

**VG111**

**Beetroot genetic improvement**

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**Queensland Department of Primary  
Industries**



*Know-how for Horticulture™*

VG111

This report is published by the Horticultural Research and Development Corporation to pass on information concerning horticultural research and development undertaken for the vegetable industry.

The research contained in this report was funded by the Horticultural Research and Development Corporation with the financial support of Edgell Birds Eye (QLD).

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Cover price: \$20.00  
HRDC ISBN 1 86423 553 5

Published and distributed by:



**HRDC**

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# **BEETROOT GENETIC IMPROVEMENT**

**HRDC REFERENCE NO.: VG 111**

## **FINAL REPORT**

### **INTRODUCTION**

More than 90 % of Australia's beetroot is produced in S. E. Queensland, with more than 98 % of the crop canned by the Golden Circle and Edgell-Birds Eye factories located in Brisbane. The market predominantly requires a sliced product with a smaller requirement for small, whole beetroot. Canning beetroot production is concentrated on farms in the Fassifern and Lockyer Valleys with Forest Hill being the main area.

In recent years the beetroot industry has become less profitable. Seedling establishment problems are very severe during wet years while quality problems including low root sugar levels significantly increase processing costs. This project set out to identify superior varieties for processing which gave higher yield, better colour and flavour and higher sugar levels.

Approximately thirty varieties of beetroot were collected from overseas breeding organisations and major Australian and overseas seed companies and assessed for processing in Queensland during this project. Major root characteristics being assessed were yield, uniformity, size of leaf attachment, internal colour, sugar and flavour.

Root shape was found to be a major contributor to yield with the newly developed elongated varieties having a yield potential at least 50 % above the traditional round or blocky (near round types). The first elongated variety to be tested, terete - was relatively low in sugar and had a sour (or earthy) taste, so was rejected by processors. In contrast, more recent introductions such as BT-58, 636, Formanova and CXA-9026 have higher sugar levels and improved flavour. However, slicing of elongated varieties requires specialised equipment, not available in Australian factories.

Several new varieties including BT-58, Terete, Red Orbit and Formanova have exceptional root colour. Many new varieties had higher root sugar levels than Detroit (the standard variety grown) in the 1993 trials, including, BEE-06 (58 % higher), BT-58 (66 % higher), 636 (33 % higher), CXA-9027 (33 % higher), Red Ace (67 % higher) and Formanova (15 % higher).

This project has identified beetroot varieties with increased yield, more uniform roots, superior colour, smoother skins, finer root attachments and increased sugar levels.

**Project Details :****(i) Collection of Varieties World-Wide**

During this project varieties were collected from Australian seed companies and from overseas seed companies and beetroot breeding centres in Europe and the US. Details of varieties, seed source, seed type and root shape are shown in Table 1.

**TABLE 1 : Details of Beetroot varieties sown at GRS in 1991**

VARIETY	SEED SUPPLIER	SEED TYPE	ROOT SHAPE
Detroit	Daehnfeldt	Open Pollinated	Blocky
Formanova	"	"	Elongated
Forono	"	"	"
Bee 05 F1	Fairbanks	Hybred	Round
Bee 06 F1	"	"	"
Bee 07 F1	"	"	"
Ruby F1 (Bee 02)	"	"	"
Solar F1 (Bee 04)	"	"	"
Terete (Bee 03)	"	Open Pollinated	Elongated
Warrior F1	"	Hybred	Blocky
Boltardy	Northrup King	Open Pollinated	"
Garnet	"	"	"
New Globe	"	"	"
NKX 49	"	"	"
NKX 54	"	"	"
Randoro	"	"	"
Libero	Rijkzwaan	"	"
Best Bet	Yates	"	"
Bee 01	Fairbanks	Hybred	"
Detroit	(Asgrow) New World	Open Pollinated	Blocky
Sel Bee 08	Fairbanks	Hybred	"
XPH 3646	Asgrow	Open Pollinated	Blocky

