winter	4		05-Jun	Solubor	3 kg / ha	Boomspray	5						0.6					Leaf and weekly growth
				Green Grove / 77S	100 kg / ha	Post-plant band		13	2.2	14							19.6	
	5		12-Jun	Zinc Sulphate	5 kg / ha	Boomspray together								1.1			0.53	Leaf and weekly growth
				Iron Sulphate	5 kg / ha										1		0.55	
				Manganese ??	2 kg / ha											0.4		
	6	Start bulb development	19-Jun	Solubor	3 kg / ha	Boomspray	5						0.6					Leaf and weekly growth
	7	Mid bulb development	26-Jun				5											Leaf and weekly growth
	8	End bulb development	03-Jul	Solubor	3 kg / ha	Boomspray together prior to irrigating	5						0.6					Leaf and weekly growth
				Urea	5 kg / ha			2.3										
				Magnesium Sulphate	10 kg / ha							1						
	9	Start bulb expansion	10-Jul															Leaf and weekly growth
	10		17-Jul	Solubor	1.5 kg / ha	Boomspray together prior to irrigating	7						0.6					Leaf and weekly growth
				Urea	10 kg / ha			4.6										
				Magnesium Sulphate	15 kg / ha							1.5						
	11		24-Jul	Zinc Sulphate	5 kg / ha	Boomspray together								1.1			0.53	Leaf and weekly growth
				Iron Sulphate	5 kg / ha										1		0.55	
				Manganese ??	2 kg / ha											0.4		
	12		31-Jul	Solubor	1.5 kg / ha	Boomspray together prior to irrigating	7						0.6					Leaf and weekly growth
				Urea	10 kg / ha			4.6										
				Magnesium Sulphate	15 kg / ha							1.5						
	13		07-Aug															Leaf and weekly growth
	14		14-Aug	Solubor	1.5 kg / ha	Boomspray together prior to irrigating	7						0.6					Leaf and weekly growth
				Urea	15 kg / ha			6.9										
				Magnesium Sulphate	20 kg /ha							2						
	15		21-Aug															Leaf and weekly growth
	16		28-Aug	Solubor	1.5 kg / ha	Boomspray together prior to irrigating	7						0.6					Leaf and weekly growth
				Urea	10 kg / ha			4.6										
				Magnesium Sulphate	15 kg / ha							1.5						
Spring	17		04-Sep															Leaf and weekly growth
	18	Peak bulb expansion	11-Sep	Solubor	1.5 kg / ha	Boomspray together prior to irrigating	7						0.6					Leaf and weekly growth
				Urea	10 kg / ha			4.6										
				Magnesium Sulphate	15 kg / ha							1.5						
	19		18-Sep															Leaf and weekly growth
	20		25-Sep	Solubor	1.5 kg / ha	Boomspray together prior to irrigating	7						0.6					Leaf and weekly growth
				Urea	10 kg / ha			4.6										
				Magnesium Sulphate	15 kg / ha							1.5						
	21		02-Oct															Leaf and weekly growth
	22		09-Oct	Solubor	1 kg / ha	Boomspray together prior to irrigating	5						0.6					Leaf and weekly growth
				Magnesium Sulphate	10 kg / ha							1						
	23	Harvest	16-Oct															Soil and yield / rejections
	Total						102	79	69	47	353	11	6.5	2.2	2	0.8	796	

NOTE: these recommedations may change depending sampling results, weather and observations

Two days prior to harvest on-farm yield was determined through 12 x $1m^2$ random samples undertaken for both the slice and baby grade beetroot. The results are:

Slice

Site	Farm Yield
Treatment	43 t / ha
Standard	38 t / ha

Baby

Site	Farm Yield
Treatment	26 t / ha
Standard	23 t / ha

Quality alignment to Golden Circle requirements was measured through standard Golden Circle sampling procedures. This consists of a random sample obtained at Golden Circle before and after the cookers within beetroot processing. The sample is then inspected by Golden Circle inspection staff to determine the percentage of material not suitable for processing for each consignment (rejection). Outlined below is a table of the Golden Circle Limited rejection assessment summary:

Rejection Assessment Summary

	Slice		Baby	
	Standard	Treatment	Standard	Treatment
Pre Cook Assessment (%)				
Soil and Leaf	4.24	2.59	2.95	4.62
Oversize	0.00	0.00	42.86	45.99
Undersize	6.17	5.43	1.16	0.16
Zoning	6.20	3.55		0
Hollows	0.65	3.25		0
Sub Total	17.26	14.82	4.11	4.78
Post Cook Assessment (%)				
Canker	8.86	10.11	31.46	43.49
Misshapen	9.89	9.13	16.49	14.06
Splits	2.90	3.27	0	0
Harvest Damage	0.00	0.00	0.22	0.21
Tops and Tails	0.00	0.38	1.25	3.72
Rodent Damage	0.00	0.00		
Sub Total	21.65	22.89	49.42	61.48
Total	38.91	37.71	53.53	66.26
Percent oversize to slice grade			42.86	45.99
Undersize to babies - rejections (%)	21.05	42.85	0	0
Total on-farm yield (tonnes)	38.00	43.00	23	26
Total Value (dollars per acre)	2772.15	3205.42	5691.87	7691.52
Variance	433.27		1999.65	

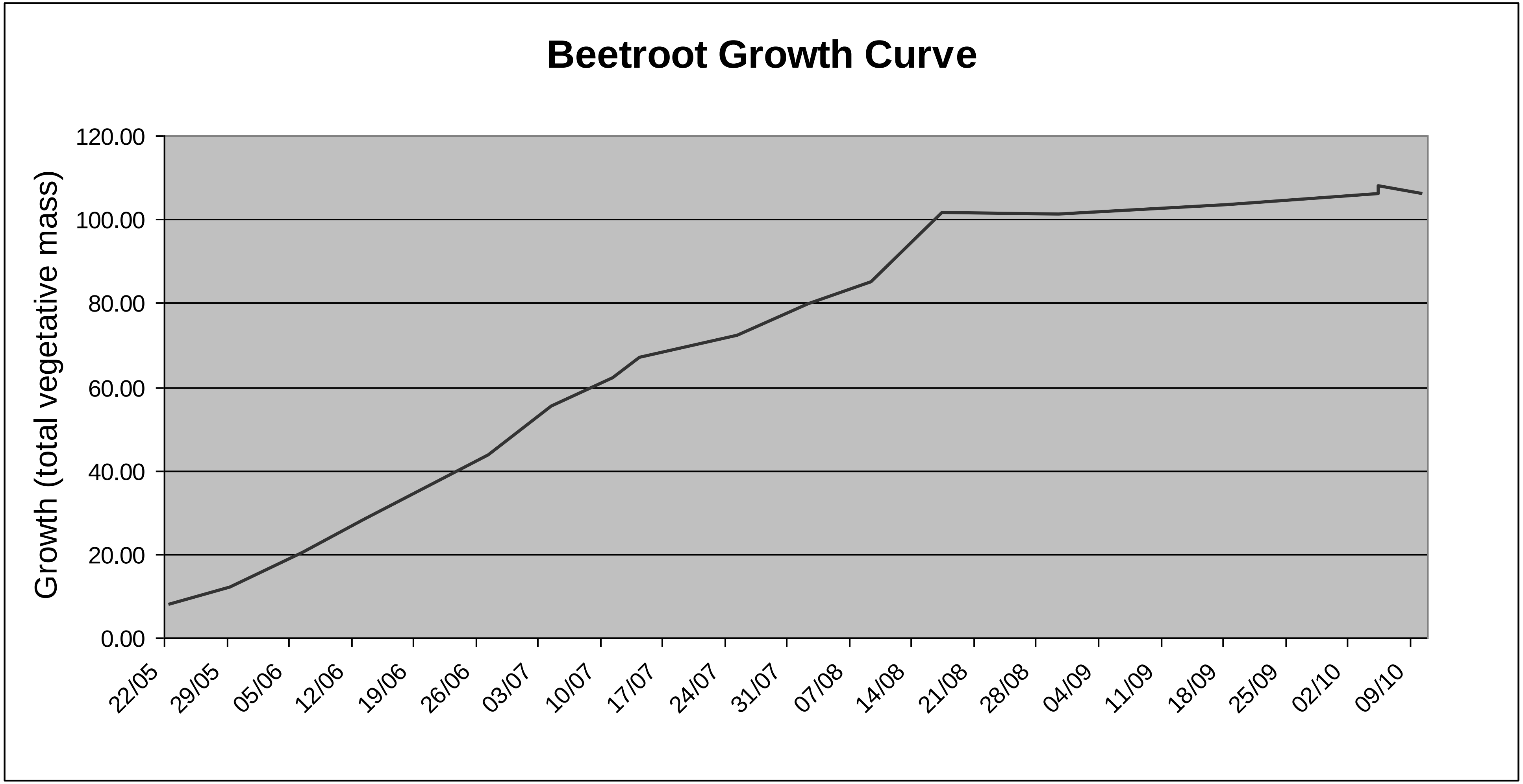
The slice results of the pre cooker assessment had a positive variance for the treatment block of 2.44% with improvement in all quality parameters except hollows. This suggests high growth at bulb development resulting from excessive levels of the major elements. In the post cooker assessment the treatment had marginally higher rejections due to 1.25% increase in canker. Overall for slice grade beetroot the total rejections were similar for both trial blocks. The major difference was the amount of rejectable undersize beetroot downgraded from slice to baby grade. This was significantly higher in the treatment block but the overall percentage of undersize was less. Grower margins generated from the value of the slice grade and value of the undersize slice in the baby grade created an improved return of $433.27 per hectare in the treatment.

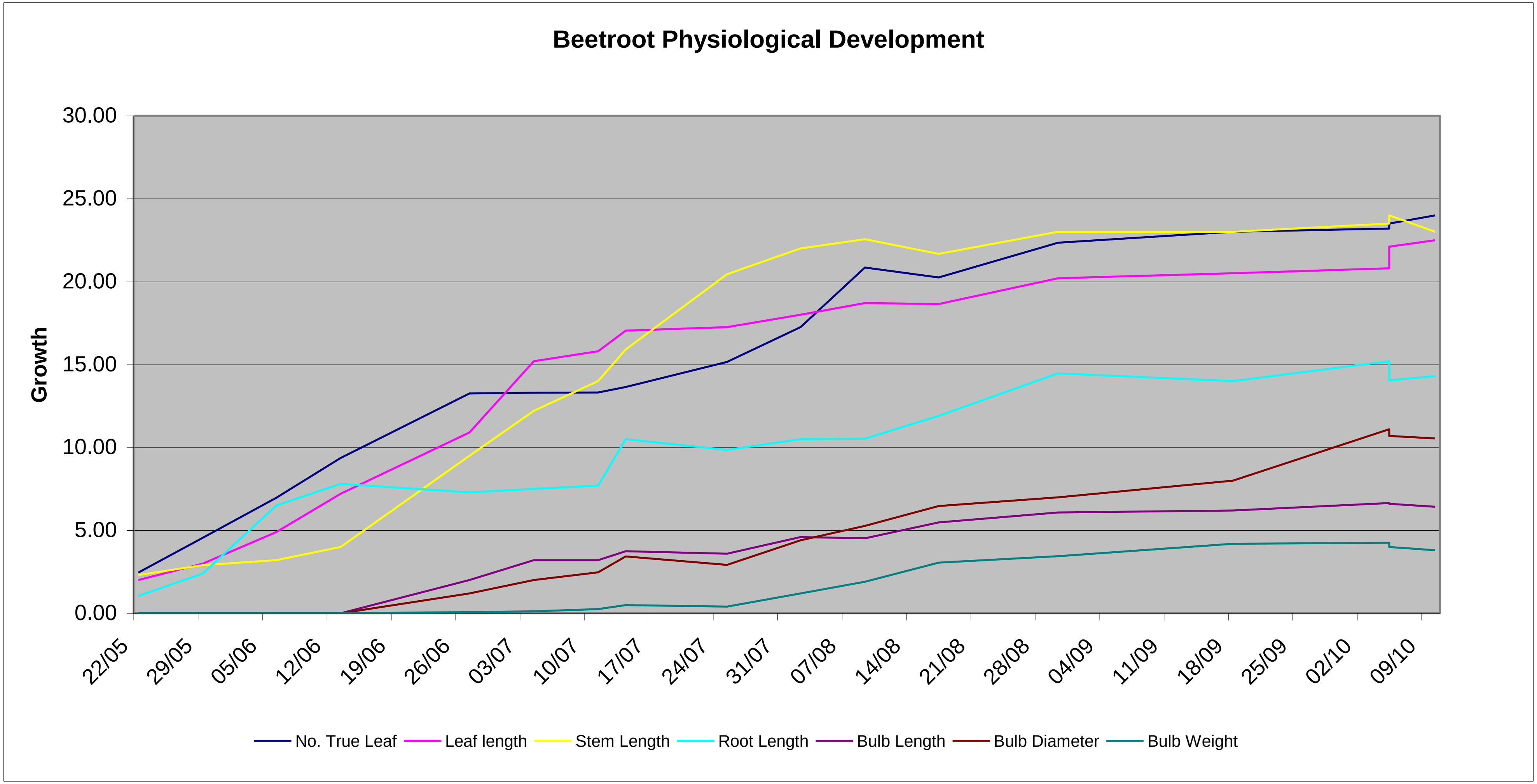
The baby results of the pre cooker assessment had a negative variance for the treatment block of 0.69% due to higher oversize and soil and leaf contamination. This suggests faster growth throughout the entire cropping cycle producing higher levels of oversize. In the post cooker assessment the treatment had significantly higher rejections due to a 12% increase in canker. Overall for baby grade beetroot the significantly higher rejections for the treatment were due to the discrepancy in canker. Canker is still an unknown factor in beetroot production and the highest rejectable parameter in slice and baby grade assessments. Grower margins generated from the value of the baby grade and value of the oversize baby in the slice grade created an improved return of $1,999.65 per hectare. Although, rejections were similar for slice grade and significantly higher for baby grade the marginally higher yields in both grade are the greatest contributing factor to gross returns to the grower.

Beetroot Growth Curve

All nutritional programs are based on supplying nutrients to the plant at the correct timing and quantity that best achieves maximum growth and highest market quality at the most economical cost. To develop the optimal nutritional program the growth curve needs to be established. To determine the beetroot growth curve numerous physiological measurements were undertaken. They were:

1. Number of true leaves;
2. Leaf length;
3. Root length;
4. Stem length;
5. Bulb diameter;
6. Bulb height;
7. Bulb weight; and
8. Plant weight.

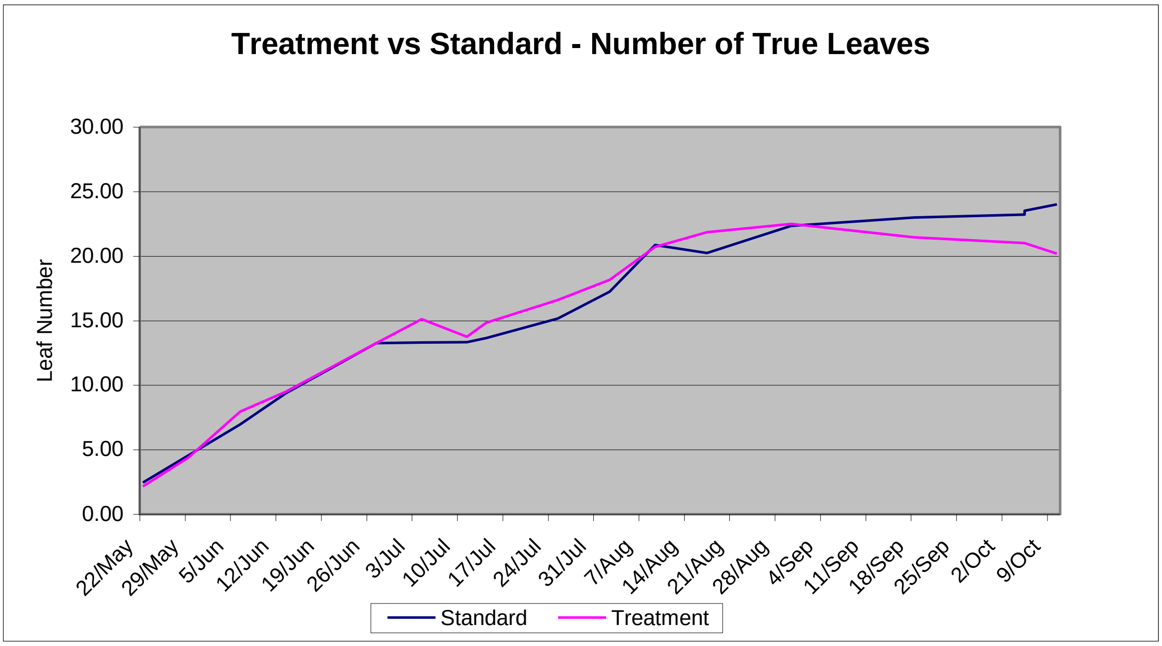

Beetroot Growth Curve
Growth (total vegetative mass)
120.00
100.00
80.00
60.00
40.00
20.00
0.00
22/05
29/05
05/06
12/06
19/06
26/06
03/07
10/07
17/07
24/07
31/07
07/08
14/08
21/08
28/08
04/09
11/09
18/09
25/09
02/10
09/10

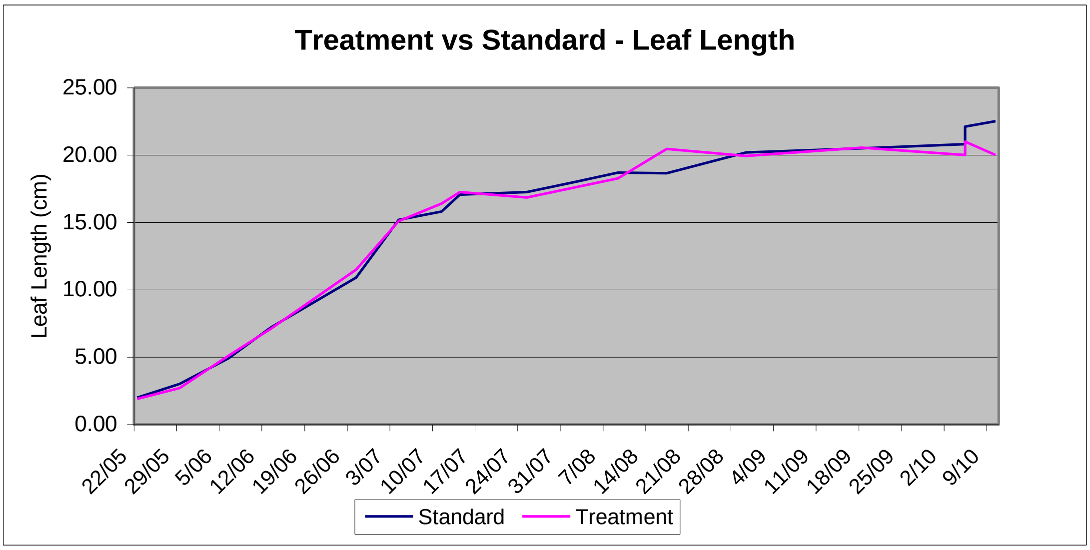


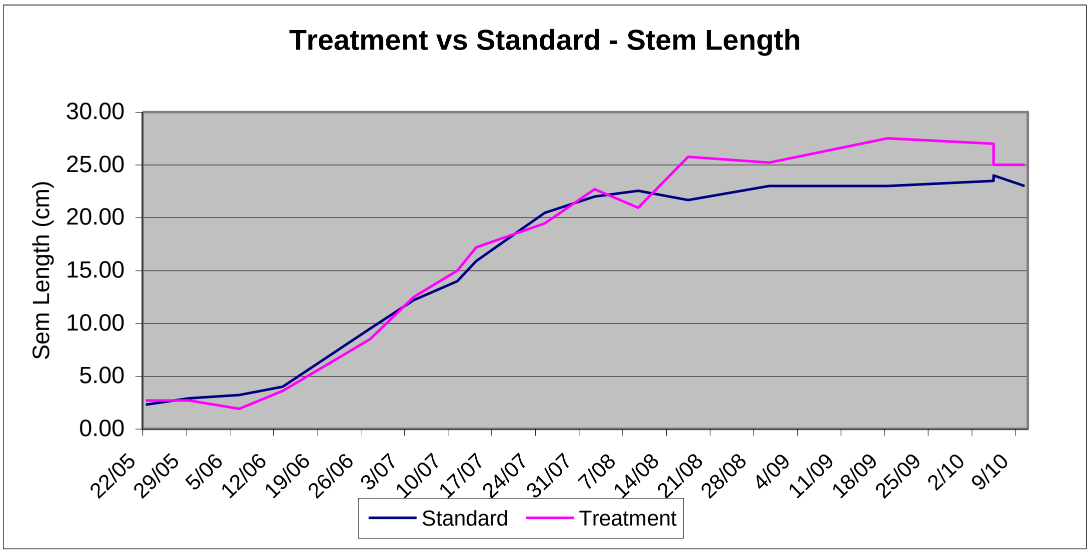
Beetroot Physiological Development
Growth
30.00
25.00
20.00
15.00
10.00
5.00
0.00
22/05
29/05
05/06
12/06
19/06
26/06
03/07
10/07
17/07
24/07
31/07
07/08
14/08
21/08
28/08
04/09
11/09
18/09
25/09
02/10
09/10
No. True Leaf
Leaf length
Stem Length
Root Length
Bulb Length
Bulb Diameter
Bulb Weight

Growth Curve

The beetroot growth curve is represented as total beetroot growth by all the physiological features measured at sampling. The total beetroot growth curve is stereotypic of normal growth patterns for most plants. It often begins with a lag phase allowing seeds to germinate and establish. This is followed by slow seedling growth whilst the effects of water, nutrient and environmental conditions initiate physiological processes within the plant i.e. leaf, stem and root development. Once initiated exponential growth begins with leaf and root expansion until 10 weeks pre-harvest, when growth slows but not stops through to harvest. Soon after the beginning of exponential growth initial stages of pubescence begin with the formation of bulbs otherwise referred to as bulbing. It is essential for exponential growth to begin prior to bulbing as the synthesis of photosynthates must exceed a critical mass for vegetative growth, here the unused photosynthates are then sent to the bulb to be stored as starches.







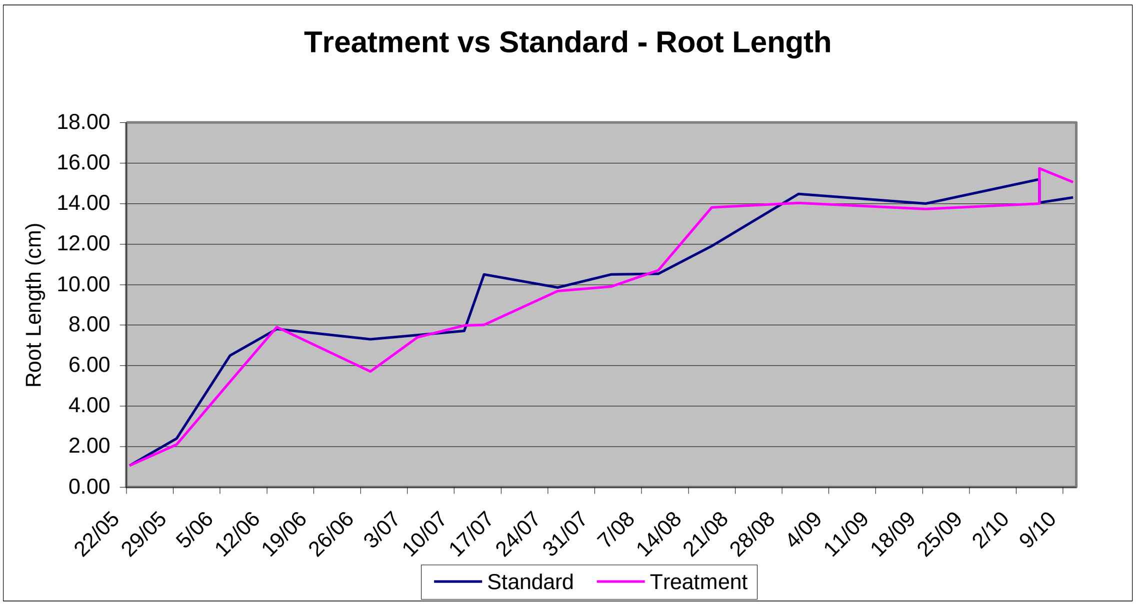
Effects on the Leaf

Both nutritional programs were compared and effects on the leaf, leaf length and stem length determined. The critical points of the leaf: 1) the production of photosynthates which is directly related to leaf area. 2) balancing leaf area to bulb development over the crop cycle.