VARIETY	SEED SUPPLIER	SEED TYPE	ROOT SHAPE
BTO - 46	Northrup King	"	"
Red Orbit	South Pacific Seeds	Hybred	"
SPS 636	South Pacific Seeds	Open Pollinated	Elongated
BT 72	Northrup King	"	"
BT 73	"	Open Pollinated	"
BT 58	"	"	"
Hy-beet CXA 9026	Alf Christianson	Hybred	"
Hy-beet CXA 9027	"	"	"
HY-beet Red Ace	"	"	Blocky
Detroit Short Top	"	Open Pollinated	"

## (ii) Variety Evaluation

Screening trials were conducted at Gatton Research Station throughout the winter production season in the first two years of this project culminating in a larger trial in the Laidley production area in 1993. Varieties showing severe limitations were rejected from the program, so the varieties in the 1993 trial were generally high quality and adaptable to south Queensland.

The project was conducted over 3 stages - Stage 1 : 1991 - introduction of the first elongated varieties which were grown in the 1991 variety screening trial and compared with traditional round types. Stage 2 : 1992 - more detailed evaluation of root characteristics and quality was conducted in the 1992 variety screening trials. Yield and quality was assessed at 2 levels in a replicated density trial - (a) replicated yield and density trial to compare yield between elongated and round shaped beetroot and (b) the assessment of a yield comparison of four baby beet varieties was a secondary objective. Stage 3 : 1993 - detailed quality assessment of 3 plantings of selected round and elongated varieties suitable for the sliced beetroot market were carried out in the 1993 variety screening trial grown in the main production area of Forest Hill.

### Treatments :

Nine varieties were sown in 2 reps on 24/4/91, whilst eighteen varieties were sown in 2 reps from a second planting on 19/6/91 at the G.R.S. in the variety screening trial in 1991.

The 1992 beetroot trials involved both a variety screening trial and a yield / density trial. The variety screening trial, consisted of monthly sowings on 5 different planting dates to assess physical characteristics of both round/blocky and elongated shaped beetroots. Planting dates were early season (30/3/92), early mid-season (6/5/92), mid season (1/6/92), mid late season (30/6/92) and late season (28/7/92).

The density trial compared the yield of an elongated variety (terete) and a round/blocky shaped beetroot (detroit) at 2 densities - 300 seeds X 2 rows at 0.76 cm apart and 150 seeds X 4 rows at 0.38 cm apart. Detroit was planted at only 1 density of 300 seeds X 2 rows.

Assessment of a yield comparison of four baby beets was a secondary objective. Detroit and terete were assessed at 2 densities - 600 seeds X 2 rows and 300 seeds X 4 rows. Warrior and NKX 49 were only assessed at a density of 600 seeds X 2 rows.

The 1993 variety screening trials were grown on Mr. Peter Lerch's, Forest Hill property. Three reps were included in each of the 3 plantings. Nine varieties were sown on 29/4/93, with 13 varieties (one variety detroit with primed seed) being sown mid-May and mid-June.

#### **Data Obtained :**

Beetroot for the sliced processing market were harvested when they reached 10 cm in diameter. Physical characteristics assessed in the 1991 and 1992 variety screening trials, were internal colour, skin texture, root shape, boron cracking and other minor defects. All varieties from the 1992 screening trial were sent to Edgell Birds-Eye in Brisbane to further assess flavour and sugar:nitrate ratio after cooking. Yield comparison between a round/blocky variety (detroit) and an elongated variety (terete) at varying densities formed part of the 1992 density trial. A second part of this trial was a yield comparison of 4 baby beet varieties at varying densities as a secondary objective. These beetroots were harvested when they reached a maximum of 5 cm and a minimum of 3 cm.

The 1993 variety screening trial involved more detailed assessment of quality characteristics such as yield, root uniformity, size of both leaf and root attachments, internal colour, sugar and flavour.

#### **Results :**

Plots were harvested as beetroot reached a maximum diameter of 12 cm, minimum of 8 cm.

##### **(i) The 1991 Variety Screening Trial**

Roots were harvested by hand and visually assessed at G.R.S. for shape, internal colour, defects and given an overall quality rating. Promising varieties were sent to the Edgell Bird's-Eye factory in Brisbane for more detailed evaluation. A summary of results is contained in Table 2.