General observation from the trial saw the number of true leaves were similar until eight weeks from harvest. The GCL treatment displayed a stabilisation of leaf numbers whilst the standard continued to produce new leaves. Stem length was similar up to 8 weeks pre-harvest where the GCL treatment was slightly longer. Leaf length was similar for both treatment and standard.

The primarily elements that would effect this variation in leaf and stem growth would be nitrogen and to a lesser extend magnesium. The continued development of leaf number was reflective of the large quantity of nitrogen (black urea) in the standard practice applied late in the cycle. The rapid peak in nitrogen initiated the development of additional new leaves, small in size and had no effect on total leaf area. However, applications of nitrogen in the GCL treatment were small in quantity at regular intervals creating consistent nitrogen levels within the plant. This did not produce any additional new leaves but increased stem length.

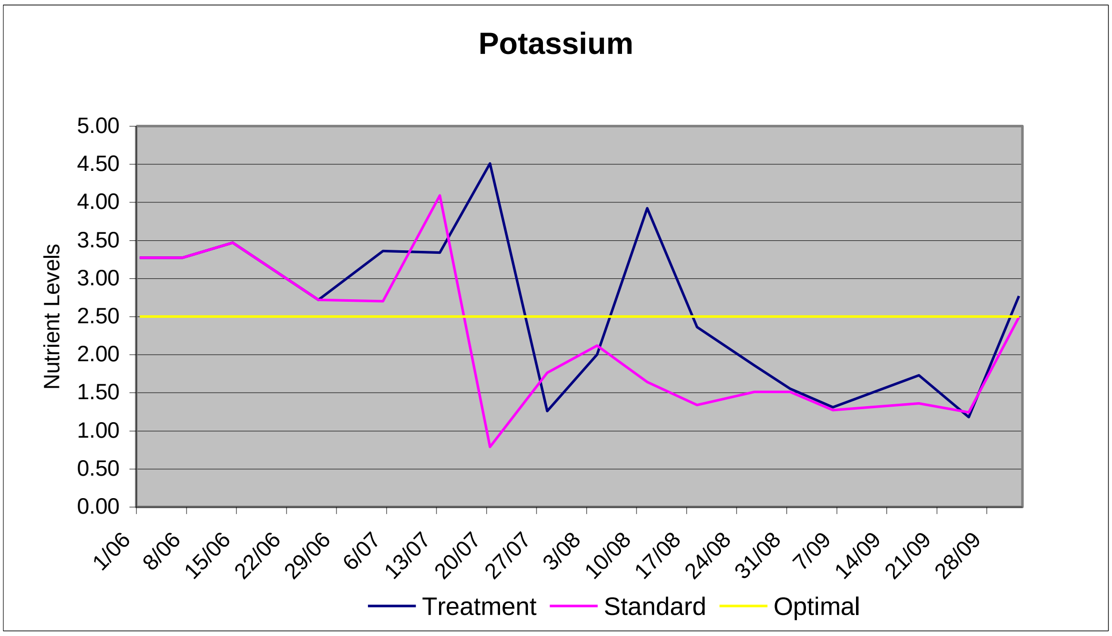
Therefore, leaf area and growth was similar in both GCL treatment and standard. Weather nitrogen levels in the plant were maintained at consistent levels as in the GCL treatment or irregular spiking levels in the standard there was no physiological gain. In addition, it is highly questionable that nitrogen being applied 8 - 10 weeks prior to harvest has any commercial gains.

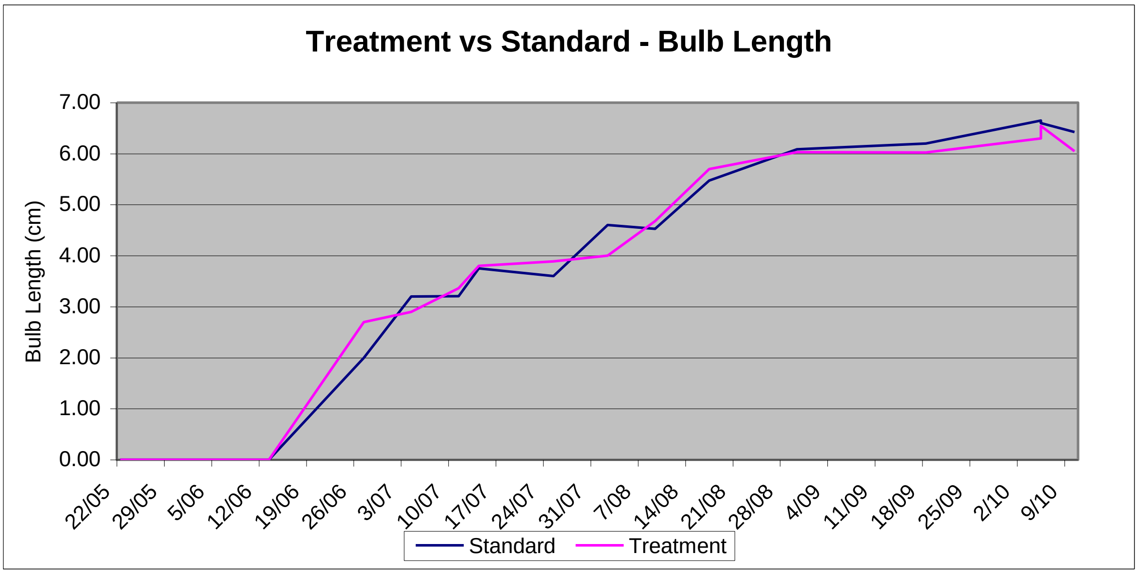


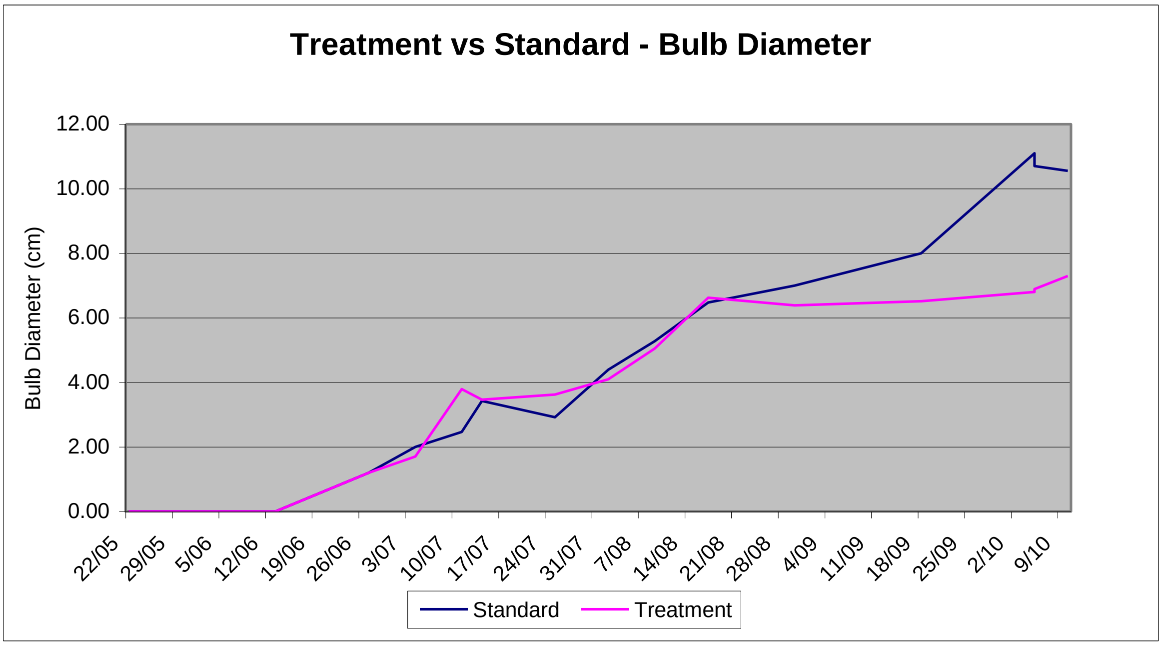
Effects on the Roots

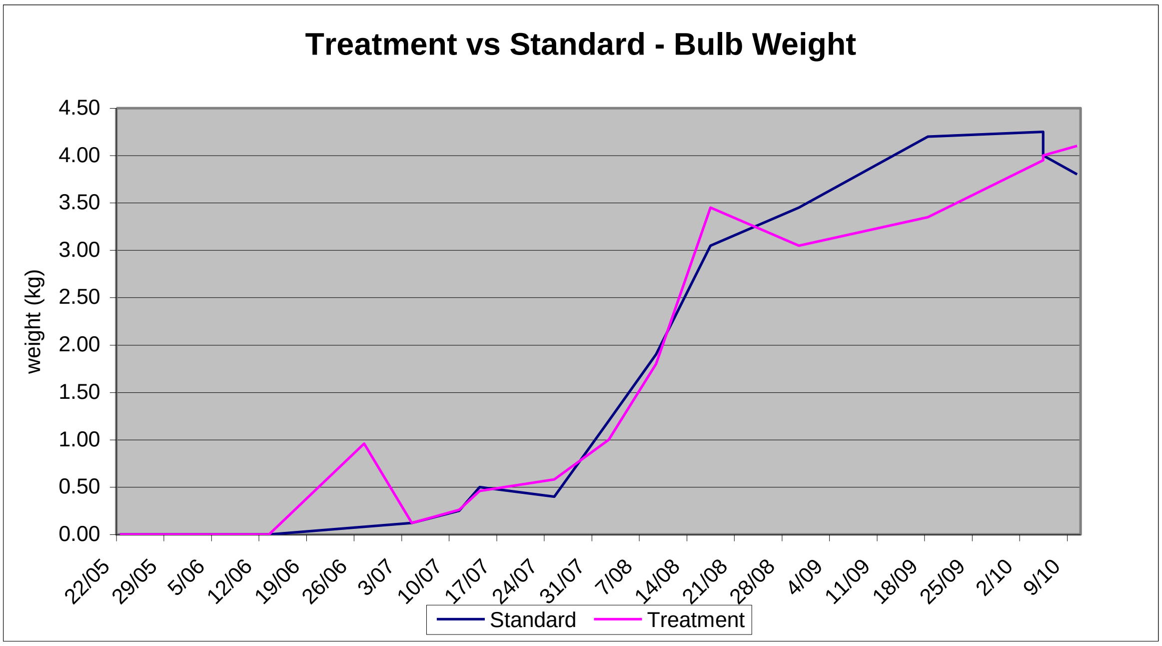
Both nutritional programs were compared and the effects on the roots were determined. The critical points: root mass directly affects the absorption of nutrient and water requirements for photosynthesis.

General observations determined that there was no difference in root length in both GCL treatment and standard. The only variations were the large differences in fertiliser programs applied to achieve these results. In the standard, two applications of 200kg/Ha of NPK were split into pre and post planting. The GCL treatment applied 250kg/Ha Green Grove or 77s in the pre- plant and 100kg/Ha in the post plant in addition to 300kg/Ha Tri-phos. (Note the high application level of Tri-phos as a pre-plant was primarily for bulb development and with an aim to have no applications in post plant due to known agronomic inefficiencies with phosphorus as a foliar spray). From the results it can be determined that a pre and post application of a multi elemental fertiliser with NPK does have positive results on root growth. However, primary elements such as potassium were unable to be maintained above optimal in both programs and additional applications are required in the foliar.