Table 2: Root Quality Summary of the 1991 Beetroot Trials conducted at G.R.S.

VARIETY	ROOT SHAPE	OVERALL ASSESSMENT *	COMMENTS
Warrior	Round, variable sizes	3	Moderate pitting, variable colour, with some yellowing and white rings present
BEE 01	Round	1	Flat, no root pitting
Ruby BEE 02	Round, variable sizes	2	Moderate root pitting, large top, medium red colour, with some yellowing
Terete BEE 03	Long elongated shape, fine tapered ends	4.5	Slight pitting, smooth skins, excellent deep purple colour. Some yellowing in core. High yielding, good tops
Solar BEE 04	Round, variable sizes	3.5	Severe pitting, uniform red colour, some with white rings
BEE 05	Round	2	Severe pitting & cracking. Pale in upper half with some white rings
BEE 06	Round	3.5	Slight pitting, good colour, good top, some with white rings
BEE 07	Round, variable sizes	2.5	Severe pitting, average colour, some with white rings. Reasonable tops
NKX 54	Round, variable sizes	2	Moderate pitting and root cracking, poor colour, some yellowing
NKX 49	Round	4.5	No pitting or cracking. Slight variation in colour, small top. Some fibrous centres in larger beetroot
Boltardy	Round	3	Not assessed - poor germination, commercial samples have moderate pitting, average colour
Garnet	Round	1	No pitting, poor internal colour, large top

VARIETY	ROOT SHAPE	OVERALL ASSESSMENT *	COMMENTS
New Globe	Round	3	Severe pitting, pale uniform red colour, with some white rings. Small top
Rondoro	Round, variable sizes	2.5	Moderate pitting, uniform pale red with some white rings. Rough skin
Detroit	Round, variable shapes & sizes	2	Severe pitting, pale internal colour some with white rings. Small top attachment, extremely low root nitrate. Rough skin
Forono	Long, elongated with tapered ends	3	Some cracking, smooth skin. Irregular colour. High yielding
Libero	Round	3.5	Moderate pitting, light red colour, some with white rings. Smooth skin, good tops
Best Bet	Round	3.5	Slight pitting, deep red colour, with some white rings. Variable uniformity
Formanova	Long, elongated shape, variable sizes	3	No pitting, deep red colour with white rings. High yielding

**\* OVERALL ASSESSMENT**

- 5 - Excellent potential with no limitations
- 4 - High potential with slight limitations
- 3 - Some potential with limitations
- 2 - Unlikely to have potential due to limitations
- 1 - Severe problems - no potential

**(ii) a - The 1992 Variety Screening Trial**

Physical characteristics assessed in the 1992 variety screening trial were, internal colour, skin texture, uniformity of root size, size of both tails and tops, boron cracking, minor defects and an overall quality rating. All varieties were sent to Edgell Bird's-Eye in Brisbane to further assess flavour and sugar:nitrate ratio after cooking. A summary of results is contained in Table 3.

TABLE 3: Root Quality Summary of the 1992 Beetroot Trials conducted at G.R.S.

VARIETY	SHAPE	SKIN TEXTURE	INTERNAL COLOUR	*OVER ALL ASSESSMENT	COMMENTS
Ruby	Round	Rough top, smooth bottom	Deep red with some dark rings & occasional white rings. Beet with large areas of orange pigment	3.1	Average quality, with white rings & orange pigment being a significant problem
Formanova	** Elong	Smooth	Deep uniform purple in first 3 plantings. In last 2 plantings there was a severe problem with white rings	3.2 Good in first 3 plantings poor in last 2	A deterioration in colour from first to last planting
Terete	Elong	Smooth	Uniform purple-red. Has a slight tendency to have white marks in larger beet. Occasional spot of orange pigment present	4.4	Excellent internal colour & smooth outer skin
Detroit ST (std)	Round	Rough top, smooth bottom	Good uniform red in first 2 plantings. Problem with white rings appearing in larger beet in last 3 plantings	3.1	Average internal colour
XPH 3646	Round	Some rough tops, smooth bottoms	Uniform deep red, with some dark rings visible. Has a tendency to have orange pigment	3.5	Good internal colour. Field spacing may have to be adjusted because it clumps readily. Orange pigmentation may be a problem. Boron was present in 3rd planting
NKX 49	Round	Smooth	In first 3 plantings beet were a dark red, purple with dark rings present. In last 2 plantings, beet were an inconsistent red with white spots in larger beet	3.9	Good quality beetroot both internally & externally. Internal colour not quite as good in last 2 plantings
Solar	Round	Rough tops, smooth bottoms	Internal colour, uniform red to red with white rings & it has a tendency to have orange pigment	3.1	Average beetroot. Some problems with internal colour

VARIETY	SHAPE	SKIN TEXTURE	INTERNAL COLOUR	*OVER ALL ASSESSMENT	COMMENTS
Bee 08	Round	Rough tops, smooth bottoms	In first 2 plantings, it was deep red in colour, however in last 3 plantings, colour was poor with white rings present & orange pigment	2.9	Poor quality beetroot. Severe problems with internal colour. Boron was present in the last planting
Libero RZ	Round	Smooth	Blood red with dark rings in first 2 plantings. Colour quality was poor in last planting with white rings prominent	2.8	Poor quality. Severe problems with internal colour. Boron was present in the 2nd planting
Carrillon RZ	Elong	Smooth	Deep red-purple in 2nd planting. Medium red colour with white rings in 3rd & 4th plantings	3.1	Average quality beetroot. Variable internal colour
Bee 05	Round	Smooth	Medium red with dark rings & pale rings found in later plantings	3.1	Average quality beetroot. Variable internal colour
Warrior (std)	Round	Rough tops, smooth bottoms	Poor internal colour with white rings found throughout sample. Orange pigment was found predominantly within samples	1.9	Very poor quality beetroot, not suited to Gatton conditions
Larka RZ	Round	Smooth	Good uniform blood red, with dark rings found only in 2nd planting	3.6	Good quality beetroot with good internal colour & smooth skin. Boron was present in the 4 th. planting
Bee 06	Round	Smooth	Excellent deep red colour with dark rings	4.1	Excellent quality beetroot for internal colour & smooth exterior
Best Bet	Round	Rough tops, smooth bottoms	Deep red with dark rings in first couple of plantings. White rings & a severe problem of orange pigment were prominent in later trials	2.5	Not suited to Gatton conditions

**\* OVERALL ASSESSMENT**

- 5 - Excellent potential with no limitations
- 4 - High potential with slight limitations
- 3 - Some potential with limitations
- 2 - Unlikely to have potential due to limitations
- 1 - Severe problems - no potential

**\*\* Elongated shaped beetroot**

**(ii) (b) - The 1992 Replicated Yield X Density Trials**

The density trial aimed primarily at a comparison of yields between terete, an elongated variety and detroit a traditional round/blocky variety. Beetroot was harvested when the roots reached a diameter of maximum 10 cm, minimum 5 cm. The results are shown in Table 4.

**Table 4 : Results of Density / Yield Trials of Slicing Beetroot grown at G.R.S. in 1992**

Variety		Yield t/ha	Days from sowing - harvest
Planting 1. Sown 30/6/92			
Detroit	300 seeds x 2 rows @ 0.76 cm apart	28.5	127
Terete	300 seeds x 2 rows @ 0.76 cm apart	36.4	165
LSD (5 P.C.) N.S.			
Planting 2. Sown 6/5/92			
Detroit	300 seeds x 2 rows @ 0.76 cm apart	35.2	128
Terete	150 seeds x 4 rows @ 0.38 cm apart	51.7	137
LSD (5 P.C.) 15.0			
Planting 3. Sown 1/6/92			
Detroit	300 seeds x 2 rows @ 0.76 cm apart	36.5	122
Terete	300 seeds x 2 rows @ 0.76 cm apart	91.0	125
LSD (5 P.C.) N.S.			
Planting 4. Sown 30/6/92			
Detroit	300 seeds x 2 rows @ 0.76 cm apart	59.6	112
Terete	300 seeds x 2 rows @ 0.76 cm apart	112.8	140
LSD (5 P.C.) 65.5			