Potassium
Nutrient Levels
5.00
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
1/06
8/06
15/06
22/06
29/06
6/07
13/07
20/07
27/07
3/08
10/08
17/08
24/08
31/08
7/09
14/09
21/09
28/09
Treatment
Standard
Optimal


Treatment vs Standard - Bulb Length
Bulb Length (cm)
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
22/05
29/05
5/06
12/06
19/06
26/06
3/07
10/07
17/07
24/07
31/07
7/08
14/08
21/08
28/08
4/09
11/09
18/09
25/09
2/10
9/10
Standard
Treatment

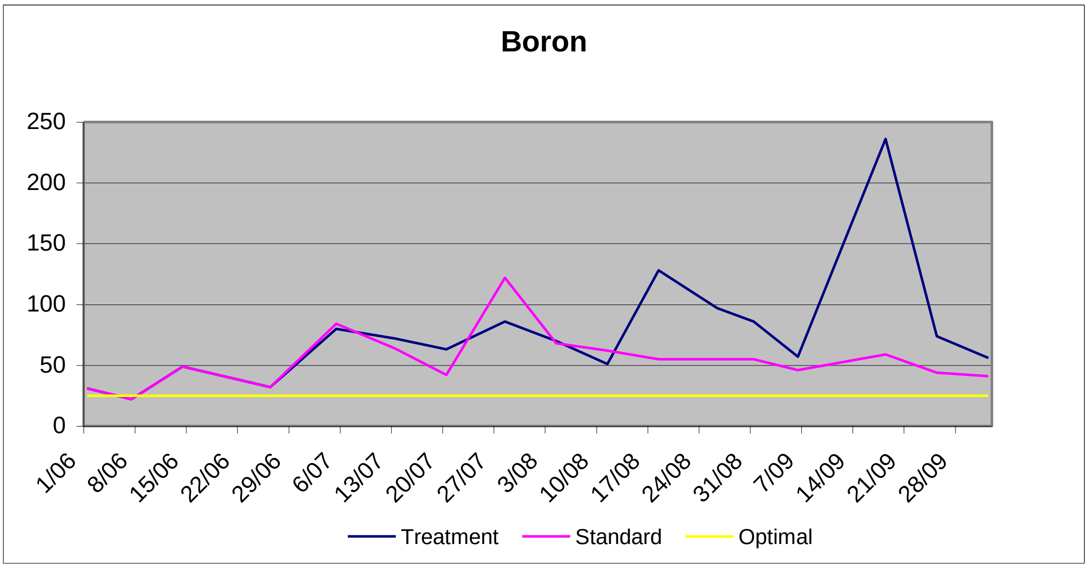


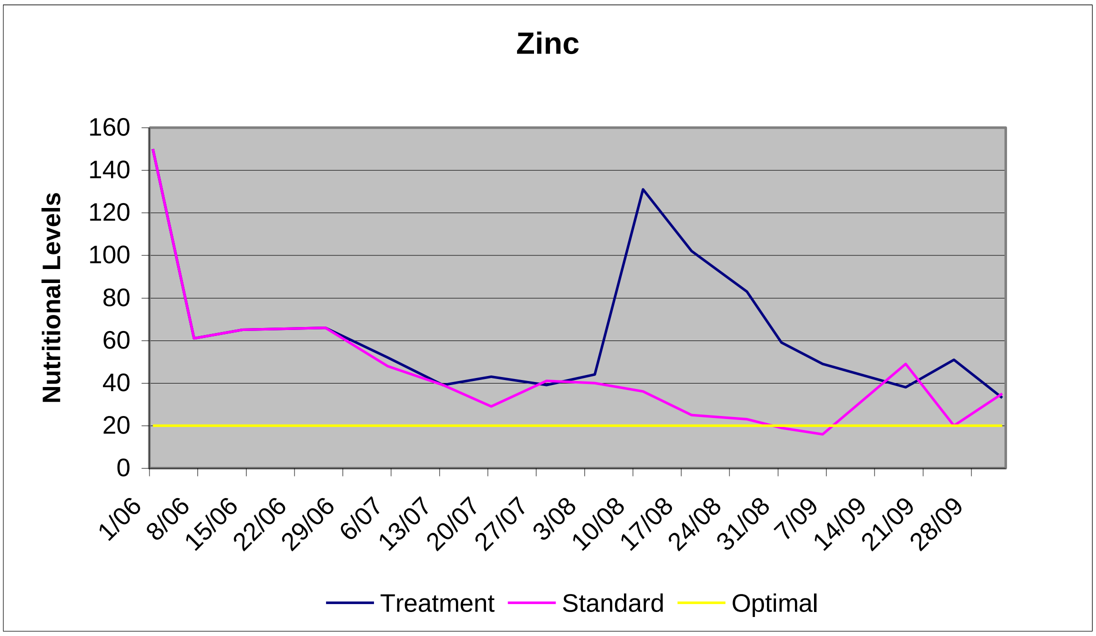


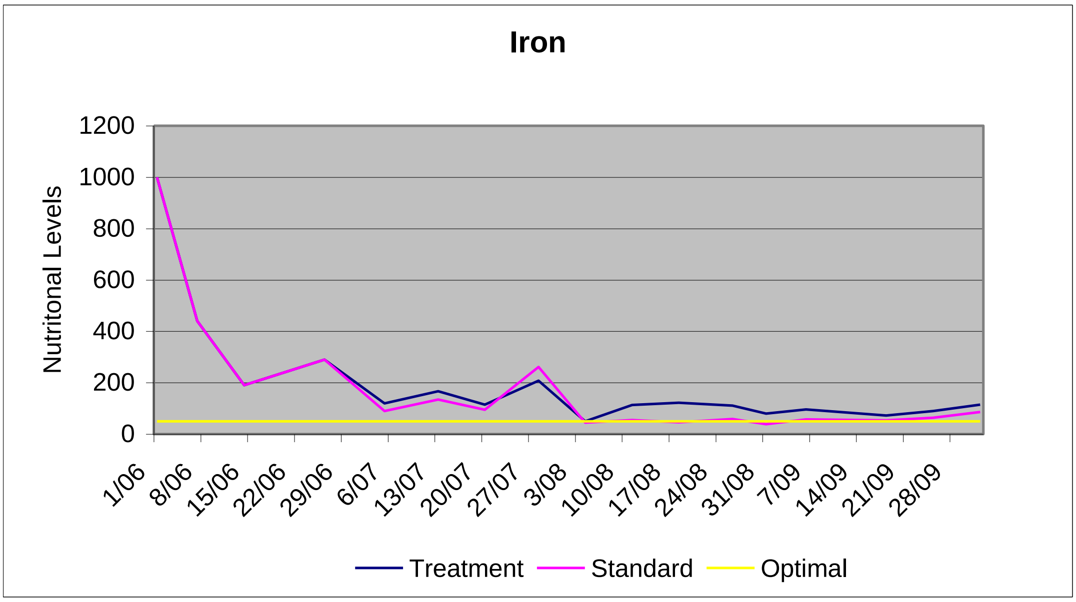
<u>Effects on the Bulb</u>

Both GCL treatment and standard the effects on the bulb were determined. The effects on the bulb for the standard and GCL treatment showed a variance in beetroot shape. In the standard the beetroot consisted a wide diameter (100mm) with a short height (650mm), whilst the GCL treatment consisted beetroot that were round with similar heights and diameter (600 - 700mm). From a Golden Circle processing perspective the desirable shape would be that beetroot produced from the GCL treatment block, due to oval shaped slices that would be removed from the beetroot in the standard block.

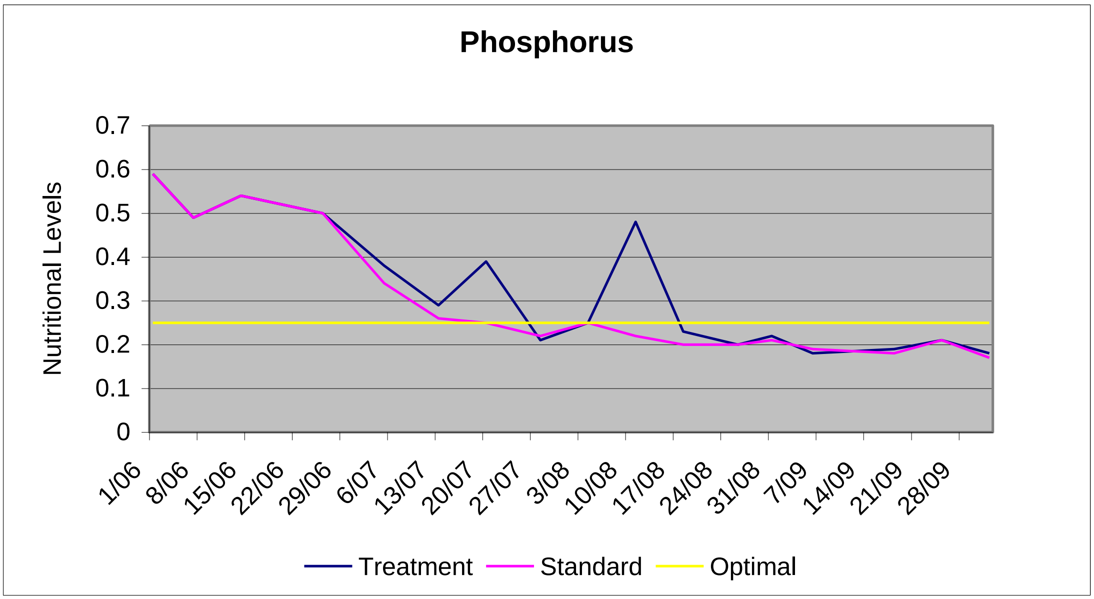
In the standard growth in beetroot height slowed at 8 weeks pre-harvest however growth in beetroot diameter continued through to harvest. In the GCL treatment exponential growth in bulb diameter and height slowed at 8 weeks pre-harvest. This may be the result of significantly higher levels of micro-elements throughout the GCL program


Boron
250
200
150
100
50
0
1/06
8/06
15/06
22/06
29/06
6/07
13/07
20/07
27/07
3/08
10/08
17/08
24/08
31/08
7/09
14/09
21/09
28/09
Treatment
Standard
Optimal


Zinc
Nutritional Levels
160
140
120
100
80
60
40
20
0
1/06
8/06
15/06
22/06
29/06
6/07
13/07
20/07
27/07
3/08
10/08
17/08
24/08
31/08
7/09
14/09
21/09
28/09
Treatment
Standard
Optimal



One of the elements that play a major in bulb development was phosphorus. In both program phosphorus was below optimal late in the cropping cycle.



The average bulb weight which directly relates to tonnage per hectare was similar. In general, the standard produced a greater percentage of big beetroot small in height and large in diameter. This potentially may have effected the development and size of surrounding beetroot, resulting in greater numbers of smalls / babies. The GCL treatment produced greater percentages of round beetroot that potentially had lesser influence on the development of neighbouring beetroot. This may of resulted in a more consist beetroot size across the block with fewer smalls / babies.

Cost Analysis

A detailed cost analysis was undertaken outside of the HAL research programme. The cost analysis determined the cost of applying fertiliser under standard practises. The results are as follows:

Slice

Site	Cost
Treatment	$705.34 / ha
Standard	$633.45 / ha

Baby Grade

Site	Cost
Treatment	$615.85 / ha
Standard	$538.51 / ha

In conclusion, in both slice and baby treatment the fertiliser programmes consisted addition applications of pre-plant and post plant solid and foliar fertiliser. The extra cost of product and application would increase fertiliser costs by 11 – 12% in the treatment blocks.

Evaluate Grower Returns,

To determine the effect on grower returns three elements of the production need to be measured, 1) Yield per hectare, 2) Cost of production and 3) beetroot payment. These will be compared for both slice and baby grade beetroot within treatment and standard blocks.

Gross Margins Analysis

Slice

Site	Gross Margin
Treatment	2,945.13 $/ha
Standard	2,786.17 $/ha

Baby

Site	Gross Margin
Treatment	3,545.51 $/ha
Standard	3,208.12 $/ha

In conclusion, the gross margins for both the slice and baby grade beetroot had improved returns for the growers. Although rejections were similar or greater in the treatments, the resulting increased yields justified the additional cost of production.

Evaluating the Best Method of Applying Fertiliser

The best methods of applying fertiliser were determined in the initial nutritional trials in 2006 but were continually monitored throughout the nutritional research. It was found that a combination of pre-plant / side dressing and foliar were required for certain elements, fertiliser types and requirements of the crop.

This was monitored through the relationship between fertiliser applications, beetroot growth and elemental levels within sap analysis. In these trials the best method of applying macro-elements was determined to be solid fertiliser through pre-plant incorporation or post plant banding.

This method was the most beneficial, by allowing available nutrient to the plant for best growth results in the most economical method of application. For micro-elements the best method of application was through the use of soluble fertilisers via foliar boomspraying. For low application rates of 2 – 4 kg/ha boomspraying was the most consistent and uniform method of applying these fertilisers when compared to fertigation.

In the final season, a good understanding of crop growth and nutritional requirements had been established. The treatment fertiliser programme could be refined to meet the requirements of the crop. The recommended programme is as outlined on page 31.

Slice - Treatment

Week	Date	Fertiliser	Rate	Application Method
-2	11-May-08	77S	500 kg / ha	Pre-plant incorporation
-1	18-May-08			
0	25-May-08			
1	1-Jun-08			
2	8-Jun-08			
3	15-Jun-08			
4	22-Jun-08			
5	29-Jun-08			
6	6-Jul-08			
7	13-Jul-08			
8	20-Jul-08	S77	200 kg / ha	Post-plant band
9	27-Jul-08			
10	3-Aug-08	Solubor	2.5 kg / ha	Foliar
11	10-Aug-08			
12	17-Aug-08	Solubor	1.5 kg / ha	Foliar
13	24-Aug-08			
14	31-Aug-08	MgSo4	5kg/ha	Foliar
		FeSo4	1kg/ha	Foliar
		Solubor	1.5 kg / ha	Foliar
15	7-Sep-08	MgSo4	5kg/ha	Foliar
		FeSo4	1kg/ha	Foliar
		Solubor	1.5 kg / ha	Foliar
16	14-Sep-08			
17	21-Sep-08			
18	28-Sep-08			
19	5-Oct-08			
20	12-Oct-08			
21	19-Oct-08			

Baby - Treatment

Week	Date	Fertiliser	Rate	Application
-2	16-Jun-08	77S	300 kg / ha	Broadacre incorporation
-1	23-Jun-08			
0	30-Jun-08			
1	7-Jul-08			
2	14-Jul-08			
3	21-Jul-08			
4	28-Jul-08			
5	4-Aug-08			
6	11-Aug-08	S77	200 kg / ha	Post-plant band
7	18-Aug-08	Solubor	3 kg / ha	Foliar
8	25-Aug-08			
9	1-Sep-08	MgSo4	5kg/ha	Foliar
		FeSo4	1kg/ha	Foliar
		Solubor	1.5 kg / ha	Foliar
10	8-Sep-08			
11	15-Sep-08	Solubor	3 kg / ha	Foliar
12	22-Sep-08			
13	29-Sep-08			
14	6-Oct-08			
15	13-Oct-08			

Slice - Standard

Week	Date	Fertiliser	Rate	Application Method
-2	11-May-08	Soft Rock	200kg/ha	Boradacre Incorporation
-1	18-May-08			
0	25-May-08			
1	1-Jun-08			
2	8-Jun-08			
3	15-Jun-08			
4	22-Jun-08			
5	29-Jun-08	77S	250kg/ha	Boradacre Incorporation
6	6-Jul-08			
7	13-Jul-08			
8	20-Jul-08			
9	27-Jul-08			
10	3-Aug-08			
11	10-Aug-08			
12	17-Aug-08	Solubor	2kg/ha	Foliar
13	24-Aug-08			
14	31-Aug-08			
15	7-Sep-08	s14	300kg/ha	Banded
		Solubor	2kg/ha	Foliar
16	14-Sep-08			
17	21-Sep-08	Solubor	2kg/ha	Foliar
18	28-Sep-08	s14	200kg/ha	Spreader
19	5-Oct-08			
20	12-Oct-08			
21	19-Oct-08	Urea	100kg/ha	Foliar

Baby - Standard

Week	Date	Fertiliser	Rate	Application
-4	2-Jun-08	Soft Rock	200 kg / ha	Broadacre incorporation
-3	9-Jun-08			
-2	16-Jun-08			
-1	23-Jun-08			
0	30-Jun-08			
1	7-Jul-08			
2	14-Jul-08			
3	21-Jul-08			
4	28-Jul-08	77S	250kg/ha	Spreader
5	4-Aug-08			
6	11-Aug-08			
7	18-Aug-08			
8	25-Aug-08	s14	250kg/ha	Banded
9	1-Sep-08			
10	8-Sep-08			
11	15-Sep-08	s14	150kg/ha	Banded
12	22-Sep-08			
13	29-Sep-08	Solubor	2kg/ha	Foliar
14	6-Oct-08			
15	13-Oct-08	Solubor	2kg/ha	Foliar

Two days prior to harvest on-farm yield was determined through 12 x $1m^2$ random samples undertaken for both the slice and baby grade beetroot. The samples were then assessed by Golden Circle inspection staff and the analysis is as follows:

Treatment vs Standard Reject Results

	Slice		Baby	
	Standard	Treatment	Standard	Treatment
Soil	1.00	3.14	0.43	0.54
Leaf and top	2.60	1.87	3.00	4.39
Zoning	0.00	0.00	0.00	0.00
Hollows	0.00	0.00	0.00	4.89
Canker	19.34	11.61	14.67	2.42
Misshapen	14.89	4.29	0.81	6.78
Splits	0.51	0.22	18.41	5.07
Harvest Damage	0.30	0.24	0.00	0.00
Tops and Tails	0.00	0.00	0.00	0.00
Rodent Damage	0.81	0.00	0.32	1.35
Total	39.45	21.37	37.64	25.44

	Slice		Baby	
	Standard	Treatment	Standard	Treatment
On-farm yield (tonnes / ha)	41.00	44.00	32.00	36.00
Cost of Production ($ / tonne)	98.00	90.00	151.00	135.00
Market Price - ($/tonne)	205	205	420	420
- Rejections (%)	39.45	21.37	37.64	25.44
Gross Margin ($/tonne)	4387.00	5060.00	8608.00	10260.00

In summary, the trials and evaluations were repeated with the refined fertiliser programme. The treatments for both slice and baby beetroot proved to be lower in rejects in almost all facets of production verse standard practices. Treatment rejects were significantly the greatest variance with 10 – 18% less, yield remained higher and cost of production less by 10 - 15% in slice and baby grade.

Increased gross margins are achieved in the treatment block, by raising on-farm yield, to achieve more benefit than any increases in the cost of production and payment to the treatment over the standard block. After three years of trial programs a new fertiliser program has been developed which will improve gross margin compared to traditional practices. This will assist with the sustainability of the beetroot industry.

The following points were the findings from the nutrition trial:

- Optimal application methods consist of the application of macro-elements as solid fertilisers, at pre and post planting, and application of micro-elements through foliar applications.
- Pre-plant fertilise with 100% of calcium requirement and high levels of phosphorus in addition to base Nitrogen Phosphorus & Potassium (NPK) at a minimum of 200kg/Ha.
- Additional requirements of phosphorus and potassium are required throughout bulbing.
- After planting follow-up with multiple applications of post plant NPK up until 8 – 10 weeks pre-harvest.
- Eliminate all nitrogen applications 8 weeks prior to harvest.

- Maintain high levels of microelements (boron (Solubor), Zinc (zinc sulphate), iron (iron sulphate or chelate) and manganese), from true leaf stage to harvest.

Research Project 4: Growing locations

Currently, Golden Circle's beetroot supply comes from 9 beetroot farms spread over a 50 km area in the Lockyer Valley. One the risk associated with the current structure of the beetroot grower base is potential effects of natural disasters or other larger scale events at a regional level. In the event of such incidences potential reductions in available supply can be devastating for the industry, especially within the production seasons.

Strategically, new areas of production should be identified to allow for out of tradional season production, to minimise risk should the Lockyer Valley experience such an event.

Yandina on the Sunshine Coast was indentified as a potenial viable growing area for beetroot; to dry land farm and to trial a "shear lift" harvesting method as opposed to the standard "pull top" method.

The farm selected is owned by Murray Oakes – which is approximately 100 km north of Brisbane and 5 km east of the Coolum Beach. The farm consists of 1000 acres of lower flat coastal soils with consistent annual rainfall of 1,500 mm.

Standard practices were adopted minus irrigation and current harvesting method. The variety was Detroit Dark Red. The site was planted in May 2006 then harvested October 2006. From the results it was determined that dry land farming is not an option for beetroot production. Although consistent rainfall did occur, the timing was not correct to met the requirements of the beetroot. This resulted in yield reductions of 60% which eliminated any possibility of growing beetroot under these farming methodologies. In addition, shear lift harvesting had moderate success, with 90% of beetroot harvested however the level of soil contamination required further modifications by this practice.

In summary, there are areas to expand the production windows of beetroot production. However, these areas must meet basic criteria needed for beetroot production requirements:

- Irrigation
- Temperature range
- Alkaline soils
- Farming infrastructure

The identified areas are:

- Mareeba
- Western Darling Downs
- North Western New South Wales
- Bundaberg
- Burdekin

The locality of the different areas allows for both early and late expansion of planting windows.

Research Project 5: Standardised planting densities and geometry for slice and baby grade beetroot

Plant density and geometry trials were undertaken on Greg Lerch farm in 2006. The trials used standard varieties of Detroit Dark Red for slice grade and New Globe for baby grade beetroot. The area under trial was approximately 1 acre and grown under standard practices. The trail was planted in May 2006 and harvested October 2006.

Currently planting geometry is based on mechanical harvesting suitability only. This may result in poorly shaped bulbs, thus increasing misshapen rejects and decreasing farm yields. Therefore a small trial using standard cultural practices was planted on different row spacing to determine if the current industry standard of 24 inch row spacing still delivers the optimum yield and quality.

All blocks planted for the 2006 season were measured at planting, five weeks from planting and at harvest. The initial results indicated that the early season blocks were being planted at densities where by large numbers of plants are not reaching the minimum size specifications. A possible reason for this is growers have had to plant at higher densities for the last two years to counteract the negative effects of high temperature at this time of the year (March). However, this season, temperatures were not as high and as such more seedlings survived.

Other information gathered from all blocks is the size range at harvest. This information will be used to determine the optimum population which will achieve certain desired size ranges. These size ranges are determined by the standard can sizes for the product range (e.g. 225g, 450g, 850g & 3.2kg).

This will allow for a more accurate pack out of each can size requirements, reducing finished goods inventory holdings from one season to the next, thus reducing costs in the total supply chain.
The results attained from the slice beetroot trials indicate the industry standard (24 inches) yields the highest pay weight. However, the level of rejects is higher than the level of rejects associated with row spacings between 20 and 12 inches.

The results attained from the baby beetroot trials indicate that 20 inch row spacing yields higher and has lower levels of rejects. However, it was noted that these results are followed closely by the 16 and 24 inch row spacings.

This report recommends, given the current supply chain model where all growers grow both slice and babies, that the current row spacings for slice and baby beetroot be retained.

Achieving an optimum plant population in beetroot growing is difficult. This is primarily because the beetroot seed used is a 'poly germ' meaning it has more than one shoot per seed. The other factors which affect population are soil tilth, the time of season being planted, variety, soil moisture etc.

The aim of this research was to determine if there was a relationship between beetroot population and yield, quality & size range. Using random sampling and assessing techniques, a wide range of facts and measurements were recorded from each block planted during the season. The results of this have led to the conclusion that population's relationship with yield and quality is weak. However there is a strong relationship between population and the size of beetroot.

The data collected in this project is very practical and will continue to provide data on many aspects regarding population and its correlation between all of the other variables measured. For example, results have provided growers with a target population which will deliver set volumes of the various size ranges. This will improve the efficiency of beetroot production. Growers will not have to grow surplus volumes outside of the optimum growing window to ensure that the desired volumes for canning are produced.

Research Project 6: Inter-fallow Management

The trials and observations on inter-fallow management were undertaken on current beetroot farms within the Lockyer Valley. These were Linton Brimblecombe, Michael Newman and Ashley Zelenski. Agronomic issues were identified on each farm and relevant fallow cropping was applied.

Numerous crops had been identified across the grower base as suitable for fallow cropping, and new crops were included into the trials. Inter-fallow crops were classified under various attributes – disease break, cash crops, soil health, etc and planted on farms with the relevent issues.

A cost analysis was undertaken on each crop. The analysis costed standard practices and identified savings created by the inter-fallow cropping. Research undertaken in inter-fallow management consisted a number of observations and evaluations of inter-fallow cropping systems currently used across the industry. In many situations inter-fallow management is a critical consideration in the management of a beetroot production system. The fallow is a primary opportunity to replenish or balance the chemical and physical properties of the soil. More importantly break the monoculture and directly minimise the disease cycles that effect beetroot production. In addition, create direct financial benefits to the profit of the business and indirect or cost neutral financial benefits by improving production or supplementing input costs. There are many benefits of inter-fallow cropping:

- Generates cash flow for the farming business
- Spreads the cost of capitol and risk
- Breaks the monoculture of beetroot farming and the effects of pest and disease pressure
- Improves the soil physical and chemical characteristics for subsequent beetroot crops

The numerous inter-fallow crops across the beetroot industry, two major crops were focused upon. These inter-fallow crops are:

- Sorghum (grain and Jumbo)
- Mung beans

<u>Sorghum</u>

Predetermined Advantages

- Key market in providing feed grains to the beef, dairy, pig and poultry industries.
- tolerates heat and moisture stress / drought tolerance, and
- sorghum usually yields on poor fertility soils.
- substantial export market for sorghum, especially to Japan.