Variety		Yield t/ha	Days from sowing - harvest
Planting 5. Sown 28/7/92			
Terete	300 seeds x 2 rows @ 0.76 cm apart	77.0	112
Detroit	300 seeds x 2 rows @ 0.76 cm apart	80.0	126
Terete	150 seeds x 4 rows @ 0.38 cm apart	104.0	119
LSD (5 P.C.) 9.1			

Assessment of a yield comparison of four baby beet varieties were also carried out as part of the 1992 density trial. These beetroots were harvested when they reached a diameter of maximum 5 cm and a minimum of 3 cm. The results are shown in Table 5.

**TABLE 5: Results of Density / Yield Trials of Baby Beetroot grown at G.R.S. in 1992**

Yields kg/ha										
Variety	*	Planting 1 30/3/92	*	Planting 2 6/5/92	*	Planting 3 1/6/92	*	Planting 4 30/6/92	*	Planting 5 28/7/92
Detroit 300 x 4	1	5453.2	3	19671.5	2	1065.6	4	12971.8	2	11524.7
Detroit 600 x 2	2	6407.0	1	6273.4	3	11169.4	1	6301.7	1	11143.1
Warrior 600 x 2	3	8479.0	4	19865.0	1	7617.3	2	7564.7	3	11748.3
NKX 49 600 x 2	4	8865.2	2	8386.9	4	13687.5	3	8051.5	4	14984.7
Terete 600 x 2	5	9123.8	5	22970.4	5	34337.2	6	50071.7	5	40796.8
Terete 300 x 4	6	11931.8	6	28574.8	6	35981.7	5	48151.0	6	56649.7
LSD (5 P.C.)		1623.8		5845.9		5127.4		28253.0		4056.3

### (iii) The 1993 Variety Screening Trials

Plots were harvested when beetroot reached 10 cm in diameter. Roots were visually assessed for shape, internal colour, skin texture, top height and size of attachment, root uniformity, root defects and raw root flavour. A summary of results is contained in Table 6. Promising varieties from the 2nd and 3rd plantings were sent to Edgell Birds-Eye in Brisbane for

detailed evaluation after cooking. A panel of 3 assessors rated sliced product for flavour, colour and texture as well as an overall rating. These varieties had a sugar : nitrate ratio rating assessment as well. These results are included in Table 7.

**TABLE 6 : Root Quality Summary of the 1993 Beetroot Trials grown at Forest Hill**

Variety	Shape	Skin Texture	Top Attachment	Root Uniformity	Internal Colour and Presence of Ringing	Root Sugar %	Sugar % (as a % of Detroit)	Raw Root Flavour
Bee-06	Semi-blocky	Smooth	Fine	Uniform	Dark Red	9.5	158.3	Above average
BT-58	Elongated	Smooth	Medium	Variable - some root twisting; thick stand	Dark purple, slight white ringing and orange pigment	10.0	166.7	Bland
XPH-3646	Semi-blocky	Smooth	Medium	Uniform	Red	4.5	75.0	Above average
636	Elongated	Smooth	Fine	Variable - some root twisting	Dark red - slight white ringing	8.0	133.3	Bland
Terete	Elongated	Smooth	Fine	Uniform - some root twisting	Dark purple	6.25	104.2	Sour
Red Orbit	Blocky	Smooth	Medium	Variable	Purple - slight black ringing	6.25	104.2	Above average
CXA-9027	Half elongated	Smooth	Fine	Very uniform	Red - slight white ringing	8.0	133.3	Bland
Detroit Primed	Round	Rough top, smooth bottom	Medium	Uniform	Red - moderate white ringing, orange pigment	8.25	137.5	Above average
Red Ace	Round	Smooth	Large	Variable; thin stand	Red - slight black ringing	10.0	166.7	Above average