Predetermined Disadvantages

- adequate control of summer weeds (especially grasses) is necessary within 4 - 5 weeks after planting or risk yield loss
- water stress during grain filling is the common problem causing reduced yield, causing lodging and reduced grain number and grain size.
- the major insect pests are a complex of soil-borne insects

Inter-fallow crops were evaluated for the following requirements:

- Disease break – break the beetroot monoculture without the accentuation of soil disease such as Rhizoctonia and Pythium.
- Economics – produce direct financial benefits to the farming business through sale of crop.
- Soil health – improving the physical and chemical properties of the soil; and
- Suitability to the Lockyer Valley – suitability to black earth soils, declining water availability and climate.

Crop	**Suitability**	**Disease**	**Soil Health**
Sorghum	High	Moderate	Moderate
Mung Beans	Mod - High	Low	Moderate

Late summer Crop Profit Comparisons				
	Sorghum	Corn	Sun flower	Mung
YIELD t./ha	4.5	4.0	1.5	1.25
Yield: t./ac	1.8	1.6	0.6	0.5
PRICE $/t	240	300	650	750
Return $/ha	1080	1200	975	937
Fuel/Repairs	80	80	80	80
Fallow Spray	42	42	42	42
Seed cost	32	80	36	45
Fertiliser	160	160	85	20
Other costs 1	90	95	70	85
Grow Costs	404	457	313	272
O’head costs	220	220	220	220
Profit $/ha	456	523	442	445

Sorghum and mungbean are better inter-fallow crops in rotation with beetroot then other cropping alternatives or bare fallow. This is resulting from the average financial benefits to the farming business, a high suitability to the conditions of the Lockyer Valley, low / moderate disease suppressing capabilities and moderate positive effects on soil health.

Research Project 7: Harvesting, Grading and Cleaning Evaluation

The harvesting process evaluations in 2007 consisted of a number of trials and assessments. The current harvesting process has a number of limitations that dramatically effect grower returns and processing efficiencies. These range from harvester machine capabilities and limitations, harvesting damage and advantages of cleaning and grading beetroot.

Evaluating the harvesting process consisted of numerous observation and evaluations in each of the key three areas of the harvesting process, which are 1) Harvesting, 2) In-field cleaning and grading and 3) In-field washing and grading.

The advantages and disadvantages were observed through the commercial use of beetroot in-field cleaning and grading systems. The process was observed and key points listed and evaluated. The effects of cleaned verse uncleaned on beetroot processing will be determined and cost comparisons undertaken.

Firstly, the process of beetroot in-field cleaning and grading was mapped. This process is:

Method One – In-field washing and grading

The current beetroot grower base consists nine individual farming enterprises spread over a range of 50 kilometres. Amongst these growers only two growers have the capability for in-field washing of beetroot. The following information was collated at Ashley Zelinski's farm, Lowood.

Step 1: Receivals and Cleaning
Once harvested beetroot are loaded directly into the receivals tank. The tank is full of water with low level agitation to remove the bulk of the dirt. The beetroot are then removed from the tank using a submerged conveyor.

Step 2: Threshing
Once leaving the receivals tank beetroot move through a rotating threshing drum to remove excess leaf and dirt.

Step 3: Threshing Drum to Grader
Clean beetroot of all sizes move from the threshing drum onto the feeder conveyor to the grader.

Step 4: Grader
Beetroot are then graded based on diameter by rotating augers that grade out under and over sized beetroot. Over and undersized beetroot are seperated to be disposed of by the grower.

Step 5: Transfer
All beetroot are then transferred onto conveyor belts and moved onto specified loading areas.

Step 6: Loading
Premium beetroot are then elevated into bulk loading containers for storage until transport.

Method Two – In-field cleaning and grading

Those growers who do not have washing capability undertake in-field grading through machinery sharing arrangements by BHMG (beetroot harvest management group) which harvests for 5 growers, and by Moira farming which harvests for two growers. These harvesting operations grade only and dry clean beetroot only. The following information was collated at BHMG operations at Forest Hill.

Step 1: Bulk unloading
Bulk haul-out vehicles loaded by the harvester in-field unload directly into a hopper at the end of the cleaner –grader unit.

Step 2: Grading
Beetroot are fed along a chain conveyor with approx 25mm spacings to remove dirt, then beetroot is fed along a series of finger rollers interspersed with reversing bars to remove leaf material. The beetroot is then size graded by a series of rollers

Step 3: Transfer to bulk loader
Beetroot within size specification are then loaded onto trucks for shipment to processing.

In summary, the table below outlines the percentage of total rejects that are the result of harvest damage and the inability of machinery in the harvesting process to grade out beetroot or condition beetroot within specifications.

Rejection	Percent of Total Rejections
Tops and Tails	10.57
Soil and Leaf	11.62
Harvest Damage	1.96
Over Size	0.2
Under Size	8.78
Total	33.13

Total reject tonnage for 2007 was 7,550 tonnes with 33.13% resulting from infield losses or inefficiencies at harvesting or harvesting process. This equates to 2,501 tonnes valued at $706,532 (assuming equivalent amounts of slice to baby grade beetroot).

Washing Beetroot Advantages

- Reduce potential for soil and leaf rejects

In 2007 the Golden Circle Limited rejection system identified the total amount of beetroot with soil and leaf contamination was 877 tonnes equivalent or 11.62% of total the 33.13% rejects. This equates a total beetroot value of $175,400. The potential is there for reducing soil and leaf to less than 3% .

- Reduces clogging of mud and soil in factory

The majority of the beetroot growing areas in the Lockyer Valley are located on black earth soils. These soils are high in clay content and soil moisture causing numerous issues within the harvesting and grading processes. These issues primarily result from clay attaching to the beetroot. This causes clay to be harvested with the beetroot and then transported to processing facilities. Therefore this places more requirements at the processing facility to remove the clay from the beetroot which slows processing throughputs. There is also an indirect cost to the supply chain through excessive wear on processing equipment. The direct total cost to remove soil and leaf at Golden Circle Limited is $75,000 in 2007.

- Reduced freight and logistics cost from farm to factory

Currently, the location of beetroot production in the Lockyer Valley is approximately 150 kilometres from Golden Circle Limited. The cost of freight from farm to factory is a combination of raw beetroot and waste - soil and leaf. The additional freight cost of waste material is approximately $13,155 in 2007.

- Greater factory throughputs

Processing throughputs at Golden Circle Limited are approximately 250 tonnes on a standard eight hour shift. Assuming the total soil and leaf contamination is equal per day an average of 6.5 tonnes / day is processed. This equates to 2.5% reduction in factory efficiencies.

Wasing Beetroot Disadvantages

- Additional cost to growers with no subsidy or return on investment under the current payment system

The current payments system has no subsidy or additional payment for washing beetroot. The cost of washing is approximately $13.50 / tonne and on contractual basis $26.00 / tonne to cover high volume and permanent labour.

- Less shelf life of beetroot when washed

Harvesting contractors BHMG were evaluated and service to the Golden Circle factory was measured and calculated. The harvester was evaluated for overall effectiveness and cost efficiencies. The following parameters were analysed.

- Accessibility and mobility in field under wet soil conditions

In the Lockyer Valley beetroot is grown primarily in black earth soil. The characteristics of this soil type are heavy clay with high moisture holding capacity. Under conditions of moisture the clay component of the soil forms a smooth, sticky surface with deep profiles that smears under weight. These characteristics do not allow beetroot harvesting to be undertaken after any precipitation of 10 – 15mm. The resultant effect is bogging, incorrect cutting height and anchoring of the cutting head

- Excessive amounts of mud collected in wet soil conditions

As previously discussed the characteristics of wet soil in the Lockyer Valley cause great issues to the general operations of the harvestor and contamination of beetroot. The sticky behaviour of the soil tends to stick to beetroot and the cutting heads of the harvestor. This results in increased contamination of soil on beetroot and poorer leaf cutting due to blocked knives.

- Lack of flexibility harvesting variations in row spacing

The harvestor flexibility in adapting to varying row spacing is limited. The heads of the harvestor are fixed with only the pointed feeders creating the flexibility. The spacing between the pointed feeders are 18cm and limited to ± 9cm variance to the midpoint of the cutting head.

- Percentage of beetroots left in field

Limitations on the current harvester were identified. Yield losses were measured by small scale trials that determined the amounts of beetroot left behind in a harvesting operation. In addition, harvest damage was determined at the factory and cost estimated. The total lost in field and harvester damage was totalled.

A trial block in Lockyer Valley by the BHMG harvesting group had equivalent losses of beetroot left behind in the harvesting process are as follows:

Grade	Losses (kg/m2)	Equivalent (t/ha)	Usable	Total Value
Slice	1.1	4,741	2,370	414,750
Baby	0.7	1,869	1,214	473,460

Note: assuming all harvesting machines have equivalent losses to the BHMG harvester and that lossed to this block was representive of all blocks.

- Moderate to strong leaf stand to harvest beetroot

The beetroot harvestor is a ‘top pulling’ type harvester. The principle behind this type of harvesting requires a strong leaf stand to effectively harvest the beetroot. This is greatly influenced by poor or stressed crops through agronomic issues, or the physical environment such as heavily moist soil which require higher pulling force to remove beetroot. Subsequently, tearing the leaf of the beetroot whilst still in the ground and leaving beetroot in-field.

- Direct effects on soil physical conditions

As a secondary consideration the effects of heavy machinery such as the harvestor and haul out vehicle on the black earth soil has negative effects on soil structure and general soil health.

BHMG Harvester – Lockyer Valley

Harvester damage is the direct result of mechanical damage to the beetroot through the removal, denting or cutting of the beetroot surface. The total rejects for 2007 was 1.96%. This has a total value of $78,890 in raw beetroot material.

Research Project 8: Pest and disease management

Objectives

- To review current practices for the management of beetroot disease, insect, weed and other pests
- To identify gaps in pest management practices for beetroot production; and
- To find solutions to gaps in pest management strategies.

Methodology

- Will revisit the initial beetroot grower surveys undertaken to establish the best practices manual (BMP) for pest management.
- Update any new management practise that has been proven in the last 2 years.
- Identify any changes to pest / s of economical importance to beetroot production.
- Evaluate effectiveness of current pest management practises and identify any deficiencies.

Undertake small scale trials to find solutions to any gaps identified in evaluation.

Focus on traditional pests such as Rhizoctonia are still very important, but implementation in the field of proper integrated pest management strategies may be limiting. Other smaller refinements will be necessary such as minor adjustments to herbicide and insecticide practise within legal requirements of the APVMA.

WEED MANAGEMENT

The primary method of control weeds is through the use of two primary herbicides Tramet and Betanal. Tramet will control the following weeds: Barley grass, chickweed, cleavers, fat hen, fumitory, prairie grass, redshank *Amaranthus sp*, shepherd's purse, summer grass, winter grass, wireweed. Betanal will control fat hen, chickweed, potato weed, pigweed, common thornapple, bitter cress, bellvine, penny cress, corn spurry, alkanet, wild radish, common groundsel, charlock, common sowthistle, shepherd's purse, dead nettle, dwarf nettle, common fumitory, redshank, *green amaranth, *bind weed, *persicaria, *winter grass and *blackberry nightshade. The requirements for managing weeds using these registered herbicides are:

TRAMET 500SC®

Tramet is a pre and post emergent herbicide for control of certain broadleaved weeds and grasses. For post emergent applications weeds should be at the seedling to four leaf stage. Prior to sowing any follow up crops other then beetroot should be thoroughly tilled. Pre-emergent treatments with Tramet may be followed by post emergent application of Betanal or a mixture of both.

Pre-emergence management – apply at 4 – 6 L/ha before weeds or crop emerges, either pre-or post sowing of crops. Use high rate on heavy soil or where *Amaranthus spp,* prairie grass or wireweed are a problem.

Post Emergence management – apply 2 L/ha Tramet and 5 L/ha Betanal to crop at 2 – 4 leaf stage. Apply to weeds when they are larger then 2 – 4 leaf stage either as a band or broadacre application.

BETANAL®

Betanal is a post emergent herbicide that acts via the foliage. Susceptible weeds are completely killed within 7 – 10 days. For best results the interval between application and rainfall or irrigation should not be less then 6 hours. Application should follow pre-emergence of weeds if required or a second application is possible for later germinating weeds provided a minimum of 7 days is observed between treatments.

The application rates for management of these weeds are:

- Apply 5.5 L/ha to susceptible weeds at a uniform 2 leaf stage with fine spray using 350 – 300 L water /ha.

- Apply 8.5 L/ha to susceptible weeds no later than 2 – 4 leaf stage. Use a fine spray with 250 – 300 L/ha water.

- For weeds marked with the * control at cotyledon stage at 5.5 L/ha or 2 – 4 leaf stage at 8.5 L/ha rate.

For the weeds listed above plus barley grass, summer grass, prairie grass, cleavers, wireweed and winter grass, use 5 L/ha Betanal plus 2 L/ha Tramet 500 SC. Apply where the wider spectrum of weed control and extended activity are required.

For best results the interval between treatment and subsequent rainfall or irrigation should be at least six hours. When used as a pre-emergent, apply to moist soil surface. Ensure nozzles are set at the correct height to of 50 – 60 cm above the crop, pressure 200 -300 kPa. Do not use extra hard or contaminated water, do not apply to beetroot crops that are wet, do not use when temperatures exceed 30^{o}C within the following 8 hours, do not apply to weak or stressed plants, do not use wetting agents, do not use high pressures and do not add with other herbicides unless stated.

These recommendations are best practices and outlined in the Best Management Practices Manual

DISEASE MANAGEMENT

In the beetroot industry *Rhizoctonia solani* and *Pythium spp., aphanomyces cochlioides* are the primary soil diseases involved in beetroot root rot complex. The main key physiological stages of infection are early establishment killing young plants from germination to bulb development. An integrated approach is required to minimise the effects of soil disease. It is difficult to totally control the effects of Rhizoctonia and Pythium once established but management can reduce these effects.

The main controls in the beetroot industry are:

1. Rizolex – active constituent 500 g/kg Tolclofos-methyl WP or 500g/L Tolclofos-methyl liquid for control of Rhizoctonia root and crown rot. Application in furrow at 120 g or 120 mL / 10,000 metres of row length. Alternately, seed dressing 8g or 8 mL / kg of seed.

2. Dithane - active constituent 800 g/kg Mancozeb for control of downy mildew and Cercospora leaf spot. Apply at 1.7 – 2.2 kg /ha when disease symptoms first appear and then repeat at 7 – 10 day intervals during weather conditions favourable to disease development. Note 14 day withholding period.

3. Apron - active constituent 350g/L Metalaxyl-M for control of Pythium – damping off. Apply at 100 mL/100 kg seed with diluted water before sowing. Note do not store treated seed for more then six months.

4. Controlling soil moisture through drainage.

5. Good irrigation scheduling, fertiliser practices and other pest management programs that can directly affect plant health.

6. Rotations with other crops especially corn or oats has been advantageous in suppressing particularly Pythium.

These recommendations are best practices and outlined in the Best Management Practices Manual

INSECT MANAGEMENT

In the beetroot industry the insect damage in beetroot is of a small nature compared to disease and weed pests. The major insect species are:

- Earwig
- Cutworm
- Webworm
- Ground Aphid
- Heliothis
- Hassid
- Field cricket

The primary insecticides for control of insect pest in beetroot are:

1. Diazinon 800 – active constituent Diazinon for control of webworm. Apply as a boom spray as necessary at 700mL /ha use 1L/ha for advanced crops. Note some control of aphids will be achieved.

2. Chlorpyrifos 500 EC – active constituent Chlorpyrifos for control of cutworm. Apply at 700mL/ha immediately after infestation is observed. Increase concentration to compensate if application is below 1000L spray /ha. Note: spray should cover soil out to at least 20cm on both sides of row crop. Retreat as necessary. For control of field crickets apply 100 mL/10kg bran. Apply as pest populations indicate.

3. Dimethoate – active constituent Dimethoate for control of aphids, thrips and jassids. Apply 75mL/100mL water when pests appear and repeat at 3 weekly intervals as required.

These recommendations are best practices and outlined in the Best Management Practices Manual.

In general, all disease management practices were achieving their required results and no modifications were required. The only consideration was the maintenance of chemical registrations and continual access to new pesticide technology.

Research Project 9: Pesticide registration review

Objectives

- To identify the key chemical requirements of the beetroot industry;
- To identify key individual chemicals to fulfil gaps in beetroot production; and
- To allow access to key individual chemicals through the permit or full registration process with the Australian Pesticide and Veterinary Medicines Authority (APMVA).

Methodology

- Undertake a full chemical review of beetroot production and identify the longevity of pesticide registrations, permits and other factors i.e. resistance, pesticide rotational requirements.
- Where additional pesticides are required, undertake a small scale screening trials to identify potential in the beetroot industry.
- For those pesticides identified begin the registration process with the APVMA.

A full pesticide review was undertaken on all registered and permitted pesticides in the beetroot industry. The following pages contain a summary of registered pesticides. Please refer to the labels for details. For more information on registered pesticides for beetroot visit the Agricultural Pesticides and Veterinary Medicines Authority website www.apvma.gov.au under PUBCRIS.

From the review two pesticides were identified as having requirements for the beetroot industry and with very separate issues. Firstly, Rizolex™ is a fungicide critical in the management of soil disease. Soil borne disease is the greatest on-farm problem that exists for beetroot growers in the form of Rhizoctonia and Pithier. Rizolex™ the main control measure for these diseases in currently on an expiring permit with the APVMA. Measures to attain full registration are critical to the beetroot industry with no other economical options available to growers. To undertake this task Golden Circle Limited has been communicating with the manufacturer Sumitomo for some time and both have decided to take Rizolex™ to registration with the APVMA. Sumitomo currently manufacture the product and are leading the task forward to the APVMA with assistance and support from Golden Circle Limited and beetroot grower representatives.

The second pesticide is Dimethoate (Rogar™) which is a systemic insecticide for the control of sucking insects. Currently, the APVMA is reviewing this product and determined registration will lapse for all users in the coming years. Dimethoate is only a minor pesticide for secondary pests in the beetroot industry and other alternatives are available to supplement this pesticide.

There were no other gaps in the beetroot pesticide lists requiring further investigations.

Research Project 10: Evaluate the causes of beetroot quality rejections

Objectives

- To identify the all slice grade rejections from the 2007 production year;
- To quantify each slice grade rejection and list in order of highest to lowest the most economically damaging;
- List the top three slice grade rejections and investigate the causes of each rejectable parameter; and
- Investigate potential solutions to each rejectable parameter.

An analysis of the 2007 rejection reports for all growers for slice grade beetroot was undertaken, with each rejection parameter being ranked in order of severity. The most economically damaging rejections parameters to both growers and the factory were identified. An investigation into the main causes of the defects through literature review, in field and factory monitoring and small scale trials was completed on numerous farms across the beetroot grower base.

In this analysis " canker" was significantly higher then any other reject. Canker is a disease with potential inflection points in field through bulb damage from numerous sources and in factory through contaminated water.

The second parameters may be misshapen, the result from multi-embryonic seed and high germination rates inhibiting normal growth. The third parameter was splits which may potentially resulting from variety and or growth rates.

BEETROOT INDUSTRY REJECTS 2007 - ALL GRADES

Reject	Code	Quantity (kg)	Percent
Canker	CA	2,261,377	29.95%
Misshappen	MS	1,335,514	17.69%
Splits	SP	979,328	12.97%
Soil and Leaf	SL	877,410	11.62%
Tops and Tails	TT	798,375	10.57%
Under Size	US	662,771	8.78%
Hollows	HO	435,906	5.77%
Harvest Damage	HD	148,190	1.96%
Zoning	ZO	31,350	0.42%
Oversize	OS	15,155	0.20%
Pest Damage	RA	4,910	0.07%
TOTAL			7,550,286

Canker

Samples of raw and cooked beetroot were obtained from Golden Circle on August 15, 2008. *Geotrichum* sp. was consistently identified in the cooked baby grade beets, whereas isolation results from raw beetroot samples were more variable and included a wider range of fungi. Although isolates of

Geotrichum sp. were not identified to species level at this stage, it is likely to be the commonly occurring species *Geotrichum candidum*. *Geotrichum candidum* is a fungus which causes postharvest decay (sour or yeasty rot) in a number of fruit and vegetables, such as tomatoes, citrus and cucurbits. The fungus is common on decaying plant matter in the soil, and is spread to fruit by wind and water.

Geotrichum candidum can only infect through skin injuries (e.g. mechanical or insect injuries), and disease development is favoured by hot, wet weather. While most infection originates in the field, disease development primarily occurs after harvest. Spread of the fungus from fruit to fruit rapidly occurs in contaminated wash water.

While *Geotrichum* sp. was the predominant fungus isolated from cooked grade beets, further studies are needed to confirm its pathogenicity in relation to the "canker" symptom. Further investigations are also required to determine at which stage from harvesting to processing that infection of beets is occurring.

Sour Rot in post cooked beetroot

Misshapen

Misshapen beetroot consist of bulb shapes that are non circular in appearance or irregular in form. This is primarily the result of the multi-germ formation of the seed. In general, beetroot seed naturally occur with 2 or more individual germplasm with each establishing a seedling and resultingly a bulb. In most situations, the germplasm establish a seedling at differing rates within 3 – 7 days. The close proximity of the expanding bulbs inhibits normal growth through physical contact, resulting in irregular bulb shape. To manage misshapen there are a number of measures:

- Avoid the use of varieties with high multi-germ seed i.e. New Globe;
- Ensure optimal densities allowing sufficient seed spacing for bulb expansion; and
- Use monogerm seed varieties or techniques to separate current germplasm on current multi-germ varieties. These options are often expensive or have other related problems.

Splits

Split beetroot consist small to large lesion like cracks often vertically located on the outer surface of the bulb. Splits are caused by irregular or rapid moisture uptake into the bulb through the expansion phase of bulb development. The unbalance moisture potential within the 'growth rings' of the bulb expands layers at differing rates resulting in splits. To manage splits there are a number of measures:

- Reduce the osmotic potential of the bulb to outside environment by maintaining consistent soil moisture through correct irrigation practices;
- Maintain equal levels of Electrical Conductivity (EC) between the internal bulb and outside environment through fertiliser practices and saline irrigation water.

DISCUSSION

The focus of the project was on yield, cost and quality whilst aligning to customer requirements. These targets were to be achieved in the key areas of beetroot quality and rejections, nutrition, geometry and densities and varietal selection.

The key elements to a successful nutrition program are in limiting cost whilst maximising on-farm yield and improvements in beetroot quality. In summary, the Treatment for both slice and baby has proven a reduction in rejects of 10 – 18%, yield remained higher and cost of production reduced by 10 - 15% in slice and baby grade. Thus satisfying all objectives of the project. This was primarily achieved through the identification of nutritional requirements of the crop across all stages of growth, and developing a nutritional program based on fertiliser quantities, timing and application method.

The plant densities evaluation results attained from the slice beetroot trials indicate the industry standard (24 inches) yields the highest pay weight. However, the level of rejects is higher than the level of rejects associated with row spacing between 20 and 12 inches. The results attained from the baby beetroot trials indicate that 20 inch row spacing yields higher and has lower levels of rejects. However, it was noted that these results are followed closely by the 16 and 24 inch row spacing. In this situation, production costs, yield and quality objectives of the project had been achieved by industry under standard practices. The evaluation reaffirmed these practices, and removed any doubt for further investigation.

The results of the varietal evaluations lead to the conclusion that Action and Boro provided a much higher yield (32% and 23% increase respectively) and improved quality (28% and 3% decrease respectively) when compared with industry standards. Again, these results aligned to the project objectives of yield and quality improvements.

TECHNOLOGY TRANSFER

The transfer of technology focused on the adoption of research findings throughout the project. The early stages of the project regular research meetings were undertaken. Here results were presented in lecture style format with open discussion on general topics. In addition, experimental site visits and open field discussions took place. The later stages of the project formalised extension workshops were undertaken, where sessions began with open discussion of topics with guest speakers specialising in various areas of expertise, then followed by a farm walk.