Variety	Shape	Skin Texture	Top Attachment	Root Uniformity	Internal Colour and Presence of Ringing	Root Sugar %	Sugar % (as a % of Detroit)	Raw Root Flavour
Formanova	Elongated	Smooth	Fine	Uniform	Purple - slight black ringing	6.9	115.0	Bland
BT-72	Elongated	Smooth	Fine	Uniform - some root twisting	Red	2.0	33.3	Bland
CXA-9026	Elongated	Smooth	Fine	Uniform - some root twisting	Dark red - slight black ringing	6.25	104.2	Bland
BT-73	Elongated	Smooth	Fine	Variable; thick stand	Dark red - slight black ringing	4.25	70.8	Sour
Detroit (standard variety)	Round	Rough top, smooth bottom	Medium	Uniform	Dark red - slight black ringing	6.0	100.0	Above average

TABLE 7: Factory Beetroot Quality Rating after Cooking and Canning mid and late season Trial - 1993

VARIETY	Collated Results of a Taste Panel of Three				
Planting 2	COLOUR*	FLAVOUR*	TEXTURE*	OVERALL QUALITY*	FACTORY DETERMINED SUGAR %
636	4.7	3.0	3.3	3.3	10.4
BT 58	4.0	3.7	3.0	3.7	9.6
9027	2.7	3.3	3.0	2.7	9.6
Orbit	3.0	4.0	4.0	3.3	12.4
Bee 06	3.0	3.3	3.3	3.7	10.4
Detroit (Control)	3.7	3.3	3.3	3.3	N.A.
Planting 3					
XPH3646	4.0	4.0	3.7	4.0	9.7
Red Ace	3.3	3.3	3.3	3.3	9.5
Detroit	4.0	4.0	3.7	4.0	9.4
Detroit (Control)	3.0	2.7	2.7	2.7	N.A.

- \* **Taste Panel Quality Rating**
- |   |               |
|---|---------------|
| 1 | Very poor     |
| 2 | Below average |
| 3 | Average       |
| 4 | Above average |
| 5 | Excellent     |

## **DISCUSSION INCLUDING RECOMMENDATIONS**

### **(i) Extension/Adoption by Industry of Research Findings**

The series of trials conducted by this project indicated the genetic potential exists to improve the quality (fewer defects, better shape, higher root sugar levels) of beetroot. All trials were assessed in conjunction with cooperating farmers and processors with results discussed at meetings including meetings of the Processing Vegetable Technical Discussion Group.

In the round or blocky shaped varieties, there is no yield advantage over traditional varieties, so benefits of improved quality will mainly benefit processors. With the cooperating processor in this project going through a major programme of manufacturing rationalisation, and processing beetroot struggling for survival, enthusiasm to adopt the results of this project has been disappointing. Adoption of results will be slow as the initiative must come from the processor as distinct from the producers.

This project clearly demonstrated elongated shaped beetroot have the potential to increase yields by 50% over traditional blocky shaped varieties. There are quality problems with the elongating varieties secured for this project, but overseas breeders are committing more resources to breeding elongating varieties (because of higher yield potential) so over the next few years processors will follow this development with interest. The switch to elongating varieties would require investment in new slicing equipment (yet to be developed) so the ongoing restriction on capital investment in the processing vegetable industry in Queensland may restrict development in this area.

### **(ii) Direction for Future Research and/or Activities Supported by the HRDC**

There appears to be no requirements to work on improving beetroot genetics at this time as all available material was assessed in this project. Future requirements will depend on the progression of varieties with higher sugar contents and/or the acceptance of elongating varieties by processors.

### **(iii) Financial/Commercial Benefits of Adoption of Research Findings**

It is difficult to predict the future for the Queensland processing beetroot industry as industry rationalisation throughout Australia continues. It is interesting to note that one of the elongating varieties was rated as having the best overall quality of all varieties tested. It would be reasonable to expect that being approximately 50% higher yielding than traditional shaped varieties processors would continue to develop this type of variety. In reality, adoption of new varieties is expected to be very slow.