Visiting small scale variety trial

Research Steering Committee Meeting 25 Sept 2006

This meeting was held on the 25th September 2006 at the Gatton D.P.I. & F offices. Six growers and three Golden Circle representatives were present. The meeting commenced with farm visits to the trials planted for the 2006 season. The minutes of the meeting were forwarded to all growers.

Research Steering Committee Meeting 6th Nov 2006

This meeting was held on the 6th November 2006 at the Gatton D.P.I. & F offices. Eight growers and three Golden Circle representatives were present. The minutes of the meeting were forwarded to all growers

Information transfer session 6th Nov 2006

This meeting was held on the 6th November 2006 (after the Research Steering Committee Meeting outlined above) at the Gatton D.P.I. & F offices. Seven growers and two Golden Circle representatives were present.

The Interim "Best Practices Manual" was formally presented to growers. Tim Wolens presented the manual and led the group through a discussion on its contents. Growers indicated that it was a good summary of the current horticultural practices currently employed and would form a good basis for the final "Best Practices Manual".

Grower group at Information transfer session

It should be noted, that some of the results from milestone 3 have been implemented in the 2007 season. The results from the beetroot variety trials have been adopted to the extent that seed availability has allowed. For example, 18% of the beetroot grown in 2007 will be Boro variety and 3% will be Action variety.

Also a target population has been determined from the results of the 2006 block population analysis. This population has been adopted by growers for 2007.

<u>Research Steering Committee Meeting 23rd March 2007</u>
This meeting was held on the 23rd March 2007 at the Gatton D.P.I. & F offices. Seven growers and two Golden Circle representatives were present. The minutes of the meeting were forwarded to all growers.

<u>Weekly Consultation</u>
Researchers conducted weekly visits to all growers during the 2006 growing season. The progress and findings of various trials were discussed. This facilitated an opportunity to collect suggestions regarding any alternative approaches for consideration by the wider grower group at research meetings.

Extension Workshops

A series of research oriented workshops following a “shed meeting-farm walk” style format designed to:

- encourage information sharing amongst the industry;
- to give visibility to research activities being carried out on individual farms, and to;

- encourage growers to set the future direction of their own research activities.

CASE STUDY
Extension Workshop: Moira Farms, Forrest Hill
Friday May 8 2009

Agenda

1. Welcome and overview of general format of workshop/shed meetings
2. Summary of visits to seed company open days – Bejo and Rijk Zwaan.
3. Research Projects
    a. Variety trials.
    b. Discussion of GC's process for approving new varieties
    c. DPI Canker investigations.
    d. Nutrition trials – summary of plan for 2009 and nomination of growers to carry out trials
4. Farm walk
5. Venue and agenda for next meeting
6. Refreshments

Workshop: Moira Farms, Forrest Hill

Recommendations

This project produced significant outcomes with an aim to standardise the industry's production practices. Throughout the research period numerous experimental works were undertaken, and in some cases produce further questions that cold not be addressed in this project. The recommendations for future work were:

- The determination of canker disease infection sources throughout the supply chain;
- Restructure of the current harvesting group and further expansion of the harvesting group model into other areas of beetroot production; and
- Continuation of the grower workshops to further role out and monitor the adoption of practices.

The clear conclusions from the project are a range of standardised practices for producing beetroot for the slice and baby grade market. These practices target improvements in on – farm yield, quality and reducing cost of production. Thus, sustaining a viable beetroot supply chain, that can compete strongly in the global market.

ACKNOWLEDGEMENT

The commencement of the project had numerous key contributors that assisted the implementation of experimental trials and information. The most outstanding collaborator was beetroot grower Glenn Lerch who established numerous research blocks in every year of the project. In addition, Ashley Zelinski and Peter Voight who also assisted with other experimental blocks.

APPENDIX ONE – BASELINE DATA SURVEY

BEETROOT BASELINE DATA SURVEY

SITE SELECTION

What is the optimal temperature range for beetroot growth:

Maximum temperature ___________ ^oC

Minimum temperature ____________ ^oC

What is the lowest and highest tolerable temperatures before plant damage occur:

Highest Temperature ____________ ^oC

Type of Damage ____

Preventative Measures ____

Lowest temperature ______________ ^oC

Type of Damage ____

Preventative Measures ____

Describe the optimal orientation / aspect for production______________________

Describe other considerations i.e. mechanisation, irrigation, etc

____

SOIL TYPE

What is the optimum soil pH and range:

Minimum soil pH ____________

Maximum soil pH ___________

Optimal soil pH _____________

Why ____

Describe the soil drainage requirements and reasons why:

____

What is the best soil type and describe their advantages / disadvantages:

Soil Type ____

____

Soil Type ____

____

Describe other factors important in soil type: ________________________

____

____

____

FALLOW

What is the duration and frequency (rotation) of the fallow describing the purpose / reasons ____

____

What rotational crops are planted:

Crop ____

Purpose ____

Crop Management ___________________________________

____

Crop ____

Purpose ____

Crop Management ___________________________________

____

Crop ____

Purpose ____

Crop Management ____________________________________

____

Describe other factors when considering a fallow (rotation):

____

____

GROUND PREPARATION

Describe the method of crop removal if undertaken:

Machinery Type ____

Number of passes ____

Timing ____

Describe the tillage operation when preparing ground:

(1) Machinery Type ____

Number of passes ____

Timing ____

Purpose ____

(2) Machinery Type ____

Number of passes ____

Timing ____

Purpose ____

(3) Machinery Type____

Number of passes ____

Timing ____

Purpose ____

(4) Machinery Type ____

Number of passes ____

Timing ____

Purpose ____

(5) Machinery Type ____

Number of passes ____

Timing ____

Purpose ____

Describe other considerations for ground preparation i.e. drainage, etc:

____

____

____

BED FORMATION

Describe the bed formatting operation:

Machinery Type ____

Number of passes ____

Frequency of passes ____

Timing ____

Describe other considerations in bed formation:

____

____

VARIETTIES

Complete the following table for slice beetroot:

	Varieties				
Parameter					
Yield t / ha					
Disease					
Oversize					
Undersize					
Soil and Leaf					
Rodent					
Misshapen					
Splits					
Tops / Tails					
Harvest Damage					
Establishment rate					
Establishment Timing					
Disease susceptibility					
Others:					

Preferred variety (s):____

Complete the following table for baby beetroot:

	Varieties				
Parameter					
Yield t / ha					
Disease					
Oversize					
Undersize					
Soil and Leaf					
Rodent					
Misshapen					
Splits					
Tops / Tails					
Harvest Damage					
Establishment rate					
Establishment Timing					
Disease susceptibility					
Others:					

Preferred variety (s):____

CROPPING CYCLE

Complete the following table for Slice Beetroot by filling in a date in the plant and harvest column under the various crops the farmer will grow:

	Crop 1		Crop 2		Crop 3		Crop 4	
	Plant	Harvest	Plant	Harvest	Plant	Harvest	Plant	Harvest
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								

	Crop 5		Crop 6		Crop 7		Crop 8	
	Plant	Harvest	Plant	Harvest	Plant	Harvest	Plant	Harvest
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								

Comments:

Complete the following table for Baby Beetroot by filling in a date in the plant and harvest column under the various crops the farmer will grow:

	Crop 1		Crop 2		Crop 3		Crop 4	
	Plant	Harvest	Plant	Harvest	Plant	Harvest	Plant	Harvest
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								

	Crop 5		Crop 6		Crop 7		Crop 8	
	Plant	Harvest	Plant	Harvest	Plant	Harvest	Plant	Harvest
Jan								
Feb								
Mar								
Apr								
May								
Jun								
Jul								
Aug								
Sep								
Oct								
Nov								
Dec								

Comments:

PLANTING LAYOUT

Describe the planting layout for slice beetroot:

What is the optimal planting density ______________seeds / sq. metre

What is the optimal seeding arrangement ___________________________

Please draw:

What is the optimal number of rows per seedbed ______________________

What is the optimal distance:

From bed centre to bed centre ____________________________ metres

From walking space to top of bed __________________________ metres

From row centre to row centre _____________________________metres

From row centre to edge of bed ___________________________ metres

For planting depth ____metres

For row length ____ metres

Describe the planting layout for baby beetroot:

What is the optimal planting density ______________ seeds / sq. metres

What is the optimal seeding arrangement ___________________________

Please draw:

What is the optimal number of rows per seedbed ______________________

What is the optimal distance:

From bed centre to bed centre ____________________________ metres

From walking space to top of bed __________________________ metres

From row centre to row centre _____________________________metres

From row centre to edge of bed ___________________________ metres

For planting depth ____metres

For row length ____ metres

PLANTING OPERATION

Describe the planter type ____

____

____

____

What is the average establishment rate for slice beetroot __________days

What is the average planting rate for slice beetroot __________ seed / hr

What is the average establishment rate for baby beetroot _________days

What is the average planting rate for baby beetroot __________ seed / hr

How is seed / soil contact achieved at planting ______________________

____

ESSENTIAL NUTRIENTS

Complete the table of essential macro elements required to grow beetroot over a full lifecycle (kg/ha)

Element	Total Crop Requirement	Source
Nitrogen		
Phosphorus		
Potassium		
Calcium		
Magnesium		

Complete the table of essential micro elements required to grow beetroot over a full lifecycle (kg/ha)

Element	Total Crop Requirement	Source
Boron		
Manganese		
Copper		
Iron		
Zinc		

PRE- PLANT FERTILISER PROGRAM

Complete the following table for pre-plant fertiliser program (kg/ha)

Product	Rate	Method	Timing

POST PLANT FERTILSER PROGRAM

Complete the following tables for post-plant fertiliser program (kg/ha)

Month	Product Name	Application Type	Rate (kg / ha)	Water Volume
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

IRRIGATION

Describe the following irrigation activities:

What is the frequency ______________________________ days

What is the amount ________________________________mm

What is the method of application ___________________________________

What is the irrigation layout ____

____

How is soil moisture monitored _____________________________________

What is the daily crop water usage __________________________mm / day

What are the water sources _______________________________________

____

What is the optimum annual water requirement for beetroot production __________mm

When is water most required, how much and what is occurring on the farm at that time i.e. March 20mm seed establishment:

Amount__________ mm

Activity ___________________________________

Amount__________ mm

Activity ___________________________________

Amount__________ mm

Activity ___________________________________

Amount__________ mm

Activity ___________________________________

Amount__________ mm

Activity ___________________________________

Amount__________ mm

Activity ___________________________________

At what soil moisture levels is disease induced:

____

WEED MANAGEMENT

List major and minor weed species:

	Major Weeds			
Method				
Application Rate				
Volume Water				
Timing				
Application Method				

	Minor Weeds			
Method				
Application Rate				
Volume Water				
Timing				
Application Method				

List other management options_______________________________________

____

____

DISEASE MANAGEMENT

List disease control measures:

Chemical control:

Chemical	
Application Rate	
Volume Water	
Timing	
Application Method	

Describe other management options (IPM) ___________________________

____

____

INSECT MANAGEMENT

List Major and Minor Insect Species:

	Major Insects			
Chemical				
Application Rate				
Volume Water				
Timing				
Application Method				

	Minor Insects			
Chemical				
Application Rate				
Volume Water				
Timing				
Application Method				

List other management options

____

OTHER PEST MANAGEMENT

List Major and Minor Pest Species i.e. rodents

	Major Pests			
Chemical				
Application Rate				
Volume Water				
Timing				
Application Method				

	Minor Pests			
Chemical				
Application Rate				
Volume Water				
Timing				
Application Method				

List other management option

OTHER DISORDERS

List other disorders that effect beetroot production i.e. Wind damage, Heat Stress

	Disorders			
Management Options				
Chemical				
Application Rate				
Volume Water				
Timing				
Application Method				

Describe other management practices ___________________________________

____

____

____

MONITORING

Outline the process of nutritional monitoring:

Soil Analysis

Outline the sampling method _____________________________________

____

____

Length of time prior to planting ______________________________weeks

Leaf Analysis

Outline the sampling method _____________________________________

____

____

How often are samples taken ______________________________weeks

Pest Monitoring

Outline the pest monitoring:

Outline the sampling method ____________________________________

____

____

____

List pests monitored for: ____

How often is sampling undertaken ________________________________

HARVESTING

Outline harvesting method _____________________________________

Outline harvesting rates ____

Outline grading methods ____